IN THE UNITED STATES DISTRICT COURT
FOR THE MIDDLE DISTRICT OF PENNSYLVANIA

TAMMY KITZMILLER, et al	:	
	:	CASE NO.
v.	:	4:04-CR-002688
	:	
DOVER AREA SCHOOL DISTRICT, et al	:	

TRANSCRIPT OF PROCEEDINGS
BENCH TRIAL

AFTERNOON SESSION

BEFORE: HON. JOHN E. JONES, III

DATE : September 26, 2005
1:47 p.m.

PLACE : Courtroom No. 2, 9th Floor
Federal Building
Harrisburg, Pennsylvania

BY : Wendy C. Yinger, RPR
U.S. Official Court Reporter

APPEARANCES:

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For the Defendants

THE COURT: All right. We welcome you all back from our lunch break. We're two or three minutes later than we wanted to be, but you'll excuse that, I hope, and we'll proceed. Mr. Walczak, back to you.

MR. WALCZAK: Thank you, Your Honor.

DIRECT EXAMINATION (continued)

BY MR. WALCZAK:

Q. Dr. Miller, I want to now switch gears from the discussion of the textbook Of Pandas and People to Professor Behe. Who is Michael Behe?

A. Michael Behe, I believe, is a professor of biochemistry at Lehigh University.

Q. And has he done research on intelligent design?

A. Well, to be perfectly honest, I'm not sure that he's done research on intelligent design. I'm aware of some of his published peer reviewed literature and can say that it concerns a wide variety of topics. I believe nucleotide and nucleic acid biogenesis, and most recently, a study on random replacement of neucleoties in genes; in other words, sort of a moving around of the genetic code and see happens to a gene.

Q. So Dr. Behe has published some peer reviewed articles, but these are not on intelligent design?

A. To my reading, none of them actually are on intelligent design. He's published a fair number, good

number of peer reviewed articles in leading peer reviewed scientific journals, no question.

Q. What is it that Professor Behe brings to the concept of intelligent design? Does he bring some idea to the table here?

A. Yes, I think he does. And the idea that he brings to the table, as you put it, is that the classic argument from design, which has been around for hundreds, thousands of years, that biological systems are complex and suggest the existence of a designer can also be phrased in terms of biochemistry.

So I believe Dr. Behe's book, Darwin's Black Box, was subtitled the Biochemical Challenge to Evolution, so what he brings to the discussion basically is the old argument from design written up in the new language of biochemistry.

Q. Let's take that in a couple of steps. First of all, you mentioned Darwin's Black Box. And I direct your attention to Plaintiff's Exhibit 434. Is this the book to which you refer?

A. Yes, sir, it is.

Q. And is this the book that Professor Behe wrote which explains his idea of irreducible complexity?

A. Yes, sir, it is.

Q. Now let me ask you. Is this a peer-reviewed

publication?

A. To my understanding, no. Books like this are subject of what you might call a kind of peer review, which is a discussion between you and the editor and perhaps the copy editor, in the same way that my own box, Finding Darwin's God, was subject to those discussions. But by the standards of science, neither my book nor Dr. Behe's book counts as a peer-review publication.

Q. Now you said a moment ago that Dr. Behe's idea isn't actually new. What do you mean by that?

A. Well, the essential argument that some features of living things are too complex to have been generated in any other way other than by attribution to a designer is an idea that, to my poor understanding of ancient philosophy goes back to the Greeks. And in western culture, very often one would go back to a book called Natural Theology that was written by the Reverend William Paley and published, I believe, in 1802.

And Paley's book had what's probably the best pre-Charles Darwin classical formulation of the idea of intelligent design. Paley was quite a naturalist. And he really understood the complexities of living systems, of living organs. He understood how they work with each other, how delicate the interplay is. And he said that

this very complexity argued for the presence and the existence of an intelligent designer who drafted all these organisms and created each of them individually.

Q. And did Reverend Paley use certain examples that we might be familiar with?

A. Yes, he did. Paley used a whole variety of examples. And I believe some of them included the nervous system, the muscular system, the digestive system. And he used them in a variety of different types of organisms. So it was a very interesting book to read, and still is a very interesting book to read. The example of Paley's that I think is remembered the best is the example of the eye.

And he pointed out that the eyes that we humans have -- because among the animal kingdom, we have very good eyes. Very few animals that can surpass the human eye. Our eye is a complex multi-part system. And I can't name all the parts not being an anatomist. But we have the cornea, we have the lens, we have the iris, we have the aqueous humor, the vitreous humor. We have the retina in the back of the eye. And for proper vision, all of these parts have to work together as a coordinated whole. And that was part of Paley's example.

Paley said, for example, what good would a lens

be without a retina? And what good would a retina be without a lens? And, therefore, all the parts would have to be assembled together. And, therefore, only a designer could do that.

Q. So his conclusion was that, there could not be a natural explanation for this complex system, the eye, therefore, there was a designer?

A. That is correct.

Q. And did Paley identify the designer?

A. To Reverend William Paley, there was absolutely no doubt as to who the designer was. He said it was God.

Q. And so how does Dr. Behe's argument differ from Reverend Paley's?

A. Well, as far as I can tell, it differs in two essential respects. The first respect is that, Dr. Behe, although he praises the arguments of William Paley in several areas of his book, argues that the argument from design, as Paley's argument is known, is made most effectively at the level of the cell, at the level of the molecule.

So he basically has attempted to update Paley's argument, not by looking at large organ systems, but by looking at biochemical machines that exist inside individual living cells. And the second way in which

his argument differs from Paley is that, Dr. Behe, after coming to the same conclusion, that there had to be an independent designer, a creative force that created these machines, these pathways, and put them into being, Dr. Behe is unwillingly to name the identity of that designer.

And I believe he suggests that the designer, of course, could be a divine force, but it could be super intelligent space aliens from Mars or perhaps time traveling cell biologists going into the past from the future and causing the structures to be put together.

Q. And have you actually heard Dr. Behe use these examples?

A. Yes, sir, I have. Dr. Behe and I have discussed and debated this issue a number of times, and these are examples that he has used in those discussions.

Q. Now Dr. Behe advances an idea known as irreducible complexity. Can you explain to us what that idea consists of?

A. Sure. The idea of irreducible complexity starts with the observation that living cells contain complex biochemical systems and machines. They are composed of many parts. He then suggests that, that complexity is irreducible. What he means by irreducible complexity is, if we start to take a few parts away to see if we

can make a simpler machine, we very quickly discover that we can't, that a machine stops functioning.

Now I've prepared a few demonstratives with quotes from Dr. Behe's work to sort of illustrate this point, if it's all right for the Court to show these.

THE COURT: Yes.

BY MR. WALCZAK:

Q. Could we have the bacterial flagellum power point?

A. So this is, in a way, a summary of Dr. Behe's argument. And one of the things that I think is important to make clear to the Court is that, it is absolutely true that there are many, many structures in the living cell, many biochemical pathways for which we don't have a detailed biochemical -- excuse me, a detailed evolutionary explanation. That is a point that all scientists will concede. Do Doctor --

Q. I'm sorry. Is that true just about evolutionary theory or is that true about any science?

A. That's true about anything. In cell biology, for example, I think most people and the court are aware that when a cell divides, the chromosomes that carry the genetic information of a cell are moved apart and separated into the two daughter cells. We have enormous arguments in the field of cell biology as to what the

exact mechanism is by which that force is generated. We can all see it happen. Any high school student can watch the separation of chromosomes under a microscope in a high school laboratory. But we still don't know exactly what the motor or the mechanism is that moves these apart. There are many, many other unsolved problems in biology.

Q. I'm sorry. Please continue.

A. Sure. So it's important to note that Dr. Behe's argument does not say simply, well, there are complex structures within the cell for whom we do not understand the detailed evolutionary origin of, that's absolutely true. But his argument really rises to a different level. What I've shown on this slide is a diagram of the bacterial flagellum.

Now bacteria, of course, are very, very simple cells. They're found everywhere in nature. They're found, for example, in our digestive systems. They're found in the skin. They're found on the surface of the table. Some bacteria have little whip like structures called flagellum. You might almost considers them to be outboard motors. And these things whip around at very high rates of speed, and they propel the bacteria through water, or sometimes they pull the bacteria in sort of a screw like motion through the water.

So it's marvelous machines. They are acid powdered reversible rotary engines. These are marvelous little machines, and they are made of a whole series of protein parts, some of which are shown in this little diagram here. Now if we can animate this slide a little bit. Next point.

Now what I wrote here is that, Dr. Behe has made very clear in what I think is fairly called his biochemical argument from design, that that argument depends upon a much bolder claim than simply saying, scientists have not completely explained how this structure evolved. And that bolder claim is shown in the next animated section of this slide.

And that is that, the evolution of complex biochemical structures cannot even or ever be explained in principle. And, of course, what he means by that is, there is some aspect of this complexity, which means we can say not just, we haven't figured it out yet, but we will never figure it out, and that's where the evidence for design lies.

Now if I may advance to the next slide. I'll try to use Dr. Behe's words to explain why he holds this point of view. The reason that evolution cannot explain, he says, the origin of such structures is because they have a property, which he calls irreducible

complexity, or they are irreducibly complex. I thought it best for the Court to read the description of irreducible complexity in Dr. Behe's own words.

So in the lower part of the the slide, I have a quotation from page 39 of his book, Darwin's Black Block. And I will read that to the Court. Quote, By irreducibly complex, I mean a single system composed of several well-matched, interacting parts that contribute to the basic function, wherein the removal of any one of the parts causes the system to effectively cease functioning.

And now, from my point of view, the key part of the argument, and I'll continue to read. An irreducibly complex system cannot be produced directly by slight, successive modifications of a pre-cursor system -- and that's how evolution would have to produce it -- because any pre-cursor to an irreducibly complex system that is missing a part is by definition non-functional.

So his argument is that, if you have a multi-part system, and all the parts are necessary to function, you can't produce that system five parts at a time, six, seven, and gradually build up the complex system, because there is no function possible until the last part is snapped into place. And that's why evolution cannot produce that system.

Now the next slide is another quote of Dr. Behe's that tries to make this point absolutely explicit as to why you need the system to be working. He points out, another quote, Darwin's Black Box, page 39, quote, Since natural selection can only choose systems that are already working -- and if you remember, his contention is, if you're missing a part, you're not working -- then if a biological system cannot be produced gradually, it would have to arise as an integrated unit, in one fell swoop, for natural selection to have anything to act upon, closed quote.

And Dr. Behe rightly points out that, to imagine such complex systems arising spontaneously in one fell swoop is something that no serious biologist would argue could happen, and I will not argue either. So his point is, as long as irreducible complexity holds, then any system we can identify as irreducibly complex couldn't have been produced by evolution. It's a very, very coherent argument.

Q. Does he identify some organisms that he calls irreducibly complex?

A. Well, counselor, not so much organisms, but he certainly identifies some machines and some structures that he regards as irreducibly complex, one of which, of course, is the bacterial flagellum. And I pointed out,

this slide contains a diagram of the flagellum. And to the right is actually sort of what we call a false color, but an electron micrograph showing a bacterium with several flagellum protruding from one end.

So that is one of the principal systems to which he points. Now the next slide, please. And I should also point out, to be a little more responsive than I have been to your question, that Dr. Behe also says, the blood clotting cascade that we talked about earlier as an example of an irreducibly complex system, the eukaryotic cilium, similar system to the flagellum, that's irreducibly complex, the vesicle targeting system that parcels out things in living cells, and also the immune system are all examples of irreducibly complex systems.

Now what I did in this slide was to prepare a graphic to make this point as clear as possible to those of us in court today. And that is to emphasize that complex biochemical machines composed of multiple interacting parts, if they work, they can have a function that's favored by natural selection. The essence of the biochemical argument from irreducible complexity, however, is that the individual parts of that machine have no function of their own.

And because they have no function on their own,

they cannot be produced by natural selection and, therefore, the impediment, the reason you can't get to here from there, you can't go from individual parts to the machine, is because the individual parts have no functions of their own.

Now evolutionary biology has grappled with this problem before. And the next slide shows how evolutionary biologists generally explain the evolution of complex machines. And that is, they agree, yes, there are such machines. You need all these parts for a particular function. But where these machines come from is, they come from pre-existing machines which have functions of their own, and that the individual parts of these machines originate in components that have different functions.

So the way in which evolutionary biology picks up Dr. Behe's challenge is to basically say, you're wrong, that the individual parts of these machines cannot have a function that is favored by natural selection. Now that, of course, in this slide, this is not evidence, of course, in the scientific sense. This is merely an argument.

But the reason I like the way that Dr. Behe has put his argument, and I like sort of describing it this way, is because it actually is amenable to a scientific

test. Something that most arguments for intelligent design are not. And the next slide.

Q. I'm sorry. This is -- is Dr. Behe's argument for irreducible complexity, is that an argument directly for design?

A. That's a good point. The answer is, no, it's not. It really is an argument that says why such systems are not produceable by evolution. So it's a negative argument against evolution. It is in itself not evidence. Even if the argument were correct, it's not evidence of a designer, it's not argument for design, it simply is an argument that the evolutionary mechanism wouldn't work in this case.

Q. So that's why this argument is testable?

A. That is correct. As I mentioned earlier, one of the problems with intelligent design is that it doesn't make any testable predictions. This actually isn't a testable prediction of design either. This is simply an argument as to why evolution wouldn't work. And that can be subjected to a test.

Q. Please continue.

A. Thank you. Next slide, please. So what I have done in this slide is to place the graphic summaries of the argument from irreducible complexity that I just made in the upper left-hand corner of the slide, and in

the upper right-hand corner, I have basically put the evolutionary explanation using the same graphic convention. And the nature of the test that I or any other scientist would propose is pretty simple.

If you animate the slide, you'll see that Dr. Behe's prediction is that the parts of any irreducibly complex system should have no useful function. Therefore, we ought to be able to take the bacterial flagellum, for example, break its parts down, and discover that none of the parts are good for anything except when we're all assembled in a flagellum.

If evolutionary theory holds, however, and we can animate again, and we'll show that in the right-hand side, evolution makes an extremely straight forward prediction. And that is, when we look at these irreducibly complex structures, we ought to be able to find parts of those systems that actually do have useful functions within them.

So we can do a very straight forward either/or test to distinguish between these two alternatives. So what I'd like to show in the next slide is how such a test can be conducted. This is a -- in the upper right-hand corner of the slide is a graphic representation from a review article showing some of the proteins involved in the construction of the bacterial

flagellum.

Now the individual names of the gene products need not concern us. They often begin with FL for flagellum. But as you can see, just as Dr. Behe says, this is a complex multi-part biochemical machine. Now the test that I would propose, we can animate the slide, please, to start with this flagellum. And if Dr. Behe is correct, if we take away even one part, there should be no function.

But I'm going to propose that we take away not one, not two, I'm going to propose we take away 30 parts. And what I'm going to propose to do is, take 30 of these proteins away and see what is left. And the slide that I set up is animated, and what we have done is -- actually, could you go back for the animation and then do it again?

And let's watch the Court do it, and we'll do the animation now. Thank you. And you can see the parts that I have removed are on the outside and the inside, and what are left are 10 proteins that span the inner and outer membrane. These bacteria, many of them are surrounded by two membranes.

These 10 remaining parts are shown in the next diagram, which will come up on the slide. And this is a diagram showing where these 10 parts are. They exist at

the very base of the flagellum near one of the cellular membranes.

Now the prediction that is made by Dr. Behe in his book is extremely straight forward, which is, since this was an irreducibly complex machine, and we've taken away most of its parts, what's left behind should be non-functional because, you remember, he wrote, any pre-cursor to an irreducibly complex machine that is missing a part is, by definition, non-functional. This guy is missing 30 parts.

Next slide. Well, it turns out that what is actually left behind when we take those parts away is a little structure with those 10 parts, which is known to microbiologists as the type III secretory system. And I can see, Mr. Walczak, you're saying, why, of course, it's the type III secretory system.

THE COURT: That certainly was on my mind.

THE WITNESS: Exactly. Now I was expecting a question of, how do you know it's not type II or type IV? The type III secretory system is a little molecular syringe that some of the nastiest bacteria in all of nature have. Yrsinia pestis, for example, which is the organism that causes bubonic plague, is a type III secretor. And what it does is, it gets inside our body, crawls up alongside, and uses this syringe to inject

poisons into a human cell.

And in the lower left-hand corner of the slide, I have some diagrams showing the operation of a type III secretory system. Now the connection between this and the flagellum is that the type III -- the 10 proteins in the type III system are almost a precise match for the corresponding 10 proteins in the base of the bacterial flagellum.

So it's very clear that a subset of those proteins has an entirely different function, a beneficial function, not for us, but for the bacterium, and a function that can and is favored by natural selection. Can I have the next slide, please? So the summary of this example is really very straight forward.

When we take this complex multi-part system, which is the bacterial flagellum, the prediction made by Dr. Behe from irreducible complexity is when we break the parts apart, we should have no useful functions. Anyone missing a part is, by definition, non-functional. We follow that up. We do break it apart. And lo and behold, we find -- actually, we find a variety of useful functions, one of which I have just pointed out, which is type III secretion.

What that means, in ordinary scientific terms is that, the argument that Dr. Behe is made is

falsified, it's wrong, it's time to go back to the drawing board.

Q. And does Dr. Behe focus on just one type of cell? I'm sorry if I'm using the wrong terms here.

A. No, he doesn't. His arguments extend to a wide variety of cells and a wide variety of systems that he identifies as irreducibly complex.

Q. But the reasoning, the analysis that you just went through is -- applies in the same fashion to these other examples, is that correct?

A. Yes, it would. And if I could redirect the Court's recollection to earlier today, one of those systems was, in fact, the blood clotting cascade. And Pandas, and as it turns out, Dr. Behe's book, Darwin's Black Box, makes the same statement, which is that, all of the parts have to be together for blood to clot effectively.

The exact quotation, I think, is, if even one part is missing, the system fails and blood does not clot. And I then showed that when we look for, for example, at the genome sequence of the puffer fish, we find that three of the parts are missing and blood still clots perfectly well.

That is exactly the same kind of argument, which we just examined, and also found wanting in another of

Dr. Behe's chosen examples, which is the flagellum.

Q. I asked you, in preparation, to select a third example, and that was the immune system. What is the immune system?

A. Well, it's a very good question, because we all depend for our very lives on a functioning immune system. It's a system of our body that is widely distributed. We have cells from our immune system sort of engaging in patrol, floating throughout the blood stream and the tissues. And it's a system that enables us to identify, defend against, and to repel foreign invaders.

When I was a little boy, for example, it was on vacation, too, which I never really liked very much, I got the chicken pox, and I was very, very sick. And it was during spring vacation, so I had the wonderful experience of being sick during vacation week. But chicken pox is a virus when invades the human body, the immune system recognizes the code proteins on the virus, makes cells that can continue to recognize it, and produces proteins called antibodies that will bind to the surface of the virus.

What that meant is, once I had gone through that miserable week with the chicken pox, I could be confident I would never get it again. I would be

permanently immune to the chicken box. This is a very important realization for medicine to have because, of course, most of us in this room have received vaccinations designed to stimulate our immunity from diseases far worse than chicken pox such as, for example, polio and diptheria and whooping cough in an effort to stipulate our immune systems to make sure we never get sick from those diseases.

Q. Have you prepared a presentation on the immune system that will help you to explain this?

A. Yes, sir, I have. And if we could show the first slide, I want to start -- and, Your Honor, I may have to stand up to --

THE COURT: That's fine.

THE WITNESS: Thanks. I thought I would start by pointing out an essential protein of the immune system. You can't work without it. That essential protein is sometimes -- it is called by researchers an immunoglobulin, but it is more commonly called an antibody. These are the essential molecules of the immune system.

In the upper left-hand corner of the slide, there is a molecular diagram for what an antibody actually looks like. It basically is a little Y shaped molecule with two binding sites. And you'll notice in

the slide, those binding sites are labeled foreign particle binding sites. I hope I have antibodies circulating in my bloodstream against chicken pox. So if I get chicken pox virus in my body, that foreign particle binding site on my chicken pox antibody will bind to the surface of the virus. Another one will bind to the other site.

And gradually, the virus will be cross linked into a mesh world, which my immune system recognizes, eliminates from the circulation, and destroys. And that's why, hopefully, I'm not going to get chicken pox again. Now in the lower right-hand is a more diagrammatic view of this molecule. It's made up of four parts.

These are each polypeptides, and they're diagrammed. And you'll notice that part of these -- each of the polypeptides is colored blue, and another part is colored red. The red says, variable region. Now I know some of my own vaccination history, so I've been vaccinated against polio, diptheria, measles, and a number of other diseases.

The antibodies in my body against polio differ from the antibodies I have against diptheria in the variable regions. They have a different shape because the viruses or the bacteria have different

molecules on the surface.

The genius, if you will, of the immune system, is that it can produce an antibody that will attach to, stick to, identify, and destroy just about anything. So one of the most important things in our immune system is the ability, basically, to produce antibodies against any conceivable molecule that might get inside our body. Can I have the next slide?

Now about 20 years ago, a scientist working at MIT named Susumu Tonegawa -- I know I'm going to have to spell that for the court reporter -- determined exactly how antibodies had the ability to produce such diversity. And that is, it turns out to be a system in the genes of cells in the immune system known as a VDJ recombination system.

And this system is not at all unlike a dealer shuffling a deck of cards, and that at a certain point in development, parts of DNA, in a variety of genes, are literally shuffled. They're tossed from one side to another, and they are rearranged to form a final gene. Now some elements of this shuffling are random just like you hope the dealer, when you go to Las Vegas, is shuffling those card randomly so you don't know what you're going to get.

But it's in that random shuffling that our

immune system develops the ability to produce an antibody to just about anything. That shuffling is at the heart of why the immune system works. If anything goes wrong with this process, the individual in which it goes wrong loses the ability to make diverse antibodies, they get very sick, and they're in big trouble when they start to see foreign organisms.

Now the next slide. Where did this system come from? That's the question that people interested in evolution always try to answer. About 10 years ago, a number of scientists, including Nobel Prize winner David Baltimore, speculated that this process, which is called VDJ recombination, might actually have evolved from a system known as transposition, a system in which genes jump around.

What I have placed on the slide in addition to this diagram and the reference to the Baltimore group's paper in the proceedings of the National Academy of Sciences is a quotation from this paper illustrating his hypothesis. They, and he means the gene shuffling system, could have been part of retrotransposons and had a DNA rearrangement function this their previous life. It's possible that the ancestors of these genes, they're called RAG genes, may have been horizontally transferred into a metazoan multi-cellular animal lineage at a

recent point in evolution.

So he argued, he suggests there might be an evolutionary way to explain where this system came from. It's a very interesting suggestion. And as I wrote in the slide, perhaps the three part system arose from a type of mobile genetic element known as a transposon. It's a hypothesis, but the important point, and the reason it's useful is that, it is a testable hypothesis.

Can I have the next slide, please? Now Dr. Behe was aware when he wrote Darwin's Black Box of the speculations of the Baltimore lab.

BY MR. WALCZAK:

Q. I'm sorry, what year was Black Box written?

A. That was written in 1996.

Q. And the Baltimore article was?

A. 1994.

Q. So Dr. Behe addressed that. And he regarded this as mere speculation. And he also basically told researchers, don't bother. And the reason you shouldn't bother is actually given in the bottom of the slide. On page 130 of Darwin's Black Box, he wrote, and I quote, In the absence of the machine -- that's the gene shuffling machine -- the parts never get cut and joined.

In the absence of the signals for where to cut, it's like expecting the machine that's randomly cutting

paper to make a paper doll. And, of course, in an absence of the message for the antibody itself, the other components would be useless, closed quote. So he basically argues, because this is a multi-part system and all parts had to be together for it to work ahead of time, you're not going make any progress.

A few pages later, he's even more explicit about that. On page 139, he wrote, quote, As scientists, we yearn to understand how this magnificent mechanism came to be, but the complexity of the system dooms all Darwinian explanations to frustration. Sisyphus himself would pity us. I hope you're up on your classical mythology.

Q. That's what Dr. Behe wrote in his book in 1996?

A. That is correct, sir. He basically told scientists, don't bother to try to investigate the evolution of this because it's irreducibly complex, it's multi-part, you cannot solve it with evolution.

Q. So what's happened since then?

A. What's happened since then is, I think, very interesting. Can I have the next slide? This is the quote from Dr. Behe. The complexity of the system dooms all Darwinian explanations to frustration. If you animate the slide, please.

In 1996, the same year that Darwin's Black Box

came out, very strong biochemical similarities were found between this shuffling process, the VDJ recombination, and the way in which retroviruses shuffle their DNA, very suggestive.

Q. Now when you say, found, where was this found?

A. The -- well, the report is in the journal Science. This particular case, I believe, was found in a prokaryotic system because retroviruses can go into all sorts of systems. But the important point is, these investigators noticed there were biochemical similarities between the way the genes are shuffled in the immune system and the way that retroviruses go into other cells.

Q. This is a publication that has been peer reviewed?

A. That is correct. This is the journal Science, one of the best scientific publications in the United States. And, obviously, this was peer reviewed research.

Q. Please continue.

A. Happy to. Two years later in the journal Nature, which I have plugged repeatedly as a great publication, it turns out that the cutting and transposing enzymes that are normally used for these transposable genetic elements can be replaced by the RAG enzymes, which do

the cutting and pasting in the immune system. So that's suggested a further biochemical similarity between these two systems published in 1998 in the journal Nature. Also, of course, peer reviewed. Can I have the next element, please?

In 2000, the RAG enzymes were shown to cause transposition in mammalian cells. What this meant was, not only can they shuffle the immune system pieces of DNA, they can shuffle other pieces of DNA as well. So little by little, we're beginning to understand that elements of the Baltimore hypothesis are being born out by published research in peer review journals.

Q. What is Blood? Is that also a peer reviewed publication?

A. Blood is also a peer reviewed journal. This is an original research paper subjected to the usual process of review. Can I have the next slide, please? Once again, the quote that we've been talking about, if you could advance it, in 2003, the VDJ recombinase was shown to cause transposition -- in other words, shuffle DNA around -- not just in mammalian cells, but in human cells as well.

The next animation, please, will show the transposases were discovered in nature not associated with the immune system that are a perfect mimic for the

way the immune system gene shuffling machine works in human cells. And this was in the journal Nature.

And finally, the last part of this puzzle was put together in the last year, and that is the actual transposic from which these enzymes and insertion sequences evolved were identified by a paper printed in the public library of science, which is a brand new, but very highly regarded peer review journal, and this is Kapitonov & Jurka in 2005.

It's worth noting how these researchers described their own work. And the next slide will show a facsimile of the paper, and also has a quotation from the abstract. Now this is absolutely filled with technically latent language, but it shows how thoroughly researchers have explored this particular -- this particular hypothesis.

And what I will do is, I will read, and I'm going to skip parts of this, but I'm going to read, starting at the quotation marks, and I will skip over some of the technical terminology. Quote, The significant similarity between the transib transpases and RAG core, the common structure of these transpases and others, as well as the similar size of these basically catalyzed by these enzymes directly support the 25-year-old hypothesis of a transposon related origin of the VDJ

machinery.

And the researchers then point out, there have been other hypotheses that have been considered. Previously, the RAG transposon hypothesis was open to challenge by alternative models of convergent evolution. Because there were no known transpases similar to the gene shuffling ones, the RAG ones found, it could be argued that our gene shuffling enzymes, the RAG1 independently developed some transposon-like properties rather than deriving them from a transposable element encoded transpases. These arguments can now be put to rest.

And they're very straight forward about saying, we have solved the puzzle of where this system came from. It came from evolution. And it came from a transposable element system. Can I have the next slide, please? Okay.

So the summary of what we have just gone through, and this is a tree analysis of these transposons and humans and mammals are right down where it says, mammals, is that the summary is that between 1996 and 2005, each element of the transposon hypothesis has been confirmed and, furthermore, when the enzymes that do this gene shuffling are actually put to an analysis to see how closely related they are to see if they

themselves match the evolutionary predicted tree, they match that tree perfectly. So we've got it.

Q. So what do you tell your mother about what all this means for Dr. Behe's theory?

THE COURT: Or me?

THE WITNESS: I was about to say, my mother and Your Honor, but Your Honor, not being a retired nurse like my mother, my mother is deeply interested in immunity. And I often remind her that the reason I got chicken pox in the first place is because she wanted me to have immunity to it, so she marched me down the street to play with Denny Marsh who had chicken pox at the time to make sure that I would get sick. And she forgot to realize that 10 days later, which is the incubation period, was going to be spring break for me, spring vacation for me.

Your Honor, I've never forgiven my mother for that to this day. So we'll have to take that up. So the important point basically is that, we have, in our immune system, as an essential part of our survival, the ability to shuffle genetic information so as to make it possible for our immune cells to make an antibody to just about anything.

That shuffling ability was proposed 10 years ago to have evolved from sequences known as transposable

genetic elements. In 10 years of research, every step of that hypothesis has been confirmed. And we, therefore, do know, as the result of investigation using evolutionary theory, where that came from and how this gene shuffling ability arose. It also means -- could we advance to the next slide, please? Actually, I'm sorry, I forgot that. I'm finished with the slides. It also means that the prediction that Dr. Behe quite confidently made on the basis of intelligent design theory, that this system would not be amenable to Darwinian investigation, that there would be no evolutionary explanation for it, turned out to be wrong, and I am happy to say that fortunately research scientists did not listen to him.

If they had listened to him, they might not have done this research, and we might not have had this fundamental breakthrough in how the immune system works.

BY MR. WALCZAK:

Q. Did Dr. Behe, in fact, rely on this argument, that the immune system could never be explained by natural selection to argue that, in fact, there must be an intelligent designer?

A. Yes, sir, he did. And this is actually one of several arguments that he raises in Darwin's Black Box to say that, if you cannot, in principle, explain the

origin of a complex system by evolutionary means, that is by invoking the negative, that is evidence for an intelligent designer. This is another essential example in his list of irreducibly complex systems.

Q. Let me direct your attention now to Plaintiff's Exhibit 665. And not to be redundant, but, in fact, is there now even more research on the immune system that has come out even this past week?

A. Well, yes, it has. And as I was getting ready to pack up and come to Harrisburg for this trial, I happened to glance over the Internet at the latest issue of the journal Nature, which has actually not yet appeared in print. I'm still waiting for my copy in the mail. But fortunately, you can on look at things on the Internet several days ahead of time.

The VDJ recombination system is not the only important part of the immune system. There is another important part known as the compliment system. And in this case, compliment does not mean, say something nice about somebody. Compliment in this case is a system that compliments or completes part of what's known as the immune response.

And it consists of a series of proteins that target and destroy. And they destroy, in a molecular sense in a most vicious way possible, foreign invaders,

especially bacteria and foreign cells. One of the key elements of this is a compliment component now as C.. this article reported, and this is from Jansen et al. It's from a combined Dutch and Scandinavian group. And again, it's in the latest issue of Nature.

They, for the first time, worked out the detailed structure of compliment C.. and the structure of compliment C. Immediately told them how this compound must -- how this protein must have evolved. It was made up of a series of modular units of exactly the sort that one would expect to arise by gene duplication, and the molecule had unmistakable sites in which pieces of another gene became recombined with it to produce the complete molecule. Hence, they title this work structures of compliment component C. Provide insights into the function and evolution of immunity.

So the entire idea of evolutionary theory is providing a fruitful avenue of investigation into every aspect of the immune system, not just the gene shuffling that I've talked about, but into this other area known as compliment.

Q. So Sisyphus isn't that envious?

A. I don't think so.

Q. I'm listening to the arguments that you have described Dr. Behe is making, that these components are

irreducibly complex, and that science cannot explain them. And in some cases, he's been shown wrong. But is that essentially the argument, that scientists currently can't explain some aspects of evolution?

A. In essence, that is the argument. It is what a philosopher might call the argument from ignorance, which is to say that, because we don't understand something, we assume we never will, and therefore we can invoke a cause outside of nature, a supernatural creator or supernatural designer.

Q. And is this not a completely negative argument? I mean, it sounds like this is an attack on evolution?

A. This is in every respect a completely negative argument. And if one combs the pages Of Pandas and People or, for that matter, if one looks at Dr. Behe's book or if one looks at the writings of other people who consider themselves to be intelligent design advocates, all that one finds is example after example, argument after argument, as to why evolution couldn't produce this, didn't make that, and doesn't provide an explanation for the following.

I have yet to see any explanation, advanced by any adherent of design that basically says, we have found positive evidence for design. The evidence is always negative, and it basically says, if evolution is

incorrect, the answer must be design. Never considers an alternative idea.

Q. Now let me just stop you. Just because science today cannot explain something, does that mean it can never be explained?

A. Of course not. And if it did, no one would do scientific research. What attracts scientists to research is the lure of the unknown. There is nothing more dreadful than to wake up one morning and think that all the fundamental problems in your field has been solved. On the day that I think all fundamental problems in cell biology have been resolved, I will retired to Sussex and keep bees, as Sherlock Holmes once said.

You want unsolved problems. You're attracted to them. I'll just give you a very simple example. Proteins are built by hooking together strings of amino acid, almost like beads on a string. The machine that does that building is called a ribosome. We have worked for years to understand the detailed molecular structure of the ribosome.

As a result of work that's been published in the last couple years, we know the internal structure of the ribosome down to the atomic level. We can now look inside it, and we can see the molecular details of how

these two amino acids are brought into very close proximity.

But do you know what? There's still an unsolved problem. We still don't understand the chemistry that forges the link between those two beads on a chain. There was a very popular hypothesis that was put forward by Peter Moore at Yale University. But in the last year, a number of experimenters, including Al Dahlberg at my own university, has shown that Moore's ideas are wrong.

So what scientists everywhere realize is, there's a great prize to be won. That's very exciting. To find the mechanism by which these are joined together. What no one is doing is to say, we'll never solve it, we're going to attribute the formation of the bond between amino acids to an unseen outside force operating beyond nature and, therefore, any chemical explanation is doomed to failure.

That's something we never say in science, because if we did, it would be a research stopper. It would tell us, give up, go home, we'll never figure it out.

Q. What is Dr. Behe's argument? What evidence does Dr. Behe, and -- well, strike that. Dr. Behe's argument is consistent with the arguments made in Pandas, I believe you testified before?

A. Yes, sir, that's exactly what I testified. The term irreducible complexity, which is a feature of Dr. Behe's book, does not appear in Pandas. But the core idea behind irreducible complexity, which is in these complex systems, all parts must be assembled in order to have function, that is at the heart and soul of the arguments which are in Pandas.

Q. Now what I've heard are these negative arguments about evolution. What is the evidence in Pandas? Let's start with Pandas. What is the affirmative evidence for a designer?

A. I'm not aware that there is any affirmative evidence for a designer anywhere in that book.

Q. And what about in Dr. Behe's work?

A. As far as I can tell, there is no affirmative evidence for a designer in Dr. Behe's book either. Both books rely entirely on negative inferences by saying that, if evolution has problems, if evolution is wrong, if evolution cannot provide complete explanations, then we can go ahead and say it's a designer.

Q. So how do they make that argument? I mean, even if there's no evidence? What's the rationale? What's the reasoning for getting to that designer?

A. Well, with all due respect, I believe I've already answered that question, which is, I don't find

there is any reasoning in that area at all. It's the sort of logical fallacy in which you might say, well, I have theory A, and I have theory B. And I can prove theory B by showing theory A is wrong. And in science, you say, excuse me, just a minute.

Besides theory B, there's an infinite number of other possible theories. So you don't, quote, prove one by showing that another one is wrong. If you show another one is wrong, you've shown that it's wrong. All other alternative theories are now equal contenders. So the logic of picking out intelligent design, which is inherently untestable, and saying that any evidence against evolution is evidence for intelligent design employs a logical fallacy that I think most scientists reject.

Q. So the argument is that, if science can't explain it, that default is, a designer?

A. That is the argument, as I understand it, and as it is expressed in both of these books.

Q. Has the scientific community taken a position similar to yours about intelligent design not being science?

A. Well, the scientific community, of course, is large and diverse, and I'm sure there are a few people who are enamored of intelligent design. As I mentioned

earlier, the largest scientific organization in the United States, the one organization that probably can fairly be said to speak on behalf of the scientific community in this country is the American Association for the Advancement of Science, or AAAS. I know they have indeed taken a position on this issue.

Q. Could I direct your attention to exhibit -- Plaintiff's Exhibit 198? Do you recognize this?

A. Yes, sir, I do. This is a board resolution by the governing board of AAAS on intelligent design theory.

Q. If we can highlight the passages. And Dr. Miller, could you read the highlighted text?

A. I'd be glad to. Quote, Whereas ID, intelligent design, proponents claim that contemporary evolutionary theory is incapable of explaining the origin of diversity of living organisms, whereas to date, the ID movement has failed to offer credible scientific evidence to support their claim that ID undermines the current scientifically accepted theory of evolution, wheres as the ID movement has not proposed a scientific means of testing its claim, therefore, be it resolved that the lack of scientific warrant for so-called intelligent design theory makes it improper to include it as a part of science education, closed quote.

Q. That is the official position of AAAS?
A. That is correct, sir.
Q. That is the largest association of scientists in North America?
A. That is absolutely correct. And this is the organization that really speaks on behalf of the scientific community in our country.
Q. Now has the National Academy of Science taken a position on intelligent design?
A. Yes, sir, I believe it has.
Q. Could I ask you to take a look at Plaintiff's Exhibit 192? This is the publication we viewed earlier today?
A. Yes, sir, it is.
Q. Could you turn to page 25, please? And could we highlight the third paragraph on that page, please? And this is from the conclusion of this publication, Dr. Miller?
A. Yes, sir, I believe it is.
Q. Could you please read for the record the highlighted text?
A. Quote, Creationism, intelligent design, and other claims of supernatural intervention in the origin of life or of species are not science because they are not testable by the methods of science. These claims

subordinate observed data to statements based on the authority, revelation, or religious belief. Documentation offered in support of these claims is typically limited to the special publications of their advocates.

These publications do not offer hypotheses subject to change in light of new data, new interpretations, or demonstration of error. This contrasts with science where any hypothesis or theory always remains subject to the possibility of rejection or modification in the light of new knowledge, close quote.

Q. Are you aware of any scientific organizations that have taken a position that intelligent design is science?

A. I am not aware of any scientific organization that has taken a position that intelligent design is science, not one.

Q. Why do you believe that intelligent design, as described in Pandas and by Professor Behe, is a form of, I think as you put, special creationism?

A. I believe that as a proper analysis for the following reason. Each of the systems described by Dr. Behe had their origination, their first appearance at some time in the natural history of this planet. Each

of the organisms described in Pandas and People and said to appear suddenly, fully formed in the fossil record had their origin at a particular time in the past. To say that such organisms are designed or such pathways are designed is only to tell part of the story.

Because, for example, if the blood clotting cascade had only been designed, our blood wouldn't clot. That pathway had -- that design had to be executed. It had to be created. It had to be put into physical form. And by any definition, that is an act of creative energy and power.

What that means, for example, the bacterial flagellum perhaps originated a billion years ago. It means the first organism containing that flagellum had to be created. The blood clotting cascade came into existence, we think, about 450 million years ago. The genes, the co-factors, the pathways had to be created. Advocates of intelligent design point to the first appearance of many major animal groups in what is known as the Cambrian period of geologic history.

If one says that those organisms were designed, they also had to be created. So that the natural history of this planet, according to intelligent design advocates, is marked by instance after instance after instance of specific and special creation. Saying that

something is designed, as I mentioned, is only part of the story. We won't know about the design unless somebody created it and put it into execution, and that is what makes intelligent design inherently a theory of special creation.

Q. Now does intelligent design differ from creation science or scientific creationism what you are debating in the early 1980's?

A. In the early 1980's, the scientific creationist movement proposed a number of essential tenants or doctorates. One of them was that, the earth is about 6 to 10,000 years old. Another one is that, all of the geological column of this planet was formed in a single world wide flood, so that geologists are wrong when they talk about ages in the past; in fact, everything was laid down in about 40 days and 40 nights, that humans and apes have separate ancestory, that biochemical and biological systems show evidence of design, and that the mechanism of evolution does not work.

These are all elements, as I understand them, of the creation science or the creationist or scientific creationism movement. Now the difference between this movement and intelligent design ironically is that intelligent design has withdrawn the testable scientific predictions made by scientific creationists.

The statement that the earth is only 6000 years old is a testable scientific statement. They've withdrawn that. The statement that all of the geological formations of this planet were laid down in a 40 day, 40 night flood, that's actually a testable statement. They've withdrawn from that.

The only thing that they have left is an untestable assertion, and that assertion is that the living things on this planet are too complex to have been explained by evolution and, therefore, they must be the work of a supernatural designer creator working outside of the laws of nature unidentifiable and not subject to detection, analysis, or identification.

So, as I said, ironically, intelligent design is somewhat less scientific in terms of the prediction it makes than scientific creationism, but it shares that core belief, and that is that design can be attributed to a supernatural designer or creator.

Q. I want to switch gears now and bring us back from the classroom, so to speak, to the classroom at Dover, Pennsylvania. I'd like to direct your attention to Plaintiff's Exhibit 124. Again, this is the four paragraph statement that was read to the students in January of 2005.

You indicated earlier that you did not -- you

believed that this statement did not promote students' understanding of evolution in particular or science and biology generally. I'm wondering if you could comment a little bit more specifically about your views on this four paragraph statement. And perhaps we want to take it paragraph at a time?

A. Yeah, I was going to -- thank you very much. I was simply going to ask for the whole statement to be put up there. I'd be happy to discuss this statement with you in a number of ways. We could parcel it word by word and line by line, if you had the patience to do that.

But I think it's probably better to take it first a paragraph at a time and basically see what it says. Well, that first paragraph basically says, kids, we have to teach evolution whether we want to or not because the State of Pennsylvania requires us to.

The second paragraph says, oh, by the way, we don't really believe this stuff, it's a theory not a fact. There are gaps. There's no evidence. We're very skeptical of this.

The third paragraph said, by the way, there's another alternative really good idea called intelligent design, and we're going to provide you with curricular material and the book Pandas and People so you can

explore it. And I say that because I note that, there's no statement in here that intelligent design is theory not a fact, that it has gaps which cannot be explained. Those are only pointed out for evolution.

The third paragraph says, basically we think this is a pretty good theory, and we're giving it our endorsement. The fourth one basically reminds students basically, go home, discuss this with your families, and reminds them again, oh, by the way, we have to test you on this stuff whether we want to or not because the State of Pennsylvania requires us to.

Now when I read this, and I try to think of how a student will react to this, what it basically tells students who have studied theory after theory and subject after subject and hypothesis after hypothesis in earth science, in physical science, in chemistry and biology, it says, oh, by the way, of all the stuff you studied, we want to warn you about just one of those things. And that one thing is evolution. We have to teach evolution whether we like it or not. We think it's pretty shaky.

There is this other theory called intelligent design which we think is on a very sound footing. Go home, talk it over with mom and dad, and, oh, yeah, remember, we have to test you on evolution.

Q. Dr. Miller, I'd like to focus your attention back onto the second paragraph. And this makes various assertions about evolution generally. And maybe we could go through that sentence by sentence.

A. Okay. I'd be glad to do that. The first sentence reads, quote, Because Darwin's theory is a theory, it continues to be tested as new evidence is discovered, closed quote. Well, it certainly is true that the theory of evolution is a theory. That's almost redundant. That's obvious from the terminology.

It continues to be tested. All scientific theories are continued to be tested. So to pick out evolution and say, by the way, it's a theory, and we're going to keep testing it, implies to students that really this is the only theory that we have to continue to keep testing. Other theories, they're fine. They're on sound footing. But this one, we have to keep working on.

Q. I'm sorry. From your textbook, evolution is not the only theory that is presented for 9th grade biology?

A. Of course not. And we talk about cell theory and the germ theory of disease. We even talk about the pressure flow hypothesis of phloem transfer. I've never seen a statement in the textbook saying, keep your eye on that special pressure flow hypothesis in phloem

transfer.

This is the only theory people seem to be concerned about. The Dover statement, first of all, basically begins in this paragraph by calling special attention to just one part of the curriculum, and that is evolution.

Now the second sentence, the theory is not a fact. As far as that reads, that's actually a true statement. No scientific theory is a fact. That's not because we're sure of facts and we're not certain about theories. It's because theory is a higher level of scientific understanding than fact. Theories explain facts.

And if this statement said, no scientific theory is a fact, but rather, theories are based on facts and supported by facts, and theories explain facts, it would be fine. But by saying, the theory is not a fact, it essentially invites students to say, you know what, other theories might be factual, this one isn't. And that implication is incorrect.

The next sentence reads, gaps in the theory exist for which there is no evidence. I continue -- I have to tell you, I have read that statement hundreds of times, and I don't understand what it means by gaps in the theory. There certainly are elements in the natural

history of our planet for which evidence is missing. There are pieces of our natural history that we don't know, just like there are pieces of our political, military, and human history that we don't know.

I can only trace one part of my family back to about 1850. I don't know what happened before that. That doesn't mean I couldn't possibly be here because I don't have any ancestors before 1850. It means, I don't have the whole story. Well, that's true about evolution as well. There are parts of our recent past that are gaps, that are missing, that we don't have the story.

But to say that's a gap in the theory strikes me as very very strange. There are missing pieces of evidence but not gaps in the theory. And then the last sentence, a theory is defined as a well-tested explanation that unifies a broad range of observations. Do you know what? That's fine.

And if evolutionary theory had been introduced in this paragraph by saying, evolutionary theory is a well-tested explanation for the origin of life that unifies -- for the origin of species that unifies a broad range of observations, I'd be saying, terrific, that's a very useful thing to tell students.

Q. As an author of a textbook, biology textbook for high school students, does this promote sound scienc

education?

A. No, I certainly don't think it does. I think it, in fact, undermines sound scientific education in a number of ways. First of all, it misleads students into the relationship between theory and fact. Secondly, it undermines the scientific status of evolution in a way that it does to no other scientific theory as if to pretend to students, we are certain of everything we're going to teach in biology this year except for evolution.

And that certainly gives students a false understanding of evolution. And I think, as an experimental cell biologist, it gives them a false certainty of the rest of science, which is equally damaging. And then finally, to say that there are gaps for which there are no evidence, once again, is targeting evolution for a very specific purpose, and that is to create doubt and confusion in the minds of students about the scientific status of evolution and evolutionary theory.

Q. I believe you were here for the opening statements this morning?

A. Yes, sir, I was.

Q. The School District argues, you know, it takes a minute to read this statement. I haven't timed it. It

takes about a minute to read this statement. What's the big deal? What's the harm in reading this to Dover School District students?

A. That's a very interesting point. And if they raised the issue, what is the harm in reading it, one might well turn around and say, well then why read it in the first place, if it makes so little difference, if it is of so little consequence? Then why have you insisted on doing this and why are you in court today?

The only thing I can infer from turning that question around is that the Dover School Board must think this is enormously important to compose this, to instruct administrators to read it, to be willing to fight all the way to the court. They must think that this performs a very important function.

Now turning it around back to my side of the table, do I think this is important? You bet I think this is important for a couple of reasons. One of which, first of all, as I mentioned earlier, it falsely undermines the scientific status of evolutionary theory and gives students a false understanding of what theory actually means. Now that's damaging enough.

The second thing is, it is really the first attempt or the first movement to try to drive a wedge between students and the practice of science, because

what this really tells students is, you know what, you can't trust the scientific process. You can't trust scientists. They're pushing this theory. And there are gaps in the theory. It's on shaky evidence. You really can't believe them. You should be enormously skeptical.

What that tells students basically is, science is not to be relied upon and certainly not the kind of profession that you might like to go into. And thirdly, that third paragraph that we haven't talked about very much right now points out that intelligent design, which has implicit endorsement in this statement, because we don't hear that it's just a theory, we don't hear that it's being tested, it sounds like it's a pretty good explanation. It's available. It's good stuff. And students will understand immediately, as anybody does who reads Pandas, that the argument is made on virtually every page of Pandas for the existence of a supernatural creator designer.

And by holding this up as an alternative to evolution, students will get the message in a flash. And the message is, over here, kids. You got your God consistent theory, your theistic theory, your Bible friendly theory, and over on the other side, you got your atheist theory, which is evolution. It produces a false duality. And it tells students basically, and

this statement tells them, I think, quite explicitly, choose God on the side of intelligent design or choose atheism on the side of science.

What it does is to provide religious conflict into every science classroom in Dover High School. And I think that kind of religious conflict is very dangerous. I say that as a person of faith who was blessed with two daughters, who raised both of my daughters in the church, and had they been given an education in which they were explicitly or implicitly forced to choose between God and science, I would have been furious, because I want my children to keep their religious faith.

I also want my students to love, understand, respect, and appreciate science. And I'm very proud of the fact that one of my daughters has actually gone on to become a scientist. So by promoting this, I think, this is a tremendously dangerous statement in terms of its educational effect, in terms of its religious effect, and in terms of impeding the educational process in the classrooms in Dover.

THE COURT: I was going to break about 3:00, Mr. Walczak. Is that good for you. If you want to move onto another line of questioning, this might be a good time to do it.

MR. ROTHSCHILD: I'm done, Your Honor. I would just move the exhibits into evidence.

THE COURT: Is there an objection, first of all, to any of the exhibits?

MR. MUISE: No, Your Honor.

THE COURT: We'll get those in the record when we come back from the break. I think we have a list. Why don't you compare notes with Liz and make sure that we've got a comprehensive roster of the exhibits. We'll take at least a 20 minute break or so. So my friends in the jury box who look like they could use a little caffeine, this will give you ample time to patronize the local establishments and get some caffeine and come back. That not a knock on you, Doctor.

THE WITNESS: I knew I should have shown more slides, Your Honor.

THE COURT: No, it's perfectly all right. We'll see you back here shortly. We'll be in recess.

(Whereupon, a recess was taken at 2:55 p.m. and proceedings reconvened at 3:24 p.m.)

THE COURT: All right. Let's -- we'll wait on the exhibits until we're finished with this witness. I don't think there's any problem in doing that. This way, we'll make sure we have an accurate tally, and in particular, if we see additional exhibits come in. With

that, Mr. Muise, you're going to do the cross examination, I would assume?

MR. MUISE: Yes, Your Honor, I am. Thank you.

CROSS EXAMINATION

BY MR. MUISE:

Q. Dr. Miller, as a sympathetic Red Sox fan, I can't help but ask you whether you believe the Red Sox won the world series because of supernatural causes. And I guess that would be reversing the curse of the Bambino?

A. I think it's entirely within the realm of possibility, but as I indicated earlier, it's not a scientific hypothesis. And perhaps we'll get a chance to see this year in terms of how things turned out.

Q. You think it also could have probably had something to do with batting averages, on base percentages, pitching statistics, fielding percentage, for example?

A. And you forgot plain dumb luck. And I certainly agree with that.

Q. That would be logical to infer that they perhaps may have won based on observable empirical facts?

A. Well, they certainly did win on the basis of observed empirical facts in that, for four games in a row, they scored more runs than the York Yankees, and

that's an observable empirical fact.

Q. Sir, you're a cell biologist?

A. That's correct, sir.

Q. I think you indicated you weren't an evolutionary biologist?

A. That is correct, sir, I am certainly not trained as an evolutionary biologist.

Q. Not trained as a philosopher of science?

A. That is correct.

Q. Nor trained as an expert in theology?

A. That is correct.

Q. Nor an expert in mathematics?

A. That is also correct. I've taken courses in mathematics. I use mathematics in my teaching and in my research, but I would never qualify myself as an expert in mathematics.

Q. I believe you never taught a 9th grade biology class, is that correct?

A. Actually, I have taught a few 9th grade classes, but I assume you mean serving as a regular teacher for an academic year, and, no, I have not done that.

Q. You obviously consider yourself to be a scientist?

A. Yes, sir, I do.

Q. Would you agree that any person that's trained as

a scientist should have an understanding of what qualifies as a science and how the scientific method works?

A. Yes, think I would agree with that.

Q. In that respect, because you are a scientist, you believe you're qualified to give an opinion on what is and what is not science in this case?

A. I think that most members of the American scientific community would have -- would be qualified to give opinions on what is and what is not science and, therefore, I would agree with what you just said.

Q. And a biochemist is a scientist?

A. Oh, of course.

Q. I think we've already identified Dr. Behe as an professor of biochemistry at Lehigh University, is that correct?

A. I believe that's exactly how I identified him, correct.

Q. And you would consider him a scientist?

A. Of course I would.

Q. And he's a member of the scientific community?

A. Absolutely.

Q. A microbiologist is a scientist?

A. Yes, sir. Yes, sir, microbiologist is a scientist.

Q. Dr. Scott Minnich, you know him?
A. Yes, I have met Dr. Minnich.
Q. He's a professor of microbiology at Idaho University or University of Idaho -- excuse me?
A. Yes, University of Idaho, that is correct, and he is a professor of microbiology there.
Q. He's a scientist and a member of the scientific community, you acknowledge that, right?
A. Yes, sir.
Q. Sir, as an initial matter, you have no objections to the Dover Area School District putting Of Pandas and People in the school library, is that correct?
A. Well, it's an interesting question. I certainly am someone who believes that libraries should be open places, and I personally believe that the people of Dover and your elected representatives on the board of education are charged with determining what books should be in the library at Dover. So I am not about, as an individual, to make certain statements as to what books do or do not belong in that library. I think that's a decision for the people of Dover and their elected educational representatives to make.
Q. Similarly, sir, you have no objections to this book being referenced in a 9th grade biology class?
A. Well, sir, it depends upon the nature of the

reference. And again, when you say, you have no objection to it, I think that this pre-supposes that I am somehow taking it upon myself to tell the educators in Dover how they should reference or how they should conduct themselves.

I certainly, for the purposes in my earlier testimony, regard this book, Of Pandas and People, to be filled with shotty science, with misrepresentations of science, to contain serious scientific errors. And I would certainly not advise any person engaged in scientific education to use the book that was laid with errors and misrepresentations as part of their curriculum.

So my advice, if I were asked, would be not to. When you say, would I object, I don't think the decision is a -- one in which I, as a resident of Massachusetts, have any right to object, as you put it, to the decisions that are made in Dover by the elected representatives of the people of Dover. Therefore, I don't object. But if I were asked for my advice, that's what my advice would be.

Q. And you acknowledge that the board of education that makes those sorts of educational decisions for the school districts?

A. It certainly, in the state in which I live, such

decisions are made by the board of education and by their professional, their selected professional agents, such as superintendent of schools and so forth, and I assume that in the State of Pennsylvania, things work pretty much the same way.

Q. Sir, the Pennsylvania State Academic Standards require students to, quote, evaluate the nature of scientific and technological knowledge, unquote. You have no objection to that standard, do you?

A. Oh, not only do I have no objection to it, I think that's a good standard. I think students should do that.

Q. Similarly, the Pennsylvania State Academic Standards require students to, quote, critically evaluate the status of existing theories, unquote. And they include in the list of examples five different theories, one of them being the theory of evolution. Do you have any --

A. Would you be kind enough to tell me what the other theories are, sir? I'm sorry to slow you down, Mr. Muise, but I always find the context of a statement is useful in helping to formulate a complete answer.

Q. Just so the record reflects, I'm reading from Defendant's Exhibit No. 233, the academic standards for science and technology and environment and ecology. It

says, critically evaluate the status of existing theories (e.g. theory of disease, wave theory of light, classifications of subatomic particles, theory of evolution, epidemiology of AIDS)?

A. Thank you for reading that to me. I do appreciate it. So it does not say, as I understand your reading of it, that students shall evaluate these particular theories. It says that students shall evaluate all theories, and it lists a number of theories as examples of the theories they should critically evaluate. And in that context, I think that's a very, very good educational policy, and I would endorse it.

Q. You don't have a problem that they listed the theory of evolution amongst the list of the five that they included?

A. No, sir. And I also have no problem that they listed the wave particle duality of life. I think that's also worth critical examination.

Q. You've written several articles addressing, I guess, what's been described as the biological challenge to evolution?

A. Yes, yes.

Q. And essentially disputing the concept of irreducible complexity, as we heard earlier today, is that correct?

A. That's also correct.

Q. You wrote an article that was entitled The Flagellum Unspun?

A. Yes, I did write such an article.

Q. And that appeared on your website. You have a personal website at Brown University, is that correct?

A. That's correct. When I wrote the article, I put a preliminary draft of that article up. It's -- I think it's got a couple of typos and spelling errors. And then I sent it off for inclusion in a volume which has since been published. But that was a first draft of the article which is now in print.

Q. In that volume in which the article was published, what was it?

A. Well, I have to confess. I'm going to ask for your help here. There were two volumes which I contributed sort of essays to. One was edited by Neil Manson. Another one is edited by, I think, William Dembski and Michael Ruse. And I honestly cannot remember to which of those I sent The Flagellum Unspun. If you could refresh your memory, it would be very helpful.

Q. Do you believe it could have been from Debating Design from Darwin to DNA, edited by William Dembski?

A. I believe it could have been that one, and I'm

sure you have it in front of you, so if you've got it, I certainly would agree.

Q. Now that book, Debating Design, it was edited by William Dembski and Michael Ruse, correct?

A. That's my understanding.

Q. William Dembski is a proponent or advocate of intelligent design?

A. That's also my understanding.

Q. Michael Ruse is a philosopher of science?

A. Yes, I think that's right. I think Michael is a philosophy of science at the University of South Florida, Tampa -- or Florida State. He'd be furious if I got the institution -- I'm sorry. I meant to say, yes, to your question.

Q. He's an opponent of intelligent design, is that correct?

A. Yes, sir, that is correct.

Q. You know Michael Behe also contributed an article to this particular book?

A. Yes, I believe Dr. Behe wrote an article, too.

Q. His article was addressing similar topics that you addressed, this concept of irreducible complexity?

A. Yes, it was.

Q. And Debating Design was published by Cambridge University press, is that correct?

A. I think that's right.
Q. That's an academic press?
A. Yes, it's an academic press that I believe is owned by Cambridge University in Great Britain.
Q. In that article that you wrote, Flagellum Unspun, were you, in effect, disputing Dr. Behe's claims using scientific evidence?
A. Yes, sir, I was. I examined the thesis that Dr. Behe put forward in his book, Darwin's Black Box, and I subjected that thesis to analysis by reference to other research material, results from other laboratories, and I basically showed how, in my opinion, Dr. Behe's ideas were mistaken.
Q. And Dr. Behe's article, obviously, had different conclusions than what you reached?
A. Yes, I think that's only fair to say, he reached different conclusions than I did.
Q. You also wrote an article called Answering the Biochemical Argument from Design?
A. Yes, I did.
Q. That one also appears on your personal website at Brown University?
A. Yes, sir, it does. I also, as I did with the first article you referenced, I wrote a rough draft of that article, and when I sent it to the editors of the

volume, in this case I think the editor was Neil Manson, I put that rough draft up on the website so that people could see it and read it.

Q. Again, that article you relied on scientific evidence to challenge Dr. Behe's ideas?

A. Yes, sir, I did. In many cases, I relied on Dr. Behe's own examples and arguments to show why I thought these ideas were incorrect.

Q. You've authored a book entitled Finding Darwin's God, is that correct?

A. Yes, sir, that's right.

Q. You dedicated a chapter in that book, I believe it's chapter 5, God the Mechanic, to again expressing the scientific evidence, demonstrating the scientific evidence refute Dr. Behe's claims, is that right?

A. In chapter 5 of that book, which is subtitled God the Mechanic, I examined a number of arguments that are made in favor of intelligent design. Now the book, of course, was written in 1998 and 1999, so the arguments I tried to address were those that I was aware of at the time. And they included Dr. Behe's book, Darwin's Black Box.

Q. Again you relied on scientific evidence to refute these claims?

A. Yes, sir, I did.

Q. Did you know that your book, Finding Darwin's God, is in the Dover High School library?

A. I have been told that by a number of people. I've never visited Dover, so I don't have firsthand information of that, but that's what I've been led to believe.

Q. Did you know that the statement that you were looking at during your initial testimony, the one read to the students, that it was modified in June to reflect the fact that there were additional materials, different books on intelligent design included in the Dover High School library?

A. So if I understand your question, sir, you're telling me that there now is a different statement that was modified in June? I am unaware of that statement, and I haven't seen it in evidence, so, no, I don't think so.

Q. You're unaware of that, if there has been a change in the statement, is that what you're saying?

A. Well, in this proceeding, the only statement that I have seen that's composed by the Dover Board of Education is the one that was introduced into evidence this morning and I had an opportunity to comment on it. If there is another statement, I have not seen it.

Q. Now your testimony today appeared to be similar

to many of the arguments that you presented in those articles that we just addressed, The Flagellum Unspun, Entering the Biochemical Argument from Design, and in your chapter 5 Finding Darwin's God. Is that a fair assessment?

A. I think it's a fair assessment to say that what I testified about today was similar to many of those things, but quite a few parts of it were really quite different. Needless to say, the article that I quoted that it appeared in, in Nature magazine four days ago certainly wasn't in any of those. Neither were the new biochemical results from Jiang and Doolittle and other researchers on the blood clotting cascade. Neither was the evidence on the evolution of VDJ recombination systems.

So I think to be perfectly honest and to be fair and reasonable about this, a great deal of what I testified about this morning was not in any of those articles or in any of my earlier writings or presentations.

Q. You debated Dr. Behe and others in various forums debating intelligent design, is that correct?

A. Yes, that is correct.

Q. You debated Dr. Behe and Dr. Minnich at Concordia College in Wisconsin in 2002, is that correct?

A. That's my recollection as well.

Q. You debated Dr. Behe and Dr. Dembski at the American Museum of Natural History in New York somewhere in 2002, 2003, is that correct?

A. Yes, but to complete the record on that point, although in Concordia, I debated Dr. Minnich and Dr. Behe at the American Museum of Natural History program you're talking about, the evolution side, if you will, was represented by myself and by Robert Pennock of Michigan State University in addition to the two gentlemen you mentioned on the intelligent design side.

Q. That was the one at the American Museum of Natural history in New York?

A. Yes, sir, that was.

Q. During these debates, you were presenting your scientific argument against intelligent design, and Dr. Behe was presenting his scientific argument in support of intelligent design?

A. Absolutely.

Q. You also debated Dr. Behe at Haverford College in 2002, is that correct?

A. To an extent, yes. I believe, and I'm sure Dr. Behe will agree with this when he takes the stand later in the trial, that was not so much a debate as a sequence of presentations. And Dr. Behe made a

presentation, I think, of 20 or 25 minutes, and then I followed it with a presentation of 20 or 25 minutes of my own. We didn't have the sort of back and forth that one characterizes as a debate. But otherwise, yes, that's correct.

Q. It was a presentation something similar to what we saw today with the slides and the discussion of scientific evidence. You advancing your claim and Dr. Behe advancing his claim?

A. The presentation certainly did include slides. Being a microscopist by training, somebody who takes pictures for a living, I find myself incapable of talking without slides. So therefore, I certainly included them. And I made arguments based on the scientific method.

But once again, a great deal of what I brought to the Court's attention this morning simply did not exist back when we had this little discussion at Haverford College.

Q. You agree Dr. Behe will have probably a point by point opposition to the evidence that you presented previously and the new evidence that you presented today?

A. I actually wouldn't want to speculate on Dr. Behe's testimony.

Q. Has that been the practice of your prior debates, you put up your scientific evidence, then Dr. Behe will put up his scientific evidence, demonstrating the support for each of your claims?

A. I suppose that's a fair summary of any debate, which is that each side tries to marshal the evidence and the arguments that are in favor of their side.

Q. And Dr. Behe was relying on scientific evidence, correct?

A. Dr. Behe certainly relied on elements from the literature, from the scientific evidence. It's important to understand that scientific evidence, factual evidence, as I mentioned earlier, are isolated things. There's a fact here and a fact there. How you tie them together is really what the practice of science is all about.

In these discussions and debates, it's my recollection -- and there have been a lot of them. We've had a lot to say to each other.

Q. So you have a cottage industry going here between the experts?

A. I don't know if it is a cottage industry or not, but certainly Mike and I see each other quite a quit. I think it's fair to say that he relies on certain elements of scientific fact to marshal his arguments.

And the point that I think is relevant is basically that he makes, in his books and his writings, and he makes in these debates, a large number of claims regarding irreducible complexity, regarding the biochemical argument from design that have been repeatedly falsified by experiments, by observations in nature, and that's the point that I try to make in these debates, that these claims have been examined, considered by the scientific community, and generally falsified.

Q. He disagrees with you?

A. I'm sure that he disagrees with me, but, of course, he'll get a chance to say that himself, and I wouldn't want to speculate. Perhaps he'll get up here in a couple days and say, you know, I listened to everything Dr. Miller said and, by God, he's got it exactly right.

THE COURT: We'd have a real story then, wouldn't we?

THE WITNESS: Exactly.

MR. MUISE: I doubt that will happen.

BY MR. MUISE:

Q. Do you think that will happen, Dr. Miller?

A. I'd much rather make a bet on the outcome of the world series this year than to make that kind of bet.

Q. That's probably a safer bet. And Dr. Minnich

doesn't agree with your conclusions regarding the biochemical challenge to evolution, correct?

A. Well, once again, I would be inclined to let Dr. Minnich's testimony speak for itself when it comes. I've -- I believe I've only met Dr. Minnich once, and that was at the discussion at Concordia College that you mentioned, which is probably three or four years ago.

And I honestly don't know how Dr. Minnich's views on this subject have been changed by research that happens in science over the last several years. And I would look forward to hearing them if I happen to be in town or I look forward to reading them if I have access to the transcript of the trial. But again, I wouldn't speculate on what Dr. Minnich will say.

Q. Now you debated Dr. Behe and others on the Firing Line with William F. Buckley, correct?

A. That's correct.

Q. And I believe you indicated during your deposition that Mr. Buckley took the side of Dr. Behe in that debate?

A. Yes, I think I said that. This was a debate on the PBS program called Firing Line, and the title of the debate, I think, is important to understand. The title of the debate was resolved. The evolutionist should acknowledge creation. It wasn't acknowledge design. It

was acknowledge creation. So on the creation side were Dr. Behe, a writer named David Berlinski, a law professor at the University of California named Phillip Johnson, and William F. Buckley.

On the side defending evolution were myself, Eugene Scott from the National Center for Science Education, Barry Lynn from Americans United for Separation of Church and State, and Michael Ruse, the philosopher whom you've already made reference to as the editor of one of these volumes.

Again, the subject of the debate was that evolutionists should acknowledge creation.

Q. In addition to the articles that we've mentioned previously and the public debates, you debated Dr. Behe in print in Natural History magazine, is that correct?

A. Yes, that is correct.

Q. And I believe he contributed a one page article, and then you have had an opportunity to rebut that article without him having an opportunity for a reply, correct?

A. Well, I think it would be useful to the Court to describe that issue of Natural History magazine more fully, more completely. And my understanding was that the editors of Natural History decided that there was enough interest among the readership in this idea called

intelligent design that what they invited three leading proponents of intelligent design to do was to take a full page of Natural History, unedited, say anything they wanted, and they then invited three scientists to respond.

The three people they invited, I believe, were Dr. Behe, William Dembski, and Jonathan Wells. All three of these people in addition to their other positions are, I believe, senior fellows of the Discovery Institute in Seattle, Washington. They then asked three scientists to respond to each of those.

So, yes, that's right. Dr. Behe's essay was given to me, and I had a certain space to respond to it, and that's exactly what I did.

Q. These articles in this magazine are sent out for scientific review, is that correct?

A. Well, actually, Natural History is not really a scientific journal. It deals with scientific topics. And certainly the editorship is concerned with scientific issues, but the whole format and the premise of this point, counter point in Natural History was to take three people who were known as leading advocates of intelligent design, let them have their best shot, and the only editing that I'm aware of that was done was copy editing, trying to make sure it would fit in the

space, not scientific review, not peer review.

And I certainly know that my response to it was handled in exactly the same way, that my copy was edited so that it would fit, and so that it was relevant in terms of rely to what Dr. Behe wrote, but my copy, and I think Dr. Behe's copy was not sent out for peer review in the ordinary sense of a scientific paper.

Q. You also wrote an article called Life's Grand Design that was published by MIT in Technology Review Magazine?

A. That is correct.

Q. And this article dealt with some of the aspects of the intelligent design argument, is that correct?

A. Yes, this article was solicited by the magazine technology review after I gave a presentation on the evolution creation controversy, I think at the AAAS, American Association for the Advancement of Science meetings in 1993.

And they asked me if I would write an article about the emerging intelligent design movement. I wrote this article called Life's Grand Design in 1994, and just to refresh your memory about the testimony this morning, 1994 was before I had met or heard of Dr. Behe, before I had seen the book Pandas and People, before Dr. Behe's book, Darwin's Black Box, was published, and

before I participated in any other debates with respect to intelligent design.

Q. I believe you testified in your deposition that this magazine is one that is intended for the scientifically literate, but not necessarily considered a scientific journal, is that correct?

A. Yes, I believe that's correct. I believe, in essence, Technology Review is almost the alumni magazine of the Massachusetts Institute of Technology. It is a sent to MIT alumni, and it concerns itself with discussion of issues of science and technology that presumably are of interest to graduates of that university.

Q. Is there a hard and fast definition between what is scientific journal and what is a journalistic publication about science?

A. I think the honest answer to that question is, not a hard and fast definition. But basically, a scientific journal in the more general sense is a journal that publishes the original results of scientific investigation, experiments, materials and methods, techniques, and presents original, never-published-before scientific data.

In fact, a scientific journal of the sort that I have edited, such as the Journal of Cell Biology,

actually has a rule, and that is that, you cannot send into that journal any results from any experiment that have been published anywhere else before.

So we want only original micrographs, original gels, original DNA sequences, original experimental results. Some of the other journals that have just now come up in the discussion, Natural History magazine, Technology Review. And let me pick a couple of other journals that are well-known. Scientific American, Discover magazine are journals or magazines that publish science, but they don't publish original scientific work.

They're not subject to peer review in the usual fashion. And, therefore, if one had to make a rigorous definition of whether or not those are scientific journals, the answer would be, no.

Q. Now, sir, you testified about peer review in the sense you are referring to it as a staple of science, correct?

A. Yes, I did.

Q. Is there a time when peer review became that, a staple of science?

A. Well, you know, you're asking for more in the history of science than I really find myself qualified to answer. And I'm not really a historian in the

history of science. But what I can tell you is that, certainly during my entire lifetime -- I was born in 1948 -- the scientific journals that I referred to as leading scientific journals, Proceedings of the National Academy, Nature, Science, all these journals have existed.

They have all used a peer review process very similar to my description. And, therefore, the top scientific journals within my entire lifetime have all used essentially the peer review process that I described in my testimony earlier today.

Q. Well, prior to the adoption of this peer review process, you would agree that what scientists were doing was still science?

A. I think there are many ways and many forms to do science. But peer review in the formal sense of how an article gets into a journal today in many respects did not really exist; for example, in the 19th century when the institutions of science were just beginning to be developed.

But it's important to appreciate as well what peer review actually means. And what it means is subjecting your scientific ideas to the open scrutiny and criticism of your colleagues and competitors in the field. That has always been part of science, certainly

well into the early part of the 19th century.

Q. In terms of the modern description of this peer review, none of that standard, Darwin's Origin of Species wasn't a peer reviewed book as well?

A. Well, first of all, books are rarely peer reviewed today, yesterday, ever. For example, when I wrote Finding Darwin's God, I did what a lot of writers do, and I bet ya what Dr. Behe did when he wrote Darwin's Black Box, which is, I thought about a book I'd like to write.

I put together a proposal. I circulated a proposal to a few publishing houses hoping I could find an editor and a publisher who was interested in it. And when they were, we sat down, signed a contract. I got very excited, sat down and wrote the book. The sort of review that went into that book was interaction between me and an editor, me and a copy editor, and finally myself and a fact checker. And I bet ya the same process went into Dr. Behe's book.

That doesn't qualify as peer review any under circumstance. Now you raise the specific example of a book written by Darwin, called the Origin of Species. And I think it's important -- again I'm not a historian of science. I'm a real amateur here. My understanding of how the ideas in that book were developed was that,

Charles Darwin wrote many letters, essays, and small articles which were read before the royal society in London.

The discussion and criticism of those individual letters which were read was a normal part of the scientific process in Great Britain in the 1840's and 1850's. So that most of the ideas that Darwin incorporated in the Origin of Species actually had been subjected to something that today we would recognize as peer review, which is advice, criticism, analysis, critical analysis by one's colleagues.

The publication of that book, was that a peer reviewed publication? Of course not, for the reasons I've given. Were Darwin's ideas themselves subjected to peer view? The answer is, as it existed in the 1840's and 1850's, yes.

Q. You testified you wrote a critique of Dr. Behe's book, Darwin's Black Box, is that correct?

A. Yes, after his book was published, I believe I wrote a critique of it, and then I subsequently posted that critique for public inspection on the Internet.

Q. That was a scientific critique of his book?

A. Well, it depends in what sense you mean scientific. The issue, my critique of the book was based on my understanding of the scientific literature

and scientific fact, so it certainly was a scientific critique as opposed to, let's say, a grammatical critique or literary critique, neither of which I would certainly be qualified to do.

Q. And I believe Dr. Behe has responded to his critics in various articles and publications?

A. Well, my understanding is that, at the website of the Discovery Institute, there is an article that I've seen once or twice called a Response to My Critics, written by Michael Behe. If that is what you're referring to, then my answer is, yes.

Q. Is that the only publication that you're aware of where he's defended his arguments?

A. No, I don't think so. I think the Discovery Institute routinely publishes comments by their fellows on a variety of issues, and I'm sure that -- I'm not aware of all of them -- but I'm sure that Dr. Behe has a large number of articles that have been posted there on the web, and he may have published a few such responses in various magazines and popular media that I'm not aware of, and I'm sure they're out there.

Q. One of them being, for example, Debating Design, the same book that you contributed an article?

A. Well, certainly Dr. Behe had an article in Debating Design. That's a question you've already asked

me, and I've already answered. I'm sure that Dr. Behe in that article addresses many of the criticisms of his ideas.

Q. Sir, I believe you indicated falsifiability is a factor you consider to determine whether something is science?

A. I think -- I believe what I said is that, in order to qualify as a scientific theory, the scientific theory must make predictions which lead to testable hypotheses.

Q. If you can falsify it, it's a scientific theory?

A. If you can falsify it, it's a scientific theory? I'll repeat what I said, because I think that was an answer to your question. That is, a scientific theory should lead to the generation of testable or falsifiable hypotheses. So if a theory does not and cannot lead to the generation of falsifiable hypotheses, it doesn't qualify as a scientific theory.

Q. Now, sir, as a cell biologist, you engage in laboratory experiments?

A. Yes, sir, I do.

Q. You don't have occasion though to apply natural selection to your experimental work, is that correct?

A. In the sort of work that I do in the laboratory, I do not directly do experiments based on natural

selection. But it's also fair to say that several of my scientific papers have been undertaken precisely because I wanted to examine organisms which were related to other organisms in an evolutionary sense and, therefore, some of my work has indeed had evolutionary implications.

Q. I just want to make clear, with regard to the mechanism of natural selection, that's not something that you actually apply hands-on in any of the experiments that you do?

A. It is fair to say that I have never carried out with my own hands and in my own research area an experiment to test the mechanisms of natural selection, that is correct.

Q. Now a technique used by molecular biologists is known as the knock-out technique, correct?

A. Yes, I'm aware of a technique known as targeted gene replacement, which is popularly called the knock-out technique.

Q. One classic way to understand the importance of a particular component of a system is to take that component away and see how the system works?

A. Yes. As a matter of fact, it's a very useful technique. So if one has a gene and wants to know how important it is to function, what one can do is to

engineer a targeted gene replacement, a knock-out, and then generate embryonic stem cells -- this is often done in mice -- and those embryonic stem cells are then fused into an existing embryo.

You then, hopefully, grow up a mouse in which there's a patch of cells that has the targeted replacement. You find a mouse -- sometimes it takes a while -- in which these targeted replacement cells are in the gonads, in the reproductive organs.

So hopefully, you've generated a male mouse in which you have the targeted replacement in the testes, a female mouse in which you have a targeted replacement in the ovaries. You cross them. Then you get an offspring in which both genes have been knocked out. And then you can study the effect of losing that gene.

Q. Obviously, that's a legitimate technique employed by scientists?

A. Of course, it's a legitimate technique. It's a tool and technique that's often used -- it's a technique that is tricky because completely knocking a gene out can sometimes have unexpected implications. You have to interpret it carefully. But it's used all the time in research laboratories around the world.

Q. So you would agree that the cell is a collection of protein machines?

A. Would I agree that the cell is a collection of protein machines? I would agree that the cell contains a great many protein machines. It has a collection of them. It's also a great deal more. It's also a collection of complex carbohydrates, lipids, membranes, compartments, barriers, ionic radiants. But, yes, I would agree the cell also contains a collection of protein machines.

Q. Scientists refer to individual proteins or collections of proteins as being part of the DNA replication machinery, the proteins synthesis machinery, and the ion transport machinery, is that correct?

A. It is very common in molecular and cellular biology to use the term machine as a figure of speech to reflect a shorthand to a number of proteins that act together for a particular purpose.

Q. Well, these number of proteins acting together for a particular purpose actually operate like machines that we could recognize in the human world?

A. Well, only by analogy. And what I mean by that is, let's take a machine called dynein. Dynein is often called a molecular motor. It generates force. It's a very large, very complicated protein that has basically two heads on it.

And the dynein heads will interact with other

proteins. Dynein, in effect, in a molecular level looks almost like a large blob with two legs. If I can draw your attention to the front of the podium up here. Dynein will make an interaction with one compound, and then random molecular forces will wave the rest of it back and forth until it makes another connection. This will then release.

It will wave back and forth and make another connection. So, as a cartoon image, dynein almost looks like somebody walking. I'm not really aware of any machine that actually works by that particular mechanism. But we nonetheless refer to dynein as a molecular motor or molecular machine because it's a very useful figure of speech, a kind of shorthand to remind of what it does. In the case of dynein, it generates force and movement.

Q. Don't we regard the protein as a collection of interacting parts in a way that is similar to the machines that we understand the world today?

A. I'm sorry. Did you say, can we regard proteins --

Q. As a collection of interacting parts?

A. Not always. Proteins are compounds that are built out of polypeptides. And there are small and simple proteins like insulin, for example, that has only

60 or 70 amino acids, which is really -- an insulin is really not a collection of individual parts. It's one coherent part.

There are other more complex proteins. For example, the C3 component of compliment that I mentioned near the end of my testimony this morning, is a complex protein that's made up of individual segments or modules that arose by gene duplication. And in that respect, those individual segments or modules quite clearly are parts, all of which work together to make the concerted function of the machine possible. Is that a complete answer to your question, sir?

Q. I guess they use the term machines because it's a metaphor that makes it as closely replicated to what we understand as machines? Is that the utility of that metaphor?

A. Yes, I think the utility of the metaphor is that we think of the machines that we build in the human world as composed of a number of parts to achieve a particular end. In the cell, certainly. There are many assemblies of proteins and other components where the parts interact and a particular result comes out of this.

And the metaphor of the machine or the metaphor of the motor that I just mentioned or the metaphor of

the pump or the metaphor of the copying machine is often used in biology just as a shorthand to help us remember what these individual components do.

Q. Bruce Alberts, he's the president of the National Academy of Scientists, is that correct?

A. No, it's not. Bruce is no longer the president of the National Academy of Sciences because his term has expired.

Q. When did his term expire?

A. A couple months ago. Dr. Alberts is the outgoing -- it's all right. Alberts is the outgoing president of the National Academy of Sciences and a very, very highly respected molecular biologist.

Q. And he wrote an article that referred to protein to molecular machines, correct?

A. He wrote an article in the journal Cell called Educating the Next Generation of Cell Biologists. And that was subtitled, The Cell is a Collection of Protein Machines. And I might add, I find that to be a useful and valuable article, and I often assign it to the upper level students in my cell biology course.

Q. In that article, he suggests that the new modern biologist ought to take courses in engineering so they can understand the intricacies of these machines that we find in the cell, correct?

A. He does indeed make that suggestion.
Q. Sir, would you agree that science involves a weighing of one explanation against another with respect to how well they fit the facts of experiments and observations?
A. I would agree that science involves the weighing of one natural explanation against another with respect to how well they fit, the results from observation and experiment.
Q. Would you agree that all science consists of looking at the evidence and then drawing inferences from it?
A. I think that part of science is looking at the evidence and drawing inferences, but I hesitate to agree completely with your question because I certainly think that drawing just any inference from data is not necessarily scientific.
Q. I believe in your deposition, one of the examples we used in defining science the way that I just asked you that question was paleontology, correct? Do you recall?
A. To be perfectly honest, I'm sure you're right. But I can't remember -- the deposition went on for nine and a half hours. And to be perfectly honest, there are parts of it I have forgotten. But I'm willing to agree

that, yes, it probably did deal with that.

Q. Paleontology is a science which consists of looking at the evidence, the observable evidence, and then drawing inferences from that evidence?

A. It consists -- paleontology consists of looking at the accumulated evidence of past life and then applying the scientific method to make scientific testable inferences, if possible, about the nature of life in the past and also about the nature of biological change.

Q. I believe you testified previously that science doesn't prove things, is that correct?

A. Yes, I believe I did say something like that.

Q. Is it accurate to say that science disproves things?

A. But science does disprove things. And, in fact, an essential element of the scientific process is -- this is why the testable hypothesis is so important. A theory is not a useful theory unless we can generate it from -- generate from it testable hypotheses. And science will occasionally disprove those hypotheses.

And I mentioned earlier, I think I mentioned rather briefly, that the most popular hypothesis as to how amino acids are joined together inside the ribosome which has been that ribosomal RNA acts as a ribozyme, an

acid based catalyst, to put those together. Now looks as though it's been disproven by experiments that I mentioned before that were done by Al Dahlberg at my university.

That's a classic case of a really, really useful testable scientific hypothesis whose disproof leads us, hopefully, in a more productive direction. So in a few years, we'll find out what the real chemical mechanism is of bond formation.

Q. Sir, during your direct testimony, you discussed the term evolution as having sort of different meanings or can be used in different ways, correct?

A. Yes, I did. And I believe that -- and I'm sure you'll correct me if I don't have this quite right. I believe I pointed out that the word evolution in English is often used to refer to two quite different things. Sometimes the word evolution is used to refer to what happened in the past; namely, the life of the past changed into the life of the present.

And we regard evolution simply as the record of change in natural history. I think more commonly in the context of the proceedings in this courtroom, what we mean by evolution is evolutionary theory, which are the mechanisms which actually drove that change and changed the life of the past into the life of the present.

So I certainly did point out those two quite different meanings of the word evolution.

Q. In the first meaning, is it proper to say it can be regarded as a historical fact?

A. I certainly regard the record of life in the past as historical fact. And I think the science of geology, by using the testable principles of natural science, has established that the earth is old, that the geological ages are authentic, and that the pattern of life's change that we see is a factual pattern. So I think, yes, I generally agree with your question.

Q. Evolution in the second sense is where evolution is a theory, correct?

A. That is correct. And evolution is a theory in that it unites a whole series of mechanisms in terms of an effort to try to explain the process of evolutionary change that characterizes the natural history of life on earth.

Q. And as a theory, the theory of evolution is not a fact?

A. Sir, no scientific theory is a fact. All scientific theories are based and supported by scientific fact. In that respect, evolution is not exceptional.

Q. Would you agree that Darwin's theory of evolution

is not an absolute truth?

A. I certainly would for the very simple reason that no theory in science, no theory is ever regarded as absolute truth. We don't regard atomic theory as truth. We don't regard the germ theory of disease as truth. We don't regard the theory of friction as truth.

We regard all of these theories as well-supported testable explanations that provide natural explanations for natural phenomena.

Q. Included in that list would be Darwin's theory of evolution?

A. I think you've already asked that and I've already answered that. The theory of evolution is not exceptional. It is a scientific theory, like the other scientific theories I have mentioned.

Q. Darwin's theory of evolution continues to change as new data are gathered and new ways of thinking arise?

A. I would agree that all scientific theories continue to change as we advance in our understanding of science and as we accumulate scientific knowledge. And once again, the theory of evolution is not exceptional in that respect.

Q. Because Darwin's theory is a theory, it continues to be tested as new evidence is discovered?

A. No, that's not quite right. All scientific

theory is subject to testing as new evidence is discovered. So to say, because it is a theory, it continues to be tested, really misstates the scientific status of evolution. Everything in science is subject to testing. Everything is subject to revision. Everything in science is subject to critical analysis. And evolutionary theory is no different from that.

Q. What about evolution in the first sense, the historical fact? Does that continue to be tested as new evident is discovered?

A. We always in science continue to examine to see if facts are really factual. And one of the statements that I was asked to comment on this morning is that, very often facts in science change and theories don't. And that sounds paradoxical.

But what it means basically is, if we have a factual observation, for example, one of the fossils that was discovered in the Burgess Shale, which is a very famous fossil formation in British Columbia, which is part of the Cambria, one of the fossils was once regarded by Alexander Walcott, who discovered the Burgess Shale, as an entire organism. He classified it, and I believe Walcott might have even created an entire phylum, which is a major category to put this organism in.

Later on, more careful investigators, notably Simon Conway Morris, who's a British paleontologist, went back to the museums. They looked at the same fossils, the same facts, and they discovered that what Walcott thought was a whole organism was, in fact, the leg of another organism.

And, therefore, this particular fact turned out not to be correct and the fact had to be revised. All of it nonetheless still fit into the framework that the animals of the Cambrian are well represented in the Burgess Shale. They turn out to be the ancestors of the animals around today. And they represent a variety of unique biological forms.

So when you place particular emphasis on the testing of Darwin's theory of evolution, I would point out that facts in science change well, as well, and that everything we do in science is subject to revision and to change as we get better data and as we go back and we re-examine what we thought were facts in the past.

Q. So it's accurate then to say, Darwin's theory continues to be tested as new evidence is discovered?

A. Sir, it is accurate to say that all scientific theories continue to be tested as new evidence is discovered and all scientific facts are subject to examination as well.

Q. And Darwin's theory being included in that list of all scientific theories?

A. As I testified earlier, Darwin's theory is not exceptional in that regard.

Q. Sir, isn't it true that all of science is filled with gaps in a sense that scientists fill with unanswered questions using gaps as an unanswered questions as a definition of gaps?

A. If you define an unanswered question as a gap, then it certainly is true, that science itself is filled with unanswered questions. And that includes not just biology, but includes, for example, physics where there are enormously unanswered -- enormous numbers of unanswered questions about the fundamental nature of matter about the gravitational force, about the strong and weak nuclear force, and a whole variety of other issues.

So it's absolutely correct that science is filled with unanswered questions. I have to tell you, sir, that I would not refer to an unanswered question as a gap. I would not say that we have gaps in the theory of gravitation. I would say there are things about gravity we don't understand.

Q. If we understood gaps to be unanswered questions, is it accurate to say that there are gaps in Darwin's

theory of evolution?

A. Once again, let me reiterate the point here. That is, that I do not agree to your substitution of the word unanswered question with the word gap. To me, it makes absolutely no sense. Would I agree that there are unanswered questions that fall within the theory of evolution? Yeah, sure, absolutely.

Q. I'll represent to you I'm reading a statement from your biology book, and I'm just going to ask you if this is true. A stew of organic molecules is a long way from a living cell and the leap from non-life to life is the greatest gap in scientific hypotheses of earth's early history. Is that your statement?

A. Sir, would it be possible for me to see the whole page and the context in which the statement is made?

Q. Sir, I'm handing you what's previously been marked as Defendant's Exhibit 214.

MR. MUISE: Your Honor, we have additional copies if you need us to hand them up at this point or --

THE COURT: Well, I have one. I don't know -- I guess I'm the most important person to have one.

MR. MUISE: That's correct.

THE COURT: We'll go from there.

THE WITNESS: I'm sure that's correct, Your

Honor.

THE COURT: That remains to be seen.

BY MR. MUISE:

Q. Page 425.

A. Yes. I'm flipping to it right now, sir. Okay. And I'll -- I will explain -- I'll try to explain exactly what I would mean by that sentence. I'll read it again. A stew of organic molecules is a long way from a living cell and the leap from non-life to life is the greatest gap in scientific hypotheses of earth's early history.

I think in this particular case, the word gap is entirely appropriate because what we're looking for is missing evidence. It's entirely appropriate to refer to missing evidence as a gap. In this particular case, we understand from experiments that have been done in the laboratory how molecules can, to an extent, self-organize and even self-replicate.

But we don't really have an understanding of how such molecules could have gathered together, pulled together the other structures that they need, and to produce a living cell as we understand it today. So I think that is indeed a gap in the sense that we have missing evidence.

And I mentioned earlier that I have gaps in my

understanding of my own family's ancestory in the sense that I have missing evidence. I don't know what's there. Now that's a gap in evidence. That's not a gap in a theory. And I think that's sort of the point that I had been trying to make.

Q. So there's no missing evidence in Darwin's theory of evolution?

A. Okay. Let's put it this way. There are many periods in earth's history where we don't have a complete historical record, just as there are periods in the history of the United States in which we don't have a complete historical record. If one refers to Darwin's theory of evolution by saying, do we have a complete record of biological change in the past, the answer to that is, no.

But in terms of gaps in the theory, again, I think you're jumping back and forth between the theory and the nature of the evidence. Is there indeed evidence that might support the theory of evolution that we don't have? Yes. But is there a gap in the theory itself, a gap in the framework of explanation? That's essentially what I'm saying, no. I don't buy that at all.

Q. Should we regard Darwin's theory of evolution as being tentative?

A. We should regard all scientific explanations as being tentative, and that includes the theory of evolution.

Q. Darwin's theory of evolution is incomplete and unfinished, isn't that correct?

A. All science is necessarily incomplete. On the day that physics becomes complete, for example, it will be time to close every department of physics in the United States because we'll know everything. I don't expect to see that happen.

But it is a fair statement that all science, including biology, including Darwin's work on evolution or the evolutionary theory, I should say, is necessarily incomplete.

Q. Is it true that scientists do not know enough about all structures in the cell to describe how they all work or how describe how evolution could have produced each of them by step-by-step Darwinian processes?

A. Well, you ask a very interesting question. And I, first of all, am going to enthusiastically agree with the first part, which is that scientists certainly do not understand enough about all of the structures in the living cell to understand how they work. That really is the business, my business and the business of Dr. Behe.

Because the answers to that questions are going to come out of genetics -- sorry. They're going to come out of biochemistry. They're going to come out of cell biology and maybe molecular biology and genetics as well. I'll answer the second part of your question this way.

Until we understand the first part, which is how everything works, we can't even begin to understand how things evolved. So we will have to have an absolute and complete and total understanding of how everything in the cell works before we can even begin to put together an understanding of how it evolved.

Q. So there are open questions there?

A. I certainly hope so, because if there are no open questions in my field, I've written my last grant proposal. I don't think so.

Q. Isn't it true that scientists still debate and touch questions as to how new species arise?

A. Do scientists still debate such questions such as how do species arise? The answer, sir, is, absolutely. There is general agreement within the scientific community that speciation, which is to say the origin of new species, can be explained by a variety of natural causes.

And several examples of speciation are indeed

well-known and well-understood. But as to which of several mechanisms that can actually drive speciation is the predominant one or the most useful one, there is a lot of controversy within science about that, no question.

Q. Scientists still debate the question why species become extinct?

A. Scientists certainly debate that question. They don't debate the question as to -- well, sorry. Let me sort of strike that and sort of rephrase everything. Extinction, for the most part, is a historical process. It's something that, for most of us, happen in the past. We do have examples of extinction that actually happened in the present time. And sometimes we can see how that's actually happening.

But most often, extinction occurring in the past, in the fossil record, for example, is an event, meaning the disappearance of a particular species, and we don't always know whether that species starved to death, whether it was driven to extinction by a predator, whether it was terminated by disease, whether its habitat was destroyed by earthquakes or volcanic eruptions. And do scientists still debate those issues? Of course they do.

I would point out as an example, a colleague of

mine named Bruce McFadden, who is an expert in the evolution of the horse, he works at the University of Florida, he's published a number of treatises trying to trace the evolution of a horse and trying to focus in on exactly what the forces were that drove most of the historical antecedents of the horse to extinction.

In some cases, he's pinned it down to diet. In some cases, he's pinned it down to habitat loss. In other cases, he's not sure. So that's a long yes to the question you asked.

Q. It's an open question?

A. There are many open questions in science. There are some examples where we know what drove an organism to extinction. I can give you an example right now. The passenger pigeon. We killed it. Human beings hunted passenger pigeons to extinction. The same thing with the dodo.

Those are not open questions. Those are closed questions. Are there examples of extinction for which we don't know the answer? The answer to that is, yes.

Q. So the origin of life is an unsolved scientific problem, is that correct?

A. I think it certainly is fair to say that the details of the origin of life are unsolved.

Q. Would it also be fair to say, it's an area where

there is little direct fossil evidence?

A. Well, not entirely, because actually, there is fossil evidence when the first living cells appeared on this planet. It's about three, three and a half billion years ago. So we do know when the first simple cells appeared, and we also know when the first more complex cells, we know when they appear.

But it's also true that we don't really have biochemical fossils that could have shown the kinds of self-replicating molecules that might have preceded that first living cell.

THE COURT: Mr. Muise, I'll give you about a seven minute warning, unlike the NFL, where you get a little bit more time, and any place you want to wrap up from here on that you think is an appropriate break time, you can do it, because we'll go to that point today. But you can proceed.

MR. MUISE: Are we looking for a break for the afternoon or for the --

THE COURT: No, for the day.

MR. MUISE: For the day?

THE COURT: For the day.

MR. MUISE: I have about four or five more questions in this area. If I can try to get through them, that will be helpful.

THE COURT: Absolutely. Sure.

MR. MUISE: Thank you.

BY MR. MUISE:

Q. Dr. Miller, the origin of DNA and RNA in the evolution of cells is an unanswered scientific question, is that true?

A. Certainly. The origin of those compounds is not completely answered. But one of the things that is rather interesting, and the recent work of Stanley Miller, who's done a fair amount of origin of life research, has shown this, is that the current simulations of primitive earth atmospheres, under certain circumstances, can give rise to the nitrogenous bases which are found in RNA.

It turns out to be rather easy in the simulation experiments to produce adenine, and I believe also to produce cytosine, which are two of the bases. Now knowing that doesn't answer the complete question as to how the complete RNA or DNA molecule evolved, but it does show that some of the building parts of it can be produced spontaneously in the laboratory under conditions that simulate the primitive earth.

Q. That's related in a sense, is it not, to the fact that the origin of life is an unsolved scientific problem? Is that related to the experiments you just

described?

A. Yes, sir, it is.

Q. Now there are many scientists who think that Darwin's original formulation of the mechanism of evolution was either incorrect or incomplete on the basis of much better current information on how genetics, molecular biology, and what is called adaptation actually works, is that true?

A. Sir, not only is that true, but I'm one of those scientists, and if he was around today, Charles Darwin would be one of those scientists. Darwin, of course, didn't know anything about biochemistry. He didn't know any genetics because genetics hadn't been invented.

And we now understand evolution in much greater detail than Darwin ever could have. So when you say there are many scientists who believe that Darwin's theories had to be, whatever you said, updated and so forth, the answer is, yeah, all of them do. I'm one of them. And so would Charles Darwin if he was around to see it.

Q. Sir, many scientists would opine that Darwin's ideas about evolutionary change were inadequate on the basis of current discoveries related to genetic recombination, transposeable genetic elements, regulatory genes, and developmental patterns?

A. No, I wouldn't agree that. You said that many scientists would agree that Darwin's ideas about change were inadequate based on these. Now what Darwin basically said was that variation appears spontaneously in species. He didn't know where that variation came from.

And every example that you just cited is an example of where variation could come from. All of these, however, fit within the general framework of evolutionary theory. So I would rather say that Darwin's ideas were incomplete rather than inadequate. Because Darwin was, if you read the Origin of Species in detail, you'll see that Darwin is quite open about not being really sure where variation comes from or how characteristics are passed along from one generation to another.

The fact that we now know where variation comes from and we now know how information is passed along, doesn't mean his ideas were inadequate or -- it simply means that they were incomplete compared to what we understand now. They nonetheless fit within his framework.

Q. Now during the deposition you gave, Dr. Miller, where you indicated the lengthy deposition, you use the term inadequate. And let me read from page 113. And I

can show it to you. Starting on line 21. Now in discussion --

A. If you would just give me a second to get to page 113.

Q. Do you have a copy of your deposition?

A. I have it right here. Very good. Thank you.

Q. Starting on line 21, if you could read from the deposition?

A. Yes. Let's see. What I said in the deposition, starting with line 12 is, quote, Now in discussion of this issue, it is possible to bring in the opinions of many scientists who say that Darwin's ideas about currently -- sorry, that Darwin's ideas about evolutionary change were inadequate on the basis of current discoveries relating to genetic recombination, transposeable genetic elements, regulatory genes, and developmental patterns; therefore, Darwin's ideas need to be updated in view of current discoveries, but these scientists criticisms of evolution would in general not dispute the idea that the mechanisms of evolutionary change which fully understood at the natural level are still sufficient to bring about the change that the evolutionary process requires.

Q. So your use of the word inadequate, you're saying, in your deposition was not proper?

A. Well, I'm not saying, sir, that it wasn't proper. I'm just saying that today, upon reflection and thinking about it, I would prefer incomplete to inadequate. I read further in my deposition to make the point, which I think is the coherent point, which is to say that all of these ideas, whether Darwin's idea were incomplete, inadequate, half-baked, or however you want to describe them, can nonetheless fit within the general framework of evolutionary theory that he outlined.

That was the gist of this entire statement in my deposition and that certainly would be my testimony today.

Q. Do you agree that horizontal gene transfer makes it difficult to trace common dissent through micro organisms?

A. Oh, I certainly do.

Q. That was the studies of Karl Wose, I believe, demonstrated that?

A. Karl Wose was the first person to successfully demonstrate horizontal gene transfer, the transfer of bits and pieces of DNA from one micro organism to another. And the fact that this mechanism is widespread among bacteria and viruses means that it's very difficult to trace the pathway of common dissent. That's true. And that work started with Wose. It's

been continued by many others.

Q. Would you agree that scientists disagree about the relative importance of natural selection, sexual selection, chance, species, hibernation, and other factors which all influence evolution?

A. Yes, sir, I would agree to that. Scientists certainly do disagree about those points.

Q. These different ways in which different phenomena and nature might be explained?

A. I suppose the answer to that is, yes. All of the forces that you just mentioned are patterns that relate either to natural selection or to the generation of variation within the species, which are really part of the evolutionary process.

Do all of those processes occur in nature? Yes. Are they used from time to time to explain various natural phenomena? Yes.

Q. Could they be considered alternate theories that explain evolution?

A. No, I don't think so, because I think what you've done, sir, is to cite a number of phenomena and forces. Sexual selection, for example, is not a theory. It's a process. And horizontal gene transfer, once again, is not a theory in the sense of an explanatory framework. It's a process. I think all of these are forces that

can produce and rearrange genetic change within the explanatory framework of evolutionary theory.

MR. MUISE: Your Honor, I'll pick up from there tomorrow morning.

THE COURT: All right. I think we've absorbed quite a bit of information today. We'll start again with the witness tomorrow morning at 9:00 a.m. Thank you, Mr. Muise. Thank you to all counsel. Ladies and gentlemen, we'll see you tomorrow. We'll be in recess until 9:00 a.m. tomorrow morning. Thank you.

(Whereupon, the proceeding adjourned for the day at 4:30 p.m.)

CERTIFICATION

I hereby certify that the proceedings and evidence are contained fully and accurately in the notes taken by me on the within proceedings, and that this copy is a correct transcript of the same.

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