Science & Mormonism Series 1: Cosmos, Earth, and Man

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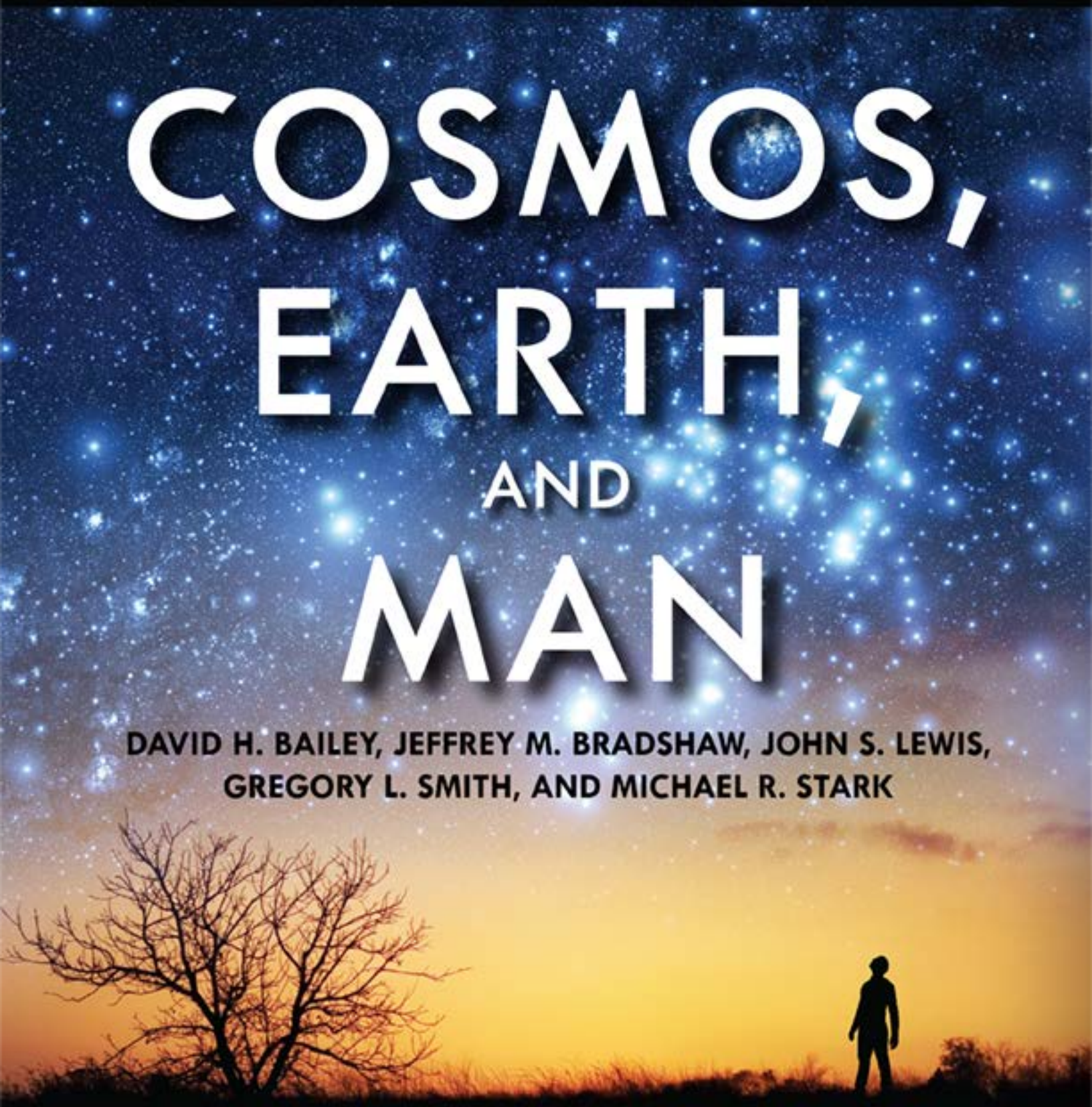
SCIENCE & MORMONISM SERIES 1



COSMOS, EARTH, AND MAN

DAVID H. BAILEY, JEFFREY M. BRADSHAW, JOHN S. LEWIS,
GREGORY L. SMITH, AND MICHAEL R. STARK

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SCIENCE AND MORMONISM 1: COSMOS, EARTH, AND MAN

David H. Bailey, Jeffrey M. Bradshaw, John S. Lewis,

Gregory L. Smith, and Michael R. Stark

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LIFE SCIENCES PANEL

Emily Bates, R. Paul Evans, Steven L. Peck, Michael R. Stark, Trent D. Stephens

Left to right: Trent Stephens, Steve Peck, Paul Evans, Emily Bates, and Michael Stark

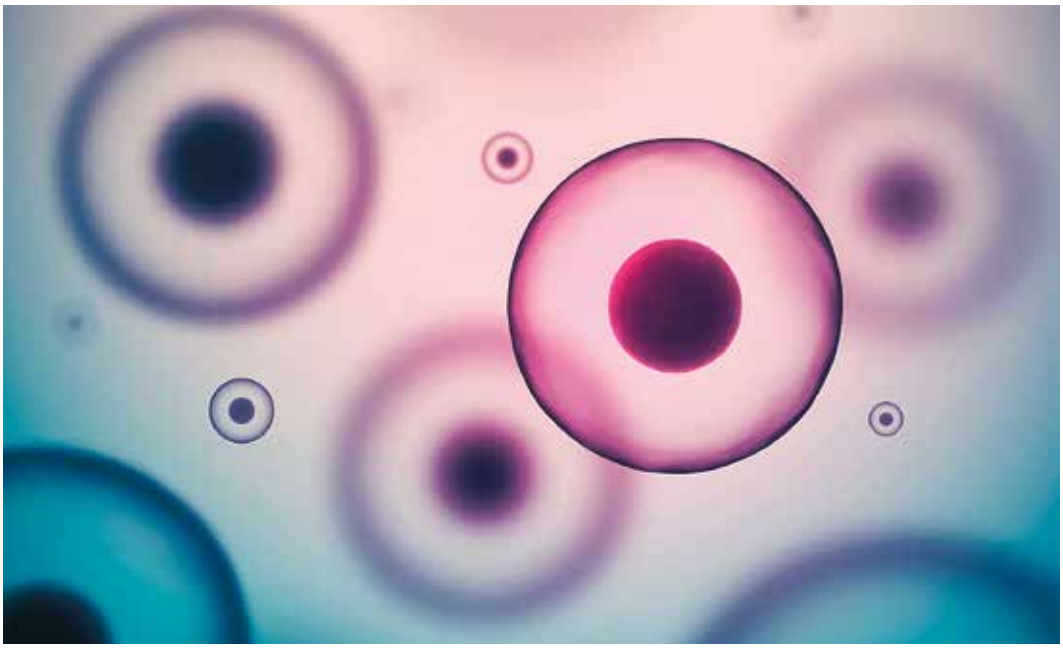
Michael Stark:

After each of you have a chance to give some introductory thoughts, we will address a few questions that have been written down. Also, we'd be happy to field any questions that anyone in the audience wants to ask.

I'll start by introducing myself. My name is Michael Stark, and I've been a faculty member at Brigham Young University since 2001. I'm in the department of physiology and developmental biology, and my background and training is primarily in cell and developmental biology.

An important part of my training came after I left Brigham Young University with a bachelor's degree in zoology. I had the privilege being mentored in research by Trent Stephens at Idaho State University, who is with us today on the panel. Trent was influential in my life, helping me to think about science in the right way and to ask interesting and important questions. After I studied with him for a couple of years, I received my PhD from UC Irvine and spent some time at Cal Tech. My main focus was studying the early development of the nervous system.

My scientific interests center on understanding what we call cell fate determination, or how different molecular and genetic programs assemble



Stem Cells

themselves in cells to push that cell toward a certain fate or a certain decision, such as becoming a neuron or becoming a muscle cell. A lot of my focus has been on understanding early nervous system development and how cells make those fate choices. I've dabbled in stem cell biology, asking questions about the molecular programs that help push stem cells toward certain fates. It's really been a fruitful and exciting career and experience for me.

I want to emphasize that as I've gone through my career, I frequently reflect back — probably on a daily basis — to the important things of my life, such as family and the gospel of Jesus Christ and how I can be a better follower of Christ. Connecting those things to my work in science is a little bit difficult, as any of these panelists would attest. Each of us has gone through different stages in our levels of understanding of biology and biological principles — how they apply to us, and how we can bring the knowledge that we obtain through science in harmony with what we believe spiritually and the teachings of the Church. There are a couple of important experiences in my life that have helped me sort through this process.

I remember being challenged as a young teenager with the idea that there was a conflict between science and religion in the age of the earth. I was asked as part of a physics class to debate my classmates, and each of us drew straws as to whether we would be on the side of the debate of a very old earth, millions or billions of years old as science teaches us, versus a young earth, just a few thousand years old as some people think the Bible is describing. That was the first time I had the opportunity to seriously wonder about truth and how we obtain it. One gift I've been privileged to obtain is to *know* that any truth we learn from any source here on earth comes from our Heavenly Father. He reveals it to righteous and unrighteous people alike

through scientific discovery, investigation, revelation, or however He sees fit. I'm grateful for that.

I'm grateful to have been part of the process in discovering some things that were not known before. Being part of that process inspires me and directs me to understand God's divine nature. It also gives me an opportunity to teach the students at BYU and others about the great opportunities we have to expand our minds and to prayerfully understand and consider the knowledge we can obtain directly through personal revelation — as well as through hard work, research, and scientific discovery. Those are the basic principles that govern my employment, my career, my scientific inquisitiveness, and also the way I try to live the gospel of Jesus Christ.

As we interact today, some questions may involve things that are in my area of expertise such as stem cell biology, early embryonic development, and gene expression — and how these things govern cell fate choices and developmental models. Now, however, the other panelists will describe their own personal background and expertise so that we can address your questions appropriately. Thank you.

Emily Bates:

I'm Emily Bates, and my first conflict between scientific inquiry and my religion occurred here in Provo, Utah. I was in school when I started learning about evolution. At the time, my Sunday School teacher had taught me that you could not believe in the teachings of The Church Jesus Christ of Latter-day Saints and also believe in evolution. I remember learning about evolution in school and thinking it made a lot of sense. There was a lot of evidence for it. So I started praying for a way to see what was wrong with this theory, so I could go on with having my faith in my Church. It was a long time before I felt I had any response. One night I woke up in the middle of the night, and I had this impression that I should read Genesis. I did that and I had this feeling and recognition that there was no conflict. I could see the order of evolution described in the scriptures. That was my first answer to prayer. It became both my testimony of God and my testimony of science at the same time.

I decided to go into science as a career because of my patriarchal blessing. I enrolled at the University of Utah, where I started working in a lab before my freshman year. As an undergraduate, I helped to publish a study about drosophila genetics. After I graduated, I went on to Harvard Medical School, where I did my PhD studying the molecular mechanism of Huntington's Disease, which is a genetic neurological disorder. My work identified potential therapeutic targets for that disorder. From there I went to University of California San Francisco School of Medicine (UCSF), and there I studied the genetics of migraines. They had a short piece about our research on National Public Radio (NPR) in May. Then I came back to Brigham Young University. For four and a half years I taught undergraduates and continued my research on migraines and genetic birth defects. I enjoyed teaching the wonderful students at BYU. I have now taken a position at the University of

Colorado Denver School of Medicine, where I have been given additional opportunities to push my research forward. I'm continuing to study syndromes of birth defects and genetic causes of different disorders. I love science; I also have faith, and I don't see a conflict between them.

Paul Evans:

I'm R. Paul Evans. Several years ago I was walking along 9th Avenue in New York City while visiting my daughter and son-in-law. We walked past the Church of Saint Paul the Apostle — that's just a few blocks away from the Lincoln Center — and they had an announcement for a book discussion that evening on early Christianity. "Well I'm gonna go to that. It looks really interesting," I thought. The author was there, outlining the thoughts of the early Christian Fathers on various theological matters. At the end there was a question and answer period, and one of the questions was, "What about the Mormons and their claim on certain ideas in early Christianity?"

The author of the book, who's a professor at a Midwestern school, thought for a second and said, "There are no new heresies." He went on to explain that all the ideas about early Christianity that our Church has brought forward were the same sorts of ideas present in the writings of some of the early Fathers that were later pruned off as Christianity reached a consensus on theology. So I think the same way when I read the ideas of the "new atheism." I think, "Well, it's not new. It's the same sort of ideas — maybe the volume is a little larger, maybe the platform is a little bit more open, but the ideas are the same." I also think in a similar way about issues of science versus religion. I reflect upon early thinkers like Socrates and his ideas about how to go forth in life, and the conflicts he had with the surrounding culture at the time. Nothing major has changed.

We're always conflicted in our discussions of what is truth and what is not, what can direct a life and what can't. As a scientist I started as an undergraduate at BYU. Then I went on to graduate school at the Medical College of Virginia — it's in Richmond, that's home for me, the Washington, DC area — and studied antibacterial resistance in bacteria. In particular, I studied the bacteria that caused tooth decay, hoping to make a vaccine against tooth decay. It didn't work. The antibodies against the bacteria that cause tooth decay also worked very effectively against heart muscle, so that didn't turn out to be a good thing.

In science you have some really great ideas, but not all of them result in the outcomes we would have wished. But it was an interesting avenue to explore. From there I went to Purdue University as a post-doctoral fellow and worked on the genes responsible for seed protein, protein type, and content in soybean seeds and manipulating those and changing those and introducing a more complete protein source into soybeans.

Since coming to BYU in 1987, I have been involved in looking at DNA sequences of populations — how they change over time, what it is that identifies individuals and

DNA Fingerprinting

populations, and how can those be reflected in geological events, in transmission events, and mutation over time. That's involved a lot of fish — especially cutthroat trout — all sorts of aquatic insects, snakes, and other creatures. I went to Egypt as a part of the BYU Egypt excavation [www.facebook.com/ByuInEgypt], where we've been looking at the DNA sequences and the biology of people of 2,000 years ago.

The idea is that if we could understand what a human population looked like 2,000 years ago — or now even with Neanderthals, you know fifty and sixty thousand years ago — we might be able to say some interesting things about the human condition today. That's where I've come from, but my life is hypothesis driven. I perform experiments that involve techniques like polymerase chain reaction. I have some ideas on how that works, and I perform the experiment with the idea that I will have a particular outcome. Experiments don't always work, and so you do it again, and you try to figure out what was wrong.

I have hypotheses about southern blot; I have hypotheses about DNA sequencing. I act on those ideas, and perform those experiments. The results are usually as expected, but there are always times where surprises happen. Surprises and failures in experiments don't stop me from trying because there's enough evidence from what I've seen, from authorities, and from what I have personally experienced that tells me where there is something I need to change in order to make the experiment work. I have the same idea about faith and prayer. Sometimes I have an idea of what I think faith is, and what I think prayer is, and what I think my relationship with my Savior is. I test the hypothesis, I act a particular way, and it doesn't always turn out the way that I thought it was going to be.

That doesn't change the reality of the presence of my Savior and my Heavenly Father. What it means is my understanding of how they do their work and what

my relationship is needs to change. So testing hypotheses, moving forward in a given direction, is not only how I operate on a scientific basis, it's also how I live on an everyday basis. This way of moving forward works for me: "Oh, that didn't work, I guess I'll have to change."

One of my favorite cartoons, which I have posted outside my office, shows a machine. Somebody walks up to the machine and pushes the button, and they get zapped by lightning. They're charred, standing there smoldering, then the cartoon splits. The top half is titled "Ordinary People" — the caption below the cartoon character says, "I'm not going to do that again." And the bottom panel is titled "The Scientist" — and the caption says, "I wonder if that's reproducible?"

Steven Peck:

I'm Steve Peck. I'm in the Biology department at Brigham Young University. How I got there is a surprising journey of faith and discovery.

I was in the Army, serving in Germany — we used to do these long maneuvers for several weeks at a time — and I drove an ammo carrier, which meant that I had to park far away from everybody. So I had a lot of time to be by myself. I spent much of the time pondering about what I should do with my life (because driving an ammo carrier didn't really seem like a long-term solution (no offense to ammo carrier drivers in the audience); I wanted something different. So I used this time "in the wilderness" trying to figure out what I wanted to do. I spent a great deal of time fasting and praying about the question.

During that time, I had a very clear revelation that I should become a teacher. From that time on that was my goal. I got out of the Army and went on a mission to Arkansas — I never really learned the language but I learned enough to get by. I came to BYU after. I've always been interested in evolution — whether I believed in it or didn't. When I arrived at BYU, I had come from reading things like Joseph Fielding Smith's *Man, His Origin and Destiny*, which, as you know, speaks out very clearly against evolution. A friend told me he was taking a class in evolution, so I went to the BYU Bookstore and found the book they were using for the evolution class, and was surprised to see it was an ordinary evolutionary biology textbook like you'd find at any other university. It was not the take down proof that evolution was wrong that I had expected. I thought, "It looks like a straight up account of regular evolution." I expected the evolution book at BYU to say evolution is obviously false and flawed, and so this intensified my curiosity about it.

I decided to major in biology, and that lasted for about a year and a half until my wife and I were in a wreck on our honeymoon, which made me think, "Well, maybe I should do something a little more marketable," so I majored in statistics with a minor in zoology. That launched me into biology from a computational perspective. I did my doctorate at North Carolina State in bio-mathematics, which

is mathematics applied to biology. Finally I came to BYU to teach and do research in the Biology Department.

On my mission I remember an experience in which I told somebody they couldn't be baptized until they gave up their belief in evolution — this is how clear the issue of evolution and the Church was to me at the time. Then I came to BYU and took classes and was presented with the data and became convinced that it was true. Speaking of Carl Sagan, whom we've applauded today, at the time I was also watching *Cosmos* and David Attenborough's show *Life on Earth*. Watching these popular programs I was completely overwhelmed with the beauty and evidence of evolution. Luckily for me, at BYU I had teachers who were at the same time faithful members of the Church and also taught evolution. I had four high school friends at other universities, and when they were presented with the evidence for evolution, they honestly believed, like I did, that there was no place for both in the Church.

So for me, this became a sort of crusade to help people who were struggling with their faith because of evolution. I wanted to help them come to terms with it, to recognize that you don't have to give up one to hold on to the other.

For me this has been an amazing and fun journey. If I have one overriding fundamental attribute, it's immense curiosity. I don't have all the answers, but I love probing things of all sorts. It gets me in trouble more often than not, but so be it. That's why I think symposia like this one are so important. I think it's very important that we get together and discuss our faith and our science, and how they work together. There are tensions. I admit that there are places where I don't have answers to how it works or why it works — but for me, I can imagine possible solutions for some of the issues that suggests to me there are yet other solutions that I haven't yet explored. Although I might not have hit upon the right ideas yet, I know enough to be able to keep hold of my faith in the hope that the tensions I see will get worked out in a satisfying way. And for me, I just love this. I have fun.

Yeah, I love science. I love my faith, and I'm glad that I can speak about it in places like this one — and express my belief that science and religion fit together well.

Trent Stephens:

My name is Trent Stephens. I'm an emeritus professor of anatomy and embryology at Idaho State University. I grew up in southern Idaho on a dairy farm. That's why I'm here. I'd rather be anywhere than a dairy farm. How many of you are familiar with Malta, Idaho?

Oh wow, a lot of you have been to Mecca, population 200. I grew up in a suburb. I've always had two thoughts in mind: one is an enormous curiosity, which I guess this panel seems to have in common, and the other is a belief that all truth is compatible, and so I've never had any problem seeking for truth and knowledge, no matter where it lies.

When I graduated from the eighth grade (in Malta, if you can imagine, there's only a grade school and a high school — not enough people for a middle school), I asked for a graduation present of a book entitled *Chromosome Numbers in Animals*. I went through the book cover to cover. There's no text in the book. There's no narrative. It is about a three-hundred page book of just tables. I decided that this was the key to disproving evolution that everyone else before had somehow missed out on. I decided that if there's a progression of evolution from less specialized and less highly developed organisms to more specialized and more highly developed organisms then that transition should be reflected in the chromosome numbers of animals. So I plotted all of these tables in a big chart that I created on a poster board. I found that there is no pattern to the chromosome numbers between closely related animals. And I thought, "Ah-ha! Finally someone has come up with a definitive argument against evolution." Unlike Steve, I didn't go quite as far as my mission in carrying that notion around in my head, but I was convinced at the time that evolution was incorrect.

The entire hominid fossil record could be fit into a shoebox in the mid-1960s, and half of the fossils were fakes. At that time when you looked at something like the Piltdown Man, everyone knew that it had been shown to be a fake. I thought, "Well, you know that stands to reason." When I signed up for BYU, I declared my major as biochemistry and my minor as art. When I got here at BYU, I found out I was a chemistry major, and that art was nowhere on the curriculum. There was no biochemistry undergraduate program at BYU in 1966 when I arrived here, so I decided, "Hey, what better time to disprove evolution than in my freshman year at BYU?"

I started to writing a thesis about the chromosome barrier to evolution. I went to the library, started doing research, and immediately came across Carson's work with Hawaiian drosophila in which he demonstrated very elegantly that you could see these chromosome inversions that mapped the exact evolutionary pattern of drosophila in the Hawaiian islands. I thought, "Wow, have I been wrong!"

I realized there was an enormous amount of evidence, and the more I looked, the more I found. At that time chromosome patterning and molecular biology, which is what I really wanted to go into, didn't even have a name yet — and the more I learned, the more I found there is an enormous body of scientific evidence to support evolution.

I ended up going on a mission for two years to Michigan and Indiana, then came back. I didn't like chemistry; it was the bio part I liked, so while I was working on construction the summer after I came back from my mission, I heard on the radio that the first gene had been isolated from *E. Coli,* and I realized that was a bacterium — I came back and changed my major from chemistry to microbiology. I spent most of my time in the zoology department, and particularly in Fanny Farkle's Fantastic Fly Factory.

E Coli Bacteria

Duane Jeffery had a great influence on my life as an undergraduate. When I finished, I had enough zoology credits that I graduated with a double major in microbiology and zoology. In the process I became very interested in the whole idea of shape and how biological form occurs. That came about in 1971 at the same time I was enrolled in the very first evolution course ever taught at BYU.

There was a big controversy in 1911, and a lot of it was focused on the Brigham Young Academy. The academy became a university in 1903 and had hired new teachers to raise the curriculum to a university level. President Joseph F. Smith made a statement in the *Juvenile Instructor* that "until we receive more light upon the subject [of evolution] we deem it best to refrain from the discussion of certain philosophical theories. … Some of our teachers are anxious to explain how much of the theory of evolution, in their judgment, is true, and what is false, but that only leaves their students in an unsettled frame of mind." And this is what I think is interesting: he didn't have a very high opinion of Brigham Young Academy [University] students. He said, "They are not old enough and learned enough to discriminate, or put proper limitations upon a theory which we believe is more or less a fallacy. … [E]volution would be best left out of discussions in our Church schools." And it was left out for the next sixty years.

"The Church itself has no philosophy about the *modus operandi* employed by the Lord in His creation of the world." He went on to say, "It is much preferred that they (the institutions of learning) emphasize the industrial and practical side of education. … If our Church schools would confine their so-called course of study in biology to that knowledge of the insect world which would help us to eradicate the pests that threaten the destruction of our crops and our fruit, such instruction would answer much better the aims of the Church school, than theories which deal with the origin of life." I find it very interesting that he talks about insect pests, because the best way for us to really understand insect pests properly is to understand their evolution and their resistance to pesticides.

So for sixty years, evolution was not taught in the Church schools — until 1971, when Duane Jeffery and Clayton White taught a course together on evolution. I was one of the students in that course. I should mention that Duane, about the same time, gave a lecture on this very intriguing little marine plant called *Asotabelaria mediterranea*. This tiny plant is about two to three inches tall and has one nucleus. It's a single-celled plant that has a nucleus big enough to see without using a microscope. It's incredible. One variety of the plant looks like a little

umbrella, and another variety of the plant looks like a little mace. One is called *Asotabelaria mediterranea*, and the other one's called *Asotabelaria crenadia*. I became so fascinated by the shape of this little plant that I decided the focus of my career would be to understand biological form.

After finishing my undergraduate degreee in zoology, I stayed on at BYU for one more year and got a master's degree with Bob Seegmiller, again in zoology. Then I went to the University of Pennsylvania to work with Dr. James Lash in looking at the issue of development of the limbs. For many, many years, my research has been looking at the question of why limbs are located where they're located on the body — how do they form developmentally. At the same time, I also became fascinated with the question of how thalidomide causes birth defects. So I've had something like two parallel career paths. After receiving a Ph.D. at the University of Pennsylvania, I went to the University of Washington for a postdoc in pediatrics. I was specifically interested in studying the range of human birth defects. Then, in 1981, I was hired at Idaho State University (ISU) to teach in their new dental school, to teach anatomy and human developmental biology. I retired from there in 2011.

While I was at ISU, I had a student in the Biology department named Forrest Peterson who was a theater major. He went to the department chairman and complained about the teaching of evolution in the zoology classes. Forrest was LDS, so the department chairman sent him to me, and I spent about two and a half hours explaining to him the beauties of evolution and how it was not incompatible with our theology.

When we finished — this was about twenty years ago — he said, "Well, now that you've told me all this, what book can you advise me to read on this subject?" I said, "There aren't any that have been written since about the early 1960s." And he said, "Well, why don't you write one?" I said, "Well, I've been thinking about it for a long time." About that time, another LDS faculty member named Jeff Meldrum joined our faculty. Jeff and I set out on a project to write a book entitled *Evolution and Mormonism*, which we published about twelve years ago. Later, we decided we needed to write another book on the topic of DNA data and Native American origins, which was published a few years later with the title *Who Are the Children of Lehi?*

About the same time, I was asked by the *Journal of Mormon History* to review a book published by Dwayne Anderson titled *Farewell to Eden*. In the introduction to his book, Anderson said that he had some questions — he has a master's degree in physics from BYU and lives in Arizona. When he went to his bishop about his questions, the bishop said, "Don't worry about them." That was not very satisfactory to Dwayne.

He went to his stake president with the same questions, and was told, "Don't worry about it." Reading about Anderson's experience really killed me. I've been a bishop twice, and I recognized that he had a real issue. If he had gone to his

Identical Sheep

bishop with a financial problem, the Church has formal, professional help for that. If he had gone to his bishop with a psychological problem, the Church has formal, professional help for that. In the *Handbook of Instructions*, it tells the bishop what to do. If a person goes to a bishop and has a problem of faith, there's nothing in the *Handbook* telling the bishop what to do. So I'm very, very interested and anxious to help any way I can, particularly in speaking with bishops and young people who are faced with perceived problems with any aspect of the teachings of the Church, including science and evolution.

Michael Stark:

Thanks to each one on the panel for your introductions. We have a handful of questions to start with, and each panelist has one or two questions already in front of them. I'll start with one that came up in a prior session. The same question was stated different ways. This version says, "Is cloning ethical, approved by God? At what point does cloning go too far?"

It's an interesting question; I get this from students at BYU on occasion. In our scientific advancement, we biologists have have been able to clone many organisms, and the question of ethics when it has to do with animals doesn't bother us too much, I suppose. However, I've never met a biologist who doesn't believe there are serious bioethical problems with attempts at cloning humans — meaning cloning for reproduction, creating a new human through the process of cloning.

The process of cloning involves taking DNA from a somatic (i.e., body) cell from an adult organism and transplanting that DNA into an egg that's been enucleated,

Identical Twins

then allowing it to develop. In theory, the technology to clone a human is available. I have heard no reports that it's ever been done. There's no easy answer, but when students ask me this question, I challenge them to think about how they would define cloning and how one would define a clone in biological terms.

Emily just mentioned one of the most common answers to the question of what is a clone — and probably a pretty correct one: It's an organism that is genetically identical to another individual. Do we have any examples of genetically identical individuals in this world? And the answer is identical twins, right? Or triplets, right? Yes. Anything else, Paul? Quadruplets, quintuplets. Any human parent of multiple births knows that the spirit of each child is different.

Emily — we'll just go down the row — what questions do you have?

Emily Bates:

This question states, "Do chemicals in [the] brain determine how we act versus God and/or agency?" This, I think, is mostly a question about what's going on in our brains, and what is predetermined versus what we can choose. There's a little bit of both, I would say.

Our genetic makeup determines to some degree what is in our brains. For example, our susceptibility to depression, our susceptibility to mental illness, maybe even our tempers can be somewhat determined by our genetic makeup. That said, we also have ways in which we can modify what's in our brains.

For instance, if you repeat a behavior many, many times, the connections between the neurons that make that process become strengthened, and it becomes easier to do that act. For instance, when you practice a violin, after a while you don't really have to think about playing a sequence of notes in a particular order — it just happens without thought. That happens because those neural circuits are practiced and strengthened, and you can modify how your brain will behave by practicing and by habit.

But because we're different genetically, we all have different tools we're working with, so we all have different struggles, susceptibilities, and different capacities as well. Things that are easy for one person may not be as easy for someone else. Each of us has agency, and each of us also has some susceptibilities or predetermined tendencies. That's why we're not supposed to judge anyone, because we don't know what they're up against — and they don't know what we're up against. I think that's why we have to leave that to God. God knows what I'm up against, and He knows what you're up against. We must do the best we can with what we have. We shouldn't feel guilty if we have a susceptibility to depression, for example, and we shouldn't feel guilty for needing treatment for depression. But we can modify our strengths by practicing good habits.

We have agency, within the sphere we've been given. We can do the best we can with the package we've got, right? That has to do with the second question, so I'll tie those together.

The second question is about sexual preference and agency. I have known Mormon men who had same-sex attraction and didn't want that life style. They wanted to have a family with a female wife, and they wanted children. They struggled because although they could choose their behavior just as I could, they couldn't choose not to be attracted to men anymore.

Sexual proclivities like this have been shown biologically as well. You can mutate one gene in a fruit fly, and the male will try to mate with other males. In mice, the part of the brain that is responsible for attraction has been identified. There are pesticides such as Atrazine that feminizes male frogs and induces the same enzymes in mammals. Exposure to pesticides during development is not a child's choice. Atrazine usage is really prevalent in the United States, but it's outlawed in much of Europe. I don't know the cause of same-sex attraction. I'm certainly not one that can judge. We're not allowed to judge anyone other than ourselves, so I leave it at that. I think we all have agency to do the best we can with the biological package we're given, but all of us have a different package, so we can't judge each other.

Paul Evans:

My question has to do with thoughts and how they would affect our gene expression, and it's prefaced by the idea of epigenetics. So if you think about the genetic information you have that determines how your cells behave — that is, what information is available that can direct cellular function and outcomes, that would be our DNA sequence, and that's what's inherited, but you can modify the DNA, and that modification of the DNA can result in different types of expression you would not expect to see just based on the DNA sequence. That's what we refer to as epigenetics — something else over and beyond genetics. You can modify it, you can organize the DNA, you can have it packaged in a different way, and that can be inherited from generation to generation.

So the question is, "Can thoughts affect genetic expression?" If I break it down, you would say, "Can my neuronal activity" — and that is, the activity of my brain and what's going on in there — "can that change how the DNA is organized, how it's modified, the DNA sequence itself, what gets expressed, what information gets played, if you will, on the piano if all the keys are there, what the score is of the piano piece that will be used?"

There's no evidence, one way or another, on that question in terms of just brain thinking — neuronal activity — directly changing the gene expression pattern of a particular gene. Now the question comes, as Emily suggested, "How about acting on those thoughts and the behavioral result? Can you strengthen particular neuronal connections and result in it being easier to behave or to think in a particular way?"

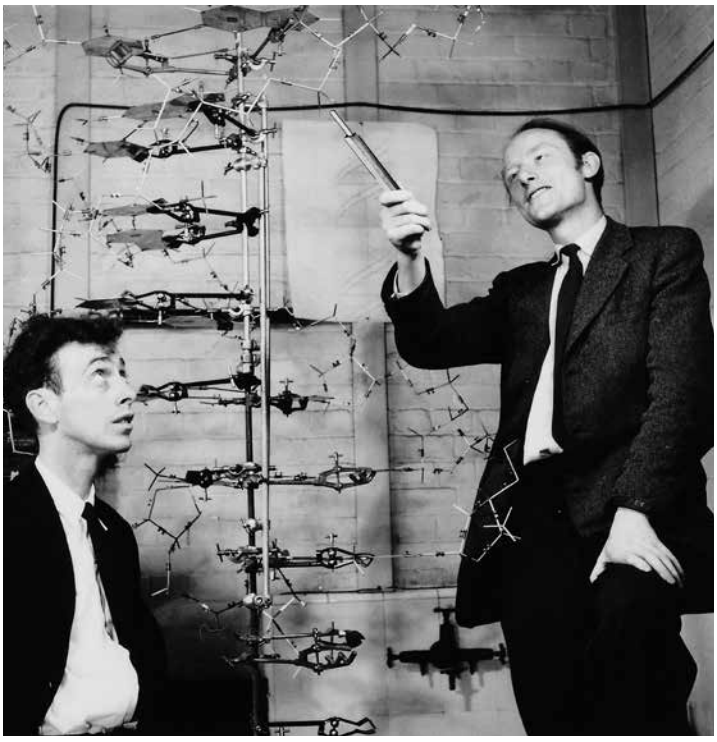
That's one of the ones where you say, "Well, maybe," but again, the question becomes, from at least a scientific approach, how to measure that, and I'm just not aware of anything that would directly get at what would need to be measured. So, the susceptibility, if you will, to our genetics or even our epigenetics is not only things that we find to be out of the ordinary, but they can also be changes or susceptibilities that would increase our likelihood of particular activities we think would be positive. Whether we see or not is due to our genetic expression. Whether we hear or not is due to our gene expression and the genes that we have. Whether we think a particular way or not also seems to be influenced by our genetic heritage, how those genes are put together, and what other modifications the environment can impose, in terms of what we eat, where we are, what we breathe — all those can have impacts.

Steven Peck:

This question is directed straight to me. "Dr. Peck, I have to respectfully disagree with your assessment of the Discovery Institute. How do you explain the complex specified information, digital code contained in DNA, and other epigenetic information in the cell if you are restricted to a purely methodological, materialistic explanation?"

This is a really good question. One of the puzzles we have in science is the origin of DNA. There is some evidence that it started with RNA, but we don't know. We don't know, and this is on top of another puzzle that's generating a lot of interest in the philosophy of science. In fact, a new book just came out this month entitled *Complexity and the Arrow of Time*. In fact, I've got a copy in my bag.

As we look at life on earth, we see it moves from very simple to much more complex. This arrow of complexity is very clear. People tend to ignore it. You find people like Stephen Jay Gould, who wrote a lot about evolution, who kind of hemmed and hawed and said, "Well, we don't know if there's an arrow of complexity; we can't say — maybe things were as complex back then." But there is a very clear signal. The stromatolites that we see, blue-green algae that looks like it was one of the very first



James Watson and Francis Crick with a DNA Model

forms of life on earth, are much simpler than, say, a rutabaga.

So this is an interesting question because it gets at the heart of one of the things about science: namely, that we don't have answers to some things. We don't have clear information about what the chemical world was like when the earth was formed, or how the process of life got started. Once we get natural selection going, evolution can take off, and then it's easy to see where complexity comes from. One of the things about evolution is that if you're in an open system like we have, with the sun pouring energy into our world, there's no theoretical reason why you can't move from simplicity to complexity. You know when you come to your kid's room, and it's in a state of complete entropy, it takes energy to turn it into an ordered state. But energy can do that — directed energy. Given that we don't know some things, the question is about how we can respond to this perplexity?

The Discovery Institute has gone through a series of supposed biological examples in which it claims, "This is too irreducibly complex to have been evolved." So the question comes over to science, and science says, "No, such a thing can evolve, and here's the mechanism." I showed you the slide with the bacterial flagellum evolving and how that has been worked out step-by-step as an evolutionary process. Now that these questions are being answered by science, the Discovery Institute has had to retreat to another kind of question, and they're now saying, "Ah, but you still don't know how DNA got started. It's information-rich. How did it happen?"

We can have two responses to such a question. One is to say, "This is a scientific puzzle, and we're going to work on it." The other response is to say — and this has been the Discovery Institute's approach, "Aha! Here's something you can't explain, therefore God must be the explanation." The trouble is that it's been for them, from their inception, that when science explains, they have to retreat — this is what people in the field call an explanation that relies on the "god of the gaps." As scientific explanations advance and start to fill existing gaps one by one, those who

take a "god of the gaps" approach keep retreating to a smaller and smaller domain that they claim for themselves because science has not yet explained it.

But, as I mentioned, the scientific response is, "Here's a puzzle. Let's see what we can do with it." Just this month progress was made in looking at the way that certain clays align certain precursors to RNA molecules, and you see a sort of arrangement that looks like it's got potential as an explanation for how life got started on earth. So the scientific approach is, "These kinds of puzzles" — and every scientist knows there are things we don't know: the quote by Lord Kelvin was just wonderful — "physics has got all the questions answered." No scientist would make that claim now. Now we've got gobs and gobs of things to work on.

But a claim like that of the Discovery Institute, that "this is too complex" and so we're going to have to insert God in there, becomes very dangerous because that kind of a God keeps getting smaller and smaller as science progresses.

My God doesn't get smaller and smaller as science progress. My God stays the same size whether science is making claims or not. On a podcast once I made the claim that how life got started on earth we may have pegged in ten years. I may have to reduce that to about five years if this clay stuff works out, but it's an empirical question, a question for science to explore.

If at the end of time, when all the science is done, and we, like Hoyle, can say, "There is no scientific explanation for how life got started on earth," we might turn to the "god of the gaps" approach, but we're a way off from that time. For now, I would say that the Discovery Institute is setting itself up for failure and setting up people for a failure of faith if they hang it on the "god of the gaps." That's my answer.

Trent Stephens:

Before I go to my question, I'd like to comment on what Steve was talking about and also Mike's earlier comment. When you look the structure of DNA and this idea of this clay template, etc., that's being looked at right now, it's somewhat related to my own research and the papers I've published on the mechanism of action of the drug thalidomide.

Back in the late 1950s, a company, a very small company in West Germany called Chemie Grünenthal, which was a cosmetic company, decided they were going to make an antibiotic, so they simply took an amino acid mixture and heated it up. It turned out that two of the amino acids fused in such a way that they made it a flat plate. When you make a molecular model of that flat plate, and you take a model of DNA, that little, flat plate of thalidomide can slide right in between the stacking nucleotides of the DNA, and apparently just by hydrogen bonding and sliding in there, it blocks transcription of certain genes with certain promoter sequences. It turns out that these certain genes are critical for blood vessel formation. So to go back and talk about the simplicity of DNA, it's a heck of a lot simpler than people

think it is. We think, "Well, it's got all this information, it must be very complex — actually it only has four letters in its alphabet. One simple drug manufactured in the late 1950s can slide into the DNA, block transcription of genes responsible for making blood vessels, and end up with people born with no limbs at all — no arms and no legs. That's pretty powerful, but it's very, very simple.

And then, going back to what Mike was talking about with cloning and with twins, I've spent my career studying birth defects, and I love to go to the extreme in all cases. So he's talking about identical twins and triplets and quadruplets. How about twins that aren't completely twins? Like a person or people — the different "personalities" tells you that these are two people — with one body, two legs, two arms, and two heads. The two heads think differently, they act differently, just like the differences between two completely separate identical twins. And then you ask the question, how many spirits are we dealing with here? I have no answer to that question, but I think it's really interesting to think about.

Here's a question specifically directed to me: "In your book, *Evolution and Mormonism,* you make a case for something called 'bounded randomness.' Could you explain how this is different from Intelligent Design? Has the evidence changed in this?"

That really follows up on Steve's discussion of the Discovery Institute and Intelligent Design, and some people have actually written that what composes bounded randomness in our book is just another way to talk about Intelligent Design. Let me say it is not the same at all. I'll tell you a little bit about how I got there.

To answer this question, I will begin by saying that when I started as a post-doc at the University of Washington, it was like being in Camelot. For someone like me who is interested in human birth defects, this was Mecca, this was Camelot. Anybody who was anybody in birth defects in the 1970s was at the University of Washington. The luminaries were there, and every Friday we had a roundtable discussion of various birth defects, and it was just fabulous. Right after I arrived there, one of these luminaries — his name is David Smith. How many have ever heard of David Smith? More of you know Malta than know David Smith — so Dave gave a seminar on a new book he had just published called, *Recognizable Patterns in Human Deformations.* He had previously published a book called, *Recognizable Patterns in Human Malformations,* of which I had a copy of as an undergraduate and had read and absorbed, but this was a rather different approach.

First of all, when I met Dave, I thought, "Man, this guy is not very bright. He's big, freckle-faced, red-haired" — reminded me of a Swedish farmer — "and he is coming off in this real weird proposal that if you have a baby — a fetus that's developing — and it's mal-positioned in the pelvis of the mother, its head becomes not malformed, but *de*formed. There's no genetic problem, no molecular problems with the fetus, it's perfectly normal — it's being pushed by outside forces." I had just

finished a PhD at the University of Pennsylvania focusing on molecular mechanisms of development that said no to this idea. I argued that this could not be true because all development has a molecular foundation to it. And Dave said, "If these are caused by outside forces, we should be able to correct them using outside forces." So he showed how you could mold a little football helmet for this newborn baby and push the head very gently and correct this rather severe deformation.

A Baby Girl with an Orthopedic Helmet

I thought, "Wow, my mind has been changed!" The data, which is the basis of science, gave the evidence that this was indeed the case. And while Dave was giving this talk, he referred to a very, very important book in biology entitled *On Growth and Form,* published in the 1930s by D'Arcy Thompson. Since that time I've told my students that the most important book in biology that you'll ever read — and you should read it immediately if you haven't — is *The Origen of Species* by Charles Darwin, and I challenge you to find a scientifically invalid concept in that book. Beyond the science, as pure prose it's elegant.

The second most important book in biology is called *On Growth and Form* by D'Arcy Thompson. Now, in this book D'Arcy Thompson says, "I am not degrading or denigrating genetics" — and I would add the words "or molecular biology" (molecular biology didn't exist by that time) — but, he said, "we also need to look at physical forces on biological form." He said that every leaf, every shell, every bone is sculpted by physical forces in addition to the genetic forces there. To me this became a very critical idea. Very few people have followed up on D'Arcy Thompson, but, in my opinion, in the 1930s he was way ahead of his time — and I think he's still ahead of *our* time.

I decided I would take these concepts that D'Arcy Thompson proposed, and I would apply them to developmental biology. So I have spent a lot of my career looking at *non*-genetic forces in development. That's where this concept of bounded randomness comes in. It relates to the concept of chaos theory and how that determines shape. If you think of chaos theory outside of *Jurassic Park*, which has a very poor explanation of it, and if you think of this sphere, you think of a domain called a strange attractor and, for a given phenomenon, everything that's going to happen is within this sphere. One of the concepts of chaos theory is that any given point in this sphere is equally probable as any other point in this sphere, therefore,

this randomness concept. A lot of evolutionary biologists have looked at this concept and talked about evolution as being entirely stochastic, driven by molecular mechanisms, a matter of mutation, and so forth, and that's very true, so that fits inside this strange attractor domain. But because of the work of D'Arcy Thompson, and some works later published by François Jacob, who was a Nobel Laureate, I thought, "You know, everybody's focusing on what's going on in the center, but why do we have a boundary here? What creates the boundary, and how does that relate to biological form?"

So, just to give you a very simple example: a chicken lays an egg. Everybody knows what the shape of an egg is — it's "egg-shaped," right? But that's not the egg; that's just the coverings. The egg is what we refer to as the yolk. What shape is the yolk? It's a sphere. Why is it a sphere? Are there genes in the chicken for "sphereness"? Why would there be? If you make an oil drop the size of that yolk and suspend it in water, it's a sphere. Physics takes care of it so you don't have to assign genes in a limited genome to make spherical eggs because the physics deals with that. So that's what I've been investigating for a number of years and called "bounded randomness." You have stochastic events inside of a strange attractor, yet you have bounded that strange attractor in a way that limits the extent of what those variations can be. It's scientifically testable. One can conduct experiments to test it. It is *not* Intelligent Design; it's almost the antithesis of Intelligent Design.

One experiment I conducted, looking at this issue, is that if you start out with the concept of a sphere, and you think of a salamander embryo as basically a pipe draped over the sphere, it turns out that the legs — I mentioned here that I'm interested in how arms and legs form — the four legs occur where the pipe ends on the sphere, so I thought, that's really interesting from a physics perspective. I wondered, "Could I tweak this system in any way?" What I found was that if I went in with a very young salamander embryo, and cut a little slit to separate the body axis, which is the tube, away from the sphere, that the hind legs no longer form where the yolk and body axis came together, but they now form where the new body axis and yolk attachment are. Up to six whole vertebrae more cranial, so I can take a salamander that normally has twelve dorsal vertebrae and make a salamander with only six dorsal vertebrae by simply making a slit in the embryo. This suggests that there are physical factors affecting shape in addition to genetic factors. So there is predictability in this random genetic milieu. So what's really interesting in looking

at strange attractors is asking, "what's the boundary?" rather than "What's going on inside?"

Michael Stark:

There's a set of questions we've been answering throughout the day, and this relates to historical statements made by General Authorities related to science and religion and evolution. Does anyone on the panel want to comment on this?

Emily Bates:

I'll just be really brief and say that just because evolution challenged the testimony of someone in authority doesn't mean that it has to challenge your testimony. A lot has been discovered since some of these statements have been made. There is not as much to question about evolution anymore.

Questions on science and religion don't need to challenge your faith. As social stigmatization arises, you can show your discipleship by your actions. If you believe that creation occurred following the laws of nature, that shouldn't change your behavior or your belief and respect and love for humankind. That shouldn't change how you follow the commandments. Just talk about your own belief and relationship with God, and focus on that. People are wrong sometimes, even church leaders. That is human. President Uchtdorf talked about that in the last General Conference. Our own belief in God need not be challenged by new knowledge. We don't have to fear new scientific knowledge.

Michael Stark:

Other comments on that subject? Are there other questions that you have before you that you need answered? Paul, you first, and then Trent has one briefly.

Paul Evans:

One question here relates to this discussion, and it's this idea that in the scriptures we have statements that may be construed as being literal and those that are perhaps symbolic and instructional. To follow up on what Emily said, if you run across some data inconsistent with your hypothesis, it does not change the fundamental truth underlying it. It might just mean that your interpretation of how things work is wrong, and you need to rework that. The experiential evidence you have is individual, and the faith you have continually tested and seen over the period of your life is not negated by the fact that you interpreted incorrectly how things work.

You just have to change that interpretation, and as a scientist, I throw out my hypotheses of how things work on a regular basis. I often hold five competing hypotheses at one time of how things work and to try to figure out how it goes

together. When I run across data not supported by my own experience and by others' observations, I can simply conclude that my hypothesis is wrong.

The question was, "How do you view the temple creation story, purely symbolic or literal?" I would just point out that throughout history of man, stories have been put together to explain how the world was created, and that's one possibility, but in reality if the true mechanism of how the world was created were given even today, let alone 2,000 years ago, it's very likely to be totally unintelligible.

I'm really looking forward sometime to seeing the movie that explains everything and how it works. I'll probably be so amazed by how it's so unlike how we *think* it works, I'll be amazed that it could have worked at all — in terms of our theories of how things work. But when I rent that movie, I do want to sit between Darwin and Joseph F. Smith to see their reactions. Better bring extra popcorn, Bob. So how do I view those stories of the creation that we have? My personal answer is that I see them as eternal and moral instructions delivered to me and to others in the framework of our temporary and material world. Somewhere in between are some elements we can connect with that help us relate, but it's an eternal and a very moral instruction and meant to make me a better person. So that's my answer.

Steven Peck:

One of the things that amazes me about scripture is its timelessness. That the same set of instructions and words and insights can be given to very ancient — and from our modern perspective, primitive — people, that meant something deeply to them, can thousands and thousands of years later be read by somebody in our culture, and for me this is the real power of scripture. The power of scripture is that they are deep enough and timeless enough to transcend culture and time, that they're written literally for every time, and that we can find value and insight and inspiration across these vastly different cultures is to me amazing. And for me, that's part of the depth I find.

Trent Stephens:

This question was directed specifically to me, "Can you elaborate on your suggestion that Adam's status as the first man is perhaps more a title than a chronological indicator, and the Fall of man associated with that?"

First of all let me say that I believe in a literal Adam and Eve, a literal Garden of Eden, a literal Tree of Life and Tree of Knowledge of Good and Evil, and that

the Fall was a specific event that happened. I view the Garden of Eden as a point of isolation because in the scriptures it's talked about in reference to other places. I view Adam and Eve as being plucked out of the mainstream of humanity, if you will, and isolated in the Garden of Eden — in fact, throughout the thirty years I taught anatomy, I constantly challenged my students who came up to me with questions — evolution is what I teach in anatomy and I'm also religious — when the students discover this, one of the first questions was, "How do you reconcile the two?" my question back quite startled most of them. I said, "Were Adam and Eve inherently immortal in the Garden of Eden?"

Inevitably the students would say, "Yes."

I would say, "Okay, a thousand dollars to whomever can give me the scripture that supports that." There is no scripture that supports that. Unless you canonize John Milton's *Paradise Lost,* then you have an easy case there. Then I ask the next question: "If Adam and Eve were inherently immortal, why was there a Tree of Life in the Garden of Eden?"

What was the function of the Tree of Life? It made them immortal. Well, duh! If they were already immortal, why do you have to have a tree to make them immortal? Why was it such a big deal to place cherubim and a flaming sword? Only one thing — not even the Ark of the Covenant — has been guarded by cherubim and a flaming sword. In the entire history of the world, only the Tree of Life. That was a pretty big deal. We're told it was guarded so Adam would not go back and partake of the fruit and live forever in his sin. That one sentence tells us an enormous amount.

Let's then consider that Adam and Eve were mortal beings plucked out of the mainstream of humanity and that beautiful, beautiful cave art you saw earlier by this person, who probably lived 12,000 years before Adam, who had put his or her handprint outline in this cave. You can't tell me that's not a human.

So here are a couple of possibilities: one, John Lewis suggested that Adam was the first person with a spirit, and we talked about the idea that agency doesn't have to be with the physical person but is more of the spiritual person; that's a very interesting concept. But there's another concept: John's reference to that suggests the 128th Section of the Doctrine and Covenants, which I immediately turned to and read, and it's very interesting because you have a comparison. You also see this in Corinthians, the comparison between Jesus Christ as the first fruits and Adam, as the first man, as the cause of the Fall, and Christ then atoned for the Fall. We know that Christ's Atonement is both anticipatory and retroactive. There is no question about that.

But we as Latter-day Saints have a very unique perspective on the Fall. Much of the rest of the Christian world believes that the Fall was an accident. An accident? With an omniscient God? That's incompatible. We know that the Fall was just as much a part of the plan as the Atonement was and that we all agreed to it in the Preexistence.

Now, I don't claim to understand why all of the Fall part was necessary; I don't understand it — I believe it, I don't understand it. But what if — this is my speculation — what if Adam and Eve were put in the Garden of Eden for the purpose of partaking of the Tree of Knowledge of Good and Evil (we know that) and that the words, "first man" is not a chronological statement but a title of position? He was the representative for all of us in the Fall, and that representation was not just anticipatory for everyone born after Adam, but it was also retroactive for everyone born before Adam, who would have also agreed to that same plan. It makes perfect sense from a scriptural perspective. I'm still tinkering with it.

Michael Stark:

All right, thank you, Trent for expounding on that subject. I hope you can see from the biologists — not just on this panel but from the community of LDS biologists whom we represent — that they are at their core thoughtful, humble individuals trying to understand our place on this earth, how we relate ourselves to our Father in Heaven, and so forth.

And we'll end with this question — and I think we've answered it implicitly throughout the day — "Do you know or do you believe that God is real?" I hope all of us and all of you have taken the opportunity to build a relationship with your Heavenly Father and through personal revelation and experiences that you know certain things. And we are, as Trent is, still tinkering with some ideas, still wondering about many things, and hoping to come to a better knowledge to look forward to in the future. Thank you very much.

EMILY BATES

Emily Bates earned her Bachelors of Science in Biology at the University of Utah, where she studied the genetics of development. She then served a full-time mission for The Church of Jesus Christ of Latter-day Saints in Geneva, Switzerland.

After her mission, she earned her Ph.D. in genetics at Harvard Medical School. Her thesis work identified potential therapeutic targets for neurodegenerative disease, focusing on Huntington's Disease. Dr. Bates spent a year teaching at Harvard University as a teaching fellow for molecular biology, cellular biology, and biological anthropology and serving as a resident tutor. She completed her postdoctoral research at UCSF School of Medicine and was part of the team to identify a genetic cause for migraine headaches.

Dr. Bates taught Chemistry and Biochemistry at Brigham Young University in Provo, Utah for four years. She is currently a member of the research faculty at the University of Colorado Denver School of Medicine in the Department of Pediatrics.

R. PAUL EVANS

R. Paul Evans joined the BYU faculty as a molecular biologist in the College of Biology and Agriculture (now known as the College of Life Sciences) 29 years ago. Previously he was a research fellow at Purdue University and received his PhD in 1983 from the Medical College of Virginia at Virginia Commonwealth University and BS from BYU in 1995 (this is not a typo).

His greatest joy is his best friend and companion, Jaelyn Bartyn Evans. They met in Camarillo, California and have been married for 38 years with two daughters, Crystal Ann and Cambria. He is the oldest of the seven children of Richard and Patty Evans of Vienna, Virginia.

Paul's research at BYU has centered on using DNA to study the changes that occur in families, populations, and species over time. Working with international, federal, and state agencies, he and Dennis Shiozawa have defined the genetic identity of fishes and aquatic insects throughout the world. Other projects have involved lobster populations along the coast of Oman, penguin colonies in the Antarctic, water snake families in Texas, and most recently, thorny headed parasites. In the course of the river related work, he has been "required" to raft through much of the white water and rapids of the western United States, including a month of rafting, collecting, and yes, "working" in the Grand Canyon.

In 1994, Paul was perfecting techniques to recover DNA from fish bones recovered at archaeological sites. One day, Wilfred Griggs walked into his office and asked, "If you can get DNA from fish bones, can you get DNA from the bones of Egyptian mummies?" Since then he has excavated in Egypt during ten seasons and is the team's resident biologist performing forensic pathology, age/gender determination, and anything else biology.

STEVEN L. PECK

Steven L. Peck is an Associate Professor in the Biology Department of Brigham Young University. He holds a Ph.D. in Biomathematics and Entomology from North Carolina State University; an MS in Biostatistics from the University of North Carolina at Chapel Hill, and a BS in Statistics/Computer Science from Brigham Young University. He uses computer simulation to study ecological and evolutionary processes in insects. He has published over forty scientific papers in such journals as *American Naturalist; American Entomologist; Biological Theory; Biology & Philosophy; Ecological Modeling; Evolution; Life Sciences, Society and Policy; Philosophy Study; Philosophy & Theory in Biology; Proceedings of the National Academy of Science;* and *Trends in Ecology and Evolution*.

He has also been active in the academic study of science and religion with papers in *Zygon: Journal of Science and Religion*. He also recently published a book on faith and science in the Neal A. Maxwell Institute for Religious Scholarship Living Faith series called *Evolving Faith: Wanderings of a Mormon Biologist*.

He is also an award-winning fiction writer. His novel, *The Scholar of Moab*, won best novel of 2011 by the Association of Mormon Letters and was a finalist for the Montaigne Medal, a national award. His novella, *A Short Stay in Hell*, is currently being made into a full-length feature film. He also recently published a book with Zarahemla Books of LDS short stories, *Wandering Realties*, which includes several award-winning stories.

His greatest achievement, however, is he and his wife Lori's four sons and one daughter. He served a mission in the Arkansas Little Rock Mission and currently is the High Priest Instructor for his ward.

MICHAEL R. STARK

Michael Stark joined the faculty at BYU in 2001. He teaches anatomy, developmental biology, and neuroscience classes in the Department of Physiology and Developmental Biology. Michael's research focus is on early nervous system development, and his experiments primarily use the chick embryo model. During his tenure at BYU, dozens of undergraduate and several graduate students have been mentored in the Stark Lab, funded mostly through NIH and BYU grants. He and his wife, Susanne, have seven children (two girls, five boys). The family recently spent six months living in Cambridge, England while Michael conducted research at the University of Cambridge in the Department of Physiology, Development and Neuroscience.

Much of Michael's early life was spent in and around the small town of Kimberly, Idaho, where he moved with his family at a young age. His father became very involved in the local agricultural community, eventually turning a small seed production facility into a worldwide supplier of garden seeds. After high school, Michael attended Idaho State University for a year before serving an LDS mission in Thailand. Upon returning, he attended BYU where he received his BS degree in Zoology. Later he earned his MS degree from Idaho State University (Biology), and his PhD from UC Irvine (Developmental and Cell Biology). Michael worked as a postdoctoral fellow at the University of Utah for three years prior to his current appointment at BYU.

Michael was recognized with the BYU Young Scholar Award in the 2006, and awarded the College of Life Sciences Outstanding Research Award in 2010. He received the Physiology and Developmental Department Faculty Achievement Award in 2011, and was selected to organize the LDS Life Science Research Symposium in 2013. In 2014 he was named a Parke-Davis Fellow, which supported his research visit to the University of Cambridge, England. Michael regularly serves as an ad-hoc reviewer for various funding agencies, including NIH, NSF, and UK's BBSRC, and he regularly reviews scientific articles in his field of expertise. For many years he has provided editorial service, such as serving as consulting editor of developmental biology for McGraw-Hill's *Yearbook of Science and Technology*, and as a member of the editorial board for the journal *Developmental Dynamics*. He is the director of the confocal microscope facility at BYU, is a member of the neuroscience faculty, and is currently the chair of curriculum for the Department of Physiology and Developmental Biology. His BYU faculty profile can be found at http://lifesciences.byu.edu/~mrs97.

TRENT D. STEPHENS

Trent Stephens graduated in 1966 from Raft River High School, Malta, Idaho. He served a mission to the Great Lakes (1967-1969) and then married Kathleen Brown in 1971. He graduated from Brigham Young University in 1973 with a BS in Microbiology and a BS in Zoology. He earned an MS in Zoology from BYU in 1974 and a PhD in Anatomy from the University of Pennsylvania in 1977. He completed a post doc in Pediatrics at the University of Washington in 1981 and took a position teaching Anatomy and Developmental Biology in the Idaho Dental Education Program at Idaho State University the same year. He retired in 2011 after teaching at ISU for thirty years. However, he continues to teach Gross Anatomy every year to the dental students and PA students. He was selected as the ISU Distinguished Teacher (1992) and Outstanding Researcher (2000).

Trent's research is the study of normal and abnormal biological form, including birth defects. He has published approximately one hundred papers and books on the subject, including several scholarly works on the relationship between birth defects and medieval beliefs. He has been building toy and model castles for forty years. He has a castle website (buildmodelcastles.com) and has been teaching classes about the history of castle construction, life in medieval castles, and the modeling of medieval castles for over twenty years. With his daughter Brittani Hobson and niece Carrie Reed, he is launching a huge international party website called Frolic Parties.

Trent has authored or co-authored about twenty books, including several leading-selling Anatomy and Physiology textbooks and the critically acclaimed history of thalidomide (Stephens and Brynner, *Dark Remedy: The Impact of Thalidomide and Its Revival as a Vital Medicine*, Cambridge, MA: Perseus Books, 2001). Trent is considered one of the world's leading authorities on thalidomide, and has been invited to speak at several international conferences. Beginning in 2012, he has functioned as an expert consultant to several law firms and has helped identify over 200 thalidomide victims (now in their early 50s) in Australia, New Zealand, the UK, and the US. He has also coauthored books on the relationship between science and religion (Stephens, Meldrum, and Peterson, E*volution and Mormonism: A Quest for Understanding*, SLC, Utah: Signature Books, 2001; Meldrum and Stephens, *Who Are the Children of Lehi? DNA and the Book of Mormon*, SLC, Utah: Kofford, 2007).

Trent is an Eagle Scout and Silver Beaver awardee (1991). He served for many years as Cubmaster and Scoutmaster. He has been an Elders Quorum President and has taught Gospel Doctrine, Teacher Development, and Family History courses. He has served as a counselor in a bishopric and as bishop twice. He has served on a High Council and as High Priest Group Leader. He has also been a temple worker in the Idaho Falls Temple.