

Charles Darwin and the Tree of Life: Some Assembly Required  
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*Note: This was a graphics rich presentation, so some of the text below may seem a bit confusing without the accompanying slide.*

*Introduction*

I am pleased to speak to you today, and share with you a little bit of the enthusiasm that I have for the work I do at Brigham Young University. The first thing you should know about me is that I am an entomologist; that is, someone who studies insects. Insects have fascinated me for as long as I can remember. My mother recalls that when I was being delivered in a rural South American hospital, there were large beetles crawling up and down the walls, and that made her very nervous. She is certain that this experience is somehow related to my entomological predilections. One of my earliest memories is of a stick insect that was evading my attempts to capture it. Even in high school, I was given the nickname of “bugs”. It is hard to imagine anyone who was more predestined to study insects than I was.

But how could one not love bugs? Nature is complex, beautiful, and full of a wide diversity of forms, and in no place is this more apparent than when one takes a moment to contemplate the insect. One cannot look at insects without being amazed at their sheer beauty, their stunning colors, and their bizarre forms. But Biological Diversity is not a random assemblage of forms; there is order and pattern to Nature. Much of science lies in documenting the patterns we observe in nature, and then postulating processes that may account for those patterns.

*Patterns and Process*

Let me give you a simple example. This is a picture of my daughter at lunchtime about a year ago, and what I want you to notice how nice and clean her tray is. Anyone who has children recognizes that this particular pattern of cleanliness is short lived at best. Now if I were to walk out of the room for a moment and walk back in, I would observe a striking new pattern. Chocolate smears with vestiges of mangled teddy bear crackers artistically sprinkled throughout. This is a pattern. A much more interesting pattern than observed before. As a parent, ones first thought is to clean it up. But as a scientist, I am left to wonder: “what processes gave rise to this pattern”? Notice, I am not asking: “who gave rise to this pattern”. I am pretty confident I know the culprit here. I am only interested in discovering the specific processes associated with forming this particular pattern. How did she do it? For instance, I might hypothesize that the ridges of pudding present in the middle of the picture were created by finger smearing as opposed to, let’s say, elbow smearing or face smearing. On collecting additional data, I am able to confirm the finger-smearing hypothesis (though it does not rule out the face smearing hypothesis). Now remember, I was not there. I did not see it happen. But I can infer something about a

process in the past by carefully examining the pattern that remains. Pattern provides evidence for deciphering process.

### *Patterns Throughout History*

The notion that patterns exist in nature, and that they can be organized in a regular and orderly fashion is not a new idea. Aristotle was a keen observer of nature, and he thought deeply and profoundly about how his observations should be sensibly organized. He thought that all of nature could be organized into a ladder, the “Systema Naturae”. At the base of this ladder are the simple plants that were not much different from non-living matter. At the pinnacle was the human species, and each group of organisms had a place within the hierarchy that roughly corresponded to their level of complexity. But it was a ladder and not an escalator. There was no notion that any species could transform into any other, nor was there any idea of progression. There was a place for every species and every species had its place.

Let us now jump to the 17<sup>th</sup> century, and consider for a moment a body of thought that became prevalent with the writings of John Ray. Ray was a Cambridge professor who championed the idea of Natural Theology. Natural Theology taught that by studying the creation, one can learn about the attributes and characteristics of the Creator. Living things showed adaptations to their environments, which for Ray were signs of God's design and benevolence. So why does a lion have sharp claws? It is because God could not let lions go hungry. Why do the birds sing in the trees? It is because they are singing the praises of a just Creator.

*“All creatures of our God and King, lift up your voice and with us sing”*

Ray affirmed powerfully that Nature was a worthy subject for study and reason, and that such activity was pleasing to God.

Ray, of course, was not the first natural theologian, and we have from Alma a similar sentiment. “...yea and all things denote that there is a God; yea, even the earth, and all things that are upon the face of it, yea, and its motion, yea, and also all the planets which move in their regular form do witness that there is a Supreme Creator”. Hence according to Alma, one purpose of the creation is to be a witness for the Creator.

### *Charles Darwin*

This brings us next in our whirlwind tour to Charles Darwin. Here on the left we see him pictured as a 7 year old in 1816 posing with a beloved flower; on the right we see what the rigors of science does to ones features over time.

Darwin was born 12 February 1809 in Shrewsbury, England. This was the same day that Abraham Lincoln was born, and only 3 years after the birth of Joseph Smith. These three men – Smith, Lincoln, and Darwin – were all contemporaries who profoundly changed mankind’s view of religion, politics, and science. Darwin was in fact influenced by many of the same religious and social pressures that Joseph Smith was, and some of the same social forces, which molded Joseph Smith and the early church were also operating on Darwin. It is interesting that these men were contemporaries during a time when the Lord saw fit to rain down knowledge upon the earth.

Charles Darwin provided profound insights into the nature of nature. He saw what everyone else saw, but provided a new way of putting the information together. He was a meticulous observer and managed to digest and synthesize a tremendous amount of information. The theories he produced continue to influence everything we do in biology today.

I might mention here, that one often hears Darwin portrayed as a man eager to destroy faith and tear down religion. Often, these are the same detractors who paint Joseph Smith and the history of the Church with a similar paintbrush. But this caricature is not true to the record. Certainly the ideas that sprung from Darwin's work had a profound influence on religious thought, and still continue to do so, but by all accounts Darwin was a loving father, a kind man, afraid of confrontation, and someone who would much rather study the mining habits of earthworms, than be involved in a debate over science and religion.

Those who know a little about Darwin's history will recognize the historic voyage of the H.M.S. Beagle, and the role that Darwin played as the ship's naturalist. It was this 5 year period during which Darwin collected the initial observations, that would chart the course for the rest of his work. This was a grueling voyage, and Darwin kept a precise and fascinating record. I imagine you are all acquainted with his stop in the Galapagos Islands, and the unusual organisms he found there. He saw flightless birds, penguins and sea lions frolicking side by side with iguanas, which grazed on marine algae, and finches which varied in beak size across the islands, and of course, the islands' namesake, the giant tortoises. In case you are a bit confused here, this is not Darwin on the tortoise; this is me at age 5, contemplating, much as Darwin did, what all these patterns might mean. Darwin returns to England in 1836, and continues his working of observing patterns, during the next 23 years. He saw the pattern; he was trying to understand the process.

In 1859 he publishes "The Origin of the Species", which is jammed packed with observations and the connections he tries to make between these observations. The species illustrated here are just some of the many he discusses in his chapter on Natural Selection. For the first time, someone was trying to draw a connection between the jaws of a stag beetle, the ornate feathers of the peacock, the blooming patterns of plums, and the behavior of honeybees. He was postulating a process to explain a pattern. So what processes did Darwin hypothesize? You are probably familiar with them. This is a slide from my wedding. This is my immediate family; a happy family of ten. You can tell it's my wedding picture by the bug nets with flowers in the upper corners. My mother is sitting on the right. This is my mother's brother and his family, at a similar time and occasion. I can't count them all, but I can tell you that we're outnumbered. Darwin recognized that some individuals were more successful at leaving offspring than other individuals, and recognized the implications of this simple math. So according to Darwin, my uncle is much more successful than my mother. Isn't ironic that this is the same conclusion that many Mormons might draw?

Darwin also recognized, as all mothers do, that not all the kids are the same, and this is true throughout all of nature. In any given species, there is variation in characteristics

and behaviors, which lead to differential survival. In other words, not everyone makes it. If you are an eager beaver who tends to stand on the wrong side of the tree, you might not make it. This is Natural Selection. I use this slide to motivate students in all my classes to study hard. One of Darwin's key insights was that the old Aristotelian system of organizing species into a ladder does not fit the patterns of biological diversity he observed. Darwin suggested that a branching pattern that resembles a tree is a better comparison. He states: "*The affinities of all the beings of the same class have sometimes been represented by a great tree. I believe this simile largely speaks the truth.*" So just as there is a giant pedigree which connects all humans, Darwin postulated a pedigree which connected all species.

Here is a version of the tree of life illustrated in the late 19<sup>th</sup> century, which may be the sort of tree that you've seen before. Notice we have amoebas down at the bottom of the trunk of the tree, with insects coming off the right branch half way up the tree, and mollusks coming off the left branch. Darwin provides a vast array of insights into the biological world, and is deservedly given the status as the most influential biologist of all times. Among his many contributions, Darwin pointed scientists towards using trees as the central organizing system in biology. We now believe that all species fit together into a single big tree, but exactly how the pieces fit together is still puzzling. This is because Nature is diverse, and the tools needed for reconstructing the Tree of Life required later technical advances. Charles Darwin gave us the tree of life, but some assembly is required.

Think of it this way. Imagine you are walking across the desert and you come upon a tree buried in the sand, so that only some branches and tips are exposed. Now it is your task to determine what that entire tree looks like, from only observing the tips and the branches sticking out of the sand. This is a difficult, but not impossible task. The sand represents time. The exposed leaves and branches are the species that are still around today, those which we can observe, and branches buried beneath the sand represent extinct species. It requires special tools to remove the sands of time, but we have these tools available to us. Digging reveals a great tree, with all twigs and branches interconnected from a common trunk. And in the digging process, one often reveals buried treasure. Let me explain, in the most general terms, how we do the digging and reconstruct evolutionary trees.

### *Tree Building Example*

We are going to play the game of "which of these things is not like the other" with some animal species. We will start off with three species, and ask which two appear to be the most similar. In this example, I have selected a cougar, a chipmunk, and a chicken. It does not take an astute observer of nature to recognize that the chipmunk and cougar are more similar to each other, than either is to the chicken. The chipmunk and cougar share a number of features lacking in chickens, such as the presence of hair, mammary glands, and other features. So we can diagram this relationship by putting a circle around the chipmunk and the cougar, and indicate that it is the shared presence of hair, which supports this relationship. I can diagram the same relationship by drawing a tree, with the chipmunk and the cougar joined together by two branches that meet, with the chicken

placed outside on a separate branch. This diagram tells us the same information as the circles above. Ok, for fun, let's add a lizard and ask where it would sit in relation to the other three species. Those of you who are astute herpetologists and ornithologists would recognize that lizards and chickens both have scales: chickens have them on their legs and lizards have them all over. Thus we can draw a circle around the chicken and lizard, and indicate that they form a group based on the presence of scales. Furthermore, we can say that all four species, as a group, share the characteristic on the amnion being present. The amnion is a membrane that protects the egg from drying out, which helped vertebrates move from water to land. Just as above, we can represent this relationship in tree like form by joining the chicken and lizards with scales supporting their union, and the presence of an amnion supporting the grouping of all four species. So we are beginning to build a respectable tree. Let's do it one more time by adding this cute green frog. The frog has neither hair nor scales nor an amnion, so it is placed by itself, outside of the group uniting the other four species. In the tree diagram below, this corresponds to placing it at the base of the tree. Now all of these species are tetrapods: that is, they all have four limbs, so we can indicate this feature on the tree. So now we have a tree, with the frog at the base, the chicken and the lizard in one group and the chipmunk and cougar in another group.

Now the example I am giving you is pretty straightforward, and we all know the differences between mammals, chickens, lizards, and frogs, so making a tree is not difficult. There are many cases, however, where anatomical features provide little help, and this is where DNA evidence comes in. If we were to characterize the DNA of these species, we can use shared similarities in the DNA sequence to build a tree in the same way that we use anatomical features. DNA provides another set of evidence to support a particular tree.

So now that we have this tree, what can we do with it? Well, we can use it to build a classification, and say that our tree suggests that the chipmunk and the cougar should be combined into a single group, which we might call mammals. But we can also use this tree to answer perplexing questions. I am about to answer a riddle, with which all of you are familiar. No doubt, this has perplexed you at one time or another. In fact, it is such a classic conundrum, that it has become a metaphor for any sort of question, which evades solution. So let me ask you this question: which came first, the chicken or the egg? The chicken came here. This is the branch leading to chickens. The egg came here. The egg was first. The egg is present in the chicken and the lizard, and a modified form of the egg is present in all mammals. So, from an evolutionary standpoint, there were eggs present long before there were chickens. The amniotic egg, the type of egg a chicken has, was present in the common ancestor to mammals, birds, and lizards, but not present in frogs, and developed long before the chicken did.

This is an example of how a Tree of Life can answer difficult questions. The tree establishes patterns, and once the patterns are in place, we can ask questions and resolve issues that could never be addressed otherwise. It is no different than looking at a smear of pudding on a tray and using that pattern to select among alternative processes.

### *Tree of Life*

The centrality and importance of assembling the tree of life is now finally broadly recognized within science. For basic biological research, we can ask “chicken and egg” types of questions. For scientists trying to save threatened species, a Tree of Life helps us decide which species are the most critical to save to maintain biological diversity. For an epidemiologist trying to predict the outbreak and spread of HIV, a Tree of Life helps decipher what viral forms are resistant to drug therapies. For a snakebite victim, the Tree of Life helps a doctor decide which anti-venom to use.

Five years ago, the National Science Foundation announced a program with the stated goal of assembling a Tree of Life for all known species. This is an ambitious goal; from a biologist’s standpoint, it is equivalent to sending a man to the moon. This goal was unthinkable even a decade ago. But now work is underway across the country to assemble the Tree of Life, and BYU is playing a leading role in this endeavor.

At BYU we are assembling a Tree of Life for reptiles, nematode worms, insects, and we hope to soon begin on crustaceans and beetles. Since I work on the insects, let me tell you a little bit about how this is done. There are roughly 32 different major groups of insects that entomologists place in groups called orders. Beetles make up one order; flies, praying mantises, butterflies, and other insects each make up other orders. Despite being the most abundant group on the planet, we know very little about who is related to whom. Everyone can tell the difference between a butterfly, a bee, and a beetle, but entomologists are still not sure which two are more closely related.

### *Whiting Lab Research*

The first thing we have to do is obtain specimens from around the world for our DNA analysis. This map represents some of the places that my lab group has been in the past four years, and we spend a tremendous time in the field catching bugs. We do DNA research, so we need nice, fresh specimens. Here are some pictures from our work in Papua New Guinea. On the top left, you can see the sort of pristine rain forest that we work in. On the top right, you see one of the most populous highland villages that we visited. On the bottom left, you can see the small Cessna airplane we used to get in and out of these remote villages. These are rusty old machines, which sound like one of those old Volkswagen beetle cars, which cough and wheeze when they warm up. It is a heroic experience to be in one of these, as they rattle down the grass airstrips and just manage to clear the forest canopy. Sitting next to me is my wife, Alison, who happens to be a herpetologist, someone who studies reptiles. (Whenever we have disagreements, she reminds me that her creatures can eat my creatures). There are few things that test a marriage like 10 weeks in the rain forest together. In the bottom right is a colleague Michael Hastriter, who came with us to catch fleas. The dilapidated shack in the background is the terminal.

And here are the fruits of our labors. I am delighted with an afternoon’s collection of walking sticks, while Alison just beams with the lizards she collected in a recent survey. You have to love someone who gets such joy from dead lizards. As I mentioned earlier, these sorts of trips can be harrowing. Here you can see a local woman we met during one

of our long tracks, who, when I showed an interest in her spread of weevil larvae, insisted that I partake. They do not taste like chicken. And here I am, gazing upwards to heaven, seeking strength before performing the daily ritual of leech removal. These leeches are terrestrial, occur on the trail, and are marvelously suited to latch on, despite our best efforts.

I am not the only one who gets the fun of leeches in the field, and many of the students in my lab travel to exotic places, all in pursuit of very specialized and unusual insects. Pictured are undergraduates, graduate students, and postdoctoral researchers who work in my lab, each of whom work on a specific branch of the insect Tree of Life. In the top picture is Katharina who is surveying a bat cave in Mexico. Katharina works on a specialized kind of fly that only lives on the belly of bats, so she spends her time spelunking across the world. The bottom pictures shows two graduate students, who are in Tasmania, vigorously pursuing a weird bug that feeds on moss in the snow. This is my graduate student Gavin dressed as a telephone repair man. He specializes in rainforest canopy collecting, and here he is, setting up special traps to catch insects in the canopy in India. We are finding many new species that are unknown to science. We set up high power lights in the forest, and the insects often come pouring in, as in these pictures from a trip to Peru. I know for some of you, this constitutes a nightmare, but for us this is a dream come true. We sometimes also attract curious people.

Once we bring the insects back to the lab, we sort, identify, and catalog what we collected. The specimens are kept frozen at in a very cold freezer to preserve DNA quality. In fact, BYU has the largest frozen bug collection in the world. (We should put that on a tee shirt and sell it at the bookstore). One of the reasons why BYU has become a center for the many tree of life projects is because of the excellent DNA sequencing resources available here. Here you see Johnnie and Sarah, each happily processing DNA. Once the DNA sequences are generated, it takes a row of undergraduates to begin processing the data...and a row of graduate students to oversee the undergraduates. My lab uses postdoctoral researchers, graduate students, and undergraduates, all working together as a team, to conduct research on the Insect Tree of Life. One result of this team effort is that these students get to present their research at national and international scientific meetings. The undergraduate students pictured here, took home the top research awards from national scientific meetings. This has helped secure outstanding graduate opportunities for these students, and has given BYU the reputation of being an excellent place to recruit students for the sciences.

As I mentioned earlier, one of the reasons why Darwin was unable to assemble the tree of life was because he lacked the technology necessary for such an enormous undertaking. We now live in a world of computers, which help assemble and analyze the information needed to make a Tree of Life. But there is still one problem. It turns out that individual computers do not have sufficient computational power to analyze our deluge of data. One clever solution to this problem is being developed right here at BYU by Professors Quinn Snell and Mark Clement from the Computer Science Department. They have developed software applications, which allow cluster computers, supercomputers, and idle desktop computers to communicate with each other, and work together on solving

our analysis problems. Thus a second major reason why BYU has become a center for assembling the tree of life is because of the excellent computational resources available to us.

### *Fungus beetles*

What I would like to do now is just give you a quick overview of just three projects to come out of my lab, in an attempt to try and tie all of this together. The first project comes from the research of an undergraduate, James, who left my lab last year and is pursuing a doctoral degree at the University of Georgia. James was interested in a group of insects known as “pleasing fungus beetles”. The reason why they are called “fungus beetles” is because they feed on fungi throughout the tropics. The reason why they are “pleasing” is because they are just so beautiful. Wouldn’t you be pleased to find one of these? No, we did not paint these beetles; this is how they look in nature. In fact, the Latin name given them is “erotylidae”, which translates to “little darlings”. (So now you know how to call your sweetheart a little darling in Latin; just whisper in her ear “erotylidae”). Fungus beetles sequester toxins present in the fungi, and place them in their own bodies, as a defense against would be predators; biting into them is like biting into a toxic mushroom. We think the fancy colors help advertise their distaste to predators.

James wanted to understand the evolution of color patterns in these beetles. He spent time in the field in Peru and other places, he collected lots of fungus beetles, sequenced their DNA, and made a tree. James discovered that body patterning does not follow strict genealogical lines, and this finding had implications for how these beetles develop and used their warning coloration in Nature. This research helped James get into graduate school, and secured funding to pay for his entire education, not to mention turning the fungus beetle research community on its ear.

### *Glorious mantids*

Let’s leave the world of beetles, and talk about praying mantids. Praying mantids are spectacular creatures, filled with style, charm, and charisma. Here are just a few examples of the glorious mantids. All mantids are predators, and there are about 3,000 species of them throughout the world. Mantids live in the tropics in the tops of the rainforest canopy, in the deserts where they run around on the ground after their prey, and in every conceivable bush or tree.

My graduate student Gavin recognized that the predatory strategy of mantids falls into three basic categories. The first are the generalists: these are the mantids that are not too picky about how they get their meals, and will catch them anyway they can. The second are the cursorial mantids, which means they run on the ground and chase after a meal. The third are the sort of mantids that you are probably most familiar with: the ambush mantids. These are the ones that stalk their prey, hold very still, and then strike with lightening speed. The vast majority of mantid species use this ambush strategy.

Gavin is trying to learn something about the evolution of this hunting behavior. After he sequenced their DNA, and made an evolutionary tree, a pattern emerged. It appears that

ambush mantids all came from a single ancestor who was an ambush mantid, and that the development of an ambush lifestyle led to the radiation and diversification of mantids. In other words, when mantids first became ambush hunters, they hit upon a strategy that assured their success, which gave rise to many more mantid species than their less advanced cousins.

### *Walkingsticks*

This final example comes from my own research on walkingsticks. Walkingsticks, as their name implies, are insects shaped like leaves or sticks, and they use camouflage to fool predators into thinking that they are just bits of trees. When they move, they sway their bodies back and forth so that they look just like twigs moving in a breeze.

Walkingsticks come in two major forms: The first are those with wings as pictured in this slide. On top is a large species, about the length of my forearm, and on the bottom is a leaf mimic. The leaf mimic species even has false veins and mold spots on its body to complete the illusion. And then there are walkingsticks without wings. These are lovely creatures often found at the base of trees, and some are quite spectacular in size. Here you can see me holding a few species. I believe in hands-on science. Now we know that walkingsticks are relatively advanced insects, and that they came from an ancestral insects that had wings. Here are some examples of some of the close relatives of stick insects, including roaches, mantids, and others. Since nothing was known about the walkingstick tree of life, I began a project, with the help of another undergraduate student, to assemble one.

When we assembled the tree we found a very unexpected surprise. It turns out that the walkingstick phylogeny indicated a very unusual pattern: primitive walkingstick insects were actually wingless, and wings were only acquired later on during stick insect evolution. This was quite a shock, because we know that the distant ancestor of stick insects had wings, and our results suggested that these wings were lost and subsequently regained, later during stick insect evolution. To give you some perspective, to an entomologist this is as shocking as if you were to observe a whale regrow its legs, get up out of the water, and start walking around.

In standard evolutionary theory, you either use it, or lose it. It has been thought that if a particular structure no longer serves a function, then the underlying genes coding for that structure will also cease to function, and you cannot get the structure back again. It is rather like tearing down your home, ripping up the blueprints, and then asking someone to rebuild you an identical home from scratch. But our results suggest an additional evolutionary process, which helps maintain biological complexity over long periods of time. The details of this study are not important here, and I won't elaborate on why our conclusion makes a lot of sense to evolutionary biologists. I simply wish to emphasize the point that the patterns seen in the stick insect tree of life provided us with new insights into evolutionary processes.

### *Life of an Entomologist*

You know, being an entomologist always leads to interesting conversations. Whenever I visit a new ward in my travels, the typical conversation goes something like this.

I am asked: "what do you do for work?"

I respond: "I study insects"

Usually they raise an eyebrow and ask, "what is it about insects that you study?"

I respond, "I study their genealogy or evolutionary relationships"

"Well, who pays you to do that?" and I respond, "BYU".

Their eyes open wide as saucers, their jaws drop, and I can tell what they're thinking.

Their first thought is, "does the church have some new family history program that I haven't heard of". But invariably their second thought is, "how can you do that at BYU? Doesn't evolution teach things diametrically opposed to the teachings of the church?"

No doubt, some of you are thinking the same sort of thing.

What is evolution? Well, to me it is simply the scientific study of the underlying mechanics of the creative process. It studies the patterns of creation and seeks to define the processes which gave rise to these patterns. It does not preclude the existence of God, nor does it challenge his role in the creation.

Recall the analogy of my daughter that I began with. I know who was responsible for smearing the food; I was only interested in how she did it. But by studying this pattern she created, I learned a whole lot about her. She is messy. Or maybe she is creative. Or maybe she just really likes pudding.

This is very much the way I view my own research. I know who is responsible for the creation, but my research just focuses on learning something about how it was done. I view my work in very much the same way as a Natural Theologian, where I seek to learn something about the Creator by studying the creation. Only I move it back one step by asking, "What does the creative process teach me about the nature of the Creator?"

In the 1920's, there were about 400,000 species of beetles described, and this number was vastly larger than any other group of organisms. The naturalist, J. B. S. Haldane, was asked by a cleric about what he might infer about the Creator, based on his wide-ranging study of life. Haldane replied, tongue in cheek, that the creator had "an inordinate fondness for beetles".

#### *What Have I Learned?*

So what have I learned about the nature of the Creator from my own studies? I will attempt to summarize it with this slide. This is a close up of *Ctenocephalides felis*, the cat flea. Look at how remarkable this organism is. It has combs on its head and legs to help it remain attached to the hair of the cat. It has mouthparts modified into an efficient pump, all the better to feed on its host with. It has the most amazing modifications of its hind legs, which permits it to jump to dizzying heights, so it can move from one cat to the next. No one is more amazed with the complexity and beauty of a flea than I. To paraphrase the poet: "I think that I shall never see a poem as lovely as a flea".

We often glory in the end products of the creative process: all the species which surround us and stun us with their vibrant colors, amazing behavior, and peculiar features. And we

are right to do so: there is something that brings us closer to the divine by contemplating the grand diversity of life. We also glory in a benevolent Creator, and ascribe glory to Him for all of this work. This is also right.

However, I do not think we fully appreciate just how good a job He did in creating the earth. All of my studies lead me to believe that not only did the Lord create the earth, but that he did so in a supremely intelligent fashion. Consider for a moment DNA. You have four basic blocks, which comprise the DNA molecule. From a biological standpoint, the only difference between every species that inhabits the planet is how these four blocks are arranged in long strings, like numbers in a telephone book. Alma was right: “by small and simple things, are great things come to pass”.

Let me put it another way. I can admire a beautiful pot made from clay, and I can admire the potter who makes it. I can even study and understand the techniques the potter uses to take a shapeless lump of clay and turn it into a beautiful pot. But I cannot make a pot, and I marvel at the skill displayed when I watch a really excellent potter throw a really excellent pot. It is not as easy as it looks, and not just anyone can do it. So I admire the potter, the pot, and the skill required—the process—to make a pot. I can likewise marvel at the skill of a Creator who has made a very excellent creation in a very excellent way.

I believe the Lord set certain laws in place which resulted in a world filled with diversity, beauty, and form; each species interacting with every other, tied together in a glorious whole. Now I do not understand what all these laws are — this is why I study the things I do — but from what little I know, I am left to rejoice in the Intelligence behind the creation.

I think that Charles Darwin felt a very similar sentiment from all of his studies. This is the very last sentence from his *Origin of Species*:

*There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved*

Recall that Joseph Smith and Darwin were contemporaries. While Darwin was in the midst of his travels on the HMS Beagle, Joseph Smith received the following revelation:

*Yea, verily I say unto you, in that day when the Lord shall come, he shall reveal all things Things which have passed, and hidden things which no man knew, things of the earth, by which it was made, and the purpose and the end thereof Things most precious, things that are above, and things that are beneath, things that are in the earth, and upon the earth, and in heaven.*

The Lord indicates that the day will come when we will learn all of these precious things, and he specifically mentions the earth and how it was made. However, I do not think that this verse means that we can learn nothing about creation until the Lord comes, and that we shouldn't even try. To claim that we can learn nothing about the creative process in

this life, is the same to me as the claim that we can learn nothing about the nature of God until he comes.

So what do we do? What do we do when some ideas in evolutionary theory seem to directly contradict the doctrines of the church? What do we do when people around us seem to be so unsettled and so disturbed by ideas that they find hard to reconcile?

Let me suggest that perhaps we should be humble.

Let's not get bent out of shape. Let's not insist that we must have all of the answers and have them now. Let's not demand that the Lord reveal it now or that the scientists stop studying it now. Let's stop thinking that we know more than we do.

The Lord has not yet revealed the mechanics of creation; the scripture we just read confirms this. And scientists are still probing around in the dark, the best we can, to try and understand even the basics of the creative process. In the meantime, let's be humble and grateful to live in a world, which inspires such deep contemplation.

The world is beautiful and filled with the diversity of forms. My work leads me to believe that the creation was nothing short of miraculous, the Creator was intelligent, and that he built the world in an intelligent fashion. BYU is playing a leading role in deciphering the Tree of Life and rightly so. Can you think of a better place to try and decipher the handiwork of God than at BYU? I give you my testimony that God is an intelligent Creator, and as we try to learn more about the Creation, we will indeed learn more about him. I am grateful for a creation, which evokes such awe in all of us, and to be at institution that allows me to study it in such detail.