Neil Shubin

502nd Convocation Address: "Learning to See,"

March 19, 2010

"Learning to See"
by Neil Shubin

The initiation to my life's work was inauspicious. I grew up wanting to find fossils, much like the dinosaurs you see at the museum, so entered graduate school to study paleontology. During my first year in the program, I received a huge opportunity—I was one of the invitees to a field expedition headed to the deserts of northern Arizona, a land of mesas, buttes, and barren red rock. Exploring those rocks was our goal—we were sent there to find 200 million-year-old fossils. Typically, fossils just erode out of the rock, so you spend days walking and scanning the surface for the fossil bones and teeth that emerge.

Not knowing a thing about finding fossils myself, I shadowed one of the seasoned veterans on the team, a man named Chuck who had spent the better part of forty years on expeditions of one kind or another. Chuck was generous with his time and for days we walked the vast plains together looking at the rocks on the surface. For several weeks, Chuck talked and picked up fossils at our feet while I found absolutely nothing. I returned home each day empty-handed. Where Chuck saw bones, all I saw were dirt and rock.

With the growing frustration of each passing day, I remember asking Chuck how he finds bones, what they look like, and what kinds of cues he uses to recognize them. He described his methods, but for the life of me I could not understand him. And, to add insult to injury, he was picking up bones, sometimes with my own boot print on top of them.

Then, one day I saw it—a brilliant piece of bone that sparkled in the light. It was a tooth and the way it glittered was different from every other rock I had seen to that point. As I looked around, I saw more teeth and more bone. Suddenly, it was as if the entire desert floor opened up in front of me and I was wearing a new pair of glasses; bones were everywhere. My fossil turned out to be a jaw of an ancient mammal-like animal. This was the first time I had seen bones on the surface, but actually, I'rd been looking at them for weeks. What was mere rock to my eyes just days before, was now fossil bone.

What changed?

The thing that changed was my ability to see.

I had learned to find fossils by seeing objects around me in a whole new way. Now, 25 years later, I find myself going through the exact same mental process I experienced with Chuck each time I go somewhere new. Rocks and bones look different in each place, and I need to learn to see again in a whole new way. I need to unlearn my past search images and find new ones. My experience working in different places has given me confidence, and the patience that comes with it, that somehow I'll eventually learn to see.

Physicists can tell you a lot about light, lenses, and color. Biologists can speak of how light travels through the different structures of our eyes, and how nerve impulses carry the signal to different parts our brains. But seeing is more than optics and vision. What led me to the Arizona deserts and other remote places in the years since is a much more profound way of seeing.

We use the phrase "I see" when we understand something, when an observation's meaning becomes clear, or when we come to agreement about an interpretation of our world. This type of seeing derives from the ideas that shape the ways we learn about and interpret our world. At any given time, our own seeing is derived from thousands of years of people challenging existing thought to look at the world in a whole new way. What is utterly obvious today would have been bizarre to previous generations. And, of course, some of our own cherished truths will be seen as bizarre notions to those in the future.

My own field is a case study in how ways of seeing have emerged over time. People have looked at rocks for hundreds of thousands of years. Our ancestors made tools out of rocks, used them for shelters—even dug through them to mine ores and minerals. And, during all of this digging through rock, people saw things that looked like teeth, shells, and bones. But what was their meaning? For most of recorded history, these objects spilling out of the rocks were thought to be no different than the rocks themselves. They were just rocks that happened to look like teeth and bones. The whole concept of a fossil, so utterly familiar today, did not exist.

Then, Leonardo da Vinci, Nichola Steno, and a few others challenged that view. They saw that the teeth and bones are found in layer after layer of rock and that many of them are versions of creatures walking the earth today. They proposed the radical notion that those teeth-like objects and bony looking things in the rocks aren't just malformed rock. They are the remains of long dead animals. In their view of the world, these things aren't just bizarre mimics, they are the bits and pieces of once living creatures buried inside the rocks. People looked at fossils for years, but da Vinci and Steno learned to see them.

Armed with da Vinci's and Steno's views people found fossils from all over the world. Fossil after fossil was described. But it would take others to see these fossil remains for an even deeper meaning—as evidence of lost worlds.

Like the chain of events that was set off when a Professor of Theology descended a cave in southern Germany in 1748. Accompanied only by a local gamekeeper as a guide, he entered another world, recorded by a poem he originally wrote in Latin that went something like: "The gruesome, terror-inspiring cavern, the lightless grotto... as I look down, I see horrendous human bones.... I can see bodies turned to stone and skeletons left lying on the floor."

The real meaning of these cave monsters was to emerge at the hands of the German anatomist, Johann Christian Rosenmuller. Rosenmuller had a motto that was to prove vital in his interpretation of the cave bones. "We should always, when forming opinions about the events in Nature, assume the most natural and common process... if we believe our senses, we shall have no grounds for self accusation." What did this sensibility lead Rosenmuller to conclude about the bones? With large teeth, jaws and skulls, they were from a bear, not a human. But they were different any bear known to science at that day. To Rosenmuller, the conclusion was obvious: the bones were from a kind of bear that went extinct. Why was this so revolutionary? The whole concept of extinction, something that spawns innumerable conferences, laws, and public policies today, was virtually unknown at this time.

These new ways of seeing were only a prelude to a much more powerful idea. The reality of fossils and the fact of extinction were grist for Charles Darwin. To Darwin, these different insights were really part of a fundamental way of seeing the world. He proposed that species are not fixed, they evolve, and go extinct. And he revealed that the creatures on the planet today share a history. Just as our families have a history, described by a family tree, so do species. Our family tree extends to all other creatures.

So great were his insights that we call the fruits of them the Darwinian Revolution. Why? There was a way of looking at the world before his ideas, and a whole new way of seeing it after. Before him, species were considered to be immutable and mankind was a special creation; after Darwin, all species are considered ephemeral and mankind is but one of many forms of life in a great family tree of all life living on the planet.

Thus one great idea gave us a new way of seeing the connections among observations, ideas, and whole fields of inquiry that were formerly separate. With a single insight, creatures as seemingly different as birds,

mice, and people were revealed to have a shared past contained in the structures of their bodies and the fossils in the rocks in the world.

My own way of seeing this can best be told through a uniquely University of Chicago experience. I am in what used to be the Anatomy Department and one of our main teaching duties is in the Pritzker School of Medicine, teaching the Human Anatomy course. This is the classic course of the first year, where our students learn the structure of the body, including the names of every muscle, nerve, bump, hole, and bone. It can also be very stressful because of the sheer amount of material we cover and for the fact that we learn this mostly from dissection of human bodies. Consequently, it is a very intense and emotional experience; students form images and friendships that often last a lifetime

I remember those first days in the course. Students wanted to learn about me, about what I do, and what kind of physician I am. I'd tell them that actually I'm a paleontologist who works on fish. Though too polite to ask for a refund of their tuition money, the students would give me looks I'll never forget. At first glance you could not have imagined a worse candidate to teach future doctors.

But within weeks it became clear that being a paleontologist, and not just any paleontologist, a fish paleontologist, is a powerful way to teach human anatomy. Why? The best and often simplest roadmaps to our own bodies are seen in other animals. The nerves inside our heads are a complicated jumble that only makes sense when you compare them to the simpler state of affairs in sharks. The basic structure of our bodies, including the DNA that builds them, is seen in fish, worms, and flies. The Darwinian view is a powerful way of seeing ourselves: the best keys to understanding ourselves lie in the fossils, genes, and embryos of other creatures.

In fact these connections will help to define our future. Just look at the Nobel Prize in Medicine or Physiology to ask what types of medical research have been honored in the past seventeen years. It has gone to people working on yeast, mice, flies, sea slugs, and sea urchins. In fact two Nobels have gone to five people in the past seven years who work on a little worm the size of a comma on a piece of paper. Yet that tiny and simple worm is providing insights into how our cells die, and how our DNA can be turned off in diseases like cancer.

I like to think that as we discover cures to everything that ails us—from Alzheimer's to various cancers — the breakthroughs that make our lives better will originally be derived from work on worms, flies, and fish. I

cannot imagine a more powerful statement on the importance of our connection to the rest of life on our planet than that.

And how did this come about? By people looking at their world, challenging existing views, and learning to think and observe in new ways: from understanding fossils for what they are, seeing the deep history of life and the planet, and from breakthroughs in genetics, molecular biology, and geology too numerous to mention. With each new great idea, we come to see and to appreciate all the surprising and wonderful things that are right under our noses.

The power of great ideas reminds me of that day walking with Chuck 25 years ago. One moment I was looking at just rock, and the next, I saw the floor of the desert open up to reveal bone after bone. And the same is true with great ideas: they become lenses to make us see our familiar world in a whole new way.

I hope that your time with us at the University of Chicago has enhanced your appreciation of the beauty and the power of great ideas and, in the process, cultivated your ability to see what is important to you, to understand the meaning of what you see, and before you get too comfortable, to challenge your own ways of seeing.

Congratulations all.

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