Confidence in Historical Knowledge

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Adapted from web essay:
http://www.jefflewis.net/confidence_in_historical_knowledge.html

Ever since I first realized that there were people that doubted evolution and the 4.5 billion year age of the earth, I've followed the debate. One of the arguments that seems to be somewhat common among the people who'd like to reject the science, is that there's no way to be sure about those things because they happened in the past and we can't go back and directly witness them. But this line of thinking just isn't true. Based on enough evidence, we can be as sure about things that have happened in the past as we can be about anything.

Ground Rules

I'll start off by saying that science does operate on a few assumptions. The first is the most basic - that evidence can be taken at more or less face value. I say this in defense of a philosophical argument, which is impossible to disprove scientfically - that the universe could have come into existence at any point, with the appearance of old age. This could be a religious creation story, such as literal interpretation of Genesis, but it could also be the idea that the universe started exactly one second ago, or yesterday (as in Theodore Sturgeon's "Yesterday Was Monday"), with everything looking like the universe is ancient, and all of us having false memories (this is also referred to as the Omphalos hypothesis in theology, or, somewhat derisively, as Last Thurdayism[1]). There's no way to disprove that, so you more or less accept the evidence as it appears (Occam's razor and all that). When you see evidence of erosion, you assume it was caused by erosion. When you read a book, you assume it was actually written by a person. When you find a skeleton, you assume it came from an animal that used to be alive. When you look up into the night sky and see a star, you assume the photons originated at that star the same way they do from our sun, and have been travelling away from that star at the speed of light ever since. (Of course you have to be on the lookout for hoaxes and mechanisms you might not have known about before, but that's why I said "more or less" at face value - you assume there's an actual mechanism responsible for the evidence, and that it didn't just appear out of nowhere.) It's kind of analogous to arguing against solipsism (the idea that we can only be sure about what's going on in our own minds, so how can we be sure about anything external - maybe it's all just a dream) - there's no good way to do it, and it isn't very productive, so you just move past it to the more interesting problems.

Another assumption is that the general laws governing the universe work in the same way throughout the universe, and have worked generally the same way throughout history. The "constants" may not be constant, but the equations are of the same form. As an example, the force of gravity can be determined from the equation:

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[1] http://en.wikipedia.org/wiki/Last_Thursdayism

$$F = \frac{Gm_1m_2}{r^2}$$

It is possible that G, the universal gravitational constant, may vary throughout the universe, or that it has varied in the past, but the force of gravity can always be calculated based on the mass of the objects, and is inversely proportional to the square of their distances. Another example is the issue of radioactive decay rates, which is perhaps more pertinent to people rejecting an ancient universe, since these are commonly used as a dating method for objects such as fossils. I recently came across an article on the website, TalkOrigins, discussing this[2]. The reader is encouraged to read that essay for more detailed discussion, but the gist is that radioactive decay rates are governed by several well established theories and associated constants, and physicists *have* looked for evidence of the fundamental constants changing, but they haven't found evidence of any major changes.

"Origins" as an Artificial Distinction

In various ways, I have seen it argued that "origins," such as the origin of humanity, species, the solar system, or the entire universe, are something that we as humans will never be able to know with certainty. The arguments I've seen are as simple as asking, "Were you there[3]," to claiming that science can't study the past because we can no longer experiment on it[4]. However, I think that lumping "origins" into a separate category from any other past event is an artificial distinction. Just because things happened before people were around doesn't mean that we can't still know things about them. To say that we can be sure about things such as the U.S. Civil War, but not about the evolution of life, ignores the way that we gather evidence to determine things. Consider this - my own personal origin was my birth. Is that to say that I can't know anything about what came before me, because I wasn't there to witness it? Should I doubt the existence of the U.S. Civil War? Of course not. Things happen. When things happen, they leave evidence. You study that evidence to try to determine what it is, exactly, that has happened. That's not just science, but everyday life. Sometimes, we are eye witnesses to an event, but even that is not absolute proof - consider magicians and optical illusions, to show just how easily our perception can be fooled. If we aren't an eye witness to an event, or even to verify that we weren't deceived, we have to rely on other forms of evidence. Sometimes, other people were there to witness the event, so we have their recollection of what happened. But while historical accounts are certainly a valuable form of evidence, they're not always entirely accurate, and they're certainly not the only evidence there is.

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[2] http://www.talkorigins.org/origins/postmonth/aug06.html

[3] http://blogs.answersingenesis.org/aroundtheworld/2006/10/03/studio-60-on-the-sunset-strip-uses-ken-hams-were-you-there/ - "One of the ways I teach children to understand the philosophy of science is to teach them, based on Job 38:4 (when God asks Job, "where were you when I laid the foundation of the earth") to ask "Were you there??" when someone talks about millions of years, etc." – Ken Ham

[4] http://sciencetheoryreligion.angelcities.com/index.html - "The contention in this examination of the origins debate is that the debate should have never been placed within science because it cannot be established within its jurisdiction. This online article will continue to explore the indicators that the study of ORIGINS is outside scientific theory and inaccessible by scientific methodology." – unkown author

I'll use a specific example to illustrate this - ice core sampling. We can currently witness the processes forming ice in glaciers and polar ice sheets. We can drill core samples into that ice and study those samples. What we find is consistent with the processes occuring right now. We can even find evidence of events documented in historical accounts, such as volcanic eruptions, to verify the dating determined in those core samples. So, here we have a line of evidence about the past independent of historical accounts, but which does match up when compared to historical accounts. The thing is, though, that these ice core samples go back a long way, hundreds of thousands of years in some cases, back beyond the time for which historical records exist. So the question becomes, if these cores were validated with historical accounts back as far as the historical accounts go, and beyond that, the cores keep going, forming a consistent record, what reason is there to doubt them? And when you further consider that these samples can be compared to ice cores taken from other locations, or even to such things as ocean sediment cores, our confidence in them can be even higher.[5]

How Science Can Be Applied to Past Events

An extension of this concept that we can't be sure of the past because we weren't there, is, as was stated above, that studying the past is outside the realm of scientific investigation. The logic goes that there's no way to test scientific theories about the past, because it's a "done deal" that we can't perform experiments on. However, some ideas about the past can be tested through observation; they can be falsified. That is why some of them can be regarded as scientific theories, and not just ideas. Like any other historical event, they are a "done deal," but we certainly don't have all the evidence. So, with every archaeological dig, every astronomer looking into a telescope, every biologist studying DNA, we are compiling more evidence to test the current theories about the past. Look at it this way - the way electrons work is already a done deal. Electrons were just the same in Benjamin Franklin's time as they are in ours. However, by performing laboratory experiments, our knowledge of electrons increased. Nothing has changed about electrons since we began to experiment on them, but we do understood them better. History will not change, either, but as we gather more evidence, we can understand it better, too.

As an example, consider evolution. Evolutionary theory predicts a "tree" of life, where all animals alive today can be traced back through common ancestry. This is falsifiable. One way would be to find ancestors of an animal that didn't fit into this tree. Let's look at whales, since they're one of the more dramatic examples of animals evolving to live in an entirely different environment from their ancestors. Whales are warm blooded, give birth to live young, have mammary glands, and a whole host of other traits that place them squarely as mammals. So, whales must have the same ancestors as the other land-based mammals. Finding transitional fossils from whales to fish, for example, instead of whales to land based mammals, would falsify evolutionary theory. Another way to falsify evolutionary theory would be finding animals out of chronological order. To pick a more personal example, since we know humans, chimps, and bonobos share a common

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[5] http://www.sciencedaily.com/releases/2000/02/000229074731.htm

ancestor, finding fossils of humans (or chimps or bonobos) that predate that common ancestor would disprove the theory, as well.

Another reason why some people argue that history is outside scientific investigation, is that because it's already completed, you can't make any predictions about it. But scientists can, in fact, make predictions. A very good example of this just made the news recently - Tiktaalik Roseae, a transitional animal between fish and tetrapods. Before the discovery of this fossil, scientists already knew about some of the transitional animals between fish and tetrapods, such as Panderichthys, which was more fish-like, and Acanthostega and Ichthyostega, which were more tetrapod-like. Based on the ages of those known animals, paleontologists were able to predict when an intermediate form must have been alive - the early Late Devonian. Also, because it was an intermediate between fish and land animals, they had a pretty good idea of what habitat it most likely lived in (shallow waters - so probably swamps or rivers). So, when they set out on an expedition specifically in search of this creature (not knowing exactly what it was going to look like, but having a pretty good idea), they knew where to look for it, and they found it - in an early Late Devonian fossilized river bed. That is a pretty powerful prediction based on evolutionary theory. (In anticipation of the people that would confuse this as a case of bias, saying that scientists were influenced into calling Tiktaalik a transitional species because that's what they were expecting to find - that's not the case, any more than predicting that when you let go of a ball that it will drop is a bias towards Newtonian physics. It is simply a prediction based on the evidence they had, operating in the framework of evolutionary theory.)[6,7]

Scientists can also observe today some of the processes involved in evolution. Consider speciation - using the commonly accepted definition of species as groups of animals that can't interbreed. Speciation is necessary for evolution to have produced all the diversity we see around us, or ancestral populations wouldn't have been able to "branch out" like evolutionary theory predicts. And speciation has been observed in modern times. One example is a new species of mosquito that was observed in the London subway system.[8]

Mutation and natural selection are the two other big terms you hear about when talking of evolution, and both of those are also observed in modern times. A good recent example was actually studied on the Galapagos. When a population of a species of finch arrived on an island and began competing with the finches that were already there, natural selection acted on the existing population - those with smaller beaks that were directly competing with the newcomers fared better, and so there was a shift to smaller beak size throughout the population.[9]

For an even more dramatic example of what mutation and selection can accomplish, one needs only look to domesticated animals (or plants). Some would argue that this is "artificial" selection, not "natural" selection, but the fundamental processes really are the same. There's genetic variability being introduced through random mutations, and some

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[6] http://www.sciencedaily.com/releases/2000/02/000229074731.htm
[7] http://www.scienceblogs.com/pharyngula/2006/04/tiktaalik_makes_another_gap.php
[8] http://www.madsci.org/posts/archives/2000-04/956696920.Ev.r.html
[9] http://abcnews.go.com/Technology/wireStory?id=2188243

factor that causes the organisms with certain mutations to have more offspring than other organisms. Just look at what breeders have been able to do with dogs, the amount of differences there are between the different breeds. (And to all the people that say, well, they're still just dogs - I know. But this example does illustrate that mutation and selection can introduce rather large morphological changes.)

So, just like with the ice core example, the processes that would drive evolution can be observed today - speciation that can turn an original population into two separate breeding populations, and genetic mutation and selection which can create changes in those populations. Studying the evidence from the past seems consistent with those processes. So, what reason is there to doubt that evidence?

Are Scientists Biased by Preconceptions?

I'd like to briefly discuss the notion of preconceptions - the idea that scientists interpret the evidence differently based on their preconceptions (for example, that other ideas may fit the evidence as well as typical evolutionary theory, but that scientists are so biased by their preconception that evolution is true, that they interpret all the evidence to fit). While scientists are human, and subject to mistakes just like anybody else, I will use two examples to show how scientists have changed their view based on the evidence, even though most of them were operating under different preconceptions.

The first example is the theory of plate tectonics. For centuries, scientists, and most people for that matter, believed the earth was largely static. Yes, there were earthquakes, and Charles Lyell's very influential *Principles of Geology* of the 1830's recognized that land and ocean levels could rise and fall[10], but nobody thought that entire continents were moving. Continental drift came about as a theory, positing that continents moved through oceanic crust, which never really caught on. Finally, in the 1960's, plate tectonics was proposed, where the entire crust of the earth was made up of plates which were floating on the magma of the mantle. Within a couple decades, all those scientists who had the preconception of the earth being static, accepted plate tectonics. Actually, the Wikipedia entry says it much better than me, so I'll quote part of it below:

> The acceptance of the theories of continental drift and sea floor spreading (the two key elements of plate tectonics) may be compared to the Copernican revolution in astronomy (see Nicolaus Copernicus). Within a matter of only several years geophysics and geology in particular were revolutionized. The parallel is striking: just as pre-Copernican astronomy was highly descriptive but still unable to provide explanations for the motions of celestial objects, pre-tectonic plate geological theories described what was observed but struggled to provide any fundamental mechanisms. The problem lay in the question 'How?'. Before acceptance of plate tectonics, geology in particular was trapped in a 'pre-Copernican' box.

[10] http://en.wikipedia.org/wiki/Charles_Lyell

> However, by comparison to astronomy the geological revolution was much more sudden. What had been rejected for decades by any respectable scientific journal was eagerly accepted within a few short years in the 1960s and 1970s. Any geological description before this had been highly descriptive. All the rocks were described and assorted reasons, sometimes in excruciating detail, were given for why they were where they are. The descriptions are still valid. The reasons, however, today sound much like pre-Copernican astronomy.[11]

As the second example, I'll use the big bang theory. Prior to the 1920's, most astronomers and scientists (including Einstein), thought that the universe was static, that it had been around, well, forever, and would continue to exist forever. Then, in the 1920's, observations were made that very strongly indicated that the universe was expanding, and with a few more observations, the big bang theory was born. Once again, scientists put aside their preconceptions, and followed the evidence.[12]

Among humanities endeavors, science may be young. But it has been around for long enough, practiced by enough people, and born out enough practical results, that we can be pretty sure that it works, and we can trust the results we get from it. We can be as sure about things such as the universe being billions of years old, humans and other apes having a common ancestor, birds evolving from dinosaurs, and the overall view of the geological column, as we can be about things such as the civil war, or knowing that the Earth revolves around the Sun. Sure, there are still some uncertainties, making our view of the past a bit cloudy, but we're not completely blind, and we do our best to clear away that fog with every new discovery.

[11] http://en.wikipedia.org/wiki/Plate_tectonics
[12] http://en.wikipedia.org/wiki/Big_bang