What do we really know about Dino DNA?

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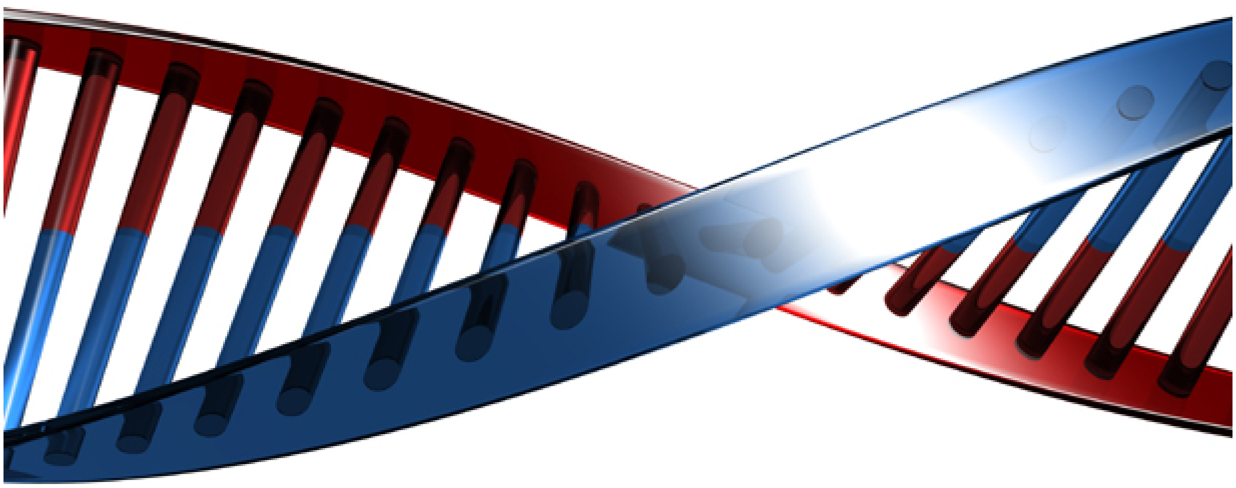

Ever since finding that soft tissue can preserve in dinosaur fossils, paleontologist Mary Schweitzer has been asked the "Jurassic Park" question – will we ever be able to find original dinosaur DNA? And if so, could we someday recreate these awesome animals?

The answers to these questions can get pretty complicated, so Dr. Schweitzer has offered to help us understand what we currently do know about dinosaur DNA, and what may be possible.

Can we get DNA from fossils?

The question should be, "Can we get dinosaur DNA?" Bone is made up of hydroxyapatite mineral. This mineral has such a strong affinity for DNA and many proteins that it is used in modern labs sometimes to purify these molecules. Because this dinosaur bone has been sitting in the ground for 65 million years, the likelihood is high that if DNA were actively sought, it could be found, just because certain biomolecules, including DNA, stick like Velcro to the mineral. However, the challenge isn't necessarily in finding DNA, it's in making a strong case that the DNA is dinosaurian in origin by ruling out other sources. Is it possible that we may someday recover authentic DNA from dinosaur bone? The scientific answer is "yes"…..all things are possible until disproven. Have we disproven this possibility? No. Have we recovered "authentic" dinosaur DNA? No. Therefore, it is an open question.

How long can DNA last in the fossil record, and how can we tell for certain that it is dinosaurian, and not a modern lab contaminant or DNA that has leached in from the environment?

Scientists have proposed that DNA has a pretty short shelf-life, most saying that it is unlikely to persist as long as a million years, and surely not more than five or six million years at the most. That sort of leaves out the possibility that we will ever obtain it from dinosaurs that last walked the earth over 65 million years ago! But how did they get this number?

Some have studied DNA degradation by placing molecules of known length and composition into hot acid, and monitoring how long it takes to fall apart. They use heat and acidity as proxies for time, and declare that DNA falls apart quite rapidly. One study set out to recover DNA from progressively older fossils—from a few hundred years old, to about 8,000 years. They found that the amount of recoverable DNA declined with age, and they used this to model a 'rate of decay.' They then predicted, but did not test, that DNA as small as 175 base pairs was extremely unlikely to persist in Cretaceous bone. Oddly, this same study showed that age alone could not account for DNA loss or preservation.

On the other hand, we have used 4 different lines of evidence to suggest that a molecule chemically similar to DNA localizes to bone-forming cells in our bone, and is consistent with what we might expect to find, if it were dinosaurian. So, how do we tell if DNA recovered from bone is truly dinosaurian, and not contaminant?

The idea that DNA can persist that long is a long shot at best, so anyone claiming to find/recover dinosaur DNA has to meet the most stringent of criteria. We suggest the following:

1. DNA sequences recovered from bone should match what we would expect from other data. For example, there are over 300 characters that link dinosaurs to birds, and strongly suggest that the origin of birds lies within theropod (meat-eating) dinosaurs. So, DNA sequences obtained from dinosaurs should also follow that pattern, being more similar to bird DNA than to crocodile DNA, but clearly a little bit different from either so they can be confidently differentiated from modern sources.
2. If DNA is original, it is likely to be highly fragmented, and difficult to analyze by our current methods, developed to sequence happy healthy DNA. If "T. rex DNA" comes in long pieces that are relatively easy to sequence, it is likely to be a contaminant.
3. DNA is proposed to be fragile, relative to other molecules. So, if authentic DNA is present, other, more durable molecules should also be present. DNA sequence from dinosaur bone should

always be accompanied by evidence, including sequences, for the persistence of other molecules that are known to be decay resistant while in bone—collagen protein, for example. If one can show DNA that is similar in sequence to avian and crocodilian DNA, and can also show collagen sequences that point to a similar evolutionary relationship, the case for "real" dinosaur DNA goes up. One should also be able to demonstrate the persistence of lipids that make up cell membranes, for example. Lipids are more resistant overall than either protein or DNA.

4. If DNA and proteins are shown to persist, other methods than sequence should also support this conclusion. For example, binding of proteins to specific antibodies can be used to show that protein signal is localized to the tissues, and not present in surrounding sediments. In our studies, we were able to localize a substance chemically similar to DNA inside the bone cells recovered from this T. rex, using both DNA specific stains, and antibodies to proteins associated with vertebrate DNA.
5. Finally, and probably most importantly, for all steps of any test, adequate controls should be employed. Samples that yield DNA should be co-extracted with the sediments that surrounded the fossil, and also, all buffers and chemicals used in the lab should also be treated to the exact same conditions as the fossil bone. If these also contain the sequences of interest, then it is most likely a contaminant.

So will we ever be able to clone a dinosaur?

In one sense, cloning as is usually done in the lab involves taking a known fragment of DNA, inserting it into a bacterial plasmid, and letting that fragment of DNA replicate over and over each time the cell divides. This results in many, many copies of identical DNA from the insert–clones. In the second case, cloning involves taking the whole complement of DNA from cells within a tissue, and inserting it into viable cells from which the native nuclear material has been removed. This cell is then inserted into a host, and the donor DNA dictates the formation and development of the offspring, which are genetically identical to the donor—i.e., clones. Dolly the sheep is an example of this. When people refer to "cloning a dinosaur," they usually mean something along these lines. However, this is an incredibly complex process, and despite the unscientific nature of it, the likelihood that we would ever be able to overcome all of the obstacles between fragments of DNA in a dinosaur bone and producing a living offspring is so incredibly small it would rank a "not possible" in my book.

But just because the likelihood of visiting a "real" Jurassic Park is miniscule it doesn't mean that it is impossible to recover original DNA or other molecules from ancient remains. In fact, these ancient molecules have much to tell us.

Because all evolutionary change must first occur in genes (and the proteins they encode), molecules can directly inform us of evolutionary processes. We can also learn about the durability of molecules under naturally occurring conditions more directly than using lab proxies, such as heat, to estimate rates of molecular degradation. Finally, recovering molecules from fossils, including dinosaurs, yields important information on the origin and distribution of evolutionary novelties, like feathers.

We still have a lot to learn in the molecular analysis of fossils, and we should proceed with the utmost caution, never overstating the data we obtain. But there is so much we can learn from molecules preserved in fossils that we believe it is worth the effort.

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