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The four rules of dinosaur feathers

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If you just read the media, you must be confused, were many dinosaurs feathered or not? New contradictory headlines are published all the time. Here I check the scientific literature to answer this question and present the four rules of dinosaur feather evolution.

Artistic interpretation of a large feathered dinosaur and its habitat: *Yutyrannus huali* (animal from PNG Free Images, habitat from Wikimedia 1 and 2.

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reptile and bird characteristics, and if you choose one type over the other, you will be half right, but also half wrong, and many paleontologists have done just that. Feathers are a good example.

Briefly, in the 19th century, Thomas Huxley noticed their bird-like like characters and imagined bird-like dinosaurs [1,2]. There were no feather fossils at the time, but it was not unreasonable to think that animals with bird-like skeletons also had bird-like skin. However, the reptile school won and, for many years, feathers were not part of dinosaur reconstructions, only the leathery or scaly skin of extant reptiles. This situation only changed over a century later, when fossils with feather impressions were described in the 1990's. It is hard to change our minds, and some researchers, faced with the evidence, noticed that all fossils with feathers represented small species, so they imagined that large dinosaurs, like the superstar *Tyrannosaurus rex*, did not have feathers, at least as adults. In a very creative way, the producers of the 2015 documentary *T. Rex Autopsy*, imagined *T. rex* adults with feathers that looked like bristles, so the reptile skin was still there, defining how the animal looked.

The argument that only small dinosaurs had feathers stood until 2012, when *Yutyrannus huali*, a feathered relative of *T. rex*, was described from fossils that showed it had 20-centimeter-long filamentous feathers

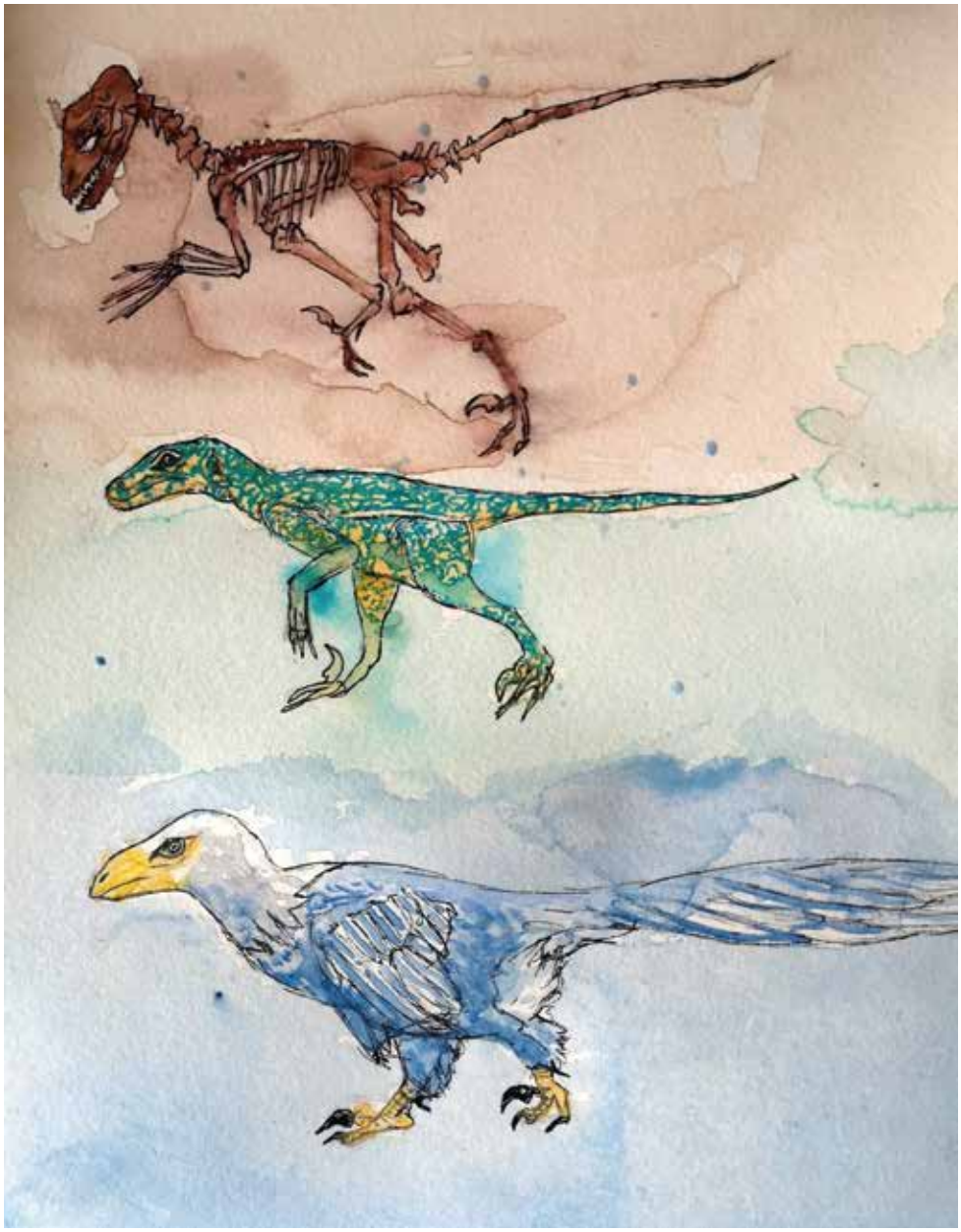
on several parts of the body; this dinosaur was large, it was over 7 meters long and weighed over a ton[3,4].

What is a feather?

Feathers can look, for example, like the typical feathers we think of when we hear the word "feather", but they can also look like hairs –think of kiwi birds--; and like cottony down (chicks). There is no reason to think that dinosaurs had only one feather type[5].

Newer fossils indicate that adult *T. rex* had a scaly skin, and this makes sense because it was a large animal living in a hot climate; the same applies to the rhinoceros and the elephant. But *Y. huali* lived in cold habitats, so it needed the feathery coat.

There are some unnecessarily extremist views about dinosaur feathers, for example, the *T. rex* in 2014's film *Dinosaur Island*, which looks like a giant macaw. But scientific evidence does not point to extremes, it points towards complexity. Please keep the following in mind whenever you read about feathers in dinosaurs: dinosaur feathers probably followed the same four rules they follow in their extant relatives: (1) they changed with age, possibly being like down in early stages; (2) in highly seasonal habitats, they changed for camouflage, for example white for snow, spotted brown for dry seasons; (3) they could adapt to the needs of body parts, like in the ostrich,



Deinonychus dinosaur reconstructions: skeleton; old reptilian interpretation and more recent bird-like interpretation. Watercolor by Julián Monge-Nájera, inspired by reconstructions by Marcelo Wilkiwalker, Scott Hartman and Emily Willoughby.

where they are thick in most of the body, but sparse in the neck, and absent in the legs; and (4) they helped the animals to attract mates, following the rules of sexual selection, with the sex that invested less in the offspring having the most spectacular plumage (for example, brilliant contrasting colors, oversized feathers and even erectile feathers). Additionally, always remember that most birds today have both feathers and scales (just look at the feet of the nearest chicken).

If you keep these evolutionary principles in mind, you will be able to make science-based interpretations of the new fossils that are unearthed every year: those fossils are like tiny sponges that, bit by bit, clean that dirty glass of our window to the past.

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