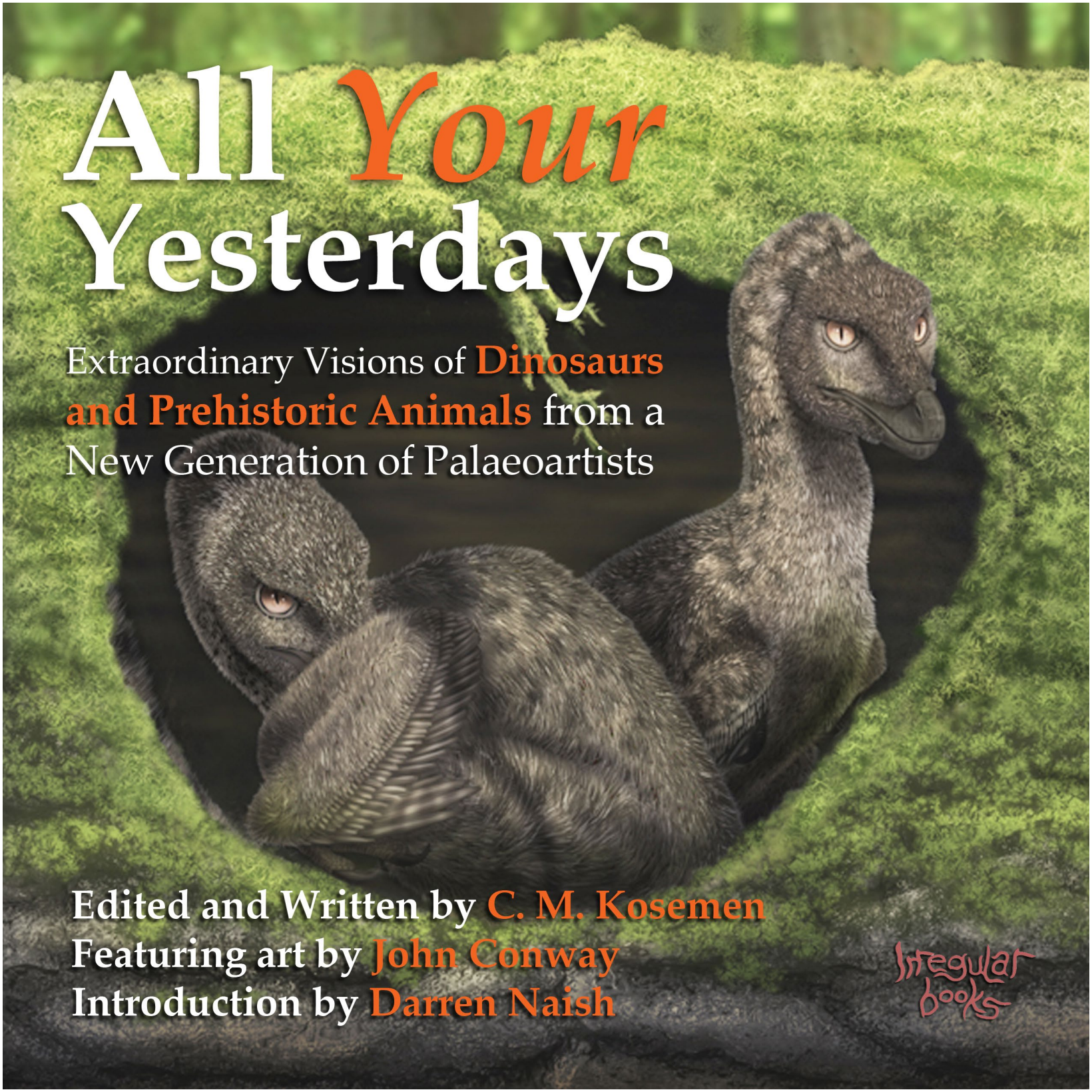
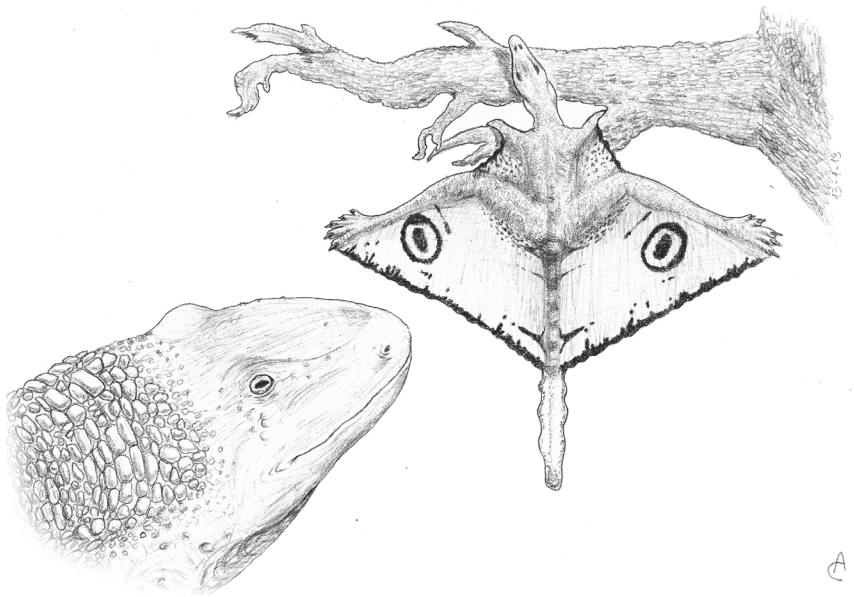




"*Sharovipteryx* eye-spots"
artwork by Alessio Ciaffi

All *Your* Yesterdays

Extraordinary Visions of Extinct Life from a New Generation of Palaeoartists

Written and edited by C. M. Kosemen

Featuring art by
artists of the
All Your Yesterdays contest

An Irregular Books Free Book

Second Edition
Updated on the 31st of July, 2017

Introduction
by **C. M. Kosemen**

In a way, the book you are holding in your hands is a sequel of *All Yesterdays*, which was published in December 2012 by myself, John Conway and Darren Naish, with the valuable contributions of Scott Hartman. Therefore, it is best to first consider the original *All Yesterdays* before talking about this volume.

All Yesterdays was based on our misconceptions about dinosaurs and how they may have looked. For a long time, me, John and Darren had been thinking about the mistakes in popular dinosaur reconstructions. Artists were duplicating each other's work, sometimes without even realising. Animals were typecast into a few predictable roles, mostly as monster-like predators versus "peaceful" herbivores. Most important of all, they weren't reconstructed as regular animals, but as "shrink-wrapped" fantasy beasts, with every bone and skull opening visible through their skin. Most often, they were removed from any ecological setting and greeted the viewer as isolated, itemised monsters; a freak show of strange beings, parading for the shock factor. The old narrative of dinosaurs as "alien" beings as opposed to "normal" everyday creatures was still alive and well in palaeoart.

With *All Yesterdays*, we wanted to go beyond these stereotypes. We wanted to show dinosaurs and other prehistoric animals looking and acting like animals today. They would have thick coverings of body fat. They would do things and act in ways that did not make sense. They would have strange and fascinating mating rituals, soft-tissue fat deposits and skin integument. We knew that most such details were impossible to tell from fossils alone, but what we could not deduce from bones, we speculated. To drive home the message, we also had an "All Todays" section, where we knowingly reconstructed modern-day animals with the same mistakes we see in contemporary palaeoart.

We launched *All Yesterdays* in December 2012, with a big meeting at London's Conway Hall (no, it wasn't named after John.) Sold both as an ebook and a "regular" book, it surprised us with the attention it received and the positive reviews it generated. It was even hailed as the "most important palaeoart book of the last 40 years." Within days of the launch we found ourselves giving interviews to radios in Scotland and magazines in Brazil. With all this attention, fans of the book soon began posting their own *All Yesterdays* - themed artwork online.

All in all, it seemed that we'd tapped into a "second renaissance" of dinosaur art. It would be brash to assume that *All Yesterdays* was the catalyst of this resurgence, although we are proud to be playing an important role in it. More than the result of a single work or author, this renaissance is the product of a number of factors, all rooted in the growth of digital technology, and the increase of scientific literacy through the internet.

To begin with, research and science news are now far easier to disseminate. This specialist knowledge rests at the core of palaeoart. Scientific journals, which were either too expensive and difficult to procure, have now been ousted by peer-to-peer sharing of pdf files and new online publishing platforms such as PLOS ONE. Now, even the casual palaeoartist can have access to the newest discoveries, theories and data. Skeletal diagrams and other reference material is on his or her fingertips, far easier to procure. Feeding on this information, networks of palaeoartists, palaeo-admirers and professional scientists regularly exchange views and comments on a number of websites and other online platforms. Their discussions frequently generate new and insightful ideas for art and science alike. *All Your Yesterdays* was borne out of the response generated by our first book, on this cyber-culture of dinosaur art and science. Initially, we were simply going to hold the contest and announce the winners in two months.

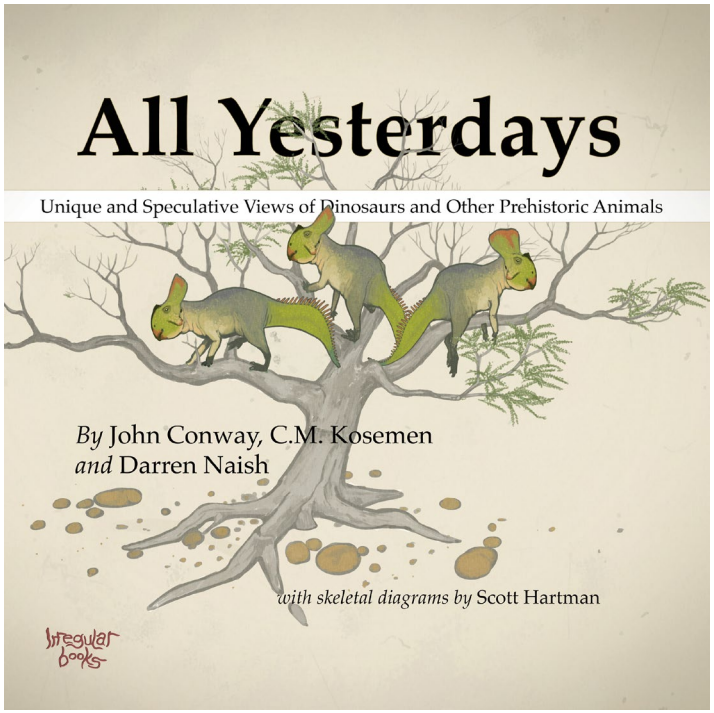
However, two things convinced me to turn *All Your Yesterdays* into book. The first and foremost was the quality and quantity of the submissions that began arriving from all corners of the world. From Russia to Brazil, The United States to Bulgaria, fellow palaeontology enthusiasts sent us top-notch artwork and unique concepts for the contest. Some works had the same level of craftsmanship and attention to detail as the legendary masters of palaeoart. It

would not do these submissions justice to simply announce winners and move on.
The second reason for making this collection into a book was the criticism we received for the original All Yesterdays. It was found be too short by some reviewers. We felt that we owed our fans a lengthier foray into the world of speculative palaeontology.

But what about copyrights, money issues? Although we are confident that most of our contributors would not object to us actually selling this book – we decided on publishing All Your Yesterdays as a free e-book. This would also be resonate well with the online renaissance of palaeoart explained above. Anyone interested in dinosaurs and palaeoart will able to download our book and read it on their computer, tablet device or e-reader and share it with their friends. Because we know that great art never views the same way on a screen as it does on paper, we created a print-friendly version as well. You can print this book at any local print shop, bind it and place it in your personal library.

We hope that this book inspires new artists as the original All Yesterdays inspired the artists within it. A new generation is looking at the past with a new perspective, so discard the tropes, sharpen your instruments and feel free to speculate!

Istanbul, August 2013



Above,
The cover of the original *All Yesterdays* volume.

On *All Your Yesterdays*
by **Darren Naish**

When C. M. "Memo" Kosemen told me and John of his plans to invite people to send in their own *All Yesterdays* style illustrations for an *All Yesterdays*-themed competition, I thought it was a tremendously bad idea. I expected a few, poor to mediocre bits of art that would most likely be silly and outlandishly speculative. How wrong and stupid I was. The actual results – included in the volume you have in front of you now – are nothing short of spectacular; I'm blown away by the quantity and quality of the work the invitation attracted. Those interested in palaeoart – wherever they find themselves in the world of science and art – will, I think, relish this book and the quality of its illustrations. Already I can't stop thinking about some of my favourite images and I'm secretly afraid that some of them will stay in my mind whenever I look at, or think about, the creatures concerned. The project that Memo decided to title *All Your Yesterdays* has, in short, been an outstanding success. *All Your Yesterdays* is a thing of great beauty.

There are so many personal highlights in the volume that it's difficult to know which pieces to honourably mention in a summary. The invitation attracted professionals and semi-professionals as well as interested amateurs; it's thrilling to see several pieces by the brilliant and increasingly well known Emily Willoughby, I love Jaime Headden's Dixon-inspired 'Giraffapteryx', and Raven Amos's 'Bowertyrants' piece is wonderful. Other highlights that make the book appear way more professional in appearance than I ever expected include the contributions of *All Yesterdays* triumvirate member John Conway, and the brilliantly innovative and imaginative works of Joschua Knuppe and Oscar Mendez. The invitation attracted contributions from several household names in the palaeoart ubernerd community: Mike Hanson, Mike Keesey, Julio Lacerda and Simon Roy among them. Seriously: wow. Just… wow!

Remember also that the contributions included in *All Your Yesterdays* were essentially done for fun, sent in by people purely because they wanted to, not because they were seeking financial gain. It's probably best here that we don't get into the whole issue of how palaeoartists (and, indeed, artists in general) can make a living from their work (for the record, the deal isn't any different for writers and some scientists, either). The point worth making here is that the internet has changed everything: long gone are the days where an artist had to strive to get work published in a mainstream published outlet (like a magazine or book) before their work was noticed or considered worthy. While – given the hardships – we wouldn't necessarily recommend that anyone try to get into palaeoart or even writing as a possible career path, we sincerely hope that our promotion of the work included here helps its creators in some way.

Above,
Darren Naish's drawing of the flightless pterosaur *Lank*, which appears in Dougal Dixon's book about speculative dinosaur evolution, *The New Dinosaurs*. One of the artworks in this volume also referes to this speculative critter - read on to find out!

Does the world need more speculation in palaeoart? It's complicated

Are we wise in encouraging people to speculate when it comes to palaeoart? This is a complex subject. Scientists tend to think that palaeoart 'belongs' in some way to Science, and that people who produce reconstructions of extinct animals can only do so when they portray ancient animals and environments in rigorously accurate fashion, paying attention to the most up-to-date knowledge. Scientifically rigorous art of this sort certainly has its place: we would expect to see it, for example, accompanying a press release on a newly announced fossil animal, or adjacent to a fossil specimen in a museum (for palaeoart of this sort we very much recommend William Stout's 2009 *Prehistoric Life Murals* and Steve White's 2012 *Dinosaur Art: the World's Greatest Paleoart*). However, the fact that palaeoart combines an element of artistry and speculation – be honest, even the most rigorous, most conservative piece of palaeoart still involves an amount of speculation – means that it is sometimes unclear where the 'facts' end and the speculations begin. Remember that animals are often shown eating, standing or resting in certain postures, frequenting specific environments, and are decorated in a given livery. Those are speculations, and even when they appear conservative, they aren't necessarily correct or worthy.

One of the criticisms levelled at *All Yesterdays* is that the entire project seemingly made it ok for people to speculate away and do whatever the hell they liked, evidence, conservatism and critical thinking be damned. By inviting people to speculate away and produce even more artwork of the same sort, maybe we're exacerbating things, arguably opening the floodgates to an endless torrent of evidence-free arm-waving.

There are several responses that need to be made to this claim. As we tried to make clear in *All Yesterdays* (look at p. 10 in the Introduction), scientific reconstructions of fossil animals should indeed incorporate whatever hard data we have on ancient animals and their environments (Conway et al. 2012). We typically have detailed information on the bony anatomy and thus the proportions and basic shape of a given animal, for example; we can infer a lot about its musculature and integument based on what we know about its living relatives; and we should try to incorporate whatever data we have on environments, climates and the local vegetation. The scientific palaeoart that I and many of my colleagues would consider 'good' ticks all of these boxes (though, at the risk of sounding like a stuck record, I will repeat a point I often have; that some of the palaeontologists who advise palaeoartists aren't aware of the required technical data, or honestly don't care about the way ancient animals are depicted. These two problems explain the many terrible illustrations we still see in some mainstream books).

However, when it comes to soft tissue anatomy and behaviour, many of the cherished ideas and themes of conventional palaeoart are not always obviously less speculative than the sorts of images we explored in *All Yesterdays*: they frequently represent historical tropes that were arrived at by accident, they represent assumptions and conventions, and they are even, arguably, reflective of cultural and societal expectations. Sure, there are some illustrations in *All Yesterdays* that might be a tad unlikely (example: a stegosaur with a giant flexible penis, a plesiosaur that camouflages itself by lying on the seafloor), but they aren't any that are obviously more unlikely than many of the other illustrations that have been endorsed elsewhere (for example, stegosaurs with hyper-mobile plates, skim-feeding pterosaurs, ceratopsians that form defensive circles, theropods that roar at their prey, and so on).

In short, speculation in palaeoart should be seen as a sliding scale. At which point does a speculation render itself too extreme? And is it even possible to reach said extreme given the ridiculous soft tissue structures and absurd behaviours present in the modern world? It is, in fact, surprisingly difficult to come up with a speculative piece of palaeoart that is unconditionally ridiculous (at least, so long as the basic rules of anatomy, biology and physics are applied, as they are in science-based reconstructions). Critics and detractors would do well to remember this when criticising speculative palaeoart, especially when the art concerned is clearly labelled – as it is – as an exercise in speculation. Remember that, if we've learnt anything about living animals and about palaeobiology, it's that things are more complex, stranger, and more wonderful than we have typically assumed.

It should also be accepted that depictions of ancient animals do not 'belong' wholly to science. Images of living animals are frequently incorporated into abstract, fantastical and surrealist works of art: nobody ever said that every image of an animal, ever, has to be an anatomically correct study that faithfully depicts the creature in its natural environment. Art depicting extinct animals can obviously play the same game. Speculative, fun, and even deliberately 'wrong' depictions of extinct animals are therefore 'allowed' in cases where the artist is not claiming to produce a rigorous scientific reconstruction. Some of the art included here can be seen in this vein. It is not necessarily offered as a scientific bit of palaeoart, but as a stylized image that features a fossil animal.

On that note, much of the palaeoart of the past is now regarded as woefully wrong. The animals have the wrong body shapes, the wrong postures, they are shown engaging in unlikely or absurd behaviours, they are in the wrong environments, the wrong climates, and so on. This does not stop them being worthy, and even beautiful, pieces of art. A few people that admire and love the style created by Knight, Burian, Parker and many of the other great artists of the past are depicting 'retro' palaeoart that does not pretend to be scientifically accurate – rather, it is a homage to a specific style. Again, this is 'allowed' as an artistic convention; it doesn't mean that the artist is necessarily trying to portray an imagined reality.

The human experience is rich. We should love what we do; we are passionate, we enjoy thinking about and depicting scenes from the world, from the past, from our lives and from our minds. Art can be driven by science, but it can be divorced from it entirely. Speculative art, 'retro' palaeoart, and accurate, high-fidelity reconstructions all have their place in the way we choose to portray the animals of the past. We hope you enjoy the remarkable selection of images we include here. And well done and thank you to everyone that contributed.

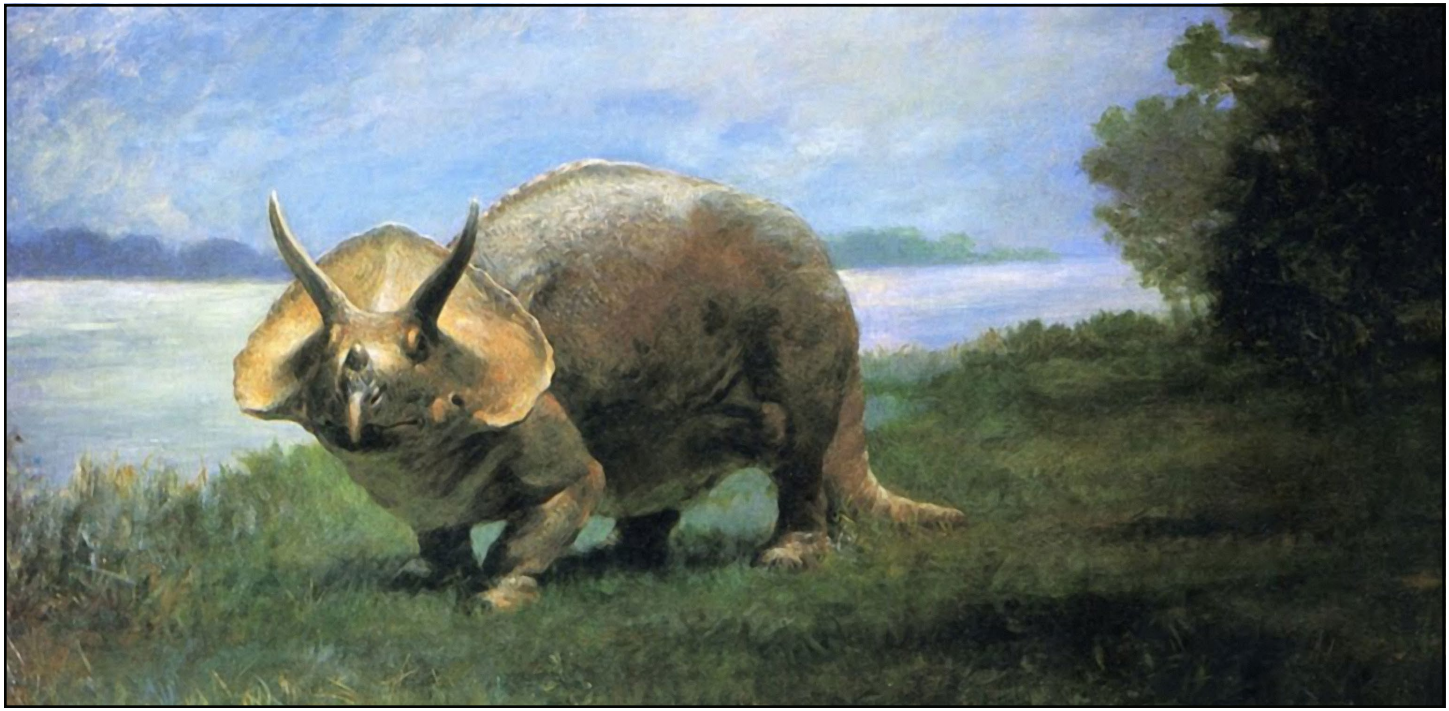
References:

Conway, J., Kosemen, C. M. & Naish, D. 2012. All Yesterdays: Unique and Speculative Views of Dinosaurs and Other Prehistoric Animals. Irregular Books.

Stout, W. 2009. Prehistoric Life Murals. Flesk, Santa Cruz.

White, S. 2012. Dinosaur Art: the World's Greatest Paleoart. Titan Books, London.

Above and Right,
Obsolete but meaningful: These dinosaur paintings by Charles Knight are now scientifically outdated, yet they remain impostant as artistically beautiful and inspiring portrayals of prehistoric life.



All *Your* Yesterdays

"Leptoceratops"
artwork by Vitaly Melnik

Alessio Arena

Displaying Prenocephale *and* Compsognathus *at Play*

Alessio Arena's deceptively simple artwork shows dinosaurs as we rarely see them; as small, fuzzy animals one might call "cute." Beyond this, his dinosaurs also engage in complicated behaviors and interactions that are usually reserved for more "complicated" animals such as mammals and birds.

Thus, Arena's couple of *Compsognathi* are seen playing with a feather they have found on the ground. *"Some birds like corvids and hawks engage in play behavior also using objects they find (feathers, leaves and such), maybe Mesozoic dinosaurs did the same, who knows?"* says the artist when explaining this depiction. The small, meat eating dinosaurs are depicted with excessively "bushy" tails in reference to *Sciurumimus*, a meat eating theropod dinosaur which may have been related to *Compsognathus*. Among the best-preserved fossils in the world,[1] *Sciurumimus* sports a similar, squirrel-like tail.

Arena's *Prenocephale*, on the other hand, belongs to a different group of plant-eating dinosaurs, the **pachycephalosaurs.** These animals bore very thick, dome-like skulls, which may have been used for defense, combat for social dominance, or both. This male *Prenocephale* looks especially flamboyant with its colorful skull dome, facial patches and its thick coat of filamentous integument.

While feathered theropods, the bird-like, meat eating dinosaurs, have been more-or-less common in palaeoart for the last decade, Alessio Arena is one of the few artists who have been restoring the plant-eating ornithischian dinosaurs with an equally extensive covering of filaments.

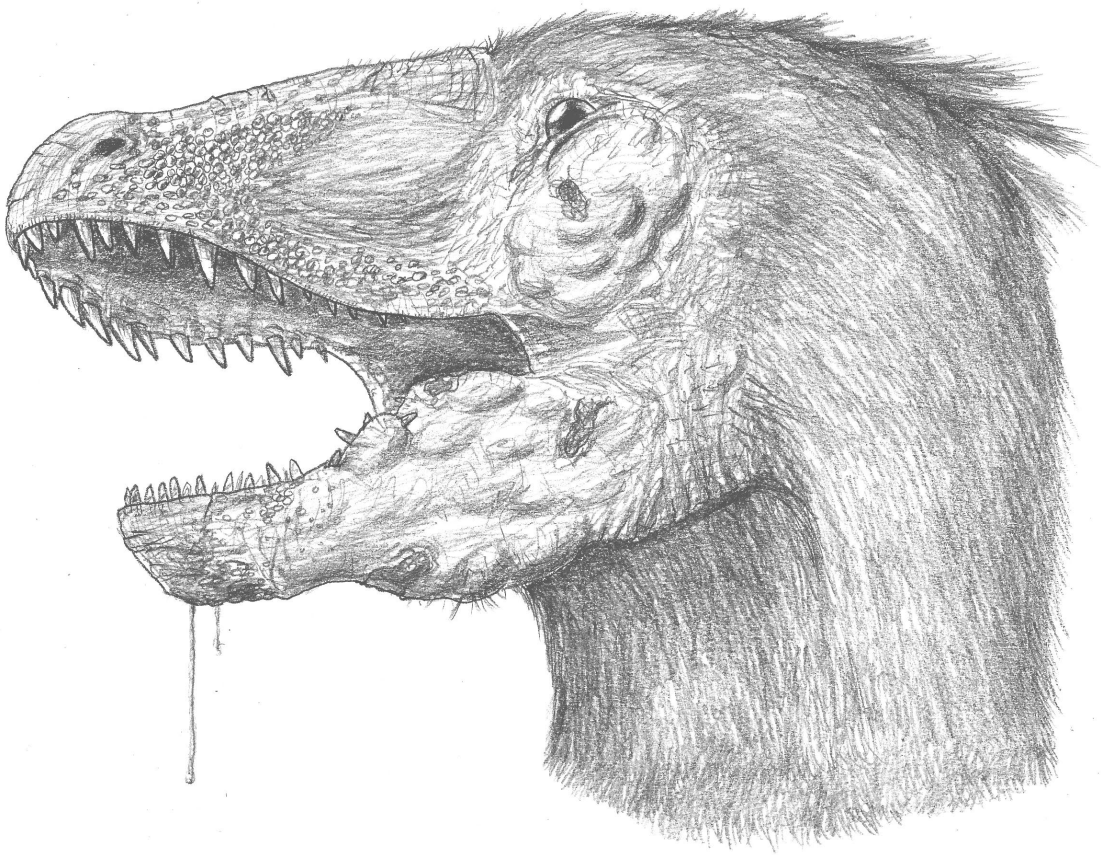
1 Rauhut, O. W. M.; Foth, C.; Tischlinger, H.; Norell, M. A. (2012). "Exceptionally preserved juvenile megalosauroid theropod dinosaur with filamentous integument from the Late Jurassic of Germany". Proceedings of the National Academy of Sciences 109 (29): 11746. doi:10.1073/pnas.1203238109.

Alessio Ciaffi

Cancer

Disease, not predation, kills the majority of animals in real life, but it is almost never represented in artwork, let alone palaeoart. Italian artist Alessio Ciaffi highlights the grim reality of disease with this poignant drawing of a female *Deinonychus* infected with facial tumors.

Ciaffi has dedicated this artwork to his late grandfather, who also succumbed to the dreaded disease in what he describes under "*similar conditions.*" Being a disease of organized tissues, cancer is present in all animals, even insects. It seems rational to assume that dinosaurs would also suffer from tumors in various locations.



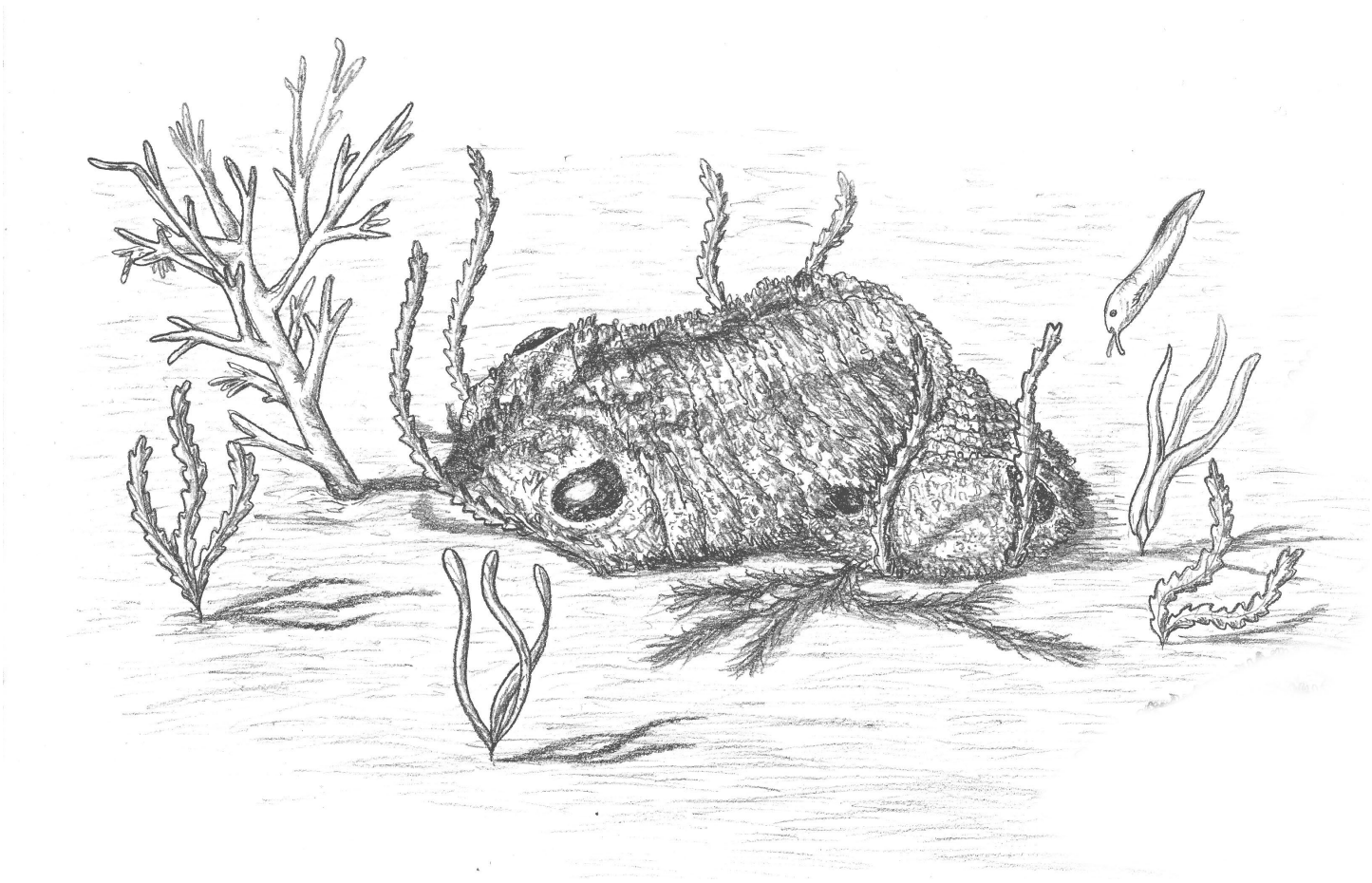
Alessio Ciaffi

Collaborative Camouflage by The Trilobite Palaeolenus

It seems that dinosaurs and other mesozoic reptiles are the stars of palaeoart in the public mind. Prehistoric mammals and amphibians are only slightly less-commonly represented in artwork, and **invertebrates**, barring some spectacular forms such as gigantic sea scorpions, usually come the last when it comes to artistic popularity. This is a pity, because fossil invertebrates, such as the ancient **trilobites** shown here, come in a great diversity of interesting forms.

Trilobites are a completely extinct group of arthropods that lived in the primordial seas. At a centimeter long, *Palaeolenus* is one of the most common fossil trilobites of the **Cambrian** period. It is usually discovered in mass aggregations, which has led the artist to portray it as a camouflaged bottom dweller. In this picture, two *Palaeolenus* sport patterned carapaces that mimic the texture of the seafloor and frond-like antennae that resemble sea plants. Artist Alessio Ciaffi imagined that two or more individuals could come together to form cryptically-shaped units that help disguise them even more.

As a final note, we can see tiny, fish-like animals known as *Haikouichthys* swimming around the trilobites. These creatures are some of the earliest known free-swimming **chordates**, members of the group which later gave rise to fish, amphibians, reptiles, dinosaurs and ultimately ourselves.



Alvaro Rozalen
Archaeopteryx *and* Ctenochasma

Talented palaeoartist Alvaro Rozalen offers us a glimpse of a time in Earth's past when two different lineages, the **pterosaurs** and the newly-evolved **birds**, co-existed in the planet's skies. This scene depicts an *Archaeopteryx*, famously known as the "first bird," (actually just a pretty ordinary feathered theropod dinosaur which just happened to be discovered the first,) looking up at a flock of *Ctenochasma* pterosaurs flying in a V formation, much like migrating geese or other large birds today.

At this stage of their evolution, birds, while producing volant forms, hadn't fine-tuned their adaptations for flying and had not yet expanded into the extensively aerial niches which they occupy today. Such roles were occupied by pterosaurs. Eventually, however, birds increased in diversity while only the largest flying pterosaurs remained alive by the end of the Mesozoic era. Some theories on this decline suggest a "battle for the skies," with the evolution of the birds actively contributing to the winged reptiles' demise, but it is debatable if the decline of pterosaurs had anything to do with the evolution of birds.[1] In fact, the so-called "decline" of the pterosaurs may not even have happened, and the rarity of pterosaur fossils from the last epochs of the Mesozoic can simply be an artifact of preservation.

1 Butler, Richard J.; Barrett, Paul M.; Nowbath, Stephen and Upchurch, Paul (2009). "Estimating the effects of sampling biases on pterosaur diversity patterns: implications for hypotheses of bird/pterosaur competitive replacement". Paleobiology 35 (3): 432–446. doi:10.1666/0094-8373-35.3.432.

Alvaro Rozalen
Shellfish-Eating Citipati

Oviraptorosaurs were a group of extremely bird-like dinosaurs known for their bizarre head crests and extraordinary mouth structure. Most animals in this group had mouths that were devoid of all teeth, except for two spike-like protuberances on the mouth roof.

Needless to say, this arrangement elicited a lot of hypotheses about the oviraptorosaurian diet from the day these animals were discovered. Initially, they were thought to be egg-eaters from the way one skeleton was discovered next to a nest of eggs, almost as if caught in the act. Later studies, however, revealed that the eggs belonged to the same species as the "thief," [1]and the question become unresolved again.

Here, Alvaro Rozalen is continuing the debate by illustrating *Citipati*, one of the largest oviraptorosaurs, in the act of crushing a crab which it has caught from a freshwater lake. The animals are using their sharp mouthparts to crack open shellfish instead of eggs.

1 Norell, M.A., Clark, J.M., Chiappe, L.M., and Dashzeveg, D. (1995). "A nesting dinosaur." Nature 378:774-776.

Alvaro Rozalen

A Parrot-Like Oviraptorosaur

Continuing the speculation on **oviraptorosaur** skulls and diet, Alvaro Rozalen here reconstructs an oviraptorosaur as a fruit-eating animal after observing the similarities of the their beaks and those of parrots. Shellfish, hard fruits, bones have all been suggested as parts of the oviraptorosaur diet. Perhaps these strange animals ate a bit of everything.

Alvaro Rozalen
Epidexipteryx

Preserved with elongated, ribbon-like structures adorning its tail, *Epidexipteryx* is one of the most unusual feathered dinosaur discoveries of the past decade. [1] It is also noteworthy in having very large eyes and apparently featherless arms, whereas most dinosaur fossils preserved with integument bear long feathers on their forelimbs. This could be an artifact of preservation, or it could be a specialized adaptation, especially if one considers that related species such as *Scansoriopteryx* and *Epidendrosaurus* both have extremely long fingers, which may have been used in probing trees for insect larvae and other food items.

Alvero Rozalen has noticed the similarity between these mystifying anatomical features and the anatomy of a living primate, the Aye-Aye. (*Daubentonia madagascarensis*) This famous denizen of Madagascar also has long, grub-probing digits and large eyes adapted for a nocturnal life. Inspired by the Aye-Aye, Rozalen has rejected traditional reconstructions of *Epidexipteryx*, which look like tiny birds with fingers and no tails bimbling about on the forest floor.

He has drawn this animal as a nocturnal tree dweller with bright eyes that reflect the moonlight. Adaptations for an arboreal lifestyle can force animals to assume deceptively scary forms with large eyes, long limbs, sharp, insect-crunching teeth and cryptic body shapes. The living Aye-Aye also looks terrifying, yet it, like Rozalen's hypothetical *Epidexipteryx*, is only harmful to tree-living insects.

1 Zhang, Fucheng; Zhou, Zhonghe; Xu, Xing; Wang, Xiaolin and Sullivan, Corwin. "A bizarre Jurassic maniraptoran from China with elongate ribbon-like feathers". <http://www.nature.com/nature/journal/v455/n7216/full/nature07447.html> Nature 455, 1105-1108 (23 October 2008) | doi:10.1038/nature07447 PMID 18948955.

Alvaro Rozalen

Troodon: *Young Hunters*

If dinosaurs were as similar to birds as fossils show them to be, this similarity may have extended to their development and the care of their offspring too. [1] Certainly, the more bird-like dinosaurs may have taken extensive care of their young. This could have been especially true for bird-like dinosaurs with large brains, such as **troodonts**. Usually hailed as **the smartest dinosaurs**, these animals may have had complicated behaviors and elaborate social displays. Such advanced cognitive skills would have necessitated a relatively long period of infancy and learning.

This stunning portrait shows two hatchling *Troodons*, smart and bird-like meat-eaters, in their tree burrow nest as they wait for their parents to return from a foraging trip. Like hatchlings of certain birds today, they have a mottled, camouflaging pattern of feathers. The developing remige, or flight feathers, are clearly visible on the arm of the hatchling which is shielding itself from the sun. When they grow, these feathers will get longer, and their arms will resemble wings. The hatchlings are scanning their surroundings with wary, intelligent eyes, on the lookout for potential danger or the return of their parents.

Many artworks depict *Troodon*, but Alvaro Rozalen has done a truly masterful job at portraying them as real animals; not "reptiles," not proper birds, but graceful, unique beings of their own.

1 Varricchio, D. J.; Moore, J. R.; Erickson, G. M.; Norell, M. A.; Jackson, F. D.; Borkowski, J. J. (2008). "Avian Paternal Care Had Dinosaur Origin". Science 322 (5909): 1826–8. doi:10.1126/science.1163245. PMID 19095938.

Andrea Gassler
A Scansoriopterygid with Wings

Believe it or not, this bat-like creature is actually a speculative reconstruction of a long-fingered **scansoriopterygid** dinosaur, related to the owl-like *Epidexipteryx* shown in the previous pages.

Swiss artist Andrea Gassler has come up with a novel interpretation of these animals. He postulates that the long finger, understood by many artists and researchers as an adaptation to probe for grubs and insects under tree bark, was actually the support for an extensive, wing-like membrane. **Bats** and the flying reptiles known as **pterosaurs** also have wings derived from similar adaptations.

As one can expect, portraying a dinosaur with membranous protowings results in a truly bizarre beast, and this **pterosaur-mimic** reconstruction has to be appreciated as food for thought rather than a genuine hypothesis. A similar idea has been proposed by the Italian palaeontologist Andrea Cau and illustrated by the palaeoartist Lukas Panzarin in 2012. [1]

2017 Update:
There was, it turns out, something prophetic about this artwork and the ideas behind it. In 2015, a new species of scansoriopterygid dinosaur named *Yi qi*[2] was discovered in China, with not only extremely long fingers, but also a strange, elongated, wing-like wrist bone, and covering them all, a set of membranous, bat-like wings. These surprising structures were similar to the configuration pictured here by Andrea Gassler.

1 Andrea Cau (2012-07-07). "Il ritorno del paraviano pterosauro-mimo?" Blogspot.com. Retrieved 2013-05-28. http://theropoda.blogspot.com/2012/07/il-ritorno-del-paraviano-pterosauro.html

2 Xu, X.; Zheng, X.; Sullivan, C.; Wang, X.; Xing, L.; Wang, Y.; Zhang, X.; o'Connor, J. K.; Zhang, F.; Pan, Y. (2015). "A bizarre Jurassic maniraptoran theropod with preserved evidence of membranous wings". Nature. 521: 70–3. PMID 25924069. doi:10.1038/nature14423.

Andrew Dutt

Bones Away

One of the strangest flying reptiles, or **pterosaurs**, *Dsungaripterus* is famous for its extraordinary skull, which combines an upturned, tweezer-like tip with tough, heavy dentition. This odd morphology was possibly used for consuming durable prey items, possibly shellfish. Here, however, the New York-based palaeoartist Andrew Dutt considers a different feeding strategy for this extraordinary pterosaur;

"So what does a flying reptile with crushing jaws living in a terrestrial environment sustain itself with? Surely Dsungaripterus *wouldn't pass on small terrestrial vertebrates if it came across them, but it probably put those knobbly teeth and strong jaws (for a pterosaur) to good use. Its beak could have probed into carcasses and with its jaws it could have crushed bones to obtain nutritious bone marrow. If its bite wasn't strong enough to shatter larger bones, it could have engaged in a behavior similar to the one practiced by today's bearded vulture: fly high up over cliffs and outcrops and drop the bone in order to smash it against the rocks below."*

This work is as interesting in its style as it is in its content. Dutt's use of flat colors and sharp contours differs markedly from most other palaeoartists, who usually aim for a more photorealistic approach. By using this visually-appealing style, he has made *Dsungaripterus*' extraordinary anatomy more prominently visible.

Asher Elbein

Pterodactyl Mating Flight

As attested by their extraordinary crests and brain casts showing enlarged optical lobes, Pterosaurs were **visually-oriented creatures**. It is thus highly possible that their mating habits made use of visual signals as well. In fact, **sexual selection** may have been the driving force in the evolution of exaggerated crests on pterosaurs and dinosaurs. [1]

Starting from this assumption, artist Asher Elbein has portrayed two pterosaurs, a male and a female of the same species, in an colorful aerial ballet of mating signs and displays. As in birds and most reptiles, the male is the more colorfully-ornamented member of the couple and he is doing his best to impress the larger, drably-colored female. Seeing that the males of many modern-day animals sport colorful crests, sacs and wattles which would not be preserved in the fossil record, Elbein has also adorned the male pterosaur with bright, inflatable sacs on his face and throat.

1 Hone, D. & Naish, D. & Cuthill, I. C. 2012. Does mutual sexual selection explain the evolution of head crests in pterosaurs and dinosaurs? Lethaia 45, 139-156.

Bethany Vargeson
Ambulocetus *Couple*

It's a pity that **fossil whales**, being the spectacular, transitional forms they are, do not get more attention from palaeoartists. Their transformation from land-living animals to gigantic swimmers is one of the most extraordinary stories in the history of mammal evolution. [1]

Whales started evolving 50 million years ago, in what became Pakistan, India and Afghanistan today. The earliest whales resembled **deer-like animals** with short necks and long, thick tails. Soon after, they diversified into more aquatically-adapted forms, such as the large-headed, almost crocodile-like *Ambulocetus* seen here.

About the size of a person, *Ambulocetus* is usually illustrated as a naked, semiaquatic lurker in swamps or lakes. Bethany Vargeson has broken this tradition, not only in illustrating *Ambulocatus* as a furry, cute yet still believable animal, but also depicting it like a gigantic sea otter, able to venture into more open waters.

1 Carl Zimmer (2007-12-19). "The Loom : Whales: From So Humble A Beginning". ScienceBlogs. Retrieved 2007-12-21.

Brian Engh
Diamantinasaurus *in Caves*

Sauropods are the iconic "big plant eater" dinosaurs with their long necks and tails. In the past, most sauropods were reconstructed as slow, swamp-dwelling titans which could not even stand up properly on land. Later on, additional discoveries and new theories of dinosaur evolution revised our image of sauropods. No longer consigned to the swamps, they were seen as fully-terrestrial animals. Ultimately, however, this view also turned into a sort of orthodoxy. Sauropods are now drawn as sleek, unadorned land-dwellers with monotonous regularity.

With this one image of *Diamantinasaurus*, a sauropod dinosaur that lived at the end of the Cretaceous, California-based palaeoartist Brian Engh has challenged the conventional wisdom of how these animals are represented, on multiple fronts.To begin with, we see the animals in an otherworldly cave, with strange geologic formations and colonies of bioluminescent bacteria that light the ceiling like stars. Engh does not suggest that these animals lived in caves, but caves undoubtedly did exist in the world's past, and some animals, no matter how ungainly, may have entered them to obtain salts or other necessary minerals. In today's Africa, elephants visit similar underground caves in order to obtain salt. By picturing the large sauropods inside a cave, Engh successfully draws attention to the fact that in nature, **animals often do extraordinary things** and venture into unlikely places.

A second extraordinary detail in this picture is the restoration of *Diamantinasaurus* with keratinous "whiskers" adorning their faces. This is a speculative feature never before illustrated in such animals, yet it is not any more or less-likely than a traditional, reptile-headed reconstruction. Engh explains;

"My Diamantinasaurs *exhibit keratinous defensive spines, display spines along their back, and specialized elongated quill-like scales on their faces, which serve as whiskers to help them navigate caves and dark forests at night."*

The true nature of sauropod integument may never be known, but considering that other dinosaurs have been discovered with protofeathers or spiky filaments, it won't be surprising if in real life, these animals bore structures that would make this reconstruction tame in comparison.

Carlos de Miguel Chaves

A Melanistic Sabretooth

Smilodon, or the **saber-toothed tiger,** is one of the most familiar prehistoric mammals in public knowledge. What is less commonly known is that there was not one species *Smilodon*, but three or possibly more, the largest of which was markedly different from others with its heavy structure, long front legs and hyena-like sloping back. Here, artist Carlos de Miguel Chaves has illustrated this largest species of *Smilodon*, *S. populator*, in an extraordinary melanistic form.

Melanism is a condition characterized by an overabundance of dark pigments in an animal's skin. Like albinism, it affects many different species of animals, including deer, lions, snakes, owls, salamanders and others. Thus, "black" versions of familiar animals are not necessarily different species, simply individuals afflicted with a melanistic condition. In today's world, "black panthers" are not a unique species, but melanistic forms of jaguars, cougars and leopards. In the past, similar individuals must have appeared among *Smilodon* populations as well.

Christian Masnaghetti
Miragaia *and the Opportunists*

In nature, smaller animals occasionally take shelter besides larger, well-defended ones, usually herbivores, for protection, easier access to food, or both.

Palaeoartist Christian Masnaghetti has thus depicted *Miragaia*, the extraordinary armored **stegosaurian** dinosaur with a long neck, with an associated pack of smaller, opportunistic herbivorous dinosaurs known as **hypsilophodonts**. Looking like a gigantic porcupine with dangerous spines on its flexible tail, *Miragaia* was certainly a tough adversary for any predator. The hypsilophodonts would not only find the larger beast useful for safety, but would also help themselves to the small prey it stirs up, or even find sustenance in its parasites or droppings.

Besides suggesting a plausible behavior, Masnaghetti has also distinguished this work by illustrating both *Miragaia* and the opportunistic hypsilophodonts (actually distant relatives,) with **bodily integument**. In *Miragaia*, this takes the shape of dense, protective quills, whereas in the smaller hypsilophodonts the same structures have evolved into a dense, bushy covering of fur-like fibers.

Christian Masnaghetti
Symbiosis

Christian Masnaghetti returns here with a more speculative suggestion of **symbiosis** between a large herbivorous dinosaur and an arachnid.

Here, a gigantic spider purposefully spins a web in between the horns of a *Diaboloceratops*, a large, horn-faced plant eating dinosaur, to feed on insects buzzing around its head. According to Masnaghetti's words, however, *"it won't refuse an occasional gargantuan feast"* of a tick bird, another commensal, if the opportunity presents itself.

While this arrangement seems unlikely, a very similar situation was observed with an impala in 2010 by the wildlife photographer Frank Solomon.

Christian Masnaghetti
Two-Headed Zupaysaurus

Bordering on the surreal, a small meat-eating dinosaur known as *Zupaysaurus* surveys its lakeside territory with two heads. While this looks like a complete work of fantasy, it might be surprising to know that **polycephaly**, or the presence of more than one head in a single organism, is a very real phenomenon in nature.

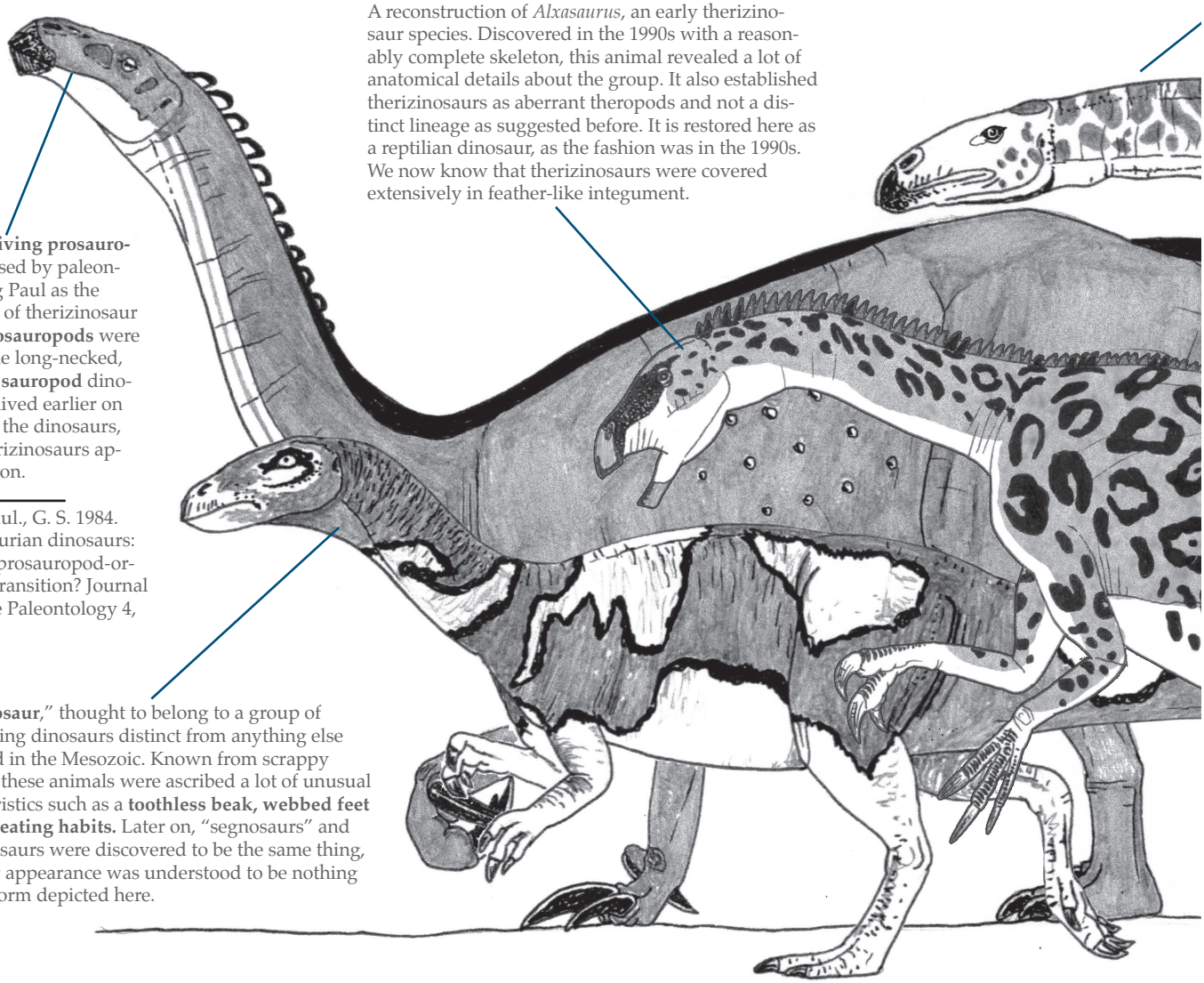
Polycephaly is a birth defect that occurs when two embryos fail to separate properly and end up as a single fetus with two heads or two front halves of the body. This condition is almost always fatal, but certain individuals can manage to survive for long periods under captive care or other favorable conditions. There are records of polycephalic fish, turtles and snakes, but also of "higher" animals such as cows, pigs and cats. There are even people with this condition: **Abigail and Brittany Hensel** of Minnesota, USA, have been sharing a single body since they were born. Polycephaly is also known from past eras; there exists a 120-million year-old fossil of a juvennile aquatic reptile named *Hyphalosaurus* with two heads.

All this being said, it would have been extremely unlikely for any dinosaur or other prehistoric animal to remain alive for long if born with polycephaly. Predators, exposure or other environmental factors would limit the life of any polycephalous hatchling. Even the basic task of walking would be immensely difficult, if not impossible, with two different heads controlling the two separate halves of the animal's body. Considering all these disadvantages, this (these?) *Zupaysaurus* must have been very lucky to have survived into maturity.

Darren Naish

Therizinosaurs Old and New

Throughout paleontological history, certain fossil lineages have been interpreted in a variety of different ways. Either due to scrappy fossils or poorly-formulated theories, a wide variety of identities have been suggested for certain **"problematic" lineages.** Famous zoologist Darren Naish contributes to this collection with a parade of unusual forms, all representing one such lineage, the **therizinosaurids**. Since their discovery, this lineage of **long-clawed dinosaurs** were assigned a succession of different identities.



A reconstruction of *Alxasaurus*, an early therizinosaur species. Discovered in the 1990s with a reasonably complete skeleton, this animal revealed a lot of anatomical details about the group. It also established therizinosaurs as aberrant theropods and not a distinct lineage as suggested before. It is restored here as a reptilian dinosaur, as the fashion was in the 1990s. We now know that therizinosaurs were covered extensively in feather-like integument.

A **"late surviving prosauropod**," proposed by paleontologist Greg Paul as the true identity of therizinosaur lineage. [1] **Prosauropods** were cousins of the long-necked, herbivorous **sauropod** dinosaurs. They lived earlier on in the age of the dinosaurs, whereas therizinosaurs appeared later on.

1 Paul., G. S. 1984. The segnosaurian dinosaurs: relics of the prosauropod-ornithischian transition? Journal of Vertebrate Paleontology 4, 507-515.

A "**segnosaur**," thought to belong to a group of plant-eating dinosaurs distinct from anything else that lived in the Mesozoic. Known from scrappy remains, these animals were ascribed a lot of unusual characteristics such as a **toothless beak, webbed feet and fish-eating habits.** Later on, "segnosaurs" and therizinosaurs were discovered to be the same thing, and their appearance was understood to be nothing like the form depicted here.

A "**gumby**" early reconstruction, based on the work of artist Ely Kish, of a segnosaur/therizinosaur, with long claws, an awkward, penguin-like body stance, a long, stiff neck, no tail and no feathers. This was the view of these animals during the later half of the 90's. They were believed by some researchers to be diggers, and their long claws were seen as adaptations to **tear open insect nests.**

A more modern, but featherless view of therizinosaurs, namely the giant species *Therizinosaurus*, known only from its **seventy-centimeter-long claws.** Our current view of this animal is more-or-less close to this version, except that it possibly had a covering of **protofeathers**, and its claws were folded against the animal's body in a more wing-like posture.

Elia Smaniotto
A Violent Male Caviramus

Not knowing much about the way animals compete and reproduce, one may falsely assume that nature is fairly idyllic when it comes to relationships. Nothing could be further from the truth. Without going too much into details, suffice it to say that nature is full of acts and practices that one might call **depraved**. It would be wrong to assume that similar acts did not take place in the age of dinosaurs.

Here, a male pterosaur of the species *Caviramus* is seen brutally raping the corpse of a rival which it has killed in an aerial duel of dominance. Before assuming that the artist, Elia Smaniotto, has a particularly disturbing imagination, however, you must realize that the exact same act has been documented by scientists among ducks, [1] and this work is merely an adaptation of that behavior.

1 C.W. Moeliker (2001). "The first case of homosexual necrophilia in the Anas platyrhynchos (Aves:Anatidae)". Deinsea - Annual of the Natural History Museum Rotterdam 8: 243–247.

Emily Willoughby
Microraptor

Palaeoartist Emily Willoughby is well known for her beautifully detailed renditions of **dromaeosaurs**, or "raptor" dinosaurs. Her animals are exceptional for looking first and foremost like birds, creating an unexpected surprise for viewers who are used to outdated reptile or dragon-like representations.

Here, Willoughby has depicted *Microraptor*, the famous **"four-winged,"** possibly flying dromaeosaur species from China, with two spectacular artworks. In the overleaf picture, a *Microraptor* is seen feeding on fruit - a definite surprise in palaeoart. Perhaps because it is still a "raptor" in people's eyes, many previous artworks show *Microraptor* in a predatory role, relentlessly chasing down small reptilian or avian quarry. Willoughby considers the animal an omnivore, and comments that like many birds in today's world, it too would have fed on fruit if the opportunity presented itself.

The second *Microraptor* shows a very angry or scared individual, puffing up its feathers to look bigger to potential aggressors. Advanced birds possess what amounts to a **"smart suit"** in their covering of feathers. [1] By raising or lowering individual feathers, they can change their body contours and engage in a variety of social displays, or assume cryptic body shapes for camouflage. Being so similar to modern birds, *Microraptor* may have possessed such a "smart suit" as well.

1 Kaiser, Gary W. (2007). The Inner Bird: Anatomy and Evolution. Vancouver, BC: UBC Press. p. 19. ISBN 0-7748-1343-1.

Emily Willoughby
Utahraptors *on the Beach*

Moving from one of the smallest to **one of the largest dromaeosaurs,** Emily Willoughby has here depicted *Utahraptor*, a veritable giant of the dromaeosaur lineage at up to six, or even eleven meters long. [1] This was the animal whose distorted version became popular in the movie *Jurassic Park*, although it was called a "Velociraptor" in the film.

Here, a decidedly non-Hollywoodian *Utahraptor* is seen on a beach, with members of its pack in the background. Willoughby has resisted a popular trend and avoided drawing these gigantic "raptors" as exaggerated movie monsters. Instead, her animals are calm, reserved and at peace with their surroundings, much like a lion or tiger today. They look less like reptiles and more like the birds they were related to.

A similar scene, with a *Utahraptor* pack exploring the vast expanse of a prehistoric beach, also takes place in palaeontologist Robert Bakker's fictional novel *Raptor Red*, [2] which chronicles the life and fortunes of a female *Utahraptor* and her relatives.

1 Britt; Chure; Stadtman; Madsen; Scheetz; Burge (2001). "New osteological data and the affinities of Utahraptor from the Cedar Mountain Fm. (Early Cretaceous) of Utah". Journal of Vertebrate Paleontology 21 (3): 36A. doi:10.1080/02724634.2001.10010852.

2 Bakker, Robert (September 1996). Raptor Red.Bantam Books. p. 4. ISBN 0-553-57561-9.

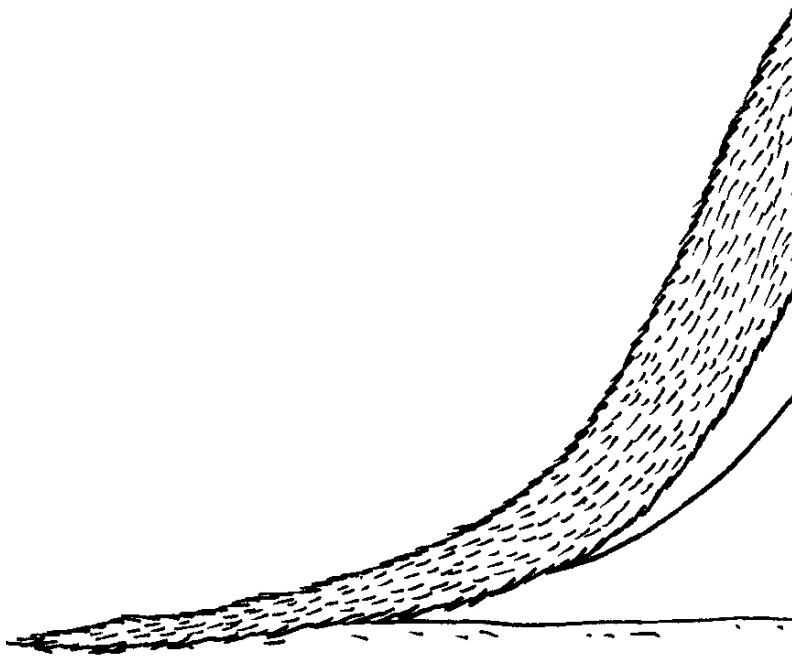
Ethan Schmunk
A Test of Strength

In this lovely, concise pen-and-ink image, artist Ethan Schmunk has portrayed a full-grown *Tyrannosaurus rex* in the act of felling a tree with the help of his thick, muscular tail - but why exactly is he doing it?

The answer, Schmunk speculates, is that males of many species engage in seemingly pointless acts designed to show off their strength - to potential rivals as well as the members of the opposite sex. From dueling reindeer to human males working out in gymnasiums, males rely on such exercises of power to establish their **social dominance** and mark themselves as **suitable mating partners.**

Schmunk continues his line of speculation by imagining the male pushing the fallen tree to a location where a potential mate can easily find it. The uprooted tree serves as a potential hunting blind and a "bait" for passing herbivores, making it an impressive gift for any female *Tyrannosaurus*.

These details, of course, are all speculative. However, **nuptial gifts** feature strongly in the behaviors of many animals, ranging from spiders (*Pisaura mirabilis*) [1] to shrikes, (*Lanuis excubitor*). [2] Even people have such traditions. Is any marriage proposal, no matter how much from the heart, ever complete without a wedding ring?



1 Stålhandske, Pia (2001). "Nuptial gift in the spider Pisaura mirabilis maintained by sexual selection". Behavioral Ecology 12 (6): 691–697. doi:10.1093/beheco/12.6.691.

2 Tryjanowski, Piotr and Hromada, Martin (2005). "Do males of the great grey shrike, Lanius excubitor, trade food for extrapair copulations?". Animal Behaviour 69 (3): 529–533. doi:10.1016/j.anbehav.2004.06.009.

Fabio Manucci
Lazy Dimetrodons

Dimetrodon is everyone's favorite "sail-backed reptile," mistakenly thought to be a dinosaur and frequently included in toy sets and second-rate dinosaur books as one. In fact, one might be surprised to know that this animal actually lived before dinosaurs and is a distant cousin of us mammals. It belongs to a lineage called **synapsids**, which exhibit the first skull and teeth morphologies that would later come to characterize mammals. More familiar mammalian characteristics such as a erect limbs, a covering of fur, lactation, etc. evolved later on.

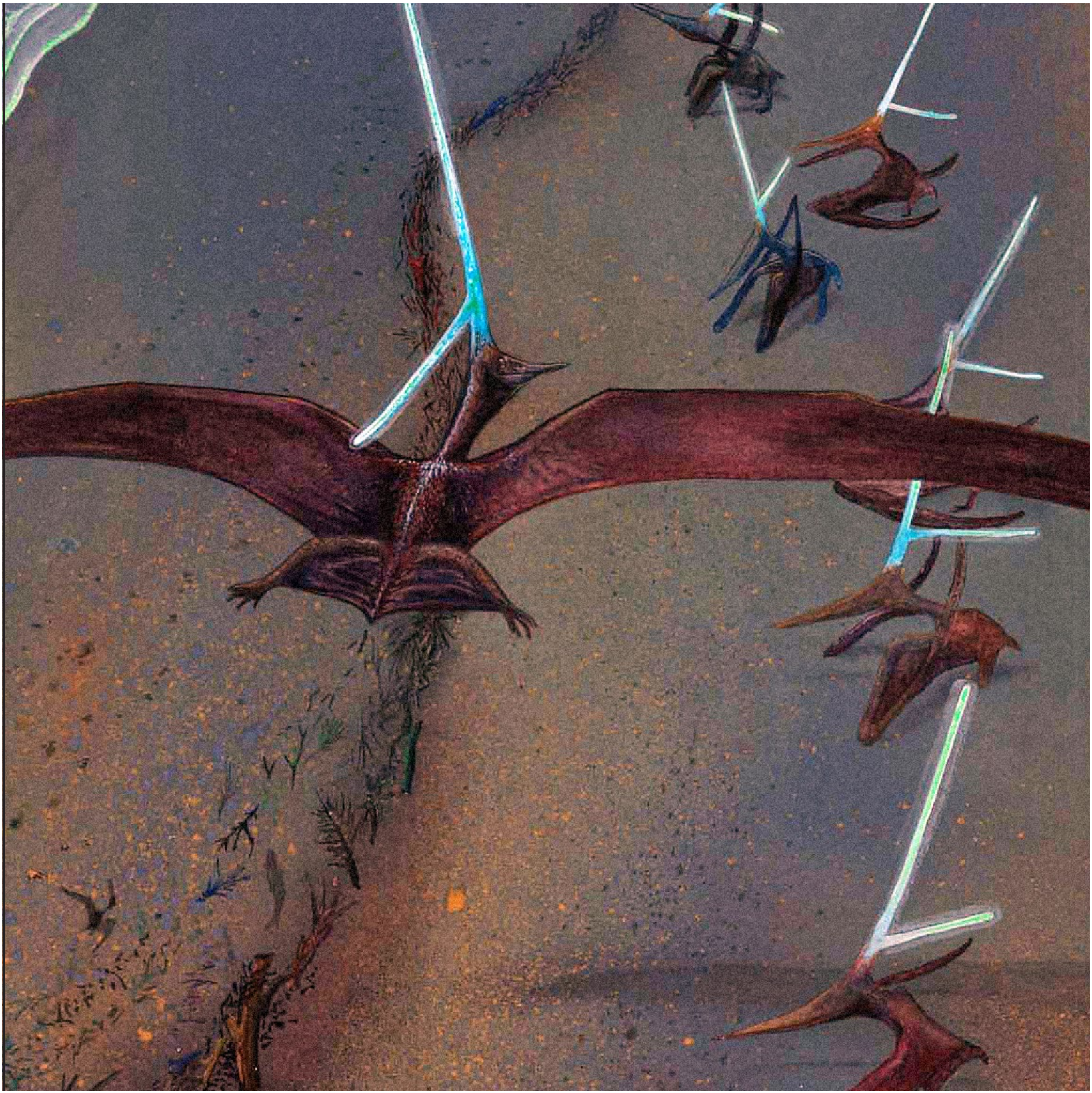
Italian palaeoartist Fabio Manucci has here illustrated *Dimetrodon* as a lazy, sleepy predator, lounging in a pond in-between bouts of hunting. Like many predators living today, the sail-backed **protomammal** must have taken plenty of hours to rest in order to conserve energy and digest its food.

Gareth Monger
Bioluminescent Nyctosaurus

This painting by UK-based palaeoartist Gareth Monger, depicting a flock of flying reptiles from the genus *Nyctoasaurus*, can be considered fairly speculative with the surreal, spear-like crests of these animals lighting up the night with bioluminescence. It might surprise you, however, to learn that the bioluminescence of their crests is the only speculative detail about the animals in this picture. The comparatively gigantic, antler-like growths on the heads of these *Nyctosauri* are all too real [1] - to the endless puzzlement of palaeontologists and palaeoartists alike.

Just what function this crest served is a topic of debate. At one time, it was believed that the two branches of *Nyctosaurus*' prong-like horn supported a sail of skin in between, and this somehow helped helped the animal in its flight. But factors such as the presence of crests only in certain individuals weigh heavily in favor of it being a feature for mating displays. *Nyctosaurus*' perplexing crest might thus be one of those exaggerated structures that evolve as a result of sexual competition. It confuses us only in hindsight, and whether it glowed in the dark or not, was actually about as ordinary as deer antlers, or the tails of peacocks.

1 Bennett, S.C. (2003). "New crested specimens of the Late Cretaceous pterosaur Nyctosaurus." Paläontologische Zeitschrift, 77: 61-75.



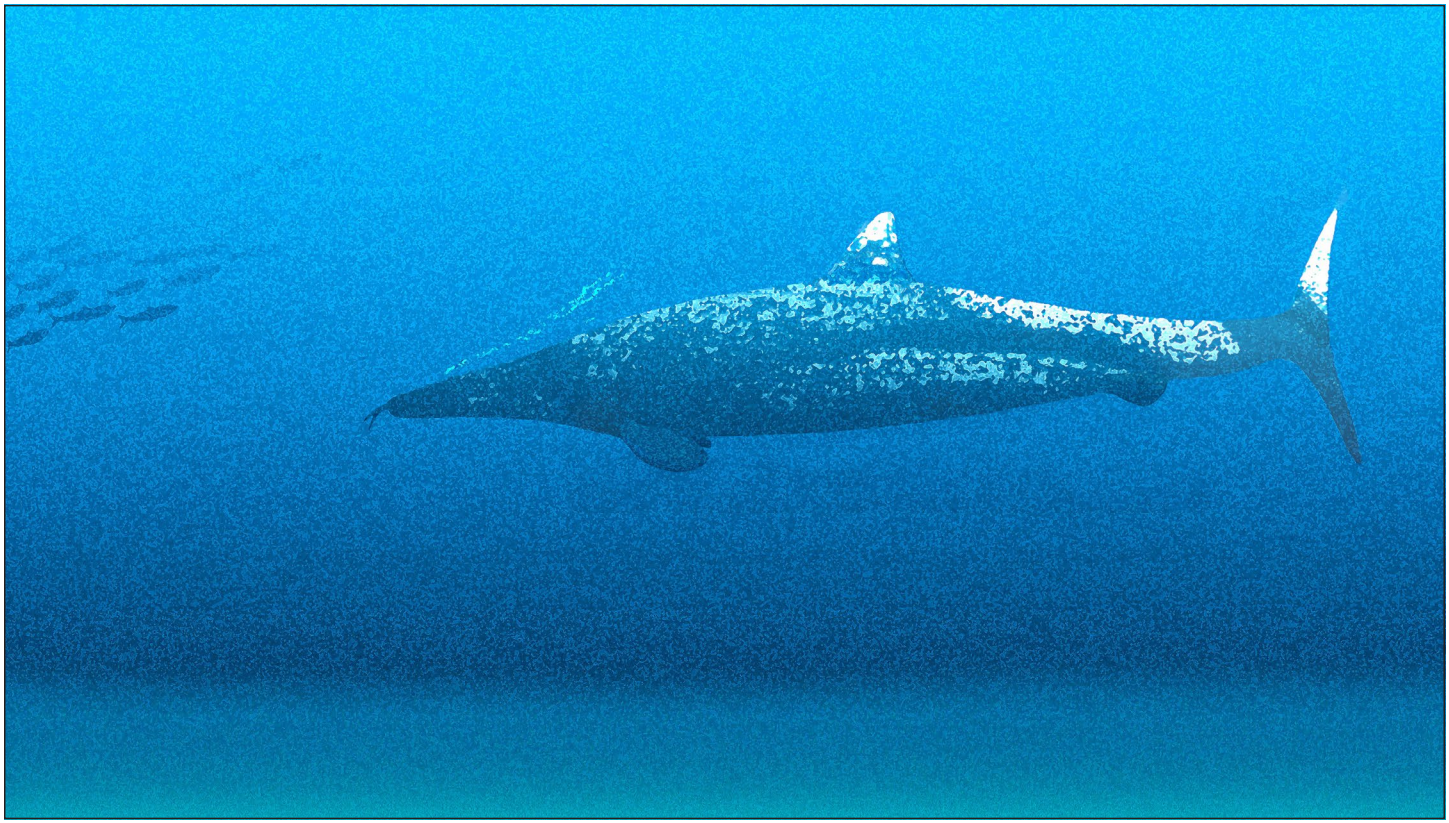
Geunhong Pius Park
Clidastes velox

This breathtakingly subtle composition was one of the best works we received for the *All Your Yesterdays* contest. It shows a **mosasaur** known as *Clidastes*, a large prehistoric marine lizard related to today's **monitor lizards**, swimming about in its daily foray in the warm, shallow seas that covered the North American continent at the end of the Mesozoic era. It is a pretty ordinary scene, but it offers a sublime new look at these extraordinary marine reptiles.

Because they were reptiles, mosasaurs were assumed to have a "shrink-wrapped" covering of muscles and skin that closely followed the contours of their bones. As a result, many illustrations of these animals resembled overgrown sea lizards with fins instead of legs. Such depictions still dominate the realm of palaeoart. However, the recent discovery [1] of a mosasaur named *Platecarpus* shows that at least some mosasaurs had fish-like flukes on their tails. This discovery led to a revision of the way we looked at mosasaurs.

The pressure of living in specialized environments such as the open sea seem to drive the development of similar features in unrelated organisms. This phenomenon is known as **convergent evolution**. Much like mosasaurs, sea reptiles known as ichthyosaurs have also evolved similar, fish-like body plans. Among mammals, whales and sirenians (the group which includes dugongs and manatees,) and pinnipeds; seals, sea lions and their kin, have independently evolved streamlined, torpedo-like bodies and stabilizing fins. Even birds have produced similar forms with penguins. With this many independent groups evolving such convergent body plans, it was perhaps naive to think that mosasaurs alone remained as finned lizards in their marine environment. Park's artwork is one of the few that depict mosasaurs in this new, lifelike interpretation.

1 Lindgren, J.; Caldwell, M.W.; Konishi, T.; and Chiappe, L.M. (2010). "Convergent Evolution in Aquatic Tetrapods: Insights from an Exceptional Fossil Mosasaur". In Farke, Andrew Allen. PLoS ONE 5 (8): e11998. doi:10.1371/journal.pone.0011998. PMC 2918493. PMID 20711249.



H. Esdaile
Tool Use in Jinfengopteryx

This spectacular artwork addresses one of the most interesting debates about dinosaurs: How intelligent were these animals? **Intelligence** and **tool-making** were once seen as exclusive gifts to mankind. Other animals were regarded as little more than instinct-driven automata. As time passed, however, signs of self-awareness and complex emotions [1] were observed in animals and this embarrassing stereotype slowly began to be discarded.

Tool-making also proved to be much more common than thought before. Crows, bears, elephants and numerous species of birds and primates, not to mention "primitive" animals like octopi were observed using and even manufacturing tools. Based on this growing body of evidence, palaeoartist H. Esdaile has speculated about tool use in dinosaurs. In his words:

*"New Caledonian crows (*Corvus moneduloides*) fashion sticks into harpoons and use them to snag tasty grubs out of holes and rotting wood. I wanted to draw a dinosaur using tools the same way, and I figured if any dinosaur was clever enough to figure it out, it would be a troodontid. So here is* Jinfengopteryx elegans*, a small troodontid from China that lived around 122 million years ago."*

1 Bekoff, M.; Jane Goodall (2007). The Emotional Lives of Animals. ISBN 1-57731-502-2.

Jaime Headden
"Giraffapteryx"

The extraordinary lineage of pterosaurs known as **azhdarchids** have been the subject of much debate in recent years. These flying reptiles were among the largest species of their group, with certain species such as *Quetzalcoatlus* and *Hatzegopteryx* growing as tall as giraffes and sporting wingspans up to 12 meters wide. Their anatomies are also unusual: azhdarchids have comparatively huge heads and very long, stiff necks made up of elongated vertebrae.

With such features, it is no wonder that much speculation has been made on these animals' lifestyles and behavior. How could such beasts move, feed and live? The debate has been long and complex, but suffice it to say that the most plausible suggestion so far has been that azhdarchids lived and fed like **gigantic quadrupedal storks.** [1]

Here, the well-known palaeoartist Jaime Headden takes things one step further and proposes that the stork-like azhdarchids may have been selectively fed on fruit and vegetation, emulating giraffes as they used their extraordinary long necks to browse in trees.

This work is also a homage to the 1980s book, *The New Dinosaurs*.[2] Portraying animals from a world where dinosaurs did not become extinct, *The New Dinosaurs* featured a flightless, giraffe-mimicking pterosaur known as the Lank. While most animals in the book seem severely outdated or erroneous in the light of our contemporary understanding, the Lank has stood the test of time surprisingly well.

1 Witton, M.P., and Naish, D. (2008). "A Reappraisal of Azhdarchid Pterosaur Functional Morphology and Paleoecology." PLoS ONE, 3(5): e2271. doi:10.1371/journal.pone.0002271

2 Dixon, D. 1988. The New Dinosaurs: An Alternative Evolution. Salem House Publishers, Topsfield, MA.

Jessica Pilhede
Whiskered Albertonykus

Even the average person knows that dinosaurs came in a variety of different lineages. There are the long necked sauropods, the terrifying tyrannosaurs, the horn-faced ceratopsians and so on. But there are also numerous groups of **little-known dinosaurs** that are just as intriguing as their larger, more popular relatives.

Albertonykus belongs to one such group, a clade of dinosaurs known as the **alvarezsaurs**, characterized by their long legs and extraordinarily thick, short arms which sported only one finger each. Just how these limbs functioned has been a matter of debate. One recent theory suggests that they lived like **dinosaurian anteaters**, digging out ant or termite nests with their strong arms and eating the insects with their toothless beaks. However this conclusion is not certain and the possibility remains that their arms were used for a completely different purpose.

In this image, palaeoartist Jessica Pilhede approaches the riddle of alvarezsaur lifestyles with a novel approach. She imagines them much like kiwi birds, (*Apteryx* sp.) forest-floor dwellers with thick, fur-like protofeathers and whisker-like filaments on their faces. They don't use their arms for any specialized purpose. Instead, these organs have been maintained much like the stunted wings of flightless birds, bearing no specific advantage or detriment to their owners.

John Conway
Balloon-Headed Allosaurus

Celebrated palaeoartist and **Irregular Books co-founder** John Conway also participates in this collection with a selection of works that were created after the origial All Yesterdays volume.

Here, two *Allosaurus* males are gesturing to each other with, balloon-like air bladders emerging from the top of their heads. Conway has observed *Allosaurus* skulls and was intrigued by the **presence of holes on the top surface.** Taking into account the levels of **pneumaticity**, the spread of air sacs inside the body in large theropods, he has interpreted the holes as the basis of inflatable display sacs.

John Conway

Giraffatitan brancai
at the Mudbaths

In a spectacular, never-before-seen rendition of what he calls "*the best dinosaur*," Conway shows the long-necked, giant herbivore *Giraffatitan*, also known as *Brachiosaurus*, enjoying a fine day with a group of friends. There are literally thousands of renditions of this animal, but Conway has made this particular one more interesting and more memorable than most.

These mud-bathing Giraffatitan look nothing like the stock image of the sideways-viewed, thin necked, **shrink wrapped** versions we have been used to! Their necks are sleeved with **giant, inflatable sacs** that help them keep cool and the male has a highly-conspicious orange sac, complete with a much deeper neck. A ring of thorn-like spines, derived from the **protofeathers** of their earliest ancestors, tops its head like a mighty, surreal crown.

John Conway also uses this artwork to showcase his thoughts on a particular debate about **dinosaurian resting postures.** Recently, debates over how large dinosaurs rested took place between different palaeontologists and palaeoartists, mostly on online forums. One side suggested that dinosaurs could lay down on their sides like large mammals today, while another school suggested that they adopted a crouching posture like **birds**. Here, Conway points out the artificial nature of this debate by showing his *Giraffatitan* in both postures, crouching **and** lying down.

Conway's subtle commentary hints that many other such "debates" in palaeontology have unnecessarily become black-or-white pictures due to scientists supporting opposing views as unshakable cornerstones of their careers. In nature, things rarely exist in black- or-white; usually both answers, or **something completely different** may be correct.

John Meszaros
"Ceticaris"

In this extraordinary artwork, artist John Meszaros tackles one of the most interesting epochs in the evolution of life, the **Cambrian period**. Taking place long before the age of the dinosaurs, approximately from 541 to 485 million years ago, the Cambrian was the first time when reasonably large, hard-bodied organisms diversified in the planet's oceans. Animals that evolved in this period included the first ancestors of vertebrates and the great arthropod lineages, but also certain forms which seem very different from anything living today.

One such example was *Anomalocaris*, [1] a gigantic predator for its time. About as big as a cat, this animal bore large, well-developed eyes, a series of frond-like fins, two crushing, jaw-like appanages that lined the front section of its body and a mouth composed of serrated plates arranged in an overlapping, circular pattern. These unusual organs were first discovered as disarticulated fossils, and each was mistaken to be a separate creature. The jaw-like limbs were thought to be crayfish-like arthropods, the body was thought to be a big, sea-cucumber-like organism and the circular mouth was mistaken for a jellyfish. Only later did researchers realize the error, and correctly identified *Anomalocaris* as a large swimming predator.

This artwork does not depict *Anomalocaris*, but instead a speculative, filter-feeding relative which the artist has dubbed "*Ceticaris*." In the past, there was a trend of portraying the Cambrian as too much of an alien period, full of unique and freakish "new phylums." [2] While it is true that many Cambrian animals were quite different from the forms alive today, they now seem to be distantly related, not alien to, the major groups of animals such as arthropods, echinoderms, etc. today. The discovery of Cambrian-era fossils in China have revealed that even extraordinary species such as *Anomalocaris* were not one-off "experiments," but parts of distinct and consistent lineages. Therefore, John Meszaros imagines that the anomalocarid famil tree may have included filter-feeding representatives as well.

This artwork is also distinct in that it depicts the imaginary (but completely plausible) *Ceticaris* with a host of **commensal organisms.** Primitive fluke-like vertebrates swim after it for morsels of food, and derived echinoderms, very distant cousins of today's starfish, cover its body like red barnacles. Less familiar organisms are also tagging along with *Ceticaris* for the ride. The animal's underside is colonized by orange, frond-like **vendozoans** and tiny, five-eyed, shrimp-like **opabinids** dwell among them. Small, tadpole-like animals from a group called **vetulicolians** attach to *Ceticaris*' carapace like prehistoric remoras. All in all, Meszaros has depicted a colorful, congruent riot of life instead of a procession of Lovecraftian "freaks." Just because it was ancient did not mean that the Cambrian period had to be devoid of sophisticated ecosystems.

2017 Update:
This artwork is now one of the proudest pieces in this collection. In 2014, a year after the first edition of **All Your Yesterdays**, a filter-feeding anomalocarid with mouthparts resembling that of "*Ceticaris*" was actually discovered in North Greenland.[3] The animal was named *Tamisiocaris* by its discoverers, and its subfamily was named **Cetiocaridae** in honour of this very artwork.

1 Whittington, H.B.; Briggs, D.E.G. (1985). "The largest Cambrian animal, Anomalocaris, Burgess Shale, British Columbia". Philosophical Transactions of the Royal Society of London B. 309 (1141): 569–609. doi:10.1098/rstb.1985.0096.

2 Gould, Stephen Jay (1989). Wonderful life: the Burgess Shale and the nature of history. New York: W.W. Norton. pp. 194–206. ISBN 0-393-02705-8.

3 Jakob Vinther, Martin Stein, Nicholas R. Longrich & David A. T. Harper (2014). "A suspension-feeding anomalocarid from the Early Cambrian". Nature. 507: 496–499. PMID 24670770. doi:10.1038/nature13010.

The Art of Joschua Knuppe

Already dubbed a "Teutonic master of palaeoart", German palaeoartist Joschua Knuppe is one of the most accomplished young palaeo-artists of the decade. His artwork, executed digitally or with color pencils and gouache on paper, depicts such vivid and believable creatures that one wonders if Knuppe's visions come from actual glimpses of the fossil past. Beyond pure artistry, Knuppe also stands out in showing the animals' behavior as realistically as their forms, which deviate refreshingly from the tropes we've grown accustomed to as a generation. Needless to say, we migwht expect to see more of this young artist's work in the future.

Knuppe has participated in *All Your Yesterdays* with a diverse selection of scenes, each depicting a different species from the past, in a new perspective.

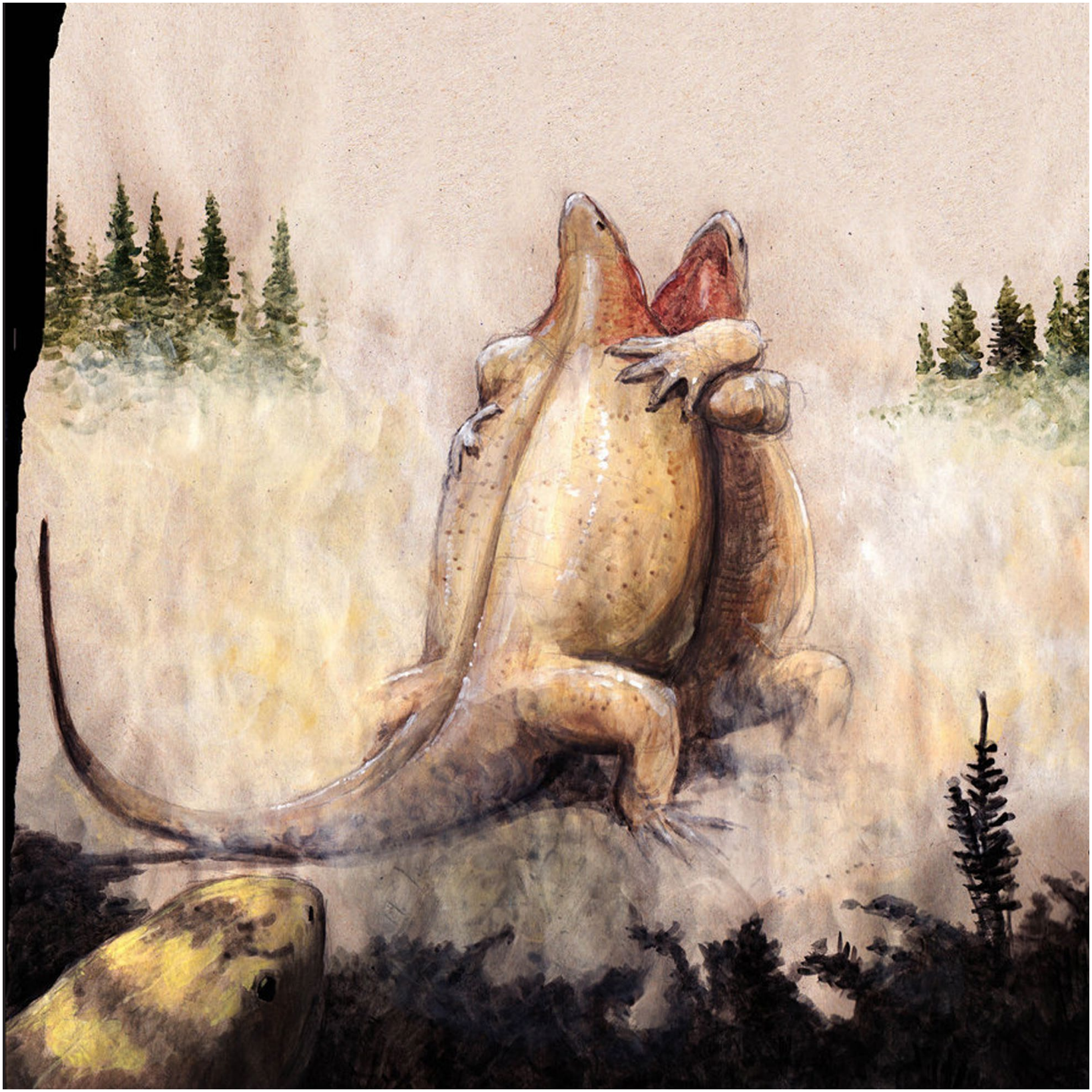
Dueling Cotylorhynchus ▶

Growing over six meters long with enormous bodies, massive limbs and tiny heads, the **mammal-like reptiles** known as **caseids** were doubtless some of the most comical animals to ever walk the Earth. Here, two of the largest caseids, of a species known as *Cotylorhynchus*, engage in a clumsy, sumo-like wrestling match for social dominance while a female watches them with interest. *Cotylorhynchus* and relatives lived in the **Permian** period, long before the appearance of the first dinosaurs.

Protoceratops *in Snow* ▼

The horn-faced dinosaurs known as **ceratopsians** had a remarkable image revision after the recent discovery of hair-like integument on the tail of an ancestral form. [1] Knuppe has extrapolated from this discovery and has illustrated *Protoceratops*, one of the most familiar ceratopsians, entirely covered with fur-like body hairs. On top of this, he has also shown it walking bipedally across a cold, snow-covered landscape. The result looks strikingly alien, yet it is no less plausible than the traditional image of *Protoceratops* as a naked, quadrupedal reptile in a desert.

1 Mayr, Gerald, Peters, D. Stephan, Plodowski, Gerhard & Vogel, Olaf. (2002). Bristle-like integumentary structures at the tail of the horned dinosaur Psittacosaurus. Naturwissenschaften 89: 361–365.



Masiakasaurus knopfleri

Masiakasaurus is an extraordinary meat-eating dinosaur from the Late Cretaceous period of **Madagascar**. This animal is famous for its jaws, which are lined at the tips with long teeth that project outwards. Many reconstructions of this animal exaggerate these features, but in real life teeth as long as Masiakasaurus' would be protected by oral tissues and consequently be less prominently visible. Thus, Knuppe has restored Masiakasaurus as a more conventional, bird-like dinosaur instead of a snaggle-toothed monster.

Nanshiungosaurus: *A Mesozoic Moose*

Here, the large therizinosaur known as *Nanshiungosaurus* is seen having a perfectly ordinary day as it wades through a swamp, browsing for food and keeping its young safe on its back. **Therizinosaurs** were bird-like members of the meat-eating dinosaur lineage known as **theropods**. Unlike many theropods, they had adapted to a **herbivorous diet.** Portraying dinosaurs as "ordinary" animals is one of the hardest tasks in palaeoart, and Joschua Knuppe has done a masterful job with this portrait of *Nanshiungosaurus*.

Epidexipteryx *Burrows*

We know from previous pages that the long-fingered, bird-like dinosaurs known as **scansoriopterygids** might have been specialized for a climbing life. Conventional wisdom assumes these animals were tree-climbers, but what if they lived in a different environment? Here, a few *Epidexipteryx* are seen nesting in burrows constructed in a rocky canyon wall.

Can You Recognize Hesperonychus?

Able to form a myriad different crests, patterns and colors, **feathers** are a very versatile form of body covering. Most dinosaur artists thoroughly underestimate the visual potential offered by feathers. Even bird-like reconstructions of dinosaurs shy away from extreme crests, wings or tail feathers, opting mostly for a contour-hugging outline that immediately gives away the skeletal details of the animal.

In real life, things may not have been so easy to tell. Can you recognize this portrait as *Hesperonychus*, a smaller relative of *Velociraptor*? Possibly not. The animal's characteristic muzzle is almost completely obscured by a circular crest of feathers. Many animals in the past possibly had such striking integument, and Joschua Knuppe thinks that palaeoartists can afford to be more daring in their portrayal of feathered dinosaurs.

Tasty Soil

A bird-like dinosaur known as *Incisivosaurus* is engaging in what at first seems to be an unusual act - it's using its chisel-like teeth to eat soil from a hillside. The act of eating soil, clay, rocks or other minerals is known as **geophagy** and is not as uncommon as one might believe. In today's world many animals, especially birds, ingest earthy substances to obtain vital minerals such as calcium and sodium.

Dinosaurs would not have been much different in their need of mineral supplements.

Shuvuuia deserti

Current reconstructions of bird-like dinosaurs dress them up with bird-like feathers, but for some reason the avian attire abruptly stops at the animals' heads, which are still drawn in a reptilian manner. It's as if the illustrators, no matter how modern, are still stuck to the old template of dinosaurs as reptiles, at least when it comes to their faces. Here, Joschua Knuppe breaks this tradition by portraying *Shuvuuia deserti*, a one-fingered **alvarezsaur**, in a complete covering of bird-like feathers. It looks like an ordinary bird, but then again, perhaps most dinosaurs did so as well.

Dust Bath

A lot of animals, especially birds, like to roll around in sun-baked dust in order to clean themselves and get rid of parasites. This *Struthiomimus* is following suit by cleansing its feathers in a similar manner.

Projectile Defence

No matter how complete, fossils almost never preserve the **behaviors** of extinct animals. Even "ordinary" dinosaurs could have had extraordinary defense mechanisms. Here, Joschua Knuppe speculates on *Heterodontosaurus*, one of the early plant-eating dinosaurs, defending itself from predators with a **jet of foul-smelling feces.**

Beipiaosaurus

A wary *Beipiaosaurus* is here seen scanning its surroundings as it feeds on plants. *Beipiaosaurus* was one of the earliest **therizinosaurs**, a lineage of feathered, bird-like dinosaurs famously known from gigantic, long-clawed species like *Therizinosaurus*. At slightly less than two meters long, *Beipiaosaurus* was nowhere as large. Nevertheless, it caused quite a stir in palaeontological circles because at the time of its discovery, Beipiaosaurus was **one of the largest dinosaurs preserved with a feathery integument.** [1]

1 Xu, X., Tang, Z-L., and Wang, X-L. (1999). "A therizinosauroid dinosaur with integumentary structures from China." Nature, 399(6734): 350-354.

A Violent Game

Play behavior is an important part of many animals' lives. Here, Joschua Knuppe illustrates a dinosaur at play to challenge conventional ideas about dinosaurian predators and prey. In this painting, a herbivorous *Edmontosaurus* is playing with a dead juvenile *Albertosaurus*, (a relative of the famous *Tyrannosaurus*,) tossing its body about.

The *Edmontosaurus* may even eat the little predator's corpse after it has had its fun. Occasional animal prey might have featured in the giant herbivore's menu for extra helpings of mineral and protein. In today's world, there are similar cases of cows and deer eating chickens, bird nestlings, dead squirrels and other animals. Once again, our familiar concepts of predator, prey, hunter and the hunted are not as clearly defined in nature.

A Sleeping Trinisaura

There is a recursive pattern to certain hypotheses in the world of palaeontology. A case to the point is **arboreality**, tree-living, in small dinosaurian herbivores. In the beginning of the century, a tree-living way of life was proposed for small, plant eating dinosaurs known as **hypsilophodonts**. [1] This idea was based on the structure of their feet, which was seen more or less like that of perching birds. Indeed, the entire group that included hypsilophodonts was named **ornithopoda**, or bird-feet. Later on, however, this idea was discredited and ornithopod feet were understood to be adapted for walking and running over firm ground.

As we look more into nature, however, it becomes apparent that not all animal behavior can be discerned from the anatomy of their bones. Even if their feet were not adapted for perching, it is not implausible that some ornithopods may have sought refuge in trees. To illustrate this point, Joschua Knuppe has painted the small ornithopod known as *Trinisaura*, sleeping in a tree. *Trinisaura* is also one of the few dinosaur species known from Antarctica. [2]

1 Abel, O., 1912, Grundzüge der Palaeobiologie der Wirbeltiere, E. Schweizerbart'sche Verlagsbuchhandlung Nägele und Dr Sproesser, Stuttgart

2 Coria, R. A.; Moly, J. J.; Reguero, M.; Santillana, S.; Marenssi, S. (2013). "A new ornithopod (Dinosauria; Ornithischia) from Antarctica". Cretaceous Research. doi:10.1016/j.cretres.2012.12.004.

Live-Birthing Drepanasaur

With lizard-like bodies, very muscular arms and fragile, bird-like heads, the reptiles known as **drepanosaurs** were among the strangest animals in history. It is thought that their lives may have been convergent with those of chameleons; drepanosaurs may have lived by clinging to branches and snapping up small insect prey with their long necks and delicate heads.

Here, artist Joschua Knuppe adds another twist into the drepanosaur lifestyle mystery, and speculatively portrays one giving **live birth** as it dangles from a branch with its prehensile tail.

Live-Birthing Hesperornis

In this picture, we see the prehistoric marine bird known as *Hesperornis* in a rather unlikely act; **it's giving live birth!** The possibility of dinosaurs and kin bearing live ofspring has been considered before, for dome-headed dinosaurs known as **pachycephalosaurs**, sea-going crocodiles, large, herbivorous **sauropod** dinosaurs and the *Hesperornis* shown here. So far, however, there are no confirmed fossils that suggest dinosaurs or their relatives may have given birth rather than laying eggs. This may be so because dinosaur and bird embryos depend on their eggshells as a vital calcium reservoir during development. [1]

Live-bearing or not, *Hesperornis* was one of the most extraordinary animals in the Mesozoic seas. With practically no front limbs, it relied on its powerful legs for swimming. Its mouth contained teeth alongside a keratinous beak. Hesperornis and relatives all became extinct at the end of the age of dinosaurs.

1 Packard, G. C., Tracy, C. R. & Roth, J. J. 1977. The physiological ecology of reptilian eggs and embryos, and the evolution of viviparity within the class Reptilia. Biology Review 52, 71-105.

Nemicolopterus *Nests*

Here, we see a *Nemicolopterus*, one of the smallest known pterosaurs, nesting in an extraordinary location - the back of an armored sauropod dinosaur known as *Saltasaurus*.

Artist Joschua Knuppe speculates that the nest would be cemented on top of one of the bony nodules covering the back of the animal, and would be strengthened with a mixture of mud and saliva. The constant movement of the large animal could have made this arrangement unlikely, but it could work if the pterosaurs only occupied this "nest" temporarily.

Caviramus *and the Frog*

This splendidly naturalistic illustration depicts *Caviramus*, a primitive pterosaur known from the late Triassic period of **Switzerland**, impaling its amphibian prey onto branches, much like shrikes (*Laniidae,*) living today.

Pterosaurs, having no modern relatives, are often portrayed as outlandish organisms. One particular trope is the desire to show every bone, joint and digit in the pterosaurs' long, finger-derived wings. In this artwork, the wings present a smooth outline and their structure is not easy to discern at first glance. Joschua Knuppe's illustration is thus a welcome departure in its subtle, un-exaggerated depiction.

A Climbing Mosasaur

Pannoniasaurus is a mosasaur, from a lineage of large, prehistoric marine lizards that also includes the *Clidastes* illustrated on the previous pages. *Pannoniasaurus* was unique among its relatives because so far, it is the only mosasaur known to have lived in freshwater. [1]

Artist Joshua Knuppe has seized this point to raise another speculation. He suggests that the young of *Pannoniasaurus* may have retained their clawed hands and feet, and used them to exit water, be it in order to escape from predators or to disperse to other rivers, lakes and lagoons. As they grew, the animals' digits would disappear and their clawed limbs would slowly turn into streamlined paddles.

This idea, of course, is entirely speculative but similar phenomena exist among animals living today. The hatchlings of Hoatzin birds (*Opisthocomus hoatzin*) still retain claws on their hands, and use them to climb branches. As they grow the claws disappear and the hands gradually change into wings.

1 Makádi, L. S.; Caldwell, M. W.; Ősi, A. (2012). "The First Freshwater Mosasauroid (Upper Cretaceous, Hungary) and a New Clade of Basal Mosasauroids". In Butler, Richard J. PLoS ONE 7 (12): e51781.

Umoonasaurus

Dinosaurs shared their world with a diverse host of **marine reptiles.** We picture all these animals as sea-dwellers, but certainly some must have adapted to estuarine, if not freshwater habitats in the 186 million-year-span of the Mesozoic era. In today's world, dolphins, marine mammals, have given rise to different freshwater species in the rivers of Asia and South America. Artist Joshchua Knuppe has here decided to portray a species of marine reptile, *Umoonasaurus*, as a **freshwater-living form**. Unlike its sleek, streamlined marine relatives, Knuppe's *Umoonasaurus* has a cryptic body shape evolved to hide in riverbeds and marshlands. Fast pursuit in open waters is no longer its forte. It has another adaptation for freshwater life in its tongue; the organ shaped like a worm in order to lure in inquisitive prey animals.

Umoonasaurus belonged to a group of marine reptiles called **leptocleididae**, some members of of which seem to be specialized for a freshwater lifestyle. [1] As a result, the portrayal of *Umoonasaurus* as a river-dweller may not be entirely speculative.

1 Kear, B. P. & Barrett, P. M. 2011. Reassessment of the Early Cretaceous (Barremian) pliosauroid Leptocleidus superstes Andrews, 1922 and other plesiosaur remains from the nonmarine Wealden succession of southern England. Zoological Journal of the Linnean Society 161, 663-691.

Julio Lacerda
Taboo

Talented palaeoartist Julio Lacerda, known for his photorealistic compositions of birdlike dinosaurs, presents us here with a thought-provoking picture that is only "taboo" for people, and only certain people at that. His artwork depicts a **homosexual couple** of bird-like dinosaurs known as **caenagnathids**.

Lacerda explains; *"Same-sex copulation, bonding and parenting is well-documented in many animals, especially birds and mammals. The exact reason why these behaviour exists... is not really known. But it is much more common in nature than most people would think, with unusually high rates of homosexual pairing in species like giraffes, bonobos, ducks and penguins. In certain cases it even leads to the adoption and successful raising of surrogate offspring by such couples.* [1]

In my work, a male pair of caenagnathid oviraptorosaurs are engaging in mutual courtship - something that would definitely not be preserved in the fossil record. Their colouration is inspired by black swans, 25% of whose pairings are male to male. [2]*"*

1 Eric Silver (2 August 1999). "Gay vulture couple raise surrogate chicks". London: The Independent News. Retrieved 2009-09-21.

2 Braithwaite, L. W., 'Ecological studies of the Black Swan III – Behaviour and social organization', Australian Wildlife Research 8, 1981: 134-146.

Lew Lashmit
"Georgosaurus"

In the history of palaeontology, there are certain fossils which, through their sheer strangeness, have led to wildly different theories about their origin and the way they looked in life. A classic case is that of *Therizinosaurus*, known only from a set of forearms with **claws that were almost a meter long**.

Many theories have been proposed to explain the true identity of these animals. They were seen as turtle-like reptiles, [1] enormous predatory dinosaurs that tore plant eaters' bellies open, late-surviving cousins of the earliest, long-necked **prosauropod** dinosaurs, or to a lineage of dinosaurs completely unique unto themselves. In the end, however, more fossils and discoveries of related species led to a picture of *Therizinosaurus* as a large, bird-like theropod dinosaur with extraordinarily long claws. It was most possibly a herbivore with a long neck and a small head.

This "retro" illustration by Lew Lashmit, however, is not about our current interpretation of *Therizinosaurus*. Purposefully executed in a cold-blooded 1950s - 60s style, it is a delightful, tongue-in-cheek speculation about *Therizinosaurus* as a **farming dinosaur** that used its claws to plough the soil, and plant and harvest root-like tubers.

Clearly, this interpretation has nothing to do with reality, but it does not stop Lasmhit's artwork from being thought-provoking. *Therizinosaurus* was surrounded by over-the-top theories from the day it was discovered. Clearly, a farming dinosaur is no less ridiculous than a giant turtle-beast, or a Freddy Kruger-like slasher as was proposed back in the day.

1 Maleev, E.A. (1954). "New turtle–like reptile in Mongolia [in Russian]." Priroda, 1954(3): 106–108.

Michael Hanson
A Diving Rhamphorhynchus

With its rudder-tipped tail, short beak and needle-like teeth, *Rhamphorhynchus* is one of the most familiar pterosaurs, second only to the crested *Pteranodon* in the public eye. This animal is mostly portrayed as a bat-like flyer, clinging to branches and rocks and soaring around seaside landscapes. Here, however, Michael Hanson has speculatively illustrated it in an unfamiliar ecological role - this *Rhamphorhynchus* is adapted for aquatic life as a diver.

The idea of pterosaurs as aquatic, as opposed to aerial, animals is not a new one. In the 1830s, German scientist Johann Wagler interpreted them as **marine animals**, and allied them together with a mismatched crew of marine reptiles and monotremes, the group that includes echidnas the duckbilled platypus, in a unique class of animals known as **Gryphi*!*** [1] To Wagler, this group occupied a unique position between mammals and birds.

As funny as aquatic pterosaurs seem to us now, there might be reasons to think things twice, at least about *Rhamphorhynchus*. In today's ecosystems, birds such as penguins, cormorants, auks, or diving-petrels have adapted numerous times for aquatic life. Many fossils of *Rhamphorynchus* were found in marine deposits. There are even instances of *Rhamphoryncus* preserved together with large, gar-like fish that were trying to eat them. [2] Conventional theories suggest the flying reptiles fell into the sea after dying, but perhaps the *Rhamphorhynchi* were actually swimming in the Jurassic seas when they perished.

1 Wagler, J. (1830). Natürliches System der Amphibien Munich, 1830: 1–354.

2 Frey, E.; and Tischlinger, H. (2012). "The Late Jurassic pterosaur Rhamphorhynchus, a frequent victim of the ganoid fish Aspidorhynchus?". PLoS ONE 7 (3): e31945. doi:10.1371/journal.pone.0031945.

Mike Keesey
Texan Mama: Dimetrodon

Dimetrodon, the familiar, **sail-backed** cousin of mammals, is usually portrayed as a lizard-like beast. The fact that it is related to mammals is overshadowed by its more "reptilian" features such as the sprawling limbs and the unusual sail of skin. But what if mammalian characteristics such as a moist skin full of sweat glands, appeared earlier on in mammal evolution than we think? If this was indeed the case, then *Dimetrodon* would not have looked like a reptile at all. Artist Mike Keesey explains:

"In this piece, I have pushed the origin of fur and milk back to an extremely early time - Dimetrodon *is one of the furthest stem-mammals from mammalia proper. While we know that a later stem-mammal,* Estemmenosuchus*, had glandular skin without any sign of fur, (1) it is possible that fur evolved earlier and was simply lost or reduced in some lineages, as it has been in many placental mammals today.*

I have also posited parental feeding, but not, strictly speaking, lactation. Other animal groups, including caecilians and pigeons, have evolved ways of feeding the young from foodstuffs produced by the mother. This mother Dimetrodon's *sides are swollen with nutritious substances which seep out as her pups gobble it up.* ***Is it milk?*** *Sort of and sort of not."*

Mike Keesey
A Siberian Denisovan

The Denisova hominin, or "**the Denisovan**," is one of the most enigmatic chapters in the story of human evolution. Known from a few fragmentary bones from the Denisova caves in Siberia, it preserves a DNA trace that is distinct both from modern people, *Homo sapiens,* and the closely-related neanderthals, *Homo neanderthalensis.* [1] Before the Denisova discovery, us and the neanderthals were thought to be the only major groups of humans in the ice-age world. Now, it seems that a **distinct third sub-species** also existed.

It is a pity that only finger and toe bones are left from this puzzling lineage of human beings. This lack of remains is frustrating, but it also opens up room for speculation. Mike Keesey elaborates on what our distant cousin might have looked like, and their attitudes towards *Homo sapiens*.

*"Here I've imagined a Siberian Denisovan as a sort of "*polar Neandertal*". As with polar bears, his skin is dark, trapping heat, but his pelage is light, allowing for camouflage against the taiga and tundra. He is the last of his kind - his southern kin mixed with the strange, baby-faced people who keep invading from the west..."*

1 Krause, Johannes; Fu, Qiaomei; Good, Jeffrey M.; Viola, Bence; Shunkov, Michael V.; Derevianko, Anatoli P. & Pääbo, Svante (2010), "The complete mitochondrial DNA genome of an unknown hominin from southern Siberia", Nature 464 (7290): 894–897, doi:10.1038/nature08976, PMID 20336068.

Mitchell Seymour

Diplocaulus, *an Amphibian Stingray*

Mitchell Seymour's naive and vivid, cartoon-like artwork was a great addition to this book. Combining reasonable speculation with a sense that prehistoric animals don't need to be portrayed as photorealistic figures or "gritty" monsters, they encourage the viewer to look at extinct life in a new perspective.

Here, the boomerang-headed prehistoric amphibian *Diplocaulus* is seen hiding at the bottom of a lagoon, inconspicuous and safe. Most reconstructions of *Diplocaulus* aim to highlight its strangely-shaped head for a bizarre "wow" factor. In doing so, however, they negate any details about how it lived and how these organs were used in life. The organism is disconnected from its ecological and evolutionary setting, and is reduced to a freak-show specimen.

This artwork doesn't show *Diplocaulus*' wing-like head flanges, but it does give the viewer an idea about how its strange anatomy may have helped it in life. For Seymour, the skull flages help the animal burrow into the seafloor sediment. If one was able to travel to the past, chances are they would be more likely to see *Diplocaulus* this way, rather than with its skull plainly visible for everyone to see.

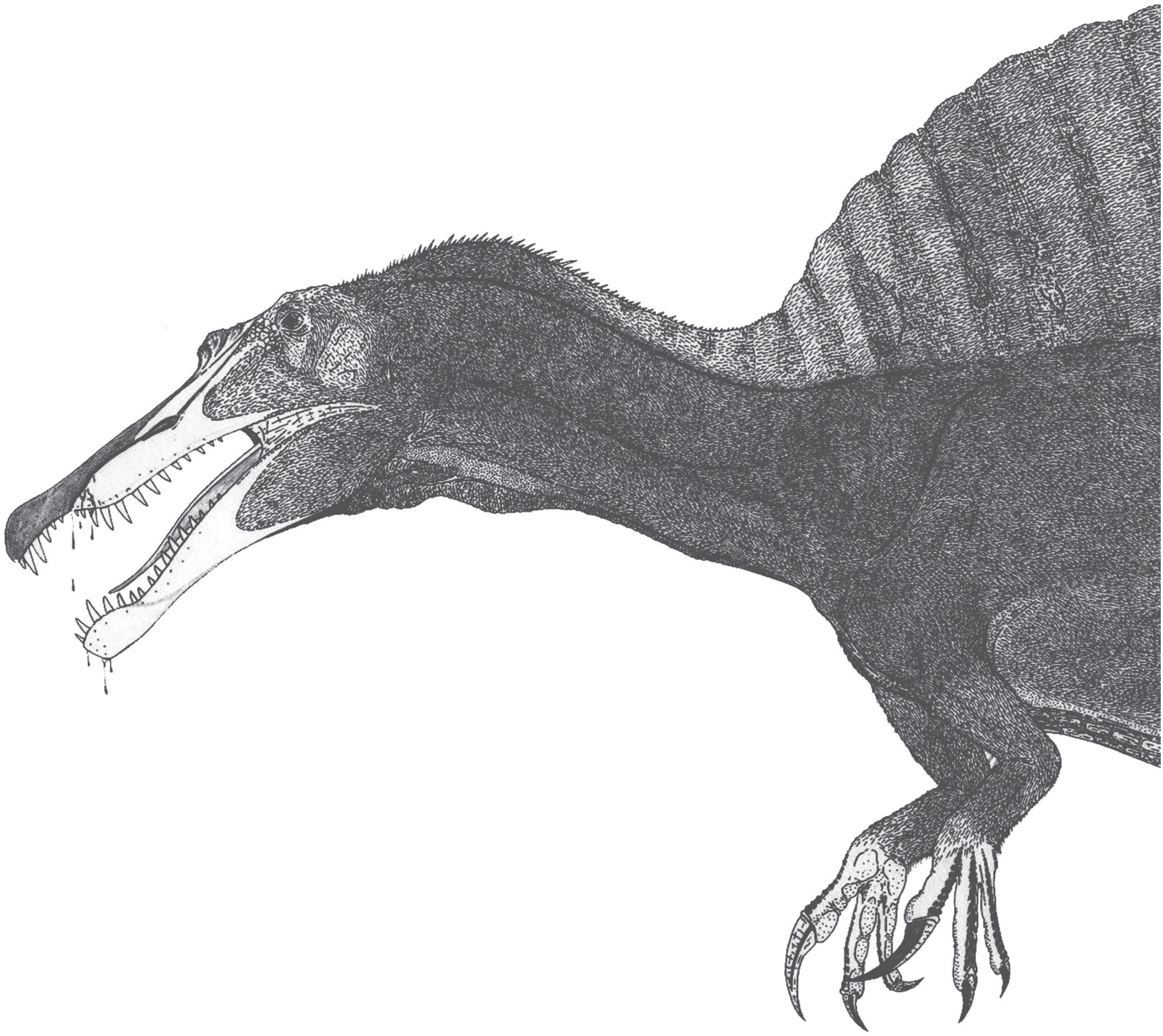
Miyess Mitri
A Feathered Spinosaurus

Out of all the meat-eating dinosaurs, the superficially crocodile-like **spinosaurs** proved to be the most resistant, in the mind's eye, to the "**feathering**" brought about by new discoveries of dinosaurian integument. One can easily imagine bird-like *Velociraptors* and even the famous *Tyrannosaurus rex* covered in feathers, but it is difficult to mentally picture the extraordinary spinosaurs with plumage.

Here, artist Miyess Mitri has attempted to visualize feathers on a spinosaur. Instead of contour-inflating plumage, it is covered with a dense layer of short, bristle-like feathers, much like the ones we see in penguins today.

Why is this so? Because there is a distinct possibility that spinosaurs may have **spent most of their time in aquatic environments.** A recent comparison of oxygen isotopes from spinosaur bones has revealed that these animals' isotope ratios are closer to habitually aquatic organisms such as sea turtles and crocodiles. [1] If they spent a lot of time swimming, it would make sense for the enigmatic spinosaurs to have supported a coat of hydrodynamic, insulating fibers.

1 Amiot, R.; Buffetaut, E.; Lécuyer, C.; Wang, X.; Boudad, L.; Ding, Z.; Fourel, F.; Hutt, S.; Martineau, F.; Medeiros, A.; Mo, J.; Simon, L.; Suteethorn, V.; Sweetman, S.; Tong, H.; Zhang, F.; and Zhou, Z. (2010). "Oxygen isotope evidence for semi-aquatic habits among spinosaurid theropods". Geology 38 (2): 139–142. doi:10.1130/G30402.1.



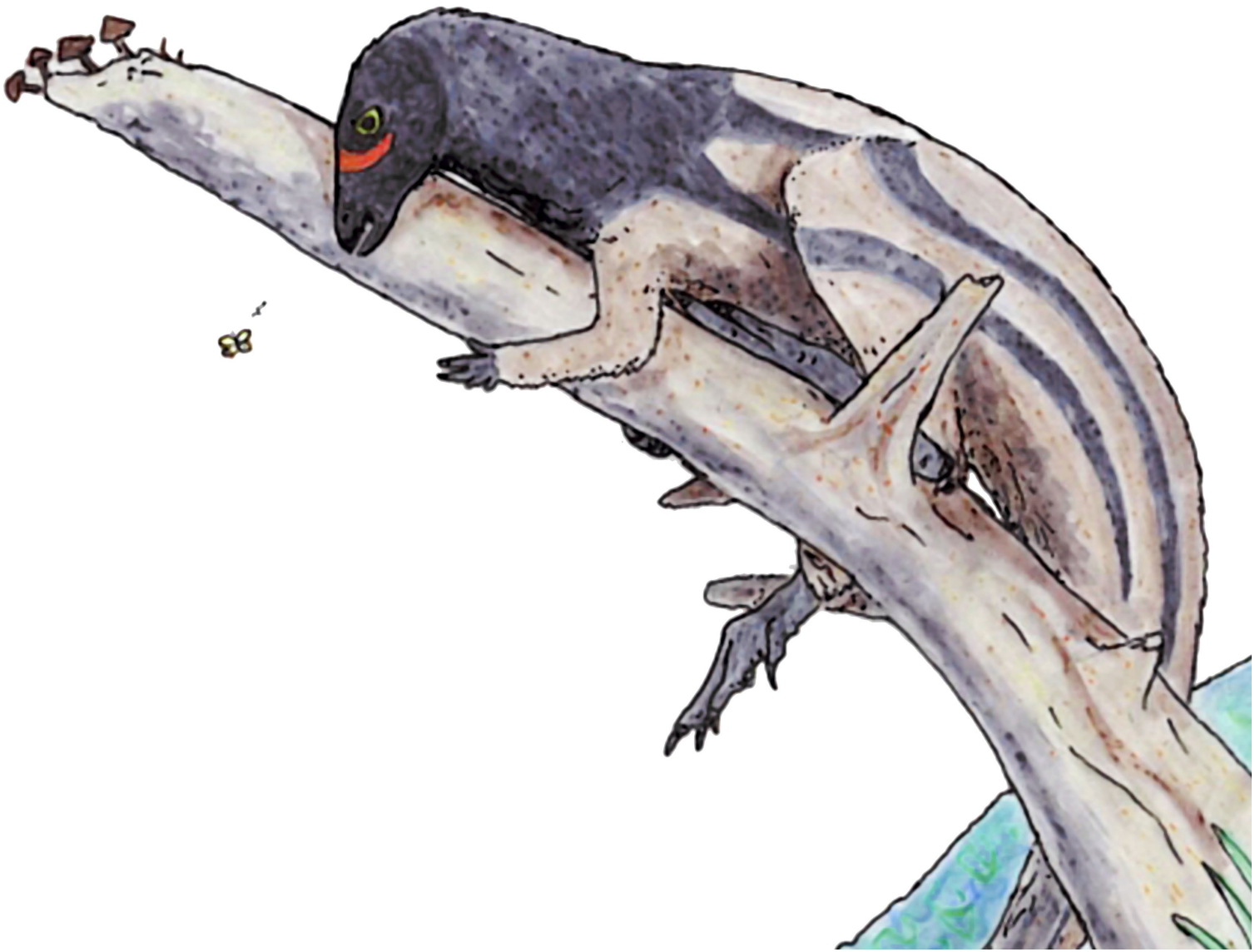
Peter Buchholz
Parksosaurus *Dreaming*

Palaeoartist Peter Buchholz has created this whimsical-but-plausible scene of an adult *Parkosaurus*, a plant-eating dinosaur, in an **inebriated state** after eating some mushrooms with **psychoactive** ingredients.

Consumption of plants and fungi for their narcotic properties is not uncommon in nature. In today's world, elephants regularly get drunk on fermented fruit and reindeer have been observed consuming *Amanita muscaria* mushrooms, [1] apparently for their psychoactive properties.

As animals with well-developed nervous systems and social instincts, dinosaurs were certainly advanced enough to have enjoyed an occasional natural "high" every now and then.

1 Wasson, R. Gordon (1968). Soma: Divine Mushroom of Immortality, p 238. Harcourt Brace Jovanovick. ISBN 0-88316-517-1.



Rachel Lowrie

Vanquished

In this colorful piece, palaeoartist Rachel Lowrie has depicted two male *Fruitadens*, plant-eating dinosaurs, in a duel for social dominance. Although nature can be host to a variety of unfortunate and violent interactions, same-species duels for social dominance rarely end in death. Usually, animals have a **surrender signal** that lets their conspecifics know that they have given up.

For these *Fruitadens*, the signal is lying flat down on the ground in a submissive posture. The victor plucks the loser's quills to further assert its power.

Although this behavior is speculative, it is not unlikely given the diverse contests for social dominance seen in birds today. The Mesozoic must have been host to countless similar displays, duels and struggles for social and sexual dominance.

Rachel Lowrie
Wrestling Plateosaurus

Once more, Rachel Lowrie focuses her art on the theme of **social dominance.** On this occasion, the combatants are of the genus *Plateosaurus* - the forerunners of the long-necked **sauropods**.

Unlike their quadrupedal descendants, *Plateosaurus* still walked on two legs and their front limbs bore sharp claws which may have been used for defence, or for duels as shown here. Rachel Lowrie has also adorned her *Plateosauri* with **brightly-colored necks** and **inflatable throat sacs,** which makes them stranger, but also more believable than the bare, snake-necked portrayals we have gotten used to.

"Ramul"
Tastes Like Chicken

As told before, palaeoart has developed its own **unquestioned conventions** and **typecast roles** when it comes to certain scenes. The almost classical scene of a mid-sized, herbivorous ornithischian being viciously torn apart by a pack of predatory *Deinonychi* is one such trope.

Such acts of predation are not impossible. In fact, there are *Deinonychus* fossils preserved alongside the bones of *Tenontosaurus*, a mid-sized **ornithischian** herbivore.[1] However, the outcome of these encounters may not always have been in the predators' favor. With this artwork, German palaeoartist Ramul shows a stark reversal of the commonly-held stereotype. This time, a plant-eating dinosaur has killed a sub-adult *Deinonychus* by simply stomping on it.

Many people fail to understand just how strong a moderately-sized herbivore can be, even if it has no sharp claws or teeth. For example, even a present-day horse can be an extremely intimidating and dangerous opponent if in an aggressive mood. Growing almost as big as elephants, with powerful, muscular legs, arms and tails, herbivorous dinosaurs could certainly hold out on their own against small to mid-sized predators. As a final detail, the herbivore is eating the remains of its would-be assailant. Such behavior has also been observed in nature, with herbivorous mammals occasionally consuming small animals or bird hatchlings they come across.

1 Maxwell, W. D.; Ostrom, J.H. (1995). "Taphonomy and paleobiological implications of Tenontosaurus–Deinonychus associations". Journal of Vertebrate Paleontology 15 (4): 707–712. doi:10.1080/02724634.1995.10011256.

Raven Amos

Swamp Dragon - Ichthyovenator

With this gorgeously stylized painting, talented palaeoartist Raven Amos addresses the unusual **sail-like ridges** found in **spinosaurid** dinosaurs. As seen before in this book, spinosaurs were a group of meat-eating dinosaurs with possible adaptations for an aquatic lifestyle. Some members of this group bore very tall vertebral ridges on their backs. While these structures were conventionally assumed to have been "skin sails," Raven Amos interprets them as an adaptation for an exitence spent in water.

"I have depicted Ichthyovenator *as living a semi-aquatic life-style like a crocodile or alligator. Rather than an ornamental bony sail, its large neural spines serve an armor-encrusted anchor point for enormous tail muscles that propel it through reed and duckweed-infested swamplands."*

This work also stands out in this collection in the balance it strikes between stylization and attention to detail. *Ichthyovenator* and the surrounding scenery is rendered in flat blacks and greens as opposed to "realistic" color. This makes certain details, like the cleft in the animal's back and even the genus of the fish it is eating, far more visible and interesting to the casual viewer. Locked in what seems to be a cycle of realism, prehistoric art can certainly benefit from daring techniques such as those used in this artwork.

Raven Amos

Bowertyrants

In today's world, **bowerbirds** (family Ptilorhynchidae,) are well-known for their extraordinary mating habits, in which males carefully curate and arrange a selection of brightly-colored objects with hopes of getting the females' attention. With this piece, Raven Amos has speculated on a similar behavior for the famous **tyrannosaurs**. For her, the tyrannosaur species known as *Gorgosaurus* has become the "lesser bowertyrant."

Instead of colorful stones, flowers and bits of plastic, these bower-builders are using carefully-arranged logs, bones and the skulls of their victims to woo their mates. The drably-colored female looks impressed by her suitor's carefully-arranged aisle of driftwood and whitish stones, his bright skin patches and the exquisite selection of a *Lambeosaurus* skull as a focal display object. Will this be his lucky day?

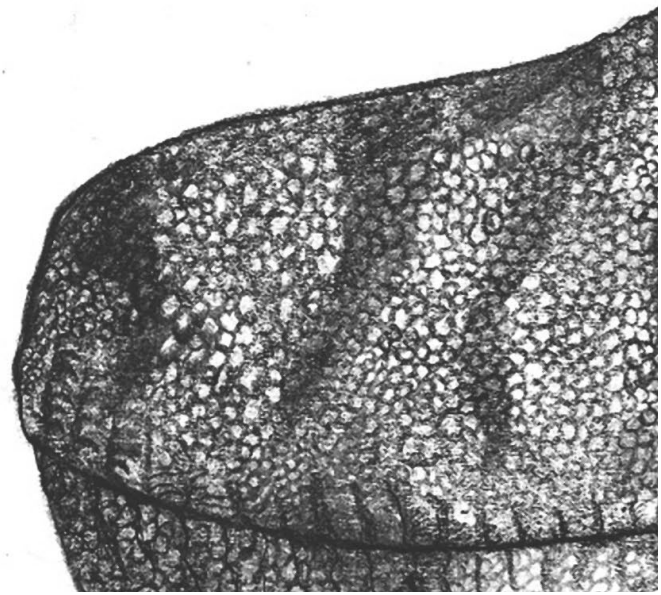
Perhaps this scenario looks a bit too tongue-in-cheek, yet it still leads to new ideas about dinosaurian social life and mating habits. Co-incidentally, this is one of the first new illustrations that depict tyrannosaurs with an extensive covering of feathers. Even when feathers were known for smaller dinosaurs, artists were reluctant to draw large tyrannosaurs with feathers, assuming they were too large to need insulation. However, the recent discovery of a large tyrannosaur, *Yutyrannus*, [1] preserved with feather-like integument, has led artists to revise their depictions of these majestic predators.

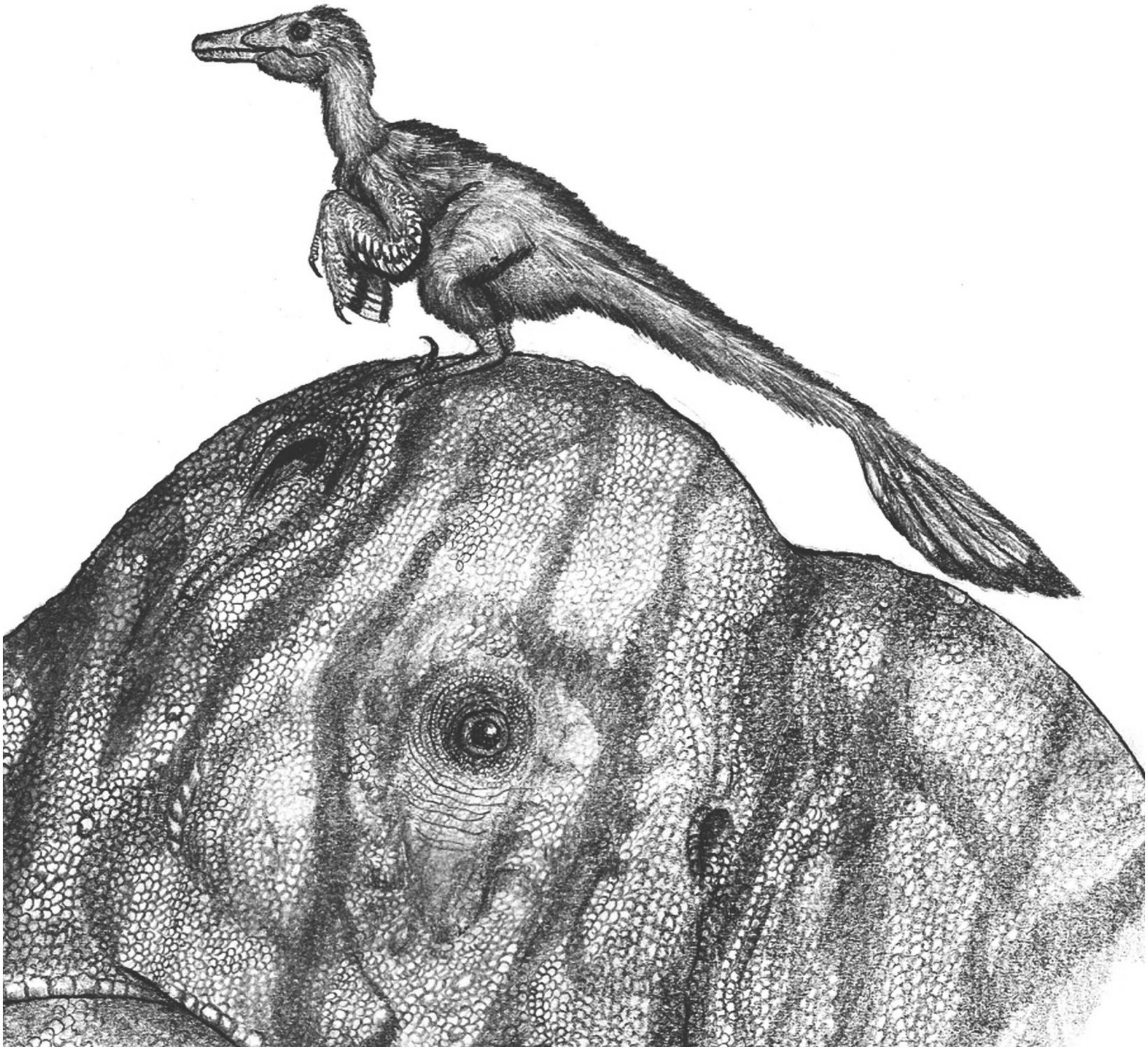
1 Xu, X.; Wang, K.; Zhang, K.; Ma, Q.; Xing, L.; Sullivan, C.; Hu, D.; Cheng, S. et al. (2012). "A gigantic feathered dinosaur from the Lower Cretaceous of China" (PDF). Nature 484: 92–95. doi:10.1038/nature10906. PMID 22481363.

Robinson Kunz
Guardpost

Not many dinosaur-themed artworks show mutually beneficial interactions between animals. Done mostly for "awesome" value, mainstream palaeoart focuses on predator-prey scenes with almost predictable repetition. Couldn't these animals have done something other than attacking, killing and eating each other all the time?

Thus, this piece by Robinson Kunz is a welcome deviation from the norm. A large, plant eating dinosaur and a smaller, bird-like species are seen in a **symbiotic relationship,** where the small dinosaur cleans the larger one of parasites, and stands on lookout for larger predators which may endanger both individuals. This relationship is similar to the one that exists today between large, savannah-dwelling herbivores and small birds in Africa.





Robinson Kunz

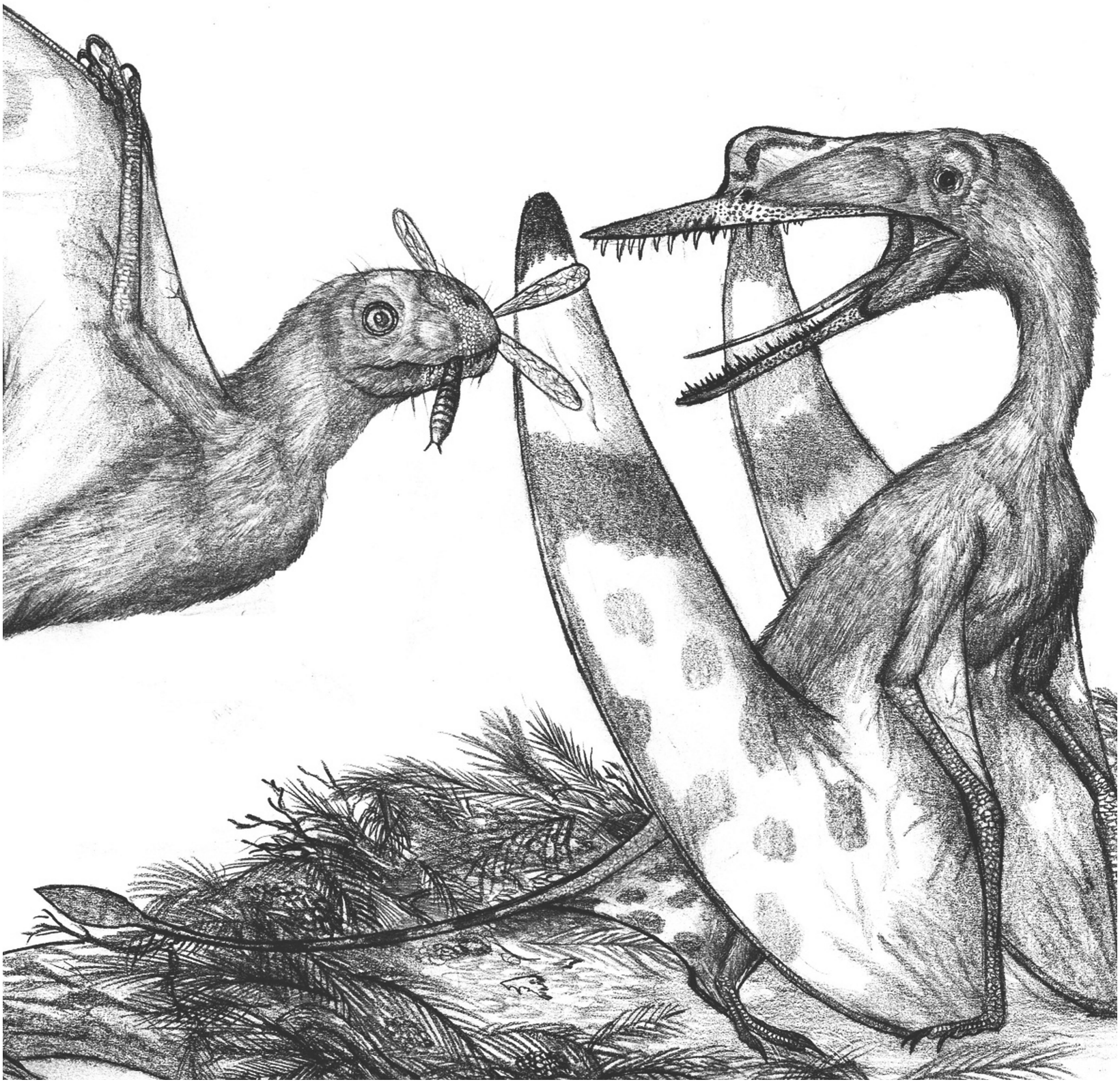
Darwinopterus *as a Nest Parasite*

Nest parasitism is an unusual phenomenon where an animal, usually a bird, lays its eggs in the nest of a different species. The unsuspecting hosts will accept the parasite hatchling as their own and raise it at expense of their own offspring. The parasite hatchling may even kill its nestmates in order to ensure its survival.

In today's world, various cuckoo species and even certain ducks practice nest parasitism. Who knows what the nest parasites of the past may have looked like? Robinson Kunz has come up with this depiction of the long-tailed *Darwinopterus* as a pterosaurian nest parasite. A desperate *Anurognathus*, another kind of pterosaur, is also visible, trying futilely to sate the appetite of its "offspring."

While this is a speculative scenario, it should be noted that a lot of factors remain frustratingly unknown about the nesting and r**eproductive habits of pterosaurs**. Current fossil discoveries indicate that pterosaurs, unlike birds, were able to fend for themselves at a very early stage of their lives, perhaps even right after hatching. [1] If this was indeed the case, nest parasitism may have been unfeasible for these animals. But pterosaurs were a very diverse group, an as it is often the case in nature, there could have been exceptions to the rule.

1 Unwin, David M. (2006). The Pterosaurs: From Deep Time. New York: Pi Press. p. 246. ISBN 0-13-146308-X.



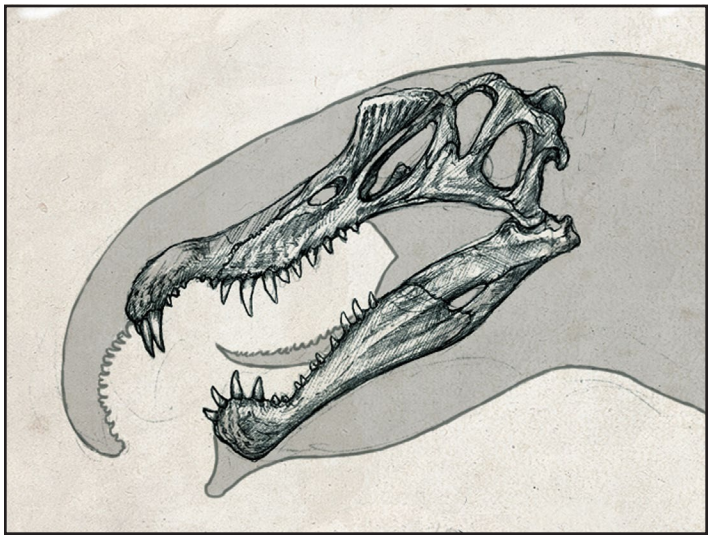
Rodrigo Vega
A Speculative Spinosaurus

As seen before, the predatory dinosaur *Spinosaurus* has been the center of much palaeontological speculation with its possible lifestyle and the soft-tissues covering of its extraordinary bony sail. With this spectacular work, conceptual artist Rodrigo Vega purposefully delivers the **most outlandish interpretation of *Spinosaurus* he can conceive.** Every detail of the animal's anatomy, from the skull to the sail-like bones on its back, has been interpreted as a basis of an unconventional anatomical feature.

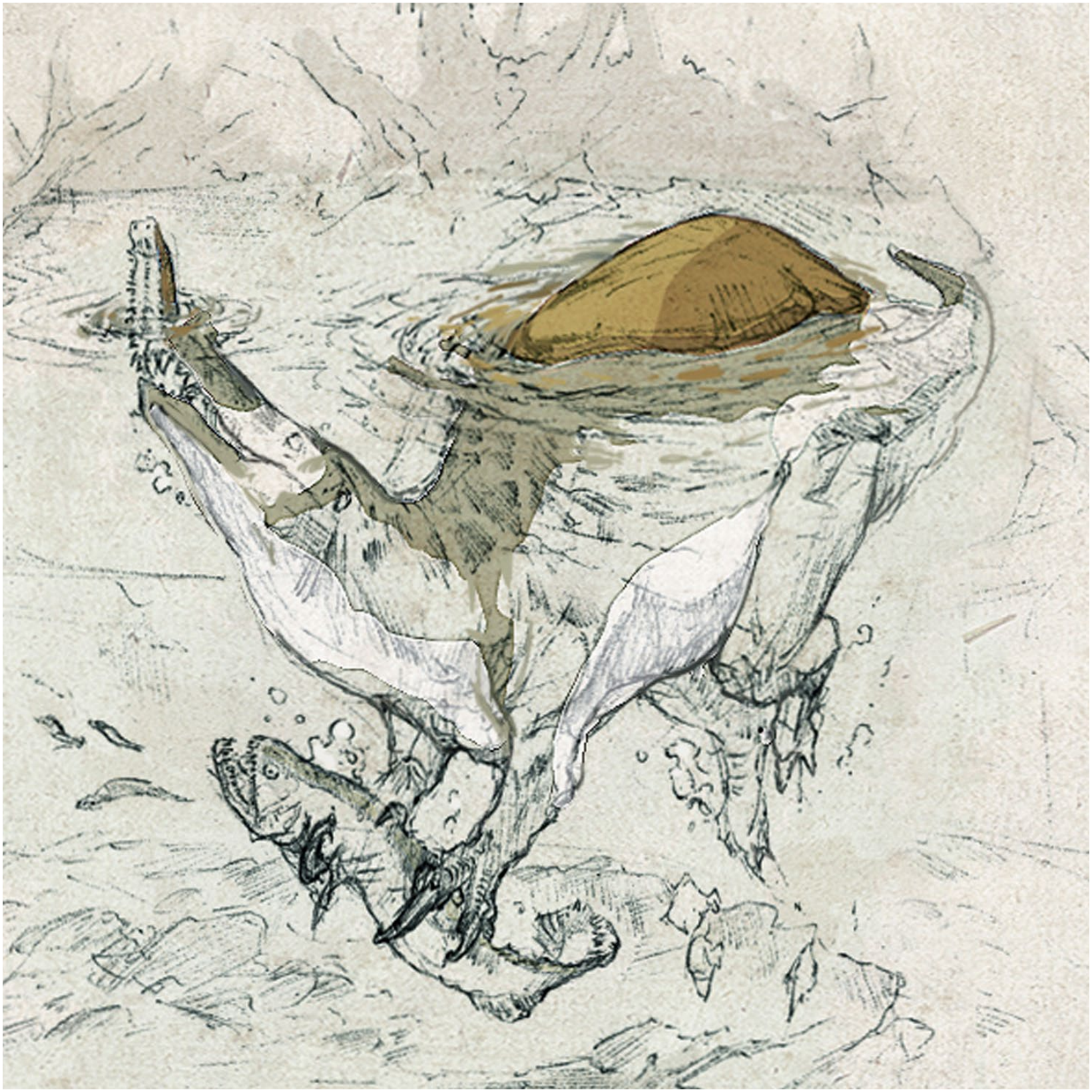
Take, for example, the strange, tapir-like **trunk** on the animal's face. *Spinosaurus* has a long, almost crocodile-like snout. Traditional reconstructions leave the animal's face bare, but Vega has speculated that the small crest and the rear-placed nostrils could have formed the basis of a muscular, soft-tissue trunk. He speculates that this organ could have been used like a snorkel when the animal was diving, and would also help it snatch prey items. In today's world, **brown bears** dexterously use their upper lips to catch salmon in mid-leap. Perhaps, Vega muses, *Spinosaurus* had a similar adaptation. The presence of trunks, or trunk-like organs in dinosaurian faces, by the way, is not a new idea. Proboscis-like facial organs were proposed for the plant eating sauropod dinosaurs as far back as 1975. [1] It is not certain if such organs were present on any dinosaur, but even if inaccurate, Vega's trunked *Spinosaurus* gets viewers thinking; perhaps **there was something more to dinosaurian faces than bare, grinning teeth?**

Another novelty of Vega's *Spinosaurus* is on its back. The tall neural spines, so often thought as supports for a thin, reptilian sail, have been re-interpreted as the basis for an enormous, bison-like hump. To support the weight of this structure, the animal has reverted to a semi-quadrupedal stance, using its muscular arms to carry itself. Vega speculates that *Spinosaurus* may have used this fatty hump as a food reservoir for lean seasons.

Put together, these small, speculative tweakings create a fantastically different picture of *Spinosaurus* than the running, sail-backed crocodile we have gotten used to. Artist Rodrigo Vega admits that his interpretation is possibly too extreme, but it serves a very important purpose for people interested in dinosaurs and palaeontology - it gets us thinking about the relation between fossils and the features they supported in real life.



1 Coombs, W. P. 1975. Sauropod habits and habitats. Palaeogeography, Palaeoclimatology, Palaeoecology 17, 1-33.



Santa Mazzei
Austroraptor *Chicks*

At first glance, this artwork seems to depict a tiny duckling about to be snatched by a vicious, long-jawed predator. But look closer, and details hint that this is not the case. To begin with, the "duckling" is not a duck. It has tiny claws where its wings should be, and small, nascent teeth gleam in its beak. Its tail is also longer than one would expect a duck's to be. This chick is **a dinosaur chick**, of a species known as *Austroraptor*. The toothy maw in the picture it is not that of a menacing predator, but of one of its protective parents.

Austroraptor is a **dromaeosaur**, a relative of "raptor" dinosaurs such as *Deinonychus* and the famous *Velociraptor*. Unusually for its group, it had very short arms and an elongated snout lined with conical teeth. [1] It was also one of the largest of the dromaeosaurs, growing up to five meters long. Austroraptor's snout and teeth have been interpreted as adaptations for a fish-eating diet, which is why artist Sante Mazzei has restored it like a waterfowl.

Perhaps, Mazzei speculates, *Austroraptors* started out as more-or-less aquatic juveniles, and graduate to a more terrestrial existence as they grew. For a present-day analogy, imagine a mammal that would live like a mouse at infancy, like a jackal in adolescence, and a tiger in adulthood. Such "niche shifts" would enable a single species of dinosaur to occupy the roles of different small, medium and large sized-animals simultaneously. Some researchers think that this model of growth occurred in most, if not all dinosaur species. [2]

1 Novas, Fernando E.; Diego Pol, Juan I. Canale, Juan D. Porfiri and Jorge O. Calvo (2008-12-16). "A bizarre Cretaceous theropod dinosaur from Patagonia and the evolution of Gondwanan dromaeosaurids". Proceedings of the Royal Society B (The Royal Society) 276 (1659): 1101–7. doi:10.1098/rspb.2008.1554. PMC 2679073. PMID 19129109.

2 Codron, D. et al., 'Ontogenetic niche shifts in dinosaurs influenced size, diversity and extinction in terrestrial vertebrates', Biology Letters, 2012. doi:10.1098/rsbl.2012.0240.

Sarah Goss

Mating Dance - Tapejara

Tapejara was one of the most elaborately crested **pterosaurs**. In this evocative digital painting by Sarah Goss, a *Tapejara* couple is seen "sky dancing," holding each other's feet and nuzzling while in a downward plunge. We have no evidence of such a ritual in the fossil record, and pterosaur wing membranes likely did not leave their legs free for such activities, but nevertheless this piece leaves a great emotional impact.

The sight of two creatures in loving courtship leads us to think about the feelings prehistoric animals may have experienced in their lives. After all, animals share homologous structures such as skeletal parts, limbs and sense organs. Perhaps we have **homologous emotions** too.

Sarah Goss
A Flamboyant Therizinosaurus

The strange, long-clawed dinosaur *Therizinosaurus* is rendered even stranger, but also more lifelike with this portrayal, featuring an attention-gathering suite of **display markings,** long feathers and bulging throat sac.

Therizinosaurus, as strange as it was, belonged to a dinosaur group that was not too far removed from the ancestry of birds, yet it is mostly portrayed as a hulking, bare-skinned beast in popular books and websites. Sarah Goss's **bird-like interpretation** re-casts it as a more "ordinary" animal, one whose relations to the rest of the dinosaurian lineage are clearer.

Simon Roy
Cyclops

Comic artist and illustrator Simon Roy is famous for his subtly detailed, down-to-earth portrayals of alien cultures, people and animals. Aided with a vast reservoir of knowledge on anatomy, evolutionary biology and anthropology, he adds layers of details to his concepts and characters, resulting in an engrossing **world-building** experience. Here, Roy has produced a "what if" speculation on the **cyclops**, one of the oldest palaeontological misconceptions.

A race of terrifying, one-eyed giants, the cyclopes were mentioned first in the epic poetry of **Homer and Hesiod.** In 1914, Othenio Abel proposed [1] that the myth may have been started by the skulls of **dwarf elephants** (*Palaeoloxodon sp.*) which lived on Crete, Cyprus and isolated Aegean islands in the Neolithic era. Elephant skulls have a large hole in the center that anchors the powerful muscles of their trunks. When the animal's body decomposes, this hole resembles a big, empty eye socket on a hauntingly large, humanoid skull. Having no knowledge of extinction, fossils, evolution or anatomy, it is easy to understand how the ancient Greeks may have mistaken these for remains of **one-eyed giants.**

Simon Roy's sketch is based on this premise - what if the ancient Greeks had been right, and there really was a race of giant, anthropoid beings with singular eyes and skulls roughly like those of elephants? This mad brute is the result of his speculation.

1 Mayor, Adrienne. The First Fossil Hunters: Paleontology in Greek and Roman Times (Princeton University Press) 2000 ISBN 1400838444.

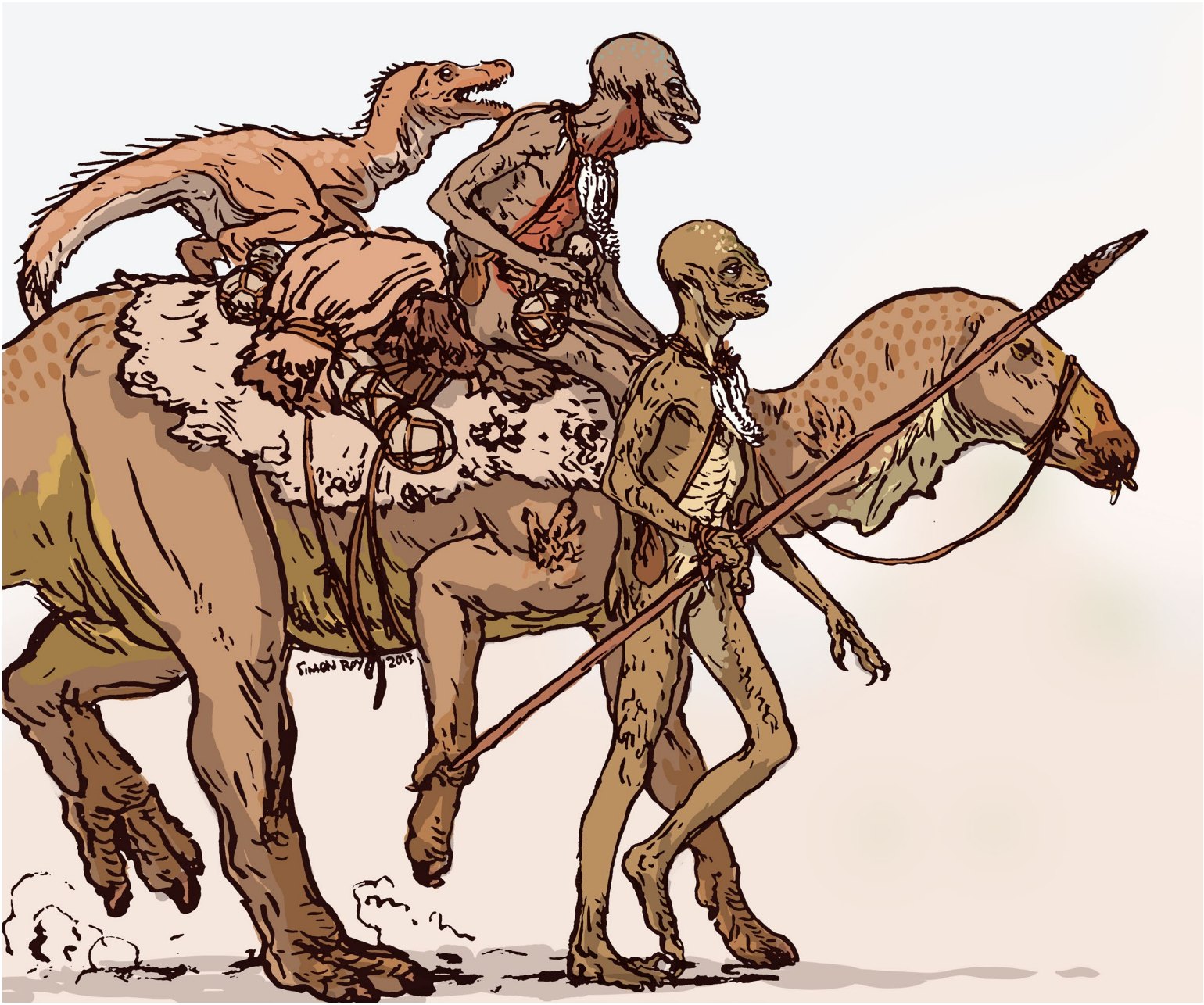
Simon Roy
Retro-Dinosauroid Tribesmen

Simon Roy here addresses one of the most interesting speculations about dinosaurs: If they hadn't died out, **would some dinosaurs evolve into an intelligent species?** Different models have been proposed for intelligent dinosaurs in recent decades. The most famous of these is Dale Russel's "**dinosauroid**," [1] which was hypothetically derived from small, smart, meat-eating dinosaurs such as *Troodon*. Published in 1978, when dinosaurs were thought to be reptile-like creatures, Dale Russel's dinosauroid looked like a green, scaly **humanoid** with large eyes, an upright stance and only the vestige of a tail. This model was later criticized because it looked too much like a human being. Would there really be an evolutionary pressure for all intelligent animals to develop a humanoid body plan? Indeed, the main theme of Russel's 1978 hypothesis seems to be the suggestion of a common, humanoid body form for intelligent animals rather than a detailed speculation on intelligent dinosaurs. More recently, in 2006, zoologist Darren Naish suggested that due to their bird-like anatomy, **intelligent dinosaurs would look more like birds.** Their bodies would be horizontally aligned, and their tails would not need to disappear. Like parrots and crows today, they would use their beaks to manipulate objects.They wouldn't need to evolve a humanoid body plan. [2]

In order to honor this debate, Simon Roy has here drawn a tribe of purposefully inaccurate, "retro" dinosauroids, complete with a reptilian steed and a featherless *Velociraptor* "watchdog" straight out of a 1970's palaeontology book. With deep knowledge of his subject, Simon Roy makes even these obsolete dinosauroids seem vividly real.

1 Russell, D. A.; Séguin, R. (1982). "Reconstruction of the small Cretaceous theropod Stenonychosaurus inequalis and a hypothetical dinosauroid". Syllogeus 37: 1–43.

2 Naish, D. (2006). Dinosauroids Revisited Darren Naish: Tetrapod Zoology, April 23, 2011.

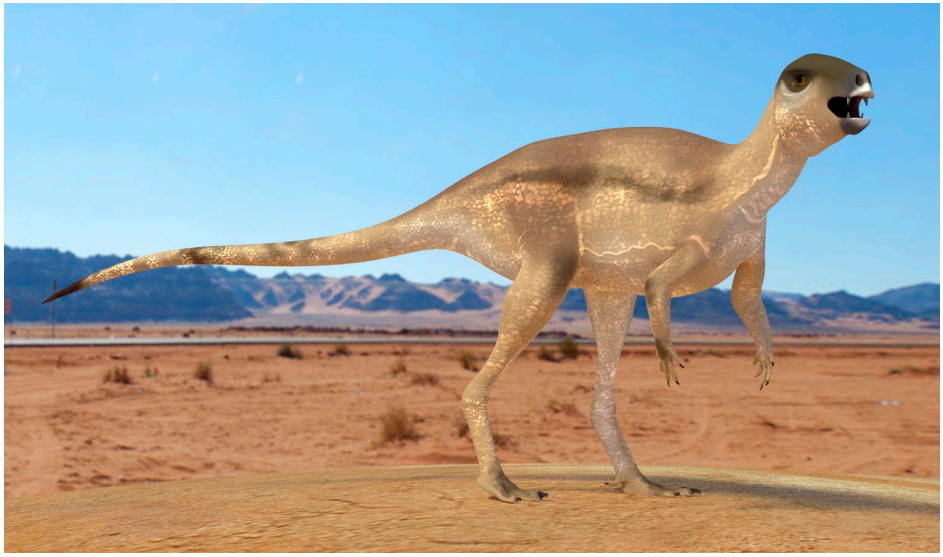


Smyslov Alexander

Seasonal Feathers

The presence of feathers in dinosaurs is almost universally accepted now, but the debate on the **extent** of feathering still goes on. Russian palaeoartist Smyslov Alexander brings in a suggestion a few have considered - what if certain dinosaurs only had **seasonal feathering**? In his hypothetical scenario, the early plant-eating dinosaur *Heterodontosaurus* has two distinct morphs for different times of the year. The animals lose their hair-like body covering during the warm season, and re-gain their plumage with the arrival of colder weather and rains. The green color of the autumnal feathering also helps the animal disguise itself from predators.

Of course, this scenario is fictitious, but animals with very similar habits really do exist in today's world. Just take a look at the arctic fox, *Vulpes lagopus*. These animals adopt a snow-white, insulating coat with the onset of winter and revert to a shorter, darker covering of fur in the warmer summer months. Closer to dinosaurs, polar birds known as rock ptarmigans, *Lagopus muta*, also have sets of brown and white plumage for camouflage in different seasons.



Smyslov Alexander
A Skin-Clad Stegosaurus

The plate-backed *Stegosaurus* is one of the most readily recognizable dinosaurs of all time. Discovered back in 1877, [1] this bus-sized dinosaur soon became a **palaeontological enigma**. No one could make sense of its bizarre plates, nor could guess exactly how they were attached to the animal's body in real life. At first, the plates were thought to be fused to its skin, like the scales of a **gigantic pangolin.** Later on, other interpretations were proposed with the plates standing erect in a single row, a side-by-side double row and so on. Some researchers though the plates were independently movable, while others disagreed. An eccentric writer even reconstructed them as tiny wings, which helped the **immense animal glide from cliffs!** [2] In the end, Stegosaurus' plates were understood to lie in **a staggered double row** across its back. There is still some debate over what function they performed, but it is certain that this did not extend to aeronautical capabilities.

It is to this historical puzzle that artist Smyslov Alexander brings a new interpretation. He maintains the plate arrangement in its orthodox fashion, but proposes a covering layer of skin, muscle and subcutaneous fat on top of them. The resulting animal looks utterly different from the *Stegosaurus* we've been used to. Alexander thinks that this arrangement could have helped the animal store extra nutrients and also strengthened the tissues of the animal's tail and back, adding power to the spine-studded **"thagomizer"** organ on its tail, with which it warded off predators.

1 Marsh OC (1877). "A new order of extinct Reptilia (Stegosauria) from the Jurassic of the Rocky Mountains". American Journal of Science 3 (14): 513–514.

2 Ballou, W. H. (1920, August 15). The Aeroplane Dinosaur of a Million Years Ago. The Ogden Standard-Examiner, pp. 8. Retrieved from http://chroniclingamerica.loc.gov/lccn/sn85058393/1920-08-15/ed-1/seq-32/

Oscar Mendez
Rumbling Ichthyovenator

Palaeoartist Oscar Mendez is well-known online with his concise and colorful drawings of dinosaurs, mostly meat-eating theropods.

In this image, he shows a male *Ichthyovenator*, a possibly aquatic **spinosaur**, conducting a "rumble" display in the water for females of his kind. He has immersed himself in a calm river and is causing the water around him to vibrate and bubble with sound waves. The extensive **system of air sacs** [1] in his lungs and chest is helping him better transmit vibrations from his body to the water. We obviously don't have direct evidence for this kind of display in *Ichthyovenator*, but it is not unlikely. In today's world, **crocodiles** perform a similar ritual, causing the water on their backs to "boil" with sonorous vocalizations.

1 Wedel MJ. Evidence for bird-like air sacs in saurischian dinosaurs. Journal of Experimental Zoology Part A: Ecological Genetics and Physiology. 2009 Oct 1;311(8): 611-28. doi: 10.1002/jez.513.

Oscar Mendez
Saurolophus *and alvarezsaurs*

Interactions between different animal species are thought to fall into one of two categories. They can either be **symbiotic**, beneficial for both parties, or **parasitic**, in which one animal benefits at the expense of another. But real life is not so clear-cut. Nature is full of opportunistic relationships that can change back and forth between symbiosis and parasitism. Indeed, this is how distinctly parasitic or symbiotic relations evolve in the first place. An animal might initially approach another as a parasite, but may inadvertently cause beneficial side-effects. In due time, such relationships may evolve into symbiosis - and vice versa.

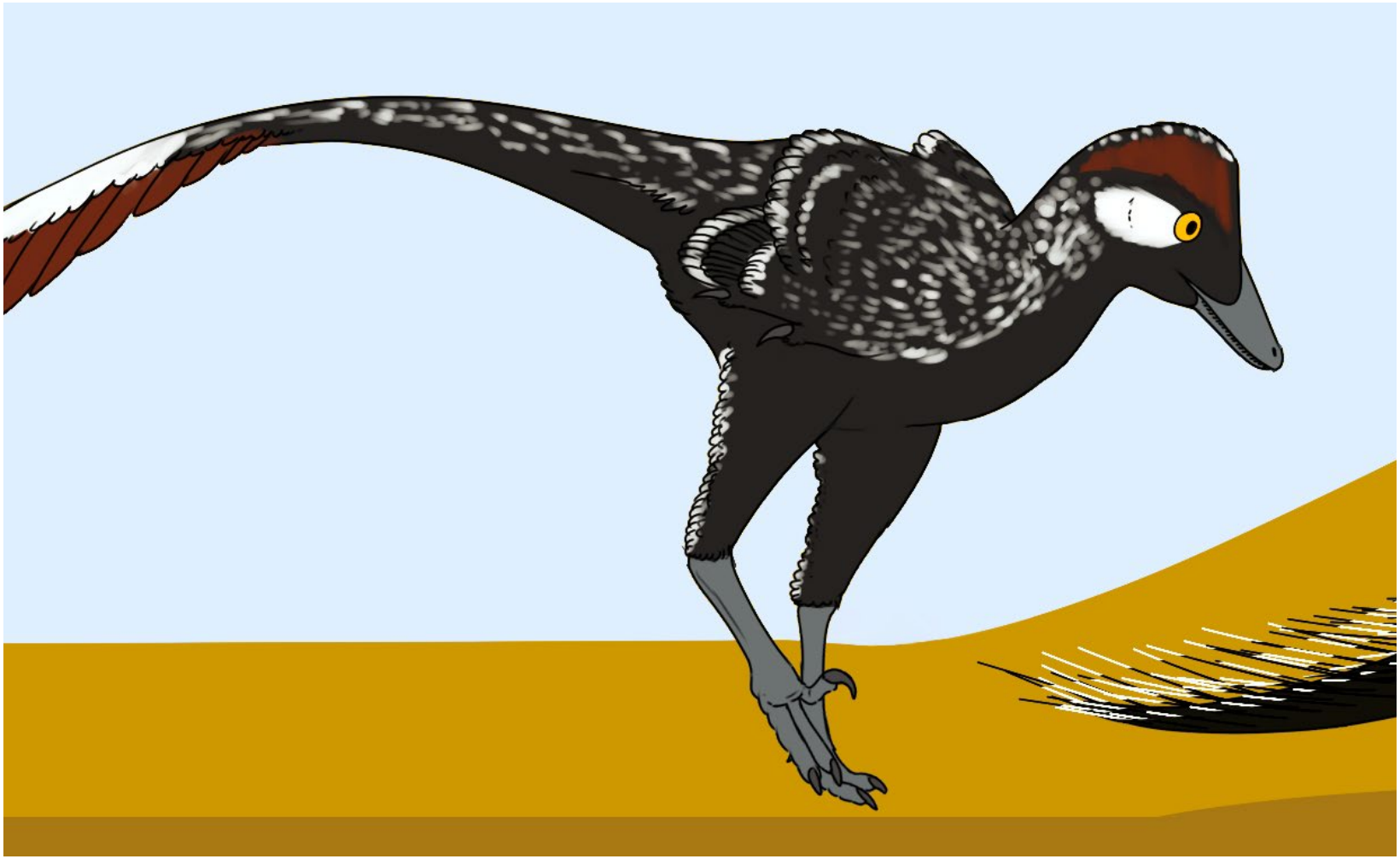
Artist Oscar Mendez has here imagined a similarly ambiguous relationship in dinosaurs. The small, bird-like, one-clawed **alvarezsaurs** are approaching the tired *Saurolophus* with intent to pick at its skin and lick the blood that issues from the wounds. But one of them is also feeding on ticks and other insects near the larger animal's head. How would one classify such an interaction? The smaller dinosaurs are costing the *Saurolophus* a few drops of its blood, but they are also cleaning it of insects that might spread potentially lethal diseases. Perhaps, from the larger beast's perspective, the blood-letting could seem like an affordable "price" to pay for the insect-cleaning operation. In due time, the alvarezsaurs could start feeding more on the insects and less on *Saurolophus* blood, and this could be the beginning of a truly symbiotic partnership.

Oscar Mendez

Passive Defense - Oryctodromeus

This stylized drawing is an excellent summary the **great image revision** that dinosaurs underwent in the last decade or so. It shows a plant-eating **ornithischian** dinosaur known as *Oryctodromeus*, being harassed by *Troodon*, everyone's favorite small predatory dinosaur. To protect itself, *Oryctodromeus* is hiding in its burrow, and brandishing its spiny tail to ward off the attacker. It's fascinating to realize that a decade ago, both animals would have been portrayed as lizard-like bipeds, distinguishable only by a maw of sharp teeth on the predator, and a stubby beak on *Oryctodromeus*. Perhaps *Troodon* would have sported a token covering of hair-like "feathers" on its neck. If drawn a few years ago, *Troodon* would have feathers, but would retain a dragon-like head. Its fingers would be visible from among a few long, feathers emerging awkwardly from its mis-aligned hands. *Oryctodromeus* would still be a quasi-reptilian kangaroo.

In contrast, artist Oscar Mendez has drawn these animals in the light of our latest knowledge, and in a wider understanding of how real animals look, move and function. *Oryctodromeus* is now sporting a heavy coat of spines, inferred from patches of similar structures discovered with a



related species. [1] Almost all prior illustrations showed these animals with specifically and only those patches present. In reality, the patchy preservation is a by-product of fossilization, and these animals must have sported a more extensive integument that even covered their faces.

Likewise, Oscar Mendez has illustrated *Troodon* as a proper, bird-like animal - instead of a reptile with a token covering of feathers. Based on careful observations of real-life birds, Mendez has given it subtle nuances of movement such as its folded wings and the flexing posture of its feet as it strides. **Accurate representations** not only make dinosaurs more interesting, they also help convey the evolutionary relationship they have with birds. They make us realize how much of conventional palaeoart is based on repetitions of patterns and tropes. Perhaps one day, new discoveries will make this artwork seem as dated as the reptile-like dinosaurs of the past.

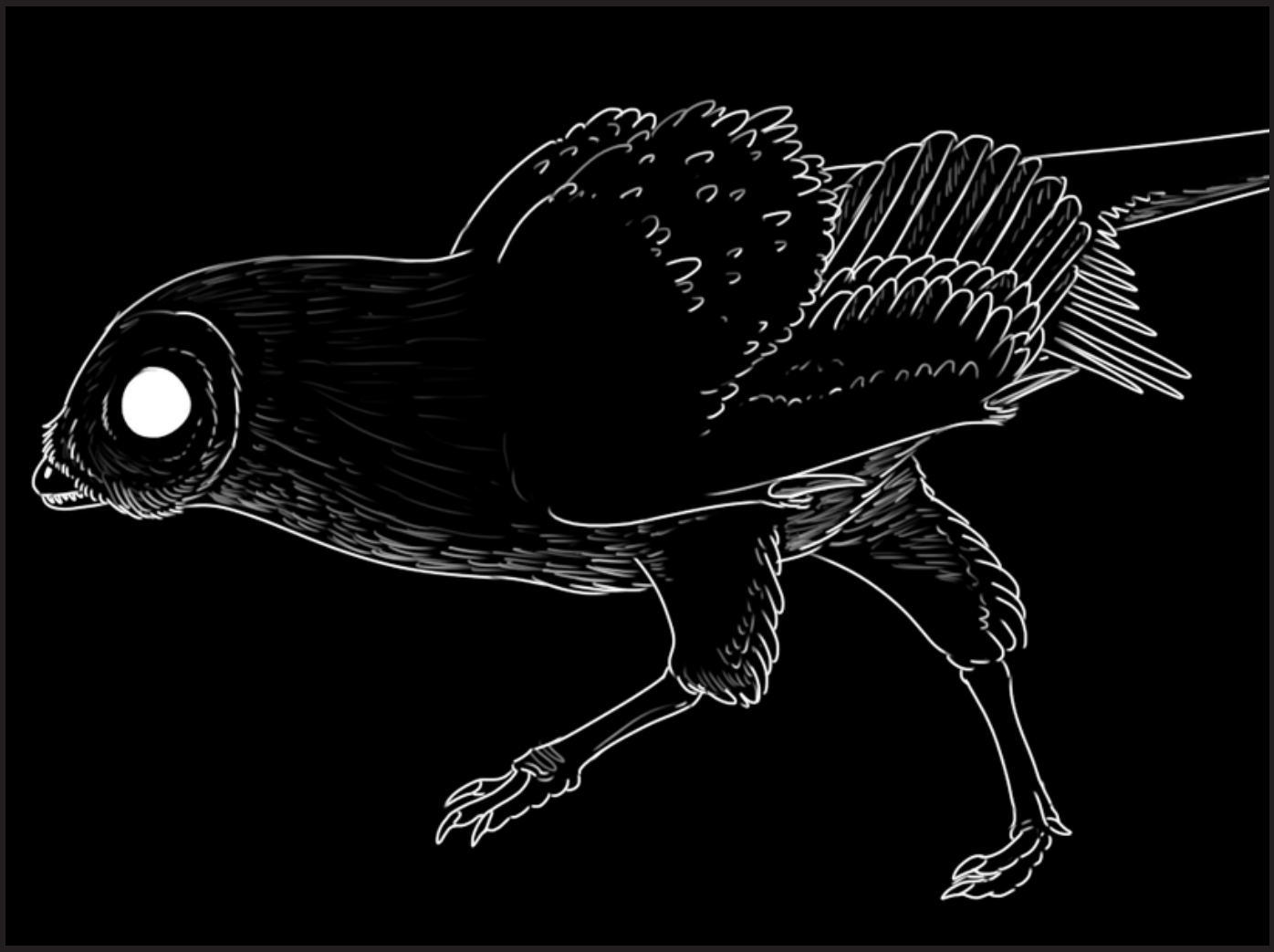
1 Zheng, Xiao-Ting; You, Hai-Lu; Xu, Xing; Dong, Zhi-Ming (19 March 2009). "An Early Cretaceous heterodontosaurid dinosaur with filamentous integumentary structures". Nature 458 (7236): 333–336. doi:10.1038/nature07856. PMID 19295609.

Oscar Mendez
A Tangent Bird

Eosinopteryx was a tiny, bird-like dinosaur, known from a well-preserved fossil from China, complete with a full suite of feathers. [1] *Eosinopteryx* had an unusual set of characteristics; its head had an extremely short snout and very large eyes. Unlike most related species, its legs and tail were not extensively feathered. Despite its small size, it did not seem to have the ability to fly. Artist Oscar Mendez has here interpreted this puzzling animal as a nocturnal, gruond-scurrying hunter of insects and other small animals, an owlish dinosaur converging with shrews and other small mammals.

Whether this interpretation is true or not, this enigmatic little dinosaur has shown us that the **evolution of birds** from dinosaurs was not as straightforward as once believed. Instead of a direct progression from small, meat eating dinosaurs to avians, the natural history of birds seems to have included myriads of side-paths, dead ends and **tangent forms.** Who knows what other strange **quasi-birds** may have shared the world with dinosaurs and their flying descendants?

1 Godefroit, P.; Demuynck, H.; Dyke, G.; Hu, D.; Escuillié, F. O.; Claeys, P. (2013). "Reduced plumage and flight ability of a new Jurassic paravian theropod from China". Nature Communications 4: 1394. doi:10.1038/ncomms2389. PMID 23340434.



Thomas Duffy
Longisquama

Thomas Duffy is well-known among today's fantasy and palaeo-artists with his outlandish, cheerfully irreverent hybrids of different fossil animals and even machines. For this collection, he has chosen to tackle the enigmatic fossil known as *Longisquama*, whose extraordinary anatomy [1] is almost as strange as one of Duffy's fantastic creations.

Longisquama is known mainly from one fossil, which only preserves its front half. It is a small, lightly-built animal with very long, **feather-like projections** emerging from its back. A variety of purposes have been suggested for these fronds, from camouflaging the animal in trees to display devices for mating, or as winglets to help it glide from branch to branch. The fronds have also been discovered in isolated fossils, which led some researchers to interpret them as vegetative remains unrelated to the animal. [2]

Lonigsquama's exact position in the tree of life is also a bit of a mystery. Because the fossil is indistinct, it is difficult to interpret diagnostic details such as the parts of the skull and the forelimbs. It was thought that *Longisquama* was somehow related to the base of the family tree that includes **crocodiles** and **dinosaurs**. However, a recent assessment has placed it closer to today's lizards and snakes. [3]

The mystery of *Longisquama* has also attracted unorthodox views. Independent researcher David Peters has claimed he was able to see the missing rear half of the skeleton by enhancing the images of the fossil in a computer, and proposed it was an ancestor of **pterosaurs**, flying reptiles of the past. [4]

Using a method which no one else can replicate, he has claimed to have seen features that nobody else can see, such as a long finger supporting a small wing, a very long tail and extra fronds on the animal's back, head and tail.

Thomas Duffy has based his fantastic drawing on this improbable view. Instead of trying to argue the errors of Peters' *Longisquama*, (which many people have tried,) he has accepted it as a fantasy and added onto it.
He has made this improbable being into a **photosynthetic animal** - one that can feed on sunlight, much like plants. Its fronds are full of symbiotic algae colonies that convert sunlight into energy and it spends most of its life hanging upside down like a **sun-powered reptilian sloth**, "grazing" on sunlight that dapples the jungle canopy. Although certain invertebrates have recently been discovered to integrate photosynthesis into their metabolisms, [5] no evidence exists for similar phenomena in vertebrates.

As fantastic as it might be, Duffy's *Longisquama* is a tongue-in cheek warning against unsupported speculations in palaeontology.

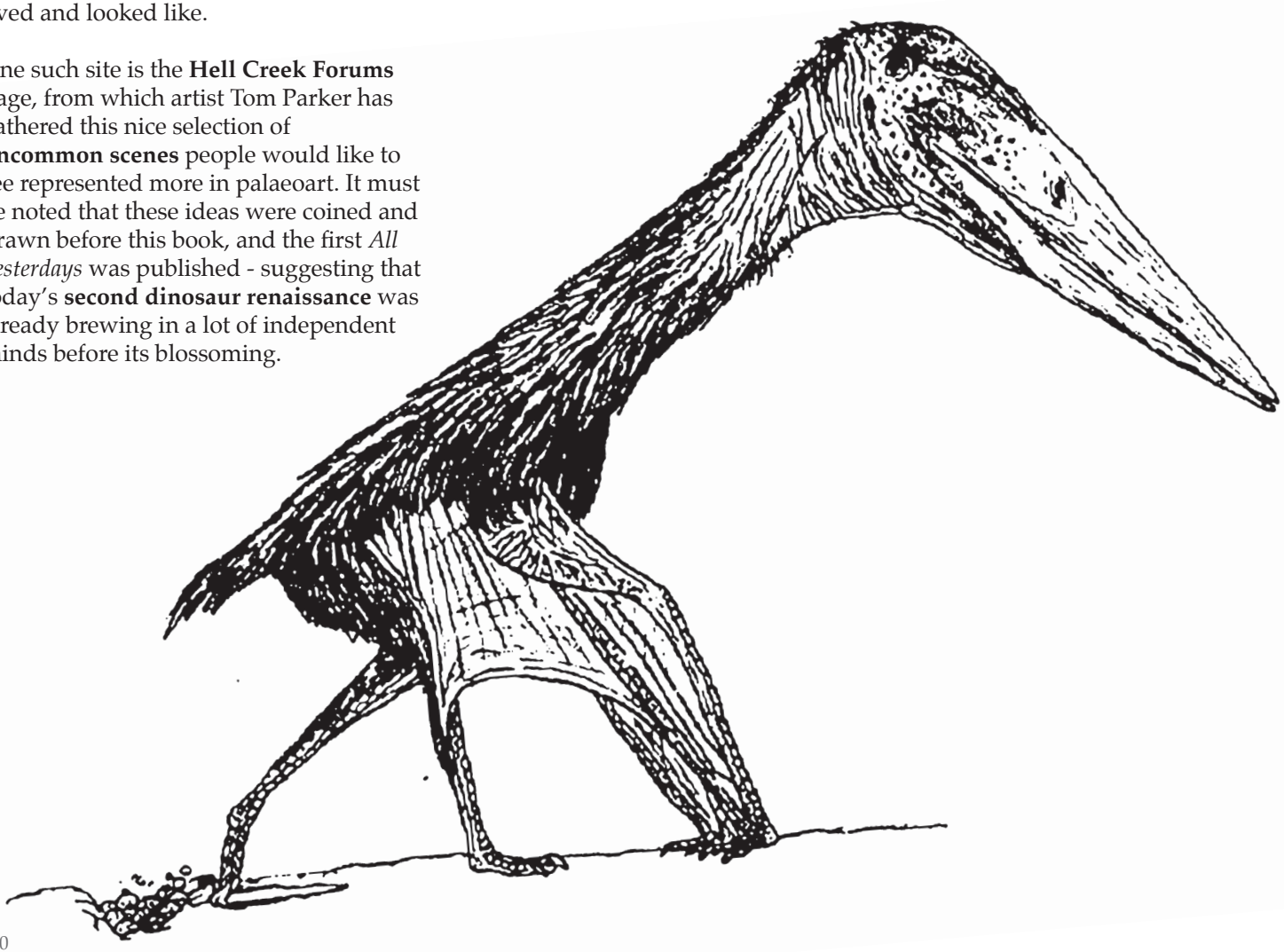
1 Sharov, A.G. (1970). "A peculiar reptile from the lower Triassic of Fergana". Paleontologiceskii Zhurnal (1): 127–130.
2 Fraser, N. (2006). Dawn of The Dinosaurs: Life in the Triassic. Bloomington: Indiana University Press. ISBN 978-025-334-3.
3 Prum, R. O./Unwin, D.M., Benton, M.J./Response; Jones, T.D., Ruben, J.A., Maderson, P.F.A., Martin, L.D. (9 March 2001). "Longisquama Fossil and Feather Morphology". Science 291 (5510): 1899–1902. doi:10.1126/science.291.5510.1899c. PMID 11245191.
4 Peters, D. (2006). "The Other Half of Longisquama". Prehistoric Times 75: 10–11.
5 Solar-powered Sea Slug Harnesses Stolen Plant Genes, New Scientist, 2008-11-24.

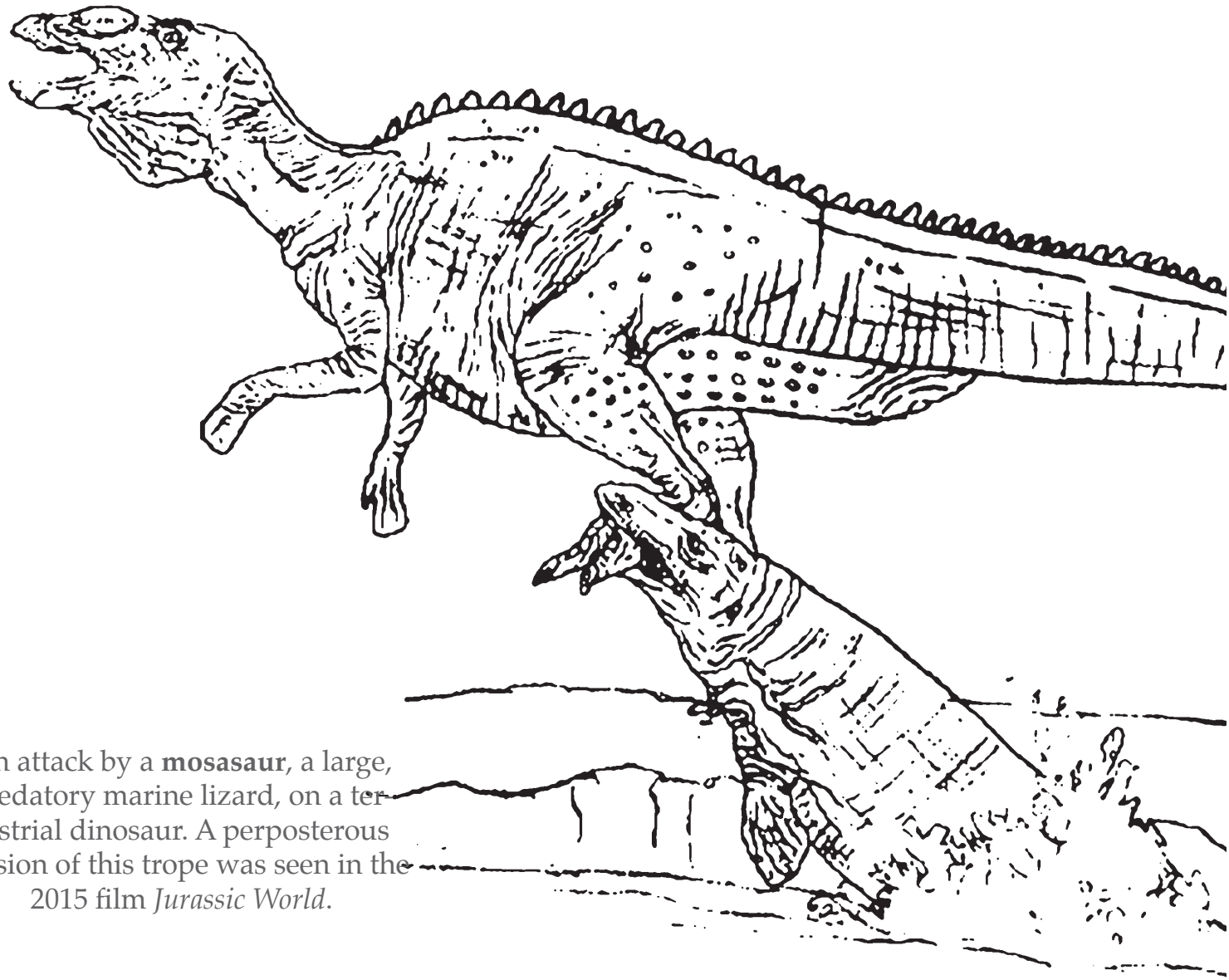
Tom Parker
Uncommon Scenes

It can be safe to say that most of today's novel palaeontological ideas are not generated in universities, labs or dig sites, but on **online discussions**. Many forums, blogs, comment sections, Youtube videos and even art sites host lively and constant discussions about ancient animals and new theories about how they might have lived and looked like.

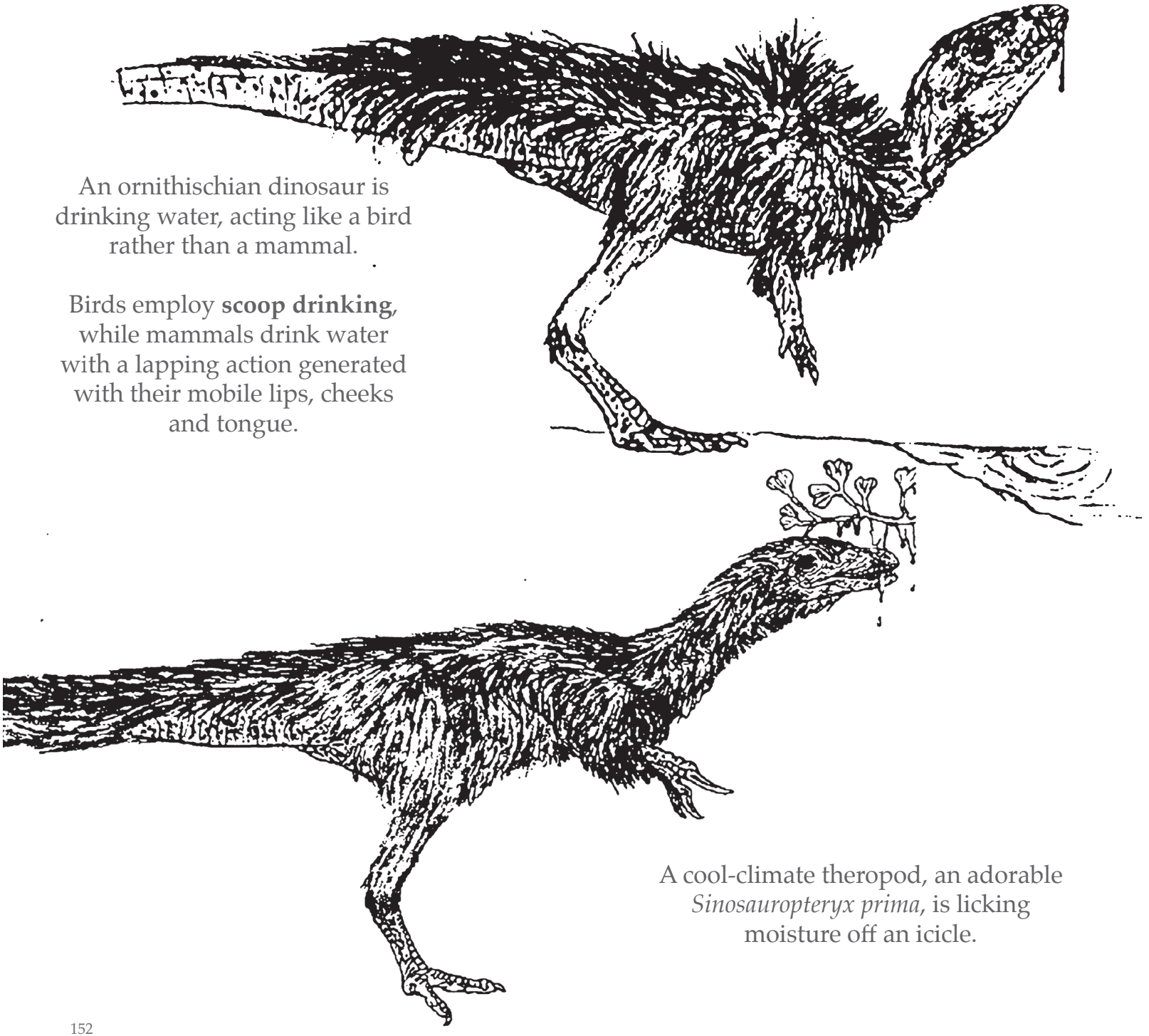
One such site is the **Hell Creek Forums** page, from which artist Tom Parker has gathered this nice selection of **uncommon scenes** people would like to see represented more in palaeoart. It must be noted that these ideas were coined and drawn before this book, and the first *All Yesterdays* was published - suggesting that today's **second dinosaur renaissance** was already brewing in a lot of independent minds before its blossoming.

A pterosaur is burying its eggs, much like a sea turtle. We still don't have many clues about how (or even if) mother pterosaurs took care of their eggs.





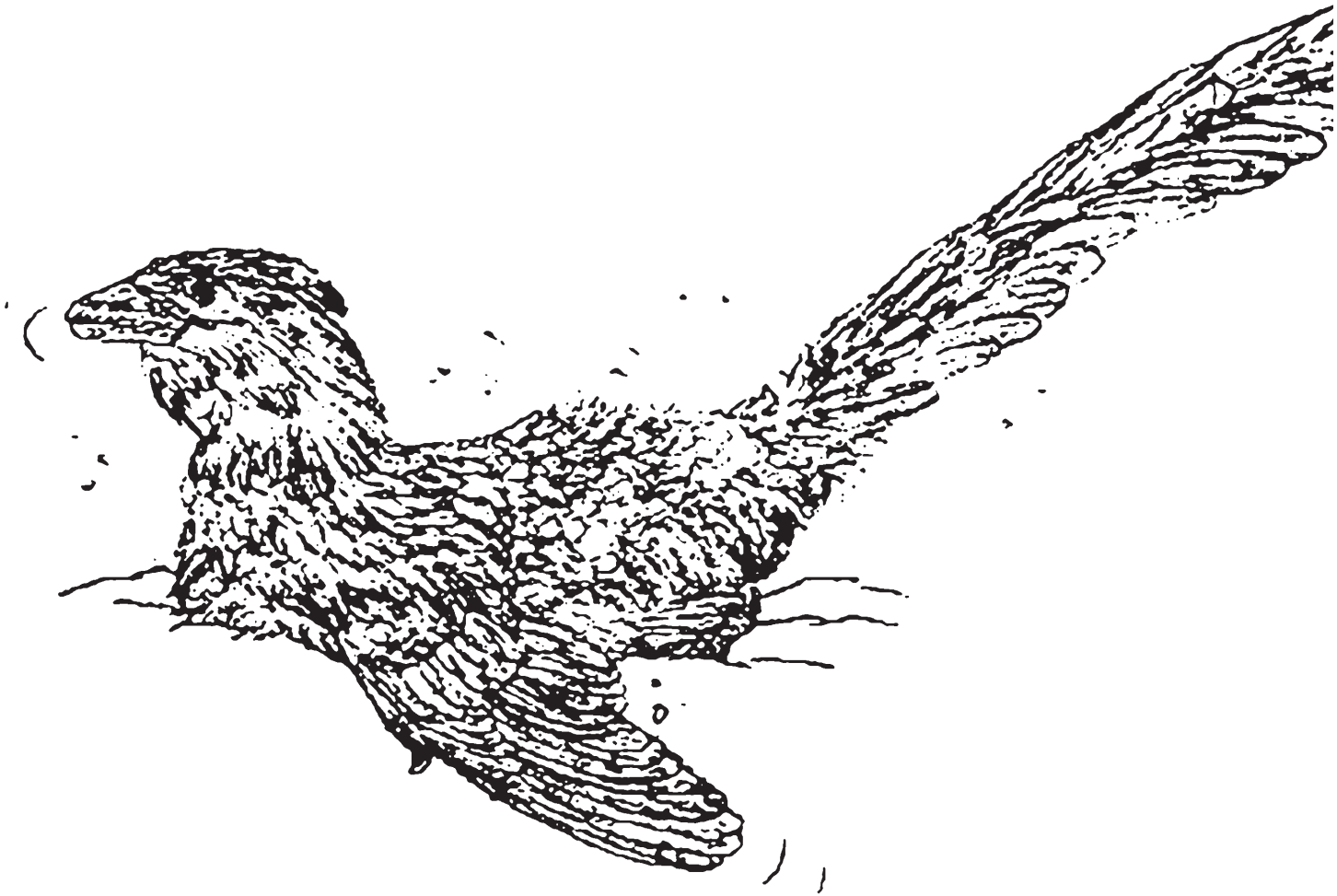
An attack by a **mosasaur**, a large, predatory marine lizard, on a terrestrial dinosaur. A perposterous version of this trope was seen in the 2015 film *Jurassic World*.



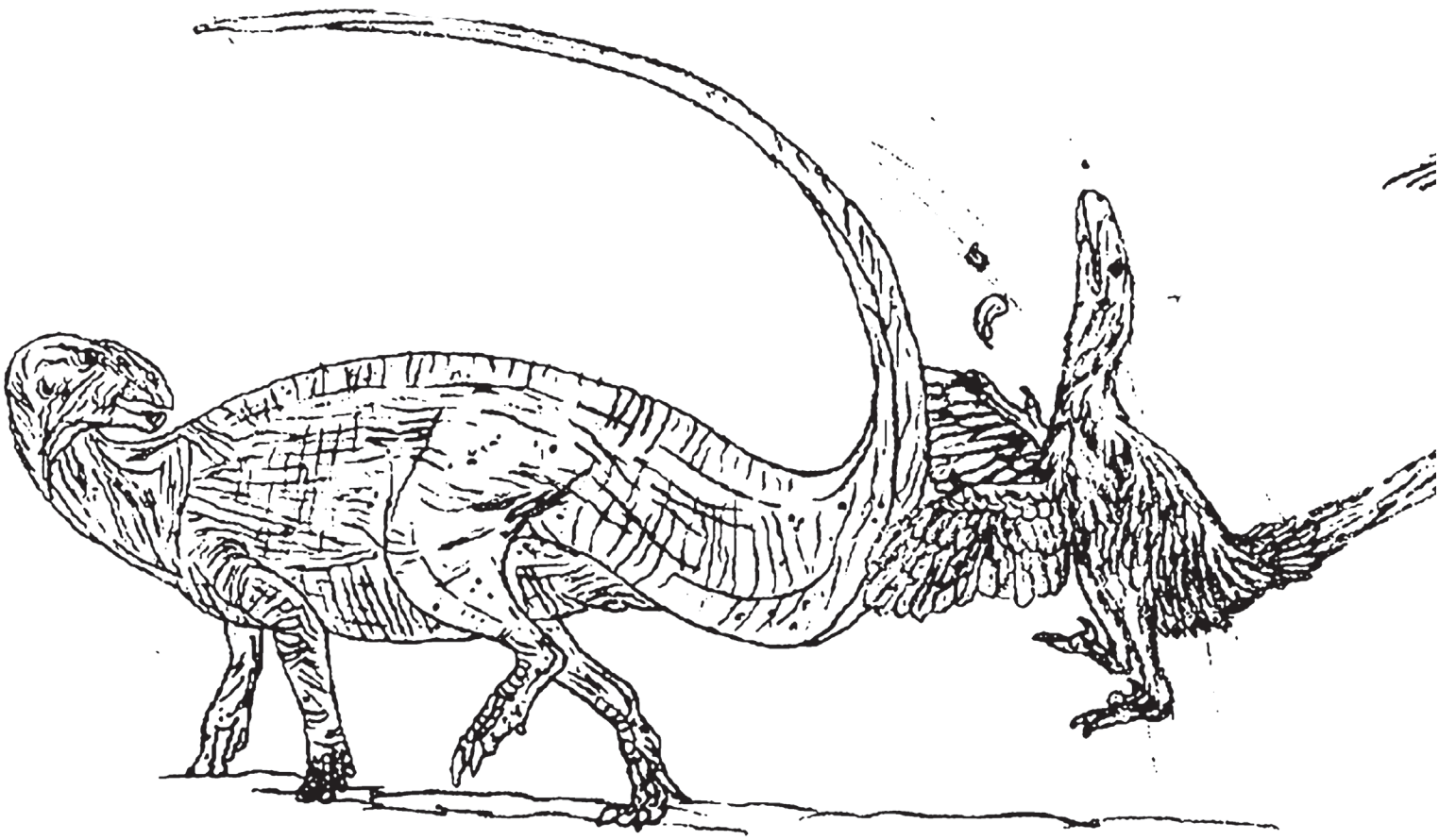
An ornithischian dinosaur is drinking water, acting like a bird rather than a mammal.

Birds employ **scoop drinking**, while mammals drink water with a lapping action generated with their mobile lips, cheeks and tongue.

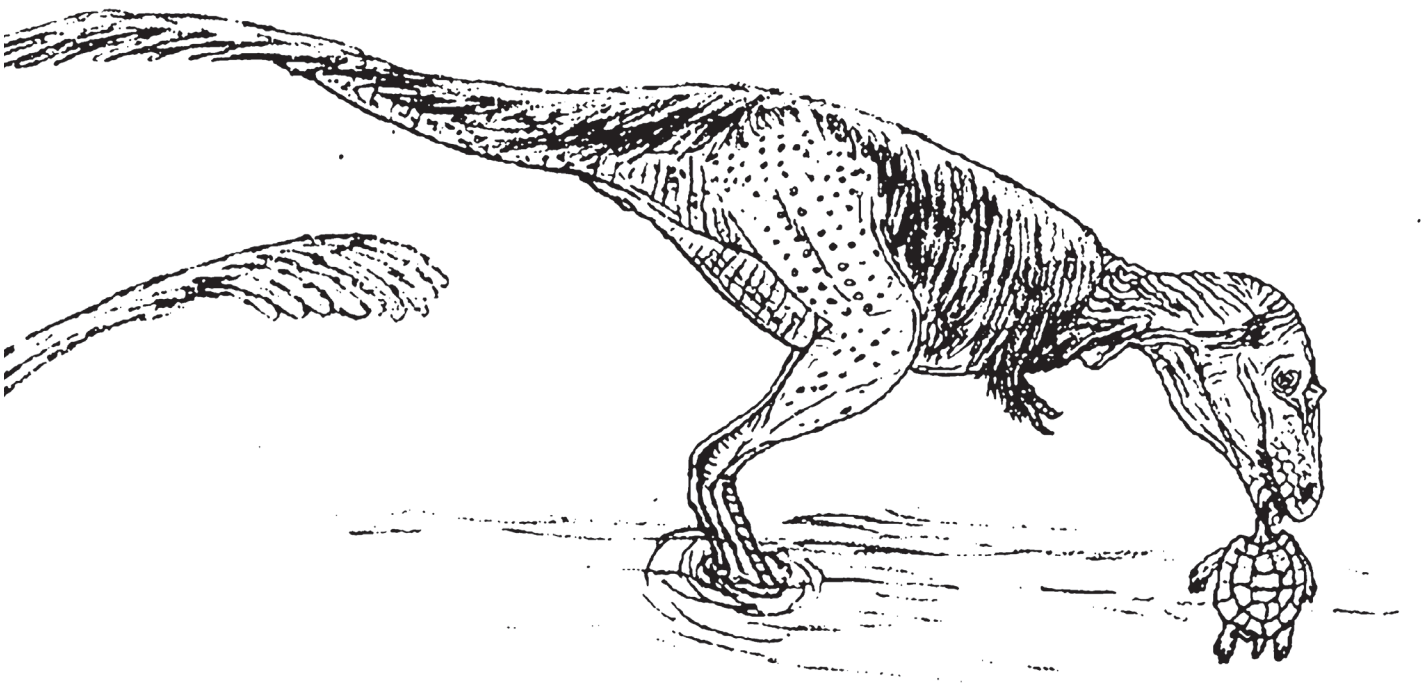
A cool-climate theropod, an adorable *Sinosauropteryx prima*, is licking moisture off an icicle.



Dust bathing by a *Velociraptor*.
This is a common (and possibly fun,) feather-cleaning activity performed by many birds living today.



A reversal of the **"raptor"** trope, with a large herbivorous dinosaur successfully defeating an attack by a predatory *Deinonychus*.



An act of prehistoric **river combing,** where an animal ranges across a stream for food. Featuring a *Gorgosaurus,* prowling a slow river for frogs and turtles.

Tuomas Koivurinne

An Accidental Death

Most of us assume that animals are immune to accidental death. In the popular, idealized and false vision of nature there are no accidents; animals always move and act in harmony with their surroundings and death is brought about only by the "natural" act of predation, or through the "unnatural" transgressions of man.

Such romantics might be surprised to know that **accidents happen in nature,** more often than we think. There are countless cases of unlucky animals breaking their limbs and simply starving to death. Cattle get struck by lightning, walruses plummet off cliffs and duelling reindeer get tangled in horn-locks and perish. Perhaps one of the strangest cases of animal death on record is the case of a giraffe perishing after getting its head stuck in a cleft tree branch.

Inspired by this incident, Finnish palaeoartist Tuomas Koivurinne has come up with this scene of an unfortunate *Giraffatitan* perishing in an arboreal accident. The **ten-meter-tall giant** has been dead for quite some time, and opportunistic scavengers are beginning to converge on his remains.

Vitaly Melnik

Prehistoric Portraits

Ukrainian palaeoartist Vitaly Melnik has participated in this collection with artwork that lets us look at dinosaurs in a new perspective - as portraits.

Too many of us are used to seeing dinosaurs and other pre-historic animals in full-body, **sideways views.** An artifact of skeletal diagrams, this viewpoint helps us visualize the animals' forms, but it also itemizes them; showing them like different models of vehicles or weapons. The scale of such representations also fails to connect viewers to the subtle, intimate anatomical details that exist in real animals.

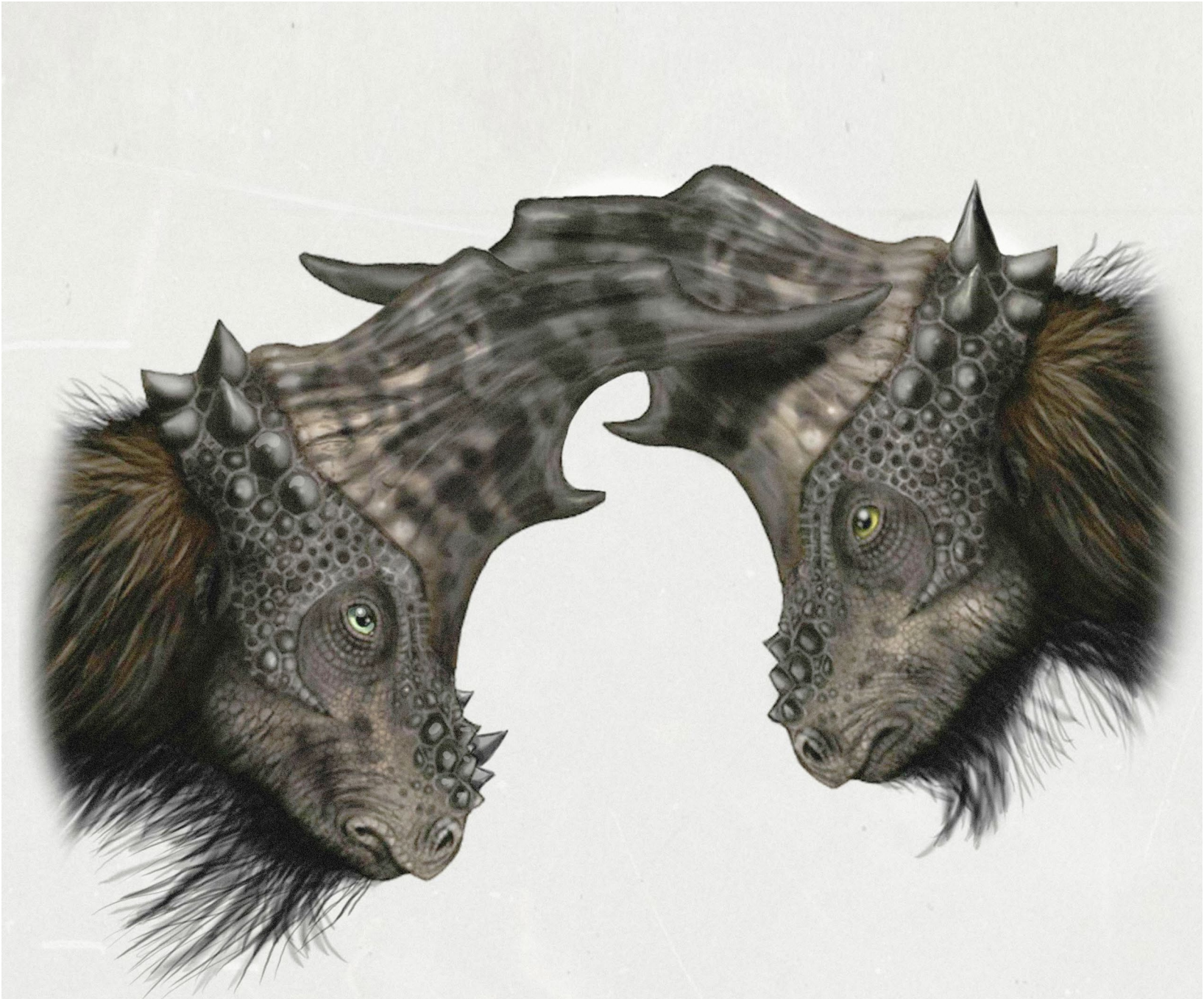
To break from this unconscious tradition, Melnik has created vivid, speculative portraits of dinosaurs and other prehistoric animals.

Portrait of *Tyrannosaurus rex*, everyone's favorite meat-eating dinosaur. This time, however, *T-rex* is feeding on **plants**, perhaps in order to relieve itself of a digestive ailment.

Portrait of *Cryolophosaurus*, a crested predatory dinosaur whose remains were discovered in **Antarctica**. Vitaly Melnik has speculated that its crest could have sported flexible, leathery folds that mimicked palm fronds. This would help conceal the animal from its quarry.

Portrait of *Anurognathus*, a tiny flying **pterosaur** with no tail and a wide, frog-like mouth.
These animals possibly occupied the ecological niches taken up by **bats** today.
In real life, this beast would be as small as a mouse.

Portrait of a baby **ornithischian** dinosaur with a drool of **"crop milk,"** a nutritious substance regurgitated by its caring mother. In today's world, certain birds also use crop milk to feed their offspring.



Portrait of two *Pachycephalosaurs*, locked in combat for social dominance. *Pachycephalosaurs* are famous for their sturdy, **dome-shaped skulls.** Vitaly Melnik has interpreted the domes as the foundations of even larger horns, much like the ones found in rhinoceroses today. Based on fiber-like fossils found in related animals, he has also restored them with shaggy, ox-like pelts.

Portrait of *Estemmenosuchus*, a very large, bear-like **cousin of the early mammals** that lived before the age of dinosaurs. It possibly fed on meat as well as plants. *Estemmenosuchus* had numerous horn-like protrusions on its face. Artist Vitaly Melnik has interpreted some of them as the bases of **keratinous, reindeer-like horns.**

Portrait of *Majungasaurus*, a predatory dinosaur from Madagascar. Since many dinosaur fossils have been discovered with feather impressions, artist Vitaly Melnik has dressed out *Majungasaurus* with an extremely-bird-like coat of **feathers**.

Vitor Silva
A Shedding Mosasaur

Sharing the seas with the last dinosaurs, **mosasaurs** were ancient marine reptiles descended from **lizards**. While new discoveries are showing them to be more fish-like than shown here, Italian palaeoartist Vitor Silva has produced his artwork with emphasis on the animals' skin rather than their bodies.

Like their relatives, **mosasaurs skins** were covered with scales. Fossil impressions show these to be very small, tightly packed and diamond-shaped. Mosasaur scales varied from larger, keeled scales in the upper parts of their bodies to smaller, smoother ones found lower down. [1] [2] In a way, this arrangement was similar to the scale patterns found in snakes.

Inspired by this parallel, Vitor Silva has elaborated on **mosasaurian moulting**. Lizards and snakes living today need to **moult**; they shed their skin every once often to accommodate their growing bodies. Almost certainly, mosasaurs would have shed their skin too. Would this take place as a single-piece moult, as in snakes? If this were the case, one could expect to find enormous moults of mosasaurs regularly washing up on Mesozoic beaches like monstrous, discarded veils. Or, would it take place in piecemeal fashion, like lizards, as Silva has illustrated here? Having only a limited number of soft-tissue mosasaur fossils, we cannot yet tell the answer.

1 Snow, F. H. (1878). "On the dermal covering of a mosasauroid reptile". Transactions of the Kansas Academy of Science 6: 54–58.

2 Kaddumi, H.F. (2009). "On the latest scale coverings of mosasaurs (Squamata: Mosasauridae) from the Harrana Fauna in addition to the description of s new species of Mosasaurus". Fossils of the Harrana Fauna and the Adjacent Areas. Amman: Eternal River Museum of Natural History. pp. 80–94.

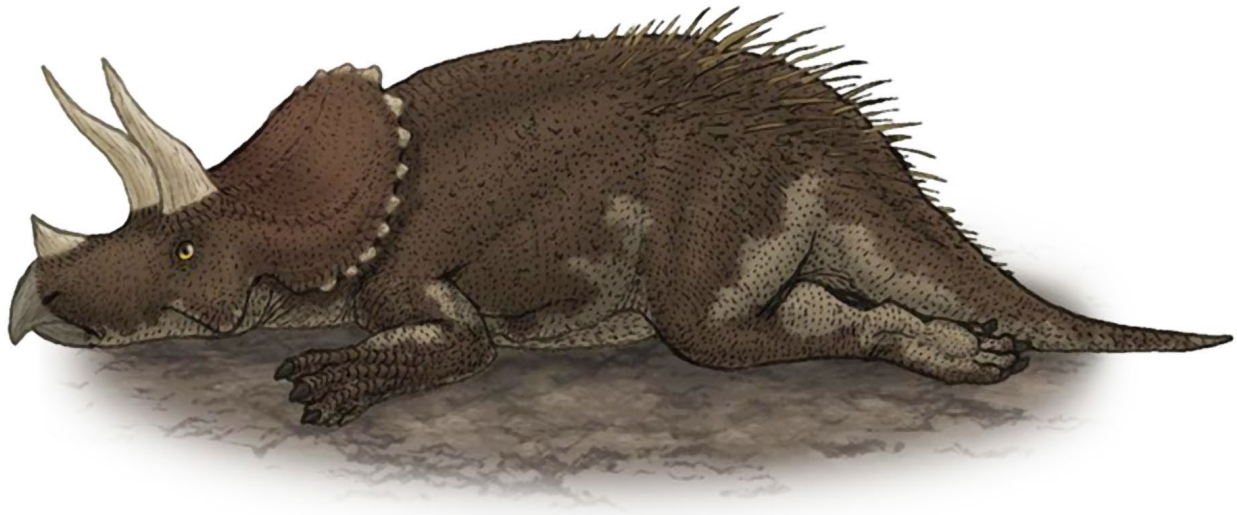
Vitor Silva

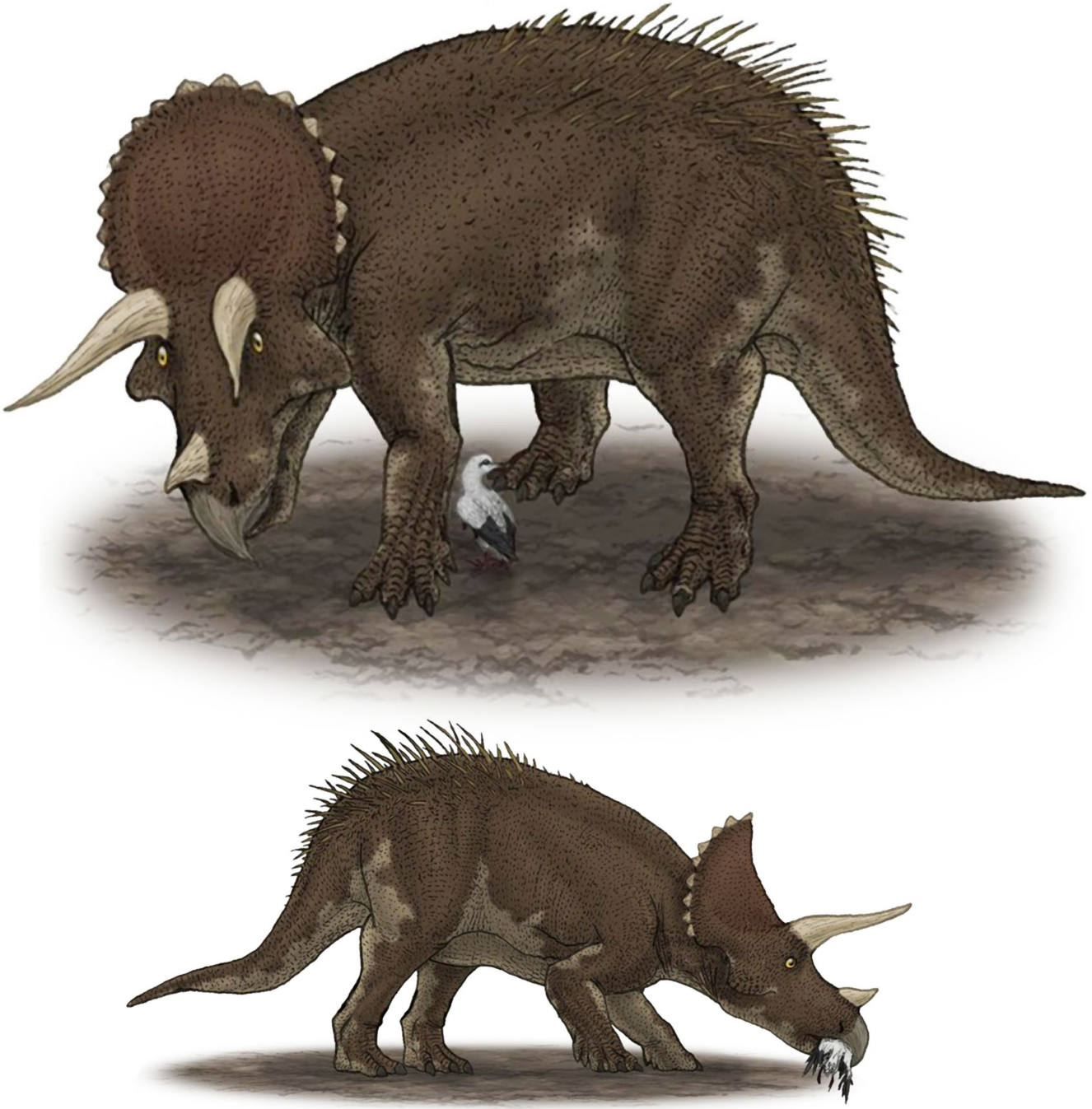
Drop-Kill Triceratops

As we know from the natural world today, a **herbivorous diet does not always translate to strict vegetarianism.** As surprising as it might seem, many herbivores will try to eat carrion or even live flesh if the opportunity becomes available. For example, animals like deer and cows have been observed feeding on bird nestlings, possibly in order to gain additional vitamins and minerals.

Artist Vitor Silva has here illustrated a similar case with the familiar herbivorous dinosaur *Triceratops*. In his speculative scenario, the heavyweight dinosaur allows commensal birds to approach it as they look for parasites on its skin. Seeking a suitable moment, the larger dinosaur unexpectedly drops all of its weight onto the bird, instantly crushing it. The *Triceratops* then eats the bird for a helpful boost of protein and minerals. The larger herbivore might even be doing this fun, as play behavior.

This might seem preposterous, but the artist has merely adapted this behavior from present-day animals. Giant tortoises have been observed "drop killing" small birds and eating them in exactly the same manner.

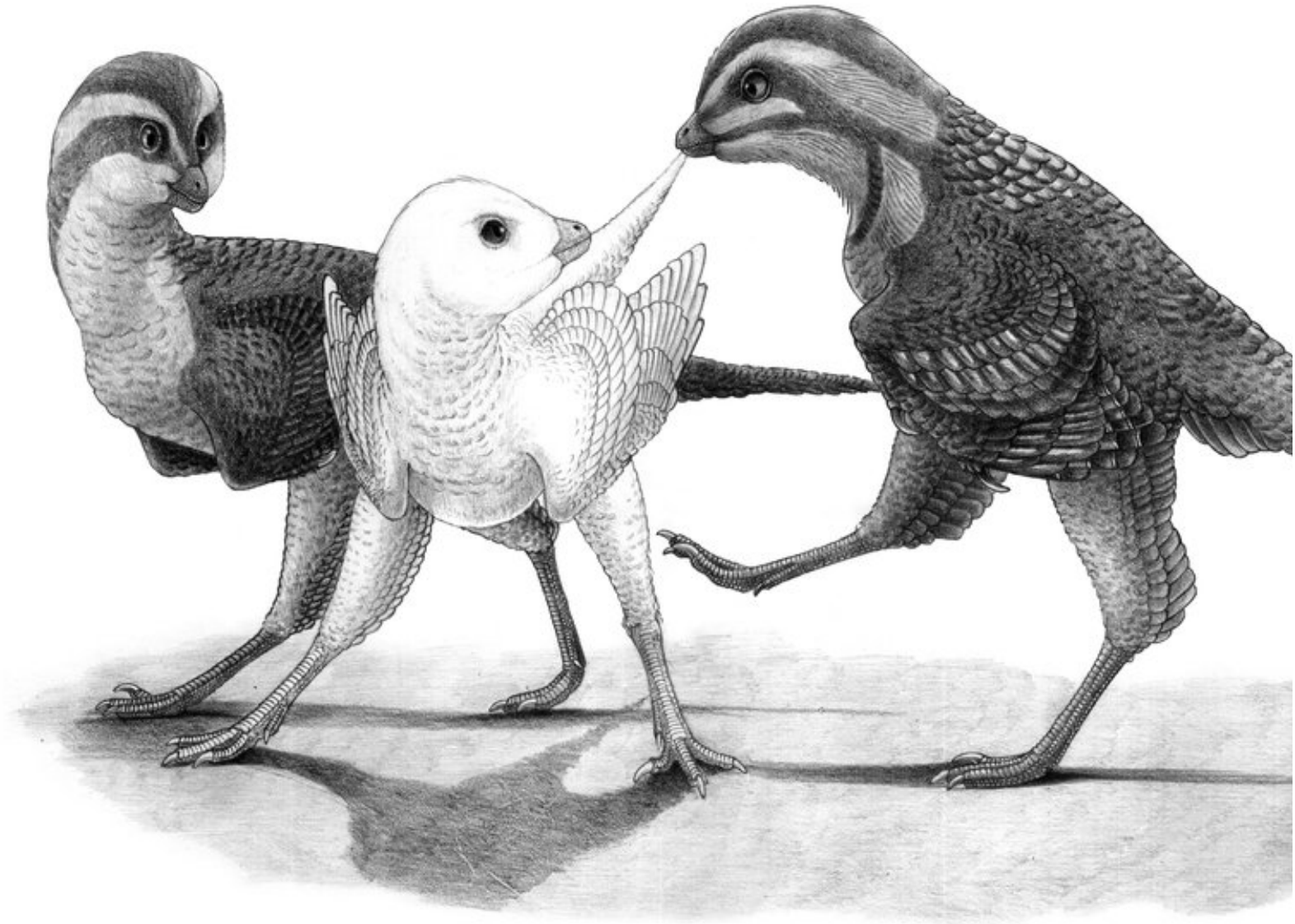




Vladmir Nikolov
An Albino Eosinopteryx

From the common pet white rabbit to extraordinary white whales, many animals exhibit **albinism** in nature. Albinism is characterized by an absence of **melanin** and other skin pigments, and is found in most animal groups, from birds to reptiles, fish and even mollusks. Doubtlessly, the phenomenon must have existed in dinosaurs as well.

Here, Bulgarian artist Vladmir Nikolov has illustrated an albino *Eosinopteryx*, an unusual, small bird-like dinosaur. Animals born with albinism face numerous obstacles in life, including an increased sensitivity to light, higher risk of skin cancer and extra visibility to predators. This little *Eosinopteryx* has made it to adolescence without much trouble, but now it faces a new threat: **harassment and ostracization by its kin.**



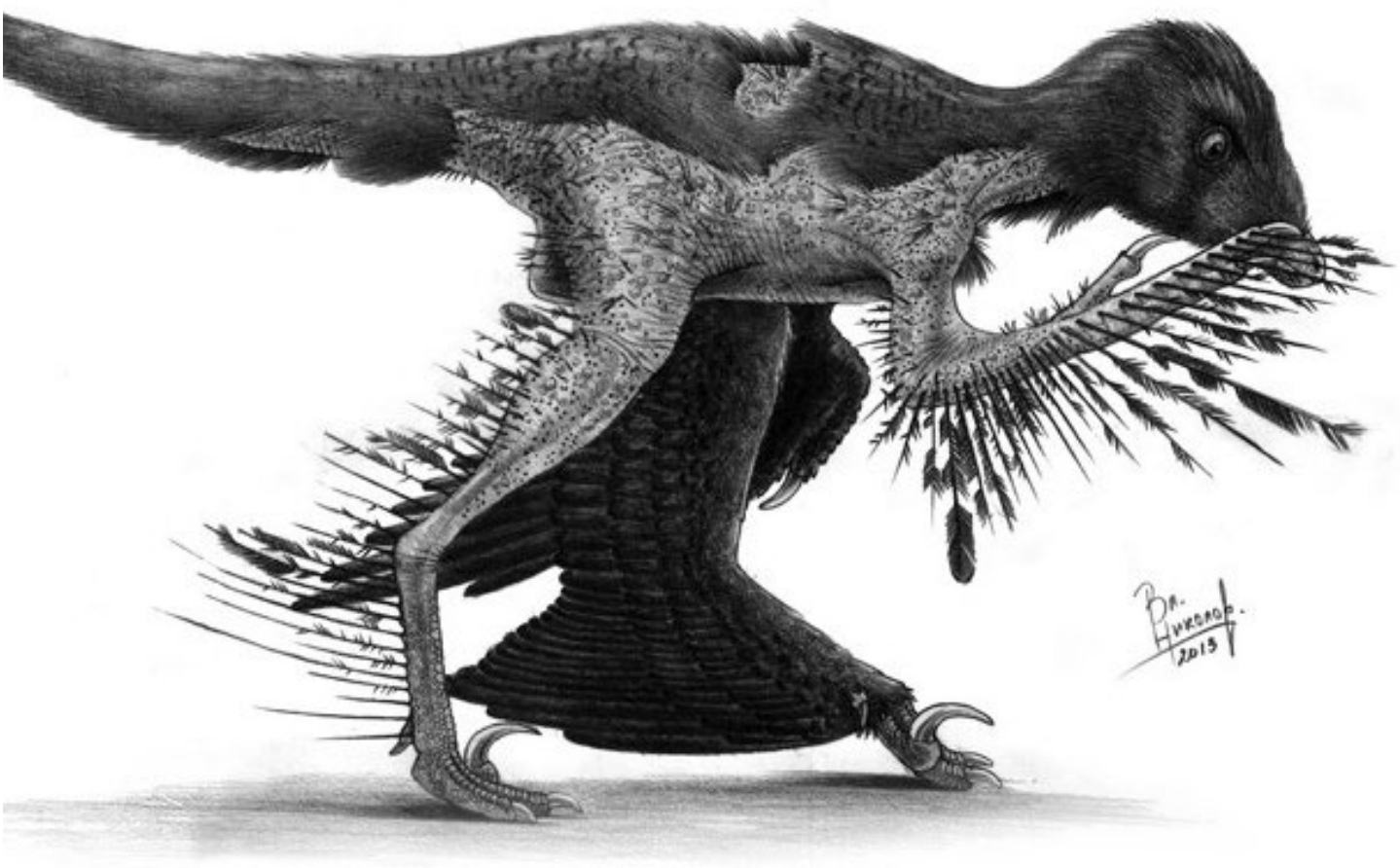
Vladmir Nikolov

Damaged Feathers

Now that feathers in small dinosaurs have become popularly accepted in palaeoart, the challenge is to produce artwork that will get people to think about the **implications of feathers** in the animals' daily lives. For example, **disease and damage to feathers** is a rarely tackled subject. In this picture, artist Vladmir Nikolov has illustrated a *Microraptor*, the famous "four winged" predatory dinosaur, [1] with half of its plumage lost in a forest fire. Fortunately the small hunter is not seriously hurt and the feathers will grow back in due time. Until then, however, this *Microraptor* won't be able to glide from branches like it used to do.

Nikolov has also used the fire-burned *Microraptor* to showcase his knowledge of bird anatomy. He has drawn the animal with a **propatagium**, a membranous flap between its upper and lower arms. Also, note that the second and third digits of its hand have been fused, for better anchorage of its long feathers. Both these features are present in modern-day birds, and by drawing his *Microraptor* with them, Nikolov hints that such "bird-like" traits may have preceded birds as we know them.

1 Xu, X., Z. Zhou, X. Wang, X. Kuang, F. Zhang, X. Du. 2003. Four-winged dinosaur from China.- Nature, 421, 335-340.



Vladmir Nikolov

Bone-Headed Dinosaur Hiding

Most people think that **pachycephalosaurs**, the famous bone-headed dinosaurs, used their extremely thick skulls for dominance duels and also as weapons against predators. With this meticulously-detailed work in pencil, however, artist Vladmir Nikolov suggests another alternative:

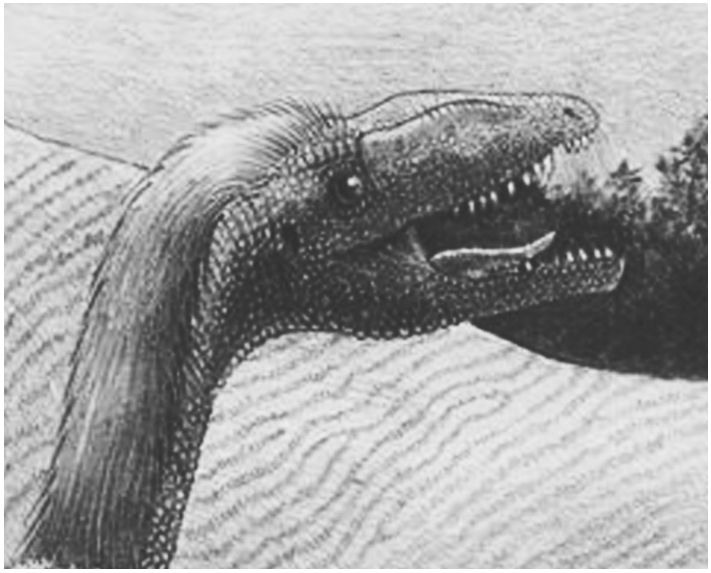
"It's known that at least some herbivorous dinosaurs had adaptations for digging and were able to live in dens. [1] *Similar adaptations are not known for pachycephalosaurs (as far as my knowledge goes), but many digging/denning animals have no obvious adaptations for such behavior either. Here, the pachycephalosaur* Prenocephale *is using a den to hide from a predator. I'm not sure burrow was made by this dinosaur, it may just be using a the den of another species. But denning is not its only protection. If some pachycephalosaurs really were able hide underground from time to time, then they could have gone even further by using* ***mimicry****. Because of the specific shape of their heads – the dome structure, some of them could have mimicked rocks, increasing their chances of avoiding predators."*

1 Varricchio, D. J., A. J. Martin, Y. Katsura. 2007. First trace and body fossil evidence of a burrowing, denning dinosaur.- Proceedings of Royal Society Biological Sciences, 274, 1361-1368.

Vladmir Nikolov
Moonlight Attack

Current reconstructions of dinosaurs are unnaturally stark. Perhaps because of a desire to represent skeletons accurately, contemporary palaeoartists leave as much soft tissue out as possible, resulting in **"shrink wrapped"** depictions. We can never tell all the fat, muscle mass, meat, hair, feathers and display features each dinosaur bore in real life, but after comparing existing animals and their skeletons, we can be certain that "shrink wrapped" dinosaurs are all wrong. **Some parts of the animals have been lost, forever unknown.**

Perhaps, instead of draping layers of skin over skeletal reconstructions, contemporary palaeoartists can create more thought-provoking images by engaging in healthy, plausible speculation. With this stunning scene from the Zimbabwe of 190 million years ago, palaeoartist Vladmir Nikolov has ventured on one such exercise. He has depicted the early long necked, herbivorous dinosaur *Massospondylus* fending off an attack by predatory *Megapnosaurs*. Most reconstructions of any long-necked dinosaur leave the neck bare like a hose, but perhaps these impressive structures bore soft tissue attachments as well. Nikolov has imagined *Massospondylus*' long neck as the support for a gigantic inflatable sac. He imagines it bellowing thunderously and expanding its dazzling sac to scare off its pursuers. There is no evidence of such a structure in *Massospondylus* or its relatives, but then again **absence of evidence is not the evidence of absence.**



Afterword and Credits

We at Irregular Books would like to thank everyone who participated in our contest. What you saw in this book was but a sliver of the new ideas, artwork and ways of thinking that will revolutionize not only palaeoart, but possibly the scientific process itself. We could not include all of the art we received for this volume, but your support, enthusiasm and creativity were the greatest driving forces for this book, and our other, upcoming projects. **Palaeoartists are unique in carrying the torches of art and science tohether.** Only a few people can do this. Whatever the future holds for your lives or careers, we hope that your passion in palaeoart never fades away.

- C. M. Kosemen

Rafael Albo
Smyslov Alexander
Yul Altolaguirre
Raven Amos
Alessio Arena
Patricia Arnold
Carlos Bernardo
Peter Buchholz
Camila Alli Chair
Rick Charles
Alessio Ciaffi
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Durbed
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Oscar Mendez
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Vladmir Nikolov
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Hayley Rowland
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Ethan Schmunk
Mitchell Seymour
Vitor Silva
Elia Smaniotto
Gray Stanback
Petr Stuchly
Dodd D Sutton
Andrew Tempest
Vasika Udurawane
Bethany Vargeson
Rodrigo Vega
Fabian Wiggers
Emily Willoughby

"Austroraptor"
artwork by Vitaly Melnik

"A cheeky *Psittacosaurus*"
artwork by Chris di Piazza

That's all folks!

The Irregular Books Crew

C. M. Kosemen

Author and artist C. M. Kosemen holds a Media and Communications Masters' degree from Goldsmiths College, and has worked as an editor in Benetton Company's *Colors* magazine. He has had several exhibitons of his evolution-themed fine art at galleries and science festivals internationally. Kosemen's areas of specialization are speculative & real zoology, history and unusual things in general. His previous work includes *Snaiad*, a self-initiated web project about life on an alien planet. Kosemen wrote and contributed artwork for the original *All Yesterdays* and initiated the contest behind this book.

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John Conway

John Conway is a palaeontological and fine artist, who's work has been used for National Geographic, Discovery Channel and the American Museum of Natural History, among others. His work has most recently appeared in *Dinosaur Art: the World's Greatest Paleoart*. John's interest in the methodology and culture of reconstructing of palaeontological subjects was the genesis of the original *All Yesterdays* project.

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Darren Naish

Author Darren Naish is a science writer, technical editor and a palaeozoologist. Darren works mostly on theropod and sauropod dinosaurs, but also on pterosaurs, marine reptiles and other tetrapods. With colleagues, he named the dinosaurs *Eotyrannus*, *Mirischia* and *Xenoposeidon*. Darren has written several books, including *Walking With Dinosaurs: The Evidence* (co- authored with David M. Martill), *Great Dinosaur Discoveries*, and more recently *Tetrapod Zoology Book One*. He is also the co-author of *All Yesterdays*. His blog, *Tetrapod Zoology*, is widely considered the world's foremost zoology blog.

When not writing about tetrapods, Darren can be found pursuing his interest in modern wildlife and conservation and resulting adventures in liz- ard-chasing, bird-watching and litter-collecting.

Website: blogs.scientificamerican.com/tetrapod-zoology/
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Oveleaf,
John Conway, C. M. Kosemen and Darren Naish during the *All Yesterdays* book launch event in London in 2012.