

揭开恐龙的奥秘

What's a Dinosaur?

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祝朝伟 译



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揭开恐龙的奥秘

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Editor's Message 编辑手记



要 成为一名古生物学家，必不可少的条件就是：要有无限丰富的想象力，一种能够让自己的想象穿越悠远的时空，去探究自然界中发生的各种可能性的能力。尽管很可能我们永远也无法确切地回答“什么是恐龙的颜色”，但古生物学家却不断地发现关于恐龙这种神奇动物的外貌、行为和生活方式等方面的信息。通过研究恐龙蛋、恐龙皮肤和骨片等化石，加上令人惊叹的现代技术，科学

家们从时间留下的蛛丝马迹中，力图复原亿万年前的前历史画面。设想要把一幅散缺很多的拼图给拼出来，这需要何等的想象力！因此，了解恐龙是一项不断进步的探索。

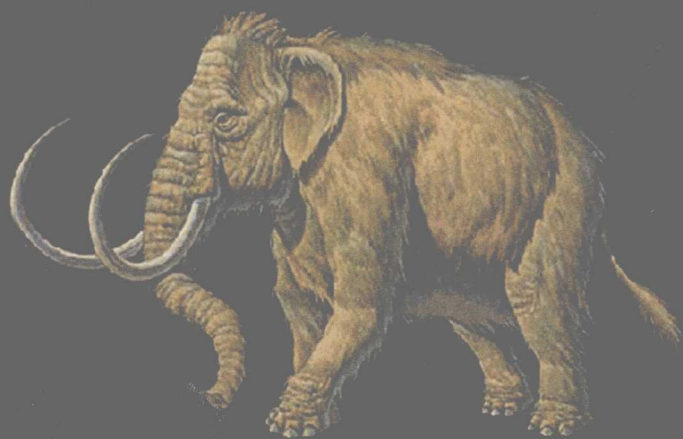
从本书的字里行间，你可以了解到 21 世纪初的人类对恐龙的奥秘有多少认识——或者说，我们认为自己对恐龙有多少认识。



并非
所有绝迹的大动物
都是 恐龙!



NOT EVERYTHING BIG AND





D DEAD IS A DINOSAUR!

by Stephen James O'Meara

Almost everyone knows, or thinks he knows, what a dinosaur is. But do they? It's not uncommon, for instance, to hear adults call woolly mammoths or saber-tooth tigers dinosaurs. It's also common for people to believe that flying creatures, like *Pteranodon*, or sea-dwellers, like ichthyosaurs, were dinosaurs. We often see dinosaurs and humans together in cartoons, such as Gary Larson's "Far Side," or Johnny Hart's "B.C." Well, if you're dinosaur-savvy, you'll laugh at these ideas.

But think about these questions: Were all prehistoric animals dinosaurs? Were dinosaurs reptiles (cold-blooded creatures without fur or feathers)? If so, how come we're hearing a lot these days about feathered dinosaurs? If birds

几乎人人都知道，或者每个人都以为自己知道什么是恐龙。但真的如此吗？举个例子来说，我们常常听见人们把长着长毛的猛犸或者剑齿虎叫做恐龙，这种情况并不少见；同样，人们常常把无齿翼龙等会飞的动物或者鱼龙等海生动物误认为是恐龙。而且，我们还在加里·拉森的《远方》、约翰尼·哈特的《公元前》等卡通片中常常看到人类与恐龙共处的情景。好了，如果你真正了解恐龙，你就会对这些幼稚想法报以一笑。

先来思考一下下面这些问题吧：所有史前的动物都是恐龙吗？恐龙是（冷血、无羽毛或者无毛皮的）爬行动物吗？如果是，那么我们最近常常听到的大量关于有羽毛的恐龙的报道又是怎么回事呢？如果恐龙是鸟类的始祖，部分恐龙曾经尝试过飞行的话，那为什么翼趾

descended from dinosaurs, and some dinosaurs may have experimented with flight, why isn't the sparrow-size flier *Pterodactylus* a dinosaur? Just what is a dinosaur, anyway?

Dr. Catherine Forster, a paleontologist at the State University of New York at Stony Brook, Long Island, says, "One thing and only one thing makes a dinosaur a dinosaur — it must be on a branch of the dinosaur tree. As long as it is descended from the dinosaur ancestor, it is a dinosaur!"

That sounds like circular logic, but it's not. Dinosaurs descended from a single common ancestor. And to determine how dinosaurs are related to that ancestor, modern researchers rely on a method known as cladistics.

Cladistics

is simply a way of

looking for ancestral relationships by searching for new, unique characteristics that animals share. If we look at a *cladogram* — a branching diagram that shows how animals are joined by these characteristics — we can see some of the major similarities.

DINOSAURS WERE ARCHOSAURS, NOT REPTILES

The first dinosaurs appeared in the middle Triassic Period. They belonged to a group called archosaurs — one of the most successful groups of land *vertebrates* (animals with backbones) ever known. The archosaurs included the earliest-known crocodiles and flying pterosaurs. During the Triassic Period, some archosaurs showed a number of changes in their anatomy, espe-

龙这种只有麻雀大小的飞鸟不是恐龙呢?说到底, 什么才是恐龙?

凯塞琳·福斯特博士是美国长岛斯托尼布鲁克(一译石溪——译者注)纽约州立大学的古生物学家。根据她的界定,“恐龙之所以成为恐龙, 只有一个标准, 而且是惟一的标准——它必须属于恐龙进化树形图上的一个分支。只要它是恐龙始祖的后裔, 它就是恐龙!”

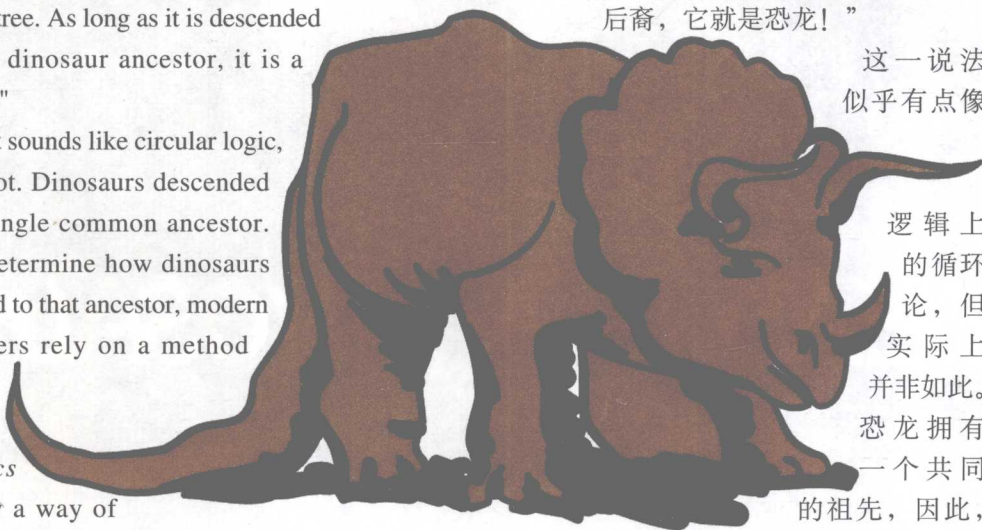
这一说法似乎有点像

逻辑上的循环论, 但实际上并非如此。恐龙拥有一个共同的祖先, 因此,

当代研究人员依赖一种叫做遗传分类学的科学来确定不同的恐龙与其共同的始祖之间的关系。这是一门通过寻找动物共有的、新颖而独特的特征来探究其始祖渊源的学问。如果我们观察动物的进化树——表明动物如何通过某些特征相互联系的进化分枝图, 我们就能归纳出一系列主要的相似点。

恐龙是祖龙属动物, 并非爬行动物

首批恐龙出现在三叠纪中期。它们属于祖龙属动物, 这是一群迄今所知最为成功的陆上脊椎动物(即有脊椎骨的动物), 包括最早为人类所熟识的鳄鱼和会飞的翼



cially of the legs. The improved leg design, especially of the hip socket, now allowed the archosaurs to tuck their legs in beneath their bodies as they walked, as well as sprawl

them
out to
the side.

Aiding this movement were complex knee and ankle structures. The archosaurs could now either run with their legs held upright, like a mammal, or walk with their belly close to the ground, their legs sprawled out sideways (like we do with our arms and elbows when we do pushups).

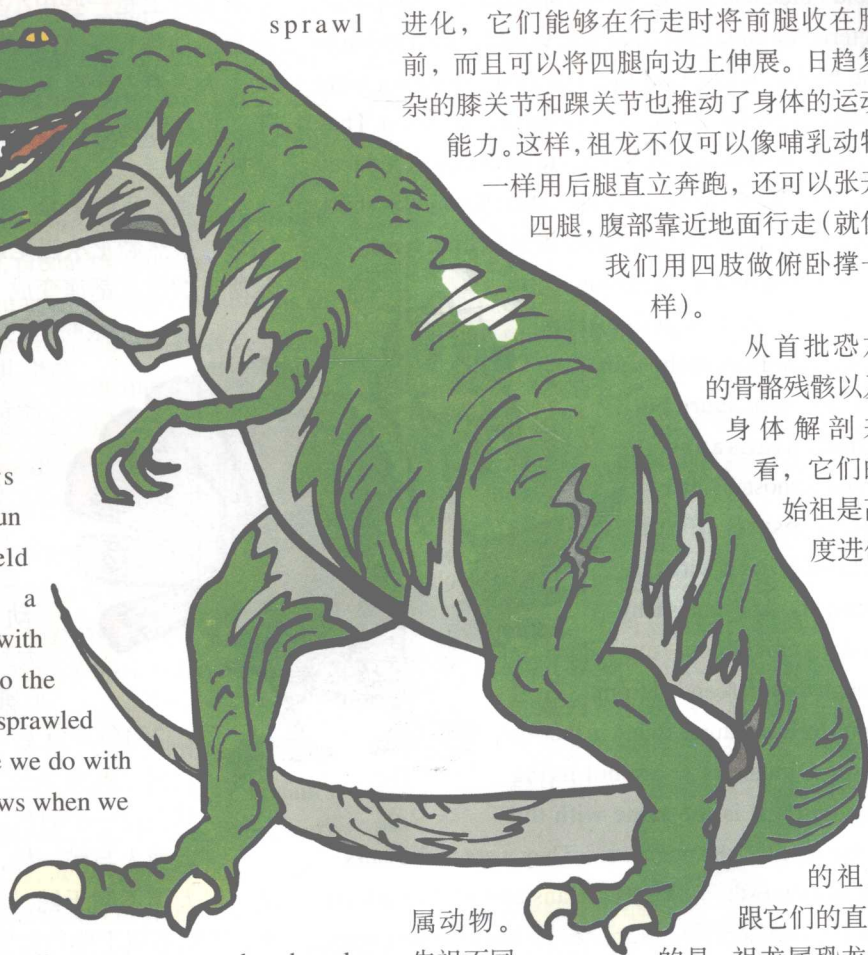
The skeletal remains and anatomy of the first dinosaurs suggest that they descended from highly advanced archosaurs. Unlike their immediate ancestor, dinosaurs had a thigh bone whose angled head allowed them to stand on two upright hind limbs. That's because their legs and muscles had developed to the point where they no longer needed the slow and low sprawl. "The characteristics shared by all dinosaurs that were present in the common ancestor are features of the ankle joint and other bony details," says Paul Sereno, a paleon-

龙。在三叠纪期间，部分祖龙的身体构造，尤其是腿部构造，开始发生变化。随着其腿部构造的不断进化，尤其是髌骨关节的进化，它们能够在行走时将前腿收在胸前，而且可以将四腿向边上伸展。日趋复杂的膝关节和踝关节也推动了身体的运动能力。这样，祖龙不仅可以像哺乳动物一样用后腿直立奔跑，还可以张开四腿，腹部靠近地面行走（就像我们用四肢做俯卧撑一样）。

从首批恐龙的骨骼残骸以及身体解剖来看，它们的始祖是高度进化

的祖龙

属动物。跟它们的直系先祖不同的是，祖龙属恐龙的后腿有一个呈一定角度弯曲的曲点，使它们能够用后腿垂直站立。这是因为它们的后腿和后腿肌肉已经高度进化，不必再缓慢地俯身爬行。芝加哥大学的古生物学家保罗·塞里诺认为：“踝关节和其他骨骼细部特征是所有恐龙共有的特点，这些特点也呈现在恐龙的共同祖先身上。”如果没有经过专门的训练，外行是很难发现这些化石特性的。但是，如果你有一个富有想



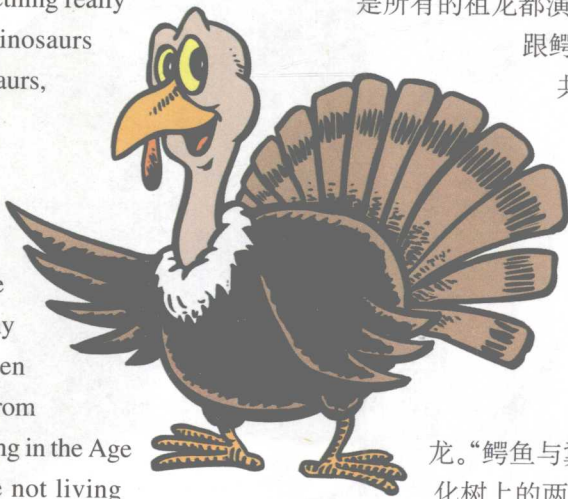
tologist at the University of Chicago. And many of these fossil traits are not easy for an untrained eye to see. But if you were to have an imaginary dinosaur field guide and wanted to see specific dinosaur characteristics and traits (like you would with a guide to the birds), you'd find that the first dinosaurs were small- to medium-size *carnivores* (meat-eaters). They walked on two legs and tended to have three-toed feet. Their necks were very mobile, their forelimbs short. And most dinosaurs probably didn't climb trees.

And now for something really

important: Although dinosaurs descended from archosaurs, not all archosaurs became dinosaurs.

Some archosaurs, like the ancestors of the crocodile, lived with the dinosaurs. And that is why modern crocodiles — even though they descended from prehistoric creatures living in the Age of the Dinosaurs — are not living dinosaurs. It is the same with the flying reptiles, the pterosaurs. They were archosaurs

but not dinosaurs. "Crocodilians and pterosaurs are simply two separate branches of the archosaur tree that lived at the same time," Forster says. "It's like whales and humans; both are mammals, but humans are not whales." Furthermore, dinosaurs are not reptiles, according to Forster. They are archosaurs because they share archosaur characteristics. "The term reptile is an old category," she says, "into which all cold-blooded modern animals were tossed. Crocs and dinosaurs have nothing to do with lizards, turtles, and snakes. Lizards and snakes are lepidosaurs."



象力的恐龙实地向导（就像你在欣赏鸟类时有一位实地向导一样），并特别留意恐龙的细部特征与属性，你就会发现，首批恐龙实际上是一些中小型的食肉动物（即肉食性动物）。它们可以用两腿直立行走，脚上大多有三个趾头。它们长着灵活的脖子，短小的前肢。大多数恐龙可能都不会爬树。

下面，我们来看一看一个至关重要的结论：虽然恐龙从祖龙进化而来，但并不是所有的祖龙都演变成了恐龙。部分祖龙

跟鳄鱼的祖先一样，跟恐龙

共生共栖。就像当代的

鳄鱼，虽然它们的祖

先是生活在恐龙时

代的史前动物，它

们并不是还活着的

恐龙。会飞的爬行

动物翼龙的情形也

大致如此。它们是祖

龙属动物，但不是恐

龙。“鳄鱼与翼龙只是祖龙属动物进

化树上的两个分支，它们与恐龙生

活在同一个时代，”福斯特解释说，

“就像人与鲸一样，二者同为哺乳动

物，但人类不同于鲸。”而且在福斯特看

来，恐龙不属于爬行动物。它们是祖龙属

动物，因为它们具有祖龙的特征。“‘爬行

动物’是一个相当老的概念，”她说，“把

所有的现代冷血动物都笼统地划归在内；

其实，鳄鱼与恐龙跟蜥蜴、乌龟和蛇类等

动物毫不相关，因为蜥蜴和蛇类属于有鳞

属动物。”

鸟类与恐龙之间的关联

过去一个多世纪的化石研究表明，恐

THE BIRD-DINOSAUR LINK

Fossil studies over the last century and more have revealed that dinosaurs belong to two distinct groups, or *clades*. (Keep in mind the cladogram.) One order is the *Saurischia*, meaning "lizard-hipped," and includes *Apatosaurus* and *Tyrannosaurus*; the other order, *Ornithischia*, meaning "bird-hipped," includes dinosaurs like *Stegosaurus* and *Triceratops*. Both orders came from small, bipedal, predatory dinosaur ancestors.

Perhaps the most surprising conclusions to come from dinosaur research in recent years are (1) that there is little doubt that birds evolved from dinosaurs, and (2) that birds descend *not* from the "bird-hipped" dinosaurs, but from lizard-hipped ones (huh?!), the closest relative being perhaps the small and agile *Velociraptor* or *Troodon*. Are modern birds dinosaurs? "Technically, yes," says Sereno, "because they are all within the group *Dinosauria* and are descendants of the first dinosaur."

So, according to this view, birds descended from one branch of dinosaurs, just as dinosaurs evolved from one branch of archosaurs. Surprised? Does it change your view of birds as warm, flying balls of bones and feathers? Do you think of them more as fuzzy dinos? Don't answer yet — check out the evidence first!

龙可以分为两种不同的类型，或者说有两种不同的进化枝（别忘了上面所说的“进化树”的概念）。一种是蜥臀目恐龙，如雷龙和暴龙；而另一种则是鸟臀目恐龙，包括剑龙和三角龙。这两种纲目的恐龙的先祖都是体形短小的双足猎食性恐龙。

在近年来的恐龙研究中，最令人意想不到的研究结论恐怕要属下面这两个：（1）毫无疑问，鸟类是从恐龙演变而来的；（2）鸟类不是从鸟臀目恐龙，而是从蜥臀目恐龙演变而来的；（啊哈！？）与鸟类亲属关系最密切的恐怕要属小而灵巧的速飞龙或楚敦龙了。那么，现代的鸟类是恐龙吗？“从技术的角度来说，答案是肯定的，”塞里诺解释道，“因为它们都属于恐龙属，都是由首批恐龙演变而来的。”

因此，根据上述观点，鸟类是从恐龙的一支演变而来的，就像恐龙是从祖龙的一支演变而来的一样。不可思议吗？这是否改变了你认为“鸟儿就是一团长有骨头和羽毛、暖血并会飞的东西”的观点？你是否会把鸟儿想象成毛绒绒的恐龙呢？对于这些问题，我们不要仓促作答——还是先找找相关证据吧！

The word "**dinosaur**" is derived from a combination of two Greek words: *deinos* (terrible) and *sauros* (lizard). So "dinosaur" means "terrible lizard." It was coined in 1842 by the famous English paleontologist Richard Owen, to describe a special order of large fossil reptiles (*Dinosauria*), creatures that far surpassed "in size the largest of existing reptiles."

NO PET DINOS!

by Gary Larson


没有宠物恐龙!

Looking back in time, we can divide the span of Earth's history into six eras. The oldest three eras are known collectively as Precambrian. The Precambrian covers all but the last half billion years or so of Earth's 4.5-billion-year history. Scientists have found an abundance of Precambrian fossils, such as algae and fungi, and the trails or burrows of wormlike creatures. But there were no dinosaurs. So dinosaurs were not around for the first 4 billion years of Earth's history. Although Precambrian animals are the oldest on Earth, they are *not* dinosaurs.

Of the other three eras in Earth's history — the Paleozoic, Mesozoic, and Cenozoic (which cover the last 570 million years) — dinosaur fossils have been found in rocks only from the Mesozoic Era. The Mesozoic Era is subdivided into the three well-known periods: Triassic, Jurassic (We've all heard of *Jurassic Park!*), and Cretaceous. The dinosaur fossils discovered to date range in age from the latest part of the Triassic Period (about 230 million years ago) throughout the Jurassic Period and up to the end of the Cretaceous Period (65 million years ago) — a duration of about 165 million years. The Mesozoic Era, then, is the Age of the Dinosaurs. The first appearance of anatomically modern humans known as *homo sapiens* occurred less than 100,000 years ago. So the Flintstones, that modern Stone Age family, shouldn't have had dinosaurs as pets!

回顾历史长河，我们可以把地球的历史分为六个时期。最古老的三个时期统称为前寒武纪。在地球长达45亿年的历史中，前寒武纪包括了除最近约5亿年以外的全部历史。科学家们发现了大量前寒武纪生物的化石，如藻类、真菌以及蠕虫类生物的踪迹或洞穴。不过，这些生物并不包括恐龙。因此，在地球史的前40亿年，恐龙还不存在。虽然前寒武纪的生物是地球上最古老的生物，但它们并不包括恐龙。

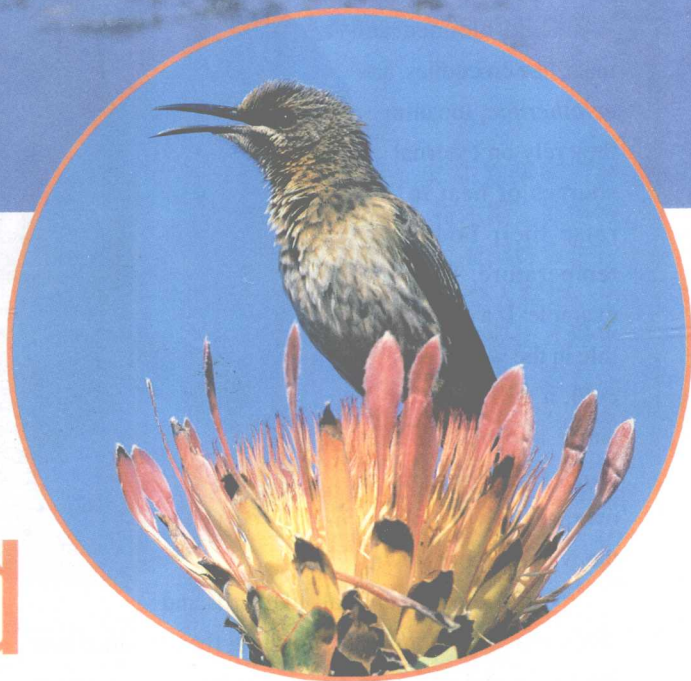
在地球史的其他三个时期（古生代、中生代和新生代，这三个时期包括地球最近的5.7亿年历史）中，人们仅在中生代以后的岩层中发现了恐龙化石。而中生代又可以进一步划分为三个著名的地质纪：三叠纪、侏罗纪（我们都听说过《侏罗纪公园》这部电影！）和白垩纪。从时间上说，迄今所发现的恐龙化石上至三叠纪后期（约2.3亿年前），历经整个侏罗纪，最后直到白垩纪末期（约6500万年前）——整个时间跨度达1.65亿年。因此，可以说中生代就是恐龙的时代。而解剖意义上的现代人类（即“智人”）最早出现于10万年前。因此，钻石取火的现代人——那个现代石器时代家族——当不应有过将恐龙作为宠物之事！



Were Dinosaurs Warm-Blooded or Cold-Blooded?

(And Other Points of Confusion)

by Stephen James O'Meara



恐龙： 温血的还是冷血的？

(以及其他疑点)

Dinosaurs were archosaurs, but so too are crocodiles and birds. Now, here's the million-dollar question: If crocodiles are cold-blooded and birds are warm-blooded, what were the dinosaurs?

Tick, tick, tick. . .ding!

Time's up. Is that your final answer? I'll bet 90 percent of you said, "Because birds descended from dinosaurs, dinosaurs were warm-blooded." Right? Well, the answer just isn't that simple, because the distinction between a cold-blooded and a warm-blooded animal is not as clear as you might think.

Cold-blooded animals, like crocodiles, are *ectothermic*, meaning they rely on external sources of heat to raise their body temperature. For example: If a crocodile in the water feels cold, it will move on-shore and bask in the sun. If it begins to overheat, it will dip back in the water to cool down.

Warm-blooded animals like birds and mammals are *endothermic*, meaning they produce heat internally and can keep a constant body temperature despite outside temperatures. This is important, because animals' muscles, nerves, and digestive systems (in fact, their entire metabolism) need to be reasonably warm to work efficiently at full speed. What's interesting is that by regulating their body temperatures externally (and thereby keeping a constant body temperature), a cold-blooded reptile's metabolism mimics a warm-blooded

恐龙是祖龙属爬行动物，鳄鱼与鸟类也是。这样就出现了一个令人头疼的问题：鳄鱼是冷血动物，而鸟类却是温血动物，那么恐龙是什么样的动物呢？

滴答、滴答、滴答……停！

时间到！想好你的答案了吗？我敢说，99%的人会说：“因为恐龙是鸟类的前祖，而鸟类是温血动物，因此恐龙也是温血动物。”那么，这一答案正确吗？也

许，问题的答案并非如此简单，

因为冷血动物与温血动物之间的区别并不像我们所想的那样清晰明了。

冷血动物（如鳄鱼）属于“外热型动物”，即依靠外部热源提升体温的动物。以鳄鱼为例，如果鳄鱼在水中体温下降，它就会上岸通过晒太阳来取暖。如果体温变得过高，它又会重新回到水中把体温降下来。

温血动物（如鸟类和哺乳动物）属于“内热型动物”，它

们通过体内产生的热量维持体温，不管外界温度如何，它们的体温恒定。对这些动物来说这是至关重要的，因为它们的肌肉、神经和消化系统（事实上是整个新陈代谢）只有在起码的温度下才能全速而有效地运作。有趣的是，冷血爬行动物依靠外界对体内的温度进行调节（以此保持体内恒温），这种新陈代谢方式是对温血动物的模仿。不过，“爬行动物仍然



animal's. But, "reptiles still don't produce body heat like mammals and birds," says Dr. Catherine Forster, a paleontologist at the State University of New York at Stony Brook, Long Island. "They may be able to keep warm during the day, but they can't run far before they poop out," she says. And it's true. An alligator, for example, might look like a big slug basking on a rock in the sun, but if it needs to, it can get up and gallop faster than a human. . .but not for long.

BIG IS BALMY

Research on alligators by paleontologists Edwin Colbert, Charles Bogert, and Raymond Cowles in 1946 proved something equally astounding: The body temperature of a small alligator tends to change much more rapidly than does the body temperature of a large alligator. In other words, the amount of heat an alligator's body holds depends on its volume. This finding was significant. When Colbert and his colleagues mathematically scaled up the size of an alligator to that of a dinosaur weighing 10 tons, they found that huge dinosaurs would have taken an enormously long period to cool down — they could have kept warm all night by retaining body heat (like a warm-blooded animal), even though the temperature around them dropped!

More recently, researchers working with giant sea turtles, the largest cold-blooded reptiles on Earth, discovered a similar trait. Giant sea turtles can migrate vast distances, crossing waters with great temperature

无法像哺乳动物和鸟类那样通过自身产生热量，”美国长岛斯托尼布鲁克斯纽约州立大学的古生物学家凯瑟琳·福斯特博士说。“白天它们可以保持身体的温暖，但一旦它们奔跑起来，跑不了多远就会精疲力竭，”她进一步解释道。事实的确如此。以美洲鳄鱼为例，鳄鱼躺在岩石上晒太阳的样子很像一条巨大的懒虫，但如有必要，它也会一跃而起，快速飞奔，其速度远比人类快得多……只不过，它高速飞奔的时间不能太长罢了。



大就是暖

1946年，古生物学家埃德温·科尔伯特、查尔斯·博格特和雷蒙·考尔斯对美洲鳄鱼进行了研究，其结果也令人震惊：小鳄鱼的体温变化要比大鳄鱼快得多。换句话说，鳄鱼体内所蓄积的热量多少由其体形的大小决定。这一发现具有重大的意义。科尔伯特及其同事运用数学的方法，根据鳄鱼和重达10吨的恐龙的身体大小比例进行了折算；他们发现，体形巨大的恐龙要花费极其漫长的时间才能使体温下降——跟温血动物一样，通过保持体内的温度，它们可以使身体在整个黑夜中一直保持温暖，即使在周围的温度下降时也是如此。

最近，研究人员对地球上最大的冷血动物——巨型海龟进行了研究，他们也发现了类似的特点。巨型海龟迁徙之时往往长途跋涉，跨越诸多温



differences, and not be affected. Their bodies are so large they retain heat, keeping their body temperature constant for extended periods of time and insulating them against sudden temperature changes.

Dr. Matt Carrano, also a paleontologist at the State University of New York at Stony Brook, points out that "at some level you need not be warm-blooded to be efficient." Just look at *Apatosaurus*, which could have been cold-blooded; size alone was enough to insulate it against minor daily temperature changes.

Warm-blooded elephants today, however, experience a very different situation from that of *Apatosaurus*. Because of their size, elephants are at risk for overheating. Their internal body system maintains a constant temperature, and when their environment heats up, their mass makes it difficult for them to cool down. That's why they have evolved huge ears — the large surface area encourages evaporation and the ears are also great for flapping to help them cool off.

Now, imagine a warm-blooded elephant the size of *Apatosaurus*, and you can see that being cold-blooded could have been quite efficient for

差极大的海域，它们却丝毫不受这些温差的影响。这是因为，巨型海龟庞大的身体可以帮助蓄积热量，保持体内温度长时间恒定不变，以此抵御温度的骤然变化。

马特·卡拉诺博士也是斯托尼布鲁克斯纽约州立大学的古生物学家。他指出：“某种程度上，动物不一定非要是温血的才能有效行动。”只要看看雷龙就能理解这一点，因为雷龙很可能就是冷血动物；仅其庞大的身躯就足以让它抵御微小的日常气温的变化。

不过，今天，身为温血动物的大象却遭遇了与雷龙截然不同的境况。大象的体形过大，时刻都有体温过高的危险。由于大象体内始终保持恒定的温度，一旦周围环境的温度升高，大象庞大的身躯就给降温造成了极大的困难。这就是所有的大象都长着大大的耳朵的原因——巨大耳朵的表面积有利于热量的蒸发，而且象耳的扇动有利于体温的下降。

现在，如果我们把温血动物大象想象成雷龙一样大小，你便会明白，对于这样一个庞然大物来说，身为冷血动物对于降温是极为有效的。但是，即使某些恐龙（如雷龙）拥有跟温血动物一样行之有效的代谢系统，并不是所有的恐龙都是这样的。“恐龙的种类成千上万，”卡拉诺说，“没有必要每一种恐龙都拥