**The Pace of Evolutionary Change**

**进化改变的步伐**

A heated debate has enlivened recent studies of evolution. Darwin’s original thesis, and the viewpoint supported by evolutionary gradualists, is that species change continuously but slowly and in small increments. Such changes are all but invisible over the short time scale of modern observations, and, it is argued, they are usually obscured by **innumerable** gaps in the imperfect fossil record. Gradualism, with its stress on the slow pace of change, is a comforting position, repeated over and over again in generations of textbooks. By the early twentieth century, the question about the rate of evolution had been answered in favor of gradualism to most biologists’ satisfaction.

最近的一个关于进化的研究引发了激烈的争论。达尔文的原始论点和进化渐进主义者支持的观点是物种会持续地改变，但非常缓慢，增量也很小。这种改变到处都是，但是短时间的近代观察是不能察觉的，并且，这个观点声称，它们通常被掩盖于不完美的化石记录的不可计数的缺口中。渐进主义，与其慢速的变化压力，处于一种令人欣慰的位置，在世代的教科书中重复出现。在 20 世纪早前之前，令大部分的生物学家满意的是，大部分关于进化比率问题的答案都支持了渐进论。

Sometimes a closed question must be reopened as new evidence or new arguments based on old evidence come to light. In 1972 paleontologist Stephen Jay Gould and Niles Eldredge challenged conventional wisdom with an opposing viewpoint, the punctuated equilibrium hypothesis, which posits that species give rise to new species in relatively sudden bursts, without a lengthy transition period. These episodes of rapid evolution are separated by relatively long static spans during which a species may hardly change at all.

有时，已经有了结论的问题必须由基于已有证据的曝光而出现的新的证据和新的论点使其重新展开讨论。在 1972 年，古生物学者 Stephen Jay Gould 和 Niles

Eldredge 用相反的论点挑战了世俗认知，即断点平衡说，它假设了物种演变为新的物种是通过相对突然的爆发，并非通过长时间的过渡时期。这种迅速的进化的发生是被相对长时间的静态贯穿的，而在静态时期，物种是几乎完全不变的。

The punctuated equilibrium hypothesis attempts to explain a curious feature of the fossil record --- one that has been familiar to paleontologist for more than a century but has usually been ignored. Many species appear to remain unchanged in the fossil record for millions of years --- a situation that seems to be at odds with Darwin’s model of continuous change. Intermediated fossil forms, predicted by gradualism, are typically lacking. In most localities a given species of clam or coral persists essentially unchanged throughout a thick formation of rock, only to be replaced suddenly by a new and different species.

断点平衡论试着去解释化石记录的一个古怪的特点，它已经为古生物学者所熟悉超过一个世纪，但一直被忽视。许多物种似乎在上百万年的化石记录中一直没有改变，这个情况对于不断变化的达尔文模型来说是不符合的。渐进学者预测，这之间的化石形成是不完整的。在大部分蛤和珊瑚的聚集地，其化石在很厚的岩石中都表现出了本质上的一致性，只是突然被另一新的或者不同的物种而取代。

The evolution of North American horse, which was once presented as a classic textbook example of gradual evolution, is now providing equally **compelling** evidence for punctuated equilibrium. A convincing 50-million-year sequence of modern horse ancestors --- each slightly larger, with more complex teeth, a longer face, and a more prominent central toe ---seemed to provide strong support for Darwin’s contention that species evolve gradually. But close examination of those fossil deposits now reveals a somewhat different story. Horses evolved in discrete steps, each of which persisted almost unchanged for millions of years and was eventually replaced by a distinctive newer model. The four-toed Eohippus preceded the three-toed Miohippus, for example, but North American fossil evidence suggests a jerky, uneven transition between the two. If evolution had been a continuous, gradual process, one might expect that almost every fossil specimen would be slightly different from every year.

北美马的进化曾经被用作经典的教科书案例来证明渐变进化论，现在却为点断平衡学提供了同样有说服力的证据。一个有说服力的 5 千万年的马祖先的进化模型，每一代都稍稍大一点，有更复杂的牙齿，更长的连，和更中间突出的脚趾，这一切都看似强有力的支持了达尔文的论点，物种是逐步地进化的。但是，对这些化石更严谨的验证现在揭示了一个不太一样的故事。马是在不连续的步骤中进化的，其中每个进化步骤中间都间隔了上百万年的不变时间，在最后被一个不同的更新的模型取代。比如四只脚趾的 Eohippus 在三只脚趾的 moihippus 之前，但北美化石证据暗示了在这之间的一个不平稳的，不均衡的转换过程。如果进化一直都是连续，渐进的过程，人们应该预期到的是每个不同年份的化石样本都会存在细微的差别。

If it seems difficult to conceive how major changes could occur rapidly, consider this: an **alteration** of a single gene in files is enough to turn a normal fly with a single pair of wings into one that has two pairs of wings.

如果很难去设想大的改变会频繁发生，想想这些：一个单一基因的改变就足以将那个飞禽的一对正常的翅膀变为两对。

The question about the rate of evolution must now be turned around: does evolution ever proceed gradually, or does it always occur in short bursts? Detailed field studies of thick rock formations containing fossils provide the best potential tests of the competing theories.

关于进化速度的问题现在发生了转变：进化过程有过逐渐发生的么？还是总是突然短时间的爆发？对含有化石的厚岩层的细致的现场调查为这两个相互矛盾的理论提供了可能的测验。

**Occasionally**, a sequence of fossil-rich layers of rock permits a comprehensive look at one type of organism over a long period of time. For example, Peter Sheldon’s studies of trilobites, a now extinct marine animal with a segmented body, offer a detailed glimpse into three million years of evolution in one marine environment. In that study, each of eight different trilobite species was observed to undergo a gradual change in the number of segments --- typically an increase of one or two segments over the whole time interval. No significant discontinuous were observed, leading Sheldon to conclude that environmental conditions were quite stable during the period he examined.

偶尔，有一个系列的化石丰富的岩石可以允许人们综合性的观察一种生物在很长一段时间中的变化。比如，Peter Sheldon’s 对于三叶虫的研究，三叶虫是一种现在即将灭绝的身体分节的海洋生物，对它的研究提供了对三百万年来在同一海洋环境下进化的一些细节。在这个研究中，八种三叶虫每一种都被观察到了经过了一个身体节数数量逐渐改变的过程，在整个时间段后，一般身体都增加了一到两节。没有明显的不连贯，这使 sheldon 得出结论：海洋环境在那段时间是比较稳定的。

■Similar exhaustive studies are required for many different kinds of organisms from many different periods.■ Most researchers expect to find that both modes of transition from one species to another are at work in evolution. ■Slow, continuous change may be the norm during periods of environmental stability, while rapid evolution of new species occurs during periods of environment stress. ■But a lot more studies like Sheldon’s are needed before we can say for sure.

相似的详尽的研究要求许多不同种类不同时间段的生物，大多数研究者预期发现两种物种进化模式。缓慢的，连续的变化可能是在环境稳定的时间段下的规律，而快速进化的新物种则发生在环境变化时期的压力下。但是，我们需要更多的像 Sheldon 的研究一样的研究区证明这个论点。