### The Cambrian Explosion

**寒武纪大爆发**

The geologic timescale is marked by significant geologic and biological events, including the origin of Earth about 4.6 billion years ago, the origin of life about 3.5 billion years ago, the origin of eukaryotic life-forms (living things that have cells with true nuclei) about 1.5 billion years ago, and the origin of animals about 0.6 billion years ago. The last event marks the beginning of the Cambrian period. Animals originated relatively late in the history of Earth — in only the last 10 percent of Earth’s history. During a geologically brief 100-million-year period, all modern animal groups (along with other animals that are now extinct) evolved. This rapid origin and diversification of animals is often referred to as “the Cambrian explosion.”

地质年代是由重大地质事件和生物事件标记的，包括46亿年前地球的形成、35亿年前生命的起源、15亿年前真核生物（细胞中有真核的生命体）的起源以及6亿年前动物的起源；其中最后的一个事件标志着寒武纪的开始。动物的起源相对处于地球历史的晚期——仅存在于地球历史时间的1∕10。在短暂的1亿年地质学周期中，所有现代动物群（包括现在已经灭绝的生物）进化了。这次快速的动物起源和分化常常被称为“寒武纪大爆发”。

Scientists have asked important questions about this explosion for more than a century. Why did it occur so late in the history of Earth? The origin of multicellular forms of life seems a relatively simple step compared to the origin of life itself. Why does the fossil record not document the series of evolutionary changes during the evolution of animals? Why did animal life evolve so quickly? Paleontologists continue to search the fossil record for answers to these questions.

一个多世纪以来，科学家们对这次大爆发一直有疑惑。为什么它发生得这么晚？毕竟多细胞生物的出现相对于生命的出现而言只是一次相对简单的进化。为什么化石没有记录下动物演化的一系列变化呢？为什么动物生命进化得如此迅速呢？古生物学家们仍旧在研究化石记录以期回答这些问题。

One interpretation regarding the absence of fossils during this important 100-million-year period is that early animals were soft bodied and simply did not fossilize. ■Fossilization of soft-bodied animals is less likely than fossilization of hard-bodied animals, but it does occur. ■Conditions that promote fossilization of soft-bodied animals include very rapid covering by sediments that create an environment that discourages decomposition. ■In fact, fossil beds containing soft-bodied animals have been known for many years. ■

关于这重要的1亿年内化石的缺失，有一种解释是早期的动物都是软体动物，它们很难形成化石。软体动物的化石比硬体动物化石少见得多，但是也是存在的。促使软体动物成为化石的条件是沉积物的迅速覆盖以形成一个抑制分解的环境。事实上，含有软体动物的化石层在很多年以前就已经为人们所知了。

The Ediacara fossil formation, which contains the oldest known animal fossils, consists exclusively of soft-bodied forms. Although named after a site in Australia, the Ediacara formation is worldwide in distribution and dates to Precambrian times. This 700-million-year-old formation gives few clues to the origins of modern animals, however, because paleontologists believe it represents an evolutionary experiment that failed. It contains no ancestors of modern animal groups.

含有最古老的动物化石的伊迪卡拉化石群就全部由软体动物化石组成。尽管伊迪卡拉是以澳大利亚的一处地名而命名，但是伊迪卡拉沉积层的分布却遍及世界各地，并且可以追溯到前寒武纪时期。这些7亿年前形成的地层为现代动物的起源提供了一些新的线索。因为古生物学家们认为它代表着一次失败的进化试验，其中并没有包含任何现代动物的祖先。

A slightly younger fossil formation containing animal remains is the Tommotian formation, named after a locale in Russia. It dates to the very early Cambrian period, and it also contains only soft-bodied forms. At one time, the animals present in these fossil beds were assigned to various modern animal groups, but most paleontologists now agree that all Tommotian fossils represent unique body forms that arose in the early Cambrian period and disappeared before the end of the period, leaving no descendants in modern animal groups.

以俄罗斯的一处地名而命名的Tommotian是一层包含动物残骸的较年轻的化石层。它形成于寒武纪的早期，并且同样只含有软体动物化石。在一段时间内，人们认为这些化石中的动物分化出了各种各样的现代动物。但是古生物学家们现在却认为，所有的Tommotian化石都仅代表在寒武纪初期出现但到寒武纪结束时就消失了的特别生物。所以它们没有在现在动物中留下后代。

A third fossil formation containing both soft-bodied and hard-bodied animals provides evidence of the result of the Cambrian explosion. This fossil formation, called the Burgess Shale, is in Yoho National Park in the Canadian Rocky Mountains of British Columbia. Shortly after the Cambrian explosion, mud slides rapidly buried thousands of marine animals under conditions that favored fossilization. These fossil beds provide evidence of about 32 modern animal groups, plus about 20 other animal body forms that are so different from any modern animals that they cannot be assigned to any one of the modern groups. These unassignable animals include a large swimming predator called *Anomalocaris* and a soft-bodied animal called *Wiwaxia*, which ate detritus or algae. The Burgess Shale formation also has fossils of many extinct representatives of modern animal groups. For example, a well-known Burgess Shale animal called *Sidneyia* is a representative of a previously unknown group of arthropods (a category of animals that includes insects, spiders, mites, and crabs).

第三种化石层既包含了软体动物也包含了硬体动物，它为寒武纪大爆发提供了证据。这种叫做伯吉斯页岩的化石群就在加拿大的大不列颠哥伦比亚石山上的约霍国家公园内。在寒武纪大爆发后不久，滑落的泥土迅速掩埋了成千上万的海洋动物，形成了极有利于化石形成的环境。这些化石层含有大约32种现代动物，还有大约20种与现在动物截然不同以至于不可能分类为任何一种现代动物的其他动物体。这些无法划分的动物包含一种叫做Anomalocaris的肉食动物和一种叫做Wiwaxia的以岩屑和藻类为食的软体动物。伯吉斯页岩化石群也含有很多现在已经灭绝了的动物化石。例如伯吉斯页岩化石群中的一种著名动物Sidneyia，就是一种典型的以前还不为人知的节肢动物（一种动物分类，它包括昆虫、蜘蛛、螨虫和螃蟹）。

Fossil formations like the Burgess Shale show that evolution cannot always be thought of as a slow progression. The Cambrian explosion involved rapid evolutionary diversification, followed by the extinction of many unique animals. Why was this evolution so rapid? No one really knows. Many zoologists believe that it was because so many ecological niches were available with virtually no competition from existing species. Will zoologists ever know the evolutionary sequences in the Cambrian explosion? Perhaps another ancient fossil bed of soft-bodied animals from 600-million-year-old seas is awaiting discovery.

像伯吉斯页岩化石群这样的化石层表明进化不能总是被认为是缓慢的过程。寒武纪大爆涉及到了快速的进化分化，接着就是很多独特动物的灭绝。为什么这种进化如此迅速呢？没有人真正明白。很多动物学家认为这是很多几乎没有任何竞争性物种的环境使然。动物学家们是否知道寒武纪大爆发的动物的进化顺序呢？或许另一些含有来自于6亿年前的海洋动物的化石亟待发现。