TPO 44 – 1 From Fish to Terrestrial Vertebrates
从鱼到陆地脊椎动物

One of the most significant evolutionary events that occurred on Earth was the transition of water-dwelling fish to terrestrial tetrapods (four-limbed organisms with backbones). Fish probably originated in the oceans, and our first records of them are in marine rocks. However, by the Devonian Period (408 million to 362 million years ago), they had radiated into★ almost all available aquatic habitats, including freshwater settings. One of the groups whose fossils are especially common in rocks deposited in fresh water is the lobe-finned fish.

水中栖息的鱼类进化为陆地四足动物（有脊椎的四肢生物）是地球上发生过的重大进化事件之一。 鱼类很可能起源于海洋，有关鱼类的最早记录是在海洋岩石中。 然而，到了泥盆纪（4.08 亿至 3.62 亿年前），鱼类的栖息地已经扩展到几乎所有可能的水生环境，包括淡水水域。 淡水沉积岩石中十分常见的是一种叶状鳍鱼化石。

The freshwater Devonian lobe-finned fish rhipidistian crossopterygian is of particular interest to★ biologists studying tetrapod evolution. These fish lived **in** river channels and lakes on large deltas. The delta rocks in which these fossils are found are commonly red due to oxidized iron minerals, indicating that the deltas formed in a climate that had **alternate** wet and dry periods. If there were periods of drought, any **adaptations** allowing the fish to survive the dry conditions would have been advantageous. In these rhipidistians, several such adaptations existed. It is known that they had **lungs** as well as **gills** for breathing. **Cross sections** cut through some of the fossils reveal★ that the mud filling the interior of the carcass differed in consistency and texture depending on its location inside the fish. These differences suggest a saclike[1] cavity[2] below the front end of the gut[3] that can only be interpreted as a lung. Gills were undoubtedly the main source of oxygen for these fish, but the lungs served as an auxiliary breathing device for gulping air when the water **became oxygen depleted**, such as during extended periods of drought. So, these fish had already evolved one of the prime requisites★ for living on land: the ability to use air as a source of oxygen.

研究四足动物进化的生物学家对泥盆纪时期生活在淡水水域的总鳍鱼纲、扇鳍鱼目叶状鳍鱼尤其感兴趣。 这种鱼生活在大型三角洲的河道和湖泊里。 它们的化石常见于三角洲岩石中，这类岩石因为含有氧化铁矿物，故而呈红色，这也表明三角洲形成时已经有干湿季节的交替。 如果有干旱期存在，任何有助于鱼类度过干旱的进化都会是有利的。 这些扇鳍鱼身上也出现了几处这样的进化。 我们知道扇鳍鱼的呼吸器官除了**鳃**还有**肺**。 一些化石的**横截面**显示，扇鳍鱼尸体内的泥的稠度和质地根据其在体内位置的不同而不同。 这些差异表明在鱼肠 [3] 前端下面的囊状 [1] 腔 [2] 只可能是肺。 鳃无疑是这些鱼的主要氧气来源，但当水中含氧量大幅减少时，比如在长期干旱的情况下，肺就会作为辅助呼吸系统来吸气。 可见，这些鱼已经进化出陆地生存的必备条件之一：将空气作为氧气来源的能力。evolved 的宾语是 requisite

批注 [1]: Terrestrial
[təˈrestriəl]
•adj. 地球的；陆地的，[生物]陆生的；人间的
•n. 陆地生物；地球上的人

批注 [2]: Vertebrate
美 ['vɜːrtɪbrət]
•n. 脊椎动物
•adj. 脊椎动物（有关）的；有脊椎的

批注 [3]: dwelling
•n. 住处；寓所
•v. 居住（dwell 的现在分词）

批注 [4]: habitat
英 ['hæbɪtæt] 美 ['hæbɪtæt]
•n. [生态] 栖息地，产地
辨析：habit
英 ['hæbɪt] 美 ['hæbɪt]
•n. 习惯，习性；嗜好
•vt. 使穿衣

批注 [5]: lobe
•n. （脑、肺等的）叶；裂片；耳垂；波瓣
finned
英 [fɪnd] 美 [fɪnd]

批注 [6]: oxidized
英 美 ['ɑksə,daɪz]
•adj. 被氧化的；生锈的
•v. 氧化；生锈（oxidize 的过去分词）

批注 [7]: carcass
英 ['kɑːkəs] 美 ['kɑːrkəs]
•n. （人或动物的）尸体；残骸；（除脏去头备食用的）畜体

批注 [8]: extended
•adj. 延伸的；扩大的；长期的；广大的
•v. 延长；扩充（extend 的过去分词）

A second adaptation of these fish was in the structure of the lobe fins. The fins were thick, fleshy, and quite sturdy, with a median axis[2] of bone[1] down[3] the center[4]. They could have been used as feeble locomotor devices on land, perhaps good enough to allow a fish to flop its way from one pool of water that was almost dry to an adjacent pond that had enough water and oxygen for survival. These fins eventually changed into short, stubby legs. The bones of the fins of a Devonian rhipidistian exactly match in number and position the limb bones of the earliest known tetrapods, the **amphibians**. It should be emphasized that the evolution of **lungs and limbs** was in no sense★ an anticipation of future life on land. These adaptations developed because they helped fish to survive in their existing aquatic environment.

这些鱼的另一个适应是在叶状的鳍。 这些鳍很厚、很有肉质感、而且十分结实，内有一条轴心骨。 在陆地上鱼鳍从一定程度上可以作为运动的装置，或许能使鱼为了生存从几近干涸的池塘挪动到相邻的有足够水和氧气的池塘。 这些鳍最终进化成了短而健壮的腿。 泥盆纪扇鳍鱼的鳍骨在数量和位置上与已知的最早的四足动物的肢骨完全匹配。 应该强调的是，**肺和四肢**的进化并不是因为它们预料到未来要在陆地上生活。 这些适应是为了帮助它们在当时的水生环境中存活下来。

What ecological pressures might have caused fishes to gradually abandon their watery habitat and become increasingly★ land-dwelling creatures? Changes in climate during the Devonian may have had something to do with this if freshwater areas became progressively★ more restricted. Another **impetus** may have been new sources of food. The edges of ponds and streams surely had ***scattered*** dead fish and other water-dwelling creatures. In addition, plants had emerged into terrestrial habitats in areas[2] near streams and ponds[1], and crabs and other arthropods were also members of this earliest terrestrial community. Thus, by the Devonian the land habitat marginal to freshwater was probably a rich source of protein that could be exploited by an animal that could easily climb out of★ water. Evidence from teeth suggests that these earliest tetrapods did not utilize land plants as food; they were **presumably**★ carnivorous and had not developed the ability to feed on plants.

是什么样的生态压力导致鱼类逐渐放弃在水中的栖息地，逐渐成为陆生生物呢？如果淡水区域逐步缩减，泥盆纪的气候变化可能与此相关。 另一个**动力**可能是新的食物来源。 池塘和溪流的边缘无疑会散落有死掉的鱼和其他水栖生物。 此外，溪流与池塘附近的陆地开始有植物出现，蟹和其他节肢动物也加入了这一最早的陆地群落。 因此，在泥盆纪时期，对于能够轻易爬出水面的生物，淡水边缘的陆地很可能是丰富的蛋白质食物来源。 对四足动物的牙齿的研究表明，最早的四足动物并不食用陆生植物；它们**可能是**★食肉动物，而且也尚未形成食用植物的能力。

批注 [9]: 从…往下
down the center
从中心往下

批注 [10]: feeble
英 ['fiːbl] 美 ['fiːbl]
•adj. 微弱的，无力的；虚弱的；薄弱的

批注 [11]: flop
•v. 沉重下坠，笨拙移动

批注 [12]: stubby
英 ['stʌbi] 美 ['stʌbi]
•adj. 短而粗硬的；又短又秃的；断株样的

批注 [13]: ecological
英 [ˌiːkə'lɒdʒɪkl] 美 [ˌiːkə'lɑːdʒɪkl]
•adj. 生态的，生态学的

批注 [14]: watery
英 ['wɔːtəri] 美 ['wɔːtəri]
•adj. 水的；淡的；湿的；松软的；有雨意的

aquatic
英 [ə'kwætɪk] 美 [ə'kwɑːtɪk]
•adj. 水生的；水栖的；在水中或水面进行的
•n. 水上运动；水生植物或动物

批注 [15]: progressively
•adv. 渐进地；日益增多地

批注 [16]: marginal
•adj. 微不足道的，不重要的；边缘的；临界的；末端的
•n. 边缘席位

批注 [17]: presumably
英 [prɪ'zjuːməbli] 美 [prɪ'zuːməbli]
•adv. 大概；推测起来；可假定

How did the first tetrapods make the transition to a terrestrial habitat? Like early land plants such as rhyniophytes, they made only a partial★ transition; they were still quite tied to water. However, many problems that faced early land plants were not applicable to the first tetrapods. The ancestors of these animals already had a **circulation** system, and they were mobile, so that they could move to water to drink. Furthermore, they already had lungs, which rhipidistians **presumably** used for **auxiliary**★ breathing. The **principal** changes for the earliest tetrapods were in the skeletal system-changes in the bones of the fins, the vertebral column[1], pelvic[2] girdle[3], and pectoral[4] girdle.

be applicable to 适应于，应用于

column[1]	pelvic[2]	girdle[3]	pectoral[4]
英 ['kɒləm] 美 ['kɑ:ləm] n. 纵队，列；专栏；圆柱，柱形物	英 ['pelvɪk] 美 ['pelvɪk] adj. 骨盆的	英 ['gɜ:dl] 美 ['gɜ:rdl] n. 腰带；围绕物；妇女紧身褡 vt. 围绕；绕…而行；用带子捆扎	英 ['pektərəl] 美 ['pektərəl] adj. 胸的；肺病的 n. 胸饰；治疗胸肺药物

批注 [18]: auxiliary
英 [ɔ:g'zɪliəri] 美 [ɔ:g'zɪliəri]
•adj. 辅助的；副的；附加的；（发动机、设备等）备用的
•n. 助动词；辅助者，辅助物；附属机构；（北美）志愿队；（海军的）辅助舰队

批注 [19]: skeletal
英 ['skelətl] 美 ['skelətl]
•adj. 骨骼的，像骨骼的；骸骨的；骨瘦如柴的

批注 [20]: vertebral
英 ['vɜ:tɪbrəl] 美 ['vɜ:rtɪbrəl]
•adj. 脊椎的；椎骨的；由椎骨组成的；有脊椎的

第一批四足动物是怎样向陆地环境过渡的呢？就像早期的陆生植物莱尼蕨类一样，这些四足动物只是产生了部分 adj.变化，这个阶段，它们仍然很依赖于水。 不过，早期陆生植物面临的许多问题并不会困扰到它们。 这些动物从祖先起就已经有了一个流通系统，它们可以移动，所以可以挪到水边饮水。 另外，它们已经有肺了，当时扇鳍鱼可能都已经将其用于辅助呼吸了。最早期的四足动物主要进化的是骨骼 adj.系统，即鳍骨、脊柱、骨盆、肩胛骨发生变化。

本文主题：骨骼，脊椎，进化，两栖
本文词汇：
fin
英 [fɪn] 美 [fɪn]
n. 鳍；鱼翅；鳍状物
vt. 切除鳍；装上翅
vi. 猛挥鳍；潜泳

TPO 44 – 2 The Use of the Camera Obscura

Camera Obscura 暗箱；[光] 投像器；针孔照相机

The precursor of the modern camera, the camera obscura is a darkened enclosure into which light is admitted through a lens in a small hole. The image of the illuminated area outside the enclosure is thrown upside down as if by magic onto a surface in the darkened enclosure. This technique was known as long ago as the fifth century B.C., in China. Aristotle also experimented with it in the fourth century B.C., and Leonardo da Vinci described it in his notebooks in 1490. In 1558 Giovanni Battista Della Porta wrote in his twenty-volume work Magia naturalis (meaning "natural magic") instructions for adding a convex lens to improve the quality of the image thrown against a canvas or panel in the darkened area where its outlines could be traced. Later, portable camera obscuras were developed, with interior mirrors and drawing tables on which the artist could trace the image. For the artist, this technique allows forms and linear perspective to be drawn precisely as they would be seen from a single viewpoint. Mirrors were also used to reverse the projected images to their original positions.

现代相机的前身——暗箱是一个密不透光的箱子，箱子上有一个带着透镜的小孔，光线由此射入。来自箱外接受光照的图像如同被施了魔法一般，在这个密不透光的箱子内壁上构成倒影。暗箱技术最早可追溯至公元前五世纪的中国。 公元前四世纪，亚里士多德曾进行相关实验；1490 年，列奥纳多•达芬奇也曾在他的笔记本中描述了这一现象。 1558 年，乔瓦尼•巴蒂斯塔•德拉波尔塔在他长达二十卷的作品 Magia naturalis（意为“自然魔术”）中介绍，增加一个凸透镜可以改善倒映在暗箱的帆布或画板上的图像质量，就可以看到图像的轮廓。 之后，便携式暗箱诞生，内置镜子和制图板让艺术家可以捕捉到图像。 对于艺术家来说，这项技术使得景物的外表和线性透视能够被精准地描绘出来，因为艺术家可以从单一的视角来观察它们。镜子的使用也使得倒立的投影变为正常。

Did some of the great masters of painting, then, trace their images using a camera obscura? Some art historians are now looking for clues of artists' use of such devices. One of the artists whose paintings are being analyzed from this point of view is the great Dutch master, Jan Vermeer, who lived from 1632 to 1675 during the flowering of art and science in the Netherlands, including the science of optics. Vermeer produced only about 30 known paintings, including his famous The Art of Painting. The room shown in it closely resembles the room in other Vermeer paintings, with lighting coming from a window on the left, the same roof beams, and similar floor tiles, suggesting that the room was fitted with a camera obscura on the side in the foreground. The map hung on the opposite wall was a real map in Vermeer's possession, reproduced in such faithful detail that some kind of tracery is suspected. When one of Vermeer's paintings was X-rayed, it did not have any preliminary sketches on the canvas beneath the paint, but rather the complete image drawn in black and white without any trial sketches. Vermeer did not have any students, did not keep any records, and did not encourage anyone to visit his studio, facts that can be interpreted as protecting his secret use of a camera obscura.

那么在当时，是否有绘画大师曾使用暗箱来描绘图像呢？一些艺术史学家正在寻找相关线索，证明确有此事。 用这种角度对其画作进行分析的艺术家之一是杰出的荷兰画家杨•维梅尔

（1632-1675）,在他生活的这段时期，荷兰的艺术和科学（包括光学）正值繁荣兴盛。 维梅尔知名的画品只有 30 幅左右，这其中包括他的著名作品《绘画艺术》。 画中描绘的房间与维梅尔的其他画作中的房间极为相似：光线都是从左边窗户照入，一样的横梁，相似的地板砖，这些都表明房内前侧方位置可能装有一个暗箱。 挂在对面墙上的地图是维梅尔现实中拥有的物品，地图的细节还原得如此真实，不得不让人质疑是否出于描摹。 当用 X 射线检测这幅画时，颜料下的帆布上并没有任何草图的痕迹，有的只是一副干净完整的黑白画。 维梅尔没有学生，没有留下任何记录，也没有邀请任何人去参观他的画室，人们解释说这是因为他在秘密地使用暗箱。

In recent times the British artist David Hockney has published his investigations into the secret use of the camera obscura, claiming that for up to 400 years, many of Western art's great masters probably used the device to produce almost photographically realistic details in their paintings. He includes in this group Caravaggio, Hans Holbein, Leonardo da Vinci, Diego Velázquez, Jean-Auguste-Dominique Ingres, Agnolo Bronzino, and Jan van Eyck. From an artist's point of view, Hockney observed that a camera obscura compresses the complicated forms of a three-dimensional scene into two-dimensional shapes that can easily be traced and also increases the contrast between light and dark, leading to the chiaroscuroartistic term for a contrast between light and dark effect seen in many of these paintings. In Jan van Eyck's The Marriage of Giovanni Arnolfini and Giovanna Cenami, the complicated foreshortening (a technique for representing an image in art that makes it appear to recede in space) in the chandelier and the intricate detail in the bride's garments are among the clues that Hockney thinks point to the use of the camera obscura.
近些年来，英国艺术家大卫•霍克尼发表了他对画家秘密使用暗箱的调查结果，声称在长达 400 年当中，许多西方艺术大师有可能借助了这一设备来描摹他们画作当中格外逼真的部分。 这些大师包括卡拉瓦乔、汉斯•荷尔拜因、列奥纳多•达•芬奇、迪亚哥•委拉斯开兹、让•奥古斯特•多米尼克•安格尔、阿尼奥洛•布伦齐诺、以及扬•凡•艾克。 从艺术家的角度来看，霍克尼观察到暗箱可以将复杂的三维场景变成易于捕捉的二维图像，并增加光与影之间的反差，从而产生了在很多这类画中常见的明暗效果。 在扬•凡•艾克的作品《Giovanni Arnolfini 和 Giovanna Cenami 的婚姻》中，枝形吊灯的复杂的短缩法（一种让艺术作品中的形象在空间上显得退后的技术）以及新娘服饰的精致细节都是让霍克尼认为是使用暗箱的痕迹。

So what are we to conclude? If these artists did use a camera obscura, does that diminish their stature? Hockney argues that the camera obscura does not replace artistic skill in drawing and painting. In experimenting with it, he found that it is actually quite difficult to use for drawing, and he speculates that the artists probably combined their observations from life with tracing of shapes.
综上，我们要得出什么结论呢？如果这些艺术家的确用了暗箱，这会不会降低他们的声望？霍克尼认为，暗箱不能取代绘画中的艺术技巧。 通过亲身实验，他发现暗箱其实很难用于绘画，于是他推测，艺术家在借助暗箱捕捉图像作画时，很可能也结合了他们生活中对原物的观察结果。

TPO 44 – 3 Seagrasses
海草

Many areas of the shallow sea bottom are covered with a lush growth of aquatic flowering plants adapted to live submerged in seawater. These plants are collectively called seagrasses. Seagrass beds are strongly influenced by several physical factors. The most significant is water motion: currents and waves. Since seagrass systems exist in both sheltered and relatively open areas, they are subject to differing amounts of water motion. For any given seagrass system, however, the water motion is relatively constant. Seagrass meadows in relatively turbulent waters tend to form a mosaic of individual mounds, whereas meadows in relatively calm waters tend to form flat, extensive carpets. The seagrass beds, in turn, dampen wave action, particularly if the blades reach the water surface. This damping effect can be significant to the point where just one meter into a seagrass bed the wave motion can be reduced to zero. Currents are also slowed as they move into the bed.
浅海底部的许多地方都被茂密的水生开花植物所覆盖，这些植物已经完全适应了浸没于海水的生活。 这些植物统称为海草。 海草床深受几个物理因素的影响。 其中，最重要的因素是海水运动：海流和海浪。 因为海草不仅生存在隐蔽的水域，也生存在相对开放的水域，因此海草需要去适应各种不同程度的水流运动。 然而，对于特定的海草系统而言，海水运动是相对恒定的。 在相对动荡的水域，海草一般会形成一个个小丘；而在相对平静的水域则倾向于形成平坦广阔的草地。 反过来，海草床也会减少波浪的作用，特别是当叶片长至水面以上时。 海草床的阻碍作用很强，一般的波浪只要遇到一米高的海草床，波动就会完全停滞。 而海流遇到海草床时，速度也会变慢。

The slowing of wave action and currents means that seagrass beds tend to accumulate sediment. However, this is not universal and depends on the currents under which the bed exists. Seagrass beds under the influence of strong currents tend to have many of the lighter particles, including seagrass debris, moved out, whereas beds in weak current areas accumulate lighter detrital material. It is interesting that temperate seagrass beds accumulate sediments from sources outside the beds, whereas tropical seagrass beds derive most of their sediments from within.
海浪和海流的速度减缓，意味着海草床经常会有沉积。 然而，情况也非绝对如此，是否有沉积主要取决于海草床下水流的强度。 遇到较湍急的海流，海草床中一些较轻的颗粒物，比如海草残骸，就会被海水流带走，而遇到较缓的水流，这些较轻的碎屑物质就会沉积下来。 有趣的是，温带海草床通常会沉淀外来物，而热带海草床的沉积物通常来自海草床内部。

Since most seagrass systems are depositional environments, they eventually accumulate organic material that leads to the creation of fine-grained sediments with a much higher organic content than that of the surrounding unvegetated areas. This accumulation, in turn, reduces the water movement and the oxygen supply. The high rate of metabolism (the processing of energy for survival) of the microorganisms in the sediments causes sediments to be anaerobic (without oxygen) below the first few millimeters. According to ecologist J.W.

Kenworthy, anaerobic processes of the microorganisms in the sediment are an important mechanism for regenerating and recycling nutrients and carbon, ensuring the high rates of productivity-that is, the amount of organic material produced-that are measured in those beds. In contrast to other productivity in the ocean, which is confined to various species of algae and bacteria dependent on nutrient concentrations in the water column, seagrasses are rooted plants that absorb nutrients from the sediment or substrate. They are, therefore, capable of recycling nutrients into the ecosystem that would otherwise be trapped in the bottom and rendered unavailable.

由于绝大多数海草系统都处于沉积环境，它们最终会积累下有机物质，进而得到有机质含量远高于比周围无植被区的细颗粒状沉淀物。 这样的积累反过来也减少了海水的运动和氧气供应。 沉积物中微生物的高新陈代谢（为生存而进行的能量转化）率，导致数毫米以下的沉积物缺氧（没有氧气）。 根据生态学家 J•W•肯沃西所说，沉积物中微生物的无氧代谢是一项重要的使得营养物质和碳再生和循环的机制，保证了有机物的高产出率——即测量到的海草床中产生的有机物的量。 海洋中其他物种的产出率受到各种藻类和细菌的限制，而藻类和细菌又依赖于水体营养物质的浓度，但海草与其不同，海草是根系植物，可以从沉积物或海洋基底当中吸收养分。 因此它们能够将海洋底部的营养物质回收进入生态系统，否则，这些营养将会永远困在海底，不可利用。

Other physical factors that have an effect on seagrass beds include light, temperature, and desiccation (drying out). For example, water depth and turbidity (density of particles in the water) together or separately control the amount of light available to the plants and the depth to which the seagrasses may extend. Although marine botanist W.A. Setchell suggested early on that temperature was critical to the growth and reproduction of eelgrass, it has since been shown that this particularly widespread seagrass grows and reproduces at temperatures between 2 and 4 degrees Celsius in the Arctic and at temperatures up to 28 degrees Celsius on the northeastern coast of the United States. Still, extreme temperatures, in combination with other factors, may have dramatic detrimental effects. For example, in areas of the cold North Atlantic, ice may form in winter. Researchers Robertson and Mann note that when the ice begins to break up, the wind and tides may move the ice around, scouring the bottom and uprooting the eelgrass. In contrast, at the southern end of the eelgrass range, on the southeastern coast of the United States, temperatures over 30 degrees Celsius in summer cause excessive mortality. Seagrass beds also decline if they are subjected to too much exposure to the air. The effect of desiccation is often difficult to separate from the effect of temperature. Most seagrass beds seem tolerant of considerable changes in salinity (salt levels) and can be found in brackish (somewhat salty) waters as well as in full-strength seawater.

其他影响海草床的物理因素包括光、温度、干化（干燥）。 例如，水的深度和浊度（水中颗粒的密度）共同或单独控制海草可获取的光照量和海草可生长的深度。 尽管海洋植物学家 W•A•萨契尔早期曾提出温度是海草生长和繁殖的关键，但研究已经证明，从 2 到 4 摄氏度的北极，到 28 摄氏度的美国东北海岸，这些广泛分布的海草都可以生长和繁殖。 当然，极端温度及其他因素一起可能会对海草的生存产生巨大的不良影响。 例如，在寒冷的北大西洋地区，冬天

海水可能会结冰。 研究人员罗伯森和曼指出，如果冰层破裂，风和潮汐可以将冰块四处移动，刮擦海洋底部，将大叶藻连根拔起。 相反，在大叶藻可以生存的南端——美国的东南部海岸，夏季超过 30 摄氏度的温度会造成大叶藻大量死亡。 如果过多的暴露在空气中，海草床也会枯萎。 干化的影响通常难于和温度的影响分开。 大多数的海草床都能适应各种盐度（盐含量）的变化，在半咸水（微咸）海域和纯咸水海域都能生存。