

TPO 18 – 1 Industrialization in the Netherlands and Scandinavia 荷兰和斯堪的纳维亚的工业化

While some European countries, such as England and Germany, began to industrialize in the eighteenth century, the Netherlands and the Scandinavian countries of Denmark, Norway, and Sweden developed later. All four of these countries **lagged** considerably behind in the early nineteenth century. However, they industrialized rapidly **in the second half of the century**, especially in the last two or three decades. **In view of** their later start and **their lack of coal**—**undoubtedly the main reason** they were not among the early industrializers—it is important to understand the sources of their success.

尽管一些欧洲国家，如英国和德国，在 18 世纪就开始了工业化，荷兰以及丹麦、挪威、瑞典这些斯堪的纳维亚半岛国家的工业化则发展得较晚。这四个国家在 19 世纪早期工业化水平非常**落后**。但是在 19 世纪下半叶，尤其是在最后的二三十年间里，他们迅速地实现了工业化。**鉴于**这几个国家的工业化起步较晚并且缺少煤炭资源——毫无疑问，这是导致他们不在早期工业化国家行列中的主要原因——了解他们成功的原因非常重要。

All had small populations. At the beginning of the nineteenth century, Denmark and Norway had fewer than 1 million people, while Sweden and the Netherlands had fewer than 2.5 million inhabitants. All **exhibited moderate growth rates** **in the course of** the century (Denmark the highest and Sweden the lowest), but all more than doubled in population by 1900. **Density varied greatly**. The Netherlands had one of the highest population densities in Europe, whereas Norway and Sweden had the lowest. Denmark was in between but closer to the Netherlands.

这些国家的人口都很少。在 19 世纪初，丹麦和挪威的人口总数不到 100 万；而瑞典和荷兰的居民数量也少于 250 万。在 19 世纪，这四个国家均**展现出了缓和的人口增长率**（丹麦最高，瑞典最低）。但是到了 1900 年，这些国家的人口数量翻了两倍有余。人口密度区别很大。荷兰是欧洲人口密度最大的国家之一，挪威和瑞典最小。丹麦人口密度处于这四国的中游水平，但是趋近于荷兰。

Considering **human capital** as a characteristic of the population, however, all four countries were advantaged by the large percentages of their populations who could read and write. In both 1850 and 1914, the Scandinavian countries had the **highest literacy rates** in Europe, or in the world, and the Netherlands was well above the European average. This fact was of enormous value in helping the national economies find their niches in the evolving currents of the international economy.

考虑到人力资本是人口的重要特征，这四个国家的优势在于受教育人口的比例非常高。在 1850 年和 1914 年，斯堪的纳维亚半岛各国的**教育普及率**是全欧洲或者全世界最高的，而荷兰远高于欧洲平均水平。如此高的比例对于帮助国内经济在世界经济的发展浪潮中找到自己

批注 [1]: while

英 [waɪl] 美 [waɪl]

conj. 在……期间；在……的过程中；与……同时；（对比两件事物）……而；虽然，**尽管**；直到……为止

•n. 一段时间；（诗、文）在此期间

•adv. 在……时候

•v. 消磨（时间）

•prep. 直到

批注 [2]: lag

英 [læɡ] 美 [læɡ]

•n. 落后；迟延；防护套；囚犯；桶板

•vt. 落后于；押往监狱；加上外套

•vi. 滞后；缓缓而行；蹒跚

•adj. 最后的

批注 [3]: in the course of

•在…过程中；在…期间

批注 [4]: 这一句显得很突兀；

理解：句子中包含了非常明显的比较词，意味着前文工业化程度比较一致，这句话的出现是为了突出 density 的不重要性。

批注 [5]: human capital

•[劳经] 人力资本，技能资本

批注 [6]: literacy rate

[ˈlɪtərəsi reɪt]

•识字率

的位置有着巨大价值。

Location was an important factor for all four countries. All had **immediate** access to the sea, and this **had important implications for** a significant international resource, **fish**, as well as for cheap transport, merchant marines, and the shipbuilding industry. Each took advantage of these opportunities in its own way. The people of the Netherlands, with a long tradition of fisheries and mercantile shipping, had difficulty in **developing good harbors suitable for steamships**; eventually **they did so** at Rotterdam and Amsterdam, with **exceptional results for** transit trade **with Germany and central Europe** and **for** the processing of overseas **foodstuffs and raw materials (sugar, tobacco, chocolate, grain, and eventually oil)**. Denmark also had an admirable commercial history, particularly **with respect to** traffic through the Sound (the **strait** separating Denmark and Sweden). In 1857, **in return for a payment** of 63 million kronor from other commercial nations, Denmark abolished the Sound **toll dues**, the fees it had collected since 1497 for the use of the Sound. This, along with other policy **shifts toward** free trade, resulted in a significant increase in traffic through the Sound and in the port of Copenhagen.

地理位置对于这四个国家来说，同样是一个非常重要的因素。这四个国家都紧邻海洋，而且这样的地理位置对于重要的国际资源--鱼，以及价格低廉的运输、海上商运以及船舶工业有重要的影响。这四个国家因势利导，很好地利用了各自的优势。有着悠久渔业和航运业历史的荷兰人在建造可以停泊蒸汽轮船的港口时遇到了困难。最终，他们在鹿特丹和阿姆斯特丹成功建造了港口，在与德国和中欧的转口贸易以及海外食品和原材料（糖、烟草、巧克力、粮食和油）加工处理方面取得了非凡的成果。丹麦同样有着辉煌的贸易史，特别是在松德海峡（隔开丹麦和瑞典的海峡）的海上交通上。在1857年，一些贸易国家向丹麦支付了6300万克朗，作为交换，丹麦废止了自1497年以来在松德海峡征收的**通行费**。这一举措与其他自由贸易政策相辅相成，使得途径松德海峡和哥本哈根港口的贸易额大增。

The political institutions of the four countries **posed** no significant **barriers** to industrialization or economic growth. The nineteenth century passed relatively peacefully for these countries, with progressive democratization taking place in all of them. They were reasonably well governed, **without notable corruption or grandiose state projects**, although in all of them the government gave some aid to railways, and in Sweden the state built the main lines. As small countries dependent on foreign markets, they followed a **liberal** trade policy in the main, though a protectionist movement developed in Sweden. In Denmark and Sweden **agricultural reforms** took place gradually from the late eighteenth century through the first half of the nineteenth, resulting in a new class of **peasant** landowners with a definite market orientation.

这四个国家的政治体制没有对工业化和经济的增长设置过多的障碍。而这四国不断发展的民主进程使他们相对平稳地度过了19世纪。这些国家被治理得井井有条，尽管政府在铁路上给予了一定的扶持，比如瑞典政府修建了一些主要的铁路干线，不过在此期间，**没有出现重大的腐败和不切实际的国家工程**。虽然贸易保护主义在瑞典比较明显，但是就如同小国家依赖

批注 [7]: implication

英 [ˌɪmplɪˈkeɪʃn] 美 [ˌɪmplɪˈkeɪʃn]

•n. 含义；暗示；牵连，卷入；可能的结果，影响

批注 [8]: exceptional results

非常成效

exceptional

英 [ɪk'sepʃənəl] 美 [ɪk'sepʃənəl]

•adj. 异常的，例外的

•n. 超常的学生

批注 [9]: with respect to

英 美 [wɪð rɪ'spekt tu]

•关于；至于

批注 [10]: strait

英 [streɪt] 美 [streɪt]

•n. 海峡，水道；（经济上的）困境，窘迫

•adj. 狭窄的；严格的，精确的；苦恼的

•adv. 严格地，精确地

批注 [11]: grandiose

英 ['grændiəʊs] 美 ['grændiəʊs]

•adj. 宏伟的；堂皇的；**浮夸的**；宏大的

批注 [12]: liberal

英 ['lɪbərəl] 美 ['lɪbərəl]

•adj. 自由主义的；慷慨的；不拘泥的；宽大的

•n. 自由主义者

批注 [13]: peasant

英 ['peɪznt] 美 ['peɪznt]

•n. 农民；乡下人

外国市场一般，这四个国家总体上还是以遵循自由贸易原则为主。在丹麦和瑞典，**农业改革**从18世纪末逐步持续到19世纪上半叶，这一**改革**导致了有着明确市场定位的农民地主阶级的出现。

The key factor in the **success** of these countries (along with high literacy, which contributed to **it**) was their ability to **adapt to** the international division of labor determined by the early industrializers and to **stake out** areas of specialization in international markets for which they were especially well suited. This meant a great **dependence** on international commerce, which had **notorious fluctuations**; but it also meant high returns to those factors of production that were fortunate enough to be well placed in times of prosperity. In Sweden exports accounted for 18 percent of the **national income** in 1870, and in 1913, 22 percent of a much larger national income. In the early twentieth century, Denmark exported 63 percent of its agricultural production: butter, **pork products**, and eggs. It exported 80 percent of its butter, almost all to Great Britain, where it accounted for 40 percent of British butter imports.

这些国家成功的关键因素（教育水平高也起了促进作用）在于它们能够**适应**由早期工业化国家决定的国际劳动力分配，并且**拓展出**非常适合他们的国际市场的专业化领域。这意味着对**波动剧烈**的国际贸易市场存在着巨大的**依赖**。但也意味着若有幸处于繁荣时期，一些生产要素的回报会特别高。1870年瑞典的出口额占**国民收入**的18%；在1912年更是达到国民收入的22%。在二十世纪初期，丹麦一度出口了63%的农产品：黄油、猪肉制品和蛋类等。其中，丹麦出口了将近80%的黄油，这些几乎都销往了英国，占了英国黄油进口总量的40%。

批注 | 14]: **adapt to**

英美 ['ædæpt tu]

•使自己适应于...

批注 | 15]: **stake out**

英美 ['steɪk aʊt]

•监视；立柱标出；派警察监视

批注 | 16]: **national income**

美 ['næʃnəl 'ɪnkʌm]

•国民收入

批注 | 17]: **pork**

英 [pɔːk] 美 [pɔːrk]

•n. 猪肉

•vt. 与女子性交

TPO 18 – 2 The Mystery of Yawning 哈欠之谜

【According to conventional theory, yawning takes place when people are bored or sleepy and **erves the function of** increasing alertness by reversing, through deeper breathing, **the drop in blood oxygen levels** that are caused by the **shallow breathing that accompanies lack of sleep or boredom.**】 Unfortunately, the few scientific investigations of yawning have failed to find any connection between how often someone yawns and how much sleep they have had or how tired they are. About the **closest any research has come to supporting the tiredness theory** is to confirm that adults yawn more often on weekdays than on weekends, and that school children yawn more frequently in their first year at primary school than they do in kindergarten.

【根据传统理论，当人们无聊或者困倦时就会打哈欠。伴随睡眠不足或无聊的是浅呼吸，而浅呼吸会降低血液中氧的含量。打哈欠可以通过深呼吸逆转这一点，增加血液中氧的含量从而达到提高警觉性的功能。】但遗憾的是，少量关于打哈欠的科学研究并没有找到任何打哈欠频率与个人睡眠时长或者疲劳程度之间的联系。最能够用来支持疲劳理论的研究成果是，成人在工作日比在周末打哈欠的频率更高，学生在小学一年级比在幼儿园时打哈欠的频率要高。

Another flaw of the tiredness theory is that yawning does not raise alertness or physiological activity, **as the theory would predict.** When researchers measured the heart rate, muscle tension and skin conductance of people **before, during, and after** yawning, they did detect some changes in skin conductance following yawning, indicating a slight increase in physiological activity. However, similar changes occurred when the subjects were asked simply to open their mouths or to breathe deeply. Yawning **did nothing special to** their state of physiological activity. Experiments have also **cast serious doubt on the belief that yawning is triggered by a drop in blood oxygen or a rise in blood carbon dioxide.** Volunteers were told to think about yawning while they breathed either normal air, pure oxygen, or an air mixture with an above-normal level of carbon dioxide. If the theory was correct, breathing air with extra carbon dioxide should have triggered yawning, while breathing pure oxygen should have suppressed yawning. In fact, neither condition made any difference to the frequency of yawning, which remained constant at about 24 yawns per hour. Another experiment demonstrated that physical exercise, which was **sufficiently vigorous** to double the rate of breathing, had no effect on the frequency of yawning. Again, the implication is that yawning **has little or nothing to do with** oxygen.

However, this is not the case.

然而，情况并非如此。

疲劳理论的另一个缺陷是打哈欠并不**如该理论所预期的那样**提高警觉性或生理活动。研究人员在（志愿者）打哈欠的前、中、后三个阶段均测量了心率、肌肉张力以及皮肤传导性，而他们测得皮肤传导性在打哈欠后的确存在一些变化，这一变化表明生理活动有轻微的增强。但

批注 [18]: closest

英 [kləʊsɪst] 美 [kloʊsɪst]

•adj. 最靠近的（close 的最高级）

是，在实验者被要求只是张开嘴或深呼吸时，皮肤传导性也发生了相似的变化。打哈欠对于生理活动的状态**并无特殊作用**。实验结果也对“打哈欠是由血液中氧含量下降或由血液中二氧化碳含量上升所引起的”这一论断**产生了**严重怀疑。当志愿者吸入普通空气、纯氧或者是含有高于正常水平的二氧化碳的空气混合物时，他们被要求想着打哈欠。如果疲劳理论是正确的，那么当人吸入额外的二氧化碳时，应该能够激发打哈欠；当吸入纯氧时应该能够抑制打哈欠。但实际上，在这两种条件下，打哈欠的频率并无任何差异，均维持在稳定的约 24 个每小时。另一个实验证明，即使是可以让呼吸频率翻倍的**剧烈运动**对于打哈欠频率也毫无影响。这再一次说明打哈欠**几乎或完全与氧气无关**。

A completely different theory **holds** that yawning **assists in** the physical development of the lungs early in life, but has no remaining biological function in adults. It has been suggested that yawning and **hiccupping** might **serve to** clear out the fetus's **airways**. The lungs of a fetus secrete a liquid that mixes with its mother's **amniotic fluid**. Babies with **congenital blockages** that prevent this fluid from escaping from their lungs are sometimes born with deformed lungs. It might be that yawning **helps to clear out the lungs by periodically lowering the pressure in them**. According to this theory, yawning in adults is just a developmental fossil with no biological function. But, **while** accepting that not everything in life can be explained by Darwinian evolution, there are **sound** reasons for **being skeptical of** theories like this one, which avoid the issue of what yawning does for adults. Yawning is distracting, consumes energy and takes time. It is almost certainly doing something significant in adults as well as in fetuses. What could it be?

一个完全不同的理论**认为**，打哈欠有助于早期肺部的发育，但是对于成年人来说并无任何生理功效。这也暗示了打哈欠和**打嗝**或许能够清理胎儿的**呼吸道**。胎儿的肺会分泌一种混合着母亲**羊水**的液体。当患有**先天性肺不张**的婴儿的肺部阻止这种液体从肺中流出时，这些婴儿出生时肺部就会变形。打哈欠很可能是通过周期性的降低肺部压力，帮助清除肺部中的这些液体。按照该理论，成年人打哈欠只是一个没有生理功效的发育残留。但是，尽管认同同达尔文进化论并不能解释所有现象，我们还是有**充分的**理由去怀疑这样的理论：它们回避了哈欠对成年人对功能问题。打哈欠是分散精力的，费时又耗力。但是，几乎可以肯定是，打哈欠不仅对胎儿，对成年人也有重要的作用。那么，究竟是什么作用呢？

The **empirical** evidence, **such as it is**, suggests an altogether different function for yawning—namely, that yawning prepares us for a **change in activity level**. Support for this theory came from a study of yawning behavior in everyday life. Volunteers wore **wrist-mounted** devices that automatically recorded their physical activity for up to two weeks; the volunteers also recorded their yawns by pressing a button on the device each time they yawned. The data showed that yawning tended to occur about 15 minutes before a period of increased behavioral activity. Yawning **bore no relationship to** sleep patterns, however. This accords with **anecdotal evidence** that people often yawn in situations where they are neither tired

批注 [19]: **congenital**
英 [kən'dʒenɪtl] 美 [kən'dʒenɪtl]
•adj. 先天的，天生的；天赋的

批注 [20]: **blockage**
英 ['blɒkɪdʒ] 美 ['blɑ:kɪdʒ]
•n. 堵塞，堵塞；封锁；妨碍

批注 [21]: **while**
英 [waɪl] 美 [waɪl]
conj. 在……期间；在……的过程中；与……同时；（对比两件事物）……而；虽然，**尽管**；直到……为止
•n. 一段时间；（诗、文）在此期间
•adv. 在……时候
•v. 消磨（时间）
•prep. 直到

批注 [22]: **be skeptical of**
•对…持怀疑态度

批注 [23]: **empirical**
英 [ɪm'pɪrɪkəl] 美 [ɪm'pɪrɪkəl]
•adj. 经验主义的，完全根据经验的；实证的

批注 [24]: **腕带式**

批注 [25]: **bear relationship to**
•vt. 和…有关（和…类似）

批注 [26]: **anecdotal evidence**
•轶事证据

nor bored, but are preparing for **impending** mental and physical activity. Such yawning is often referred to as "**incongruous**" because it seems **out of place**, at least on the tiredness view: soldiers yawning before combat, musicians yawning before performing, and athletes yawning before competing. Their yawning seems to have nothing to do with sleepiness or boredom—**quite the reverse**—but it does precede a change in activity level.

经验结果表明，虽然如此，打哈欠确实有着完全不同的功能——换言之，我们打哈欠是为活动水平的变化而做的准备。一个“对日常生活中打哈欠行为的研究”支撑了这一论断。志愿者在手腕上携带一种装置，这一装置会自动记录他们在两周里的身体活动情况。另外，志愿者也要通过点击装置上的按钮来记录自己每一次打哈欠的情况。数据显示，打哈欠大多在增强行为活动的 15 分钟前发生。但同时指出，打哈欠与睡眠状态没有关系。这一论断符合坊间的传闻：人们通常是既不疲惫也不无聊，但要准备接下来的脑力活动和体力活动时才会打哈欠。这样的哈欠通常被认为是“**不协调的**”，因为至少从疲倦状态下的角度看，这样的哈欠似乎与疲惫无关：比如战士们在开始战斗前会打哈欠；音乐家在表演前会打哈欠；运动员在比赛前会打哈欠。他们的哈欠看上去似乎与困倦、疲乏无关，**但是恰恰相反**，这一行为的确出现在了活动水平的变化之前。

incongruous

英 [ɪnˈkɒŋgruəs] 美 [ɪnˈkɑːŋgruəs]

adj. 不协调的；不一致的；不和谐的

批注 | 27: impending

英 [ɪmˈpendɪŋ] 美 [ɪmˈpendɪŋ]

•adj. 即将发生的；迫切的；悬挂的

•v. 迫近；悬空（impend 的现在分词）

impend

英 [ɪmˈpend] 美 [ɪmˈpend]

•v. 迫近；（坏事）隐现；悬而未决

pend

英 [pend] 美 [pend]

•v. 等候判定；悬挂；垂下

•n. 拱道

pending

英 [ˈpendɪŋ] 美 [ˈpendɪŋ]

•adj. 未决定的；行将发生的

•prep. 在...期间；直到...时为止；在等待...之际

•v. 待定；悬而不决（pend 的 ing 形式）

批注 | 28: out of place

•adj. 不合适的；不相称的；不在适当的位置

TPO 18 – 3 Lightning 闪电

Lightning is a brilliant **flash** of light produced by an electrical **discharge** from a storm cloud. The electrical discharge takes place when the **attractive tension between a region of negatively charged particles and a region of positively charged particles becomes so great that** the charged particles suddenly rush together. The coming together of the oppositely charged particles **neutralizes** the electrical tension and releases a tremendous amount of energy, which we see as lightning. The separation of positively and negatively charged particles takes place during the development of the storm cloud.

闪电是由雷雨云**放电**产生的一道明亮夺目的**闪光**。当带正电荷粒子区域与带负电荷粒子区域之间的**吸引力大到使**带电粒子瞬间碰撞到一起就会发生放电现象。相反的带电粒子的结合中和了电压并释放出巨大的能量，这就是我们看到的闪电。在雷雨云形成的过程中正负带电粒子相互分离。

The separation of charged particles that forms in a storm cloud has a sandwich-like structure. Concentrations of positively charged particles develop at the top and bottom of the cloud, but the middle region becomes negatively charged. **Recent measurements made in the field together with laboratory simulations** offer a promising explanation of how this structure of charged particles forms. What happens is that small (millimeter- to centimeter-size) pellets of ice form in the cold upper regions of the cloud. When these ice pellets fall, some of them strike much smaller ice crystals in the center of the cloud. The temperature at the center of the cloud is about -15°C or lower. At such temperatures, the collision between the ice pellets and the ice crystals causes electrical charges to shift so that the ice pellets acquire a negative charge and the ice crystals become positively charged. Then **updraft** wind currents **carry the light, positively charged ice crystals up to** the top of the cloud. The heavier, negatively charged ice pellets are left to concentrate in the center. This process explains why the top of the cloud becomes positively charged, **while** the center becomes negatively charged. The negatively charged region is large: several hundred meters thick and several kilometers in diameter. Below this large, cold, negatively charged region, the cloud is warmer than -15°C , and at these temperatures, collisions between ice crystals and falling ice pellets produce positively charged ice pellets that then **populate** a small region at the base of the cloud.

形成雷雨云的带电粒子的分离具有一种三明治结构。带正电的粒子聚集在云的顶部和底部，但是中间区域形成的是带负电的粒子。近期的野外测量以及实验室模拟为这种带电粒子的排列结构提供了可能的解释。实际上在此过程中在云层较冷的上部区域形成了细小的（毫米到厘米大小）冰丸。当这些冰丸飘落时，一部分会与云层中心比冰丸小得多的冰晶相撞。云层中心的温度大约在零下 15 摄氏度或者更低。在此温度下，冰丸和冰晶的撞击会使电荷发生转移，冰丸由此获得了负电而冰晶获得了正电。随后上升气流会将较轻的正电冰晶带到云的顶部。较重的负电冰丸会留在云层中部并积累起来。这个过程解释了为什么云的顶部带正电**而**中部带负电。带负电的区域非常大：厚度达数百米，直径达几千米。位于这片又大又冷的带

批注 [29]: neutralize

英 ['nju:trəlaɪz] 美 ['nu:trəlaɪz]

•vt. 抵销；使...中和；使...无效；使...中立

•vi. 中和；中立化；变无效

批注 [30]: updraft

英 ['ʌpdra:ft] 美 ['ʌpdræft]

•n. 上升气流；【建】向上之排气

•adj. 【建】向上通风的

批注 [31]: populate

英 ['pɒpjuleɪt] 美 ['pɑ:pjuler]

•vt. 居住于；构成人口；移民于；殖民于

负电区域之下的云层的温度要高于零下 15 摄氏度，在此温度下，冰晶和降落的冰丸的碰撞会产生带正电荷的冰丸，于是在云层的底部**聚集成**一小片区域。

Most lightning takes place within a cloud *when the charge separation within the cloud collapses*. However, **as** the storm cloud develops, the ground *beneath the cloud* becomes positively charged and lightning can take place *in the form of an electrical discharge between the negative charge of the cloud and the positively charged ground*. Lightning that strikes the ground is the most likely to be destructive, so even though it represents only 20 percent of all lightning, it has received a lot of scientific attention.

大部分的闪电发生在云层塌陷电荷分离的云层内部。但是，**随着**雷雨云的发展，云层下方的地面会带上正电，闪电就能够在带负电的云和带正电的陆地之间**以放电的形式发生**。击中地面的闪电是最有可能带有破坏性的，所以即使它只占有所有闪电的 20%，还是受到了很大的科学关注。

Using **high-speed photography**, scientists have determined that there are two steps to the occurrence of lightning from a cloud to the ground. First, a channel, or path, is formed that connects the cloud and the ground. Then a strong current of electrons follows that path from the cloud to the ground, and it is **that current** *that illuminates the channel* as the lightning we see.

通过**高速摄影**，科学家已经确定从云层到地面发生闪电的过程有两步。首先，要建立连接云层和地面的通道或者路径。然后强电流会沿着这条通道从云层传向地面，这股**照亮通道的电流**就是我们看到的闪电。

The formation of the channel is **initiated** when electrons *surge from the cloud base toward the ground*. **When** a stream of these negatively charged electrons comes within 100 meters of the ground, it is met by a stream of positively charged particles that comes up from the ground. When the negatively and positively charged streams meet, a complete channel connecting the cloud and the ground is formed. The channel is only a few centimeters in diameter, but that is wide enough for electrons to follow the channel to the ground **in the visible form of** a flash of lightning. **The stream of positive particles** *that meets the surge of electrons from the cloud* **often arises from a tall**, pointed structure such as a metal flagpole or a tower. That is why the subsequent lightning that follows the completed channel often strikes a tall structure.

电子从云层基部涌向地面就会开始形成通道。**当这些负电荷距离地面不到 100 米的时候**，会遇到来自地面的带正电的粒子流。一旦正负带电粒子流相遇，一条连接云层和地面的完整的通道便形成了。这个通道直径仅有几厘米，但是已经足以使电子**以一道闪电这种可见的形式**通过通道到达地面。那些与从云层涌来的电子相遇的带正电的粒子流通常来自于高大的带尖顶的建筑物，例如金属旗杆或塔。这就是为什么接下来通过完整通道的闪电往往会击中高层建筑的原因。

Once a channel has been formed, it is usually used by **several** lightning discharges, **each** of

them consisting of a stream of electrons from the cloud meeting a stream of positive particles along the established path. Sometimes, however, a stream of electrons following an established channel is met by a positive stream making a new path up from the ground. The result is a forked lightning that strikes the ground in two places.

一旦通道形成，同一条通道可以发生多次闪电放电，每一次都是来自云层的电子流在已有通道上遇到带正电的粒子。但是有时候，通过已有通道的电子流会遇到从地面新路径来的带正电的电子流。结果就是形成在两处击中地面的叉状闪电。