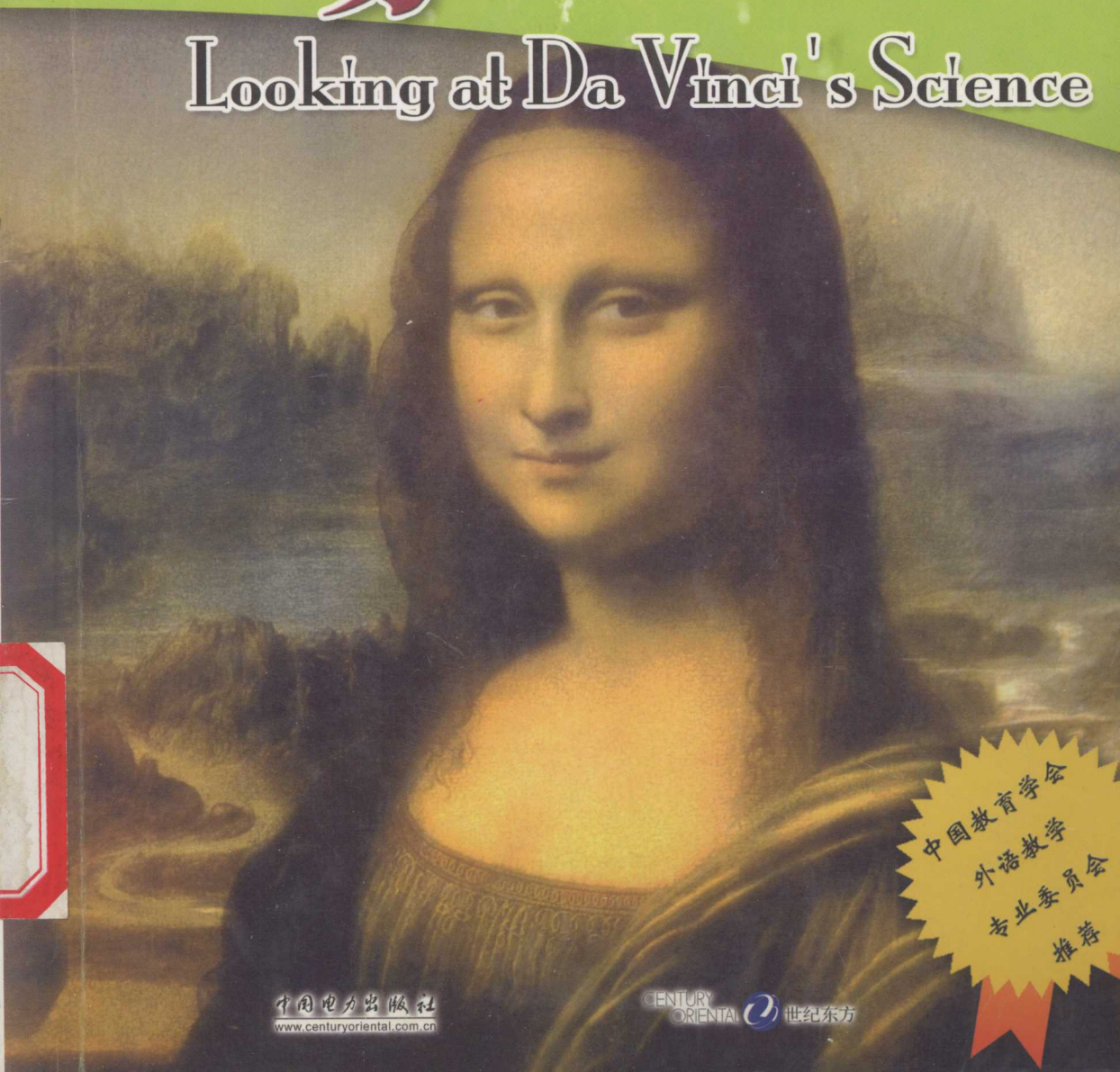


阅读空间 · 英汉双语主题阅读

达芬奇与科学

Looking at Da Vinci's Science



中国教育学会
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李静译



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达芬奇与科学

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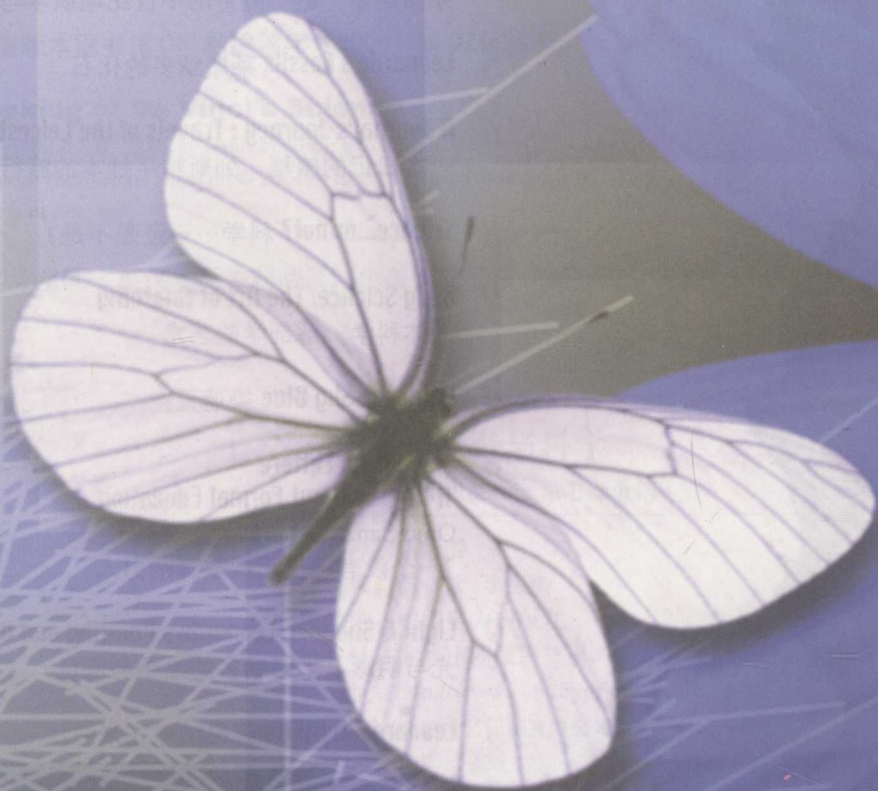
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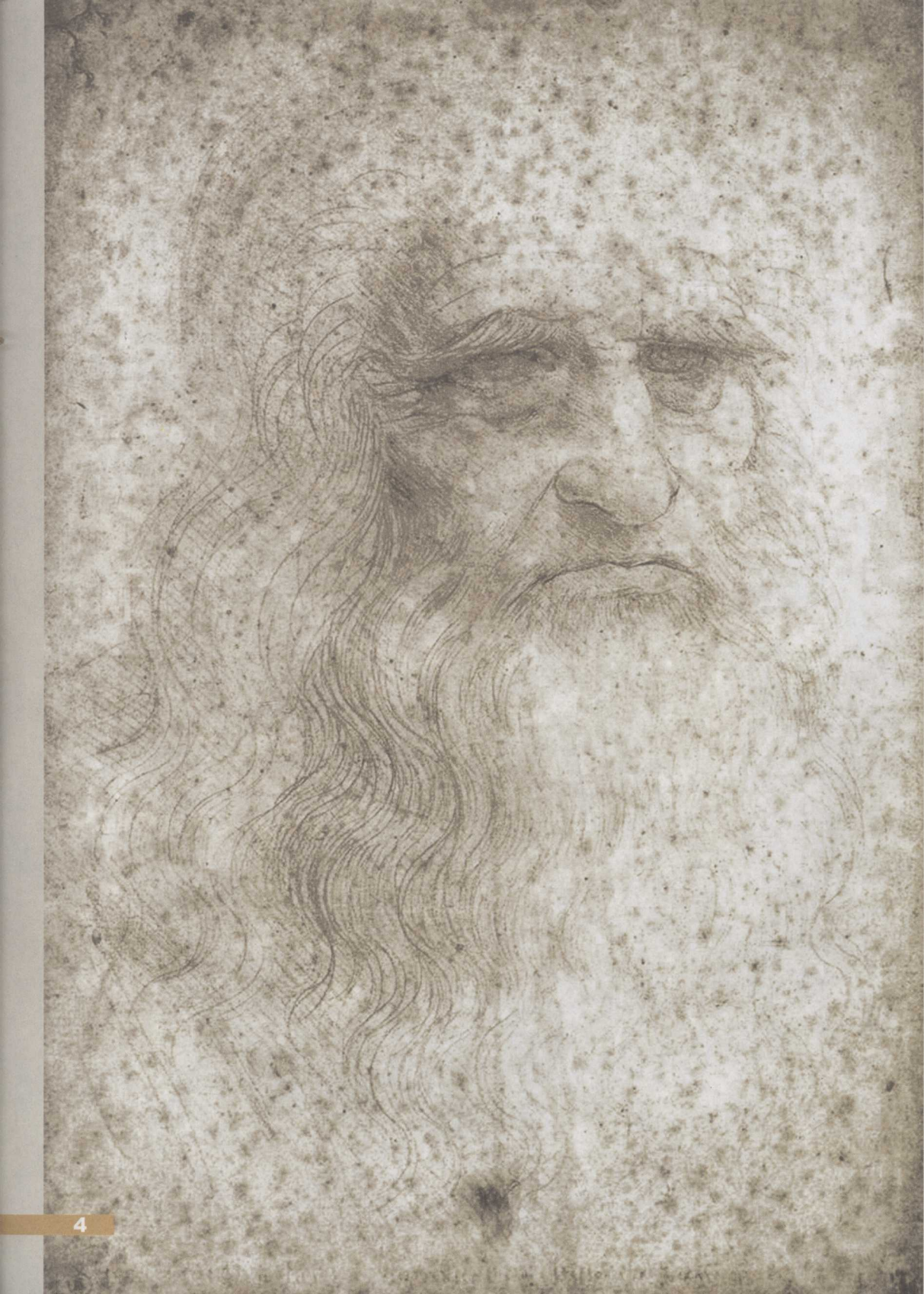
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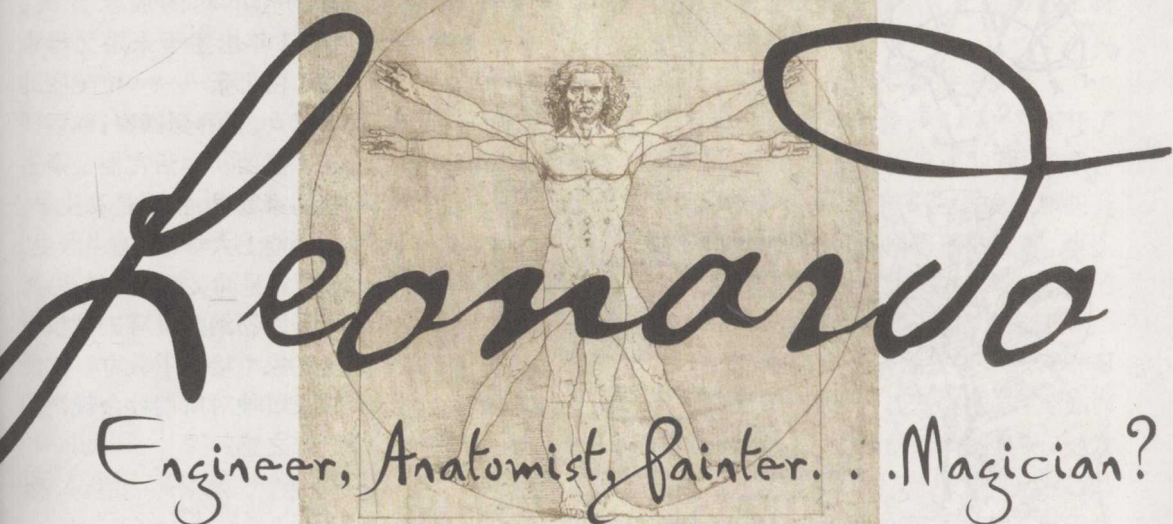


提到达·芬奇这个如雷贯耳的名字，首先进入人们脑海的印象便是文艺复兴时期的伟大艺术家，然而达·芬奇实际上却是两个世界的人杰——艺术世界和科学世界。虽然不管是在他那个时代还是在以后的年代里，达·芬奇一直都没有被作为科学家来看待过，但是他在视觉和天文学领域的发现直接导致了其后的天才科学家伽利略、开普勒和牛顿等人的探索发现。

达·芬奇是第一个用科学的方法来了解我们周遭现实世界的人，他探索现实世界的运行规则和人们如何看待这个世界。

在科技已经高度发达的今天，了解几百年前的先人对世界和科技的探索，仍然令我们充满了敬佩之情。





by Katherine S. Balch

莱昂纳多：

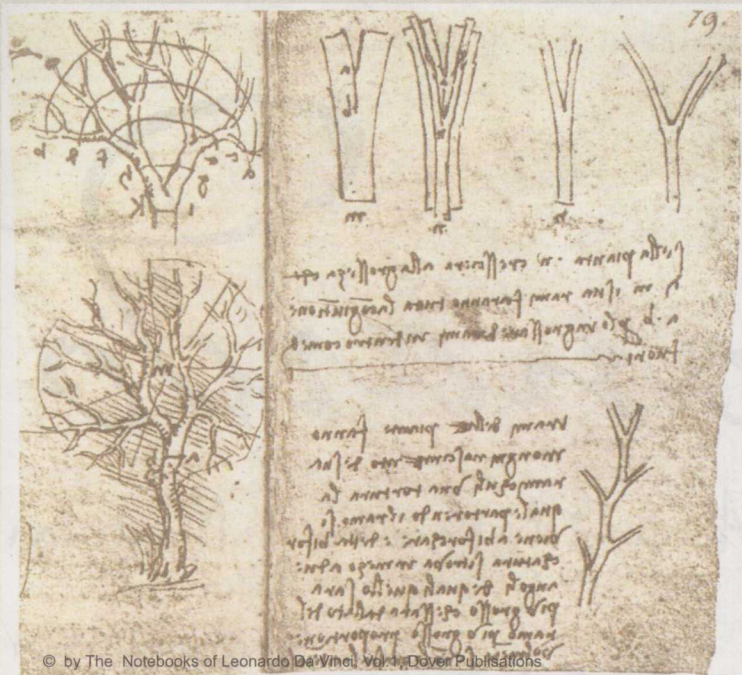
工程师，解剖学家，画家……魔术师？

If you were as smart as Einstein, as inventive as Bill Gates, as artistic as Picasso, as musical as Dave Matthews, as good-looking as Brad Pitt, and as entertaining as David Copperfield, wouldn't you have a pretty good shot at getting your dream job? In Italy, at age 26, Leonardo da Vinci was all of the above. But the Duke of Florence wouldn't hire him.

It may have been because Leonardo seldom finished a painting. He also had trouble painting what he was told to paint. Instead, he followed his inspiration. He felt that "to give orders is a gentleman's work; to carry them out is the act of a servant."

假 如果你像爱因斯坦般聪明，如比尔·盖茨般多创，又有毕加索般的艺术修养，有同大卫·马休兹一样的音乐资质，你像布拉特·彼德般英俊，如大卫·科波菲尔般长于表演，如此这般，你是不是已准备好在自己梦想的生涯中好好施展一番呢？在意大利，26岁的达·芬奇就具备以上所有条件。然而佛罗伦萨公爵却不会雇用他。

这也许是因为莱昂纳多很少能完成一幅画作，并且他还难以做到按别人吩咐的那样去作画。相反，他遵循自己的灵感，并认为：“发号施令是绅士的职责；而履行职责是奴仆的作为。”



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Leonardo's interest in the natural world extended to the plant kingdom, which he aimed to depict in his paintings as realistically as possible.

莱昂纳多对自然世界的兴趣延伸到了植物王国。他的目的是尽量实际地在他的绘画中把它表现出来。

Leonardo's rebelliousness probably began with an unconventional upbringing. Born in 1452 to unmarried parents, he was raised by his pretty peasant mother until he was about 4. Then he went to live in Vinci with his well-to-do father and his family. As a bastard child, he could not attend the university or become a doctor, professor, or notary (lawyer) like his father. So Leonardo was educated at home instead of at a school, and developed a dislike for society's rules.

SCIENCE+ART=ENTRANCE INTO WORKSHOP

When he grew restless because no one could answer his many questions, Leonardo would run to the woods and examine glowworms, lizards, or the structure of a lily stalk. He often boxed an animal to observe its behavior, and then drew it for future reference. Combining science with art was the key to Leonardo's

莱昂纳多的叛逆可能源自于他不羁的成长方式。1452年出生于未婚父母家庭，由母亲——一位美丽的农家女，抚养到四岁，以后便去了温西，生活在他父亲富裕的家庭里。由于是私生子，他不能上大学，不能当医生、教授或是同父亲一样做律师。于是莱昂纳多没有去学校而是在家中接受了教育，这便滋长了他对所谓社会规则的厌恶之感。

科学+艺术=进入画坊的通行证

每当无人能回答他那一堆问题而令他不安的时候，莱昂纳多总是会跑到树林里，开始检查那些萤火虫、蜥蜴，或是百合茎的结构。他常会把动物装在盒子里观察它的行为，并描绘出来以便将来作注解。把科学同艺术相结合正是莱昂纳多学习方法的关键。而这种方法甚至为当时佛罗伦萨名噪一时的画家安德里亚德尔所采纳，成为进入他画坊的一种入学考试。

传说中，父亲给过莱昂纳多一个猎人用的盾让他加以装饰。完成以后，莱昂纳多用他的画架支起这只盾，于是窗外射进的阳光闪烁在其表面。父亲推开门，倒吸一口气，震惊于上面那只栩栩如生的猛兽，猛烈地咆哮，像是随时可能扑将而来。而小莱昂纳多不动声

learning method. It may have even served as a sort of entrance exam into the workshop of Andrea del Verrocchio, a successful artist in Florence.

The story goes that Leonardo's father gave him a hunter's shield to decorate. When Leonardo finished, he propped the shield on his easel so that light from a window would glance upon the surface. His father opened the door and gasped, startled by a very realistic-looking beast with fiery breath that seemed ready to pounce. "The shield will serve its purpose," the young Leonardo said matter-of-factly. The shield also convinced Leonardo's father that his son had a future in painting.

LEAVES HOME TO BEGIN APPRENTICESHIP

At about age 15, Leonardo left his father's household and entered Verrocchio's workshop. Living in Florence, Leonardo now had access to scholars who could answer his questions. In fact, Florence had become the epicenter of an explosion of knowledge known as the Renaissance.

Leonardo the apprentice plunged into work, learning how to mix paint, cast bronze statues, even play the lyre. He invented perfumes to mask the stench of plague and taught his friends magic tricks.

Physically, he became quite the man: tall, with a handsome, well-proportioned face. He was so strong that he could stop a galloping horse while he stood on the ground, or bend a horseshoe with his bare hands. (Yikes!)

After a 12-hour workday, Leonardo visited the learned men of Florence to discuss mathematics, astronomy, botany, and anatomy. When he went to bed, he rigged up a water-powered alarm clock to jerk his feet upward so that he could wake up early.

At 20, Leonardo graduated from Verrocchio's workshop and joined the ranks of professional painters. Verrocchio asked him to add an angel next to his own in

色地喃喃道：“盾这样才能令人满意。”而这只盾也让父亲相信儿子在绘画上将会有所成。

离开家庭，开始学徒生涯

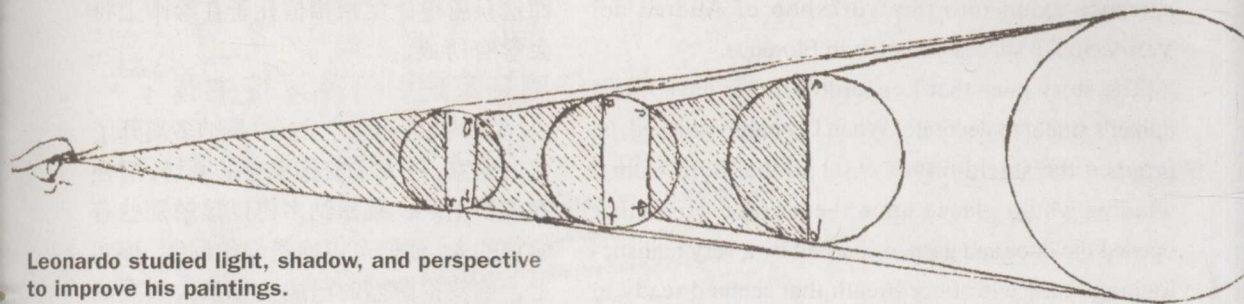
大约15岁的时候，莱昂纳多离开了父亲的家，进入了安德里亚的画坊。居住在佛罗伦萨，莱昂纳多得以接触那些有学识的人，他们可以回答他的问题，事实上，佛罗伦萨当时已成为知识大爆发的中心——这就是众所周知的文艺复兴。

莱昂纳多全身心地投入工作，学习如何调配颜料，如何雕塑铜像，甚至如何演奏里拉琴；为了掩盖瘟疫的臭味，他发明了香水，并且教朋友们玩一些小戏法。

实际上，他已经完全具有了男子汉的气度：身材高大，有着一张俊美、比例协调的脸。他很强壮，站在地上就足以拦住一匹疾驰的骏马，或是徒手就能把马蹄铁掰弯。

每天12小时的工作结束以后，莱昂纳多去拜访佛罗伦萨那些有识之士，同他们讨论数学、天文学、植物学以及解剖





Leonardo studied light, shadow, and perspective to improve his paintings.

莱昂纳多研究了光线、阴影和透视，以改进其绘画技巧。

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a painting of the *Baptism of Christ*. Leonardo's angel was so sublime that Verrocchio exclaimed that Leonardo had outpainted his own teacher! During the next 10 years, Leonardo gained a reputation as an innovative artist. Yet the Duke of Florence still would not hire him.

PAGEANT LEADS TO SCIENCE PROJECTS

Leonardo might never have acquired in-depth knowledge of so many subjects if Ludovico Sforza, duke of Milan, had not given him a job. Interestingly, the duke was most impressed by Leonardo's talents as a musician and engineer, and asked him to devise an entertaining pageant for a court feast. The spectacular show, including a revolving stage and a giant, moving display of the planets, convinced the duke to let Leonardo delve into an array of scientific projects.

SUPER-VISION AND VIRTUAL REALITY

Leonardo's notebooks show that he wanted to know not only *how* something worked but *why*. And he was lucky to have been born with a gift usually found in great athletes: super-vision. Leonardo was able to see and to portray images in

学。睡觉前，他会布置一个水力的闹钟，闹钟可以向上猛拉他的脚，这样他能早早醒来。

20岁那年，莱昂纳多从安德里亚的画坊毕业，正式进入职业画家的圈子。安德里亚曾经让莱昂纳多在一幅名叫《基督受洗》的画作中，在自己所作的天使旁边再画一个。莱昂纳多的天使相当杰出，因而他的老师惊呼莱昂纳多已经超越了自己！而在此后的十年间，莱昂纳多获得了改革派艺术家的殊荣。尽管如此，佛罗伦萨的公爵还是没有任用他。

通向科学工程的盛宴

如果米兰公爵路德维克不曾给莱昂纳多一份工作，莱昂纳多可能永远没有机会在如此众多的科学领域获得全面的知识。有趣的是，这位公爵因为被莱昂纳多作为音乐家和工程师的才能所深深吸引，而请他来为自己设计一场宏大的宫廷盛宴。这一壮阔的场面，包括一个旋转的舞台及巨大的斗转星移的场景设置，使莱昂纳多征服了公爵，令公爵信服地让他投入到一批科学项目中。

非凡的洞察力与虚拟现实

从莱昂纳多的笔记本中可以看出，他从不满足于仅仅了解事物的存在状态，而是会深究它的内在原因。而幸运的是他生来就具有通常只有伟大运动员才有的超级视力。莱昂纳多可以通过两种特殊的方法观察和描绘形象。

two special ways:

Through *visual memory*, he could freeze a bird's wing movements in his mind, distinctly remember them, and then draw them. This *scientifically accurate visual representation of wing movements* was not duplicated again until the invention of the camera.

Through *visual imagination* he could draw what he did not see in front of him but what he calculated must be there. This ability helped him to draw (1) highly accurate maps without the aid of satellite images, (2) the first transparent image of human organs long before the CAT scan; and (3) 360-degree cross-sectional views of body parts, which might qualify as the first virtual-reality images.

In addition to observation, Leonardo the scientist had a passion for experimenting and writing down his findings. He repeated his experiments from all angles and recorded them in detail. This approach was *unheard-of* at the time, and it helped him "work miracles": He unraveled the laws governing plant growth and the rules of perspective for such masterpieces as the *Last Supper*, and developed techniques for cast-

其一，通过视觉记忆，他能够让鸟儿翅膀的运动定格在脑海中，然后清晰地记住，并把它画出来。而在照相机发明以前，再没有什么能对翅膀的运动有如此科学而精密的视觉表现了。

其二，通过视觉想象，他能够画出那些并未在眼前出现但经过预测应该在那里的事物。这一能力帮助他：(1) 在没有卫星图像帮助的情况下，描绘高度精密的地图；(2) 画出第一幅人体器官透视图，而这远远早于计算机自动测试扫描仪的发明；(3) 按360度视角画出人体部位的剖面图，它可以算做虚拟现实成像的开山之作。

除了观察以外，莱昂纳多作为科学家更有着一种投身实验和记录发现的热情。他从不同角度反复试验，并作详细记录，这种方法在当时是史无前例的，也帮助了他创造奇迹：他揭示了统治植物生长的法则；发明了透视画法规则，从而有了《最后的晚餐》这样的代表作；同时他还发展了铸造世上最宏大的骏马雕塑的技术。

极受欢迎的画家和工程师

1500年，法国攻占米兰，莱昂纳多被迫到别处寻找工作。在佛罗伦萨，他开始了绘画的高峰期，创作了《蒙娜丽莎》、《圣母、孩子与圣安妮》以及《安加利之战》。他还曾经为粗鲁的军事指挥官 Cesare Borgia 工作。莱昂纳多视战争

为洪水猛兽，但仍认为有时战争是必要的——如果是“为了维护自然最高的恩赐，也就是自由”。因此他设计了坚不可摧的同心形堡垒，还有各种方案，通过改变阿诺河水的流向抵御敌人的水攻。



ing the largest horse statue in the world.

PAINTER AND ENGINEER IN GREAT DEMAND

In 1500, the French conquered Milan, so Leonardo left to find work elsewhere. In Florence, he began a prolific period of painting, working on the *Mona Lisa*, the *Virgin and Child with St. Anne*, and the *Battle of Anghiari*. He also worked for the ruthless military commander Cesare Borgia. Although Leonardo considered war a beastly madness, it was necessary "to preserve the chief gift of Nature, which is Liberty." So he devised impregnable concentric fortresses and plans to deny the enemy water by diverting the Arno River.

Although other artists, most notably Michelangelo, had been working for the pope for years, Leonardo was not invited to Rome until age 61. Like the duke of Florence who would never hire Leonardo, Pope Leo X was a member of the wealthy Medici family. When asked to prepare a peace offering for a meeting between the pope and Francis I, king of France, Leonardo showcased the first robot. Shaped like a lion (symbol of the Medici), the robot walked on its own into the room and opened its breast, showing a heart full of lilies (emblem of the French king).

Francis I invited Leonardo to work in France and provided a grand house for Leonardo and his pupils to live in. The king asked only that Leonardo talk with him, for the king "believed there had never been another man born in the world who knew as much" as Leonardo. In this house, Leonardo died at the age of 67, leaving all his notebooks and the mysteriously smiling *Mona Lisa* to a trusted pupil.

A water wheel mill building design from Leonardo's notebooks

莱昂纳多的笔记本中有关水轮磨坊建筑的设计。

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其他的艺术家，以米开朗基罗为典型，大都为教皇工作过，但莱昂纳多直到61岁才被邀请到罗马。如同佛罗伦萨那不会任用他的公爵一样，利奥教皇是富有的梅第奇家族的一员。当被要求为教皇和法国国王弗朗西斯一世间的会晤准备一件吉祥物时，莱昂纳多陈列出史上第一台机器人，它形状酷似雄狮（象征梅第奇），独自走进房间并打开自己的胸膛，露出一颗塞满百合花的心（象征法国国王）。

弗朗西斯一世邀请莱昂纳多赴法国工作，并提供一所华丽的房子给他和他的学生们居住。国王只要求莱昂纳多同他交谈，因为国王“相信世界上决不存在第二个更博学多识的人”在莱昂纳多之上。在这所房子里，莱昂纳多把所有的笔记以及带着神秘微笑的《蒙娜丽莎》留给了一位他信赖的学生，于67岁时去世。

MAKING MOUNTAINS

The background of the entire page is a reproduction of Leonardo da Vinci's painting 'The Deluge'. It depicts a dramatic scene of Noah's Ark, with the ark on the right and a chaotic landscape of mountains and water on the left. Noah, an older man with a beard, stands in the center, gesturing towards the rising waters. To his left, a woman in a red and white striped skirt looks on with a distressed expression. In the lower left, two children are shown, one of whom is holding a scroll. The sky is filled with dark, swirling clouds and a bright light source, possibly the sun or moon, creating a sense of divine intervention and catastrophe.

The Medieval & Modern Geology
of Leonardo da Vinci

by Gretchen Noyes-Hull

山的形成：

莱昂纳多·达·芬奇的
中世纪地质学与现代地质学

Imagine writing down your cleverest ideas and most thoughtful musings in a diary or journal. Figuring that sooner or later you would come back to them, you close the covers and slide the book to the back of your bookshelf, behind all the other volumes. Imagine that years later, when clearing the shelves, you rediscover your journal. What would you find? And how would you feel?

Perhaps you would discover that during the time that had passed, other people had come up with some of your ideas. You might also find that your own thoughts would have changed somewhat, for they were products of your age and understanding at the earlier time. No doubt you would be secretly proud that others had come up with some very similar ideas well *after* you had, and you also would be interested in comparing your earlier thoughts with what you know now.

Leonardo da Vinci also would be pleased with himself if he were with us today! He would not be surprised that the concepts and observations he had so diligently recorded were still highly regarded! He was well aware that his ideas on geology, in particular, were radical and even dangerous for his time. But he would be intrigued by the differences between his thoughts on the subject and ours; his ideas were rooted in another age, 500 years ago.

In fact, for more than 300 of those years the notebooks and journals into which Leonardo had poured his thoughts were scattered and lost on a great many bookshelves. While his notes were sidetracked from the progression of science, many of the same geological principles that he had recorded were independently "rediscovered" by his unknowing successors. And during that time, a whole new method of scientific thinking had become generally accepted.

"Man is the model of the world," Leonardo wrote. Immersed in a 2,000-year-old tradition that dated from

试想在日记中写下你所有最聪明的想法以及最深入的冥想。然后有一天你又回想起它们，你合上封页，把它藏在书架的最深处，隐匿于其他的书卷之后。想象很多年过去，你清理书架时，再次发现了这些日记。你会有什么样的发现？又会有什么样的感悟呢？

或许你会发觉在岁月的流逝中，也有其他人提出过你的一些观点，你也可能发现自己的想法已经有些改变，因为这些是你当时那个年龄的产物和对事物早期的理解。毫无疑问，当看到别人提出一些你早就有过的思想时，你内心会私下感到骄傲；同样，你也会饶有兴趣地拿当初的想法同现在的作比较。

莱昂纳多·达·芬奇如果仍然生活在我们中间，也会感到无比欣慰！他不会感到惊奇，那些他曾经英明记录下来的构想和论断至今仍受到高度评价！他尤其会清醒地意识到他那些地质学观点在那个时代是多么激进甚至是危险的。但他也会对这一门学科上他的想法与我们的想法之间的不同所吸引；而他的观念是植根于另一个时代的，那是在500年以前。

事实上，在300多年的历史中，莱昂纳多倾注了他个人思想的那些日记、笔记失散在许许多多不同的书架上。尽管笔记中的内容同科学发展的进程存在偏差，但他所记录的许多相同的地质学法则仍被他无从知晓的后继者独立地“重新发现”。就在那期间，一套全新的科学思维已经被逐渐接受。

“人类是世界的蓝本，”莱昂纳多写道。沉浸在一个始于古希腊先哲亚里士多德时代并延续了两千年的传统中，他也相信人体和地球均由四种元素构成：土、水、气和火。地球上的元素有这样一种倾向，就

the days of the Greek philosopher Aristotle, he believed that both man and earth were composed of four elements: earth, water, air, and fire. On earth, the elements have a tendency to settle in four concentric layers, from heaviest to lightest. But complete stability is never reached: Like the human body after which it is modeled, the earth is always changing. Water flowing down from mountain peaks takes rocks to the sea.

Leonardo set out to understand the circulation of water and the cycling of earth. He believed that "the same cause that keeps the blood at the top of a man's head keeps water at the summit of mountains." But what about the mountains?

The circulation of water on earth was a problem. Leonardo could only *surmise* that water must circulate from the sea to mountaintops in underground "veins." But he had actual evidence of the mountain-making: the occurrence of ocean fossils high on hills and peaks far from the sea. He rightfully *postulated* that these shells had been deposited in bottom sediments of shallow seas before being elevated in the form of mountains.

Leonardo made extensive and very thorough observations of fossil shells in the Italian countryside in order to disprove the accepted theories for their existence and to support his own ideas about the circulation of water and earth. He meticulously recorded his findings in the notebook known today as the Leicester Codex.

It is very apparent that Leonardo had no patience for those who supported other explanations for the fossils. The interweaving of the biblical flood story with an ancient Greek belief that lifelike shapes are created in stone according to the stars was particularly offensive! He writes of the "stupidity and ignorance of those who imagine that these creatures were carried by the Deluge to such places distant from the sea," and criticizes the other "set of ignoramuses for thinking that nature or the heav-

是由重到轻地分布成四个同心层。但绝对稳定是不可能达到的,正如它所模仿的人体一样,地球同样是处于变化中的。山顶流下来的水把岩石冲进海中。

莱昂纳多着眼于了解水的循环和地球的轮回。他相信“是同样的原因使得血液保留在人的头顶和水保留在山顶”。但山脉是怎么回事呢?

地球上的水循环是一个问题。莱昂纳多只能猜测水从海里到山顶的循环一定是通过一些地下的“脉络”。但对于山的形成他却有一套实际的证据:远离海洋的高山上以及山顶上有海洋化石的出现。他正确地提出了这一观点,这些贝壳曾在浅海的海床中沉积下来,后来在山的形成过程中被抬升。

为了证明当时被广泛接受的有关贝壳化石存在的理论中含有错误,并为了支持他自己关于水流和大地循环的观念,莱昂纳多在意大利的乡村作了广泛而细致的化石观测。他在笔记中谨慎地记录发现,这些笔记便是今天闻名于世的“列斯特手抄本”。

显而易见,莱昂纳多对于那些支持其他关于化石解释的人是毫无耐心的。圣经的洪水故事与古希腊人认为生物形状的石头是根据星辰塑造的观念混杂在一起,尤其令他不悦。他写到“那些认为化石是由洪水从海里冲到这些地方的人是多么的愚昧无知啊”,并且批评了另外“一群无知之辈”竟然认为是自然或是上天运用无上的权力创造了它们以及这些地方。此外,他还不屑地说:“这些观点根本不该存在于任何有着广泛推理能力的头脑中……!”

莱昂纳多自身的推理能力是毫无差错的。逐步地,他提供了有力的材料

Surmise
Guess.
Postulate
Assume.

ens have created them or these places through celestial influences." Additionally, he sputters: "Such an opinion cannot exist in brains possessed of any extensive powers of reasoning. . .!"

There was nothing wrong with Leonardo's own reasoning powers. Step by step, he provided data to take apart views that conflicted with his own. How could shell shapes grow to different sizes within rocks without cracking them? And if there were a worldwide flood, where would the water drain when it was all over? he asked. The evidence did not support the concept of a universal flood. There was no way that live corals and mollusks could travel as far as 400 kilometers inland in 40 days and 40 nights, nor up mountainsides. He noted that many of the bivalve shells appeared as they had in life, with the two shells still joined.

If, he said, "the shells had been carried by the muddy deluge they would have been mixed up, and separated from each other amidst the mud, and not in regular steps and layers — as we see them now in our time."

The different *strata* of now high-and-dry sedimentary rock could only have been formed from the deposits of not one, but *multiple* floods, occurring over long periods of time. Leonardo concluded that the fossils had been raised up.

The realization that the geological processes that take place today are the same as those that occurred in the long distant past is an extremely modern view. Scientists today also study living organisms to learn about the conditions under which their ancestors were deposited and fossilized. Like Leonardo, for instance, we assume that when the two shells of a bivalve mollusk fossil remain connected, the animal probably died in place. When fossil shells are all jumbled and broken, we imagine that they were once swept together by waves on an ancient beach.

It would take more than 200 years for this type of reasoning to become an accepted principle of geology. With the manuscripts dismantled and scattered, future

来驳斥那些与他相冲突的观点。贝壳在岩石中并未受到破坏的情况下也会产生不同形状，这是为什么呢？如果发生了世界范围的洪水，泛滥的水流将如何排干？他问道。这一证据不能解释关于宇宙大洪水的构想。活的珊瑚和软体动物不可能在40个日夜中就运动到400公里远的内地，更不可能爬上山坡。他指出许多双壳贝类看来在其生命过程中两块贝壳仍然连接着。

他说，如果“贝壳是被泥泞的洪水搬运，它们一定会搅拌在一起，然后在泥土中相互分离，而不是像我们现在所看到的那样，以有规律的级次和层次状排列”。

现今位处高地而干燥的沉积岩的不同地层绝不只是一次洪水中形成的，而是在相当长的时期内多次洪水中沉积而成。莱昂纳多总结出化石因此而抬升。

今天发生的地质过程与久远的过去所发生的是完全相同的，这种认识是极现代的观点。科学家们今天仍在研究活的生物体以了解它们的始祖在什么样的条件下沉积、变成化石。例如，像莱昂纳多一样，我们假设有一个双壳类软体动物，它的两块贝壳始终相连，这动物可能在某一地方死去。当贝壳化石破碎了混杂在一起，我们可以想象在远古的海岸上它们曾经有一次被海浪冲到一起。

这种类型的推理要想作为地质学原理被接纳至少需要200年时间。随着手稿的散逸，将来的科学家们不得不重新去发现莱昂纳多曾经作过的那些观察，这些观察涉及地质时代的浩瀚、沉积岩地层，以及意义无限的化石。直