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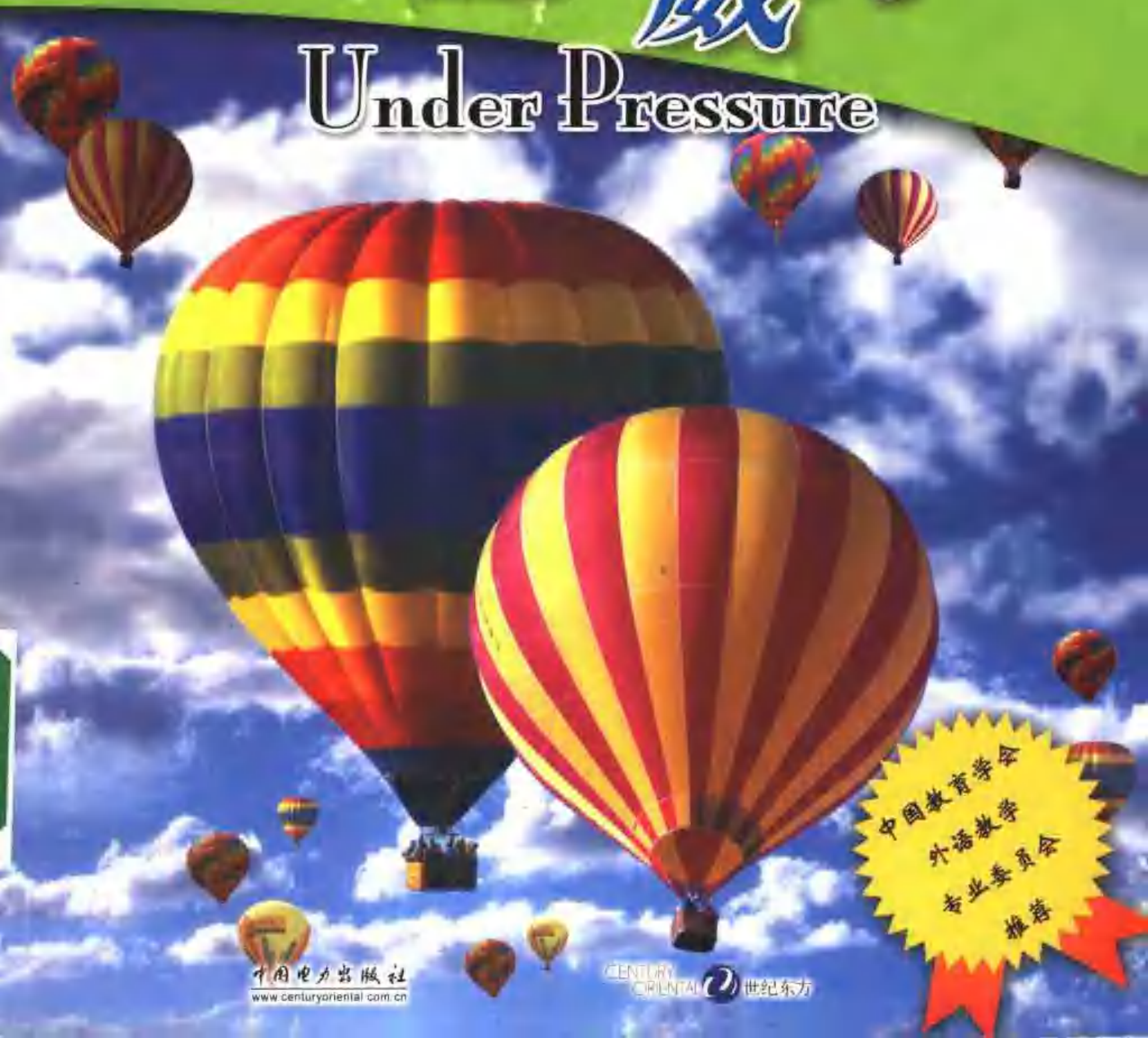
气压的威力

Under Pressure



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王 新 译

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Under Pressure

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气压的威力

原著：**Stephen James O'Meara** 等
翻　　译：王　新
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Contents 目录

Editor's Message 编辑手记

在如今这个快节奏的社会里，每个人都会面临各种各样的压力。作为编辑，我们深知一种来自心理层面的压力——截稿日期——或叫出版人的职场压力。但即将在本书中讨论的，却是另一种形式的压力——那种无形的，但总是围绕在我们身边的物理形态的压力。

你能感受到这种压力吗？它就是大气压每时每刻施加在我们身上的重力。没有这种压力，地球上的生命将会是完全不同的样子。没有这种压力，地球上就不会有钻石或枫糖浆！我们甚至都享受不到自然界的清风或温暖的淋浴了。想知道更多关于气压的神奇威力，找个舒服的角落坐下来，读一读“压力”的故事吧。

此为试读，需要完整PDF请访问：www.ertongbook.com

Cartoon illustrated by Annette Cate

The Powers of Pressure

by Stephen James O'Meara

Feeling pressured? Don't worry, so too is everyone else across the globe. It's a fact. Each day, every day, all day, Earthlings wake up under pressure. What's more, for most of us, it's inescapable – even when we sleep. Of course, most of us wouldn't want it any other way, because without this kind of pressure – air pressure, that is – life, as we now enjoy it, simply wouldn't exist.

你感到有压力？不必担心，地球上的任何一个人都会感到压力。这是一个事实。每天每日，世界上的人都在压力下醒来。并且，对我们大多数人来说，压力是无法摆脱的，就是在睡觉的时候也是如此。当然，我们大多数人也不想改变它。因为如果没有了压力——大气压——我们所享受的生活也就不会存在了。

气压的威力

It's everywhere!

Ever feel like you're walking on air? Well, you do it every day. From the tip of your head to the bottom of your feet, air surrounds you. Air molecules are invisible, but they still have weight and take up space – and their weight is pressing against you. You're so used to this air pressure that you don't feel it.

If we could weigh a column of air one inch square that extended all the way to the "top" of the atmosphere (about 500 miles), it would weigh approximately 14.7 pounds at sea level. Thus, atmospheric pressure at sea level is approximately 14.7 pounds per square inch (psi), which equals one atmosphere. Pressure does not stop at sea level. It increases as depth below sea level increases. (The opposite, of course, happens when you climb in altitude – by approximately 1.0 psi for every 2,343 feet.)

The pressures inside the Earth are tremendous – so tremendous that we have to leave behind human experience and try to picture the forces with our imaginations. Consider, for instance, that oxygen – a simple, colorless, odorless gas at sea level – would crystallize under a pressure of 55,000 atmospheres! If you could descend about two miles toward the geometrical center of the Earth, you would feel a thousand times more pressure on you than you would at sea level. If you could journey about 3,700 miles to the very core of the Earth, you'd experience a pressure of some 3.5 million atmospheres! You wouldn't have to worry about gym class anymore, because even the thought of doing a sit-up under these conditions would be painfully impossible.

压力无处不在！

你有没有在空气中漫步的经历呢？实际上，你每天都在这样做。从你的头顶到脚底，空气到处包围着你。空气分子是看不到的，但它们仍然有分量，并占据空间，而且它们的重量还压在你身上。你已经十分习惯这种压力了，所以你感觉不到它。

如果我们能够称一下底面积为一英寸的空气柱的话，从大气层顶部（大约500英里）到海平面上，它的重量大约是14.7磅（约为6.674千克）。这样，在海平面上的大气压就会接近每平方英寸14.7磅（约为6.674千克）。这就等于一个大气压。大气压并不只停留在海平面上。从海平面往下越深，气压也就越大。（当然，反过来说也是一样的。当你爬上高处时，每增高2340英尺，每平方英寸的气压就减少一磅（约为0.454千克）。

地球内部的压力是巨大的。如此的高压使人类无法靠自己的经验而必须靠丰富的想象去认识这种力量。例如，设想一下，在海平面上无色无味的简单的氧气，在55000大气压的情况下竟然会结晶！当你朝几何地心行进两英里时，你感觉到的压强是海平面上的2000倍。如果你能进入到3700英里的地核深处，你就会经历到350万个大气压的压强！那你就不用再为上体操课操心了。因为在这种条件下，做一个简单的仰卧起坐也是不可能的。

光线压力

你可以通过进入到太空来摆脱“空气压力”，太空处于一种真空状态。但这并不是说太空中没有舞动的空气分子，也并不意味着在真空状态下

© by Dennis Milun

LIGHT PRESSURE

You *could* escape "air pressure" by fleeing into space, which is a ***vacuum***. But that doesn't mean that air particles aren't zipping around space, any more than being in a vacuum means that you've escaped "pressure."

Just look at a comet. It has two tails: a dust tail and a gas tail. Both always point away from the sun. Why? The pressure of sunlight, weak as it is, can exert a pressure on dust particles flaking off a comet, blowing them downwind to form its gently curving dust tail. The comet's gas tail, on the other hand, is composed of gas being blown straight behind the comet by the solar wind – a flow of charged particles (ions, electrons, and neutrons) that continuously streams out from the sun at speeds of about one million miles per hour (about 400 kilometers per second).

Vacuum
A space empty of matter

Two white dwarf Stars merge.两颗白矮星的合并

你可以逃脱"压力"。

请观察一颗彗星。你会发现它有两条尾巴：一条尘彗尾，一条气彗尾。两条尾巴总是朝着远离太阳的方向。为什么会是这样呢？因为太阳光的压力。这种压力尽管很微弱，但它可以在彗星散落的尘埃的分子上施加压力，并把这些尘埃吹走，在下风的哪一边形成缓缓弯曲的彗尾。另一方面，彗星的气尾的组成成分主要是气体。这些气体被太阳风吹到彗星的后面，太阳风是一些带电的粒子流（离子，电子和中子），它们以每小时大约100万英里的速度（大约每秒钟400公里）从太阳中喷流而出。

压力：在遥远的太空！

谈到太阳，你是否知道它这么稳定就是因为各种压力之间斗争的结果？恒星上任何特定层面都存在一种平衡：来自重力的压力要使恒星收缩，而来自放热（热气体的向外流动）的压力又要使它扩张。

但这种平衡状态不会永远保持下去。一旦恒星用尽了它的核燃料——把氢变成氦——重力就会战胜热辐射的压力。这样，这颗恒星就塌缩了。像我们的太阳这样的恒星在生命的末期最终会缩成一颗白矮星。这是一种同地球大小相当的微小的星体，但它的质量却是地球质量的上百万倍。我们的太阳还不够大，不会进一步塌缩。

如果你能够站在一颗白矮星的表面上，你所经历到的重力压力只有在科幻电影中才能遇到。一小茶勺构成白矮星的材料的重量就有五吨半。一杯白矮星的材料的重量会超过24头大象的重量。

比太阳质量大四到八倍的恒星产生的压力会更大。当这一恒星的核心崩溃后，

PRESSURE: IT'S WAAAAY OUT THERE!

A neutron Star as seen by the Hubble Space Telescope 哈勃太空望远镜所看到的中子星。

Speaking of the sun, did you know that its very stability is a consequence of a battle between pressures? In any given layer of a star, there is a balance between the pressure of gravity trying to compress the star, and radiation pressure (an outward flow of hot gases) trying to expand it.

But this balancing act doesn't last forever. Once a star uses up its nuclear fuel – turning its hydrogen into helium – gravitational contraction wins out over the radiation pressure and the star collapses. At the end of its life, a star like our sun will ultimately collapse into a *white dwarf* – a tiny sphere about the size of our Earth, but with a mass a million times greater than it. A star such as our sun is not massive enough to collapse further.

Now, if you could stand on the surface of a white dwarf, the gravitational pressure you'd experience is the stuff that sci-fi movies are made of. A teaspoonful of white dwarf material would weigh five and a half tons; one cup of white dwarf stuff would outweigh 24 elephants!

A star four to eight times more massive than our sun is under even greater pressure. When its core collapses, the gravity is so intense that all the electrons and protons that form normal matter are squeezed further into neutrons and other exotic subatomic particles. The result is what astronomers call a *neutron star* – the densest form of matter known to exist. So a neutron star is supported by a repulsion pressure equal to a million billion times that of water. The pressure is exerted by neutrons in the nuclei of the heavy atoms

它产生的重力十分巨大。所有组成正常物质的电子和质子又被进一步挤压成中子和其他亚原子类粒子，结果就产生了天文学家所称的中子恒星——这是我们至今所了解到的密度最大的物质。因此，中子恒星靠相当于水压的一千万亿倍的斥力压强支撑着。在中子恒星的中心熔炼出重原子，正是这些原子的原子核内的中子产生了这么大的压力。

中子恒星的直径只有九英里，和一座小城市差不多大小。一小勺中子恒星物质大约有一千万吨重。从理论上讲，你可以在手掌上放置重量相当于一队战舰那么重的中子恒星的表面物质。如果你能够在这种恒星上站立的话，那重力产生的压力是巨大的——是地球重力的30万倍。

forged in the neutron star's core.

Neutron stars measure only about 9 miles across, the size of a tiny city. A teaspoonful of neutron star stuff would weigh about 10 million tons! Theoretically, you could hold in the palm of your hand a piece of neutron star surface weighing as much as a fleet of battleships. If you could stand on this star, the gravitational pressure would be immense – 300,000 times that of Earth.

What is the ultimate pressure machine? You might say a black hole. Indeed, a black hole is so massive that when its core collapses there is no pressure that we know of – not even on the subatomic level – that can prevent the core from collapsing to infinity, a mind-boggling concept indeed. A black hole's gravitational pressure is so intense that not even light can escape its pull.

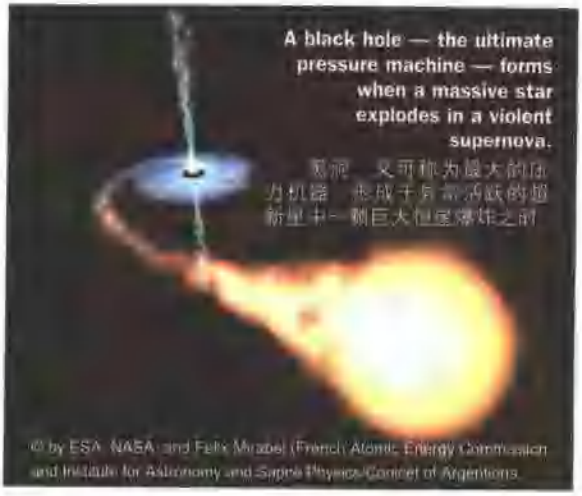
But what about a *supermassive* black hole! That's the big kahuna! While a black hole measures big on the stellar scale, it's peanuts to a supermassive black hole, which we measure on a galactic scale! Take M87, a galaxy in Virgo, for instance. The Hubble Space Telescope has found evidence for a supermassive black hole at its core – one so massive that it weighs as much as three billion suns, but is concentrated into a space no larger than our solar system! And M87 is but one of countless other galaxies – including our own Milky Way – that might contain such a "central beast".

It's useless to even try to fathom the pressure that our galaxy and its star stuff are under. So the next time you stumble out of bed, and feel so heavy that you can hardly shuffle your feet across the floor, just be thankful that your floor is on the surface. . .of Earth!

那么产生最大的压力的"机器"是什么呢？你可能会说是黑洞。的确，黑洞的质量是非常巨大的。当它的中心崩塌时，我们已知的任何压力（包括在亚原子层次上的压力）都不能阻止它无止境地崩塌。这的确是一个令人费解的概念。黑洞的压力是如此巨大，就连光也不能摆脱它的引力。

但如果是一个超大的黑洞，情况又会怎样呢？那它就是一个大巫师了。尽管黑洞同恒星比起来是非常巨大的，但在星系的范围衡量，和超大黑洞比起来，它就微不足道了。就拿室女座的M87星系来说吧。哈勃太空望远镜发现了一颗超大黑洞核心附近的证据，该黑洞的质量相当于三十亿个太阳的质量，但这么大的质量却集中在同我们所处的太阳系差不多大小的空间内。然而，M87只是无数可能包含这样一个"中央大怪物"的星系（包括我们所处的银河系）之一。

根本就不要企图推测我们所处的星系和其中的恒星承受着多大的压力，因为这都是徒劳的。所以，当你下一次踉跄下床，感到身体沉重，连脚步也挪不开的话，那你应当感恩，感谢你脚下的地板是位于……地球的表面上的。



A black hole — the ultimate pressure machine — forms when a massive star explodes in a violent supernova.

黑洞——又可称为最大的压力机器——形成于有剧烈的超新星中一颗巨大恒星爆炸之时

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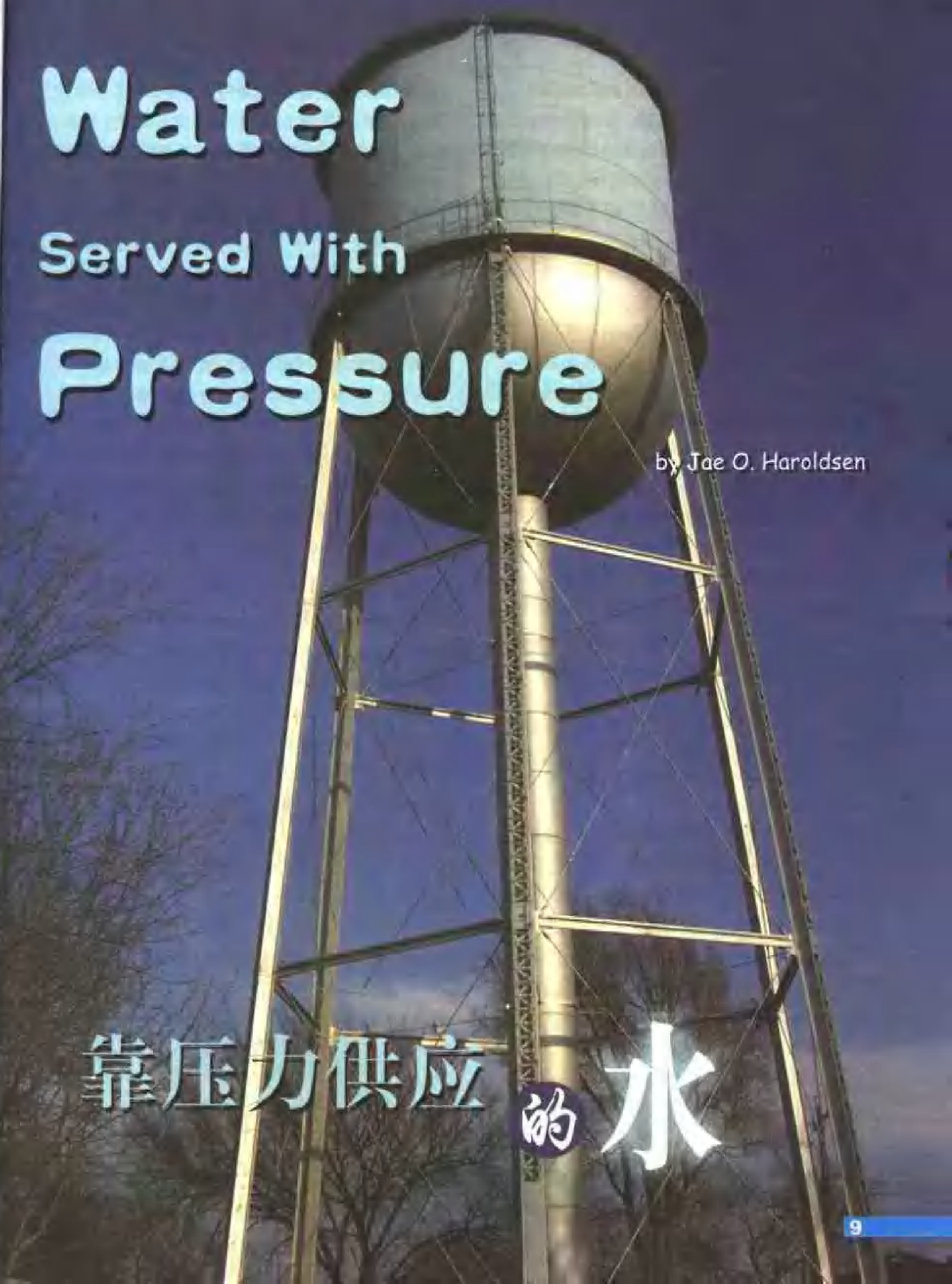
Water Served With Pressure



by Jae O. Haroldsen

靠压力供应的水

Stephanie stumbles to the bathroom at 6 a. m., finding her way more by instinct than sight. "Really," her mind tells her, "who can be awake at this hour? I need a shower. . ."

Steph's eyelids seem to blink open as steam fills the air. "Ahhh," she thinks, "morning isn't sooooo bad after all." But her thoughts are suddenly interrupted when the water streaming over her body turns ice cold! She jumps back and yells, "MOM! Turn off the water down there!"

"Sorry," her mom responds. "It wasn't intentional. I'm making breakfast. It won't happen again. . .if you HURRY!"

If someone in your household turns on the water when you're showering, do you experience cold or hot flashes? Those instant wake-up flashes are the result of water pressure that is too low.

WATER ON DEMAND

Long, hot showers are a necessity of life. . . especially for teenagers. But how does the water for that tantalizing pressurized spray get to your showerhead?

First, engineers need a reliable water source. Sometimes they drill wells and pump ground water. To supply a large population, they may build aqueducts to transport water from distant locations, like New York City did in the early 20th century. Engineers built a 92-mile (148-kilometer) aqueduct to bring water from the Catskill Mountains to the city.

But a reliable water supply won't give every house water when its occupants want it (shower) or when they need it (house fire). Water pressure does.

To supply pressure, many systems rely on

史蒂芬妮跌跌撞撞地走进卫生间，她摸索前行，靠得更多的是直觉而不是视觉。她的大脑在告诉她："谁能够在这么早醒来呢？我需要冲个淋浴……"

当空气中充满了蒸气后，史蒂芬妮的眼睛眨了眨后就睁开了。她在想："噢，清晨也并不是那么糟。"然而，当流向她全身的水突然变得冰冷时，她的思绪就被打断了。她跳了出来，大喊："妈妈！关掉你那里的水！"

妈妈回答道："对不起！我不是故意的。我在做早餐。如果你快点儿的话，这种事不会再发生了。"

你洗澡的时候，家里人突然把水打开。你是否经历过瞬间的冷水或热水呢？这种突然间水温的变化是因为水压太低。

供随时使用的水

大流量并且温暖的淋浴水是生活中必不可少的，对青少年来说，尤其如此。然而，这一令你等得着急并且带着压力的水是如何抵达你的淋浴喷头的呢？

pumps and water towers. At night, during low water use, pumps fill water towers. Then. in the morning, when everyone takes a shower, the water drains from the towers.

How do water towers supply pressure? They use gravity.

Have you ever lugged a gallon of water? Imagine the weight of one million gallons (3.7 million liters) of water stored in a tank. (A million gallons would fill 50 backyard swimming pools.) Gravity pulls on the water stored in a water tank. The water in the tank pushes on the water below it in the pipes, creating pressure. When you turn on the shower, water gushes as a result of pressure generated by pumps and water stored in elevated tanks.

THE RIGHT DESIGN

So. . .to get pressure for your shower, engineers should find the highest elevation in the area and build a water tower, right? "Wrong," says Joe Sowinski, an engineer who designs water systems in Baltimore, MD. "Water pressure depends upon the change of elevation from the storage point to the faucet. For each foot [0.3 meter] of elevation water is raised, you gain an additional 0.43 pounds per square inch [3 kilopascals] of pressure."

That feels like a size "D" battery sitting on end in your hand. What about 230 size "D" batteries?

Sowinski continues: "When the difference in elevation from your home to the top of the tank is greater than 230 feet [70 meters], you create pressures capable of bursting older plumbing [maybe your showerhead]." What a mess! But the change in elevation must be able to supply sufficient water pressure to meet fire safety requirements. Fire hydrants must be capable of supplying huge amounts of water on demand.

首先，工程师需要找到一个可靠的水源。有时，他们钻井，抽出地下水。要在人口密集区供水，他们可能还要修建水渠，把水从远处输送过来。纽约市在20世纪初就是这样做的。工程师修建了92英里（148公里）的水渠，把卡茨基尔山上的水输送到纽约市。

但在每家每户用水（淋浴）或需应急用水（救火）时，可靠的水源还不能满足他们的需要。只有水压能够做到这一点。

很多系统靠水泵和水塔产生水压。到了晚上，人们用水量较少时，水泵把水抽上来灌满水塔。到了早晨，当人们开始洗澡时，水就会从水塔里流出来。

水塔怎么会使水有压力？它靠的是重力。

你有没有引过一加仑的水？想一想把100万加仑（大约是370万升）水放到水箱里是什么样子（100万加仑的水能够填满50个后院游泳池）。重力会把储存在水箱里的水往下拉。这样，水箱中的水就会推挤其下面的水管中的水，压力就这样产生了。当你打开淋浴器的水龙头时，在压力的作用下，水就会喷射出来。这些压力是由水泵和位于高处的水箱共同产生的。

正确的设计

那么，要使你的淋浴器中有水压，工程师应该在附近海拔最高处修建水塔，对吗？乔·梭温斯基说："不对！"他是一名在马里兰州巴尔的摩市设计供水系统的工程师。"水压的大小取决于贮水处同水龙头之间的高度差。水位每提高一英尺（0.3米），那你在每平方英寸的面积上就会多得到0.43磅的压力，也就是增加3000帕斯卡的压强"。

这么大压力给人的感觉就像是把一节一号电池放到你的手上。但要是放上230节电池的话，你的感觉会是怎样的呢？

梭温斯基继续说："当你家里的高度同水箱最高处的高度差大于230英尺（70米）的话，

"To meet fire safety requirements," says Sowinski, "engineers store water 'at elevation.'" They maintain a minimum change in elevation by using electronic sensors in a tank. When the water in a tank reaches a minimum level, the system's pumps start pumping. This ensures both enough water and enough pressure to give firefighters blasting amounts of water when they need it.

YOUR WATER SYSTEM

Look around. Can you find your community's water storage?

Hilly regions may use a tank built at the highest elevation on the water system. Houses located at the highest elevation have the lowest water pressure, while houses at the lowest elevation have the highest water pressure.

Flat regions use towers. But since all homes are at a similar elevation, they have the same water pressure. In a high-rise city apartment building, your water storage may be hidden on the roof. Remember, that change in elevation supplies pressure. People living in the top floors enjoy their view of the city, but those on the bottom floors enjoy their showers.

In mountain valleys, the change in elevation from a ***reservoir*** in the mountains to the valley floor supplies water pressure. . .sometimes too much pressure! In the valley, engineers pass the water through valves to reduce pressure to a safe level. Instead of water storage, you may find a building full of pipes and valves.

Still can't find your water storage? Your water system may work solely on pumps.

However your community's water system works, remember, it's designed to deliver water with pressure. So relax! Enjoy your shower!

Reservoir
A natural or artificial pond or lake used for the storage and regulation of water

那你所得到的压力就会很大，能涨破年久的管道甚至是你的淋浴水龙头。这糟透了！然而，高度差的调整必须能够提供足够大的水压来满足消防的要求。消防栓必须能够在需要的时候提供大量的水。

梭温斯基说："要满足消防安全的要求，工程师们将水储存'在高层'。"通过水箱中的电子传感器，他们能够把水位的高度变化降到最小。当水箱内的水位降到最低点时，系统内的泵就开始抽水。这就保证了消防员在需要的时候能够获得足量、足压的水，使他们能够用猛烈的水势灭火。

你的供水系统

看一看周围，你能发现社区的贮水池吗？

在山区，水箱可能被建造在供水系统的最高点。建在最高处的房子所获得的水压最小，而建在最低处的房子能够获得最大的水压。

在平坦的地区，人们使用水塔。因为这时所有的房屋都建在差不多的高度上，它们获得的水压基本上也是一样的。在城市的高层公寓楼中，贮水处可以藏到屋顶上。要记住，高度差产生水压。这样，住在顶楼的人能够尽情地欣赏城市风景，而住在底层的人能够尽情地享受淋浴。

在山谷地区，山上的水库与谷底之间的高度差会产生水压……有时，这种水压过大。在山谷中，工程师们让水经过阀门，为的是要把水压降低到一个安全的水平。在这里，你可能看不到贮水处，却能看到一个里面满是管道和阀门的建筑。

还没找到你们那里的贮水处吗？那么供水系统可能只靠水泵工作。

无论你们那里的供水系统如何运行，你要记住这一系统的设计原理是依靠压力送水。所以，请放心，享受你的淋浴吧。

Aqueducts: Transporting Water

水渠：输水通道

by Jae O. Haroldsen

What single necessity of life determines where people build homes and cities? WATER!

The Roman Empire equated water with civilization. Romans transported water to cities using aqueducts, systems of pipes or channels that use gravity to move water. With water brought from distant sources, Romans enjoyed baths and fountains.

How did they transport water across valleys without modern explosives, steel pipe, and electric pumps? Charles Ortloff, an archaeological engineer in Santa Clara, CA, studies their efficient use of gravity, water pressure, and chiseled stone pipe.

When people think of Roman aqueducts, they usually picture water channels atop large, arched, stone bridges. These arched bridges carried water at constant gentle slopes across valleys, like a train trestle.

According to Ortloff, though, "Romans confined aqueduct bridges to a height of 150 feet [47 meters]. If the change in elevation was more drastic, they used inverted siphons." (An inverted siphon is a device that works like a U-shaped straw.) Inverted siphons require watertight pipes. They work by building pressure inside the pipes as water rushes downhill into a valley. The pressure then forces the water back up and out of the valley at nearly the same height it entered.

Modern engineers still employ gravity and siphons to transport water across small valleys. But whether they use steel or stone, the result is the same — water transported using pressure!

人们确定盖房子和建设城市的地点时，考虑最多的是哪一种生活的基本需求？是水！罗马帝国把水等同于文明。罗马人靠水渠把水运送到城市中。这种水渠是由管道（或通道）组成的，利用压力送水系统。水就从遥远的地方被输送到城市中，这样，罗马人就能享受沐浴和欣赏喷泉了。

没有现代的炸药、钢管和电动泵，那些罗马人是如何把水运出重重山谷的？加利福尼亚州圣克拉拉的考古工程师查尔斯·奥特洛夫专门研究古罗马人对重力的有效使用、水压和凿刻的石制管道。

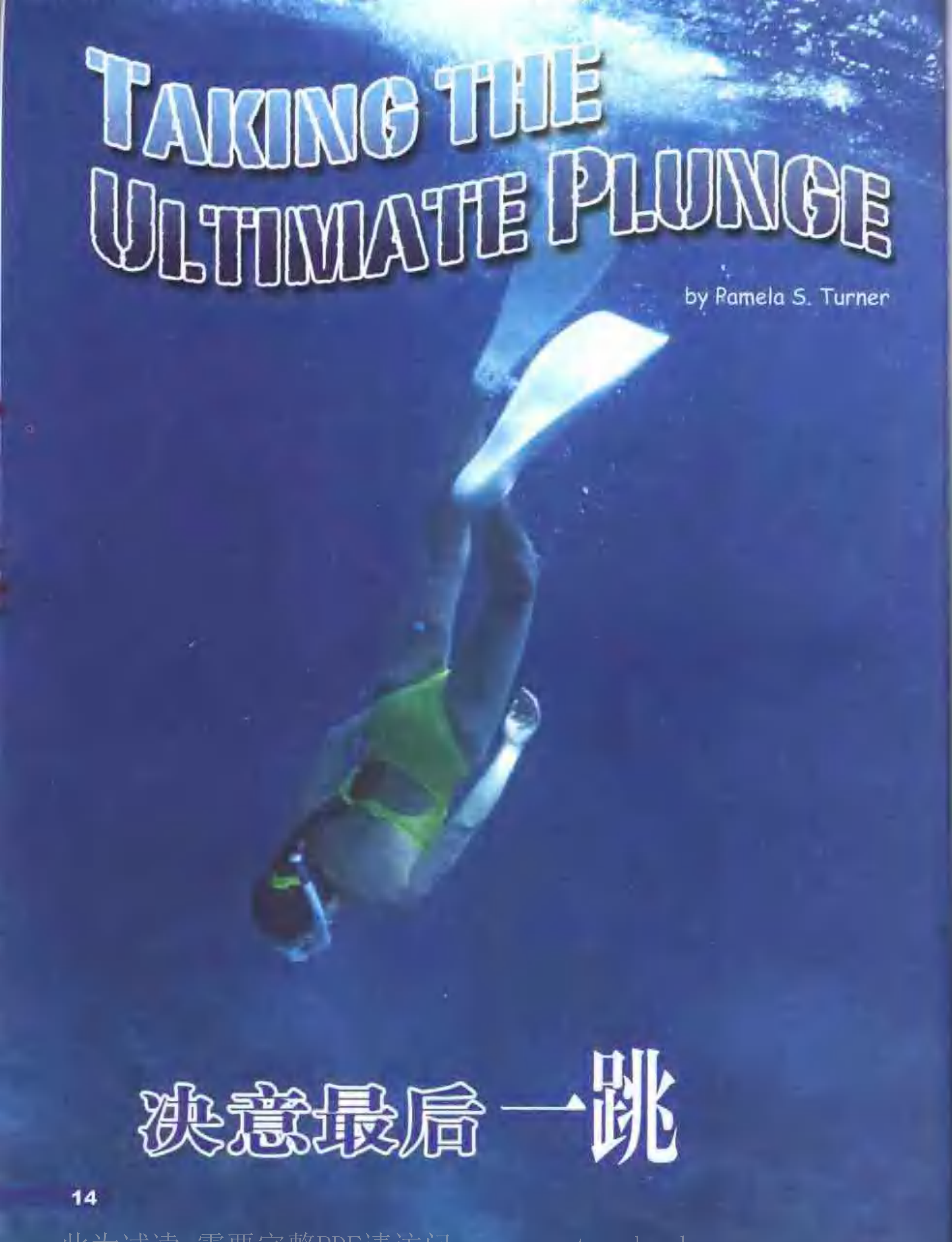
人们想到罗马的水渠时，大脑中的画面通常是高高在上的巨大的拱形石桥。这些拱形石桥顺着持续微缓的坡度把水带出山谷，样子就像铁路高架桥。

然而，奥特洛夫说："罗马人把石桥的高度限制在150英尺（47米）。如果高度的差异更加明显的话，他们就会使用倒置的虹吸管（倒置的虹吸管就像一个U型的吸管一样）。倒置的虹吸管需要由防水的管道制成。当水从山上冲下山谷时，管内就会积聚压力。这些压力就会把水推出山谷，并使其高度同进入山谷时的高度一样。

现代工程师们仍然依靠重力、用虹吸管把水从山谷中送出去。但无论他们使用的是钢管还是石制管，结果都是一样的——水是靠压力传送出去的。

TAKING THE ULTIMATE PLUNGE

by Pamela S. Turner



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