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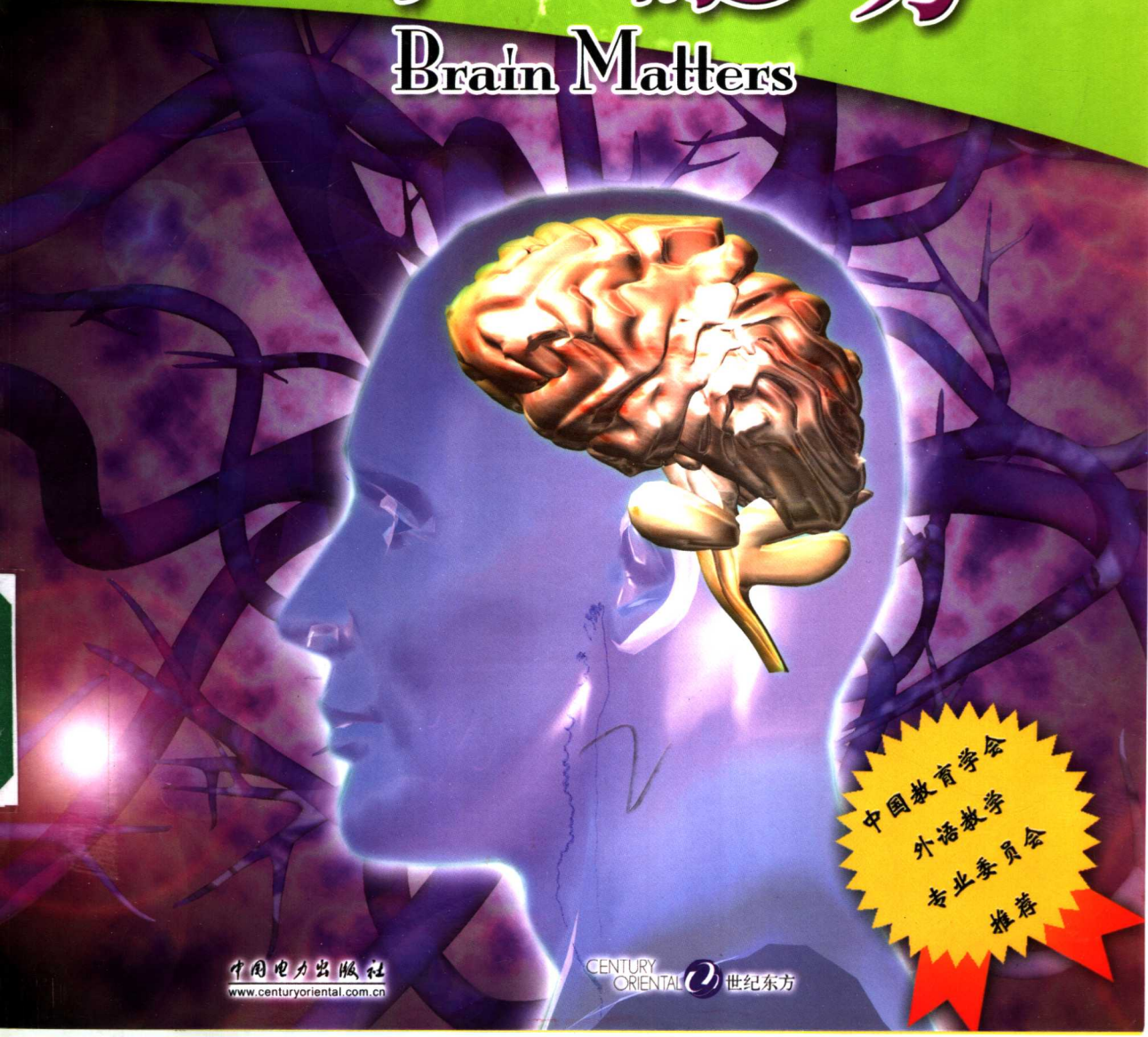
高中和大学低年级适用

不可忽视的脑力

Brain Matters



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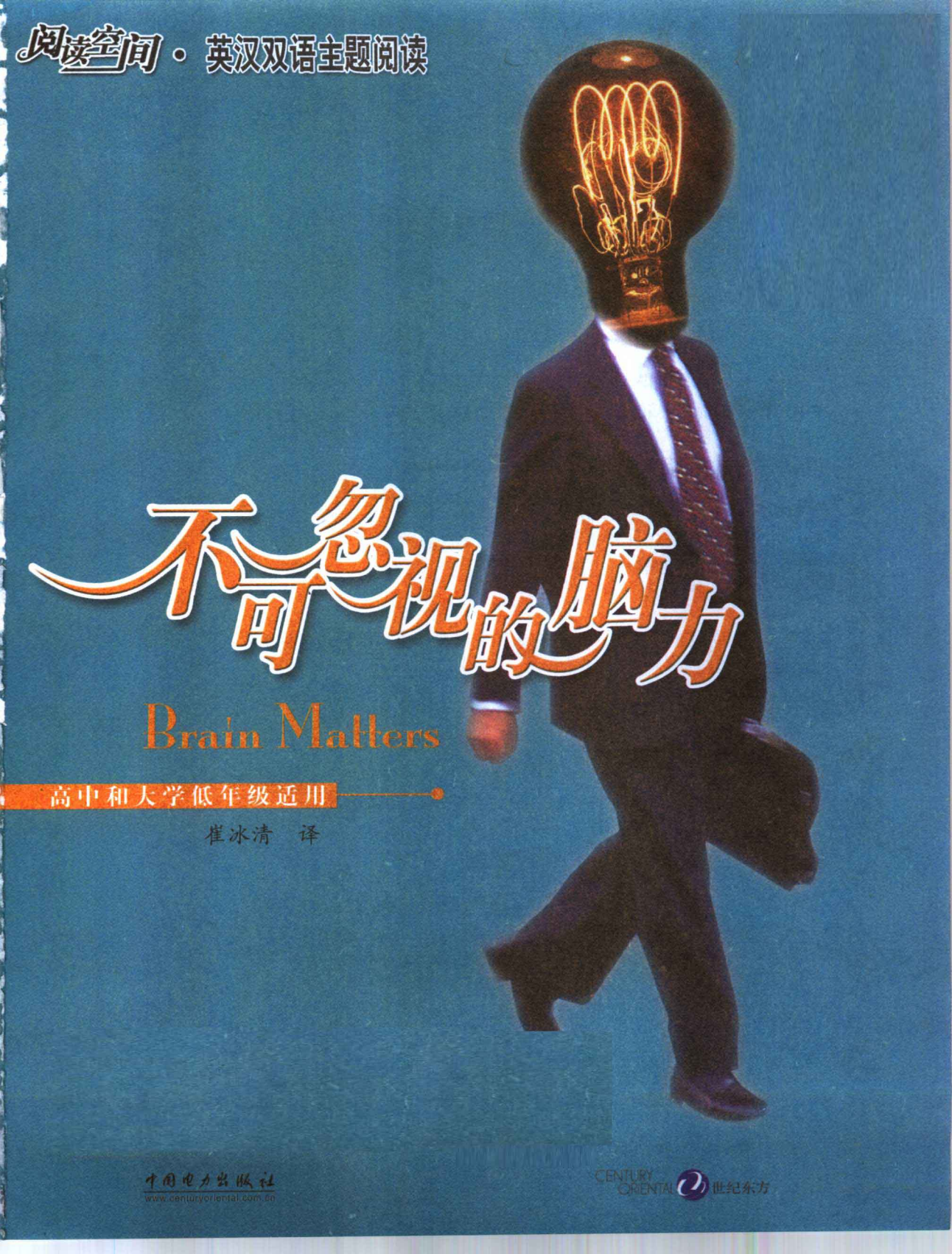

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崔冰清 译

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原著：**Dr. Eric H. Chudler** 等

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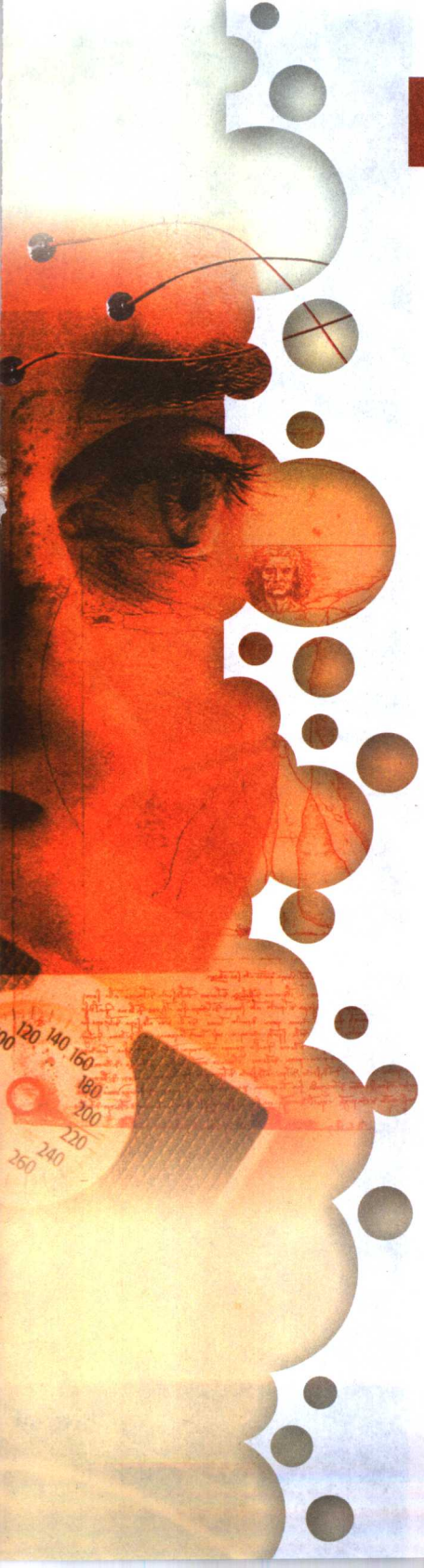

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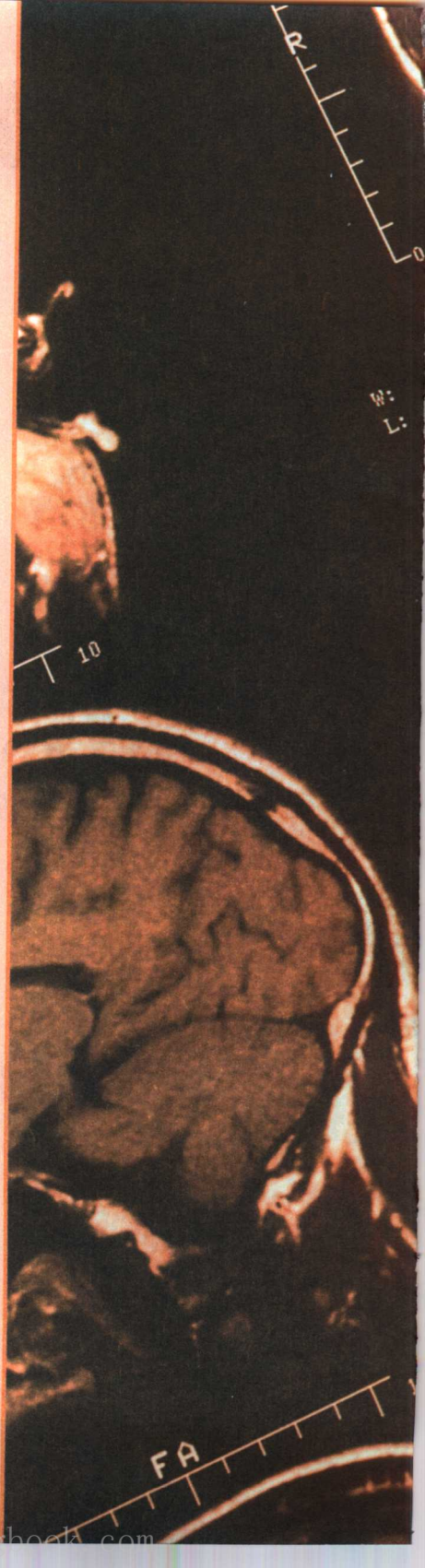
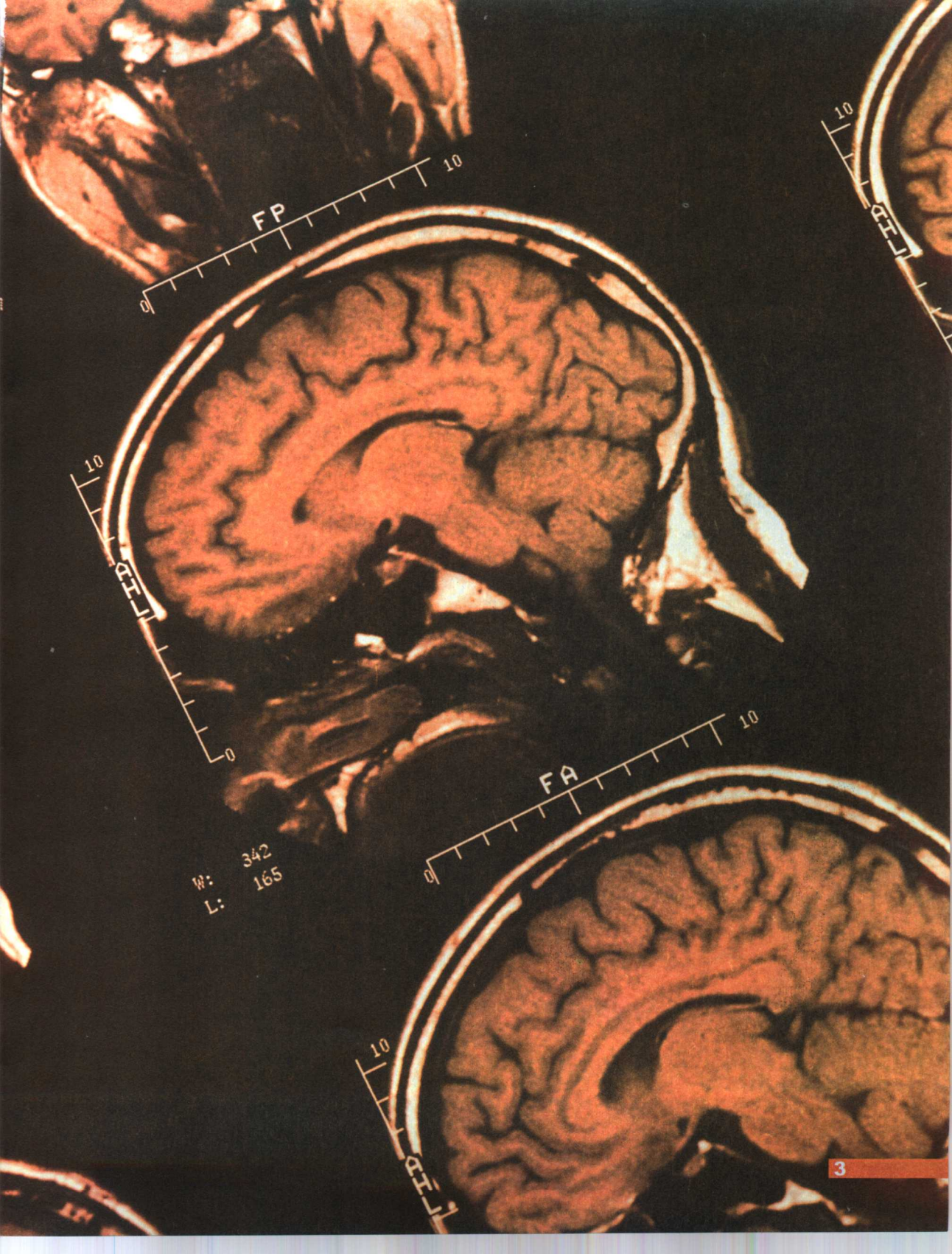
Editor's Message 编辑手记

在过去的十几年里，科学家们开始了绘制人类大脑工作图的努力。数千年来，关于人脑及其产生的意识，一直是一片混沌无知的王国。但自从1990年以来，我们获得的对人脑的认识，比以往所有积累的信息都要多。如此迅速的进步是怎样产生的？答案是：新的科学技术。

目前在医学临床和脑科学研究中应用的正电子发射断层扫描（PET）、功能性核磁共振（fMRI）和脑磁图（MEG）等技术，使研究人员可以真实地观察大脑是如何工作的，即如何思考、记忆、遗忘，或学会玩一种新的计算机游戏。不仅如此，在我们越来越重视健身强体，积极投入体育锻炼的今天，我们更有必要特别善待我们身体的主机——大脑。科学研究证明，积极健康地使用脑力，会刺激脑细胞不断生长，保持大脑持久的活力。

让我们一起来探索这个令人神往的“内层空间”——大脑宇宙。

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A Computer in Your Head?

by Dr. Eric H. Chudler

大脑中的计算机？

What has billions of individual pieces, trillions of connections, weighs about 1.4 kilograms, and works on electrochemical energy? If you guessed a minicomputer, you're wrong. If you guessed the human brain, you're correct! The human brain: a mass of white-pink tissue that allows you to ride a bike, read a book, laugh at a joke, and remember your friend's phone number. And that's just for starters. Your brain controls your emotions, appetite, sleep, heart rate, and breathing. Your brain is who you are and everything you will be.

The amazing brain has been compared to many different

什么东西由几十亿个元件组成，有万亿种连接，重约1.4千克，依靠电子化学能量运转？你猜是微型计算机？错！是人类的大脑？答对了！人脑是一堆粉白色的组织。有了它，人们可以骑车、读书、开怀大笑，还能记住朋友的电话号码。这还只是开始。大脑控制着人们的情感、食欲、睡眠、心率和呼吸。大脑关乎你是谁以及你将成为什么人。

神奇的大脑一直被比作许多不同的物体和装置——从蜘蛛网到时钟，到电话交换器。现

objects and devices – from a spider web to a clock to a telephone switchboard. Nowadays, people like to compare it to a computer. Is your brain really like the metal box that hums on your desk? Let's look at the similarities and differences between the two.

GOING TO THE SOURCE

Computers and brains both need energy. Plug your computer into the wall, push a button, and it will get the power it needs to run. Pull the plug and it will shut down. Your brain operates in a different way. It gets its energy in the form of glucose from the food you eat. Your diet also provides essential materials, such as vitamins and minerals, for proper brain function. Unlike a computer, your brain has no Off switch. Even when you are asleep, your brain is active.

Although computers and brains are powered by different types of energy, they both use electrical signals to transmit information. Computers send electrical signals through wires to control devices. Your brain also sends electrical signals, but it sends them through nerve cells, called *neurons*. Signals in neurons transfer information to other neurons and control glands, organs, or muscles.

There are fundamental differences in the way information is transferred through electrical circuits in a computer and through nerve cells in your brain. When a computer is turned on, electrical signals either reach parts of the machine or they do not. In other words, the computer uses switches that are either on or off. In the nervous system, neurons are more than just on or off. An individual neuron may receive information from thousands of other neurons. The region where information is transferred from one neuron to another is called the synapse. A small gap between neurons is located at the synapse. When information is transferred from one neuron to another, molecules of chemicals ("neurotransmitters") are released from the end of one neuron. The neurotransmitters travel across the gap to

在，人们喜欢把它比作计算机。大脑真的像你桌子上嗡嗡作响的计算机吗？让我们来看看两者之间的异同。

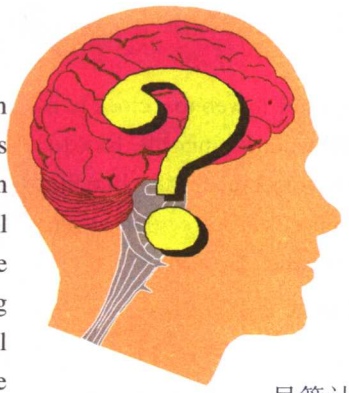
溯“源”

计算机和人脑都需要能量。插入墙上的电源，摁一下按钮，计算机就获得能量，开始运转。拔下电源线，计算机就会关机。人脑则以不同的方式运转。它的能量来源是你从食物中获取的葡萄糖。饮食还提供了大脑运转所需的重要物质如维生素和矿物质等。与计算机不同，人脑没有“关机”键。哪怕你在睡觉，大脑仍然是活动的。

虽然计算机和人脑使用不同种类的能量，但二者都使用电子信号传递信息。计算机通过电线传递电子信号以控制各种部件。人脑也发送电子信号，但是电子信号是通过神经细胞，即神经元，进行传导的。信息在神经元之间相互传导，控制着各种腺体、器官或肌肉。

计算机的电路和人脑的神经细胞传递信息的方式有着根本的不同。当计算机打开时，电子信号要么通到机器的各部件，要么就不通。换句话说，计算机使用开关，只有开和关两种状态。而在神经系统中，神经元并非如此简单。一个神经元可能会接收来自千千万万其他神经元的信息。神经元之间传递信息的区域称为突触，在突触区域中神经元和神经元之间有狭窄的突触间隙。传递信息时，神经元的末端会释放化学分子（神经递质）。这些化学分子穿过突触间隙，到达接收信息的神经元，嵌入称为受体的特殊结构中。此时接收神经元会作出轻微的电子反应。但是这个轻微的电子信号并不意味着信息会继续传递下去。别忘了，接收神经元可能会在突触

reach a receiving neuron, where they attach to special structures called receptors. This results in a small electrical response within the receiving neuron. However, this small response does not mean that the message will continue. Remember, the receiving neuron may be getting thousands of small signals at many synapses. Only when the total signal from all of these synapses exceeds a certain level will a large signal (an "action potential") be generated and the message continue.



FORM. . .AND FUNCTION

Despite the differences in the way messages are sent through wires and neurons, computers and brains perform many similar functions. For example, both can store memories – computers do it on chips, disks, and CD-ROMs, and brains use neuronal circuits throughout the brain. Both computers and brains can be modified to perform new tasks. New hardware and software can be installed in computers to add additional memory and programs. The brain undergoes continual modification and can learn new things. The brain can sometimes rewire itself when necessary! For example, after some kinds of brain injuries, undamaged brain tissue can take over functions previously performed by the injured area. I'd like to see a computer rewire itself after its hard drive failed!

Computers and brains both have the ability to monitor their surroundings and respond with behavior to manipulate their environment. Sensors attached to computers can sample temperature, humidity, and light levels. Computers can be programmed to control heaters, lights, and other equipment in response to the information they receive. Your bran is also connected to sensors or receptors in your eyes, ears, nose, mouth, and skin. Your nervous system may respond to sensory information automatically, or it may cause you to alter your behavior. For example, if a room is too cold, your brain might send signals to muscles to get

那里接收成千上万个信号。只有总信息量超过一定程度时，才会产生一个强烈的信号（动作电位），信号继续传导下去。

形式和功能

尽管计算机和人脑的信息传导方式不同，二者所实现的功能却有很多相似之处。比如，计算机和人脑都可以存储记忆——前者用芯片、磁盘和只读光盘，后者则使用遍布的神经元电路。经过调整，计算机和人脑都可以胜任新工作。电脑可以安装新的软件和硬件以增加内存或是增添新程序。人脑经过持续的调整之后，可以学会新的东西。必要时，人脑还能“重铺线路”。例如，人脑某些部位受伤后，原来由这些部位负责的功能可以转而由其他未受伤的组织来完成。真希望计算机也有这种“重铺线路”的功能，硬驱坏了可以由其他部件来实现其功能。

计算机和人脑都能够监视周围的环境，并据此作出反应来制约它们的环境。连接到计算机上的传感器可以就温度、湿度、光亮度等取样。设有相关程序的计算机可以根据这些信息控制暖气、灯光等其他设备。人脑也与眼、耳、鼻、嘴、皮肤等传感器或称接收器相连。神经系统可以自动对感官信息作出反应，或引导你调整你的行为。假如房间太冷，大脑就会给肌肉发送信号，挪到一个暖和一点的地方，或是穿上一件毛衣。

计算机的坚硬外壳可以保护内部的精细部件。头骨的作用与此相似，

you to move to a warmer place or to put on a sweater.

The delicate contents inside your computer are protected by a hard cover. Your skull provides a similar function for your brain. The external and internal components of computers and brains are all susceptible to damage. If you drop your computer, infect it with a virus, or leave it on during a huge power surge, your precious machine will likely be on its way to the repair shop. When damaged parts are replaced or the virus-caused damage is removed, your computer should be as good as new. Unfortunately, brains are not as easy to repair. They are fragile and there are no replacement parts to fix damaged brain tissue. However, hope is on the horizon for people with brain damage and neurological disorders, as scientists investigate ways to transplant nerve cells and repair injured brains.

THE BIG DIFFERENCE

No doubt the biggest difference between a computer and your brain is consciousness. Although it may be difficult for you to describe consciousness, you know you are here. Computers do not have such awareness. Although computers can perform extraordinary computational feats at astounding speeds, they do not experience the emotions, dreams, and thoughts that are an essential part of what makes us human. At least not yet! Current research in artificial intelligence is moving toward developing emotional capabilities in computers and robots.

During the month of March, people around the world will be celebrating Brain Awareness Week (BAW). During BAW, students, teachers, and scientists will be using their brains to share knowledge about the most wonderful, complicated, mysterious structure in the universe. So get your brain in gear and read this BRIAN MATTERS. It's a great way to begin.

保护着人脑。计算机和大脑的内外部件都很容易受损坏。假如计算机掉到了地上、感染了病毒或是受到高压电流冲击，恐怕这珍贵的机器就得抱去修理了。换了新部件或是清除病毒之后，计算机应该会完好如初。可惜人脑没有那么易于修理。人脑很娇贵，损伤的脑组织无法替换。然而，现在科学家们正在探索移植神经细胞、修复受损脑组织的办法，这将为脑损伤病人和神经组织紊乱的病人带来希望。

巨大的差异

计算机和人脑之间最大的区别无疑是意识。你可能很难描述什么是意识，但是你知道你在这里。计算机不可能有这样的意识。虽然计算机有惊人的计算速度供其展示非同寻常的计算本领，但它们不可能有情感、梦幻、思想等只有人类才有的经历。至少现在还不能！人工智能目前的研究方向就是让计算机和机器人具有各种情感。

在三月份，全世界的人们都会庆祝“脑力意识周（BAW）”。届时学生、教师、科学家都会用他们的大脑来分享这宇宙间最奇妙、最复杂、最神秘的结构的有关知识。所以，准备好你的大脑，读读这本《不可忽视的脑力》，这是一个很不错的开始。

To learn more about Brain Awareness Week, see:

http://www.sfn.org/BAW/index.html
(Society for Neuroscience BAW Web site)
http://www.dana.org/brainweek/
(Dana Alliance for Brain Initiatives BAW Web site)
http://faculty.washington.edu/chudler/baw2001.html
(University of Washington BAW Web site)

Mary, Mary, Quite Contrary,

by Jeanne Miller

This child's dendrites are reaching out for sensory information just as her small fingers are.

© by Photo Disc

Dendrites are to nerve cells what fingers are to hands. Extending from the palm, fingers receive sensory information from the objects with which they come in contact. In the case of dendrites, those objects are other nerve cells, but, unlike with fingers, touching isn't necessary. Messages pass from the axon of one nerve cell to the dendrite of another, across a narrow gap called a "synaptic cleft."

Professor Marian Diamond, a neuroanatomist at the University of California at Berkeley, pictures the nerve cell, or "neuron", as a miniature tree, with the trunk splitting into branches that divide again and again until the process finishes in small leafy twigs. Along a neuron's "twigs" are synapses, across which a message from another neuron can pass. The more branches, the more synapses; the more synapses, the more information the brain can receive.

树突与神经细胞的关系，就像手指与手的关系。手指是手掌的延伸，它们可以从触摸到的物体上接收感官信息。对树突来说，它接收的就是来自其他神经细胞的信息；但与手指不同，树突不需要触摸。信息从一个神经细胞的轴突，穿过一个叫作“突触”的狭窄间隙，传给另一个神经细胞的树突。

玛丽安·戴蒙德教授是加利福尼亚大学伯克利分校的神经解剖学家。她把神经细胞即“神经元”看做是一颗微型的树，树干分叉成树枝，树枝又继续分叉，最末是带叶的细小枝桠。细胞元的“枝桠”就是突触，信息在神经元之间传递必须通过突触。分叉越多，突触越多；突触越多，大脑能接收的信息就越多。

玛丽，玛丽，坏脾气的玛丽，你的树突

How Do Your Dendrites Grow?

RATS AS MODELS

How does a neuron get more branches? Before the 1960s, science taught us that, except as a result of injury, the brain could not change its structure. "At about that time," says Diamond, "Donald Hebb, at McGill University, was observing his children's rats. He thought that they should be able to run mazes better than laboratory rats who just sat in cages. It made sense, but nobody had ever quantified it. He tested them and, sure enough, the rats that were allowed to run around in a big house with lots of friends and lots of toys solved mazes better than those poor little rats in solitary confinement."

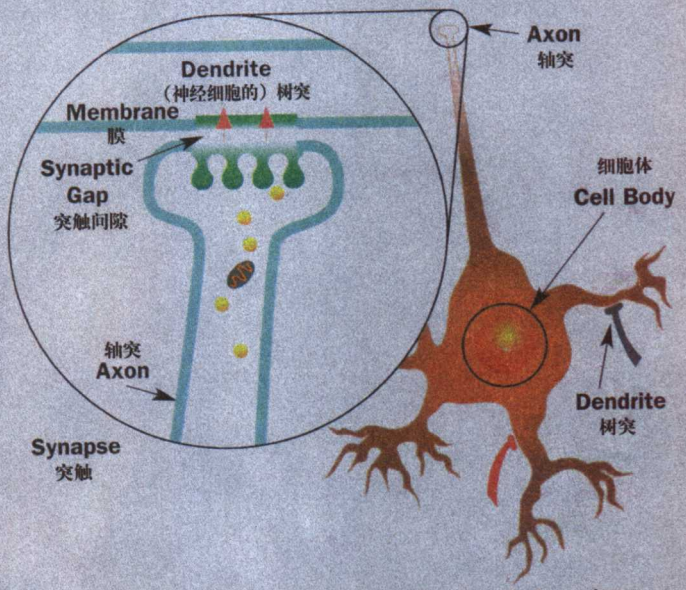
A group of researchers in Berkeley was determined to see what was going on in the brains of those rats. "They designed experimental conditions, with an 'enriched' environment – twelve rats in a large cage with toys – and an 'impoverished' environment – one rat in a small cage with no toys. The control group was housed three to a cage, the way they're normally housed in a lab."

Later, Diamond examined the brain tissue of these rats under a microscope. "We found that the cortex had increased its dimensions with enrichment and decreased them with impoverishment," she says. Further examination showed

以鼠为模型

细胞元怎样产生更多的分叉？一直到 20 世纪 60 年代，科学的说法都是：除非受伤，人脑的结构是不可能改变的。“大约那时候，麦吉尔大学的唐纳德·海勃开始观察他孩子们的老鼠，”戴德蒙教授说，“他认为如果让老鼠走迷宫，孩子们的老鼠应该比实验室关在笼子里的老鼠更容易走出迷宫。这个想法很合理，但没有人统计对比过。他做了试验，结果正如所料：在大房子里跑来跑去，有很多同伴、很多玩具的老鼠和那些被隔绝、活动空间很小的可怜的老鼠相比，前者更易走出迷宫。”

伯克利分校的一群研究人员决心研究那些老鼠的大脑在此过程中的经历。“他们设计了两种试验环境：一种‘强化’环境——12 只老鼠一个大笼子，里面有很多玩具；一种‘弱化’环境——每只老鼠一个小笼子，没有玩具。控制组的老鼠按实验室常规方法饲养，



A neuron has an *axon*, a wirelike projection that carries messages away from the cell body, and *dendrites*, branching structures that receive messages from other neurons. The place where the transmitting axon of one neuron meets the receiving dendrite of another neuron is called a *synapse*.

是怎样生长的？

that dendrites in some parts of the cerebral cortex had developed more branches, and thus those parts of the brain had grown.

Professor William Greenough, a neurobiologist now at the University of Illinois at Urbana-Champaign, carried out similar experiments and found that the rats in the stimulating environment had about 20 to 25 percent more dendrites on the average nerve cell than those rats housed separately. Does that mean those rats were smarter? They learned mazes more easily than the solitary rats, one sign of intelligence. Greenough says, "If you grow up with lots of information processed, lots of opportunities for learning, you have a brain that is more complex, that has more wiring, more connections between nerve cells."

Both groups did follow-up work showing that the brain's ability to change its structure in response to experience continues throughout life. Later studies by

三只一个笼子。”

之后，戴蒙德用显微镜观察了这些老鼠的脑部组织。她说：“我们发现强化环境中的老鼠，脑部皮质增加了，而弱化环境中的老鼠，脑部皮质减少了。”进一步的观察表明，是大脑皮质某些部位的树突分叉的增加导致了这些部位脑皮质的增长。

威廉·格林诺教授是一位神经生物学家，现在伊利诺斯大学香槟校区任教。他进行了类似的试验，发现刺激丰富的环境中的老鼠比分开饲养的老鼠每个神经元平均多20～25个树突。这是否意味着树突多的老鼠更聪明？这些老鼠比分开饲养的老鼠更容易学会走迷宫，这是智力的一种标志。格林诺教授说：“如果在成长过程中处理了大量信息、有大量学习的机会，那么你的大脑就会比其他人复杂一些，神经细胞之间的连接也更多一些。”

两组研究人员都作了跟踪研究，表明大脑根据经历改变结构的能力可以持续到生命的结束。后来的研究表明这些研究结

others showed that these findings translated well to human brains.

MENTAL. . .
AND PHYSICAL 'ENRICHMENT'

So the question is: What kinds of experiences must we offer our brain to increase its ability to learn? "Both mental and physical activity seem to be important – both affect the brain," says Greenough. The Urbana-Champaign group designed an experiment to study this idea. In one cage, they created an obstacle course that offered learning with little exercise. In other cages, they provided wheels and treadmills that offered exercise with little learning. The control group merely sat in cages, with no opportunities for learning or exercise.

As expected, the animals that learned new skills increased the number of synapses. Additionally, the animals that merely exercised and didn't learn anything didn't increase the number of synapses. However, they did add capillaries to their brains. Additional capillaries means increased blood flow.

"So you can see," Greenough continues, "that there are important and complementary effects of learning and of exercise upon the brain, with learning affecting, more or less, the connections between the cells and the brain's wiring diagram, and exercise affecting, among other things, the blood supply to the brain. You need both."

Active participation rather than passive observation is important for dendrite growth. "If you have rats watching other rats in enrichment, the watchers' brains aren't changing," Diamond says. Interacting with the environment is the key.

Interaction with a new object causes dendrite growth, but once the novelty wears off, growth subsides. In the cages intended for learning, toys are changed and rearranged daily. There are toys for

果对人类同样适用。

补充心理和身体“营养”

所以问题是：我们给人脑提供何种经历来提高它的学习能力？“心理和生理活动看来都很重要——两者都影响到大脑，”格林诺说。香槟校区研究组设计了一个试验来研究这个观点。他们给一个笼子的老鼠设计了一个障碍课程，主要进行学习，没什么体力锻炼。另外的笼子里放了车轮和踏车，可以提供体力锻炼但没什么学习活动。控制组只能在他们的笼子里呆着，没有任何学习或锻炼的机会。

不出所料，学习新技能的老鼠的突触数量增加了。只进行体力锻炼但没有学习的老鼠的突触数量没有增多，但是他们脑部的毛细血管增多了，这意味着他们脑部的血液供给增加了。

“所以你看，”格林诺接着说，“学习和锻炼对脑部的作用都很重要，是互补的。学习或多或少会影响细胞之间的联系和脑部整体的神经网络。锻炼也有很多作用，很重要的就是会影响到脑部供血。两者我们都需要。”

积极的参与对树突的生长很重要，被动的观察没有用处。戴蒙德说：“如果有些老鼠在看另外一些老鼠学习或锻炼，这些旁观者的脑部没有什么变化。”关键是和环境的互动。

认识学习新事物能导致树突增长，但是一旦活动变得熟悉，树突将慢慢停止增长。学习组笼子里的玩具每天都换新的，重新摆放。这些玩具可以刺激多种感觉：有铃铛、跑梯、有气味的东西等。格林诺说“这些老鼠每天都面临着一个新奇而有挑战性的环境”。

戴蒙德的研究小组希望确定学习与树突增长是否是一种无限制的正比关系。在

stimulation of many senses: bells, running ladders, things with odors. "Every day," Greenough notes, "the rat faces a novel, challenging environment."

Diamond's group wanted to see if it were possible to carry this too far. In a four-week study, they tried changing the toys every hour for part of the night. There were no significant increases in dendrite growth in the brains of these rats over those whose toys were changed once a day. "The rats didn't have time to assimilate information that was coming in," Diamond says. So switching constantly from one activity to another, without giving our brain any down time, will probably not contribute to increased learning capacity.

Experience matters. It can change the very structure of the brain, the way its cells connect. And it can do so throughout our lifespan. The best thing we can do for our brain is to offer it challenges, social interaction, and active participation in both physical and mental activities.

为期四周的研究中，他们夜里有段时间为部分笼子每小时换一次玩具，但是与每天只换一次玩具的老鼠相比，这些笼子里的老鼠脑部的树突并无明显增长。戴蒙德认为“这些老鼠没有时间吸收新来的信息”。所以频繁地更换活动种类，不给大脑休息的时间，很可能无法提高学习能力。

经历很重要。经历可以改变大脑的结构，改变脑部神经细胞的联接方式。这贯穿于生命的始终。所以，我们能为大脑所做的最好的事情就是为它提供各种挑战和社会交流，积极地参与各种生理和心理活动。

Are You Growing Your Dendrites?

你在培育自己的树突吗?

by Jeanne Miller

How we spend our free time can influence our mental abilities. Picture the brain as a muscle. When you stop using a muscle, it gets smaller and weaker. Use of the brain causes dendrites to grow and branch. Disuse causes the branches to shrivel. In young rats, the shrinkage is obvious after only four days of boredom. On the other hand, after only four days of stimulation, dendritic growth shows up. "'Use it or lose it' is a good rule for your brain," says William Greenough.

Think back to your most recent free day. How did you spend it?

我们怎样度过闲暇时间会影响到我们的脑力。想象人脑是一块肌肉。如果不再使用这块肌肉，肌肉就会萎缩、变弱。使用大脑可以促进树突生长、分叉。不使用脑则会让树突枯萎。小老鼠只要四天没有学新东西，脑部就会有明显萎缩。反之，四天的刺激之后，树突就开始生长了。威廉·格林诺说：“人脑的规律就是‘不用就丢了’。”

回想一下你最近的休息日。你是怎样度过这一天的？

✓Put a checkmark next to each group from which you did one or more of the included activities for an hour or more.

✓在你参加过的、持续一小时及以上的活动类别前打钩。

Physical 体育活动：

- ☐ Team sports (football/rugby, baseball/softball, basketball, soccer, hockey, rowing, volleyball, tennis, handball)
  团队运动（橄榄球，棒球/垒球，篮球，足球，曲棍球，划船，排球，网球，手球）
- ☐ Individual sports and exercise (bicycling, skateboarding, skating, skiing, horseback riding, gymnastics, dancing, track and field, martial arts, aerobics, jogging, walking, running, swimming)
  个人运动及锻炼（骑车、滑板、滑冰、滑雪、骑马、体操、舞蹈、田径、武术、有氧运动、慢跑、散步、跑步、游泳）

Mental 益智活动：

- ☐ Creative activities (drawing, painting, writing music, writing prose and poetry, cooking, doing hobbies, pondering)
  创造性活动（素描、油画、作曲、作诗、写散文、烹调、沉思、做自己爱好的事情）
- ☐ Mental exercise (playing a musical instrument, doing homework, reading, working puzzles, playing board games, building models, using the Internet to research a topic)
  智力练习（演奏乐器、做作业、阅读、填字游戏、棋类游戏、搭模型、在互联网上查资料）

Emotional 情感活动：

- ☐ Social activities (talking with family, talking with friends, participating in clubs)
  社会活动（与家人、朋友聊天，参加俱乐部）
- ☐ Nurturing activities (caring for and playing with pets, babysitting, teaching someone how to do something)
  养育行为（照顾宠物，与宠物玩乐，照看婴儿，教别人怎样做某件事情）

Now, add up the checkmarks and multiply by ten to get your total points. If your day included activities from all three categories – physical, mental, and emotional – give yourself 10 additional points. If your final score is 40 or more, you are being good to your dendrites. If your score is less than 20, you may want to boost your mental and physical activity, as well as diversify your routine. Of course, any scoring method used for an activity such as this one can only generally suggest what might be taking place inside your brain. No one really knows if any one of these activities is better than another at stimulating dendrite growth.

现在，把你的对号加起来乘以10，算出总得分。如果你这天的活动包括这三大类——体育、益智、情感，再多加10分。如果你的最终得分是40分或超过40，你在善待自己的树突。如果得分不足20分，你需要增加益智活动或身体锻炼，丰富自己的日常生活。当然，任何诸如此类的计分方法只能大体上推测大脑中发生的事情。没有人知道这些活动中的哪一些更能够刺激树突的生长。

"REWIRING

Can you teach an old brain new tricks? The answer lies in brain "plasticity" — the brain's adaptive response to change.

BRAIN WIRING 101

Packed inside your brain are 100 to 200 billion neurons (nerve cells), with branched extensions (dendrites). Stimulating a neuron's dendrites sends an electrical signal through the cell body. This signal may cause an impulse that will be carried down a neuron's tail-like axon away from the cell body. The brain's neurons could light a 60-watt bulb, but that's not their job. Instead, the brain controls almost everything your body does.

To do that, neurons form connections, primarily by "synaptic" transmission. Chemical neurotransmitters released at axon ends cross gaps, called *synaptic clefts*. The chemicals stimulate receptors on other neurons at *synapses*.

Each neuron can make up to 10,000 connections. Interestingly, most two-year-olds' brains have twice as

大脑电路入门

人脑中大约有 1000～2000 亿个神经元（神经细胞），其末端有树杈状的树突。受到刺激的神经元的树突，会产生电子信号传遍整个神经细胞。这个信号可能会产生神经脉冲，从胞体一直传到神经元尾巴一样的轴突。脑部神经元能让 60 瓦的灯泡亮起来，但这不是神经元的工作。大脑控制着人体的所有功能。

为此，神经元之间建立了很多连接，主要是通过“突触”传递。轴突末端释放出的化学神经递质穿过神经元之间的缝隙——突触间隙，刺激位于突触另一端其他神经元的受体。

每个神经元大约有10 000个连接。有意思的是，两岁多的孩子神经元之间的连接数量是成人的两倍，