TED演讲者：Aaswath Raman | 奥斯瓦斯拉曼

演讲标题：How we can turn the cold of outer space into a renewable resource | 如何把外太空的低温转变为可再生的资源

内容概要：What if we could use the cold darkness of outer space to cool buildings on earth? In this mind-blowing talk, physicist Aaswath Raman details the technology he's developing to harness "night-sky cooling" -- a natural phenomenon where infrared light escapes earth and heads to space, carrying heat along with it -- which could dramatically reduce the energy used by our cooling systems (and the pollution they cause). Learn more about how this approach could lead us towards a future where we intelligently tap into the energy of the universe.
如果我们能用外太空的寒冷黑暗来冷却地球上的建筑物，那会如何？在这场惊奇的演说中，物理学家奥斯瓦斯拉曼 (Aaswath Raman) 详细说明了他正在开发的技术，这项技术驾驭「夜空冷却」这种自然的现象，让红外线把热带离地球，送上太空前去，大大减少我们的冷却系统所需要的能源。来进一步了解这种方式如何能引领我们在未来能够智慧地发掘宇宙的能量。

www.XiYuSoft.com	锡育软件
Every summer when I was growing up, I would fly from my home in Canada to visit my **grandparents**, who lived in Mumbai, India.	在我成長過程中,每年夏天, 我會從我在加拿大的家, 搭飛機去看我的祖父母, 他們住在印度孟買。[00:13]
Now, Canadian summers are pretty mild **at best** -- about 22 degrees **Celsius** or 72 degrees **Fahrenheit** is a typical summer's day, and not too hot.	現在加拿大的夏天很暖和, 最高大約攝氏 22 度或華氏 72 度, 這是典型的夏日,不算太熱。[00:20]
Mumbai, **on the other hand**, is a hot and **humid** place well into the 30s Celsius or 90s Fahrenheit.	另一方面,孟買 是個又熱又濕的地方, 會超過攝氏 30 度或華氏 90 度。[00:31]
As soon as I'd reach it, I'd ask, "How could anyone live, work or sleep in such weather?"	一抵達孟買,我就會問: 「怎麼可能有人在這種天氣生活、工作,或睡覺？」[00:38]
To make things worse, my grandparents didn't have an air **conditioner**.	更糟的是,我的祖父母沒有冷氣。[00:45]
And while I tried my very, very best, I was never able to persuade them to get one.	我已經盡了我最大的努力, 但我始終無法 說服他們裝一台冷氣。[00:49]
But this is changing, and fast.	但這狀況在改變,且改變得很快。[00:56]
Cooling systems today **collectively account for** 17 percent of the electricity we use worldwide.	現今的冷卻系統所用的電量加總起來 佔全世界用電量的 17%。[00:59]

grandparents: n.祖父母(grandparent的复数);外祖父母 **at best:** 最多 **Celsius:** adj.摄氏的/n.摄氏度 **Fahrenheit:** adj.华氏的;华氏温度计的/n.华氏温度计;华氏温标 **on the other hand:** 另一方面 **humid:** adj.潮湿的;湿润的;多湿气的 **conditioner:** n.调节器;调节剂;调料槽 **collectively:** adv.共同地,全体地 **account for:** 对...负有责任;对...做出解释;说明.....的原因;导致;(比例)占

This includes everything from the air **conditioners** I so desperately wanted during my summer **vacations**, to the **refrigeration** systems that keep our food safe and cold for us in our supermarkets, to the industrial scale systems that keep our data centers operational.	包括從我暑假 超想要的冷氣, 到超級市場中確保我們的食物安全 且存放於低溫的冷藏系統, 到確保我們資料儲存中心 能順利運作的工業規模冷卻系統。[01:06]
Collectively, these systems account for eight percent of global greenhouse gas emissions.	這些系統所排放的溫室氣體加起來 佔全球總排放的 8%。[01:21]
But what keeps me up at night is that our energy use for cooling might grow **sixfold** by the year 2050, primarily driven by increasing usage in Asian and African countries.	但,讓我睡不著覺的, 是我們用在冷卻上的能量, 到 2050 年時可能會增為六倍, 主要的原因是亞洲 和非洲國家的用量增加。[01:27]
I've seen this **firsthand**.	我親眼見過。[01:39]
Nearly every apartment in and around my grandmother's place now has an air conditioner.	幾乎我祖母家附近的每一間公寓, 現在都有冷氣了。[01:40]
And that is, **emphatically**, a good thing for the health, **well-being** and productivity of people living in warmer **climates**.	那很明顯是件好事, 就溫暖氣候地區居民的健康、幸福,以及生產力而言。[01:46]

conditioners: [自]调节器/调料槽/调节剂(conditioner的复数) **vacations:** 假期/[法]休庭期 **refrigeration:** n.制冷;冷藏;[热]冷却 **sixfold:** adj.六倍的;六重的,有六部分的 **firsthand:** adj.直接的;直接采购的;直接得来的/adv.直接地 **emphatically:** adv.着重地;强调地;断然地 **well-being:** n.幸福;康乐 **climates:** n.[气候]气候,气氛;风气(climate复数形式)

However, one of the most **alarming** things about climate change is that the warmer our planet gets, the more we're going to need cooling systems -- systems that are themselves large **emitters** of greenhouse gas emissions.	然而關於氣候變遷最大的警訊之一, 就是當地球變得更暖和, 我們就會更需要冷卻系統, 這些系統本身就是 溫室氣體排放的來源。[01:55]
This then has the potential to cause a feedback loop, where cooling systems alone could become one of our biggest sources of greenhouse gases later this century.	這就有可能會形成一個惡性循環, 光是冷卻系統 就能在這個世紀後期變成最大的 溫室氣體來源。[02:09]
In the worst case, we might need more than 10 **trillion**	在最糟的狀況中, 到 2100 年時, 光為了冷卻,我們

kilowatt-hours of electricity every year, just for cooling, by the year 2100.	可能每年 就會需要超過 十兆千瓦小時的電力。[02:18]
That's half our electricity supply today.	那是現今我們電力總供應量的一半。[02:26]
Just for cooling.	光為了冷卻。[02:30]
But this also point us to an amazing opportunity.	但這也為我們點出了 一個很棒的機會。[02:32]
A 10 or 20 percent improvement in the efficiency of every cooling system could actually have an **enormous** impact on our greenhouse gas emissions, both today and later this century.	如果每一種冷卻系統在效能上 都能有 10%~20% 的改善, 就會對溫室氣體的排放 有非常大的影響, 對於現今以及本世紀後期都是如此。[02:37]
And it could help us **avert** that **worst-case** feedback loop.	且它能協助我們避免發生 最糟狀況的惡性循環。[02:49]
alarming: adj.令人担忧的;使人惊恐的/v.使惊恐(alarm的ing形式) **emitters:** n.发射器;排放者;发射源;[物]发射体(emitter的复数) **trillion:** n.[数]万亿/adj.万亿的/num.[数]万亿 **kilowatt-hours:** n.千瓦时;一度电(能量单位) **enormous:** adj.庞大的,巨大的；凶暴的，极恶的 **avert:** vt.避免，防止；转移 **worst-case:** adj.作最坏打算的;最糟情况的	
I'm a scientist who thinks a lot about light and heat.	我是一位常常在思考 光和熱的科學家。[02:54]
In particular, how new materials allow us to alter the flow of these basic elements of nature in ways we might have once thought impossible.	我特別著重研究新材料 如何能協助我們改變 大自然這些基本元素的流動方式, 用我們以前認為 不可能的方式來做到。[02:58]
So, while I always understood the value of cooling during my summer vacations, I actually wound up working on this problem because of an intellectual puzzle that I came across about six years ago.	所以,我一直都懂 暑假降溫的重要性, 由於六年前 我遇到的智力難題, 我實際上已經完成了 解決這個問題的工作。[03:07]
How were ancient peoples able to make ice in desert climates?	古人怎麼能在沙漠氣候下製冰? [03:18]
This is a picture of an ice house, also called a Yakhchal, located in the **southwest** of Iran.	這張照片中的是一間冰室, 也叫做「Yakhchal」, 位在伊朗西南部。[03:25]
There are **ruins** of dozens of such structures throughout Iran, with evidence of similar such buildings throughout the rest of the Middle East and all the way to China.	在伊朗各地,有數十個 這類建築物的遺跡, 有證據顯示,這類建築物 還遍及了中東其它地區, 一路延伸到中國。[03:32]
The people who operated this ice house many centuries ago, would pour water in the pool you see on the left in the early evening hours, as the sun set.	幾百年前使用這些冰室的人 會把水倒入照片左側的池子中, 時機是太陽下山, 剛剛進入傍晚的時候。[03:42]
And then something amazing happened.	接著,神奇的事就會發生。[03:50]
In particular: 尤其,特别 **southwest:** n.西南方/adj.西南的/adv.往西南;来自西南 **ruins:** n.遗迹(ruin的复数形式);废墟/v.毁灭(ruin的三单形式)	
Even though the air temperature might be above freezing, say five degrees Celsius or 41 degrees Fahrenheit, the water would freeze.	雖然空氣中的溫度還在冰點以上, 比如攝氏 5 度,或華氏 41 度, 水卻會結冰。[03:53]
The ice generated would then be collected in the early morning hours and stored for use in the building you see on the right, all the way through the summer months.	一大清早,產出的冰 就會被收集起來, 儲存放在右邊的建築物裡備用, 夏季的所有月份就是這樣渡過。[04:02]
You've actually likely seen something very similar at play if you've ever noticed frost form on the ground on a clear night, even when the air temperature is well above freezing.	你們其實有可能見過 類似的現象發生, 如果你有注意過,在晴天晚上, 即使空氣溫度在冰點以上, 地面也會形成霜,就是類似的現象。[04:11]
But wait.	但,等等。[04:20]
How did the water freeze if the air temperature is above freezing?	如果空氣溫度沒有低於冰點, 為什麼水會結冰? [04:22]
Evaporation could have played an effect, but that's not enough to actually cause the water to become ice.	蒸發的效應就很重要了, 但光是這點還不夠讓水變成冰。[04:26]
Something else must have cooled it down.	還要有其他東西來將水冷卻。[04:31]
Think about a pie cooling on a window **sill**.	想像一個派,在窗臺上冷卻。[04:34]
For it to be able to **cool down**, its heat needs to flow somewhere cooler.	若要讓它冷下來, 就要讓熱流到比較冷的地方。[04:37]
Namely, the air that **surrounds** it.	也就是,流到它周圍的空氣中。[04:41]
Evaporation: n.蒸发;消失 **sill:** n.窗台;基石;门槛;[海洋]海底山脊 **cool down:** 冷却;平静下来 **surrounds:** n.挡板;环绕物(surround的复数)/v.围绕;包围(surround的三单形式)	
As **implausible** as it may sound, for that pool of water, its heat is actually **flowing** to the cold of space.	雖然這聽起來很不合情理, 一池水的熱怎麼可能 流到低溫的外太空中。[04:44]
How is this possible?	這怎麼有可能發生? [04:53]
Well, that pool of water, like most natural materials, sends out its heat as light.	嗯,那池水和大部分的 自然材料一樣, 以光的方式將熱發送出去。[04:56]
This is a concept known as **thermal** radiation.	這概念就是大家所知的「熱輻射」。[05:02]
In fact, we're all sending out our heat as **infrared** light right	事實上,我們現在都在 用紅外線光的方式把我們的

now, to each other and our **surroundings**.	熱 發送給彼此和周遭的環境。[05:05]
We can actually **visualize** this with thermal cameras and the images they produce, like the ones I'm showing you right now.	使用熱感攝影機 就能將這現象視覺化, 它們所產出的影像, 就會類似各位現在看到的這一張。[05:12]
So that pool of water is sending out its heat **upward** towards the atmosphere.	所以,這一池水把它的熱 向上發送到大氣中。[05:18]
The atmosphere and the **molecules** in it absorb some of that heat and send it back.	大氣以及大氣中的分子 會吸收其中一些熱,再發送回來。[05:23]
That's actually the greenhouse effect that's responsible for climate change.	那其實就是造成 氣候變遷的溫室效應。[05:27]

implausible: adj.难以置信的,不像真实的 **flowing:** adj.流动的;平滑的;上涨的/v.流动;起源;上涨(flow的ing形式) **thermal:** adj.热的;热量的;保热的/n.上升的热气流 **infrared:** n.红外线/adj.红外线的 **surroundings:** n.环境;周围的事物 **visualize:** vt.形象,形象化;想像,设想/vi.显现 **upward:** adj.向上的;上升的/adv.向上 **molecules:** n.[化学]分子,微粒;[化学]摩尔(molecule的复数)

www.XiYuSoft.com	**锡育软件**
But here's the **critical** thing to understand.	但在這裡要了解一個關鍵。[05:32]
Our atmosphere doesn't absorb all of that heat.	我們的大氣並不會吸收所有的熱。[05:34]
If it did, we'd be on a much warmer planet.	如果會的話,地球就會更暖和許多。[05:38]
At certain **wavelengths**, in particular between eight and 13 **microns**, our atmosphere has what's known as a transmission window.	在某些波長, 特別是在 8~13 微米之間, 我們的大氣有個所謂的傳送窗口。[05:41]
This window allows some of the heat that goes up as infrared light to effectively escape, carrying away that pool's heat.	這扇窗會讓其中一些 以紅外線方式向上發送的熱有效地發散傳送,將池水的熱給帶走。[05:51]
And it can escape to a place that is much, much colder.	這些熱會發散到一個更冷的地方 :[06:00]
The cold of this upper atmosphere and all the way out to outer space, which can be as cold as minus 270 degrees Celsius, or minus 454 degrees Fahrenheit.	大氣上層的低溫當中, 以及一路到外太空中, 外太空的溫度可以 低到攝氏 -270 度, 或華氏 -454 度。[06:05]
So that pool of water is able to **send out** more heat to the sky than the sky sends back to it.	所以那池水發送到天空中的熱 就多於天空發送回來的熱。[06:17]
And because of that, the pool will cool down below its surroundings' temperature.	基於這個理由, 那池水會冷卻到比環境更低的溫度。[06:22]
This is an effect known as night-sky cooling or radiative cooling.	那就是一般所知的夜空冷卻, 或稱輻射冷卻。[06:27]

critical: adj.鉴定的；[核]临界的；批评的，爱挑剔的；危险的；决定性的；评论的 **wavelengths:** n.[物]波长(wavelength的复数) **microns:** n.微米(micron的复数) **send out:** 发送;派遣;放出

And it's always been understood by climate scientists and **meteorologists** as a very important natural phenomenon.	氣候科學家和氣象學家一直都知道 這是個非常重要的自然現象。[06:33]
When I came across all of this, it was towards the end of my PhD at Stanford.	當我接觸到這些資訊時, 我已經快要拿到 史丹佛的博士學位了。[06:40]
And I was **amazed** by its apparent simplicity as a cooling method, yet really **puzzled**.	這種冷卻方法表面是如此簡單, 背後卻又是個複雜的謎, 這讓我感到困惑。[06:44]
Why aren't we making use of this?	我們為什麼不好好利用它? [06:51]
Now, scientists and engineers had **investigated** this idea in previous decades.	在過去數十年,科學家和工程師 都在研究這個機制。[06:54]
But there turned out to be at least one big problem.	但結果發現,至少有一個大問題。[06:58]
It was called night-sky cooling for a reason.	它被稱為夜空冷卻,是有原因的。[07:02]
Why?	為什麼? [07:05]
Well, it's a little thing called the sun.	因為有個小東西,叫做太陽。[07:07]
So, for the surface that's doing the cooling, it needs to be able to face the sky.	要進行冷卻的表面, 必需要能夠面向天空。[07:09]
And during the middle of the day, when we might want something cold the most, unfortunately, that means you're going to **look up to** the sun.	在日正當中時, 我們最希望的就是能冷到最低點, 很不幸的,在那時候 你得要向上看向太陽。[07:14]

meteorologists: n.气象学家(meteorologist的复数) **amazed:** adj.惊奇的,吃惊的/v.使...吃惊;把...弄糊涂(amaze的过去分词) **puzzled:** adj.困惑的;茫然的;搞糊涂的 **investigated:** v.研究(investigate的过去分词);调查/adj.研究的;调查的 **look up to:** 尊敬

And the sun heats most materials up enough to completely **counteract** this cooling effect.	而太陽會把大部分的物質加熱, 熱到足以完全抵消掉這種冷卻效應。[07:22]
My colleagues and I spend a lot of our time thinking about how we can structure materials at very small length **scales** such that they can do new and useful things with light -- length **scales** smaller than the wavelength of light itself.	同事和我花了很多時間思考 要如何建構出波長極短的材料, 讓它們能與光反應 產生新的、有用的東西—— 波長要小於光本身的波長。[07:28]

Using **insights** from this field, known as nanophotonics or **metamaterials** research, we realized that there might be a way to make this possible during the day for the first time.	使用這個領域的洞見, 也就是一般所知的 奈米光子或超材料研究, 我們首次發現可能有種辦法 能夠在白天實現這一點,[07:40]
To do this, I designed a multilayer **optical** material shown here in a microscope image.	我為此設計了一種多層的光學材料, 在這張顯微鏡影像中可以看見。[07:49]
It's more than 40 times **thinner** than a typical human hair.	它比一般人髮的 40 分之一還要薄。[07:54]
And it's able to do two things **simultaneously**.	它能夠同時做兩件事。[07:58]
First, it sends its heat out precisely where our atmosphere lets that heat out the best.	首先,它能精準地把熱發送到大氣層 達到最佳的降溫效果。[08:00]
counteract: vt.抵消;中和;阻碍 **scales:** n.天平;磅秤;鳞屑;缩放 **insights:** n.洞察力;眼力;深刻见解(insight的复数) **metamaterials:** 超材料(metamaterial的复数) **optical:** adj.光学的；眼睛的，视觉的 **thinner:** adj.较薄的;较瘦的;较细的(thin的比较级)/n.(油漆的)稀释剂;冲淡剂;使变稀薄者,加稀料的制漆工 **simultaneously:** adv.同时地	
We targeted the window to space.	我們對準了通往太空的窗戶。[08:06]
The second thing it does is it **avoids** getting heated up by the sun.	第二是它能避免被太陽加溫。[08:09]
It's a very good mirror to sunlight.	它是面很好的太陽光反射鏡。[08:12]
The first time I tested this was on a **rooftop** in Stanford that I'm showing you right here.	我第一次測試它時, 是在史丹佛的屋頂上, 各位在照片上可以看見。[08:16]
I left the device out for a little while, and I walked up to it after a few minutes, and within seconds, I knew it was working.	我把這個裝置留在那裡一陣子, 幾分鐘之後,我走向它, 在幾秒鐘之內,我就知道它有用。[08:21]
How?	如何知道的? [08:29]
I touched it, and it felt cold.	我摸了它,摸起來是冷的。[08:30]
(Applause) Just to emphasize how weird and **counterintuitive** this is: this material and others like it will get colder when we take them out of the shade, even though the sun is shining on it.	（掌聲） 再強調一下這個現象 有多怪異且和直覺不符: 這種材料及其它相似的材料 如果離開陰影反而會變得更冷, 即使是被陽光直射著。[08:33]
I'm showing you data here from our very first experiment, where that material stayed more than five degrees Celsius, or nine degrees Fahrenheit, colder than the air temperature, even though the sun was shining directly on it.	各位現在看到的 是我們第一次實驗的資料, 當時那材料的溫度比空氣的溫度 低攝氏 5 度或華氏 9 度, 即使太陽光直射在它上面。[08:49]
The **manufacturing** method we used to actually make this material already exists **at large** volume scales.	實際量產這種材料的方法已然存在。[09:02]
avoids: v.避免(avoid的三单形式);避开 **rooftop:** n.屋顶/adj.屋顶上的 **counterintuitive:** adj.违反直觉的 **manufacturing:** adj.制造的;制造业的/n.制造业;工业/v.制造;生产(manufacture的ing形式) **at large:** 详尽的;未被捕的,整个的	
So I was really excited, because not only do we make something cool, but we might actually have the opportunity to do something real and make it useful.	我非常興奮, 因為我們不只是 發明出了很酷的東西, 我們可能真的有機會 做出很有用的東西來。[09:08]
That brings me to the next big question.	那就帶出了下一個大問題。[09:19]
How do you actually save energy with this idea?	要如何用這個點子,來節省能源? [09:20]
Well, we believe the most direct way to save energy with this technology is as an efficiency boost for today's **air-conditioning** and refrigeration systems.	我們相信,若要用這項技術 來節省能源,最直接的方式 就是對現今的冷氣 和冰箱系統進行效能的提升。[09:23]
To do this, we've built **fluid** cooling **panels**, like the ones shown right here.	為此,我們打造了液態的冷卻板, 就像畫面上的這種。[09:32]
These panels have a similar shape to solar water **heaters**, except they do the opposite -- they cool the water, **passively**, using our **specialized** material.	它們的外型和太陽能熱水器很相似, 差別在於功能相反, 它們能用我們的特殊材料 被動地讓水冷卻。[09:36]
These panels can then be **integrated** with a component almost every cooling system has, called a **condenser**, to improve the system's **underlying** efficiency.	這些冷卻板可以和一個元件整合, 幾乎所有冷卻系統 都有這個元件:冷凝器, 目的是要改善系統的根本效率。[09:44]
air-conditioning: n.空调系统；空气调节 **fluid:** adj.流动的;流畅的;不固定的/n.流体;液体 **panels:** n.面板(panel的复数);[建]嵌板;事务委员会/v.嵌镶(panel的第三人称单数形式) **heaters:** n.[建]加热器;取暖器(heater的复数形式) **passively:** adv.被动地;顺从地 **specialized:** adj.专业的;专门的/v.专攻(specialize的过去分词);使...专门化;详细说明 **integrated:** adj.综合的;完整的;互相协调的/v.整合;使...成整体(integrate的过去分词) **condenser:** n.冷凝器;[电]电容器;[光]聚光器 **underlying:** adj.潜在的；根本的；在下面的；优先的/v.放在...的下面；为...的基础；优先于(underlie的ing形式)	
Our **start-up**, SkyCool Systems, has recently completed a field trial in Davis, California, shown right here.	我們的新創公司叫 SkyCool Systems, 目前已經在加州戴維斯 完成了實地測試,如照片所示。[09:53]
In that demonstration, we showed that we could actually improve the efficiency of that cooling system as much as 12 percent in the field.	在那次展示中, 我們展現了我們在實做上真的能夠改善冷卻系統的效率達 12%。[09:59]
Over the next year or two, I'm super excited to see this go to	在接下來的一、兩年, 我很興奮地期待能看到 商業

its first commercial-scale pilots in both the air conditioning and refrigeration space.	規模的測試開始進行, 用在包括冷氣以及冰箱上。[10:07]
In the future, we might be able to integrate these kinds of panels with higher efficiency building cooling systems to reduce their energy usage by **two-thirds**.	在未來,我們可能可以 把這些冷卻板整合到 更高效能的建築冷卻系統中, 將這些系統所需要使用的 能源減少三分之二。[10:16]
And eventually, we might actually be able to build a cooling system that requires no electricity input at all.	最終,我們可能可以打造一個完全 不需要電力輸入的冷卻系統。[10:25]
As a first step towards that, my colleagues at Stanford and I have shown that you could actually maintain something more than 42 degrees Celsius below the air temperature with better engineering.	要做到這點,第一步, 我和史丹佛的同事 已經讓大家看到,確實可以 將物體維持在比空氣溫度 低攝氏 42 度的狀態, 用更好的工程方式就能做到。[10:32]
Thank you.	謝謝。[10:44]
(Applause) So just imagine that -- something that is below freezing on a hot summer's day.	（掌聲） 想像一下, 在炎熱的夏日,有低於冰點的東西。[10:46]
start-up: n.启动/adj.起动阶段的;开始阶段的(异体字startup) **two-thirds:** n.三分之二/三分之二的/三分之二地	
So, while I'm very excited about all we can do for cooling, and I think there's a lot yet to be done, as a scientist, I'm also drawn to a more profound opportunity that I believe this work **highlights**.	所以,雖然我對於我們 能為冷卻做出的貢獻感到很興奮, 但我認為還有很多還沒完成的, 身為科學家, 我也被 這項發明所強調出來的 深刻機會給深深吸引著。[10:57]
We can use the cold darkness of space to improve the efficiency of every energy-related process here on earth.	我們可以利用太空的寒冷黑暗 來改善地球上 每一項與能源有關過程的效能。[11:11]
One such process I'd like to highlight are solar cells.	我想要特別提出來的 其中一種過程,就是太陽能板。[11:21]
They **heat up under the sun** and become less efficient the hotter they are.	在太陽下,它們會被加溫, 當它們本身越熱,就越沒沒效率。[11:24]
In 2015, we showed that with deliberate kinds of **microstructures** on top of a solar cell, we could take better advantage of this cooling effect to maintain a solar cell passively at a lower temperature.	2015 年,我們展示出在太陽能板上方 刻意加上微結構, 就能夠更善加利用這種冷卻效應, 來被動地將太陽能板保持在較低的溫度。[11:29]
This allows the cell to operate more **efficiently**.	這樣太陽能板就能更有效地運作。[11:41]
We're **probing** these kinds of opportunities further.	我們還在進一步研究這些機會。[11:44]
We're asking whether we can use the cold of space to help us with water **conservation**.	我們在問的問題是, 我們是否能用太空的低溫 來協助我們做水資源保存。[11:47]
highlights: n.拔萃,集锦;挑染(highlight的复数形式)/v.使突出(highlight的三单形式);强调 **heat up:** 加热/变热/升温 **under the sun:** 天下;究竟 **microstructures:** n.微观结构(microstructure的复数);[生物]显微结构 **efficiently:** adv.有效地;效率高地(efficient的副词形式) **probing:** adj.好探索的;深入锐利的/n.探索;探查/v.探索(probe的ing形式) **conservation:** n.保存，保持；保护	
Or perhaps with **off-grid scenarios**.	或許協助我們不再使用電網。[11:53]
Perhaps we could even directly generate power with this cold.	我們甚至可以直接用這低溫來發電。[11:55]
There's a large temperature difference between us here on earth and the cold of space.	我們地球這裡的溫度和太空的低溫 有很大的落差。[12:00]
That difference, at least **conceptually**, could be used to drive something called a heat engine to generate electricity.	那種落差,至少在概念上, 可以被用來驅動所謂的熱引擎, 來產生電力。[12:05]
Could we then make a **nighttime** power-generation device that generates useful amounts of electricity when solar cells don't work?	那麼我們是否能夠做出 一種夜晚的發電裝置, 能夠產生夠用的電力, 在太陽能板不能運作時代勞呢?[12:11]
Could we generate light from darkness?	我們能否用黑暗來產生光? [12:19]
Central to this ability is being able to manage the thermal radiation that's all around us.	這項能力的關鍵,在於要能夠管理 我們周遭的熱輻射。[12:23]
We're constantly **bathed** in infrared light; if we could bend it to our will, we could **profoundly** change the flows of heat and energy that **permeate** around us every single day.	我們經常處在紅外線光之中; 如果我們願意改變這一切, 我們就能深深地改變每天在我們周圍 比比皆是的熱與能量之流動。[12:31]
off-grid: adj.离网的 **scenarios:** n.情节;脚本;情景介绍(scenario的复数) **conceptually:** adv.概念地 **nighttime:** n.夜间/adj.夜间的;夜里发生的 **bathed:** adj.沐浴的;淋漓的,湿透的;沉溺的/v.沐浴(bath的过去分词) **profoundly:** adv.深刻地;深深地;极度地 **permeate:** vt.渗透,透过;弥漫/vi.弥漫;透入;散布	
This ability, **coupled** with the cold darkness of space, points us to a future where we, as a civilization, might be able to more **intelligently** manage our thermal energy **footprint** at the very largest scales.	這種能力,再加上太空的寒冷黑暗, 就能為我們的文明指點未來的方向, 讓我們能更智慧地 管理我們的熱能足跡, 且能做到非常大的規模。[12:43]
As we **confront** climate change, I believe having this ability in our **toolkit** will prove to be essential.	我們正在面臨氣候變遷, 我相信把這能力放入我們的工具箱 非常的重要。[12:57]
So, the next time you're walking around outside, yes, do	所以,下次當你在外面四處走動時, 是的,當我們對

marvel at how the sun is **essential to** life on earth itself, but don't forget that the rest of the sky has something to offer us as well.	太陽 在地球生命的重要性感到驚艷時, 也別忘了天空中的其它部分, 也能為我們提供某些資源。[13:05]
Thank you.	謝謝。[13:20]
(Applause)	（掌聲）[13:21]

coupled: adj.耦合的;联接的;成对的;共轭的(couple的过去分词形式) **intelligently:** adv.聪明地,明智地 **footprint:** n.足迹;脚印 **confront:** vt.面对;遭遇;比较 **toolkit:** n.工具包,工具箱 **marvel:** n.奇迹/vt.对...感到惊异/vi.感到惊讶 **essential to:** 对.....必不可少