Biology 1 Name:

***Photosynthesis In the News -***  Date:

***In Class Reading***  Hour:

After reading your article, you will be placed into a group with other students. You must deliver the information required below about your article to the rest of the group. You are also responsible for the information below related to the other articles.

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Biology 1

***Photosynthesis In the News -***

***ARTICLE ONE***

## Naked Trees Dominated Early Forests

Analysis of 385-million year-old fossils from upstate New York paint picture of Earth's first trees

By [Nikhil Swaminathan](http://www.scientificamerican.com/author.cfm?id=1172)  | Scientific American Magazine April 18, 2007

**LEAFLESS CROWN:** A reconstruction of an ancient tree from one of Earth's first forests reveals that the plants were topped with fronds and not leaves.*Image: FRANK MANNOLINI/NEW YORK STATE MUSEUM*

The crown of a prehistoric tree found in a sandstone quarry in Gilboa, N.Y., has shed light on the look of the world's earliest forests believed to have thrived during the Devonian period between 360 million and 397 million years ago.

The 2004 discovery of this 380-million year-old, six-foot uppermost portion of an ancient tree trunk allowed paleobotanists to create a composite picture of the entire plant when they put it together with fragments of a trunk found a the same site a year later and with tree stumps recovered more than 130 years ago in another rock quarry 10 miles away. The remains have been widely touted as "evidence of the Earth's oldest forest," according to a report published in this week's *Nature*.

"The basic point of this paper is, well, two things," says lead author William Stein, a biologist at the Binghamton University in New York State. "We now have clear evidence what these stumps really were," part of the class Cladoxylopsida believed to be related to modern-day ferns, and we also have "real strong evidence of the morphology of these forms."

From the fossil reconstruction, the team of scientists determined that a tree comprising all these parts could grow about 30 feet tall. According to Stein, the base would have been massive—on the order of 2.5 feet in diameter—with a large, single trunk and longitudinal ridges (probably part of the tree's vascular system), topped by a leafless crown of a material resembling fronds on ferns and palms.

## Timeline of Photosynthesis on Earth

### Supplemental Material

* [**Overview**The Color of Plants on Other Worlds](http://www.scientificamerican.com/article.cfm?id=the-color-of-plants-on-other-worlds)

***Editors note***: This story is part of a Feature "[*The Color of Plants on Other Worlds*](http://dev.sciam.com/article.cfm?id=the-color-of-plants-on-other-worlds)" from the[*April 2008*](http://www.sciam.com/?contents=2008-04)issue ofScientific American.

Photosynthesis evolved early in Earth’s history. The rapidity of its emergence suggests it was no fluke and could arise on other worlds, too. As organisms released gases that changed the very lighting conditions on which they depended, they had to evolve new colors.

**4.6 billion years ago --**Formation of Earth

**3.4 billion years ago --** First photosynthetic bacteria
They absorbed near-infrared rather than visible light and produced sulfur or sulfate compounds rather than oxygen. Their pigments (possibly  bacteriochloro­phylls) were predecessors to chlorophyll.

**2.4–2.3 billion years ago --** First rock evidence of atmospheric oxygen

**2.7 billion years ago --** Cyanobacteria
These ubiquitous bacteria were the first oxygen producers. They absorb visible light using a mix of pigments: phyco­bilins, carotenoids and several forms of chlorophyll.

**1.2 billion years ago --** Red and brown algae
These organisms have more complex cellular structures than bacteria do. Like cyanobacteria, they contain phycobilin pigments as well as various forms of chlorophyll.

**0.75 billion years ago --** Green algae
Green algae do better than red and brown algae in the strong light of shallow [water](http://www.scientificamerican.com/topic.cfm?id=water). They make do without phyco­bilins.

**0.475 billion years ago --** First land [plants](http://www.scientificamerican.com/topic.cfm?id=plants)
Mosses and liverworts descended from green algae. Lacking vascular structure (stems and roots) to pull water from the soil, they are unable to grow tall.

**0.423 billion years ago --**Vascular plants
These are literally garden-variety plants, such as ferns, grasses, trees and cacti. They are able to grow tall canopies to capture more light.

Biology 1

***Photosynthesis In the News -***

***ARTICLE TWO***

## Local Color: Plants under Alien Suns Could Come in a Variety of Hues

Assessing how photosynthesis works on Earth helps scientists predict black plants and other exotic flora on alien worlds

By [David Biello](http://www.scientificamerican.com/author.cfm?id=1013)  | Scientific American Magazine April 11, 2007



**ORANGE GRASS:** Or a real black forest might flourish under the light of stars that produce more of different spectra of light than our sun.*Image: © CALTECH/DOUG CUMMINGS*

[Plants](http://www.scientificamerican.com/topic.cfm?id=plants) do not have to be green. To be sure, the vast majority of vascular plants on Earth are green because during photosynthesis (the conversion of photons of light into stored chemical energy) they absorb more of the red and blue wavelength light emitted by the sun. But in the murky depths of Earth's waters lurk photosynthetic bacteria that appear purple to the human eye, employing light in the infrared spectrum to store energy; more archaic plants—such as lichens and moss—utilize more of the blue spectrum in visible light. There are even red, shade-dwelling vascular plants. "We did a broad survey of organisms that perform photosynthesis in order to understand how light selects for photosynthesis pigments given different types of environments," says biometeorologist Nancy Kiang of NASA's Goddard Institute for Space Studies at Columbia University. "The photon flux spectrum peaks in the red, which is where chlorophyll has peak absorption."

In fact, the photosynthetic organisms of Earth are exquisitely tuned to take full advantage of the specific sunlight that filters down to the surface (and below the sea). By understanding how photosynthesis works on Earth, Kiang and her colleagues aim to predict how it might occur in alien atmospheres, potentially enabling scientists to identify planets that support life with future telescopes. "Photosynthesis is a very widespread, very successful process. It is the dominant form of life," Kiang says. "It is detectable at the global scale and you can see it from really big distances from the planet."

"It's much easier to see the effects of bacteria at a distance of 10 parsecs [1.9 x 1014miles, or 32.6 light-years], than the effects of giraffes," adds Victoria Meadows, lead scientist at the Virtual Planetary Laboratory at the California Institute of Technology, who helped coordinate the effort.

Based on this modeling and analysis, scientists could detect alien photosynthesis simply by measuring the light reflected from suitable alien worlds. So, for example, a cooler, dimmer but far more abundant M-type star emits photons that peak in the infrared range. If scientists detect significant absorption around that particular wavelength on a planet in its orbit, they might reasonably assume that some form of photosynthesis was taking place, Kiang argues in a paper in the current *Astrobiology*. Plants on that dark world might predominantly be black to absorb as much of the available light as possible, Kiang says.

Anyone training an advanced telescope on Earth would detect such a signature of life: Earth seems to suck up light in the red wavelength while sending back a large portion of the sun's infrared energy. "Plants are a lot less green than they are infrared," Kiang notes. "When satellites measure vegetative cover they look at the infrared signal of plants, which is a strong reflectance signal. They are not absorbing infrared."

It remains a mystery why most plants do not take advantage of this infrared light by absorbing it (snow algae and lichens seem to make use of it, for unknown reasons), but it does provide a clear signal to anyone watching that there is something going on that is more than what would be expected from its various constituent elements. And when sufficiently specialized telescopes reach Earth orbit in a decade or so, researchers may be able to detect similar signatures of photosynthesis on an Earth-size worlds orbiting an F type star (larger and hotter than our own G-type sun), for example.

Plants on that newly discovered planet would be predominantly orange, not unlike the artist's rendering of the grass above, Kiang says. But given the conditions here on Earth, plants find it easiest to be green. As Kiang adds: "Life here is very intimately adapted to the qualities of our home planet and the sun."

Biology 1

***Photosynthesis In the News -***

***ARTICLE THREE***

# Climate Study Finds Mysterious Rise in Erratic Weather

**By Wynne Parry, LiveScience Senior Writer**



updated 11/23/2011 7:56:02 AM ET

By looking at measurements of sunlight striking the planet's surface as well as precipitation records, a study has found that in certain places, daily weather is increasingly flip-flopping between sunny and cloudy, and downpours and dry days. It's not yet clear why this is happening.

This is the first [global](http://www.msnbc.msn.com/id/45414812) climate study to examine variation in day-to-day weather. So far, climate science has [focused on extremes](http://www.livescience.com/17111-extreme-weather-climate-change-report.html)— record temperatures or intense storms, for example — or on averages, such as estimates that [global temperatures](http://www.livescience.com/10325-living-warmer-2-degrees-change-earth.html)have risen 0.7 degrees Celsius (1.3 degrees Fahrenheit) since the Industrial Revolution.

"I think it turns out day-to-day variability is actually important and perhaps more attention should be paid to it," said David Medvigy, the lead researcher and an assistant professor in the department of geosciences at Princeton [University](http://www.msnbc.msn.com/id/45414812).

This is because increases in weather fluctuations have important implications, particularly for plants — which currently pull about 25 percent of the greenhouse gas carbon dioxide emitted by humans out of the air.

Photosynthesis, the process by which plants use carbon dioxide and water to create sugars and oxygen, makes [the planet's air breathable](http://www.livescience.com/16714-oxygen-breathing-life-chromium.html)and feeds the rest of the food chain. It requires both water and sunlight, and fluctuations in these can reduce photosynthesis. Increasing fluctuations have other consequences, including changing the composition of ecosystems, with different plants dominating while others dwindle, and potentially decreasing the efficiency of at least some forms of [solar power](http://www.livescience.com/2095-happened-solar-power.html).

Medvigy and Princeton postdoctoral researcher Claudie Beaulieu looked at [data](http://www.msnbc.msn.com/id/45414812)produced by satellites that measured radiation bouncing off the Earth from 1984 to 2007. This information was then used to infer how much solar radiation was hitting the Earth's surface.

Over this 24-year period, they saw that variability in sunlight reaching the surface changed significantly over 35 percent of the planet, primarily over tropical land in Africa and Asia, and seasonally in parts of the Amazon. Here, they found that, over that period, the flip-flopping between sunny and cloudy days increased on average by just under 1 percent a year, reaching a total change of 20 percent for the whole study period.

Using precipitation data collected by satellites and rain gauges from 1997 to 2007 around the globe, they found that changes in variability of precipitation overlapped with the increased fluctuations in solar radiation. These regions saw a 25 percent increase in the variability in precipitation over the 11-year period. [[Study: It Rains Less on Weekends](http://www.livescience.com/7465-study-rains-weekends.html)]

It's not clear why daily sunlight and precipitation are becoming more variable in parts of the world, but the researchers suspect it may have something to do with giant convective [clouds](http://www.msnbc.msn.com/id/45414812), created by rising warm air. These clouds, which play a role in rainfall and in blocking sunlight from reaching the ground, were found over areas where the changes in variability occurred, he said.

His research group is now investigating the connection between these clouds and the increases in weather variability.

Biology 1

***Photosynthesis In the News -***

***ARTICLE FOUR***

# Sea slug surprise: It’s half-plant, half-animal

## Scientists aren't yet sure how animals actually appropriate genes they need

**By Clara Moskowitz**



updated 1/12/2010 2:50:19 PM ET

A green sea slug appears to be part animal, part plant. It's the first critter discovered to produce the plant pigment chlorophyll.

The sneaky slugs seem to have stolen the genes that enable this skill from algae that they've eaten. With their contraband genes, the slugs can carry out [photosynthesis](http://www.livescience.com/animals/050622_extreme_creature.html) — the process plants use to convert sunlight into energy.

"They can make their energy-containing molecules without having to eat anything," said Sidney Pierce, a biologist at the[University](http://www.msnbc.msn.com/id/34824610/ns/technology_and_science-science/t/sea-slug-surprise-its-half-plant-half-animal/) of South Florida in Tampa.

Pierce has been studying the [unique creatures](http://www.livescience.com/php/multimedia/imagedisplay/img_display.php?s=animals&c=news&l=on&pic=100112-Echlorotica-02.jpg&cap=This+green+slug,+which+is+part+animal+and+part+plant,+produces+its+own+chlorophyll+and+so+can+carry+out+photosynthesis,+turning+sunlight+into+energy,+scientists+have+found.+Credit:+Nicholas+E.+Curtis+and+Ray+Martinez&title=), officially called Elysia chlorotica, for about 20 years. He presented his most recent findings Jan. 7 at the annual meeting of the Society for Integrative and Comparative Biology in Seattle. The finding was first reported by Science News.

"This is the first time that multicellar animals have been able to produce [chlorophyll](http://www.livescience.com/mysteries/070124_grass_green.html)," Pierce told LiveScience.

The sea slugs live in salt marshes in New England and Canada. In addition to burglarizing the genes needed to make the green pigment chlorophyll, the slugs also steal tiny cell parts called chloroplasts, which they use to conduct photosynthesis. The chloroplasts use the chlorophyl to convert sunlight into energy, just as plants do, eliminating the need to eat food to gain energy.

[Rarely seen creatures](http://www.msnbc.msn.com/id/23523030/ns/technology_and_science-science/t/rare-creatures-land-under-sea/)"We collect them and we keep them in aquaria for months," Pierce said. "As long as we [shine a light](http://www.msnbc.msn.com/id/34824610/ns/technology_and_science-science/t/sea-slug-surprise-its-half-plant-half-animal/) on them for 12 hours a day, they can survive [without food]."

The researchers used a radioactive tracer to be sure that the slugs are actually producing the chlorophyll themselves, as opposed to just stealing the ready-made pigment from algae. In fact, the slugs incorporate the genetic material so well, they pass it on to further generations of slugs.

The babies of thieving slugs retain the ability to produce their own chlorophyll, though they can't carry out photosynthesis until they've eaten enough algae to steal the necessary chloroplasts, which they can't yet produce on their own.

The slugs accomplishment is quite a feat, and scientists aren't yet sure how the animals actually appropriate the genes they need.

"It certainly is possible that [DNA](http://www.livescience.com/topic/DNA%20and%20Genes) from one species can get into another species, as these slugs have clearly shown," Pierce said. "But the mechanisms are still unknown."



Biology 1

***Photosynthesis In the News -***

***ARTICLE FIVE***

# Carbon dioxide in,

# oxygen out with this car

## Concept vehicle being worked on by U.S. companies and China

**By Alyssa Danigelis**



updated 5/21/2010 3:57:39 PM ET

One reason treehuggers like myself love trees is that the leaves scrub CO2 from the atmosphere, use it for energy and emit life-giving oxygen, the process of photosynthesis. Wouldn't it be great if cars — notorious for CO2 emissions — could do the same?

Chinese automaker Shanghai Automotive Industry Corporation is doing just that. They recently unveiled designs for a photosynthesizing concept [car](http://www.msnbc.msn.com/id/37279678/ns/technology_and_science-innovation/t/carbon-dioxide-oxygen-out-car/) that could take in carbon dioxide and produce oxygen. Details are still sketchy, which is understandable since it would basically be a leaf on wheels.

[SAIC](http://www.saicgroup.com/English/index.shtml), which has a partnership wtih General Motors in [China](http://www.msnbc.msn.com/id/37279678/ns/technology_and_science-innovation/t/carbon-dioxide-oxygen-out-car/), showed designs for the YeZ Concept Car recently at [Expo 2010](http://en.expo2010.cn/) in Shanghai. YeZ (pronounced "yea-zi") is Mandarin Chinese for "leaf," and it's clear why: the open buggy-like vehicle has a roof shaped like one. The overall design makes me think of a Strawberry Shortcake doll for some reason, maybe because it looks like something she would ride.

The technical details haven't been articulated, but according to [a Xinhua article](http://china.globaltimes.cn/society/2010-04/526113.html), YeZ designer Ma Zhengkun says that the roof "absorbs solar energy and transforms it into electricity while spinning rotors on the four wheels generate power from the wind."

CNET Asia blogger [Juniper Foo reports](http://asia.cnet.com/crave/2010/05/20/yez-concept-car-sucks-in-c02-exhales-oxygen/) that the two-seater would have a "metal-organic framework," which would work to absorb CO2 and water, turning them into electricity that would get stored in a lithium-ion battery.

This artificial photosynthesis concepts reminds me of [the research going on MIT in Dan Nocera's lab](http://web.mit.edu/newsoffice/2008/oxygen-0731.html). He and Matthew Kanan developed a process that uses sunlight to split water into hydrogen and oxygen. The hydrogen gets used in a fuel cell and the oxygen goes into the air.

And when writing about the YeZ, Gizmag's [Mike Hanlon cites](http://www.gizmag.com/saic-yez-concept-car-inhales-c02-emits-oxygen/15152/) the [researchers at Leiden University](http://www.gizmag.com/artificial-leaf-converts-light-to-energy/12126/) in the Netherlands who got halfway towards creating an artificial leaf last year.

These efforts mean that the artificial photosynthesis process could very well become a commercial reality by 2030.

My only concern is that the intense technical advancements it would require to make YeZ a reality could end up using far more resources for production than it ultimately[saves](http://www.msnbc.msn.com/id/37279678/ns/technology_and_science-innovation/t/carbon-dioxide-oxygen-out-car/).

As far as concept cars go, I'm still partial to Yves Behar's idea for [a hackable one](http://news.discovery.com/tech/hack-this-car-please.html). Beyond that, between golf carts and bicycles, I think we've got several workable options right now. Sorry, Shortcake.



Biology 1

***Photosynthesis In the News -***

***ARTICLE SIX***

# 'Artificial leaf' makes real fuel

***By John Roach***

It doesn't look like the leaves changing colors and piling up on the lawn, but a nature-inspired "artificial leaf" technology has taken a notable step toward the goal of producing storable and [clean energy](http://futureoftech.msnbc.msn.com/_news/2011/09/30/8064321-artificial-leaf-makes-real-fuel) to power everything from factories to tablet computers.

The leaf is a silicon solar cell coated with catalytic materials on its side that, when placed in a container of water and exposed to sunlight, splits the H2O into bubbles of oxygen and hydrogen. The hydrogen can be stored and used as an energy source, for example to power a fuel cell.

"The device both captures the [solar](http://futureoftech.msnbc.msn.com/_news/2011/09/30/8064321-artificial-leaf-makes-real-fuel) energy and stores it in the chemical bonds of the hydrogen and oxygen that are produced from the water," [Steven Reece](http://www.suncatalytix.com/team.html), a research scientist with Sun Catalytix and lead author of a paper describing the breakthrough, told me Friday.

The artificial leaf is made entirely with earth-abundant, inexpensive materials — mostly silicon, cobalt, and nickel — and it works in ordinary water. Other attempts have required more expensive catalysts such as platinum and/or extremely caustic water, noted Reece.

"What was really novel about our work is that we were able to integrate our earth-abundant catalysts with this commercial triple junction solar photovoltaic [technology](http://futureoftech.msnbc.msn.com/_news/2011/09/30/8064321-artificial-leaf-makes-real-fuel) that would then operate under benign conditions without wires and a reasonable efficiency," he said

The breakthrough was led by [Daniel Nocera](http://www.mit.edu/~chemistry/faculty/nocera.html) at the Massachusetts Institute of Technology and was reported Thursday in the journal [Science](http://www.sciencemag.org/). Reece worked in Nocera's lab before moving to Sun Catalytix, which was started by Nocera to commercialize his [solar energy](http://futureoftech.msnbc.msn.com/_news/2011/09/30/8064321-artificial-leaf-makes-real-fuel) inventions.

This new paper is the latest step in a process that has generated buzz over the years.

In 2008, the team reported on the [cobalt part of the equation](http://web.mit.edu/newsoffice/2008/oxygen-0731.html), which releases oxygen from water. They've now coated the other side of the silicon sheet with the nickel-molybdenum-zinc alloy, which releases hydrogen from water molecules.

"You just drop it in a glass of water, and it starts splitting it," Nocera said in a [statement](http://web.mit.edu/newsoffice/2011/artificial-leaf-0930.html).

He added that the device is not ready for commercial production as the systems to collect, store, and use the gases remain to be developed. "It's a step," he said. "It's heading in the right direction."

The collection and storage of the sun's energy as hydrogen fuel is a key step in overcoming one of the limitations of solar power — it generates energy when the sun is shining, but it needs to be stored somewhere to be useful at night and in cloudy weather.

Batteries are one place to store the energy, but [battery technology, while improving](http://futureoftech.msnbc.msn.com/_news/2011/09/23/7923474-battery-tech-improving-as-demand-soars), is limited. Storing solar energy as hydrogen fuel could be an answer.

"Nobody disputes the beauty of the chemistry," [reads a Nature News article](http://www.nature.com/news/2011/110929/full/news.2011.564.html) about the technology. "But whether the system is actually useful will come down to how expensive the hydrogen is to make, and how efficiently the system can use the available energy from sunlight."



Biology 1

***Photosynthesis In the News -***

***ARTICLE SEVEN***

# Western Australia's Incredible Underground Orchid

*ScienceDaily (Feb. 8, 2011)*

Rhizanthella gardneri is a cute, quirky and critically endangered orchid that lives all its life underground. It even blooms underground, making it virtually unique amongst plants.

Last year, using radioactive tracers, scientists at The University of Western Australia showed that the orchid gets all its nutrients by parasitising fungi associated with the roots of broom bush, a woody shrub of the WA outback.

Now, with less than 50 individuals left in the wild, scientists have made a timely and remarkable discovery about its genome.

Despite the fact that this fully subterranean orchid cannot photosynthesize and has no green parts at all, it still retains chloroplasts -- the site of photosynthesis in plants.

"We found that compared with normal plants, 70 percent of the genes in the chloroplast have been lost," said Dr Etienne Delannoy, of the ARC Centre for Excellence in Plant Energy Biology, the lead researcher of a study published in Molecular Biology and Evolution. "With only 37 genes, this makes it the smallest of all known plant chloroplast genomes."

"The chloroplast genome was known to code for functions other than photosynthesis, but in normal plants, these functions are hard to study," said ARC Centre Director Professor Ian Small.

"In Rhizanthella, everything that isn't essential for its parasitic lifestyle has gone. We discovered that it has retained a chloroplast genome to make only four crucial proteins.

Our results are relevant to understanding gene loss in other parasites, for example, the Plasmodium parasite that causes malaria."

Associate Professor Mark Brundrett from the Wheatbelt Orchid Rescue Project describes Rhizanthella as one of the most beautiful, strange and iconic orchids in the world.

"Combining on-the-ground conservation efforts with cutting edge laboratory technologies has led to a great discovery with impacts for both science and conservation. The genome sequence is a very valuable resource, as it makes it possible to estimate the genetic diversity of this Declared Rare plant."

Professor Brundrett has been working with the Department of Environment and Conservation and volunteers from the West Australian Native Orchid Study and Conservation Group to locate these unique orchids.

"We needed all the help we could get since it often took hours of searching under shrubs on hands and knees to find just one underground orchid!"



Biology 1

***Photosynthesis In the News -***

***ARTICLE EIGHT***

## The Light at the Bottom of the Sea

## Two miles below the surface of the sea, a mysterious glow emerges from cracks in the Earth. In that glow, the first steps to photosynthesis may have taken place, 3.8 billion years ago.

by Zimmer

From the [November 1996 issue](http://discovermagazine.com/1996/nov); published online November 1, 1996

Once it seemed that the ocean floor was a desert of darkness. As everyone knew, sunlight was what made life possible by fueling photosynthesis, and sunlight can penetrate only the first few hundred yards of the ocean’s great depths. Lower, a few creatures might still eke out a living by scrounging the organic detritus that drifts down from the surface of the sea. But thousands of feet down, in the utter blackness at the ocean’s bottom, there could be practically nothing.

Then, in 1977, underwater explorers discovered that there was in fact something, and quite a lot of it. At midocean ridges, where new ocean floor rises up as molten rock from Earth’s interior, where cold seawater mixes with the rising magma and, heated to 650 degrees, spews back up through chimney-shaped hydrothermal vents, researchers stumbled across bustling ecosystems. Clinging to the sides of the chimneys were thick white mats of bacteria; around them were eight-foot-long stalk-shaped worms, rocking in the water, while eyeless shrimp seethed around the chimneys like maggots. All were thriving on the energy bound up in the vents’ sulfur compounds. The seafloor might still be dark, but now it was known to be dotted with gardens.

In just the past eight years, however, underwater explorers have discovered that this picture is still incomplete: there is light at the bottom of the sea. Hydrothermal vents glow, and while the light is too faint to be perceived by the human eye, that hardly means it is without significance. Physicists maintain that although some of the light may be created by the intense heat, much of it must be attributed to some as-yet- unknown process. Biologists, meanwhile, say there is sufficient light at these vents for photosynthesis to take place. Researchers can’t say yet whether any creatures are actually living off this light, but if they are, they will represent the first known instance of natural photosynthesis without sunlight. The evolutionary implications may run deeper: it’s possible not only that this deep light is fueling photosynthesis now, but that, 3.8 billion years ago, it got the whole process started.

Nisbet had the idea that photosynthesis might have begun as phototaxis--simple movement by an organism in response to stimulation by light. This notion comes back around to the elementary fact that when you live at a hydrothermal vent, it pays to know where you are. Bacteria don’t have eyes like shrimp to gauge their location, but that doesn’t necessarily mean they are blind. Many microbes can sense light. Some marsh dwellers, for example, move down through the sediments to the layer in which visible light is low but infrared light still penetrates; this happens to be the place where they find the most food.

Together, Nisbet and Van Dover hashed out the following scenario for the origin of photosynthesis: Imagine a hydrothermal vent on the early Earth. At first the microbes feeding on sulfides around the vent can’t sense their position, and sometimes they drift away into the cold and freeze; sometimes they get too close to the mouth of the chimney and fry. But some of the bacteria carry molecules that serendipitously absorb the light emitted by the vent. Gradually, descendants of these bacteria develop the ability to use the light to keep themselves in a safe place (or even to figure out where the most food is on the vents), and these bacteria thrive.

Some millions of years later, this story goes, a few of these phototaxis-capable bacteria drift up from the dark depths of the ocean to shallow hot springs, where they can continue on their old diet of sulfides. Now, though, they no longer live under a faint drizzle of light from vents but under a torrent of light coming from the sun. Thanks to their vent ancestry, they can already trap photons; all they have to do now is become sensitive to visible light and then find a way to harness this captured energy, by evolving a system of molecules that can convert the captured energy into fuel. Modern photosynthesis is born.

We’re simply suggesting a starting step, but in many cases the starting step is the hardest to imagine, says Nisbet. It starts as a heat-detection mechanism, you get organisms knocked out into shallow environments, and they happen to have the equipment onboard to detect sunlight. Now they have something that gets them a free lunch from the sunlight upstairs, and then there’s a whole new world up there. As for supporting evidence, he points out that the most primitive forms of bacterial chlorophyll absorb the most light at the frequency bands that Van Dover measured at hydrothermal vents. Moreover, photosynthesis today makes use of certain elements--iron, manganese, and sulfur, to name three--that are abundant around hydrothermal vents. It’s not proof, but it is neat. We’re simply saying that the facts are consistent with the hypothesis.