

Watt's Happening? #85

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Perfect Solar Energy



The simple green leaf: we take it for granted, yet it makes life on Earth possible, and it's entirely solar powered at an amazingly high level of efficiency.

The solar revolution has begun. Nature supplies us with unlimited, constantly renewed pollution-free energy, much more than we can ever use, and it's everywhere, all around us. We need only harvest it.

The "solar module" is the standard method used to "harvest" solar energy today. Off-the-shelf modules convert about 20 percent of the sunlight falling on them into electricity – not a lot, but more than enough to make solar power the fastest growing energy source on the planet.

Although research is on going, the perfect solar panel that converts sunlight into electricity at 100 percent efficiency has not yet been invented. Or has it?

THE LEAF

You may not be a vegetarian, but by far most of the animals on Earth are. They feed on the grass in the field, the leaves of trees, the microscopic green plant-cells that fill the upper layers of the oceans. Carnivores are a rare luxury.

But plants themselves need energy too. Somehow they must build complex carbohydrates, fats and proteins from the simple raw materials they have available, mostly carbon dioxide and water. And they have only one energy source: sunlight.

"Photosynthesis" (Greek for "put together by light,") is the process, and the magic ingredient that

makes it work is “chlorophyll” (Greek for “green leaf.”)

But exactly how this magic works has been a 200-year research project that has only recently revealed an amazing fact: under ideal conditions, a green leaf converts 100 percent of the solar energy falling on it into chemical energy: it is 100 percent efficient.

QUANTUM BIOLOGY

Photosynthesis was finally explained by the new field of quantum biology, which looks at how relativity and quantum physics manifest in the real world of plants and animals.

It's all magic to me, but here's the latest quantum biology explanation of why photosynthesis works at 100 percent efficiency: the wave/particle duality of light allows photons to simultaneously try all possible pathways into the photosynthetic cell and then choose only the best paths, resulting in 100 percent efficient use of light by the cell.

Apparently, over some two billion years of evolution, life has developed the remarkable ability to capitalize on these quantum and relativistic effects, essentially to perfection.

Chemically, the green cell uses the energy of sunlight to break down carbon dioxide into carbon and oxygen, and breaks water into hydrogen and oxygen, releasing the extra oxygen into the atmosphere. These are tricks that we can do in the lab, but only with extreme heat or lots of electricity. Chlorophyll does it easily with simple sunlight at room temperature.

The scale at which the Earth's green plants manufacture organic matter and release oxygen is enormous. Each year the green plants of the Earth

(both land and ocean) combine 150 billion tonnes of carbon (from carbon dioxide) with 25 billion tonnes of hydrogen (from water) and liberate 400 billion tonnes of oxygen. Were it not for this, within a few centuries the oxygen would fall to a low level and the atmosphere would be loaded with enough carbon dioxide to kill all animal life, both from asphyxiation and a runaway greenhouse effect.

THE 10,000-WATT TREE

I have a 5,000-watt solar array on my roof that makes quite a bit of electricity, more than the building uses. So how much solar energy does a tree use, for instance, to perform its magic?

Sitting on my front porch the other day and counting leaves (strange, I know...) I estimated that a mature trembling aspen has about 100,000 leaves, for a total solar collection area of about 120 square meters.

The standard number used to calculate solar energy falling on the Earth is about 1000 watts per square meter. Since most leaves are not facing the sun perfectly or are shading each other, let's assume a modest 10 percent conversion efficiency.

Still, that gives our tree a full 10,000 watts of energy to work with, twice my roof top solar array. That's a lot!

And the 50-hectare forest on the hillside over there? On a bright sunny day it's a 500-megawatt (yes, megawatt) solar powered chemical factory absorbing carbon and releasing life-giving oxygen at a prodigious rate.

Puts a whole new light on the idea of “green” energy, doesn't it?

Quick Fact: Apple goes green

Not far from its headquarters in California, the tech giant Apple is building a new hi-tech campus powered entirely with sunlight. Called “The Spaceship” it is nearly 1.5 kilometers in circumference and will house some 13,000 employees. The huge circular ring-shaped building encloses a park, cools itself naturally and powers itself with an immense roof-top solar array.