

INTUITIVE EXPLORER

Reflecting on Holland, Rienk van Grondelle sees large water tanks full of algae. They make biodiesel, which could very soon solve our energy problems. "In ten years, these tanks will be a common sight." And that thanks to the efforts of a biophysicist who originally only wanted to know how photosynthesis works.



By Rianne Lindhout

"Nobody bats an eye at the potato fields in Haarlemmermeer, but people get all up in arms about wind turbines at sea. They fail to realize that space is needed not only for agriculture, but also for energy." Rienk van Grondelle, Professor of Biophysics, finds that odd. He explains in his office at the university: "We need just as much space for our energy needs as we do for growing food. In the southern USA, agriculture devoted to energy production is already competing for space with agriculture for food production." Add to that the fact that our addiction to petroleum will soon have to come to an end, and you realize: something must be done.

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To escape the energy crisis, we will have to live with power generating facilities in our back yards, as it were. "With solar panels on almost every house, as you see in Germany today. And we need to start making better use of algae. The Loosdrecht lakes are full of algae. We need to realize a lakeside installation for harvesting it. I have calculated that sustainable algae production in the Markermeer lake alone can provide for 20 percent of our fuel needs here in the Netherlands." Algae are an excellent biofuel that does not compete with our food supply, especially since many species of these single-cell plants also flourish in salt water.

ALGAE AS DAIRY COWS

"Our own Professor Roberta Croce is working with colleagues in Wageningen on algae that make lipids." That is even smarter than burning algae for power: get the algae to make an energy-rich substance that you can exploit. Some minor processing is all it takes, and you can fill your car with the stuff. Grow algae as if they were dairy cows. 'Algae energy' is already widespread in China, while it has not yet proved profitable in the Netherlands. Growing algae is too labour-intensive and the installations require too much maintenance. Also, the production of algae needs to be ratcheted up, which can only happen once we completely understand how it works. We can then make the

process more efficient through genetic modification. Algal growth relies on photosynthesis, the process on which nearly all life on earth depends. We can nourish ourselves because green plants store energy from light in sugars. We can breathe because oxygen is released during photosynthesis.

GREAT DISCOVERIES

This essential process of photosynthesis, which is now more essential than ever in view of our energy needs, is what Van Grondelle has been trying to fathom for his entire career. And he's been very successful! In 2009 the Royal Netherlands Academy of Sciences rewarded him with a five-year position as a Professor of the Academy. This means exemption from administrative duties, freeing up his time for research and education. The previous year, Van Grondelle received a three-million-euro grant from the European Union. This ERC Advanced Grant, given to the best researchers conducting the most groundbreaking research, has enabled him to use ultra-fast lasers to research the role of chlorophyll binding proteins in photosynthesis. The biophysicist has been working at VU University Amsterdam since 1983. Partly due to the appeal of the authoritative Laser Centre, founded in 1992, he has been able to form a large, top-notch research group. "We have made great discoveries. We have identified how sunlight is collected and what happens in the first decisive 20 picoseconds of photosynthesis." One picosecond is a trillionth of a second...

UNHAPPY

Van Grondelle works constantly, he says. Fortunately he needs little sleep these days, otherwise he would never see his teenage children. "I sometimes putter around at 2am... answering mails, writing a little, catching up on my reading." He clears his head by going on bike rides. He enjoys the colours in the dunes by the seaside, especially since he can no longer play much football due to an injury. Football was really his sport: "Giving someone a piece of your mind with a few well chosen words on the football pitch, yeah, I do that in my work, too" The hype surrounding last summer's discovery of the Higgs boson did not make Van Grondelle happy. "Lots of money gets poured into research into strange neutrinos and the Higgs boson. It puts science in a less-than-flattering light, and I disagree with that. As

if science were just a game. I think that science has a certain degree of responsibility. And the energy problem has priority, along with issues such as health and ageing. Fortunately, the EU realizes this better than the Netherlands."

LARGEST RESEARCH GROUP

In recent decades, researchers working on photosynthesis have begun to realize that their results could help to solve the energy problem. The same realization dawned on politicians in 2005. The Department of Energy in the USA called on 200 scientists in the field of solar energy to draw up a research agenda. Twenty of this number were from Europe, and Van Grondelle was one of them. "My basic research was put in the spotlight. There are now five major institutes in the US working on this issue." Together with his biotech colleague Roberta Croce, Van Grondelle runs the largest research group in the field of light-harvesting systems in Europe. "That creates quite an impression worldwide." Since the 2005 conference, Van Grondelle has been lobbying feverishly in American and European networks for industrial applications of photosynthesis – in algae, but also in organic solar cells. But his real motivation still comes from a desire to understand how it all works in a fundamental sense.

FEELING

Nevertheless, his is still keen to visualize the inner workings of his subject. His method: "I visualize the process in my mind, and then write it all down on a sheet of paper. You're doing experiments, working with complex data. To solve the problem, you need to have a conception of the final result. You need to understand that you're working on a gigantic jigsaw puzzle." The scientist visualizes how light particles transfer their energy to molecules and elementary particles in chlorophyll, how they then start to vibrate and pass on their energy to other particles, how phenomena occur between still other particles... The advanced laser equipment at the VU University Laser Centre has enabled Van Grondelle to prove many of these component steps. "The moment when everything falls into place, when the puzzle is finished, that's just fantastic. Then I go and tell my story all over the world. I get recognition, and that's great."

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Not that Van Grondelle is the only scientist working in this field: "There are other researchers who are just as capable of achieving these results as I, it's just that they aren't able to conceptualize as well. I have an intuitive feeling for how nature works." In physics, a hypothesis is usually a formula. "This approach won't work for us; it's too complicated," Van Grondelle explains. "In our work the hypothesis consists of intuition, and I am an intuitive scientist. I have a solid theoretical and mathematical background, but I need to rely on my feelings when it comes to understanding life using concepts rooted in physics." Van Grondelle tries to teach his students to work intuitively. "I train them by having them make intuitive reductions of mathematical formulas." When he was still a student, Van Grondelle found the link between physics and life to be lacking. "I wanted to discover how a special

combination of natural laws could lead to this spectacular result. Natural laws are very unforgiving, Coulomb's law, the Schrödinger equation. In fact, there is quite a bit of confusion in the world of physics. Life exists by virtue of disorder; evolution is a prime example of this. Imagine that you are the supreme being.

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You put on your engineer's cap to recreate everything. What would you do? Nature is lubricated by an 'engineering sauce'. I am looking for the recipe for the sauce."

NEW DIMENSION

The study of photosynthesis has become especially exciting in recent years thanks to the work of Rienk van Grondelle. He has added a whole new dimension to the field, which has caused the quantum mechanics research community to get interested in the subject. Quantum mechanics describes the behaviour of the smallest energy units (quanta) at the smallest (sub-atomic) level. Van Grondelle: "After years of working on fundamental processes I discovered that there's something missing: the quantum mechanical processes. I now realize that I've opened up a whole new field of research. Biosystems have a certain orientation. Decisions follow on decisions. If you introduce a number of light particles to a light system, how are the right decisions made and the poor ones avoided? How does order arise from disorder, the chaos of nature? This appeals to me. Scientists researching quantum mechanics are working on this, for example in the area of neurobiology." Van Grondelle has demonstrated to them that they can also conduct interesting and relevant research on photosynthesis.