**One of the most spectacular wonders of nature is the process of photosynthesis, which allows plants to take in carbon dioxide and water and combine it with sunshine and chlorophyll molecules to make carbohydrates**

**The beauty of photosynthesis is that it essentially produces stored chemical energy and oxygen that's ultimately used by all life on earth, including us humans.**

**That's something that hasn't escaped the attention of biologists and chemists in various research institutes around the world, who asked themselves**

**What if we could find a way of replicating photosynthesis in a laboratory to make chemcial energy just from carbon dioxide and light? After all, there is apparently an abundace of both currently available in our atmosphere.**

**So they put on the silly goggles, switched on the bunsen burners and started messing around with all sorts of green organic matter to see what they could discover.**

**And lo and behold, in August 2020 a team at the Institute for Terrestrial Microbiology in Marburg in Germany, backed by the Max Planck Institute, announced a breakthrough.**

**What they say they've created, is something called artificial chloroplasts.**

**Hello and welcome to Just Have a Think**

**I only took biology up to O' level which is an exam that was replaced by GCSE's in the United Kingdom in 1986, so that gives you a fair idea of how sketchy my understanding of microbiology is. So I had to look up chloroplasts to find out what on earth they were.**

**And I'm glad I did now becaue it turns out they're arguably one of the most important natural engines on the planet. Chloroplasts are microscopic little sacks of joyfullness living inside the cells of green leaves. The science bods tell us that they closely resemble some types of bacteria and even contain their own circular DNA and ribosomes. In fact, there is a theory that millions of years ago they were themselves once independently living bacteria.**

**Writing in an article at the Science website, journalist Bob Service outlines how they work to drive the photosynthesis process.**

**He explains that inside the chloroplasts, chlorophyll molecules perform two major photosynthetic processes called light reactions and dark reactions. The light reaction literally absorbs sunlight and passes the extra energy to molecular partners that use it to generate energy-storing chemicals. And here's where the fancy scientific names inevitably start creeping in. So these energy strorage chemicals are called adenosine triphosphate, or ATP and nicotinamide adenine dinucleotide phosphate or NADPH.**

**Then in the dark reaction, a group of enzymes, starting with something called RuBisCO causes the ATP and NADPH to convert CO2 from the air into glucose and other energy-rich organic molecules that the plant uses to grow.**

**All good so far you might think. we just get the clever scientists to isolate the RuBisCo enzyme, and job done.**

**The trouble is though, what they found was that in nature, even though it's an enzyme, RuBisCO is still extremely slow. Each copy of the enzyme can only grab and use about five to ten CO2 molecules per second, and that sets the speed limit that determines how fast plants can grow.**

**So the challege was to work out what makes the dark reaction tick and then make it tick a lot faster.**

**According to this article published at Eurekalert online,**

**"Many scientists consider artificially rebuilding and controlling the photosynthetic process the "Apollo project of our time". It would mean the ability to produce clean energy - clean fuel, clean carbon compounds such as antibiotics, and other products simply from light and carbon dioxide."**

**It was certainly a very ambitious goal. So the Max Planck Society set up an interdiscliplinary multi-lab inititative and got to work. They knew that the key to replicating and improving the processes that nature has evolved within living cells is to take out some of the randomness of the process and get all the various components to work together at precisely the right time and in exactly the right place.**

**They also knew that there were already a couple of technological developments in existence, that they could make use of. The first was something called Synthetic Biology for the Design and Construction of Novel Biological Systems. Essentially these are reaction networks that can efficiently capture carbon dioxide and convert it into other chemicals.**

**The second technology was Microfluidics, which science has developed to assemble soft materials like cell-sized droplets.**

 **The Marburg research team director, Thomas Erb explained**

**"We first needed an energy module that would allow us to power chemical reactions in a sustainable fashion."**

**And in a breakthrough that would have made Popeye extremely proud, they found the best donor for these reactions was the humble spinach plant.**

**The photosynthesis apparatus isolated from the spinach plant proved to be robust enough that it could be used to drive single reactions and more complex reaction networks with light. That took care of the light reaction.**

**For the dark reaction, the researchers used their own artificial metabolic module, called the CETCH cycle. Now I like to think I know my own limits, so I'm not even going to try to read out what CETCH stands for. Instead here's a little interlude so you can enjoy the full majesty of the expanded term for yourself.**

[**https://pubmed.ncbi.nlm.nih.gov/27856910/**](https://pubmed.ncbi.nlm.nih.gov/27856910/)

**"The crotonyl-coenzyme A (CoA)/ethylmalonyl-CoA/hydroxybutyryl-CoA (CETCH) cycle is a reaction network of 17 enzymes that converts CO2 into organic molecules at a rate of 5 nanomoles of CO2 per minute per milligram of protein."**

**After several attempts and lots of optimization and improvement, the team at Marberg finally managed to replicate the fixation of carbon dioxide in the laboratory just using spinach and the energy in sunlight.**

**And here's where that microfluidics technology comes in to play. If they were going to have any chance of automating production of their new process, the team needed a way to produce individual units on a micro scale that could then be mass produced. So they worked with a laboratory at the Centre de Recherche Paul Pascal in France, headed up by a guy called Christophe Baret, to developed a platform for encapsulating the semi-synthetic membranes in cell-like droplets.**

**The resulting microfluidic platform is capable of producing thousands of standardized droplets that can be individually equipped according to the desired metabolic capabilities.**

**Tarryn Miller, lead author of the study said**

**"We can produce thousands of identically equipped droplets or we can give specific properties to individual droplets,"**

**"These can be controlled in time and space by light."**

**Now you might think this all sounds a bit like some sort of genetic engineering, so what's new?**

**Well the scientists point out that this sort of fundamental, bottom up approach isn't necessarily bound by the limits of natural biology in the way that genetic engineering is.**

**Project Director Tobias Erb explains**

**"The platform allows us to realize novel solutions that nature has not explored during evolution,"**

**As a result, the researchers have been able to show that equipping the artificial chloroplast with their own enzymes and reactions meant they could bind the carbon dioxide 100 times faster than any previous synthetic-biological approach.**

**And the implications for our climate and environment of ramping up systems like these into mass producion all over the world are absolutely enormous. Taking carbon dioxide out of the air and converting into useful products will be a fantastic contribution towards reducing overall atmospheric concentrations for a start, but crucially, if we can make it into the chemical, pharmacueticals and other products that we currently derive from fossil fuels, then we'll also be keeping more of the black stuff in the ground where it belongs.**

**As Erb puts it**

**"In the long term, life like systems could be applied to practically all technological areas, including material science, biotechnology and medicine - we are only at the beginning of this exciting development."**

**Definitely food for thought, and if you have any thoughts or views, or if you know of other similar initiatives in development, then dive down to the comments section below and tell us all about them.**

**That's it for this week but before I go I'm delighted to let you know that the second learning module is now available at the Center for Behavior and Climate. This one takes information from my video called the Great Ocean Conveyor, which is all about the Thermohaline Circulation that controls so many aspects of our oceans and climate. You can click up there to watch the video and there's a link in the descripton that'll take you to the website where you can sign up for the module.**

**I must also say a big thank you to our amazing supporters over at Patreon who allow me to keep the channel ad-free and maintain independent content. And a sepcial shout out to the folks who've joined snce last week with pledges of ten dollars or more a month.**

**They are**

**Derek Cowburn**

**Mikaela Lizabeth Alexander**

**Christopher Barth**

**John Evancho**

**Rodney Love**

**Michael Holgate**

**and**

**Daniel**

**and of course a big thank you to everyone else who's joined since last week too.**

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**As always, thanks very much for watching, have a great week, and remember to Just Have a Think.
See you next week**