

SYNTHETIC BIOLOGY: LIFE, BUT NOT AS WE KNOW IT

Advances in genetic engineering mean scientists are now able to tweak the very building blocks of life to create new materials and organisms to suit to our needs. Mike Scott explores a brave new world and its implications for clean energy.

The defining lines around clean energy are becoming ever blurrier. Topics encroaching on investment in the sector range from agriculture and water availability to nanotechnology. Now a new subject has joined the list – synthetic biology.

What is it and why is it so important for clean energy? According to a new report from research and advisory firm Lux, “synthetic biology is a new approach to engineering DNA to create novel materials, organisms, and devices”. More specifically, it defines synthetic biology as “the discovery, invention, and manufacture of biochemical elements and systems to produce tools, materials, organisms, and devices that meet human needs”.

As academic as it may sound, the synthesis of genes, genomes, and entire organisms from basic chemicals has immediate applications in medical research, biofuels, specialty chemicals, and food.

Five years ago, the sector was non-existent but today it is a sector with more than \$1bn invested and dozens of companies involved. It is also maturing rapidly, says Mark Büniger, author of the Lux report. “Being able to tweak an organism’s natural pathway to make it do something different has gone from being experimental to being something you can do in a

factory.” Processes that were at the edge of the realm of possibilities less than a decade ago can now be done by middle school students, he adds.

This rapid development is being accompanied by a drastic fall in costs. Decoding the first human genome cost \$3.2bn and took 13 years. Complete Genomics has claimed it will be able to offer the same service for \$5,000 in 2009 and a number of companies are aiming for a \$1,000 genome by 2013.

In an article for McKinsey, Juan Enriquez, managing director of Excel Medical Ventures, says that “how well you, your company, and your industry understand this new, still esoteric language may have much to do with your company’s long-term survival and prosperity. Biology is likely to become the greatest single driver of the global economy.”

In future, wealth creation could be as closely tied to life sciences as it now is to the digital economy, he adds. The basis for synthetic biology is the recently-developed ability to decode genetic material but the manifold possibilities bring together biologists, chemists and electronic and software engineers.

At the moment, scientists are still poring over the wealth of information now available and mulling over the possible

applications. There are at least 23 US labs involved in synbio and the EU is investing millions of euros in academic and economic projects. While the US remains the leader in R&D and venture capital, Brazil is a leader in biofuels research, Japan is growing plastic car parts from bacteria and plants, and China is building a genome city, says Enriquez. Singapore, the UAE and South Korea are also investing heavily in various aspects of the technology.

As in the early days of clean energy, there are some incredibly ambitious claims for the technology that will probably never come to pass – such as giving humans the ability to photosynthesise and houses being grown from seeds – but already a number of concrete applications are emerging. Given the sector’s links to biotechnology, it is unsurprising that many of these are medical, but there are a number of areas of interest to clean energy investors.

“Synthetic biology will ultimately play a big role in alternative energy from biological sources,” says Cary Bullock, vice-president, business development for Greenfuel Technology, a company that is looking to produce fuels from algae using CO₂ from industrial installations. “When and how are the big questions. We are very much at the early stage of this – much of the science is still being done.”

Nonetheless, Craig Venter, the father of the human genome project, claims that his Synthetic Genomics will be producing carbon-negative biofuels within 18 months. This has garnered the company some \$250m in funding

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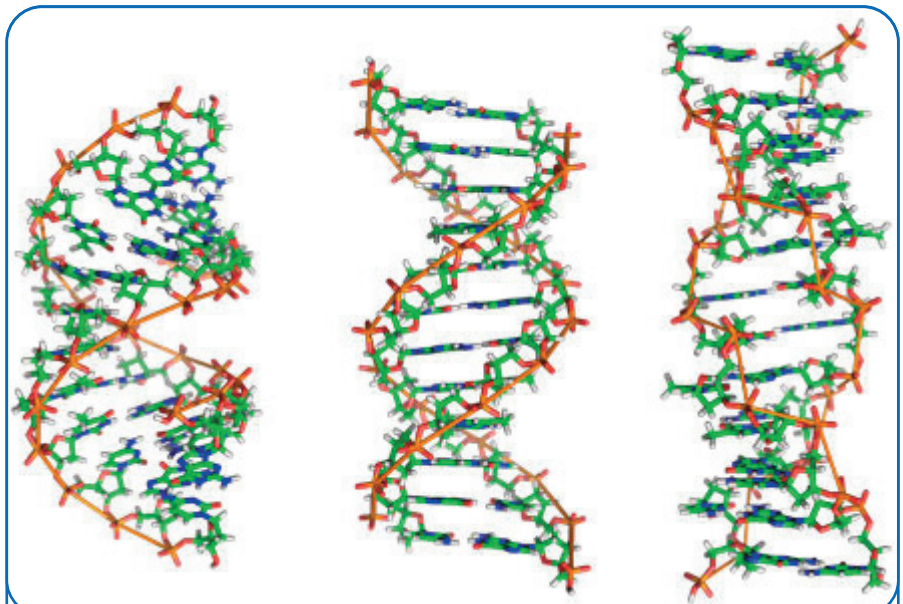
and a partnership with BP. Sequesco is another company targeting the production of fuels from algae, while Amyris shows how energy concerns may become entwined with medical issues by aiming to produce diesel, jet fuel and an anti-malarial drug.

Meanwhile companies such as Siluria and Emefcy, along with the Lee Lab at UC Berkeley, are exploring ways to use bacteria and viruses to enable nano-patterning for displays, batteries, catalysis and interconnects – processes that demand expensive, difficult-to-operate machinery today.

Other potential applications such as artificial food (synthetic meats would remove the ethical concerns and environmental and social costs of rearing animals) and biomaterials (Cargill and Dow are working on bioplastics) tie in tangentially with arguments that have raged over the sustainability of biofuels.

One of the features of synbio is the open-source development process, inspired by the open-source software movement. The BioBricks Foundation supports MIT's Registry of Standard Parts, where sequences and data sheets for biological device components are available to anyone. "This has driven a lot of innovation and attracted more people into the sector," says Bünger. "Having a large body of practitioners is great at this stage because so much of it is pre-commercial. The more people who are working in this area, the more applications will be discovered."

However, Pat Kelly, a lawyer with Ballard, Spahr, Andrews & Ingersoll, says that the issue of patents is starting to rear its head as the sector approaches commercialisation. "Every time one of these earth-shattering technologies comes along, the Patent Office has to deal with it. It is a classic problem – if someone gets early patents, does it stifle the



The recently-developed ability to decode genetic material opens up manifold possibilities for clean energy applications.
Source: Zephyris via Wikimedia Commons

industry or does it encourage others to do the same?"

Venter has sought to patent a synthetic genome, causing an outcry among the scientific community, although the business community is more sanguine. "The whole idea of patents is to encourage money into the market to take the risk," says Bullock. For venture capitalists, intellectual property is important, he says, but he adds that there are also "some things you should not be allowed to own". There are some who say this applies to synthetic biology because it is dealing with "the stuff of life".

Another issue for many applications is that it is impossible to predict future developments. "Biology is very complex," says Kelly, "and there are lots of feedback mechanisms. This has led to many unplanned issues where things have not worked or they have interacted in unexpected ways. Getting more predictability will be key."

The uncertainties that remain around the sector mean it is likely to attract attention from regulators

and raise public fears. Once people are used to the sector, these fears are likely to recede, but in the meantime there may be some vocal opposition. This will die down as synthetic biology becomes more mainstream, Bünger says. "Things that we are used to are not technology any more."

There are many opportunities for investors, but some applications are closer to commercialisation than others. Biofuels, biochemicals and biomaterials are among the more developed areas and there are likely to be plenty of opportunities for exits through IPOs or M&A by corporate giants in sectors ranging from automotive to chemicals. See Table 1 (page 17) for more detail on synbio companies active in clean energy.

"The applications in the market – and in scientists' imaginations – are astounding in breadth and ambition," says Bünger. The hard part will be to pick the applications and the companies that will succeed in the market rather than just remaining figments of the imagination. Hang on, it's going to be an exciting ride.

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TABLE 1: SYNTHETIC BIOLOGY COMPANIES ACTIVE IN CLEAN ENERGY

COMPANY	APPLICATION	INVESTORS
Amyris Technologies	Biobutanol, ethanol, isobutanol and renewable diesel	In two years Amyris has raised \$111m in two rounds. Backers include Votorantim New Business, TPG Ventures, Texas Pacific Group, Kleiner Perkins Caufield & Byers, Khosla Ventures, Duff Ackerman & Goodrich Ventures
Codexis	Drugs, biofuels, and chemicals with synthetic enzymes	Royal Dutch Shell, Merck & Co, Maxygen
Genomatica	Biofuels and chemicals with synthetic microbes	Mohr Davidow Ventures, Draper Fisher Jurvetson, Alloy Ventures
LS9	Petroleum-analog biofuels from synthetic microbes and plant-based feedstocks	Leader Ventures, Khosla Ventures, Flagship Ventures, Lightspeed Venture Partners
OPX Biotechnologies	Biofuels and chemicals with synthetic microbes	Braemar Energy Ventures, Mohr Davidow Ventures and X/Seed Capital
Sequesco	R&D company that is developing technology for CO2 capture using algae	none as of yet
Solazyme	Synthetic algae for energy (fuels), industrial chemicals, cosmetic, nutritional, and pharmaceutical ingredients	Roda Group, Harris & Harris, Braemar Energy Ventures, Lightspeed Venture Partners
Synthetic Genomics	Plans to create organisms that would produce hydrogen, secrete nonpolluting heating oil and break down greenhouse gases	BP, Biotechonomy Ventures, Draper Fischer Jurvetson, Desarrollo Consolidado de Negocios, Meteor Group

Source: New Energy Finance

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