GM and gene-editing - how to distinguish the hype from reality

Or: How GM and Gene Editing can help deliver improved crops for better nutrition
The different approaches that can be used for crop genetic improvement

- **Not subject to GM regulation**
  - Conventional breeding
    - Cross
    - Mutagenesis: Chemicals or radiation
    - Protoplast fusion
    - Selection
    - Elite variety with desirable traits
  - IP retained by Plant Breeding Rights
    - 100’s of years old

- **Always subject to GM regulation**
  - Genetic modification
    - Transgenesis
    - Cisgenesis (intragenesis)
  - Genome editing
    - CRISPR/Cas9
  - IP retained by patents
    - Since 1990s
    - Since 2010s

GM in EU...
A GM example – making omega-3 fish oils in plants

- Beneficial for human health
- A limited natural resource
- No known plant sources available
- Valuable and important ingredient of aquafeed diets

- Aquaculture consumes 80% of all the fish oils we take from the oceans.
- Aquaculture is central to feeding the global population – but needs to be sustainable
Making omega-3 LC-PUFAs in a heterologous host

The sources of genes for omega-3 LC-PUFA biosynthesis are marine microalgae, diatoms etc

Identify algal genes for the synthesis of omega-3 LC-PUFAs & transfer them to oilseeds

Express algal genes in seeds = transgenic plants with novel fatty acid traits
Using GM to deliver enhanced nutrition
GM Camelina Field Trials at Rothamsted - 2014 onwards

The UK’s only continuous GM field trials.. And all that entails
The conversion of an idea into a product takes time and money

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Creating a value chain which delivers better nutrition to the consumer and helps aquaculture to reduce its reliance on oceanic sources of fish oils

**Hurdles:** (GM) Regulation, IP/FTO, Business development, Commercialisation

[many skills & experience absent in academia]
First land-based omega-3 canola

Since 2011, Nuseed has collaborated with the Commonwealth Scientific Australia to develop canola seed with a unique profile that includes long that provide the building blocks essential for both human health and fish of fish oil.

RESEARCH AND DEVELOPMENT

Australian regulators have granted approval for the production and use i regulatory applications in other markets that recognise Australia as a rel Department of Agriculture (USDA) notification and Nuseed received US

Nuseed’s omega-3 oil will be used as an ingredient in aquaculture feed new and sustainable source of long-chain omega-3 for improved health, they are uniquely rich in DHA, a vital building block of good nutrition.

Cargill launches Latitude™, a sustainable, plant-based alternative source of Omega-3 for fish feed applications

Fish oil alternative relieves harvesting pressure on wild fish populations, while delivering on market need for a reliable, fully traceable supply of Omega-3s

[PUERTO MONTE, CHILE] October 16, 2018 – Cargill has announced the launch of Latitude™, a plant-based fish oil alternative that provides long chain Omega-3 fatty acids for aquafeed. Latitude is 100 percent traceable since Cargill manages the supply chain from the canola seed to crop cultivation and oil production—and industry-first for a product of this kind.
Gene-editing is transforming how we do life sciences

- CRISPR-Cas9 and related tools are a disruptive technique with which to edit DNA
- Incredibly precise, easy to use, “democratising” research.

- BUT – Use in EU has effectively been blocked by ECJ ruling of July 2018 (GE ≡ GM)
- Commercial use is covered by patents
- New technology largely untested at scale

Irrespective of that, it is widely expected that GE will transform plant and animal breeding, decreasing susceptibility to diseases, enhancing nutrition and decreasing environmental impact.
CRISPR plants now subject to tough GM laws in European Union

Top court’s ruling threatens research on gene-edited crops in the bloc.

Gene editing is GM, says European Court

By Paul Rincon
Science editor, BBC News website

25 July 2018

Industry shocked by EU Court decision to put gene editing technique under GM law

By Savopoulos Michailopoulos | EURACTIV.com

25 Jul 2018 (updated | 09 Aug 2018)

The European Court of Justice has ruled that altering living things using the relatively new technique of genome editing counts as genetic engineering.

Until now, gene editing, involving the precise replacement of one DNA sequence with another, has been a grey area.
UK plants its first gene edited crop

Scientists at Rothamsted Research have seen one of the world's first experimental field trials of a genome edited crop in an effort to develop more nutritious plants that are more resistant to pests. The trial involved crops that were genetically modified to make them more resistant to herbicides.

EU verdict on CRISPR crops dismays scientists

Decision to tightly regulate gene-edited plants is a blow to biotech and science, critics say.

Basic plant science may suffer, however. Detlef Weigel, director at the Max Planck Institute for Developmental Biology in Tübingen, Germany, is studying how various genetic changes can help plants adapt to climate change—and he needs to grow them outside, he says. "Again and again we have seen that there are big differences between the results we get in a greenhouse and in a field, even if we use the same earth and sprinkler the plants with rainwater." Weigel tested some edited plants in a field in Sweden this year. "Luckily we harvested the plants a few weeks ago," because the cumbersome permitting process will now make such research impractical, he says. "If we want to test a single mutant in the field, it will cost us about €500 to create that plant, and then about €200,000 to get the permit to grow it in a field."

Joyce Taht, director of the institute for Innovation Generation at the University of Edinburgh, says she understands scientists' frustration. "But I also feel the current gene-editing technology does enable you to make changes that are so significant that to claim 'this must be safe because it is natural' is stretching the evidence-based risk analysis," she says. She thinks Europe's regulatory system should focus on evaluating the risks of individual plants rather than the method that produced them. "If Europe sticks with the current system and the way it has operated the past 20-30 years, I think it will become increasingly separated from the rest of the world," Taht says.
Other targets for gene-editing

- Allergy-free peanuts
- Gluten-free wheat
- Caffeine-free coffee
- Reduced spoilage
- Reduced disease susceptibility

Gene-editing is the perfect tool for removing negative genes.
Of course, not everyone recognizes the advances offered by gene editing as positive. Although many of the suggested “problems” are not well-founded.
• **GM** is proven technology, well-established and working at scale.
  • Mainly about **adding foreign DNA to a host**
  • Has further potential to deliver a “second generation” of crops with enhanced nutrition traits

• **GE** is a new and disruptive technology
  • It is not the same as GM (although EU says it is) and some of the things GM can do can’t be done by GE (and vice versa)
  • Mainly about **removing host DNA/genes**

• If we are serious about feeding 9 billion people, we need to use every available tool and approach

  **However, without societal consent and consumer acceptance, these new genetic technologies will be restricted in the potential impact, at least in agriculture and food.**

  **Also, variation in regulatory standards will act as a barrier to trade and also further restrict investment in these new technologies**
Some other examples of modified crops with consumer benefit traits

Some took a very long to advance, some less so. Some are likely to have a big impact, some less so.
Innovation in Agriculture – Time is not on your side!

Herbicide tolerance – 17 years

Average time for agricultural innovation - 28 years

Golden Rice >35 years

DHA-Canola – 21 years


Persistence pays: US agricultural productivity growth and the benefits from public R&D spending (2009)

Professor Philip Pardey (Department of Applied Economics, University of Minnesota)
A key question for the public: Who is paying and who is benefiting?

In our experience, a lot of opposition is focused against globalisation and its impact on the food chain, rather than GM *per se.*