The Role of Biotechnology in Cotton

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The cotton industry owes a large part of its success to the efficiency and cleverness of breeding. Breeding has brought the industry varieties that could for example resist pathogens or flourish in environments where production was once difficult.

But in this industry we can never rest on our laurels, and there are major challenges facing us where breeding on its own will not be enough to overcome them.

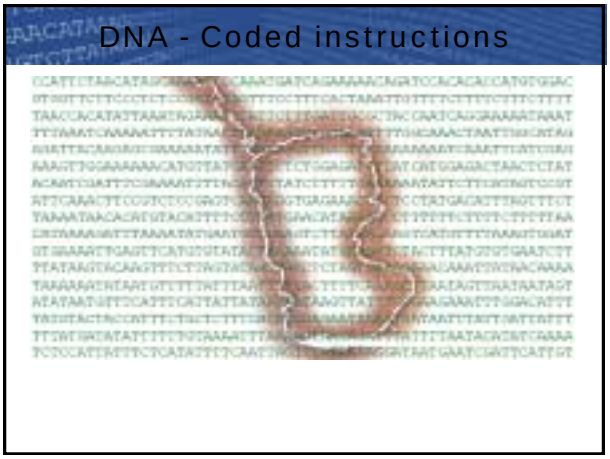
Fortunately there are new opportunities provided by biotechnology that we can use to make breeding more powerful so that the cotton industry can continue along the path that leads it to be profitable, sustainable and acceptable.

When we start to consider the role of biotechnology in cotton, I think we need to remind ourselves about what a gene is. Like any other part or component of our body a gene is a chemical substance, it is DNA and its chemical has very special properties.

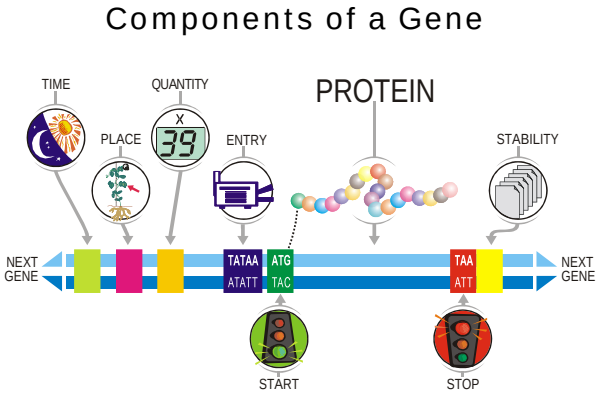
It contains coded information. In fact it is the biological software for the development of any organism and for the way in which an organism functions. The code is written in four genetic letters and this is read in triplets for the information to make proteins, the gene products (Graph 1).

The DNA molecule also contains other coded information, which controls the “activity state” of the gene. These coded regions provide binding sites for proteins that act together to switch the gene into activity (Graph 2).

It is comparable to you switching a light on. Your hand has to activate the switch before the light will come on. In fact, it is much more complicated than that, there are a number of switches that have to act together to switch the gene on.



Graph 1.



Graph 2.

So the gene is not a simple piece of code, it is a multipartite coded structure. The genetic language for the gene product is universal — it's the same in animals as in plants, but the control gear for gene activity differs between animals and plants.

This means that the criticism that you often hear of a fish gene being put into a tomato is just an oversimplification and clearly it's not going to work. The only way to have a piece of coded information from a fish protein work in a plant is to equip the gene construct with the correct series of plant switches.

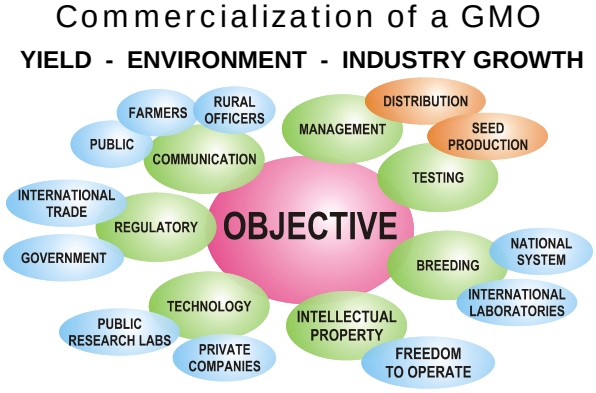
When a gene construct is inserted by a laboratory procedure into the genetic tape it is the same requirement as when the gene construct is inserted by conventional plant breeding. All the switch gear has to be intact and correct to have the gene function in the right cells at the right time and to the right amount.

It is important to note here that everyday we eat billions of genes in our food and we do not acquire the characteristics of our food whether it is animal or vegetable.

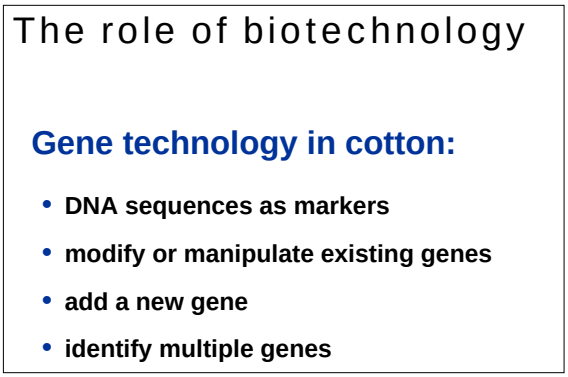
The process of developing a transgenic organism and introducing it into commercial use is also complex. In Australia the regulatory component of this process will be controlled by legislation, which is being introduced early next year (Graph 3).

But Australia has already managed this whole complex process extremely well. To get the one transgenic crop we have in Australia — the cotton crop, which is protected from insect damage by the inclusion of a new insect proofing gene — it took some years to go through all of these complex procedures as well as the safety checks required at all stages of development of the crop. In fact, to a much greater extent than is required for any new cultivar or variety that is introduced as a result of "conventional breeding".

Perhaps the one deficiency I could cite against our Australian experience is that clearly we have not been effective enough as a country in communicating about this



Graph 3.



Graph 4.

technology. There needs to be a great deal of communication in order for the public to understand and trust this technology and the regulatory processes in place. It is something new and people need to be comfortable with respect to just what exactly is involved and in particular they need to be sure that they can rely on our regulatory procedures.

They need to know the transgenic food and crops are as safe as any other food and crops we use. This failure or poor performance in communication has provided the opportunity for the fueling of emotions surrounding the introduction of the technology. It's also unfortunately provided the opportunity for a lot of misinformation and misinterpretation to be fed to the media and it has resulted in concern in the community.

So let's look at the role of gene technology — how do we apply it in cotton? (Graph 4)

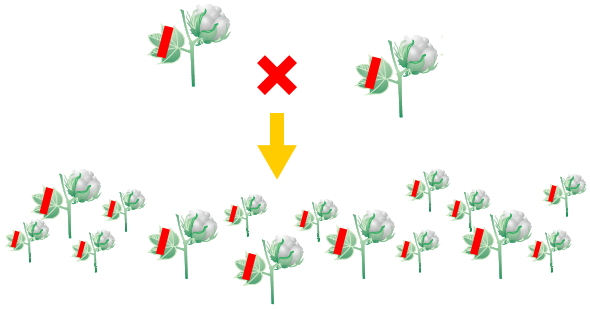
- Gene technology will provide tremendous advantages and help to conventional breeding through the application of gene markers. Although it has been difficult to achieve in cotton, we are now starting to develop techniques that work, and there is no doubt that this technology will make breeding smarter and more efficient because we have seen this occur in other crop plants.
- We can modify or manipulate existing genes.
- We can add a new gene.
- We can identify multiple genes at a time giving us the opportunity to gather far greater knowledge and understanding of gene function than ever before.

Let's look at these roles more closely and see how they are being applied (Graph 5).

DNA markers offer the opportunity to speed up conventional breeding so we can look forward to getting new varieties out to growers sooner.

DNA markers also make the breeding process smarter because breeders can pick plants with desired characteris-

DNA Markers for Cotton Breeding



Graph 5.

tics within one generation, and use only those plants to work with.

Let me give you an example of how DNA marker technology would work: With markers a DNA sequence acts as a flag for a wanted gene in a breeding program. It is just like following the Japanese group's flag carrier in the crowds at the Olympic Games.

We are exploring the use of a DNA sequence flag for a bacterial blight resistance gene. The breeder can quickly identify the cotton plants in the breeding program that have the DNA flag — the red flag — and can discard all of the plants that don't have this correct and wanted gene. Then he or she is able to make a cross to produce the variety in which all plants will have the wanted resistance gene.

It is to emphasize here that plants bred with the aid of gene markers are not transgenic. Markers are used as a guide only, like a red flag carried by tour guides that says to tourists "Here I am – follow me."

But gene technology can be used to modify or manipulate existing genes to produce what are called transgenic or genetically modified organisms. A transgenic organism is one that has a new piece of genetic code introduced or modified by a laboratory procedure. An example is the modification of cotton seed oil to make it healthier.

We can produce high oleic cotton seed oil, which is a liquid at room temperature and can be used for cooking, or high stearic cotton seed oil, which is solid at room temperature and can be used in margarine or confectionery. These oils are healthier because hydrogenation, a process that produces transfatty acids which raise blood cholesterol, is avoided (Graph 6, 7).

Gene technology also allows us to add a new gene to an organism. For example INGARD cotton, which has in-built resistance to the heliothis caterpillar. Ingard cotton has a gene from a common soil bacterium, *Bacillus thuringiensis* (Bt), that makes a chemical that kills insects. The cotton plant makes the chemical, but only in its leaves. When the caterpillar eats the leaves it dies.

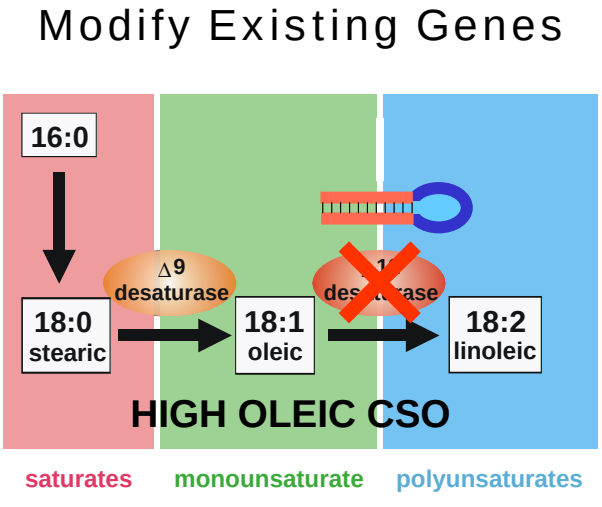
In Australia, Ingard cotton has been shown to require 50 per cent less chemical sprays than conventional cotton. That has been very good news for the environment and for the communities in cotton growing regions.

At the moment, Ingard cotton has a single gene. By 2003 we hope to have a variety with 2 Bt genes, which will see a further decline of chemical use by up to 90 per cent.

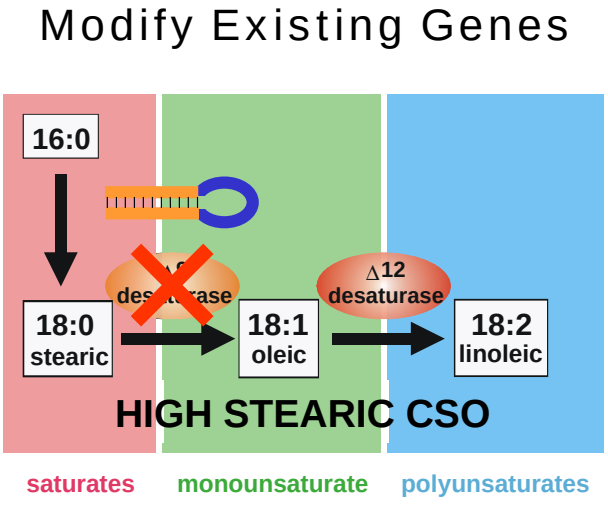
Management of the technology is critical — we've learned that through our experience with chemical pesticides where misuse or overuse has led to a build up of pest populations resistant to these chemicals.

Management of the technology is also critical because it provides a platform from which we can launch real integrated pest management (IPM) (Graph 8).

But probably gene technology's most important contri-



Graph 6.



Graph 7.

Add a New Gene

Graph 8.

bution is the new knowledge it is giving us about how plants, animals and ourselves develop and function through genomics.

Genomics allows us to identify single or multiple genes, and this has provided the basis of a major revolution in the capacities of biological research. The rate with which we have been able to increase understanding how plants work and how they grow is not comparable to anything in our history.

Genomics will enable us to better understand, for example, how a cotton plant might be able to be changed to better resist frost or even to grow in saline land or water logged land. It will also help us to understand the development of cotton fiber, and that knowledge may then be used to develop plants of specific or novel fiber qualities. (Graph 9)

Benefits

Benefits can be summed up from examples of the role of biotechnology – gene technology – in cotton (Graph 10).

- The technology has the potential to help us increase yields and also to beat pests and diseases by allowing us to achieve better management of them.
- It can bring us lint with increased market value and healthier, higher value seed oils.
- Gene technology offers us a way to a cleaner environment, for example by reducing the use of chemical sprays to control pests and we're seeing that already in the Australian experience.
- All of these benefits can create IP and therefore assets for the cotton industry.

Gene Technology: Benefits

The Science – what can it do?

- **Greater yields, beat pests and diseases**
- **Lint with increased market value, higher value seed oils**
- **Cleaner environment**
- **IP — assets for cotton industry**

Graph 10.

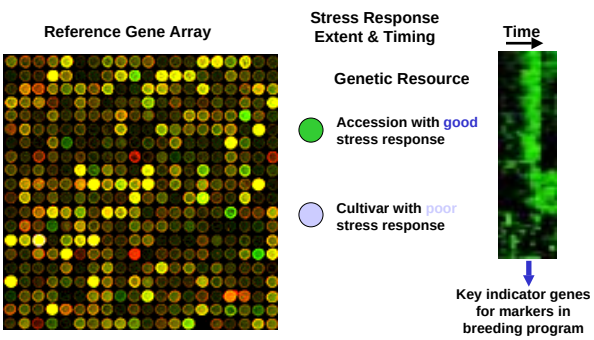
IP is one of the most important features of gene technology. It's also a complex, but worthwhile feature. (Graph 11)

IP — so important in manufacturing industries and in information technology industries — is now critical in agribusiness. Biotechnology, with information technology, has made agriculture a new economy, and the cotton industry has to be smart about IP to develop it, keep it and share its benefits.

Current Status (Graph 12)

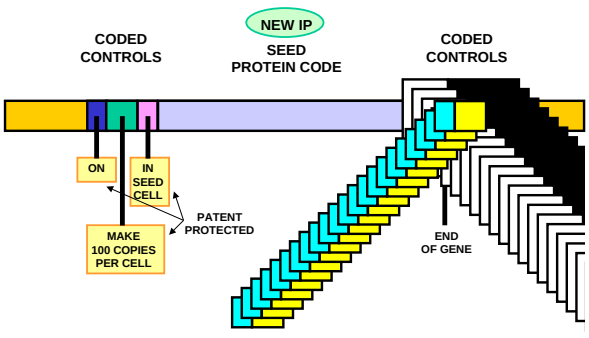
Where is gene technology at in cotton? Some of points mentioned earlier are:

Identify Multiple Genes



Graph 9.

Gene Constructs and Intellectual Property



Graph 11.

Current Status

The Science – where is it at?

- New knowledge at unprecedented rate
- Increased efficiency of breeding
- Generating IP
- Producing results - Safety tests at all stages
- Transgenic crops - 43 million ha worldwide
- Community concern - confusing messages

Graph 12.

Cotton Opportunities

- Provide sustainable agriculture
- Ensure environmental security
- Ensure human health and safety
- Promote trust in regulatory system
- Increase awareness of gene technology

Graph 13.

- New knowledge at unprecedented rate – genomics
- Increased efficiency of breeding – use of markers in breeding programs
- Generating IP – through new knowledge
- Producing results - Safety tests at all stages – INGARD cotton as an example
- Transgenic crops – 43 million ha worldwide – a major part of which is cotton
- Community concern – confusing messages. The cotton industry has the opportunity to set an example. There is a very real need to communicate with the community to work with them, to understand their concerns and raise awareness of what the technology can do, how it will be used, how it will be regulated, how it will affect them. We need to get balance back into the gene technology discussion – we all owe the community that.

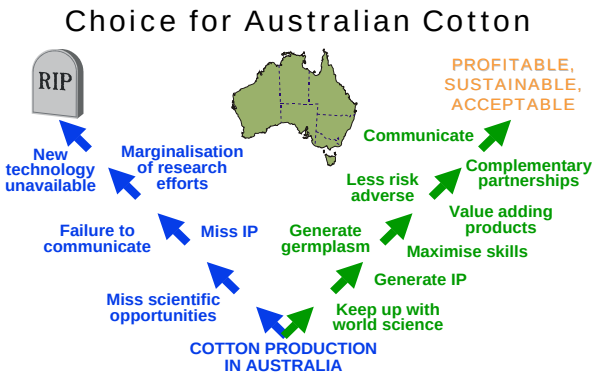
Cotton Opportunities (Graph 13)

There are some major opportunities for biotechnology in the international cotton community because of the range of products it potentially offers and the range of benefits it could bring:

- An opportunity to provide sustainable agriculture
- To ensure environmental security
- To ensure human health and safety
- To promote trust in regulatory systems
- To communicate and increase the awareness of gene technology

In conclusion, what lies ahead for the Australian industry and this probably applies to the cotton industry in many other countries. The cotton industry has two choices to make about the role of gene technology and it has to be clearly understood that the choices it makes now, will have impacts on its future survival.

- The Australian industry can choose not to go down the path of using biotechnology. But faced with an ongoing battle against pests and diseases, the need to be sustainable and to ensure a clean and healthy environment, as well as develop new and better varieties to meet consumer expectations, which would be an unwise choice.
- If the industry chooses to include biotechnology as having a role in the industry, this will lead to a profitable and sustainable industry using a technology that is acceptable to the public.



Graph 14.