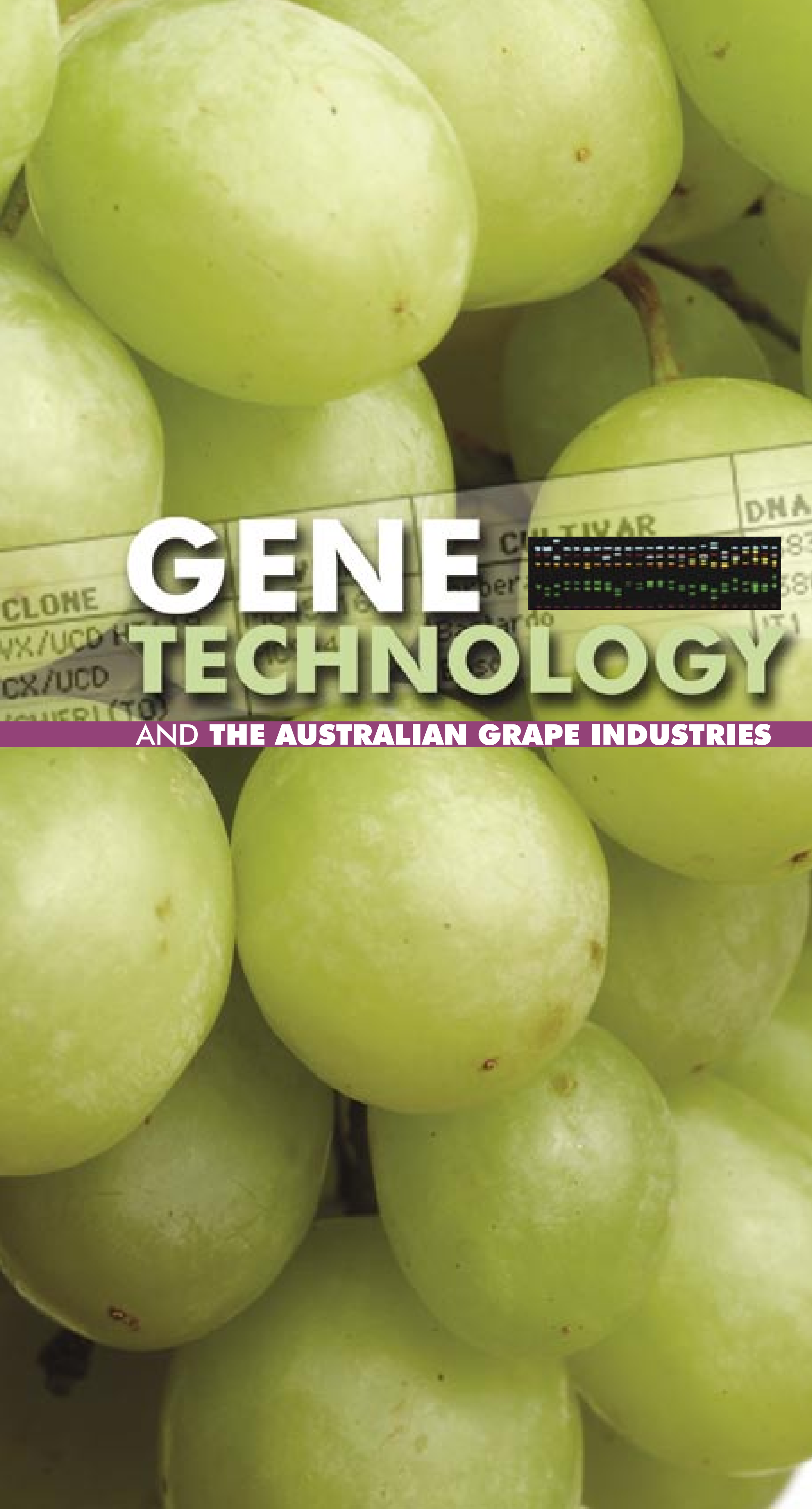
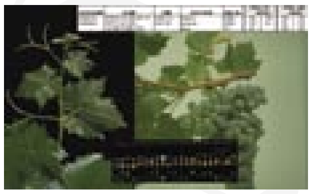
COOPERATIVE RESEARCH CENTRE *for* VITICULTURE



GENE TECHNOLOGY

AND THE AUSTRALIAN GRAPE INDUSTRIES

Number 3



Genomics – the foundation for 21st century vine research

INTRODUCTION

One very useful example of genomic research is grapevine DNA fingerprinting, pioneered by CSIRO Plant Industry, working within the first CRC for Viticulture. Grape vine varieties can be identified by analysing grape vine tissue samples and comparing part of their genome to a database of 210 known root and scion stocks. This highly accurate system is used by the Agriculture Section of the Australian Genome Research Facility, working with the grape and wine research facility Provisor. The method is also used world-wide by researchers to look back in time to discover the origin and parentage of ancient traditional grapevine cultivars.

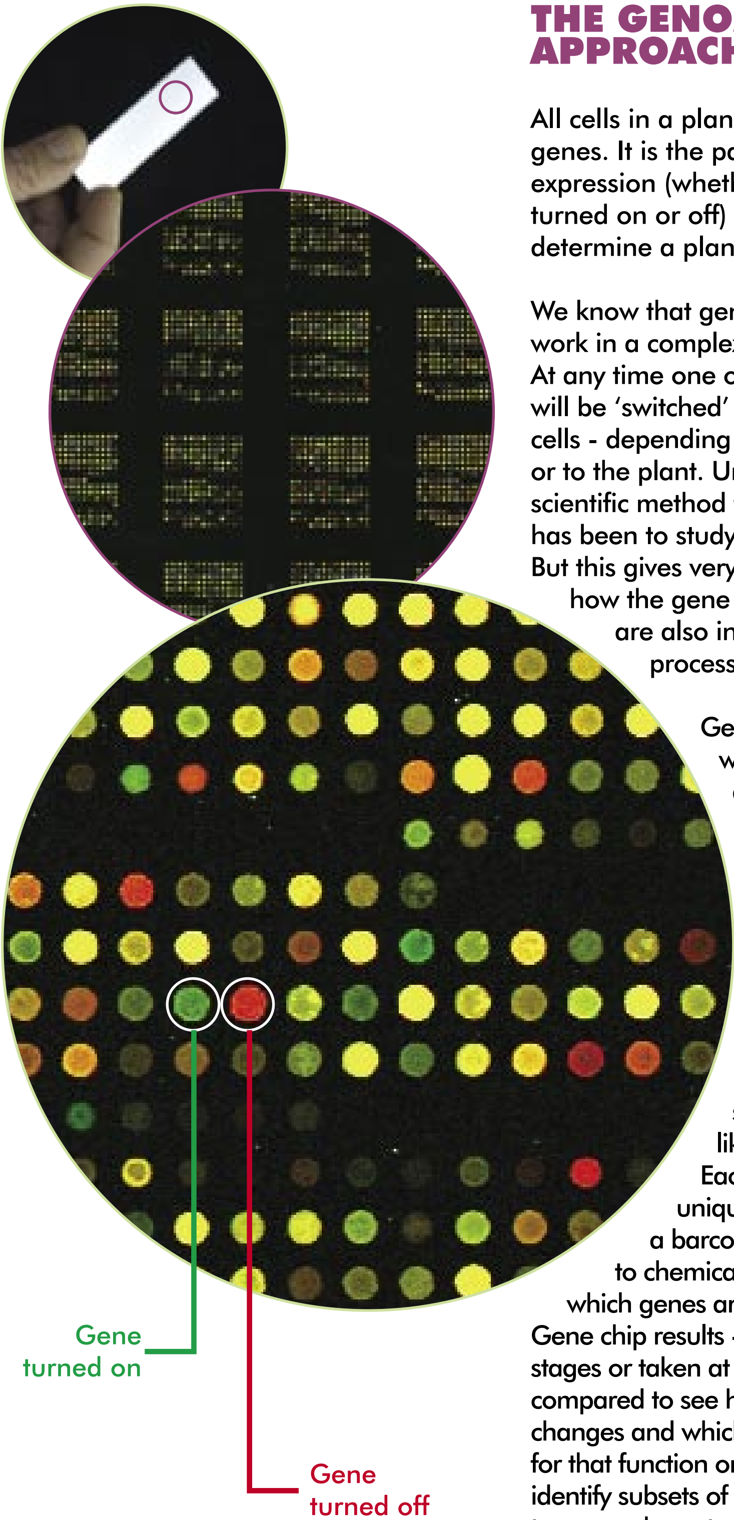
Gene Technology - the study and manipulation of DNA - began in the 1970s. As with any emerging field of research, new and increasingly efficient techniques have been developed and the rate of progress has accelerated. These days gene technology is faster and more precise than a decade ago - and it is generating more and more information.

The effect on R&D and agribusiness is becoming increasingly obvious. Agricultural chemical companies have become life science or biotechnology companies by using gene technology to produce better products. Researchers studying plant physiology, plant/ environment interactions and biochemistry are increasingly using the power of genes and genomics to help them understand specific processes.

One of the most exciting fields in gene technology research is the study of an organism's genome, known as genomics. The genome is the DNA of an organism; all of the genes on all of its chromosomes. The power of this approach lies in the fact that it can look at the genome as a whole rather than studying one gene at a time.

By scanning the whole genome it is possible to link unknown genes to important agronomic traits and to study how the interaction of genes modifies these traits.

INTRODUCTION



Grape gene microarrays - parallel expression analysis of thousands of genes

THE GENOMIC APPROACH

All cells in a plant contain the same genes. It is the pattern of gene expression (whether the genes are turned on or off) in particular cells that determine a plant's identity and function.

We know that genes in a living organism work in a complex and coordinated way. At any time one or more suites of genes will be 'switched' on or off - in particular cells - depending on what is happening in or to the plant. Until recently the common scientific method for investigating genes has been to study them one at a time. But this gives very little information about how the gene relates to others that are also involved in a particular process or function.

Genomics is becoming more widely used because of advances in supporting technologies. One technique that makes the genomic approach possible uses DNA microarrays. Simply put, a microarray is a slide or 'gene chip' bearing a small part of each gene in the form of small DNA spots, printed like microdots on the chip. Each gene is identified by its unique sequence, much like a barcode. The chip is subjected to chemical treatments that show which genes are active or inactive. Gene chip results - from different berry stages or taken at different times - can be compared to see how gene expression changes and which genes are important for that function or process. Gene chips can identify subsets of genes that are relevant to grape characteristics such as quality and fruitfulness, providing information for future research into physiology and improved management techniques.

WHAT IS A GENOME?

Each species has a unique genome - with a varying number of chromosomes and genes. Arabidopsis - the model species used in much plant research - has 25,000 genes while humans have approximately 30,000 genes. Grapevine is estimated to have about 25,000 genes.The DNA sequences, or patterns, of the entire genome of some species, including humans, have already been determined. Economically important animals and plants of the world - including cereals, vegetable crops and tree species - are now the subject of concentrated research effort.

THE RESEARCH

The Cooperative Research Centre for Viticulture (CRCV) Grapevine Gene Discovery Project is based at the CSIRO Plant Industry Horticulture Unit in Adelaide. The goal of this research is to identify genes that have a role in grape quality, development and productivity.

This is a tall order, but up-to-date, gene chip techniques are reducing the task to achievable proportions. The CRCV research group is a part of the International Grape Genome Program which has already isolated about half of the grapevine's 25,000 or so genes.

Since the grape berry is pivotal to wine quality, it is a logical place to focus effort. The starting point in gene chip analysis is to look at a large number of genes and compare gene expression in different varieties or at different developmental stages to find a suite of potentially key genes controlling specific processes.

The researchers have been comparing gene expression in grapes grown under different management regimes and at different times of berry development. This will eventually build up a picture of berry gene expression across a growing season. This information can then be linked to the biochemical and physiological aspects of berry development and quality to determine how they are controlled and by which genes.

THE INTERNATIONAL GRAPE GENOME PROGRAM

CRCV Program 3 researchers are part of the International Grape Genome Program, an international collaboration involving Australia, France, the United States, Chile, Germany, Italy, South Africa and Spain. This kind of cooperation, between countries and research agencies with common goals, is becoming more common and the benefits are obvious. Such collaborations make best use of research funds and effort, minimising duplication and encouraging researchers to share information and adopt best practice.

Some of the goals of the Program are:
- discovery of all the genes in the grapevine genome;
- development of a framework for a genetic map of the genome;
- production of genetic maps based on new DNA marker types; and
- application of the information for improving vines, grapes and wine.

A detailed map of the grapevine genome, while a long-term outcome, will form the foundation for future viticultural research, where any aspect of the vine, such as growth, disease resistance or berry quality, can be traced back to the genes involved. This will give researchers an enormously powerful, precise and effective basis for further vine research and will also help guide industry in selection and management of vines.

Go to www.vitaceae.org for more information about the International Grape Genome Program

THE POWER OF ONE GENE

Example one: FRUITFULNESS

If there was any doubt about the impact just one gene could make in grapevines (and many other plants), consider the gene that controls gibberellic acid (GA) perception. GA is a plant growth hormone produced in different parts of the plant at different times during development. GA is often sprayed onto seedless table grapes to produce larger berries.

The significance of GA became clear during the 1960s, when the breeding of crops with a reduced response to GA during development gave us high-yielding cereal varieties with much less vegetative growth.

Upper - Main shoot of the Pinot Meunier mutant plant showing bunches but no tendrils
Lower - Main shoot of the Pinot Noir plant with tendrils only

CRCV researchers at CSIRO Plant Industry's Adelaide laboratory discovered that Pinot Meunier, a sport or deviation of Pinot Noir, contained a reduced GA response gene. In Pinot Meunier the presence of the gene is indicated by the hairiness of the leaves, but its action is masked because another normal copy of the gene is also present.

Through tissue culture, the cells containing the different genes were separated and grown into two separate plants. One was a normal Pinot Noir but the other, containing a mutation in the GA response gene, was a dwarf vine, which formed bunches of fruit where there would otherwise be tendrils.

The Pinot Meunier mutant may help unravel the secret of the vine's fruitfulness. The researchers are now looking more closely at the mutant - particularly investigating fruitfulness and performance in the vineyard. These dramatic changes in vine growth and flowering are brought about by a natural mutation in just one gene that alters response to GA.

THE POWER OF TWO GENES

Example Two: GRAPE COLOUR

Red grapes are a result of the production of red pigment (anthocyanin) within the berry skin. The process is controlled by two similar genes, either of which can turn on colour synthesis.

Researchers in the CRC for Viticulture and CSIRO Plant Industry have discovered that white grapes are the result of mutations in these two genes thousands of years ago.

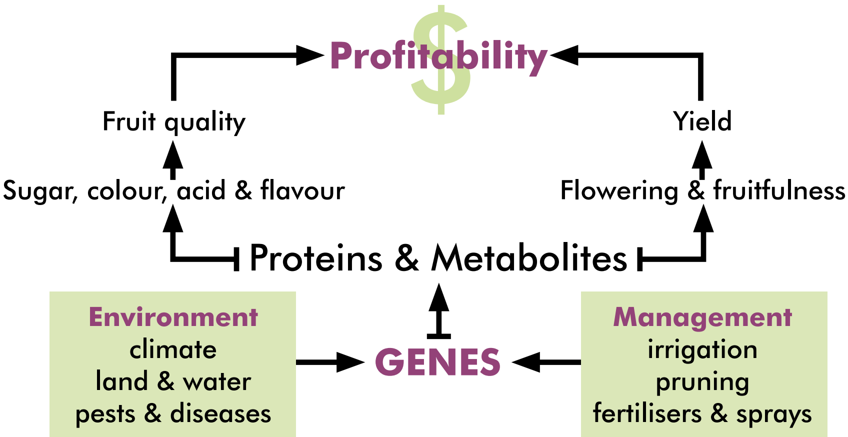
Originally all grape vines produced red berries. Rare and unrelated genetic mutations inactivated both genes in a red-berried parent vine, giving rise to seedlings which included the first white-berried grapevines. All of the modern white grape varieties are the result of ancient mutations in these two genes, giving rise to the white wines we enjoy today.

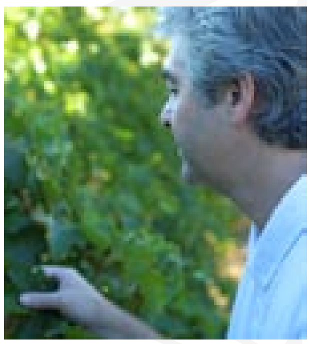
By looking for the two genes that control grape colour, researchers have produced a marker that can be used in vine breeding to predict colour in the next generation of vines, without waiting for the vines to fruit.

This important discovery could also lead to the production of new grape varieties with enhanced colour in the fruit.

GENES x ENVIRONMENT x MANAGEMENT

Genomics may help researchers better understand the relative importance of three factors that determine how well plants perform under given conditions. Genes, the environment and viticultural management all have an impact on the plant's performance. Using genomics it is possible to see how both the environment and management affect individual gene activity, and how this influences vine performance and fruit quality. This information will provide the basis for improved viticultural practices in the future.





COOPERATIVE
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for
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TO FIND OUT MORE...

There is a huge amount of information about gene technology.
To begin with you might wish to look at some of the many web sites.

Cooperative Research Centre for Viticulture (CRCV)
www.crcv.com.au

CSIRO
www.csiro.au

International Grape Genome Project
www.vitaceae.org

Australian Genome Research Facility
www.agrf.org.au

Provisor
www.provisor.com.au

Grape and Wine Research and Development
www.gwrdc.com.au/

Biotechnology Australia
www.biotechnology.gov.au

The Cooperative Research Centre for Viticulture is a joint venture between Australia's viticulture industry and leading research and education organisations. It promotes cooperative scientific research to accelerate quality viticultural management from vine to palate.

Australian grapegrowers and winemakers are key stakeholders in the CRCV, contributing levies matched by the Australian Government and invested by the Grape and Wine Research and Development Corporation in the Centre.

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