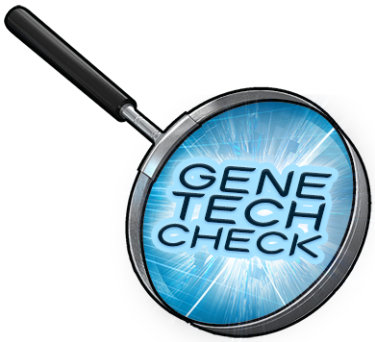
Part 6.4

Cleverly Used Genes?

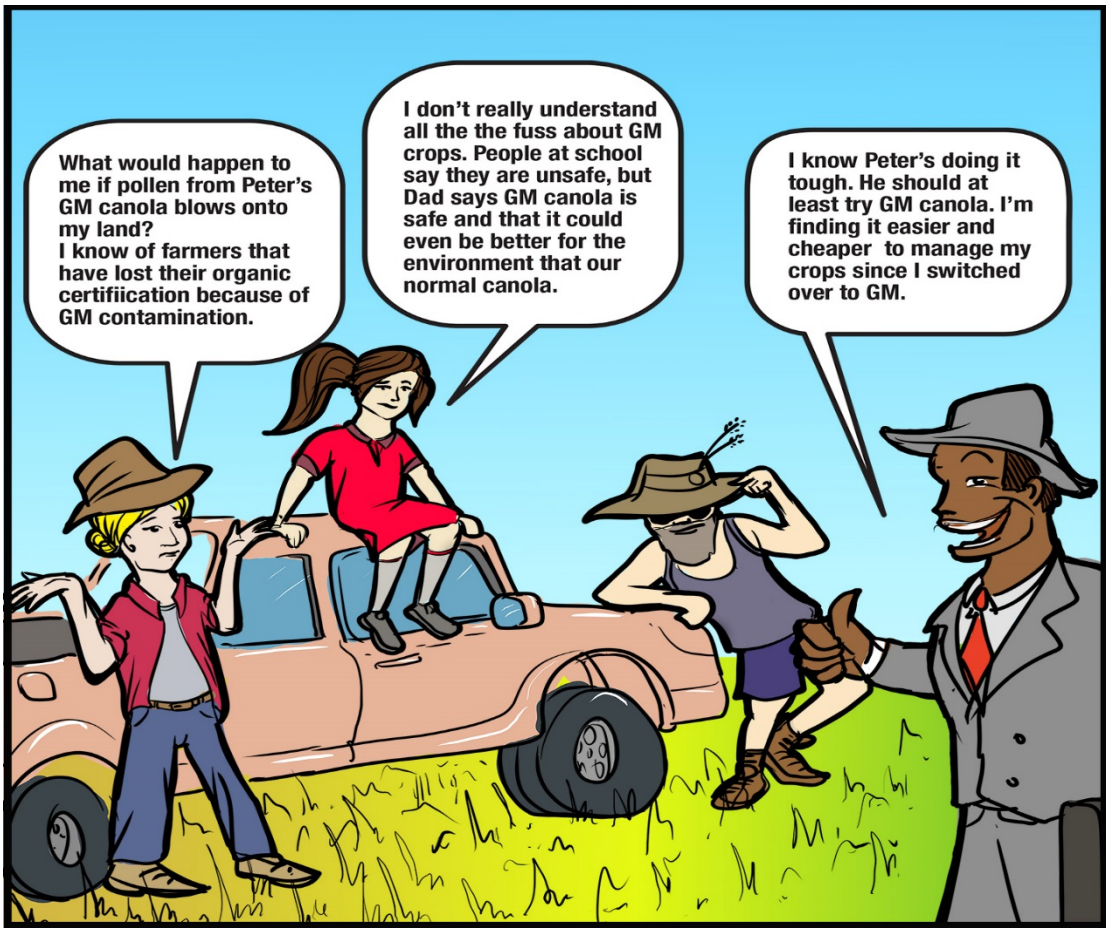


Story card

Peter and his family live on a small farm in Western Australia. Peter works long hours on the farm, six to seven days a week, making a modest income to support his family. In addition to several other crops, Peter has been growing canola on his farm for the last 10 years (canola is a plant that is grown for its oil, which is used in products like margarine and cooking oil). His canola crops have been affected by weeds though, which have reduced his yields. Peter battles weeds in his canola crops by spraying them with a range of costly herbicides. He worries about the effect of these herbicides on the environment.

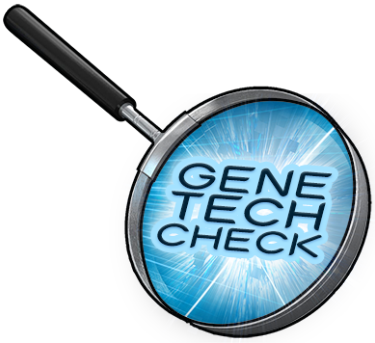
Peter's friend, Geoff, farms genetically modified (GM) canola that has been modified to be resistant to a particular herbicide. This herbicide kills a range of different weeds, so Geoff can spray his crops with fewer herbicides to kill weeds, without affecting his canola plants. Peter wants to try growing GM canola, because he thinks it will make the crops easier to manage and increase his yields. His daughter, Leah, is unsure about her dad's idea to try growing GM canola, it might make life easier, but her friends say GM crops are unsafe and controlled by large money-grabbing companies. Peter's neighbour, Sally, who is an organic farmer, has told him he shouldn't grow unnatural GM crops that could contaminate her farm.

Should Peter try growing GM canola?



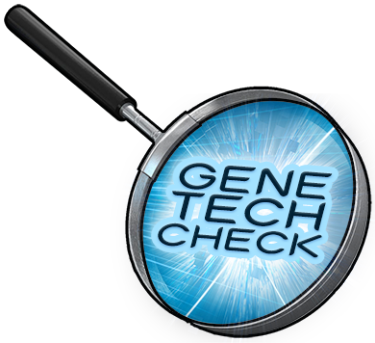
Issue card

Do we know enough about the safety of GM foods to be eating them?



Issue card

Are GM plants good news or bad news for the environment?

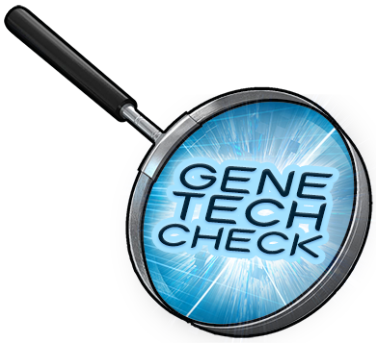


Issue card

Do we really need GM crops?

Issue card

Do GM plants benefit small farmers, or are they just a tool for large companies to make money?



Issue card

Should Peter have the right to grow GM plants next to an organic farm?

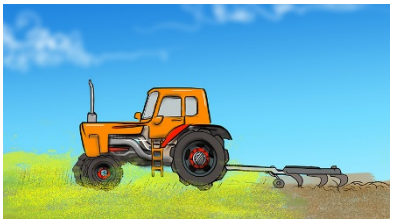
Issue card

Is it right to interfere with nature by moving genes between species?

Information card

Controlling weeds in canola

Weeds affect canola crops by competing for nutrients, sunlight and water. Farmers can reduce weeds mechanically (by tilling), but this degrades the topsoil.



To reduce the need for tilling, many farmers use herbicides to kill weeds. With conventional canola, they apply herbicide before planting, to clear the field of weeds. Later, the growing crop is often sprayed with a different herbicide to remove clover, thistles and capeweed. Grassy weeds are controlled by different herbicides again.

TURN OVER

Information card

Controlling weeds in canola (side 2)

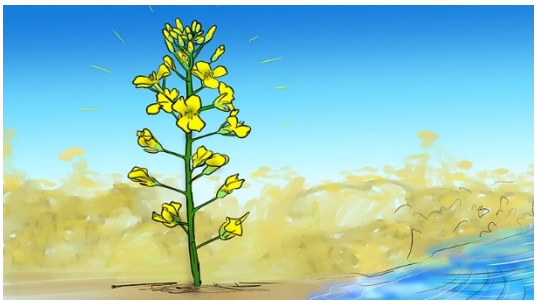
Broad spectrum herbicides are herbicides that kill a broad range of weeds. They can't normally be used on growing canola crops, because they also kill canola. GM canola has been developed to be resistant to particular broad spectrum herbicides.

Being able to use one herbicide to kill a range of weeds in the growing crop, means farmers can reduce their herbicide use.

Information card

GM crops: Benefits to the environment

One type of GM canola allows farmers to use the broad spectrum herbicide glyphosate (Roundup®). Glyphosate is better for the environment than many of the herbicides it replaces, because it is less toxic and less likely to contaminate waterways and soils.



Because broad spectrum herbicides remove a broad range of weeds, farmers growing GM canola can use fewer herbicides.

TURN OVER

Information card

GM crops: Benefits to the environment (side 2)

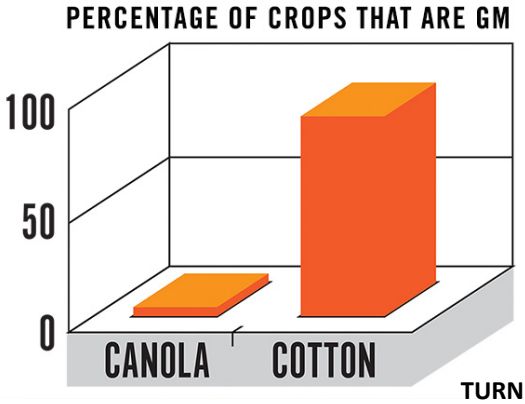
GM canola reduces the need for tilling prior to planting. A reduction in tilling, helps to protect soils from erosion, nutrient and water loss.

On a global scale, GM crops have reduced pesticide use, CO_2 emissions, and land clearing for agriculture (due to increased yields).

Information card

How common are GM crops in Australia?

- The only commercially grown GM crops in Australia are cotton and canola.
- Pest and/or herbicide-resistant GM cotton has been grown in Australia since 1996, and herbicide resistant GM canola since 2008.

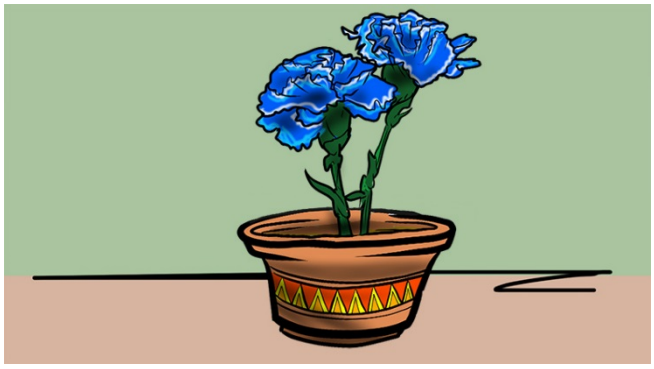


TURN OVER

Information card

How common are GM crops in Australia? (side 2)

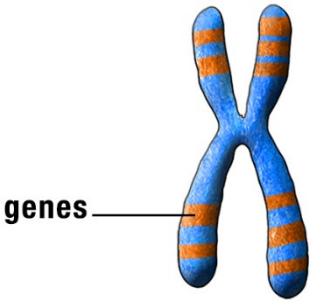
GM carnation plants that were developed for their blue colour (by a company in Melbourne) are commercially available in Australia.



Information card

Genes

Most of the DNA in cells is packaged into chromosomes. Genes are arranged along these chromosomes and carry the instructions to make molecules, such as proteins. To function properly, each cell depends on thousands of proteins doing the right job, in the right place, at the right time.

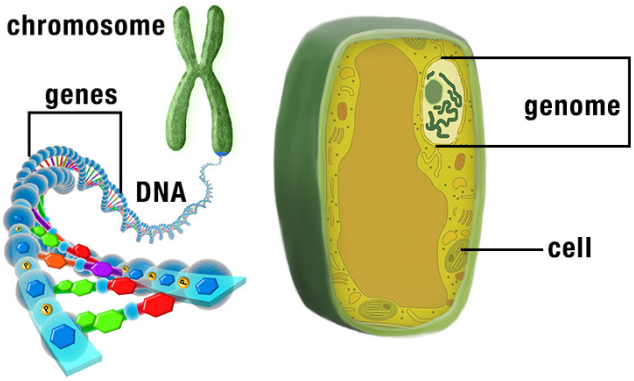


TURN OVER

Information card

Genes (side 2)

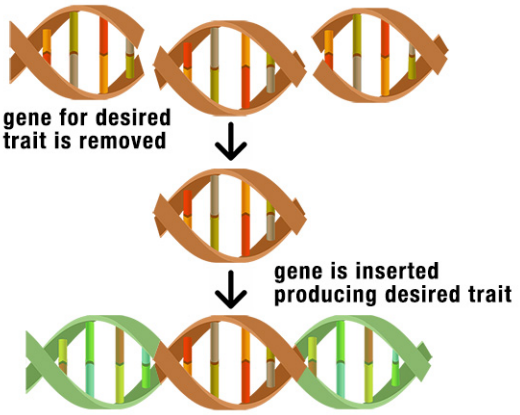
A plant's complete set of DNA, containing all the instructions required to make it, is called its genome.



Information card

GM technology

A genetically modified organism (GMO) is one that has had its DNA sequence changed by inserting (or removing) a gene.

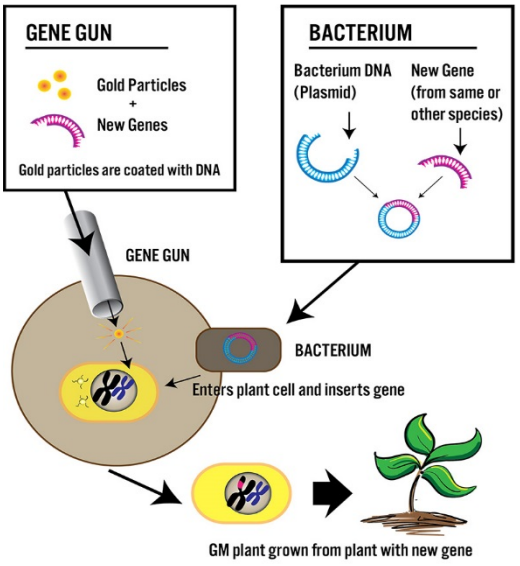


TURN OVER

Information card

GM technology (side 2)

In plants, the gene for a desired trait (like pest resistance) can be inserted into the plant's genome using a bacterium or a miniature gun.



Information card

GM crops: Effects on the environment

Some groups are concerned that:

- GM plants could cross-breed with other plants, transferring genes (e.g. for herbicide resistance) into plants in the environment.

- Pest-resistant GM plants produce a substance that could be toxic to non-target insect species and could affect soil health.

TURN OVER

Information card

GM crops: Effects on the environment (side 2)

- GM seeds could escape into the environment.

Information card

GM crops and multinationals

Are GM plants just a way for large companies to control agriculture and make money? Or are companies justified in expecting a return on their investment in developing, testing and getting approvals for GM plants?

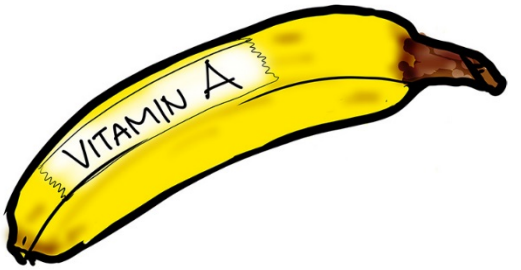
- Farmers that grow GM crops often have a contract with the company that owns the technology. This sets out conditions for growing the plants, and requires farmers to buy new seed each year, rather than being able to save seed from this year's crop to plant next year.

TURN OVER

Information card

GM crops and multinationals (side 2)

- Some non-profit organisations provide GM technology for free, such as GM plants that are rich in nutrients for people in developing countries.



- GM crops benefit both small- and large-scale farmers. In 2013, over 90% of farmers who chose to grow biotech crops, were small, poor farmers in developing countries.

Information card

Regulating GM crops in Australia

GM crops are regulated through the Commonwealth *Gene Technology Act 2000* and state legislation. This aims to identify and manage any risks with gene technology. Federal approval is needed to be able to release GM plants in Australia.

The decision on whether to allow GM crops to be grown, is up to individual states. Tasmania and the ACT, for example, don't allow commercial GM crops.

TURN OVER

Information card

Regulating GM crops in Australia (side 2)

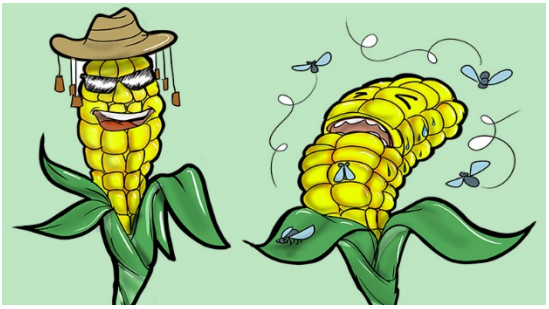
All genetically modified (GM) foods must be assessed for safety by Food Standards Australia New Zealand (FSANZ). Foods from GM crops must be labelled with the words "genetically modified", to give people a choice in what they eat.

Information card

GM crops: Agricultural benefits

GM crops can:

- reduce pests and weeds
- reduce pesticide use
- increase yields and profits
- reduce plant diseases



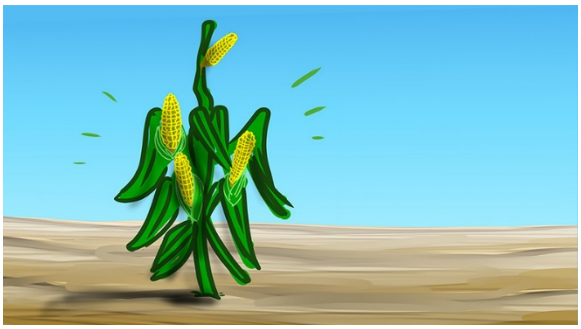
TURN OVER

Information card

GM crops: Agricultural benefits (side 2)

GM crops can:

- reduce management costs
- reduce the need for tilling, which can degrade soil quality
- allow crops to be grown in poor conditions (e.g. low water, high salinity)



Information card

GM food safety

Toxicity and allergens

Some people are concerned that inserting new genes into plant cells, could let the plant produce proteins that are toxic, or cause an allergic reaction. Before they are approved, GM foods are carefully assessed for toxins and allergens.

Naturally occurring allergens (such as in peanuts), can actually be removed from foods through genetic modification.

Nutrition

GM foods are nutritionally comparable to their non GM counterparts, if not better. For example, Australia is developing GM bananas that are high in vitamin A, to help fight vitamin A deficiency in developing countries.

TURN OVER

Information card

GM food safety (side 2)

Antibiotic resistance

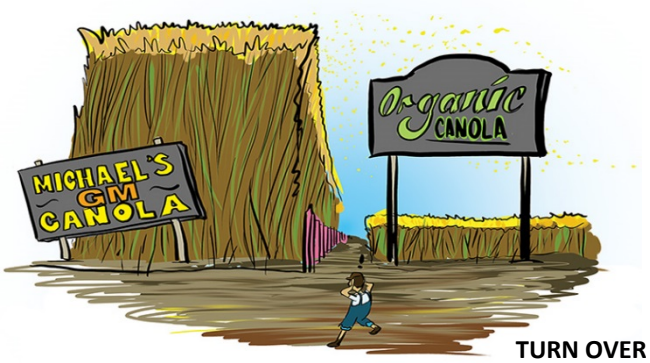
Some people are concerned that GM food could transfer antibiotic resistance genes to bacteria in our bodies, making diseases harder to treat with antibiotics.

After numerous studies, the World Health Organization and the European Commission have concluded that foods from GM crops are as safe as conventional foods.

Information card

Growing GM crops near organic farms

An organic farmer in Western Australia lost his organic certification when GM material was found on his property. In 2014, he sued his neighbour, a GM farmer. Lawyers for the organic farmer said that the GM seeds should have been contained better, while the GM farmer maintained that the organic certification process was unreasonable.



TURN OVER

Information card

Growing GM crops near organic farms (side 2)

The WA Supreme Court ruled that the GM farmer could not be held responsible for growing a legal GM crop in a conventional way.

Information card

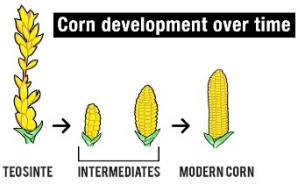
Social and ethical issues

Anti-GM

- Some believe it isn't right to interfere with nature by changing an organism's genes.
- Global food shortages are caused more by economics and politics, than by farm production.
- Large companies could dominate global agriculture through GM.

Pro-GM

- Traditional breeding has been selecting for desired genes for thousands of years.
- Genes are transferred between different species in the natural environment.
- GM crops benefit both small and large-scale farmers.



TURN OVER

Information card

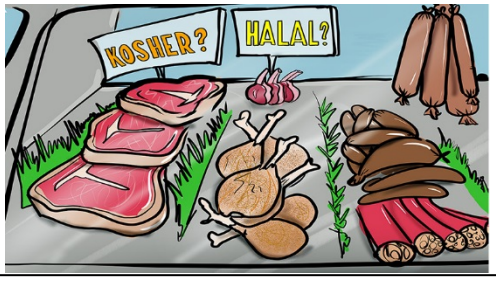
Social and ethical issues (side 2)

Anti-GM

- GM food (e.g. with pig DNA) could create problems for some religious groups (there is no consensus within the major religions regarding GM).

Pro-GM

- GM food can help to alleviate hunger, improve nutrition and benefit mankind.
- People are given the right to choose whether to buy GM products in Australia through labelling.



Information card

Canola

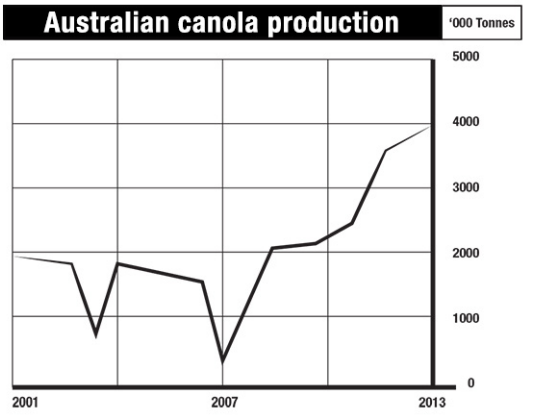
Canola is a member of the Brassicaceae family, which also includes cabbages, broccoli and cauliflower. It is grown for its seeds, which are rich in oil. Canola oil is used in food products like margarine and cooking oil. The seed matter, left after extracting the oil, is used in stock feed.

TURN OVER

Information card

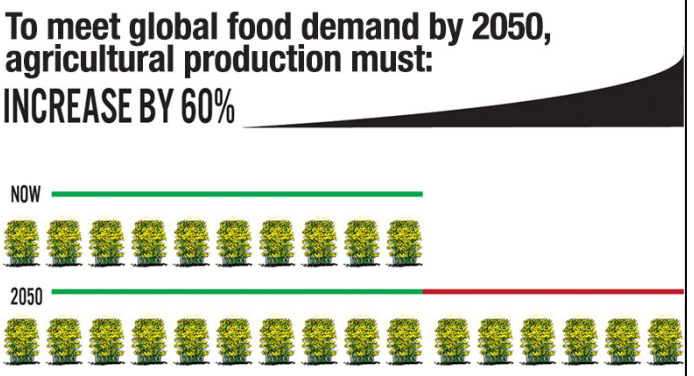
Canola (side 2)

Canola was first grown in Australia in 1969, with production rapidly expanding in recent years to become one of our most important crops, worth $2.3 billion in 2012-13.



Information card

Global food demand



TURN OVER

Information card

Global food demand (side 2)

Increased production to meet global food demand, should come from increasing yields, not from increasing the area of agricultural land. Clearing land for farming has environmental effects, including greenhouse gas emissions and loss of biodiversity.

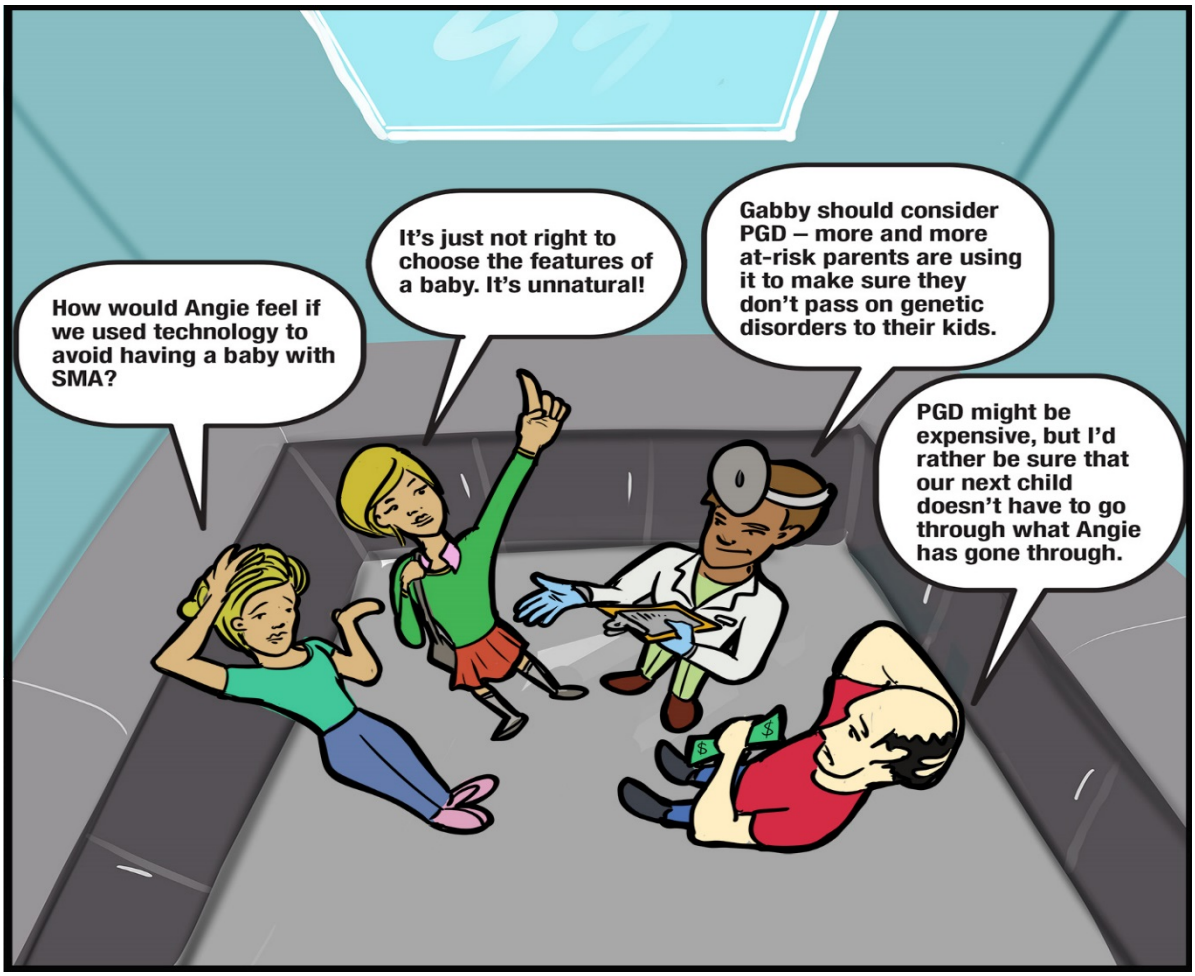
Story card

Angie will never be able to walk. She was born with Spinal Muscular Atrophy (SMA), a genetic condition that results in muscle wasting. Angie relies on her mum and dad to do everyday things like getting in and out of bed, going to the bathroom and getting dressed. She has problems breathing at night, and doctors have told her parents, Gabby and Phil, that she might not live beyond her teenage years.

Gabby and Phil want to have another child, but are worried because they have a one in four risk of having another child with SMA. Gabby's doctor has suggested that they consider a medical technique called PGD, which could help them have a child without the condition. PGD involves testing embryos for genetic disorders before they are implanted in the mother's uterus.

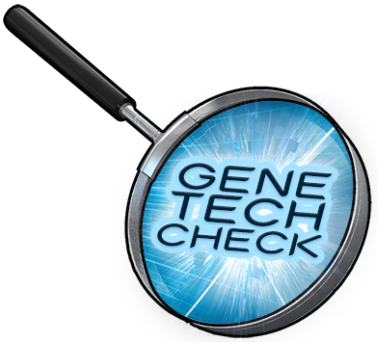
Gabby and Phil would love to make sure their next child doesn't have to suffer like Angie has, but Gabby is worried that using PGD might make Angie feel unwanted. Phil's sister, Beth, thinks it would be wrong to choose the features of their baby, she believes Gabby and Phil should leave things to nature.

Should Gabby and Phil use PGD to have a baby without spinal muscular atrophy?



Issue card

Who should be responsible for allowing genetic testing of embryos? The parents, doctors or the Government?



Issue card

Is it fair that PGD is only accessible to people like Phil and Gabby who can afford it?

Issue card

How would embryo selection to avoid a genetic disorder make people like Angie, who are living with the disorder, feel?

Issue card

Could PGD eventually lead to acceptance of ‘designer babies’ that are selected for features like physical appearance?

Issue card

Is it wrong for Phil and Gabby to choose the features of their baby?

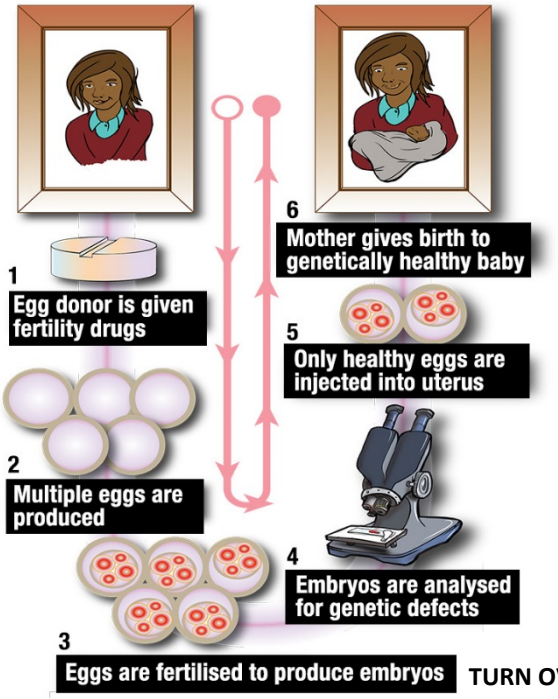
Should Phil and Gabby have the right to prevent development of a baby that will suffer with the disorder?

Issue card

Is IVF with PGD worth the risk to the embryo?

Information card

What is PGD?



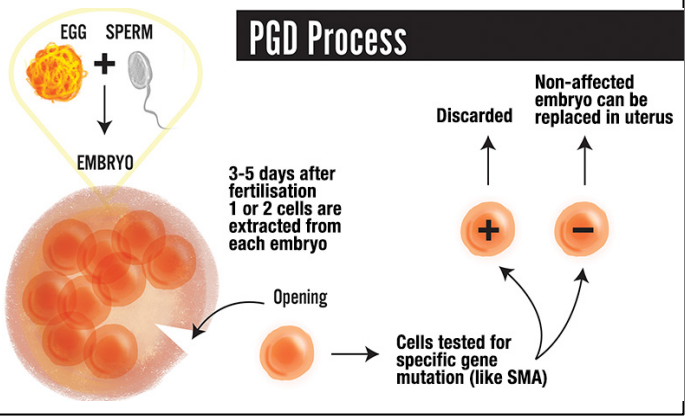
TURN OVER

Information card

What is PGD? (side 2)

PGD stands for preimplantation genetic diagnosis. This technology allows parents to select for particular characteristics in their children, usually to avoid certain genetic disorders.

In PGD, embryos are produced outside the mother's body (through IVF). They are then tested for the disorder and only 'healthy' embryos are implanted in the mother's uterus.



Information card

Ethical issues with embryo selection

- Only available to those who can pay for it.
- Some people think it is wrong to choose the features of a baby.
- By selecting against a disorder, it could create discrimination issues for people living with that disorder.

TURN OVER

Information card

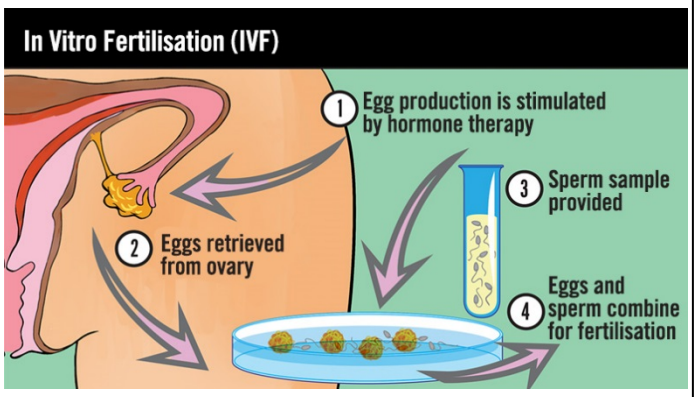
Ethics of embryo selection (side 2)

- Could lead to acceptance of 'designer babies' that are chosen for non-health characteristics e.g. intelligence, athletic ability, height, hair colour.
- Some people think it is wrong to discard unwanted embryos from PGD.
- what counts as a serious genetic condition is unclear.

Information card

What is IVF?

IVF stands for '*in vitro* fertilisation'. It is a technique that is used to help couples with fertility issues to have children. In IVF, eggs and sperm are combined outside the woman's body (*in vitro* – in a glass dish) to create an embryo.

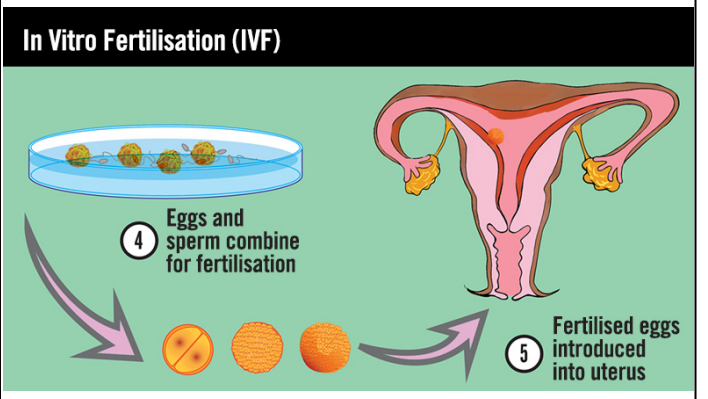


TURN OVER

Information card

What is IVF? (side 2)

Embryos are grown in the laboratory over two to five days, before being transferred into the woman's uterus.

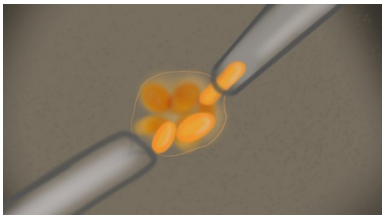


Information card

Uses of PGD

PGD can be used to help parents with a family history of a genetic disorder to have children without the disorder:

- by selecting embryos of one sex, when the disorder only affects males or females.
- by testing embryos for genes that cause a serious genetic disease (e.g. cystic fibrosis or spinal muscular atrophy).
- by testing for genes that can increase the risk of getting a disease or disorder (e.g. breast cancer).



In some countries, couples can choose the sex of their baby for non-medical reasons.

TURN OVER

Information card

Uses of PGD (side 2)

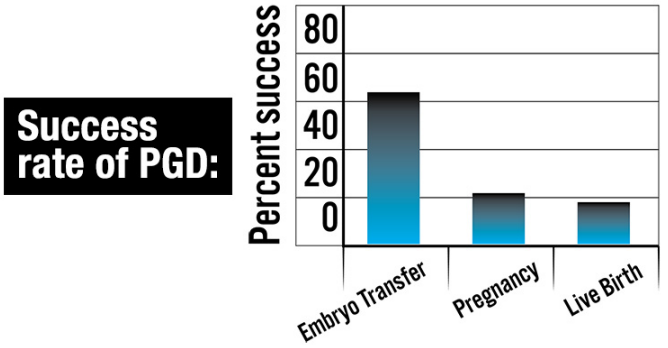
PGD has also been used by some couples to create a child that can be a blood or tissue donor for a sick sibling.

Alternative diagnosis methods (like ultrasound), test for disorders during pregnancy. If the test shows the disorder, parents may be faced with the difficult decision of whether or not to terminate the pregnancy. PGD avoids this dilemma by testing for a disorder before pregn

Information card

Success rates

Like IVF, the success of PGD can't be guaranteed. Problems can occur at each step in the process. The graph below shows the success rate in Australia (in 2011) from a total of 1182 cases of PGD.



Source: UNSW 2013

Information card

Information card

Costs of PGD

There are large out-of-pocket costs for IVF with PGD in Australia:

- IVF per cycle (after Medicare rebate) $3000-$4000
- PGD up to $4000

TURN OVER

Information card

Costs of PGD (side 2)

Costs vary depending on the clinic and the genetic test. PGD is currently only available in private clinics, with no Medicare rebate.

Many couples go through several cycles before they have a successful pregnancy, multiplying the total cost.

Information card

Regulating PGD in Australia.

- PGD is not regulated by federal law.
- To be accredited, clinics must follow guidelines set out by the National Health and Medical Research Council .
- Sex selection is only allowed if it will reduce the risk of a serious genetic condition.

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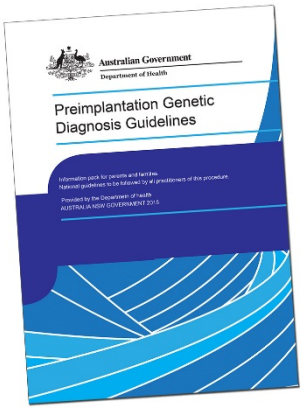


TURN OVER

Information card

Regulating PGD in Australia (side 2)

State and territory legislation varies. In some states, such as Victoria, PGD is directly addressed by legislation, while others rely on the national guidelines.

Information card

Spinal muscular atrophy (SMA)

SMA is a genetic condition affecting the nerves that control movement of muscles. This causes muscle weakness and can lead to problems with breathing, swallowing and walking.

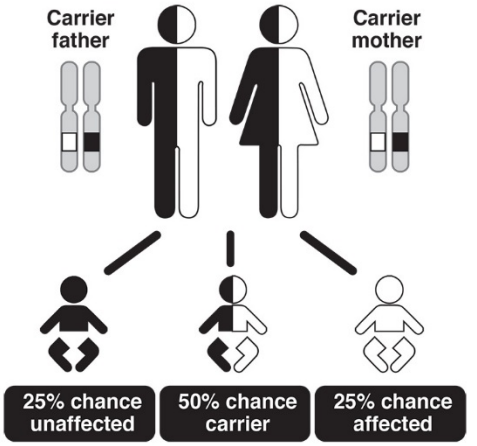
SMA is classified into types, depending on its severity. Babies with SMA type 1 usually die by the age of two. People with type 2 usually can't walk or stand without assistance, and have a reduced life expectancy. Although people with SMA type 3 and 4 are affected physically, they have a normal life expectancy.

TURN OVER

Information card

Spinal muscular atrophy (side 2)

SMA is caused by a recessive gene, so people with the condition have inherited two copies of the faulty gene (one from each parent).

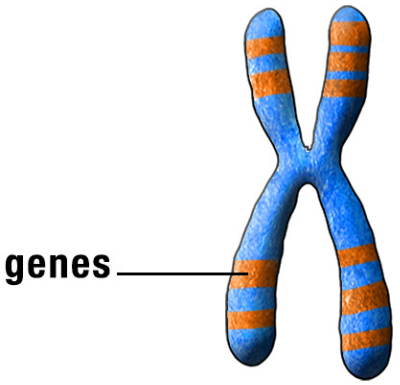


If both parents are carriers, they have a one in four chance of having a child with SMA.

Information card

Genes

Most of the DNA in cells is packaged into chromosomes. Genes are arranged along these chromosomes and carry the instructions to make molecules, such as proteins. To function properly, each cell depends on thousands of proteins doing the right job, in the right place, at the right time.

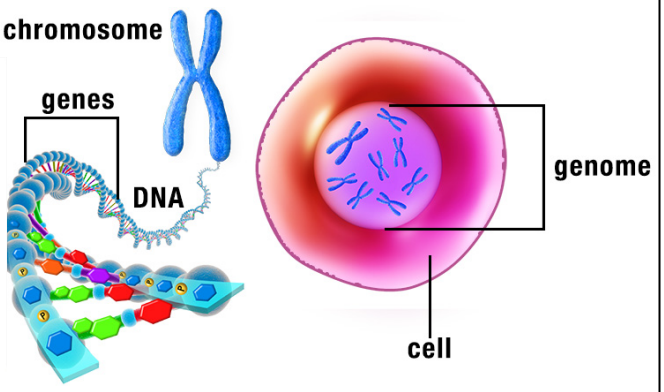


TURN OVER

Information card

Genes (side 2)

An organism's complete set of DNA, containing all the instructions required to make it, is called its genome.



Information card

The alternatives

For couples who are at risk of having a baby with a serious genetically inherited condition, their options are to:

- not have children
- risk having a baby with the condition
- use diagnostic testing to avoid having a baby with the condition

TURN OVER

Information card

The alternatives (side 2)

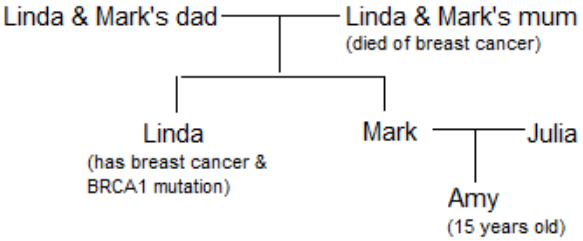
Diagnostic testing can be done:

- during pregnancy using ultrasound or by genetic testing. If results are positive, the couple may then face the difficult decision of whether to terminate the pregnancy.

- before pregnancy proceeds, by creating embryos outside the body and using PGD to only choose those without the condition.

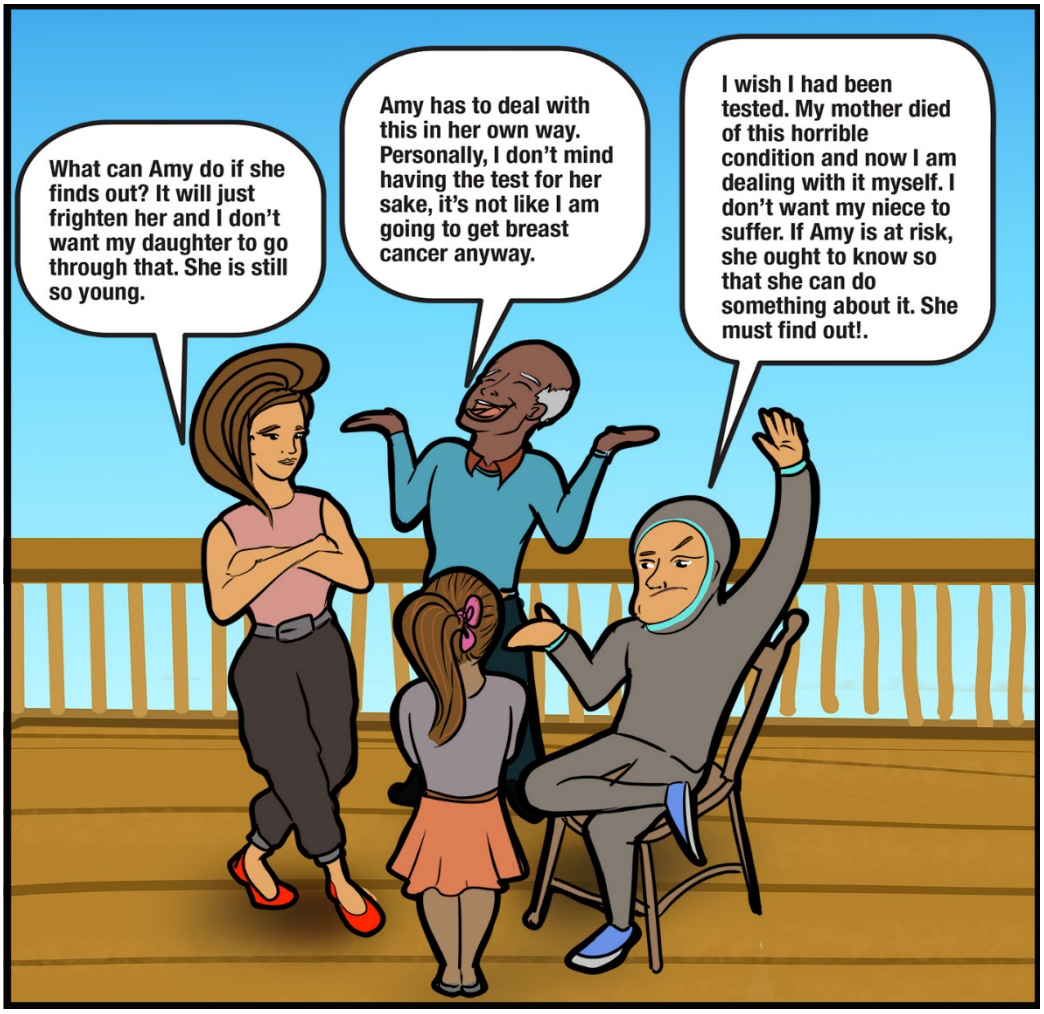
Story card

Amy is just 15. Her family has been rocked by the recent news that Amy's Auntie Linda has breast cancer. Amy's father Mark is especially worried about his sister Linda. Mark and Linda lost their mother to breast cancer shortly before Amy was born. A genetic test has revealed that Auntie Linda has a mutation of her *BRCA1* gene, which increases a person's risk of developing breast cancer.



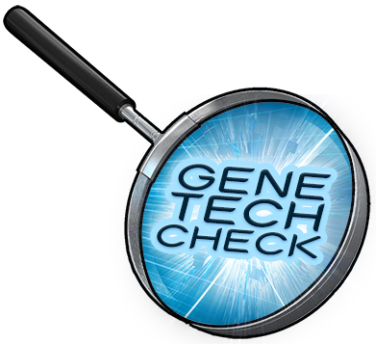
Amy wants to know if she also has the *BRCA1* mutation, but the standard procedure would be to test her father Mark first to see if he has the *BRCA1* mutation. If this is confirmed Amy could then have the test, as there is evidence that a direct relative carries the mutation. Mark is willing to be tested but Amy's mother, Julia, is against it. Julia thinks Amy is too young and is concerned about how Amy would react if she found out she was at risk of having the *BRCA1* mutation. Mark will only do the test if Julia and Amy can come to some agreement. Amy leads a healthy lifestyle – eating healthily and exercising regularly – but she is willing to do anything to avoid getting breast cancer. (cards adapted from *Genome Generation*, Genome Research Ltd)

Should Amy insist on her father Mark being tested for the *BRCA1* mutation?



Issue card

Is it better to find out as early as possible or is Amy too young to cope with this type of information?



Issue card

If Mark takes the test, who should have access to his results?

Issue card

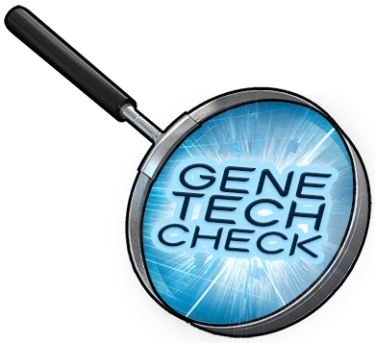
If Amy discovers she may be at risk, what should she do next? For example, should she have the test for the *BRCA1* mutation herself?

Issue card

If Mark discovers that he does not have the *BRCA1* mutation, how will that impact Amy and the rest of the family? What does Amy gain from knowing that information?

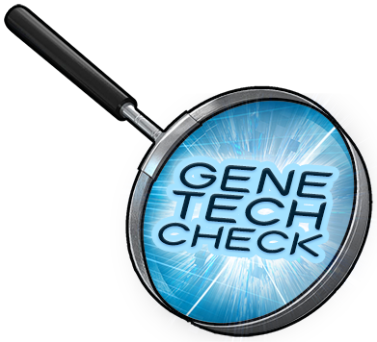
Issue card

Should this test be freely available to everyone through Medicare?



Issue card

If Mark discovers that he does have the *BRCA1* mutation what does that mean for him?

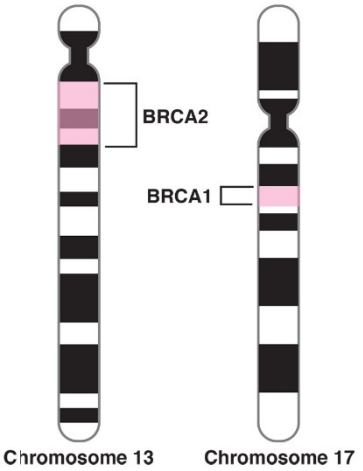


Information card

The genetics of breast cancer

Mutations in the *BRCA1* and *BRCA2* genes are strongly linked to breast cancer risk. They are also linked to an increased risk of ovarian cancer.

- Women with a *BRCA1* mutation have a 75-85% lifetime risk of developing breast cancer.
- Women with a *BRCA2* mutation have a 50-80% lifetime risk of developing breast cancer.



TURN OVER

Information card

The genetics of breast cancer (side 2)

Fewer than 1 in 500 women carry a high-risk mutation for breast cancer.

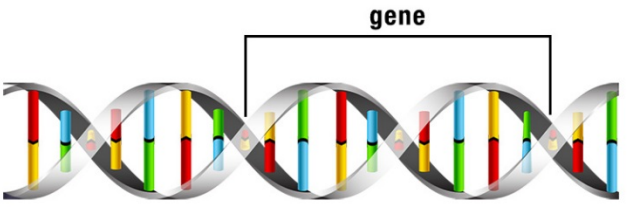
If a person carries a mutated copy of the *BRCA1* or *BRCA2* gene, it does not mean they will definitely develop cancer.

- Women with a *BRCA1* mutation have a 75-85% lifetime risk of developing breast cancer.
- Women with a *BRCA2* mutation have a 50-80% lifetime risk of developing breast cancer.

Information card

Our genes

Most of the DNA in human cells is packaged into 46 chromosomes, in 23 pairs. Our genes are arranged along these chromosomes and carry the instructions to make molecules, such as proteins.

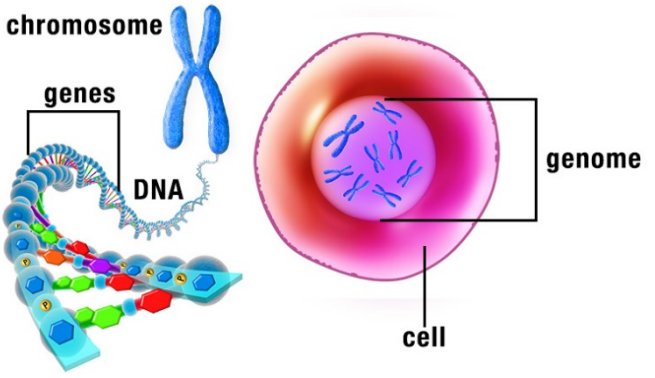


TURN OVER

Information card

Our genes (side 2)

To function properly, each cell depends on thousands of proteins doing the right job, in the right place, at the right time. Our complete set of DNA, containing all the instructions required to make us, is called a genome.



Information card

How common is breast cancer?

1 in 8 women will get breast cancer by the time they are 85.

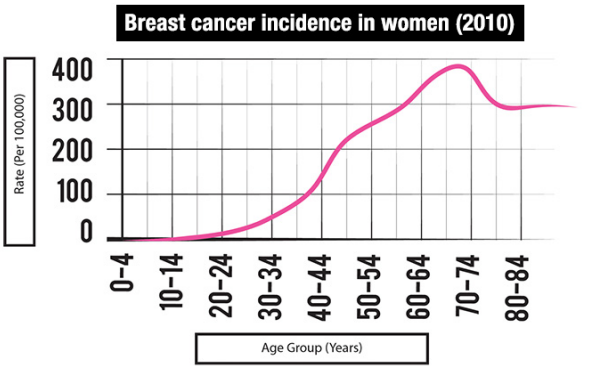
Because breast cancer is so common, having more than one relative with the disease does not necessarily mean that the family carries a higher genetic risk.

TURN OVER

Information card

How common is breast cancer? (side 2)

The highest risk factor (after being female) is age. 77% of breast cancers occur in women over 50.



Source: AIHW 2014

Information card

Gene mutations

A mutation is a permanent change in the DNA sequence. Mutations come in a number of different forms and can change the functioning of our genes.

TURN OVER

Information card

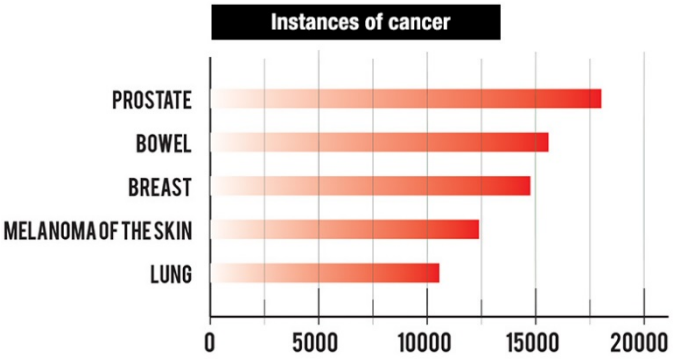
Gene mutations (side 2)

Some mutations may lead to a difference in the amount, or structure, of a protein produced by specific genes. Some mutations may switch genes on at the wrong time, preventing a protein from doing its job, or changing the *way* it does its job.

Information card

Breast cancer statistics

- Breast cancer is the third most commonly diagnosed cancer in Australia, with 14,680 new cases in 2012.



TURN OVER

Information card

Breast cancer statistics (side 2)

- In 2009, the risk of being diagnosed with breast cancer by 85 years of age was 1 in 8 for females and 1 in 724 for males.
- There were 14,560 female and 120 male deaths from the disease in Australia in 2012.

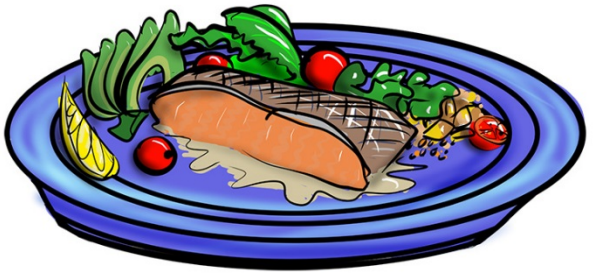
Source: AIHW 2013

Information card

Health care advice for breast cancer

All women, regardless of their family history or genetic risk, are advised to:

- examine their own breasts and report any changes immediately
- eat a healthy diet and keep fit



TURN OVER

Information card

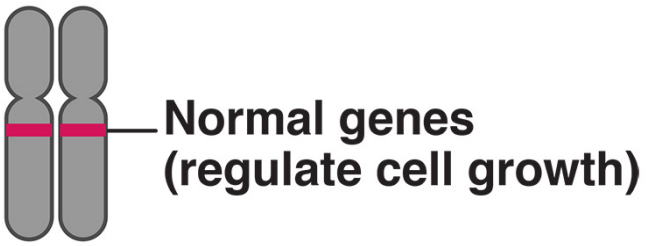
Health care advice for breast cancer (side 2)

- maintain healthy weight, especially after menopause
- moderate alcohol consumption.

Information card

Tumour suppressor genes

BRCA1 and *BRCA2* are examples of tumour suppressor genes, which play an important role in preventing cancer. Normally, if DNA is damaged, these genes halt cell division or promote cell death.

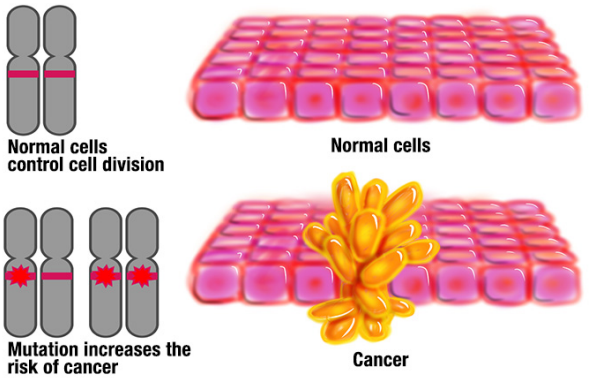


TURN OVER

Information card

Tumour suppressor genes (side 2)

We have two copies of every gene – one inherited from each parent. Inheritance of just one copy of a *BRCA1* or *BRCA2* mutation from a parent, is enough to increase the risk of developing breast cancer.



Information card

Breast cancer in men

Breast cancer is not only a threat to women. Men can get breast cancer, although it is much rarer, accounting for less than 1% of cases in Australia (127 new cases in 2010).

TURN OVER

Information card

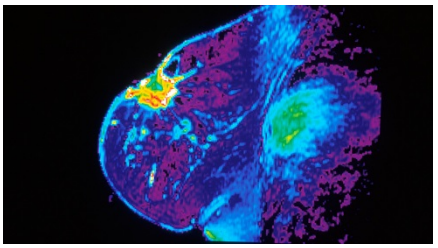
Breast cancer in men (side 2)

Lower awareness of male breast cancer means it tends to be detected at a later stage in men than in women, which means that the outcomes tend to be worse.

Information card

Monitoring women at high risk

Women with a family history of breast cancer are categorised as either 'raised risk' or 'high risk'. Less than 1% of women are at high risk.



In Australia, women less than 50 years of age at high risk of breast cancer may receive yearly MRI (magnetic resonance imaging) screening under Medicare. MRI uses a magnetic field and radio waves to produce detailed images of the breast tissue.

TURN OVER

Information card

Monitoring women at high risk (side 2)

Some high risk women choose to remove all of their breast tissue as a preventive measure, a procedure known as a pre-emptive mastectomy.

Information card

Genetic screening in at-risk families

In genetic screening, a living relative with breast cancer has to be tested first. If they have one of the mutations associated with the cancer, other family members can be tested for the same mutation.

TURN OVER

Information card

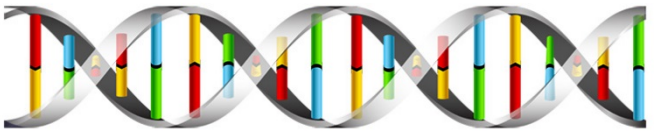
Breast cancer screening in at-risk families (side 2)

Genetic testing of under-16s for diseases that occur in adulthood is not normally advised. In Amy's case, it would be clinical practice to test the father (who has a relative with the gene mutation) first.

Information card

Our DNA

Our bodies are made up of around 50 trillion cells. Most of these cells contain a person's genetic information within a long molecule called DNA (deoxyribonucleic acid). This DNA contains the genetic information that we inherit from our parents.

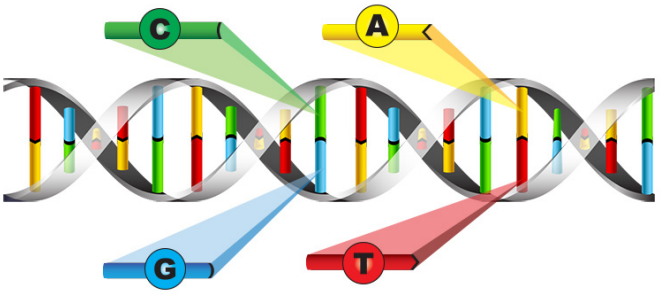


TURN OVER

Information card

Our DNA (side 2)

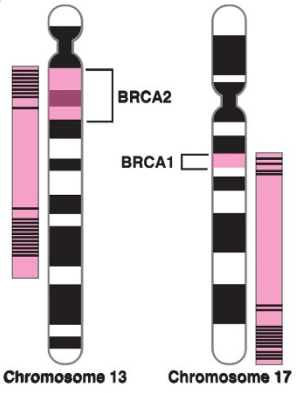
DNA is made up of specific sequences of letters or bases that encode instructions on how to make proteins. The four bases are Adenine (A), Guanine (G), Cytosine (C) and Thymine (T). They are lined up along two strands of DNA and the DNA is coiled into a double helix structure that resembles a twisted ladder.



Information card

What is cancer?

All cancers are genetic diseases. Cancer develops from single body cells that continually divide in an uncontrolled manner. Cancer cells behave in this abnormal way because of changes (mutations) in the DNA sequence of key genes, which are known as cancer genes.

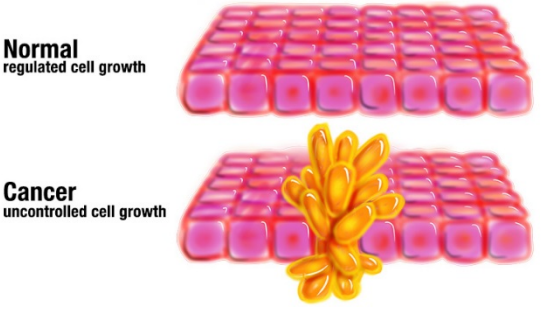


TURN OVER

Information card

What is cancer? (side 2)

The changes in the DNA provide a growth advantage to the cell. This means that the cancer cell and its offspring divide at a faster rate than that of their neighbours.

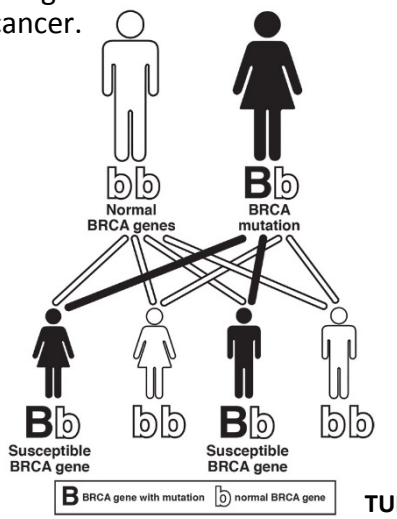


This results in tumour formation, invasion of surrounding tissue and, if left untreated, eventually 'metastasis' where the cancer spreads to other parts of the body.

Information card

What is the risk of inheriting a *BRCA* mutation?

The mutated *BRCA1* and *BRCA2* genes are inherited in an autosomal dominant pattern. This means that a child only needs to inherit one copy of the mutated gene to have an increased risk of developing cancer.

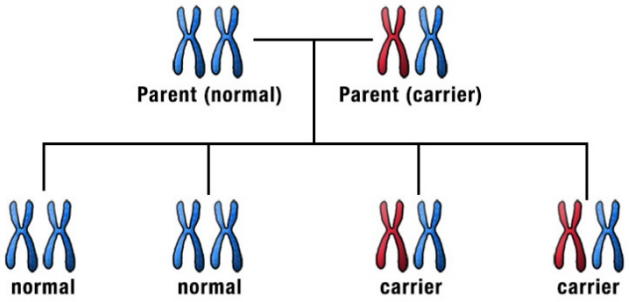


TURN OVER

Information card

What is the risk of inheriting a *BRCA* mutation? (side 2)

If one of the parents is a carrier of a mutated *BRCA1* or *BRCA2* gene, each of their children has a 1 in 2 (50%) chance of inheriting the mutated gene from the carrier parent.



Top issues

What are the top issues that you have discussed in your group?