Seed HUNTER

A **STUDY GUIDE** BY ANDREW FILDES & BRAD COLLIS

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Overview

How can we survive perhaps the greatest danger we now face – climate change? Global Warming may be a contentious issue for many but there's no argument – some areas of our planet that were once 'food bowls', abundant, fertile and productive land, are now dust bowls where people scratch a living from the dry soil and hope for rain.

This documentary and its subject, Dr Ken Street, have a very clear answer. We need to go back to our roots. Somewhere out there in the remote mountains are people who still grow the tough, traditional species of our food plants. These are the 'landraces', the hardy species and varieties that can withstand dry conditions, harsh winters and baking summers and still produce adequate crops. And oh how we need them now!

In the twentieth century, new varieties of crop plants like wheat were developed to feed the fast growing population of the world. No longer could we rely on subsistence farmers to feed the exploding population of developing nations and high yielding varieties replaced the traditional crop strains that were tough but inadequate. However, as the climate changes we now need the genes of those same ancient varieties to help develop new varieties that still have the high yield benefits of modern crops, but in addition also have the capacity to withstand hotter, drier conditions. Just a fraction of a degree change in average temperatures can be enough to stop many crops from flowering and producing seed and fruit – our food. (And climate forecasters are predicting a change of several degrees).

This is why Ken Street is a man on a mission. He takes his team into the mountains of Tajikistan where, struggling against low budgets, local officials and time, they collect ancient varieties of wheat and other grains. He is also on a search for what he calls 'green gold', one plant in particular – the wild chick pea. Chickpeas are the ultimate food for dry zones, rich in protein and nutrients; the meat that you can grow when you can't afford meat. Not only does he want to collect traditional farmed varieties but he wants the mother plant, the wild species that gave rise to the modern farm plant. He wants its toughness, its potential resilience to disease, pests, climate; its DNA with which to breed new, hardy hybrids that will grow in other places where climate change and poor soils are putting pressure on agriculture.

But everywhere he looks, the villages are growing modern wheat little different to what is found in Australia, his expedition companion informs him. And he should know – he's an Australian wheat farmer. As for the elusive chickpea, the local farmers have pretty much given up on the crop because the modern varieties have not been able to cope with the drying of the climate. And no one can tell him if any wild chickpea still exists. Is this vital wild species which can survive cold and drought now extinct?

KEN STREET COLLECTING SEEDS AT A MARKET

SEED HUNTER
360 Degree Films
Producer/Director: Sally Ingleton
52 mins
Subject Areas –
Biology
General Science
Horticulture
Agricultural Science
International Studies
Environmental Studies/Science
Key Topics
Biological adaptation
Agricultural ecosystem diversity
Plant Genetics
Plant research and breeding
Habitat loss / plant extinction
International Aid
Landforms
Land use – Tajikistan, Svalbard
Climate Change
Food Security
Level
Middle to Senior Secondary

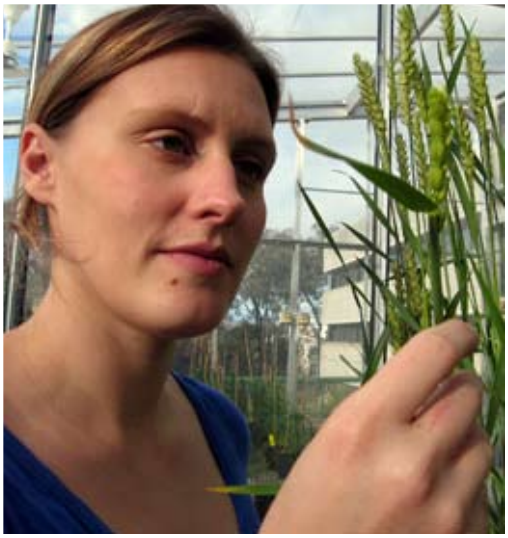
Along the way he visits one of the world's most important seed repositories the Vavilov Institute in St Petersburg and finds it sadly fallen on hard times. But the world is waking up to the threats posed to its food production and Ken travels with some of the precious, ancient seeds he has collected to the massive new seed storage facility above the Arctic Circle. It has been christened the Doomsday Vault, a storage facility cut into the remote, icy cliffs of Svalbard, a Norwegian island in the Arctic Ocean where the permafrost will keep vital heritage seed safe in its deep freeze. The vault has been built to withstand almost any disaster we can conceive. It is a vast concrete locker that could be the key to the survival of humanity.

CLOCKWISE FROM TOP LEFT: CREW MEMBERS PHILLIP BULL AND DAN MIAU • CREW MEMBERS SALLY INGLETON AND PHILLIP BULL IN SVALBARD • CREW

Viewing Questions

1 What exactly is Dr Ken Street doing in Syria?
2 What will the seed be used for?
3 Why are chickpeas so important?
4 What is threatening the wild chickpea?
5 What kind of people are on Dr Street's search and collection team?
6 Why do they go to Tajikistan?
7 If wheat is all one species, why are there so many different varieties?
8 What causes a delay in Khojand, on the third day?
9 Why is the field of mixed wheat varieties so useful in Tajikistan?
10 Why are salt tolerant plants so important to Australia?
11 What problem is climate change causing to Australian wheat crops?
12 Why is the team having a problem with finding traditional wheat?
13 What kind of work is being done in the Australian laboratory?
14 Why are the ancient village seeds so valuable to the team?
15 What is so important about the chickpea farmer's crop?
16 Why is it good that there's no road into the last valley?
17 How do they finally find the 'green gold'?
18 Where is the Global Seed Vault?
19 Why is it built there?
20 Why is valuable seed stored there?

Viewing Log	
00:00 – 02:00	Introduction – Ken Street in Syria
02:00 – 06:30	Plant research – statement of purpose
06:30 – 08:40	St Petersburg – the Vavilov Institute seed gene bank
08:40 – 10:25	Dushanbe, Tajikistan – the team and mission
10:25 – 13:50	The search begins
13:50 – 14:10	The situation in Australia – climate change
14:10 – 15:14	The team travels on a shoestring budget
15:14 – 17:20	Bureaucratic delays in Khojand
17:20 – 18:10	Back on the road – remote villages and land mines
18:10 – 20:00	The first crop of mixed traditional wheat varieties
20:00 – 21:40	The effects of the 'Green Revolution'
21:40 – 23:10	Salt tolerant plants and Australia
23:10 – 25:00	Back to the team in Tajikistan – hunting the chickpea
25:00 – 26:25	Disappointment – modern crop plants in remote villages
26:25 – 28:10	Climate change and crops in Australia
28:10 – 30:10	The problems with aid agencies
30:10 – 31:30	Cataloguing the collection of wheat, barley and bean seed
31:30 – 33:00	Working with seed in the laboratory
33:00 – 37:05	Searching for a remote village and through a Tajik market
37:05 – 37:35	Global food problems
37:35 – 38:44	Australia – developing plants for drier, saltier conditions
38:44 – 41:05	The team finds a remote village using ancient seed varieties
41:05 – 44:50	Back to the search for the wild chick pea
44:50 – 49:10	The last valley and help by helicopter. The wild chickpea
49:10 – 50:15	Ken Street brings new seed varieties to a Syrian farmer
50:15 – 51:15	The Global Seed Vault in Svalbard
51:15	End credits





CLOCKWISE FROM TOP LEFT: PHD STUDENT CAITLIN BYRT • WHEAT FARMER IAN MCCLELLAND • QUEENSLAND WHEAT BREEDER JOHN SHEPPARD • COLLECTING SEED • CAITLIN BYRT

Viewing Questions (Answers)

1 What exactly is Dr Ken Street doing in Syria? *Working for ICARDA, an agricultural research organization improving farming practices for dry regions like the Middle East and North Africa.*

2 What will the seed be used for? *Research into breeding new crop hybrid varieties that are more tolerant to climate change and weather extremes such as drought.*

3 Why are chickpeas so important? *They are almost as good as meat, a high protein crop for poor farmers (who make up most of the world's population).*

4 What is threatening the wild chickpea? *Extinction by habitat loss, cultivation of modern varieties.*

5 What kind of people are on Dr Street's search and collection team? *Russian collector, Australian wheat farmer, US wild food crop expert, Armenian genebank Deputy Head, local agricultural experts, drivers.*

6 Why do they go to Tajikistan? *Its rich topography – deserts, mountains, isolated valleys – and traditional farming practices mean that plants will have adapted to dry/hot/cold conditions and contain useful genes.*

7 If wheat is all one species, why are there so many different kinds? *Different varieties have adapted – naturally and through breeding by farmers – to different environmental conditions.*

8 What causes a delay in Khojand, on the third day? *They require a special permit to go any further and the local authorities are slow to cooperate.*

9 Why is the field of mixed wheat so important? *Because it contains several varieties making it more resilient overall. A disease may kill one variety but others may be resistant to that disease.*

10 Why are salt tolerant plants so important to Australia? *There is a serious problem with soil salinity caused initially by excessive land clearing, allowing the water table to rise and bring with it the earth's mineral salts.*

11 What problem is climate change causing to Australian wheat crops? *It is getting drier. Droughts, while natural, are lasting much longer so we need drought tolerant varieties of wheat and other crops.*

12 Why is the team having a problem with finding traditional wheat in Tajikistan? *A German aid agency had earlier given modern seed to the Tajik farmers in the area so the old varieties are no longer grown.*

13 What kind of work is being done in the Australian laboratory? *Testing new varieties for drought and salt tolerance.*

14 Why are the ancient village seeds so valuable to the team? *They are very old and many haven't been collected before – they have the potential to contain important genes that modern varieties have lost.*

15 What is so important about the chickpea farmer's crop? *It contains the oldest chickpeas they've found so far, plus old types of lentils and flax plants.*

16 Why is it good that there's no road into the last valley? *The environment beyond the bridge is isolated and therefore protected from the introduction of modern varieties of seed.*

17 How do they finally find the 'green gold'? *Through the loan of a helicopter that takes them up the valley.*

18 Where is the Global Seed Vault. *Svalbard in the Arctic Ocean. Near the North Pole.*

19 Why is it built there? *Because it is a natural refrigerator to keep the seed frozen in the permafrost.*

20 Why is valuable seed stored there? *So that it will be safe from any possible catastrophe or natural disaster.*

LEFT: KEN STREET AT VAVILOV INSTITUTE • RIGHT: JOHN SHEPPARD

Post-Viewing Questions

Discussion or Written responses

1 Why is it necessary to store genetic material in the form of seeds for the future?
2 What are the threats to traditional crop varieties?
3 Why is it traditional to sow a field with several varieties of wheat?
4 Why is it important to preserve these old and sometimes low-yielding varieties?
5 How are seeds prepared for long term storage? What problems are there with long term storage?
6 What are the threats to conventional seed genebanks that the Svalbard Vault is designed to avoid?

Activity

Middle Level Science/Horticultural Science

It is possible to purchase different varieties of seed from hardware and garden stores or on the net. Usually seed appropriate to local conditions is sold but you should be able to get different varieties from around Australia from larger distributors.

Grow mixed plots or containers of seed alongside monoculture plots or containers. If possible, vary conditions using an igloo and exposed zones. If full facilities are not available, grow to juvenile stages in plant trays or containers in a range of indoor conditions and measure rates of growth. Variables could include cooler and warmer areas, hours of light under 'grow light' UV globes, levels of watering and fertilizer, natural versus artificial fertilizers – in stressed and unstressed conditions.

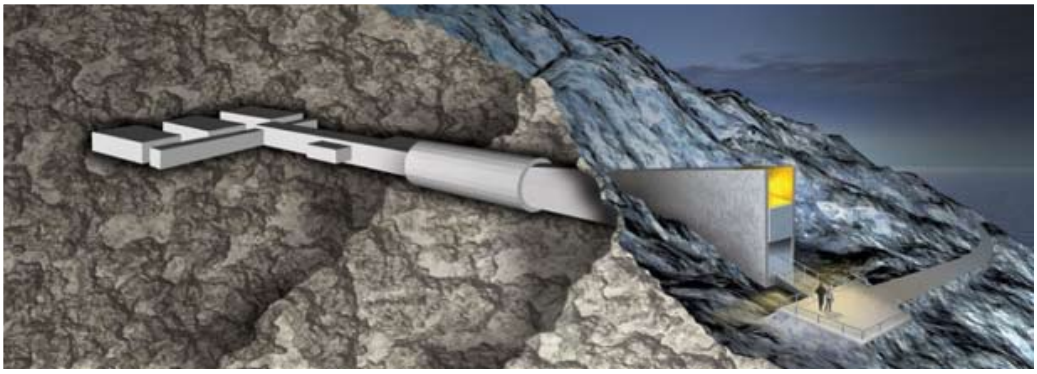
Draw conclusions on the advantages of mixed plots against single variety plots and on the performance of different cultivars in differing conditions.

Research Reports

1 Research the activities of ICARDA and the Global Crop Diversity Trust. What is their mission, who funds them and how effective are they?
2 Prepare a report on one country where these agencies are involved in either seed collection, research or seed distribution. (For instance, the CGIAR Home Page has a 'Select a country' option).
3 Select one species of plant – i.e. sweet potato, rice, wheat, etc. Prepare a report on the attempts to improve that species with details of new varieties and the characteristics that the breeders have selected for enhancement.
4 Prepare a class debate on the subject of genetically manipulated food and crop plants. One side needs to argue the 'for' case and the other 'against'. Debaters must ensure their arguments are scientifically accurate and not hearsay.

Useful Websites

- Global Crop Diversity Trust
  http://www.croptrust.org/main/mission.php
- International Centre for Agricultural Research in the Dry Areas
  http://www.icarda.cgiar.org
- Consultative Group on International Agricultural Research
  http://www.cgiar.org
- Vavilov Institute
  http://www.vir.nw.ru
- Australian Centre for International Agricultural Research
  http://www.aciar.gov.au
- CSIRO Climate Adaptation Flagship
  http://www.csiro.au/org/ClimateAdaptationFlagship Overview.html
- CSIRO Media Release – Ancient genes used to produce salt-tolerant wheat
  http://www.csiro.au/news/ps2pv.html



TOP: SVALBARD SEED VAULT • BOTTOM LEFT: OLD SEEDS • BOTTOM RIGHT: ??

Information Sheet 1

In the Fridge

The Global Seed Vault, Svalbard

The Global Seed Vault is situated near Longyearbyen on Spitsbergen Island, Svalbard – one of the most inhospitable places on earth. Svalbard is a group of Islands, Norwegian territory, roughly halfway between the northern Norwegian coast and the North Pole. Longyearbyen with just over 2000 inhabitants is the most northerly town on earth, apart from research installations and tiny Inuit settlements. Most of the inhabitants are involved in coal mining, which meant that all the equipment and skill was in place to cut the shaft.

The vault pokes out of the side of a sandstone mountain. The tunnel is buried deep in the rock of the permafrost, a zone of the ground which never thaws out. It is a natural refrigerator, with a steady temperature of -6°C which is taken down even further to -18°C in the body of the vault. By comparison, the temperature in your fridge at home is around 4°C.

In these conditions, the stored seeds are kept in suspended animation. The Nordic Gene Bank had stored frozen seed in an abandoned coal mine in Svalbard for over twenty years and the new vault was designed to replace that with a more modern and secure facility. It was funded by the Norwegian Government while operating costs are met by Norway and the Global Crop Diversity Trust which manages the vault. The trust is supported by the Bill and Melinda Gates Foundation and various national governments that wish to store seed there, including Australia.

The vault is constructed in a way that will withstand local or global catastrophe leading to its common name of 'Doomsday Vault' but that overstates its purpose. Its real purpose is to avoid the problems with conventional gene banks. There are around 1400 crop diversity gene banks around the world right now and many are threatened by war, neglect, government neglect and natural disaster. For example, the crop plant seed bank in The Philippines was virtually destroyed a short time ago by a cyclone which sent floodwaters sweeping through the facility. In the documentary, we see the Russian seed bank, once the world's most significant collection, now in a serious state of neglect due to lack of funding and government support.

Gene banks of seeds are an essential resource for plant breeders seeking to develop new strains and varieties, Often it is necessary to introduce material from older and wild varieties, by selective breeding as has always been done. Controversially this may also be used for genetic manipulation – introducing specific genes into plant cells to create certain characteristics such as cold resistance, disease resistance, increased size, higher yield per plant or even tough skins to prevent bruising (especially in tomatoes and strawberries).

This has not been well received by some people but one example of an improved 'transgenic' crop seed produced by recent research is 'Golden Rice' which increases the level of beta-carotene (provitamin A) in rice making it a significant contributor to the health of those in the third world who depend on rice as a staple food.

LEFT: LANDRACES • RIGHT: WILD CHICK PEA PODS

Information Sheet 2

The Seed Collectors

Collection

The first collectors were farmers who reserved a proportion of their crop as a seed resource for the next year's crop and even traded seed among villages to gain better and more diverse crops. They had a number of preservation techniques but these usually involved sealing grain into granaries (small buildings) or containers, with mud seals to exclude air.

The disaster of famine was usually foreshadowed when subsistence farmers had to eat their seed grain to survive the drought or other disasters. This meant that they had no way of growing a new crop when circumstances returned to normal.

By the 1920s, it was recognized that conserving 'landraces' – traditional farmed varieties in a particular area – was essential before they were swamped by new agricultural varieties that were high-performing, but had a narrower and therefore vulnerable genetic base. Landraces had specific characteristics such as climate, disease and local pest resistance that had developed over centuries. By hybridizing new varieties with the old types, even better new plants could be bred. As the documentary shows, 'better' doesn't always just mean higher producing. Sometimes it means – 'better able to cope with climatic changes.'

Although the preservation of genetic diversity has been carried out scientifically for almost a century, we are still in the early stages and the loss of old and wild forms is increasing rapidly. We are losing them at a faster rate as modern agricultural methods are adopted in developing countries. Many are becoming extinct as land is swallowed up under the spread of cities or as the local climate becomes hotter or wetter. Climate change is seen as a priority by organizations like the Global Crop Diversity Trust which is emphazising the collection of food varieties which can tolerate a range of climatic conditions, especially hotter and drier weather.

Preservation

Once important seed has been collected it is not just a question of throwing it into the freezer and going out to look for more. The seed has to be properly catalogued for its origin, type and probable characteristics. Then the preservation facility has to be secure, protected from natural and social disasters like earthquake, flood and war and also from lack of budget to maintain the appropriate conditions. Funding has to be secure. Finally, although the seed is preserved, in cold, dry conditions, it has to be regenerated.

Some seed can last a long time, even centuries in the right conditions and still germinate when planted. Most cannot. Every seed bank has to have a staff who constantly regrow small crops from the stored seed and then restore the fresh seed collected. This is expensive and labour intensive as plant varieties must be segregated during these 'grow-outs' to preserve their purity. If their pollen accidentally cross-fertilizes a neighbouring plant, then samples are contaminated. Promising varieties are also sent to other seed banks or grown more extensively to provide material for research. This is as much a part of the business of a seed bank as simple storage.

Because of this, the Svalbard Vault is used as a safety deposit for duplicates of seed that is stored and used elsewhere, especially in national government research organizations.

CLOCKWISE FROM TOP LEFT: TAJIK LOCALS • MINEFIELDS • DEPUTY HEAD OF ARMENIA GENE BANK NATALYA RUKHKYAN • SYRIAN FARMER AHMED • TAJIK SEED HUNTER SHAKHLO SAFARZODA TAKES SEED DETAILS FROM A LOCAL • KEN WITH TAJIKS

Information Sheet 3

Climate Change and the Global Food Supply

People tend to assume that the effects of global warming will be felt first and worst in personal discomfort, water shortages, extreme weather like cyclones or in flooding and sea level rises. In fact, they are likely to experience the changes first in food shortages and costs.

Perhaps no crop is more vulnerable than wheat, the plant that provides one fifth of the world's food. Wheat has quite specific requirements, specifically a cool, wet spring and a warm to hot and dry summer. This is not hard to provide in Australia in a good year – disasters occur when the spring rains don't come or the crop doesn't dry properly before harvest. In the first case, the crop cannot grow at all while in the second, the seed hit by late summer rain can begin to germinate on the stalk, ruining it for flour milling. It is then downgraded and used as stock feed.

In a global warming situation, there are significant climate shifts. Areas that were ideal for wheat growing tend to become too hot and dry. In Australia, Europe and North America, this is not such a problem – we can move our growing areas slowly southwards as conditions change and the American crops can move northward into areas of the Canadian prairie that are now too cold. However, in many parts of the developing world, that is not an option. In The Seed Hunters we see farmers who have given up on growing chickpeas because the climate in their area is no longer suitable for the species.

Ironically, the worst effects may be felt by those third world nations that are not responsible for the problem. Areas like Northern India and Pakistan have no room to move their growing areas north from the fertile plains and what little growing land is available has poorer soils and more difficult geography. Even in more promising areas of the world, there is no guarantee that rainfall will settle conveniently into useful patterns.

Humans have been in agricultural societies for the last 10,000–12,000 years and during that time, climates have been relatively stable – sometimes cooler but rarely warmer. Consequently, the plants we use have become closely adapted to regions and climates. Poor villagers have relied on 'landraces' – plant (and animal) varieties that have evolved in farmlands to suit local conditions during this period, almost without human guidance. Any significant shift in temperature and rainfall will affect these plants quite significantly. A temperature rise of one degree above the mid-thirties at key points in the season, like pollination, can reduce yields by ten per cent. By 40°C, photosynthesis begins to shut down.

The yields are already dropping in areas like the Punjab of Northern India, one of the areas that benefited most from the 'Green Revolution' of the 1970s. It is part of the Indo-Gangetic plain which grows one-sixth of the world's wheat. The success of the new wheat and rice varieties of that era are one of the reasons that we no longer see the devastating and widespread famines of forty years ago but those varieties were developed to suit the climatic conditions of the last century. Climate shifts could take us back to the past, wiping out the recent gains and causing incalculable misery. The Earth Policy Institute last year (2007) estimated the global grain stockpile as equivalent to just fifty-seven days of consumption, the worst level since the early 1970s. At that previous time, the cost of grain doubled, so rapidly increasing prices of staple foods would seem to be on our immediate horizon.

Global warming has also had a more subtle and indirect effect in the development of non-food crops for environmental alternatives. In an attempt to reduce carbon and other pollutants entering the atmosphere, there has been a move to less destructive alternative fuels such as ethanol and bio-diesel. Once these were produced from plant wastes like sugar cane trash but demand has outstripped that resource. This has put pressure on both the natural environment and the food supply as forests are cleared, crop lands used and crops like soybeans, sugar, corn and palm oil are diverted to fuel production. Still a minor issue is the use of corn to produce bioplastics as a substitute for oil based plastics, a strategy which is likely to expand significantly in the near future at the cost of food crops.

There have been optimists who argued that we can survive the dislocation of moving existing crop varieties to cooler zones; that we can grow and eat heat tolerant plants in the new warm zones, eating yam instead of potato and rice instead of wheat; even that the increase in carbon dioxide in the atmosphere will increase plant respiration rates and cause an explosion in growth rates. However, wherever we look the cooler zones seem to have poorer, thinner soils; crops like rice need much more than simple warmth and don't grow well in some tropical areas; experiments indicate that crops don't benefit much from increased atmospheric CO_2 except in greenhouses. Perhaps it's best not to rely on normal social adjustments to cope with the problem.

Organizations like CGIAR have argued for a massive program to develop new plant varieties with increased drought and heat tolerance. This would allow new forms of existing crop plants to be grown in most of the existing croplands affected by global warming, avoiding the social and economic disasters we saw in the past. Researchers like Ken Street are devoting their time to recapturing the primitive varieties of grains and pulses which have those tough characteristics so that those genes can be blended with the high yield varieties we use now, either by conventional cross-breeding or by genetic modification. The aim is to create a second Green Revolution, this time in response to climate change and to forestall future famines rather than cure an existing one.

The value of these old seed varieties is best demonstrated in the documentary by the village farmers growing plots with up to six varieties of wheat. A mixed wheat field like this is resistant to changes or unexpected events. A pest insect may attack but one or two of the varieties of wheat will be able to resist better than the others. There is a drought but there will be a plant in there better able to survive dry conditions. Whatever happens, there is a much better chance of getting a crop from a mixed plot, although with a reduced yield. These are varieties that have been grown in these areas for centuries and they have adapted to local conditions.

However this is achieved at the cost of a much reduced yield in many years. It is an adequate approach for a family or small village which needs only enough to survive in a bad year and can sell its surplus in a good year. But subsistence farmers cannot feed the world. In order to do that it will be necessary to develop high yielding, heat and drought resistant varieties which can be grown on large scale in the developing and developed world, to feed the cities.

Closer to home, if Australia is to maintain its position as a major wheat exporter it will not be enough to simply move the wheat fields south. That may not even be possible. It will be necessary to develop strains that can cope with the change in climate in the existing growing areas. And the same principle applies to other crop plants as well, including grains, pulses, fruits and vegetables. This research and development in agricultural plant genetics is an ongoing process as conditions are in a state of constant change and fresh challenges arise in the form of such things as introduced pest species and increasing ground salinity. The role of the seed banks and the seed vault is to preserve genetic stock so that the constant struggle to improve our food resources can be maintained into the future.

ABOVE: TAJIKS

Information Sheet 4

Plant Genetics and the Other Side of GM

We seem to have developed an irrational fear of any kind of genetic manipulation. And yet most of our foods are the result of a very basic form of manipulation – selective breeding. Grains like wheat, barley and rice were originally wild grasses with small seed heads. Australian Aborigines spent much of a day collecting enough seed to grind into a flour for damper. Chickens once laid thirty eggs per year, not the nearly 300 they do today. Cattle and sheep in the wild were tough and lean, nothing like the domestic breeds we have today. Even our pets are the result of selective breeding for characteristics like docility and 'cuteness'. If we had not done this enthusiastically, since the beginnings of agriculture 12,000 years ago, then we would have had no chance of feeding ourselves, or of maintaining the human population.

We also fear 'cloning' but most of us have plant clones in our gardens and aren't even aware of it. Any plant produced from a cutting or by 'tissue culture' is technically a clone and that includes many of our fruit crops as well as decorative garden plants.

In many ways, genetic manipulation is simply the next step in plant breeding. Rather than use a cutting, or culture tiny bits of plant tissue into whole plants or artificially cross pollinate different varieties, we insert the genes from one organism into the cells of another. If we can isolate a frost tolerance gene in one plant, we can insert it into another plant to create a frost tolerant plant. Many plants have quite effective natural insecticides in their leaves to protect themselves and these can be introduced genetically to food plants and other crops like cotton.

It is important to remember that in contrast to many of the health and environmental concerns that have led to protests in recent years, there has never been a single demonstrated case of a person being harmed by a genetically modified organism – a transgenic variety of an animal or plant. But there are some legitimate scientific concerns around the introduction of transgenic species. These usually involve the cross contamination of existing crop varieties by pollen from nearby GM crops or the worry that introducing bacterial genes into plants will lead to the creation of new and unexpected pathogens (diseases).

While caution and scepticism are important and essential, many objections have no scientific basis and originate from ill-defined fears in the community. (It bares recalling that such was the fear evoked by the first motor cars, they could only be driven if a man walked in front with a red warning flag.) Scientists working in the area of plant genetic modification are very aware of the potential for genuine risks, and these are discussed and explored in exhaustive detail.

It should also be remembered that this is an advanced field of science. It is more than fifty years since DNA became accessible as a medical (and later forensic) tool.

Nevertheless, the continuing community hesitation over biotechnology explains why the most successful transgenic crop in Australia is cotton, a non-food crop (although cotton seed oil is widely used in food preparation). However, the cotton example is a stark example of the potential environmental benefits of gene technology. Since the introduction of insect-resistant Bt cotton the use of pesticides on cotton crops in Australia has dropped by approximately ninety per cent, a significant environmental advance. And unlike GMOs (genetically modified organisms), pesticides have harmed many people, directly and indirectly.

The GM technology also opens the door to many potential health benefits – not merely health risks as anti-GM campaigns portray. GM technology is already the method used to produce insulin for diabetics.

The technology can also be used to develop food crops that can provide specific nutrients, such as certain vitamins, or grains like wheat that have a modified starch content to directly lesson the risk of bowel and colon cancers. These developments exist, but are being held back by the anti-GM sentiment.

For example, GM techniques were used to develop a new variety of rice that has beta-carotene (Vitamin A) in the seed as well as the husk and outer layers. These outer layers are lost when rice is polished to stop it going mouldy in tropical climates, and so this crucial vitamin is lost.

The World Health Organization (WHO) estimates that every year, up to half-a-million children go blind from Vitamin A deficiency, particularly in developing Asian countries with a diet based on rice. Of those, half die within a year of going blind as it is a symptom of general ill-health. Up to forty per cent of the world's children are affected to some extent by this deficiency.

The new rice in which Vitamin A is present in the grain was developed by two European scientists who reasoned that if they could genetically develop a rice that had beta-carotene in the seed as well as the body of the plant itself, then they could save millions of lives. Over the past twenty years, they have developed varieties of what they call Golden Rice as it has a distinctively deep yellow colour. This is now being trialled in several research institutions in Asia where it will be cross-bred with local varieties to create far healthier strains of rice, adapted to local conditions. The owner of the rights to the new varieties, the Sygenta Foundation, is donating the rights and research to these institutions and the Golden Rice Humanitarian Board and has no commercial interest in the results.

The full story can be found at <http://www.goldenrice.org> in exhaustive detail, from discussion of the effects of Vitamin A deficiency in the developing world to a full description of the science of developing this transgenic plant.

Material on this site is suitable for a range of subject areas such as Biology, SOSE, International Studies, Environmental Studies and Health. There are even some good recipes!

A number of tasks can be developed using the site and relating it to the documentary. These can be used to bring some balance to the debate on Genetically Modified foods as it is quite difficult to find anything but quite extreme anti-GM views in an internet search.

Note 1: Some parboiled rices are called Golden Rice as they take up some of the colour of the husk in the process. These are **not** transgenic Golden Rice.

Note 2: Carrots, an important source of beta-carotene for most of us were not always orange. The original Asian forms were white or purple and contained no pro-Vitamin A. The modern carrot varieties were developed by selective breeding from a mutant strain found in Holland over two hundred years ago and were popular for reasons of fashion – the royal family of Holland is the House of Orange. They also tasted less bitter. Today a carrot that wasn't orange would be thought very strange, yet it is not the 'natural' colour of the plant.

Thanks to Sally Ingleton for comments

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Australian Centre for International Agricultural Research

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