INTRODUCTION

What foods will we be eating in the future? In this lecture John looks at past developments and trends to try to predict the future of food and food production. He also looks 50 years ahead and considers the predicted growth of the world’s population, asking the questions:

- How can we best feed everyone in 2055?
- Are developments in conventional agriculture sufficient?
- What alternative technologies might be used?

PREDICTING THE FUTURE

Fifty years ago, science fiction writers predicted that, in the future, our food would come from some kind of space-age machine. They thought that you’d be able to press a few buttons, pull a few levers, and your dinner would arrive – looking something like a pill on a plate.

Of course the science fiction writers were completely wrong. But nevertheless we’re going to try to look into the future, and see if we can work out what choices you might have to make about the foods you’ll be eating in 50 year’s time. And maybe, if we’re lucky, our predictions will be more accurate than this idea was.

Food for the future is the subject of this fifth and final of the two thousand and five Christmas Lectures, from the Royal Institution in London.

But before we get going properly, I need to set a machine running. All it does is spit small balls into a large tank but it’s going to help us make an important point. We’ll come back to it later in the lecture.
TRENDS – INTRODUCTION

Today, we’re trying to look 10, 20, even 50 years into the future. But predictions are notoriously difficult. Perhaps we’ll find clues about the future by looking at the trends over the last 50 years and see what they suggest.

TRENDS – CONVENIENCE

There have been three big trends over the last 50 years. One of them is convenience. We’re all busy, we want food on the go – and the microwave oven is a symbol of that trend. When I was a kid, it took ages to prepare a meal. An oven that cooks food in minutes would have been incredible. Today, the average meal takes just 13 minutes to prepare and cook.

Microwave ovens came about by accident, when an American radar researcher noticed that the equipment he was working on melted chocolate. In an ordinary oven, heat is passed from molecules at the edge of the food to those in the middle. Ordinary ovens cook your food by making all the molecules in the food vibrate, whereas microwave radiation makes the water molecules, and only the water molecules, vibrate.

Of course, people had to learn how to use them. Today, most of us know that you can’t boil eggs in microwave ovens. The water inside the egg gets superheated, and just like popcorn, the pressure builds up until the egg bursts. It’s really quite dangerous. We also know that we can’t put metal in microwave ovens as it causes dangerous sparks.

Once we’d all learned how to use them, microwave ovens saved us a tremendous amount of time. There’s even a trend in America to build homes without kitchens, just with a microwave. The microwave isn’t the only way our food has become more convenient – we want to spend less and less time on our food, so we want our meals to be quicker to prepare too. Today, a quarter of all the meals we eat are pre-packaged, ready meals, many of them microwaveable. Each year in Britain, we consume almost 400,000 tonnes of ready meals.

TRENDS – PRICE

The second major food trend over the last 50 years has been falling prices. Our food is far cheaper now than it was. Let me give you an example:

Fifty years ago, it would have taken my dad about two and a half hours to earn enough money to buy a chicken for Sunday lunch. Now, on average, it would take your parents about 15 minutes to earn the cost of a chicken – one tenth of the time.
A typical shopping basket today costs perhaps £11. Fifty years ago, that same basket would have cost the equivalent of £29. So relative to how much we earn, food is cheaper than it’s ever been. That’s because food is now produced on an industrial scale, by a vast international industry.

The food industry has grown to be so successful, that today it’s worth £54 billion a year in Britain alone. And it’s constantly striving to satisfy our desire for convenience and price, and to provide us with a greater choice of tempting foods.

**TRENDS – CHOICE**

Choice is the third major food trend. The food industry is constantly tempting us with new and interesting foods. The range of foods we eat has expanded immensely. Fifty years ago, I’d never seen foods like peppers, pizza or olive oil – they just weren’t around. Actually, when I was young you could buy olive oil in tiny bottles from the chemists. You didn’t cook with it – you poured it in your ear to soften the earwax! As for exotic fruit and vegetables such as lychees, kiwi fruit, kumquats, starfruit, mangos and yams – they were unheard of in Britain 50 years ago.

Nobody would have suspected that chicken tikka masala would become one of our national dishes. We now consume 23 million every year, just in restaurants.

**CONSUMER RESEARCH**

The food industry is constantly trying to make us buy new foods. They spend £570 million pounds a year on marketing their products in the UK alone. But that’s not all advertising – a large part of that expenditure is on consumer research, on trying to work out what we might buy. They’re so desperate to know our likes and dislikes, they try out new ideas on us all the time.

Sometimes they trial foods in specific areas of the country, and sometimes they use focus groups – small groups of people that are representative of the market the company wants to target. I’m going to run a focus group now. Here’s a food – a sweet – that’s so new, it’s not on sale yet. This batch has been cooked up in a flavour laboratory, just for us. The experts think it could be a smash hit next year, but we’re going to put it to the test. Five people will try one of these sweets and decide how much they like them. The theory behind the sweets is that, increasingly, we like contrasting flavours, like sweet and sour in oriental cookery. So the sweets also contrast two flavours. The
first is hot chilli peppers, chemicals that excite the pain receptors in your mouth. The second flavour is menthol, which has an anaesthetic effect – it’s cooling. It’s an extremely strange contrast, and the idea is that we’ll find it interesting, and perhaps delicious.

**FOOD MILES**

We have been looking at the food trends over the last 50 years. We showed that food has become more convenient, with a bigger choice, and cheaper. But one thing we missed out was the impact of our food, in particular, on the environment. Much of the huge choice of fruit and vegetables in our supermarkets has been transported by land, air or sea from all over the world. We buy runner beans from Kenya, sweetcorn from Mexico, and asparagus from Egypt. In fact, the contents of a typical British shopping trolley will have travelled over 95,000 miles before they get to your home – that’s almost four times round the world. Even the Christmas dinners many of you enjoyed will have travelled huge distances. One estimate was more than 43,000 food miles for a typical turkey dinner. It’s great to have all this choice, and you’d be forgiven for thinking it’s a trend that’s going to continue, but we mustn’t forget that the transport burns fossil fuels and is damaging to the environment. The more our food travels, the more damage it causes. That’s one reason why people think we need to produce food locally, and with more concern for the environment.

**ORGANIC FOOD**

We’re buying more organic produce each year; already, more than 4% of the agricultural land in Britain is farmed organically. The organic food industry is expanding by about 11% a year. Organic products are increasingly popular because people want their fruit and vegetables to be grown with minimal pesticides, and our chickens to live happy lives in a natural environment. Also, organic production may be better for the environment. If organic food is going to play a big role in the future, we’ll have to produce enough to feed the world, at a price that people can afford. Currently organic food is more expensive – about 20% more in the UK. And the truth is there’s no scientific evidence yet to show that organic food is any better for you.
FUTURE FOOD – NEUTRACEUTICALS

There are some foods that claim they are better for you. In fact, there’s a whole industry trying to make even very simple foods better for our health. The first products are just starting to appear, and it looks like the industry will become huge over the next 50 years.

We’ve all seen the adverts for a type of yoghurt that contains so-called ‘friendly bacteria’. These are bacteria that already live in your colon, like bifidobacteria and lactobacillus, and that are claimed to be good for you. But does this food work in the way that it’s claimed? If they’re to be of any use to you, they have to get all the way through your digestive system and into your colon. Most estimates suggest only about one in five of the bacteria makes that journey successfully. And anyway, your colon already has 100,000 billion bacteria of its own.

So it’s not clear, scientifically, that most of us need this sort of product. It won’t do you any harm, but it might not do you any good either.

However, some products are backed up by good scientific evidence. For example, a margarine has been developed and eating it reduces the amount of cholesterol you absorb from your food. For most people, lowering cholesterol reduces their risk of heart disease. The country pioneering this sort of product is Finland, which used to have an extremely high incidence of coronary heart disease. Today, thanks to sweeping changes of diet and lifestyle, that’s been cut by half.

There’s a whole new class of foods being developed, a new frontier of research, called ‘nutraceuticals.’ They’re halfway between nutritious foods, and pharmaceuticals and we’re going to be seeing a lot more foods like this in the next 50 years.

THE LOOMING PROBLEM – POPULATION GROWTH

We’ve looked at two possible futures – more organic foods, and foods that are good for you. But there’s a problem – in 50 years’ time, the world won’t be the same as it is today. Remember the machine from the beginning of this lecture? It’s been ticking away since we started. Every two seconds, it drops three more balls into the tank. Each ball represents not one, but two extra people. Every second about six babies are born, and about three people die. This means there are three more mouths to feed every second. Since I started talking this evening, there are almost 3000 new people to be fed.
Unless something happens to stop population growth, by the year 2050 there'll be 3 billion extra people. And they'll all need to eat.
Where is the extra food going to come from?

**THE LOOMING PROBLEM – LAND YIELDS**

Could we grow more food on the farms we already have? Today we can grow about three times as much food from the same piece of land as was possible 100 years ago. That’s an amazing difference, and it’s the result of better crops, and modern farming techniques, including pesticides and, particularly, fertilisers.

Nitrogen is crucial to the growth of plants. They have to take it in through their roots and in many farmed fields there simply isn’t enough nitrogen in the soil, so the plants don’t grow as well as they could. You can add some nitrogen with things like manure. Modern chemical fertilisers have been developed that are packed with nitrogen. Use of these is one of the main reasons why crop yields have tripled in the last 100 years. But we are coming up against the limits of farming technology. These fertilisers are so good, it’s relatively easy to provide plants with more nitrogen than they can use and any excess is washed out of the field and into waterways. So, we’re not going to get much more out of the land by adding more fertilisers and we may cause more environmental damage than we are doing already.

Therefore, to grow more food, we’d have to farm more land. But across the world, most of the land that’s suitable for agriculture is already farmed. And nobody’s making any more land, are they?

**THE LOOMING PROBLEM – WATER**

There’s another limit on growing more food for the future – fresh water. We seem to have so much of it. You just turn on the tap. But in many places in the world, there isn’t enough to go round and what’s more, most of the water that’s used is used in agriculture.

In Britain it rains a lot, and we don’t need to water our crops very much. But in America almost 700 cubic metres of water, per person, is used for farming, every year. In Sudan, it’s 1000 cubic metres of water, per person per year, for farming. Globally, 69% of the water used, is used for agriculture. And the amount used is increasing every year. **By the year 2050, there simply won’t be enough fresh water to grow the food we will need.**
So what's the solution? Could we use water more efficiently? Most farmers water their crops by spraying them from above. When crops are watered like this, one third of the water is wasted. It evaporates, and never reaches the roots. So, one solution might be to find more efficient methods of irrigating crops and getting the water where it needs to be, to the roots of the plants. Systems have been developed where a moisture sensor in the soil controls a valve that lets precise amounts of water trickle to the roots. This can be tremendously effective and virtually eliminates the losses to evaporation. We can reduce evaporation losses from the soil further by combining watering systems with techniques like covering the ground with plastic sheeting. Systems like this are expensive and, even if they were used more widely, they may not be enough to solve the water problem.

**SOLUTIONS – CHOICE OF FOODSTUFF**

Could we use less water if we change the foods we eat? Let's look at the amount of water required to grow just one gram of some different foods.

Wheat is quite efficient. It takes just one litre of water to grow one gram of wheat.

It takes two litres of water to grow one gram of rice.

Surprisingly, chickens don't require much more water than rice does. Each gram of chicken takes three litres of water to grow. What's more, the food you get out of them is of higher value – you get more out of it when you eat it. So in some ways chickens are an excellent food to grow.

An enormous amount of water is required to rear cows, because cows are fed on grain crops. Each gram of beef requires 15 litres of water to grow. So to grow a cow, first you have to grow a whole load of wheat. Most of what a cow eats goes into the energy the cow needs to live, and not into growth. So while beef is an excellent food, growing it is an inefficient way of using grain, and a very inefficient use of water. All these results show that going vegetarian would help us to use less water. But the single biggest difference is in choosing which kinds of meats we eat. Globally, more than 300 million cows are slaughtered every year. And beef consumption is going up, particularly in countries like China, where it's gone up 240% in the last 10 years. So people are consuming more beef rather than less, and that's going to make the problem worse.

Are there other ways of solving the water problem, and growing enough food for everyone in the future? One thing we haven't considered so far is whether advances in science might help.
GM – INTRODUCTION

We have reached the point where there will be lots more people to feed, and are asking the question: can science help us? Since the beginning of agriculture, our ancestors started modifying the animals and plants they grew for food by selective breeding. An example that illustrates the power of selective breeding in practice is to look at different varieties of chickens that exist today. They look quite different, but believe it or not, they all come from a common wild ancestor – the Burmese Jungle Fowl.

Farmers saw there was variation, and they selected the types they wanted. It might have been size, or the plumes on the head. They bred from those individuals and the required characteristics were handed down in the genes through the generations. The characteristics become more exaggerated from one generation to the next. This kind of process has given us the livestock and the crops we farm today.

But suppose you wanted a feature that would be really useful, but that didn’t exist in the variation of the crop you were growing.

Rice is the staple food of almost a third of the world’s population. But rice plants are tricky to grow – they need lots of fresh water. They can’t grow in salty conditions. We can find a plant, however, which is the exact opposite. It’s a grass called Spartina that grows, here in Britain, on salt marshes. It’s no use at all as a food but if you look at its leaves, you can see they are covered in salt crystals. This grass grows in salt water. It manages to do that by excreting the salt through glands, out onto its leaves.

There are huge areas of land around the world where the water is too salty for crops. If we could take that property – the ability to grow in salty water – and add it to rice, the result would be amazing. There’d be millions of acres of land that could be used for agriculture.

There are two ways to do that. We could either try to breed rice that’s salt-tolerant, or we could try to find the genes that give Spartina salt tolerance, and insert them into the rice. The technology to do that is genetic modification.
GM – WHAT IS IT?

DNA exists in almost every cell of every living organism, and contains the genetic instructions for building that whole organism. The DNA molecule looks like a twisted rope ladder, or double helix. An unravelled strand of human DNA is about 3 metres long.

The individual instructions are written in short sections of DNA called genes. In human DNA there are between 20,000 and 25,000 genes. All the DNA in an organism is its genome and amazingly, 60% of the human genome is the same as that found in chickens, and 30% of it is shared with carrots. The language of DNA is astonishingly universal.

In genetic modification, the idea is to take a gene from one organism and insert it into another.

GM – WHAT CAN IT DO?

This rice could save half a million children a year from going blind. Why is that? It is yellow in colour and is called ‘golden rice’. It's been genetically modified by scientists in Germany to produce beta-carotene, which is what gives the rice its colour. Your body can turn beta-carotene into vitamin A, without which the light-sensitive molecules at the back of your eye won't work. Normal rice doesn't have beta-carotene. Children in some parts of the world, where the diet is based largely on rice, often don't get enough vitamin A and many go blind. Amazingly, just 20 grams a day of this new rice could prevent that.

It's taken many years to develop, and it'll take another few years to pass all the stages of the regulatory procedures so that people can start eating those 20 grams a day. That's one example of a genetically modified plant that solves a specific problem. And now that the techniques have been developed, it's hoped that future advances with rice like this can be made more quickly.

GM – HOW DOES IT WORK?

A lot of people are very concerned about genetic modification; they worry about the dangers either to their health, or to the environment. Because of these concerns, it's strictly regulated.

Rather than making a judgement on whether it's the right thing to do here and now, let's understand how genetic modification works. We're going to genetically modify an onion to illustrate the techniques and principles involved.

We're going to take a gene that comes, not from another plant, but from a jellyfish called Aequoroea Victoria, which swims in
the Pacific Ocean. The jellyfish has a gene that makes some of its cells produce a particular protein that fluoresces under ultraviolet light. We can take that gene out of the jellyfish, and insert it into the cells of an onion. If it works, the onion cells will fluoresce, because of the jellyfish gene.

The challenge is to get the jellyfish gene into the onion. The gene for the fluorescing protein is extracted from the jellyfish and coated onto tiny gold pellets. The pellets are fired at high speed from a scientific version of an air pistol into a very thin slice of onion where they pierce the cell membrane. This sounds violent but it has to be. The cell membrane is intended to keep things out and one way of getting past it is brute force. Once it gets inside the cell, the jellyfish gene carried on the pellet unravels, and it sometimes manages to make its way into the cell nucleus. There, it causes the cell to make the fluorescent protein. Remember, what's amazing about this, even after it has bashed through the onion cell wall and reached the nucleus, for this to work, the onion has to understand the gene and know what to do with it.

So, we can take a gene from one organism and insert into another. This is only one method of doing it; there are several others.

Of course, a glowing onion isn't much use to feed the world. But scientists are working on modifying onions, to give them a better flavour, to be healthier, and even to make you cry less. Geneticists are working to improve and develop a range of foods. Examples include crops that are tolerant to moulds and ones that produce increased amounts of omega-3 fatty acids that help reduce heart disease. This year, for the first time, a group of scientists in China has carried out field trials of a new strain of salt-tolerant wheat which can be grown in water that's much more salty than normal wheat.

There are huge challenges before that sort of breakthrough ends up on people's plates. But it's exactly the sort of development we need to help feed all those new mouths, over the next 50 years, as the population continues to grow every second.
CONCLUSION

We started by looking at the sorts of foods we might eat in the future, and about the sorts of technologies that might give us exciting new foods. However, the real challenge over the next 50 years is actually feeding the ever-growing world population. So there are some hard choices to make:

Do we want cheaper, more varied, and more exotic food – whatever the cost to the environment?

Do we want local and organic food even if it means that people in poor countries can't get richer by selling their crops to us?

And, perhaps most important of all – should we accept the risks of new technologies, or accept the risk that people will continue to die of starvation?

But it's not my generation who are going to make these choices. It's your generation. The future lies in your hands.