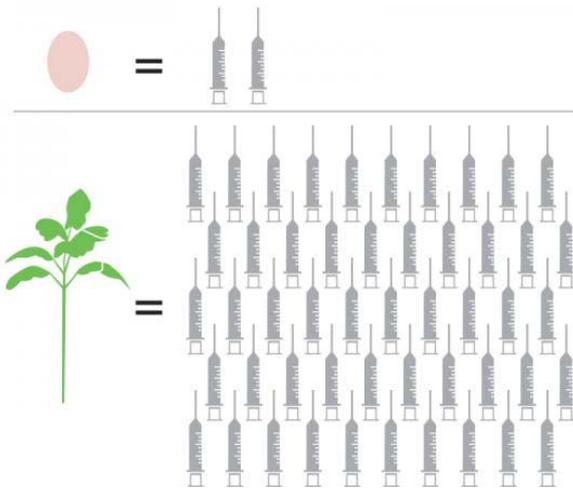


Plants for health

Harvesting vaccines

Vaccines can prevent many illnesses, but first they must be grown



An egg can grow at most two doses of flu vaccine. A tobacco plant can grow 50. CC BY 'Big Picture: Plants' (2016)

Making a vaccine against a virus often involves growing large amounts of that virus. This is because a vaccine works by training your immune system to recognise the virus, and this recognition relies on markers on viruses called antigens. The viruses can be grown in and harvested from infected animal cells.

Viruses needed to make the influenza vaccine, for instance, are usually grown in chicken eggs. However, this takes time, is costly and in a flu pandemic it might not be able to keep up with public need. Using plants can enable faster antigen production on a massive scale. Eventually, this could produce the 50 million doses in 12 weeks that the US government thinks would be needed – an impossible feat using the traditional egg-based method. Trials are already going on for influenza vaccines made using tobacco plants (which were also used for the Ebola antibodies in 'Fighting disease with pharming').

Some scientists also talk about creating oral vaccines that could be consumed in plant-based foods. An early example is a hepatitis B vaccine grown in genetically modified potatoes. In 2005, researchers immunised people against hepatitis B by feeding them chunks of potato containing a single protein from the virus. Over half of these people then produced more antibodies against hepatitis B.

Fighting disease with pharming

Scientists grow antibodies in plant cells to combat Ebola and HIV

In the last few decades, scientists have started making drugs in living cells, such as *E. coli* bacteria and hamster cells, which can be grown in large vats or fermenters. The cells are genetically modified so that they produce the drug molecules – usually proteins, including antibodies against diseases such as breast cancer. Drugs can also be produced in the cells of whole plants – a practice known as pharming.

During the Ebola outbreak in West Africa that started in 2013, limited supplies of the pharmed drug ZMapp were used to treat infected American, British and Spanish patients. The drug consisted of antibodies produced in tobacco plants grown in Kentucky. These plants had been infected with a bacterium carrying genes for making anti-Ebola antibodies and had incorporated these genes into their own plant cells to start making the antibodies themselves. Researchers are now working on pharming anti-HIV antibodies. It's even thought possible to produce several different medicinal molecules at once to make up the drug cocktails that are required for diseases like HIV. No

matter how the drugs are made, however, they still have to undergo rigorous (and expensive) trials in animals and humans before they can be approved for use.

One of the advantages of pharming is that it may be much cheaper to make the drugs required for the early stages of testing.

This approach may be safer too: plants have no risk of transmitting diseases to humans because the antibodies are produced without using the antigen or infectious microorganisms, which is necessary when production takes place in animal cells.

Do plants make us feel better?

Scientists think being near greenery could improve our health

Humans have an in-built desire to be close to nature, according to a theory known as the biophilia hypothesis. Its supporters claim that green and natural surroundings are restorative, allowing us to relax, escape from stress and better focus our attention.

This, biophilia theorists say, is because the vast majority of our development as a species took place in the natural world. We evolved to adapt and respond to that environment, which left certain preferences for nature embedded deep in our minds. There isn't any conclusive evidence to prove that this is true, but many pieces of research support the idea.

Office spaces and urban environments

Some studies suggest that simply being exposed to daylight or working somewhere with a view of trees can improve health and wellbeing. One 2008 study found that staff who worked in offices with living plants and windows were more satisfied with their work and reported better quality of life than those whose offices had neither.

And a larger UK study, surveying 10,000 people between 1991 and 2008, found that urban dwellers were happier and scored lower on a scale of mental distress if they lived in areas with more green space.

In fact, research has shown that contact with nature correlates with healthier childhood development, better concentration and memory, and faster recovery following illness or surgery. Even indirect contact with greenery, such as through pictures, seems to be beneficial in some cases.

Because of the strength of this supporting evidence, the hypothesis is being applied practically. Biophilic principles influence the design of schools, hospitals, offices and public spaces. There is even a hypothesis that adding vegetation to urban environments reduces crime.

Horticultural therapy

Biophilia is also being applied to help individuals. Horticultural therapy, for example, is used help people improve their wellbeing through outdoor activities, such as gardening. The therapists often work with people who have disabilities or mental health problems.

But the benefits of horticultural therapy may stem from it being a physical activity – the exact influence of nature on patients isn't known. With so many things affecting people's health and wellbeing, researchers have to constantly investigate what confounding factors may be influencing their results.

Keeping the doctor away

Many phytochemicals have a health benefit for humans

Of the huge number of chemicals plants produce that are beneficial to their own survival, many are also useful to humans. Phytochemicals ('phyto' means plant in Greek) are natural plant compounds, often secondary

metabolites that are not vital to the plant's primary growth and development. Some have health benefits for us. Simply by eating fruit, vegetables, nuts, seeds, cereals and vegetable oils, we absorb a lot of phytochemicals, but they are also added to certain products with the aim of improving their nutritional value.

Plant stanols and sterols are phytochemicals added to spreads and yoghurts as supplements. Eating around 2–3 g of these a day can help stop cholesterol being absorbed into the blood, thus lowering cholesterol levels and reducing heart disease risk in people with high cholesterol. The health benefits of phytochemical antioxidants such as polyphenols (which perform a range of roles in plants) and carotenoids (plant pigments) are less clear, despite widespread claims about their ability to combat disease.

Sweet wormwood and artemisinin

The plant origins – and future – of malaria treatment

In 2015, 438,000 people died from malaria. The greatest toll was on sub-Saharan Africa, where over 90 per cent of malaria deaths occur. Malaria-ravaged countries face an ever-evolving threat as malaria parasites adapt to resist our best drugs.

The primary antimalarial drug of choice – artemisinin – is produced from the sweet wormwood plant, *Artemisia annua*, and its synthetic forms. This plant has long been used in Chinese medicine. It now is used in combination with other drugs to try to stop the parasites from developing resistance to it, but even these combinations are becoming less effective.

Recent research suggests that we might be able to use the dried leaves of the whole plant to overcome the parasites' resistance: feeding mice with sweet wormwood leaves proved more effective than giving them comparable doses of standard artemisinin treatments. The researchers think the whole plant may act as a form of combination therapy, because it naturally makes a range of artemisinin-related compounds, which may have slightly different actions. However, the World Health Organization advises against using the plant this way because of the risk of taking too low a dose, which would allow the malaria parasite to survive and evolve to become even harder to stop.