



The Golden Rice

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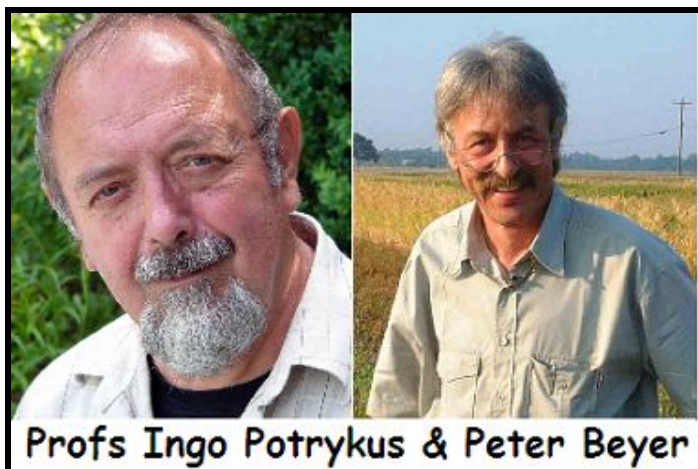
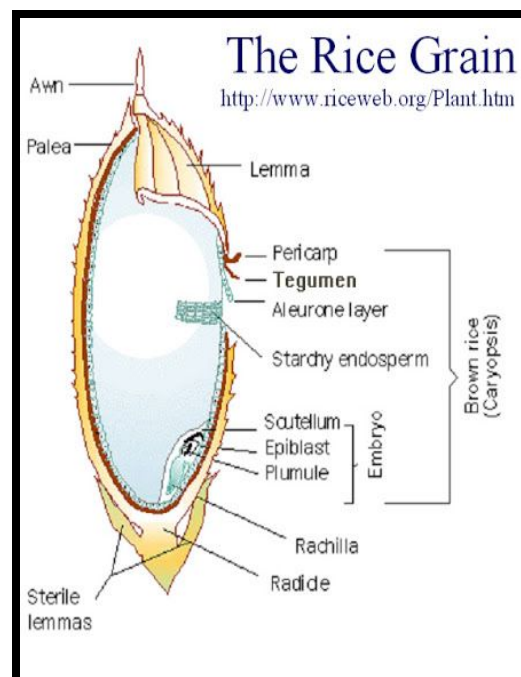
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1.Introduction

What is Golden Rice?

Golden Rice is a genetically engineered variety of rice (*Oryza sativa*). It has been modified by inserting a gene from maize and a gene from bacteria found in soil which allows the plant to biosynthesize beta-carotene in the edible parts of rice. Beta-carotene is naturally found in many fruits and vegetables, such as squash, papaya and carrots, giving them their yellow colour and it can be synthesised by the human body to make vitamin A. Characteristically, this genetic modification makes the rice grains a golden yellow colour.



The *Golden Rice Project* was first introduced in 1999, when two professors **Ingo Potrykus and Peter Beyer**, proposed their project to Rockefeller Foundation to genetically engineer rice to increase its nutrients. Rockefeller Foundation supported their goal to provide a sustainable biofortification approach to combat vitamin A deficiencies in developing countries. Vitamin A deficiency (VAD) is prevalent in developing countries whose diets are

dependent on rice or other micronutrient-poor carbohydrate foods, which do not contain vitamin A. The World Health Organization estimates that about 250 million preschool children are affected by VAD and about 2.7 million children die because of the deficiency. VAD can have numerous negative health effects such as dryness of the eye that can lead to blindness if untreated; reduced immune system response, and an increase in the severity and mortality risk of infections. Golden Rice Humanitarian Board **Ingo Potrykus** is the engine behind the

Golden Rice Project and the Humanitarian Board. **Together** with **Peter Beyer** he was one of the inventors of the Golden Rice technology

2.Motive which lead to the project of Golden Rice

The research that led to **golden rice** was conducted with the goal of helping children who suffer from vitamin A deficiency (VAD). In 2005, 190 million children and 19 million pregnant women, in 122 countries, were estimated to be affected by VAD. In particular, vitamin A deficiency is estimated to kill 670,000 children under the age of 5 each year .

The Major Problems Due to VAD

Vitamin A deficiency can result from inadequate intake, fat malabsorption, or liver disorders. Deficiency impairs immunity and hematopoiesis and causes rashes and typical ocular effects (eg, xerophthalmia, night blindness). Diagnosis is based on typical ocular findings and low vitamin A levels. Growth retardation and infections are common among children. Mortality rate can exceed 50% in children with severe vitamin A deficiency.



Primary vitamin A deficiency

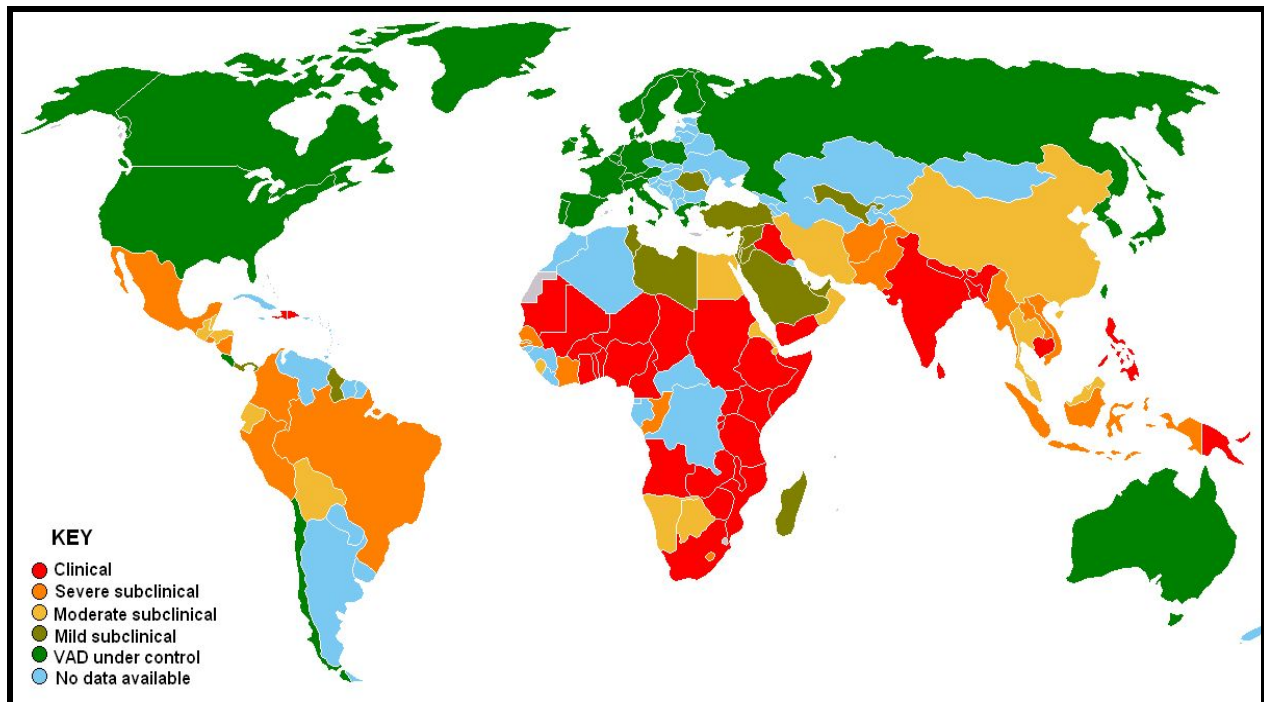
It is endemic in areas such as southern and eastern Asia, where rice, devoid of beta-carotene, is the staple food. Xerophthalmia due to primary deficiency is a common cause of blindness among young children in developing countries.

Secondary vitamin A deficiency

Interference with absorption or storage is likely in celiac disease, cystic fibrosis, pancreatic insufficiency, duodenal bypass, chronic diarrhea, bile duct obstruction, giardiasis, and cirrhosis. Vitamin A deficiency is common in prolonged protein-energy undernutrition not only because

the diet is deficient but also because vitamin A storage and transport is defective.





Prevalence of vitamin A deficiency. Red is most severe (clinical), green least severe. Countries not reporting data are coded blue. Data collected for a 1995 report.

Why Rice?

☞ Global staple food. Cultivated for over 10,000 years

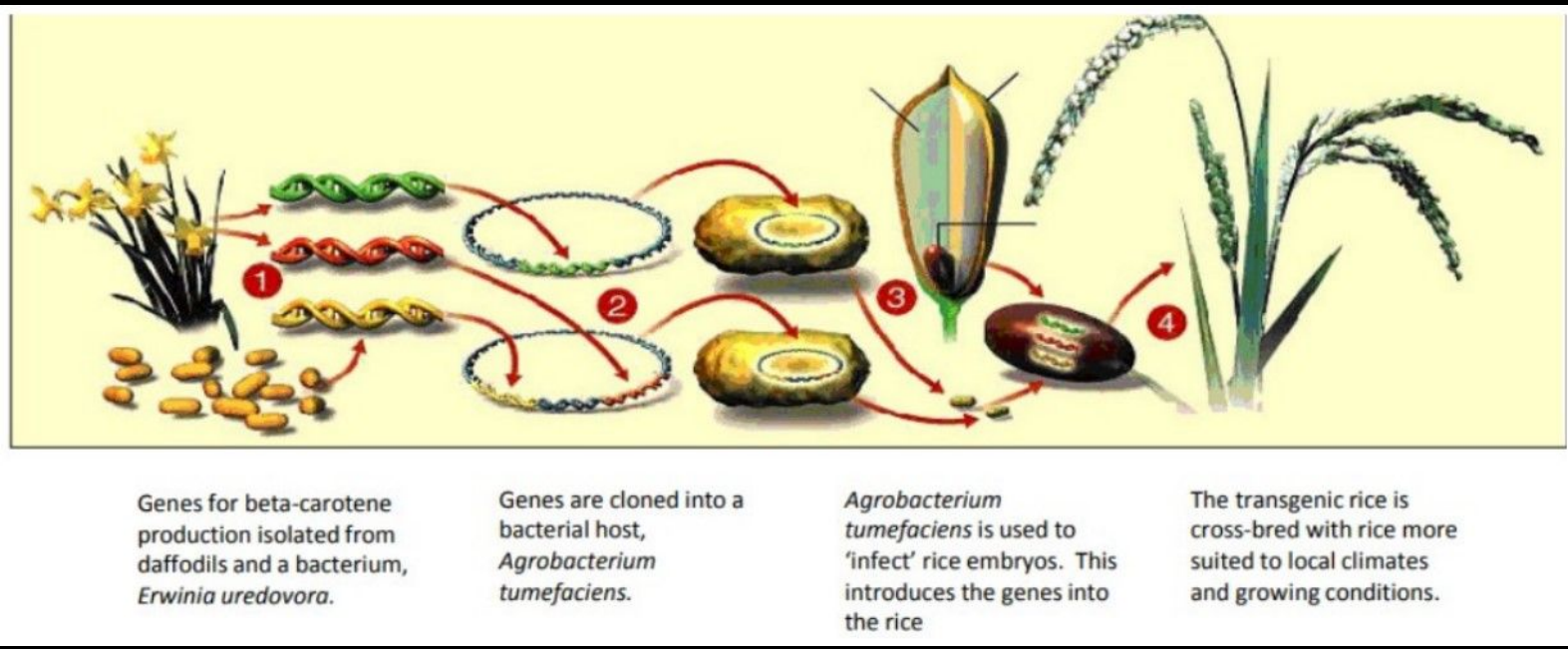
☞ Rice provides as much as 80 percent or more of the daily caloric intake of 3 billion people, which is half the world's population

☞ Other plants, such as sweet potatoes have varieties that are either rich (orange-fleshed) or poor (white fleshed) in pro-vitamin A

☞ Carrots were originally white or purple in the 1600's. A Dutch horticulturist mutated the carrot to produce carotenoids to symbolize the color of the Dutch Royal House of Orange



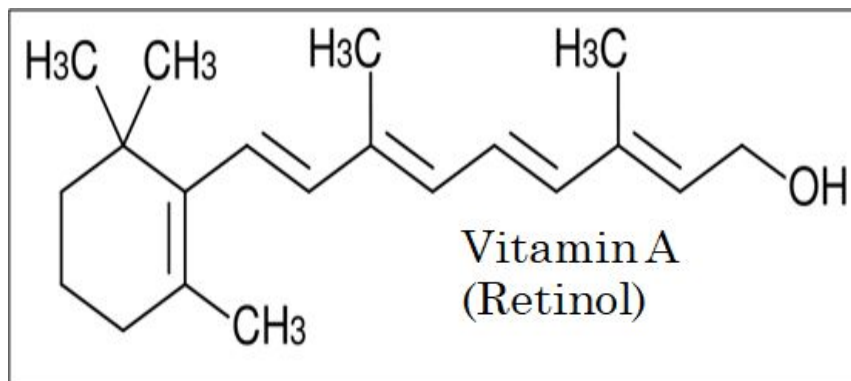
How is Golden Rice Prepared???



- The genes that give golden rice its ability to make beta-carotene in its endosperm (the interior of the kernel) come from Daffodils & a bacterium called Erwinia Uredovora.
- These genes, along with promoters (segments of DNA that activate genes), are inserted into plasmids (small loops of DNA) that occur inside a species of bacterium known as Agrobacterium tumefaciens.
- These agrobacteria are then added to a petri dish containing rice embryos. As they infect the embryos, they also transfer the genes that encode instructions for making beta-carotene.
- The transgenic rice plants must now be crossed with strains of rice that are grown locally and are suited to a particular region's climate and growing conditions.
- FINAL PRODUCT: **The Golden Rice**

3.The Development of Golden Rice

In 2000 the inventors' established a public-private partnership with agricultural technology company Syngenta to help further develop Golden Rice. Part of the relationship with Syngenta was involved in gaining patents around Golden Rice but they also carried out additional laboratory, greenhouse and field research to help raise the beta-carotene levels.



Golden Rice 2 was announced in 2005, which produces up to **23** times more beta-carotene than the original Golden Rice. At this yield it is calculated that 144g (around one cup) of Golden Rice would have to be eaten to receive a recommended daily dose of vitamin A. The Golden Rice Project now operates under a humanitarian board within the International Rice Research Institute (IRRI) and they have been working together since 2006. Golden Rice was one of seven winners of the 2015 Patents for Humanity Awards by the United States Patent and Trademark Office.

The Bill and Melinda Gates Foundation is now supporting the final testing of Golden Rice and, as of the close of 2016, it is still in development.

The first field trial of the Golden Rice in Bangladesh has yielded promising results, and it is expected that Golden Rice will be released there early as 2018.

øMutate rice plants to produce carotenoids, or organic pigments, specifically β -carotene (pro-vitamin A) in the endosperm, the edible part of the grain.

øMake *Golden Rice* accessible locally, free of charge to farmers, who are able to grow, save, consume, replant and locally sell *Golden Rice*.

Testing

The International Rice Research Institute (IRRI) has shown that Golden Rice is safe for human consumption. Specifically, they have demonstrated that beta-carotene in food is a safe source of vitamin A, that the beta-carotene in Golden Rice is the same as the beta-carotene that is found in other foods and that the proteins from the new genes in Golden Rice do not show any toxic or allergenic properties.

Any new proteins produced by the rice have been shown to break down quickly in simulated gastric fluid and a mouse feeding study is under way in a laboratory in the United States. The potential that the Golden Rice would cross-pollinate with other varieties has been studied and found to be limited, because rice is typically self-pollinated. And its production of beta-carotene does not appear to provide a competitive advantage — or disadvantage — that could affect the survival of wild varieties with which it might mix.

BANGLADESH

Biosafety approval is a prerequisite for inclusion in the rice variety listing of the National Seed Board (NSB) of Bangladesh. To complete the biosafety review process, the

Bangladesh Rice Research Institute (BRRI) lodged an application to the National Technical Co

In 2018, golden rice was **approved for consumption** in the US committee on Crop Biotechnology (NTCCB) at the Ministry of Agriculture on November 26, 2017, who forwarded the application to the National Committee on Biosafety (NCB) at the Ministry of Environment on December 4, 2017. GM crops are those that have been modified genetically to tackle certain problems or enhance their



nutrition quotient. For example, Bt brinjal, a GM variety commercially cultivated in some countries, is equipped with pest-resistant properties.

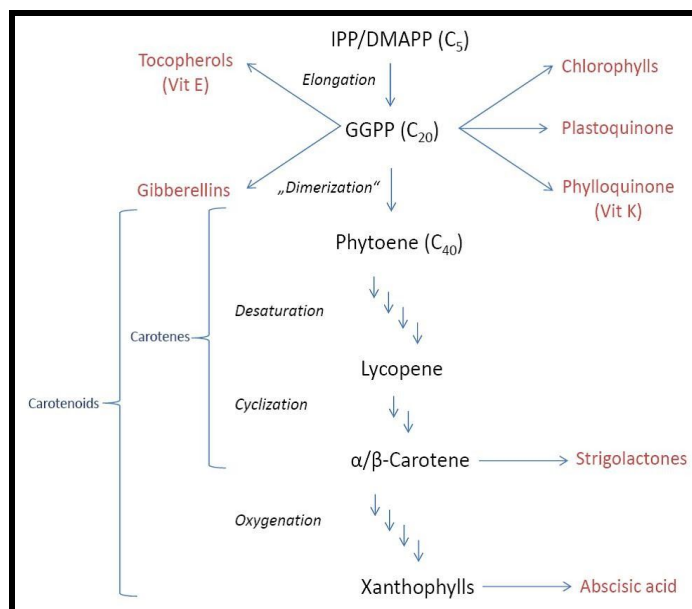
However, they have been controversial in India, with some civil society groups raising health- and environment-related concerns. The only GM crop under commercial cultivation in India is Bt cotton. India is yet to approve commercial cultivation of a genetically modified food crop. Bt brinjal was approved for cultivation in 2009, but has been under an indefinite moratorium **pending further studies** since 2010. In 2013, Bangladesh became the first South Asian country to allow the commercial cultivation of Bt brinjal, **and a study released last year claimed** it was helping local farmers earn and save more. Golden rice is meant to tackle Vitamin A deficiency, a major public health problem, especially in South Asia. Severe deficiency can lead to disorders such as childhood blindness, anaemia, and weakened immunity, increasing the risk of death from infectious diseases.

The golden rice project **first started** in 1982 as an initiative of the Rockefeller Foundation, a New York-based philanthropy. In **a scientific paper published in 2000**, researchers from Germany and the US described successfully growing genetically modified rice varieties that had the ability to naturally produce beta-carotene or provitamin A. Provitamin is a substance that can be converted into vitamins once inside the body. **Beta-carotene** is a pigment commonly found in colourful fruits and vegetables like carrots. In rice, the presence of this pigment gives it a characteristic golden colour. Canada.

4. Rewiring the grain

Metabolic engineering

Golden Rice technology is based on the simple principle that rice plants possess the whole machinery to synthesise β -carotene, and while this machinery is fully active in leaves, parts of it are turned off in the grain.



By adding only two genes, a **plant phytoene synthase (psy)** and a **bacterial phytoene desaturase (crt I)**, the pathway is turned back on and β -carotene consequently accumulates in the grain.

Pathway overview: carotenoid biosynthesis begins with a small (C5) compound, isopentenyl-diphosphate (IPP) and its isomer dimethylallyl-diphosphate (DMAPP). Chain elongation by C5 units leads to the formation of the C20-compound geranylgeranyl-diphosphate (GGPP). GGPP is a precursor that can enter several biosynthetic routes, as indicated. The head-to-head condensation of two GGPP molecules produces the first, colourless carotene, phytoene. A series of desaturation reactions lead to the coloured chromophore of lycopene, and subsequent cyclization reactions produce the β - and ϵ -ionone rings.



5. Opposition to Golden Rice



Environmental and anti-globalisation groups have provided the most significant opposition to the development and deployment of Golden Rice. The main arguments surround the

safety for humans ingesting a GMO, the environmental safety of Golden Rice as a GMO, questions around the cost of development as opposed to other ways of combating vitamin A deficiency and general complaints concerning the industrialisation of the food chain.

One of the most high-profile opponents to Golden Rice is **Greenpeace** who argue that it “is a proposed but not practically viable crop solution that has never been brought to market.”

They further argue that it is also environmentally irresponsible and could compromise food, nutrition and financial security.

A more detailed set of arguments have been provided by a group called **Science In Society**. Their main objections can be reduced to a dot-point list of 12 arguments under the heading “‘Golden rice’ is no technical improvement and more unsafe” which were redressed in [this article](#) from the Golden Rice Organisation.

The general arguments against Golden

Rice as a GMO have been rebutted in an earlier **Science Update**.



The Philippines Protests

In **August 2013** a group of 400 people broke into the Department of Agriculture Regional Field Unit No. 5 at Pili, Camarines Sur in the Bicol region of the Philippines and destroyed a 1000 square metre test crop of Golden Rice. This test site was run by the International Rice Research Institute.

Some **claims** have been made that this was a group of farmers while other sources **claim** it was a group of

MEDIA ADVISORY

Hundreds of farmers oppose unsafe genetically modified Syngenta Golden Rice at anniversary of PhilRice!

ANTI-GOLDEN RICE PROTEST AT PHILRICE

9am, November 8, 2011

Muñoz, Nueva Ecija

Farmers to cook traditional rice and vegetables rich in Vitamin A!
Please cover!

Led by
AMGL, MASIPAG and RESIST

For details, pls contact AMGL 0917-607-3158

anti-GMO activists. Whoever these protesters were, they appear to have little understanding of the science around GMO safety, relying heavily on misconceptions and fears, as well as motivated by anti-globalisation and corporate agricultural issues.

It was this protest that spurred a [petition](#) spearheaded by Nobel Laureates and other scientists in support of GM technology and Golden Rice. So far 121 Nobel Laureates and 6334 scientists have signed this petition.

6. Conclusion

Rice is naturally low in the pigment beta-carotene, which the body uses to make Vitamin A. Golden rice contains this, which is the reason for its golden colour.



Vitamin A deficiency remains a huge public health problem despite existing interventions. Biofortification of staple foods is a new policy priority internationally. Golden Rice is safe. There is excellent human evidence that it will work. It is expected to be extremely cost-effective. For successful adoption of Golden Rice as an additional intervention for vitamin A deficiency, the support of public health professionals is critical.

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