

Science as a Human Endeavour

From the SACE Nutrition Subject Outline: *Students investigate a contemporary example of how nutrition science interacts with society. This may focus on one or more of the key concepts of science as a human endeavour described on pages 38 and 39, and may draw on a context suggested in the topics or relate to a new context. Students select and explore a recent discovery, innovation, issue, or advance linked to one of the topics in Stage 2 Nutrition. They analyse and synthesise information from different sources to explain the science relevant to the focus of their investigation, show its connections to science as a human endeavour, and develop a conclusion.*

For Stage 2: Based on their investigation, students prepare a scientific report, which must include the use of scientific terminology and the following criteria

Criteria	Description
Introduction	Identify the focus of the investigation and the key concept(s) of science as a human endeavour that it links to
Nutritional Background	Explanation of relevant nutrition concepts.
Link to SHE concept(s)	An explanation of how the focus of the investigation illustrates the interaction between science and society, including a discussion of the potential impact of the focus of the investigation
Conclusion	Concluding statement
Communication	Use of biological terminology. 1500 word limit
Referencing	In-text and reference list

Performance Standards

Obviously KA3 is required, but any PS that you consider important can be used.

	A	B	C	D	E
Investigation, Analysis and Evaluation 3	Systematically analyses and interprets data and/or information to formulate logical conclusions	Analyses and interprets data and/or information to formulate reasonable conclusions	Interprets data and/or information to formulate generally appropriate conclusions	Describes data and/or information to formulate basic conclusions	Attempts to describe data and/or information and formulates a simple conclusion
Knowledge and Application 1	Demonstrates deep and broad knowledge and understand of a range of nutrition concepts	Demonstrates some depth and breadth of knowledge and understanding of a range of nutrition concepts	Demonstrates knowledge and understanding of a general range of nutrition concepts	Demonstrates some basic knowledge and partial understanding of nutrition concepts	Demonstrates limited recognition and awareness of nutrition concepts
Knowledge and Application 3	Critically explores and understands the relationship between nutrition science and society	Logically explores and understands the relationship between nutrition science and society	Explores and understands aspects of the relationship between nutrition science and society	Partially explores and recognises aspects of the relationship between nutrition science and society	Attempts to explore and identify and aspect of the relationship between nutrition science and society
Knowledge and Application 4	Coherently and clearly communicates nutrition concepts and nutrition literacy and numeracy	Mostly coherently and clearly communicates nutrition concepts and nutrition literacy and numeracy	Generally coherently and clearly communicates nutrition concepts and nutrition literacy and numeracy	Clearly communicates some nutrition concepts and nutrition literacy and numeracy	Attempts to communicate nutrition concepts and nutrition literacy and numeracy

Development of GM rice to alleviate Vitamin A deficiency in developing countries

Nutrition Course link:

Topic 3: Sustainable food systems

- *Research and Development*
 - new food products including GMO and entomophagy

Introduction:

Vitamin A deficiency (VAD) is a public health problem which affects over 50% of countries globally, specifically Africa and South-East Asia, significantly impacting young children and pregnant women in low-income communities.¹ VAD increases the risk of diseases and death from severe infections and is the leading cause of preventable blindness in children. In pregnant women, VAD may cause night blindness and increase the risk of maternal mortality.² Therefore, European scientists were prompted to **develop** genetically modified rice, a staple food in many low socio-economic countries, in order to activate the pathway that produces Beta-carotene, an essential nutrient that is converted into vitamin A in the body. In doing so, they aimed to provide a solution to combat the VAD crisis faced by many low-income countries. Yet, the **application** of recent field and human trials has highlighted the major **limitations** of nutritional content expectations of the Golden Rice (GR).

Introduction Assessment Notes:

Clear identification of key issue

- Statistics on prevalence
- Effect of Vit A deficiency on individuals

Links to SHE concepts clearly stated.

- Development of GM rice to enhance Vit A content
- Application (field trials) & Limitations (nutritional content)

Introduction: 200 words

Nutritional background:

There are two types of vitamin A; preformed vitamin A (retinol) found in animal products, and pro-vitamin A carotenoids, such as beta-carotene (β -carotene) found in plant-based foods. β -carotene is known as a precursor of vitamin A, as it is converted in the body into retinol. Retinol creates the pigments in the retina of the eye and is vital for good vision, especially night vision. Vitamin A is also important in the formation and maintenance of teeth and bones, but is also a key nutrient for the development of white blood cells required for immune system function.³

Rice is a staple food for more than half of the world's population. For many of the poorest individuals within Asia, rice accounts for more than 50% of their total daily energy intake. Rice consumption is also on the increase in Africa, with individuals moving away from tubers and cassava to rice as income increases.⁴ Rice does not contain any β -carotene, which means the body is unable to create retinol, resulting in high Vitamin A deficiencies globally.

¹ WHO | *Micronutrient deficiencies* (2020). Available at: <https://www.who.int/nutrition/topics/vad/en/> (Accessed: 5 August 2020).

² Stevens, G. et al. (2015) "Trends and mortality effects of vitamin A deficiency in children in 138 low-income and middle-income countries between 1991 and 2013: a pooled analysis of population-based surveys", *The Lancet Global Health*, 3(9), pp. e528-e536. doi: 10.1016/s2214-109x(15)00039-x.

³ Bradford, A., 2020. *Vitamin A: Sources & Benefits*. [online] livescience.com. Available at: <<https://www.livescience.com/51975-vitamin-a.html>> [Accessed 26 October 2020].

⁴ Ricepedia. 2013. *The Global Staple - Ricepedia*. [online] Available at: <<http://ricepedia.org/rice-as-food/the-global-staple-rice-consumers>> [Accessed 26 October 2020].

Deoxyribonucleic Acid (DNA) is a self-replicating molecule that contains the genetic code of organisms. Genes are segments of DNA that code for a specific protein that function in one or more types of cells in the body.⁵ Genetically modified (GM) foods are those which are derived from organisms whose genetic material (DNA) has been modified, for example; through the introduction of a gene from a different organism. This allows the introduction of new traits, as well as greater control over traits, which has assisted in the development of Golden rice (figure 1).⁶

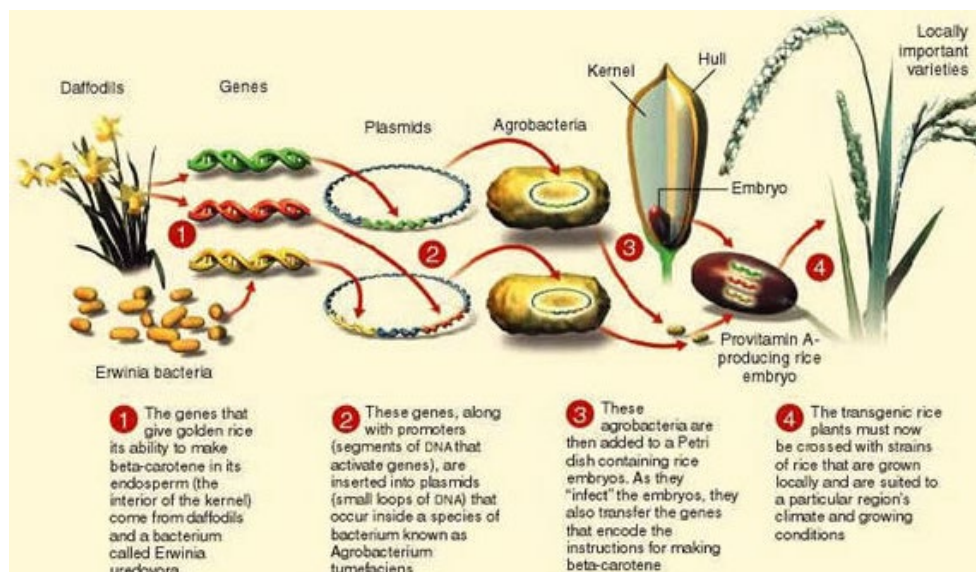


Figure 1: The image clearly shows the four-step process on how genes were inserted into the rice plant to increase the amount of beta-carotene it produces.

Golden Rice is the result of targeted genetic engineering, which consists of introducing the necessary genes to enable the rice grains to produce precursor molecules present in the grain, and thus activate the biochemical pathway to β -carotene production.⁷

Nutritional Background Assessment Notes

- Detail on function of vitamin A links to staple food impact
- Clear discussion of what GM is and how it is achieved

Nut Background: 404 words

⁵ *Genes and Chromosomes - Fundamentals - MSD Manual Consumer Version (2020)*. Available at: <https://www.msmanuals.com/en-au/home/fundamentals/genetics/genes-and-chromosomes#:~:text=Genes%20are%20segments%20of%20deoxyribonucleic,are%20in%20the%20cell%20nucleus>. (Accessed: 6 August 2020).

⁶ *Food, Genetically modified (2020)*. Available at: https://www.who.int/health-topics/food-genetically-modified#tab=tab_1 (Accessed: 6 August 2020).

⁷ Mayer, C. (2020) *Golden Rice Project*, [Goldenrice.org](http://www.goldenrice.org). Available at: <http://www.goldenrice.org/Content2-How/how.php> (Accessed: 5 August 2020).

Development

The development of genetic engineering technology were showing promising results, leading to the idea in the early 1990s to engineer rice, the staple food for over half of the world's population.⁸ A project was developed that aims to alleviate VAD in low-income communities. The team developed two versions of Golden Rice; Golden Rice 1 (GR1) and 2 (GR2), as a result of obtaining new data, see Figure 2.⁹ GR1, which was developed in 2000, only expressed the vitamin A proteins in the rice endosperm, and the levels of carotenoids obtained in the field amounted to an average of only 6 µg/g. This showed that it was possible to produce provitamin A in rice grains, but in order to combat Vitamin A deficiency, higher β-carotene levels would be required. In 2005, through systematic testing a gene from maize was found to substantially increase carotenoid accumulation.¹⁰ Therefore, GR2 was developed through improving the efficiency of scientific analysis on the genes in GR1 as it revealed new evidence that led to modifications enabling greater carotenoid accumulation. GR2 was capable of accumulating up to 37 µg/g carotenoids, of which 31 µg/g was β-carotene.¹¹ This demonstrates how efficient data collection and analysis undertaken can develop more effective technologies, enhancing the development of Golden Rice which can positively aid communities struggling with VAD.



Figure 2: The image clearly shows the progress made since the Golden Rice 1. The new generation, also known as GR2 contains β-carotene levels that will provide adequate amounts of provitamin A.

Discussion Assessment Notes – Development

- Clear steps of development of Golden Rice 1 through to Golden Rice 2 and the implications of both developments in regards to carotenoid accumulation

⁸ *The Golden Rice story – Scientific Scribbles* (2013). Available at: <https://blogs.unimelb.edu.au/sciencecommunication/2013/10/20/the-golden-rice-story/> (Accessed: 5 August 2020).

⁹ Mayer, C. (2020) *Golden Rice Project*, *Goldenrice.org*. Available at: <http://www.goldenrice.org/Content2-How/how.php> (Accessed: 5 August 2020).

¹⁰ (2020) *Goldenrice.org*. Available at: http://www.goldenrice.org/PDFs/Paine_et_al_NBT_2005.pdf (Accessed: 5 August 2020).

¹¹ *Second Generation Golden Rice* (2020). Available at: <https://www.mcgill.ca/oss/article/food-health/second-generation-golden-rice> (Accessed: 5 August 2020).

Application and Limitations

In 2009 Guangwen Tang, a nutrition scientist at Tufts University in Boston led a trial that was designed to test how efficiently the β -carotene is converted to vitamin A once ingested. The test was carried out at schools in Hunan Province, China, where school children were fed the GM rice. Although the trial presented promising results, its legitimacy was questioned in August by the environmental group Greenpeace as the Golden Rice had not undergone a safety test and therefore the potential health effects were unknown. Parents were also only aware their children were being given meals spinach or β -carotene capsules, not a genetically modified Golden rice – putting the ethics of this study in question.¹² Thus, due to the project failing to apply correct ethical evaluation and disregarding informed consent, this prevented the results from being considered, causing debates and increasing numbers of people against future trials.

Furthermore, the **application** of field trials was conducted by PhilRice between 2015 and 2016 highlighted major limitations. PhilRice and International Rice Research Institution concluded that the yields of the Golden Rice variety grown in the field trials '*proved to be a failure as they produced 59% of carotenoids*', being much smaller than 80% which was released in previous publications by Test Biotech.¹³ Therefore, the application of GM rice is hindered by overestimating its potential carotenoid yields – where yields as such, require unpractical conditions of farming, limiting the application of this technology.

In 2017, a paper published in the *Journal of Agricultural and Food Chemistry* reported that 'even if the rice produced a large beta-carotene content it would be short-lived', stating that the GM rice retained only '*60% of its original beta-carotene levels after 3 weeks of storage*' and '*13% after 10 weeks*' as oxygen exposure degrades its nutritional value. This major **limitation** indicates that GR would not be suitable for all countries, especially Africa and South-East Asia as degradation would be even more rapid under tropical farming, storage and household conditions.¹⁴

Discussion Assessment Notes – Application and Limitations

- Clear identification of applications of trials to test effectiveness of Golden Rice
- Clear limitations and impacts of disappointing trial results

Discussion: 718 words

To conclude, it is evident that Golden Rice was developed in the hope to formulate a cure for the Vitamin A deficiencies in countries of low socio-economic status. Two versions of Golden rice were developed from the start of the project, resulting in scientists gaining a deeper understanding of key genes which limit or assist in the accumulation of β -carotene. This allowed the development of a wide range of evidence that golden rice presents promising results, which led to the application of the field as well as human trials. Yet, this highlighted a range of limitations, most prominently the fact that the Golden Rice fails to produce enough β -carotene to prevent VAD. Therefore, further research must be undertaken to determine other genes which could potentially be limiting the accumulation of beta-carotene, so that it could combat VAD in low-income communities.

Conclusion - Assessment notes

- Sound summary of key points of SHE links and impact.
- Clear recommendations for future

Conclusion: 140 words

Total Word Count: 1462

¹² Qiu, J. (2012) "China sacks officials over Golden Rice controversy", *Nature*. doi: 10.1038/nature.2012.11998.

¹³ *Don't get fooled again! Unmasking two decades of lies about Golden Rice* (2020). Available at: <https://www.grain.org/en/article/6067-don-t-get-fooled-again-unmasking-two-decades-of-lies-about-golden-rice> (Accessed: 12 August 2020).

¹⁴ *GMO Golden Rice Offers No Nutritional Benefits Says FDA - Independent Science News | Food, Health and Agriculture Bioscience News* (2018). Available at: <https://www.independentsciencenews.org/news/gmo-golden-rice-offers-no-nutritional-benefits-says-fda/#:~:text=But%2C%20in%20a%20surprising%20twist,to%20make%20a%20health%20claim.> (Accessed: 12 August 2020).

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Qiu, J. (2012) "China sacks officials over Golden Rice controversy", *Nature*. doi: 10.1038/nature.2012.11998. *Second Generation Golden Rice* (2020). Available at: <https://www.mcgill.ca/oss/article/food-health/second-generation-golden-rice> (Accessed: 5 August 2020).

Ricepedia. 2013. *The Global Staple - Ricepedia*. [online] Available at: <<http://ricepedia.org/rice-as-food/the-global-staple-rice-consumers>> [Accessed 26 October 2020].

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