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# Editorial overview: Plant biotechnology

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**Ralf Reski**

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Ralf Reski studied biology, chemistry and pedagogics, obtained his PhD in Genetics and his Habilitation in General Botany, was a Heisenberg Fellow of the German Research Foundation DFG and is now a Professor of Plant Biotechnology at the University of Freiburg, Germany. He pioneered the establishment of mosses as model systems for basic biology and for biotechnology. He is a founding principal investigator of three excellence clusters and a founder of a company which focusses on the production of high value human glycoproteins in moss bioreactors.

**Ed Rybicki**

Biopharming Research Unit, Molecular & Cell Biology Department, University of Cape Town, Cape Town, South Africa

Ed Rybicki is a molecular biotechnologist who specializes in the production of high-value biologics in plants, predominantly by transient expression involving *Agrobacterium tumefaciens* and modified plant virus delivery of recombinant DNA. He leads the Biopharming Research Unit at the University of Cape Town in South Africa. He is interested in science and particularly virology

With an estimated 450 gigatons of carbon (Gt C), plants represent by far the most important kingdom of life on Earth, followed by bacteria (70 Gt C), whereas animals contribute only 2 Gt C to the approximately 550 Gt C of total life biomass [1]. In the light of such data, plant science appears to be drastically underappreciated by the public, by politicians, and by funding agencies.

Plant biotechnology has enormous potential in our modern world, for a wide spectrum of beneficial applications. These include improving food security; combating climate change; bioremediation of polluted or contaminated soil and water; provision of secondary metabolites for nutraceutical, pharmaceutical and industrial purposes; making recombinant proteins for use as vaccines and therapeutics, and antibodies for human, animal and diagnostic use. The plants used for these purposes include cereals, root crops, tobacco and mosses, and cultured cells; they may be grown in the field, in glasshouses, growth chambers or bioreactors, at scales ranging from many hectares down to the laboratory bench.

The potential benefits of modern plant biotechnology are manifold, and very wide-ranging. Biofortified or drought-resistant crop plants could benefit the poorest of communities, while plant-produced vaccines and antibodies could bring effective disease control to subsistence communities throughout developing countries — and novel and niche vaccines and therapies to everyone, and to their domestic and farm animals. Synthetic biology and precise gene-editing technologies could revolutionize plant breeding and genome engineering, to the point where conventional genetic manipulation techniques are totally superseded, and the term 'GMOs' becomes obsolete. More fundamentally, improving photosynthesis and other metabolic tweaks could lead to long-term benefits that could greatly influence crop yields and production efficiencies — on this planet, and even beyond it as plants are used for oxygenation, for food and for chemicals, aboard spacecraft.

The applications of plant biotechnology should also be universal, with all countries both participating in the science, and benefitting from the results. This is especially urgent right now, with the spectre of long-term climate change affecting all crop production, and particularly in marginal agricultural areas in Africa and in Asia.

This special collection of articles spans a wide range of modern and in particular molecular plant biotechnology, ranging from cutting-edge applications of synthetic biology and gene editing, to improving photosynthesis, through 'molecular farming' or the production of high-value biologics in plants, to environmental release of genome-edited plants. The editors have endeavored to obtain articles from as wide a geographical range as possible, and particularly from as diverse as possible a range of authors.

and vaccine advocacy via social media. He relaxes with hard science fiction, classic rock, and good red wine.

## Gary Foster

School of Biological Sciences, University of Bristol, Bristol, UK

Gary Foster studied microbiology, before seeing the light and specializing in plant virology and plant molecular biology. Originally from Northern Ireland, he can now be found playing being a Professor in Biological Sciences at the University of Bristol. He has served as an editor on a range of journals including founding Editor-in-Chief and Editor-in-Chief for leading international journal Molecular Plant Pathology from 1999–2012. Gary's research is focused on investigating a range of interconnecting themes that include plant virology, plant pathology, plant molecular biology, molecular mycology and biotechnology. The molecular mycology and biotechnology areas have also covered projects on drug discovery and manipulation supported through interactions with a range of pharmaceutical companies focusing on antibiotic discovery and development.

Metje-Sprink *et al.* [16] discuss the status of genome-edited plants in the field, with a focus on the regulatory hurdles for such GE plants in application, especially in Europe. Schindele *et al.* [17] describe the power and limitations of CRISPR/Cas technology in modern plant breeding, and how it can speed up development from bench to application. Roell and Zurbriggen [12] reviews the status of synthetic biology and provides an outlook on how these technologies can improve agriculture and nutrition in the future. Rischer *et al.* [5] notice that a major disruption of agriculture and food production is inevitable in the light of climate change and a growing human population, and discuss perspectives as to how the production of food and sustainable materials can benefit from cellular agriculture. Streich *et al.* [2] explore whether or not exascale plant biology and artificial intelligence can deliver on sustainable development goals.

A fair proportion of the articles cover the field of plant-made pharmaceuticals, also known as plant molecular farming. Here, Murad *et al.* [11] discuss molecular farming for low and middle income countries, while Tsekoa *et al.* [7] from South Africa detail efforts in molecular farming for therapies and vaccines in Africa. Sainsbury [9] discusses how innovation in transient protein expression is applied to infectious disease prevention. De Greve *et al.* [6] describe how recombinant camelid monoclonal antibodies made in plants provide new opportunities for passive immunization of livestock, while Dent and Matoba [8] review plant-made anti-cancer biologics and Tremouillaux-Guiller *et al.* [3] look at plant-made HIV multiepitopic vaccines. In the ongoing efforts to improve yield and purity of plant-made pharmaceuticals, Schiermeyer [15] critically discusses different strategies for optimizing molecular farming product quality in a variety of plant expression systems, while Jutras *et al.* [10] focus on proteases of *Nicotiana benthamiana*: an emerging battle for molecular farming. This focus is timely, as an increasing number of plant biotechnologists use the tobacco relative *N. benthamiana* for production of recombinant proteins through transient expression.

Napier and Sayanova [4] review the exciting and emerging area of enhancing nutritional value of plants, clearly a huge area in securing global food security, covered in 'Nutritional enhancement in plants — green and greener'. Wichmann *et al.* [14] explore the area of green algal hydrocarbon metabolism as an exceptional source of sustainable chemicals, again with huge importance for future sustainability. This also links nicely with the review on mosses in biotechnology by Decker and Reski [13], who cover a variety of applications from climate change, air quality control, secondary metabolites to molecular farming for rare human diseases.

We are thankful to all colleagues who submitted their manuscripts or reviews of manuscripts for this issue, and hope that all articles in this collection are broadly appreciated, both in the scientific community and more widely in public forums.

## References

1. Bar-On Y.M., Phillips R, Milo R: **The biomass distribution on earth**. *Proc National Acad Sci U S A* 2018, **115**:6506-6511.

2. Streich J, Romero J, Gazolla JGFM, Kainer D, Cliff A, Prates ET, Brown JB, Khoury S, Tuskan GA, Garvin M, Jacobson D, Harfouche AL: **Can exascale computing and explainable artificial intelligence applied to plant biology deliver on the United Nations sustainable development goals?** *Curr Opin Biotechnol* 2020, **61**:217-225.

3. Tremouillaux-Guiller J, Moustafa K, Hefferon K, Gaobotse G, Makhzoum A: **Plant-made HIV vaccines and potential candidates**. *Curr Opin Biotechnol* 2020, **61**:209-216.

4. Napier JA, Sayanova O: **Nutritional enhancement in plants - green arnd greene**. *Curr Opin Biotechnol* 2020, **61**:122-127.

5. Rischer H, Szilvay GR, Oksman-Caldentey K-M: **Cellular agriculture - industrial biotechnology for food and materials**. *Curr Opin Biotechnol* 2020, **61**:128-134.

6. De Greve H, Virdie V, Bakshi S, Depicker A: **Simplified monomeric VHH-Fc antibodies provide new opportunities for passive immunization**. *Curr Opin Biotechnol* 2020, **61**:96-101.

7. Tsekoa TL, Singh AA, Buthelezi SG: **Molecular Farming for Therapies and Vaccines in Africa**. *Curr Opin Biotechnol* 2020, **61**:89-95.

8. Dent M, Matoba N: **Cancer Biologics Made in Plants**. *Curr Opin Biotechnol* 2020, **61**:82-88.

9. Sainsbury F: **Innovation in plant-based transient protein expression for infectious disease prevention and preparedness**. *Curr Opin Biotechnol* 2020, **61**:110-115.

10. Jutras PV, Dodds I, van der Hoorn RA: **Proteases of Nicotiana benthamiana: an emerging battle for molecular farming**. *Curr Opin Biotechnol* 2020, **61**:60-65.

11. Murad S, Fuller S, Menary J, Moore C, Pinneh E, Szeto T, Hitzeroth I, Freire M, Taychakhoonavudh S, Phoolcharoen W, Ma JK-C: **Molecular Pharming for Low and Middle Income Countries**. *Curr Opin Biotechnol* 2020, **61**:53-59.

12. Roell M-S, Zurbriggen MD: **The Impact of Synthetic Biology for Future Agriculture and Nutrition**. *Curr Opin Biotechnol* 2020, **61**:102-109.

13. Decker EL, Reski R: **Mosses in Biotechnology**. *Curr Opin Biotechnol* 2020, **61**:21-27.

14. Wichmann J, Lauersen KJ, Kruse O: **Green algal hydrocarbon metabolism is an exceptional source of sustainable chemicals**. *Curr Opin Biotechnol* 2020, **61**:28-37.

15. Schiermeyer A: **Optimizing Product Quality in Molecular Farming**. *Curr Opin Biotechnol* 2020, **61**:15-20.

16. Metje-Sprink J, Sprink T, Hartung F: **Genome edited plants in the field**. *Curr Opin Biotechnol* 2020, **61**:1-6.

17. Schindele A, Dorn A, Puchta H: **CRISPR/Cas brings plant biology and breeding into the fast lane**. *Curr Opin Biotechnol* 2020, **61**:7-14.