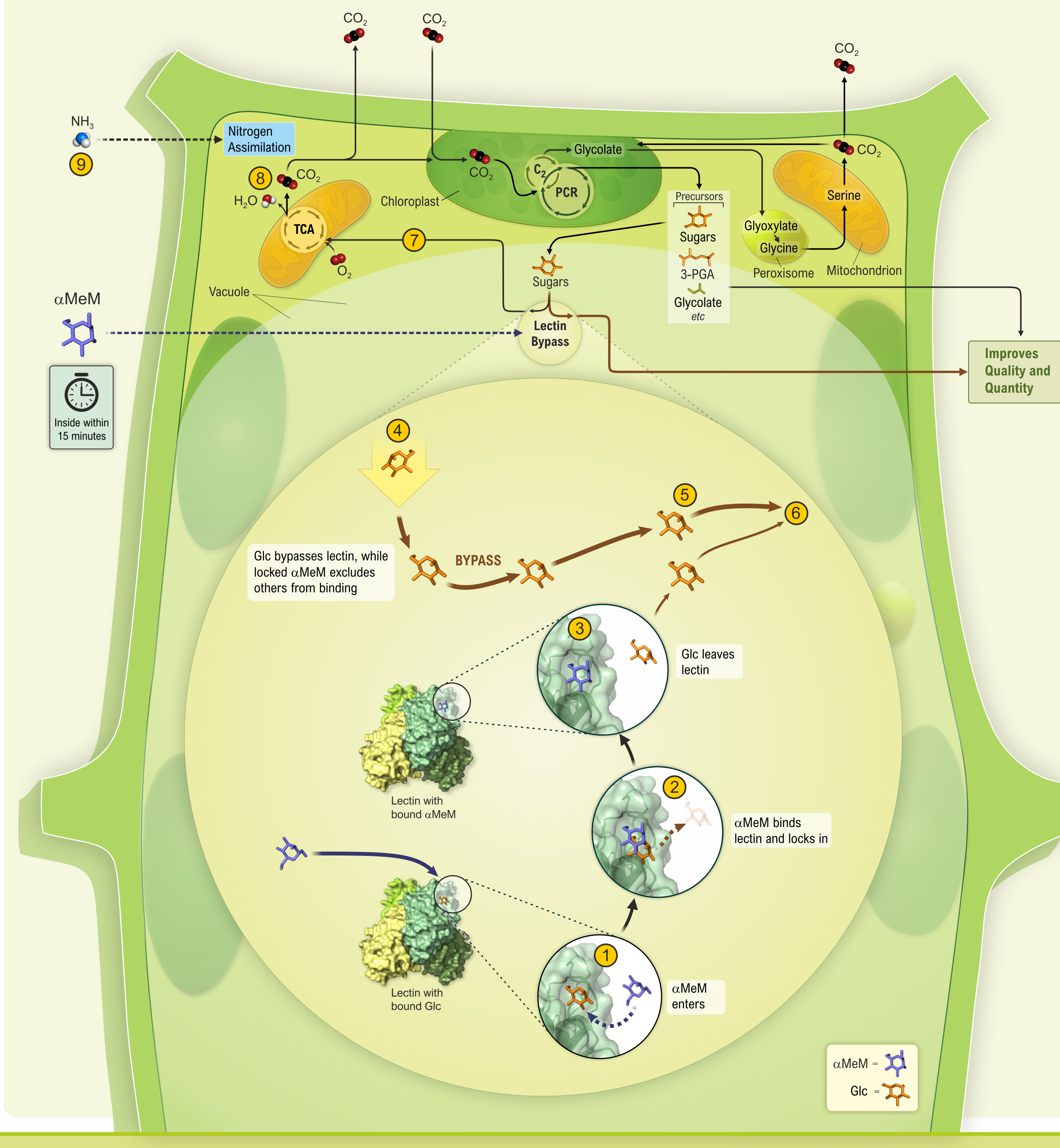
A Plant Growth Regulator for Photosynthesis

The Plant Lectin Bypass



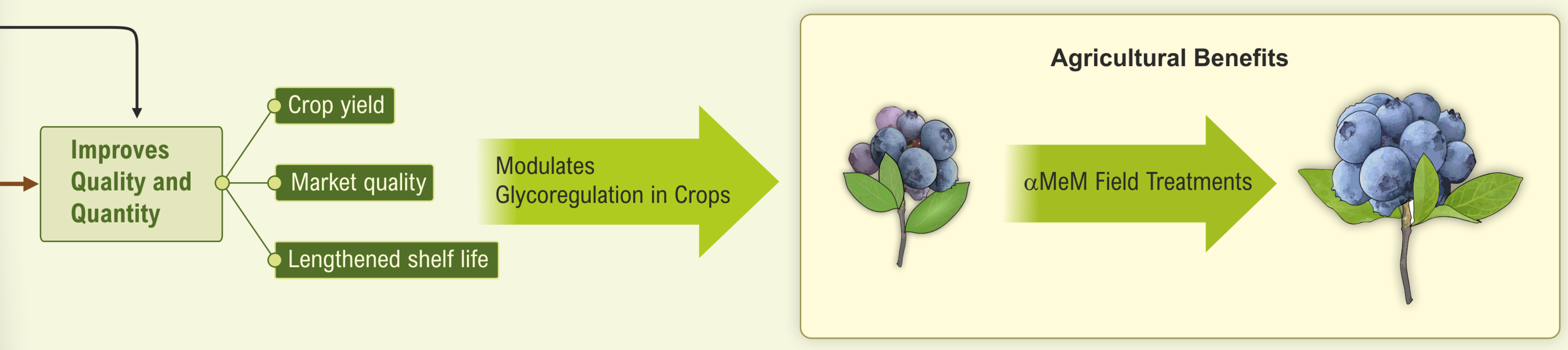


Diagram for an induced bypass of lectins in the plant cells

Lectins are carbohydrate binding proteins found predominantly in the vacuoles of plant cells. They reversibly bind sugars that compete for the same binding sites. Further, they are highly selective. For example, in several glucose/mannose binding lectins, α-D-mannosides may bind the lectin with greater avidity displacing β-D-glucosides. Treatments with highly competitive substrates of such lectins induce changes in the carbon reactions of photosynthesis. A strong binding competitor is the plant growth regulator (PGR), methyl-α-D-mannopyranoside (αMeM). It not only dislodges β-D-glucose (Glc) from specific carbon reaction lectins, but also prevents most other free sugars from binding. Within minutes after application, αMeM enters the vacuole of plant cells (1), binds the lectins (2), and displaces stored sugars that further leave the protein (3).

The Bypass

While αMeM molecules are bound to lectins, fresh glucose and other sugar products that are generated from photosynthetic carbon reduction (4) bypass the lectins (5) and this leads to growth (6). Fresh photosynthates which continue to bypass lectin for weeks after treatment may be translocated to all parts of the plant including fruits, leaves, stems, flowers, and seeds. Sugars that are translocated to the roots may be used in respiration (7) there, forming water and CO_2 (8). These end products, after upward transport from roots to shoots, may favor photosynthesis, particularly when there is elevated CO_2 in the chloroplast.

We apply αMeM as the active ingredient in BRANDT GlucoPro® PGR, in our case, and we note that it works in conjunction with added fertilizers. For example, after the bypass is induced to modulate the flow of sugars, carbon/nitrogen metabolism comes into play since these two processes are integral to nitrogen assimilation (9) for the synthesis of amino acids and proteins. Supplementation with all of the essential plant nutrients are prerequisite for the growth of crops, and even more so, to support enhanced growth after inducing the bypass. For a background on lectins, see [1].

The Growers' Choice

The metabolic pathways of photosynthesis are dynamic, with the organelles of the plant cell continuously linking their functions to productivity [1, 2]. Thus, plant growth regulation in the field [2, 3] may be expressed in the rich flavor of the fruit, vibrant color, and rigid turgor that lengthens shelf life. Utilization in the field has been shown to significantly improve the quantity of harvest and to enhance the quality of food crops including their taste, texture, sweetness, fruit pressure, foliage, size, color, and diminished sun scorch.

The Plant Lectin Cycle

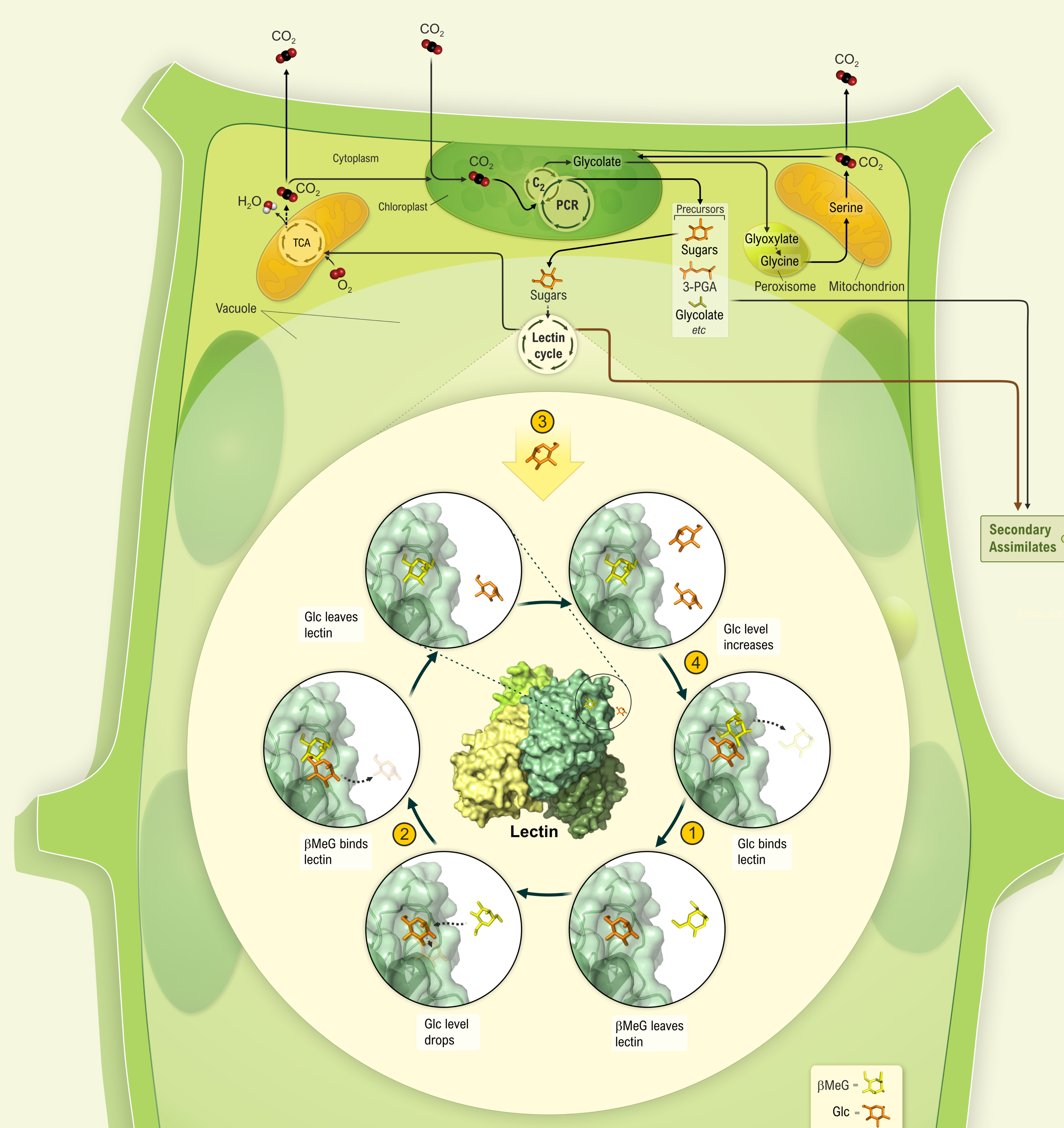
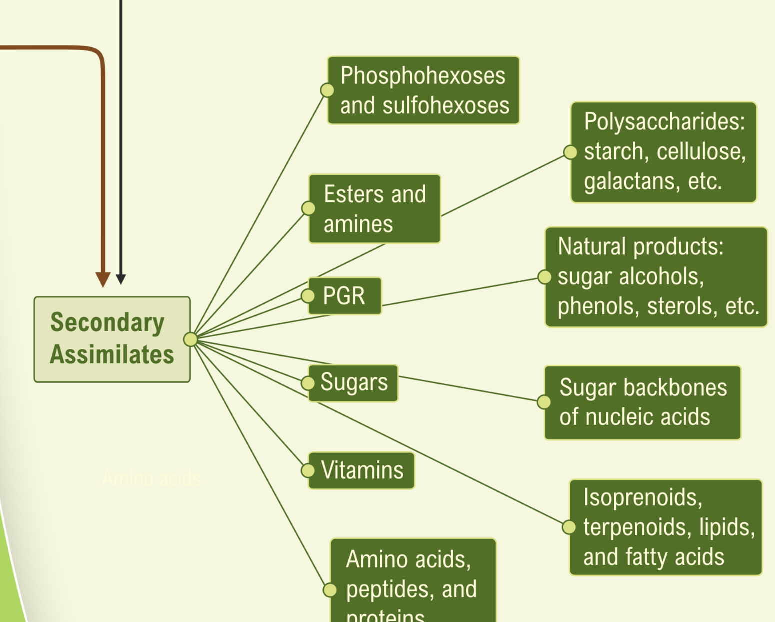


Diagram for an endogenous cycle with a role for lectins in the plant cell

Lectins are abundant in all families of the Plant Kingdom and some appear to play major roles in the carbon reactions of photosynthesis. The plant lectin cycle begins with carbon fixation. CO_2 enters cells and reaches the stroma, where the photosynthetic carbon reduction cycle operates. Some of the photosynthates are transported from the chloroplasts into vacuoles of plant cells, where sugars, such as, glucose, bind specific carbon reaction lectins (1). As Glc is consumed by respiration, its concentration decreases to a point where endogenous methyl-β-D-glucopyranoside (βMeG) is able to displace bound Glc from these lectins (2). Thereafter, as the concentration of Glc increases in the vacuole, due to photosynthesis (3), it successfully outcompetes βMeG to once again bind the lectins (4). This completes the endogenous cycle. When Glc levels are depleted, βMeG once again exchanges with Glc at the carbohydrate binding site of the lectins and the cycle repeats. For modulation of glycoregulation involving lectins, see [2, 3]; for historical perspectives of the photosynthetic carbon reduction cycle, see [4]; for teaching the carbon reactions of photosynthesis, including the plant lectin cycle, see [2]; and for further information on other aspects of photosynthesis, see [5]. For utilization of BRANDT GlucoPro in the field, see [2, 3, 6].

For convenience of presentation, the plant cell and its organelles are not drawn to scale. Send questions and comments to Arthur Nonomura (Art.N@BRANDTiHammer.co).



Abbreviations

αMeM, methyl-α-D-mannopyranoside;
C_2, C_2 oxidative carbon cycle;
βMeG, methyl-β-D-glucopyranoside;
Glc, glucose;
NH_3, ammonia;
PCR, C_3 Photosynthetic Carbon Reduction cycle;
3-PGA, 3-phosphoglycerate;
PGR, Plant Growth Regulator;
TCA, Tricarboxylic Acid cycle

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References

[1] S.S. Komath, M. Kavitha, M.J. Swamy (2006) Beyond carbohydrate binding: New directions in plant lectin research. *Organic Biomolecular Chemistry* 4:973-988. DOI: 10.1039/b515446d

[2] A. Nonomura, K.Y. Biel, I.R. Fomina, W. Lam, D.P. Brummel, A. Lauria, and M.S. McBride (2018) Benson's protocol. *In* I.R. Fomina, K.Y. Biel, V.G. Soukhovolsky (*eds.*) Complex biological systems: Adaptation and tolerance to extreme environments, Scrivener, USA. pp 463-508

[3] A. Nonomura, A. Pedersen, D.P. Brummel, L. Loveless, A. Lauria, B. Haschemeyer, M.S. McBride (2018) Brandt iH026a plant growth regulator. *Photosynthetica* 56:411-417. DOI: 10.1007/s11099-017-0739-7

[4] T.D. Sharkey (2019) Discovery of the canonical Calvin-Benson cycle, *Photosynthesis Research* 140:235-252. DOI: 10.1007/s11120-018-0600-2

[5] D. Shevela, L.O. Bjorn, and Govindjee (2018) Photosynthesis: Solar energy for life, World Scientific Publishing, Singapore. DOI: 10.1142/10522

[6] C.L. Roberts (2020) BRANDT GlucoPro® brochure; https://brandt.co/media/11012/brandt-glucopro-brochure.pdf

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