INTRODUCTION

Green Pathways

PLANTS USE COMPLEX METABOLIC PATHWAYS TO FEND OFF PATHOGENS, TO COORdinate reproduction with changes in day length, to accommodate environmental changes, and to select developmental pathways most suited to a given place and time. For these and other physiological processes, metabolism integrates inputs from both genome and environment. The process often involves the production and use of unusual chemicals that function for the plant as signals or defenses. Some of these chemicals are exploited by humans as pharmaceuticals, insecticides, spices, and nutritional supplements. This week, *Science* explores plant metabolism with a series of Reviews, Perspectives, and research Reports.

De Luca *et al.* (p. 1658) examine the diversity of plant chemical compounds used in medical settings and propose that we have the technology to discover even more useful compounds. Baxter and Dilkes (p. 1661) discuss the interplay between metabolic pathways and mineral elements available from the environment. Milo and Last (p. 1663) look for design principles that govern how metabolic pathways have arisen, insights that may help inform how we can in future tune metabolic pathways to our needs. Weng *et al.* (p. 1667) consider how the diversity of secondary metabolites may have arisen through permissive mutations, with core conserved proteins reserved for primary metabolism, where there is less room for error. And von Caemmerer *et al.* (p. 1671) discuss efforts to change photosynthesis in rice from the C_3 to the more efficient C_4 pathway, which would increase grain yield while reducing water and nitrogen needs. Finally, Gutiérrez (p. 1673) analyzes nitrogen metabolism, which lies at the core of agricultural productivity and is embedded in complex pathways of uptake and utilization.

In *Science* Careers (online), Sarah Webb explores career options in plant metabolism and uncovers work that is highly interdisciplinary, involving chemistry, biology, and computer science. Webb sees parallels between the field and translational work in biomedicine, in both the tools employed (molecular biology, analytical chemistry, and informatics) and in efforts to apply basic understanding to the solution of real-world problems.

In related research, Winzer *et al.* (p. 1704) identify a cluster of genes encoding several of the enzymes responsible for synthesis of the antitussive and anticancer alkaloid noscapine. Powell *et al.* (p. 1711) identify the transcription factor that, when mutated, led to nicely uniform tomatoes, only to discover that this same transcription factor, in normal form, promotes photosynthesis that elaborates the sugar content of the ripening fruit. Westfall *et al.* (p. 1708) present the crystal structures of enzymes that add tags to certain plant hormones, modulating their function. These examples highlight the diversity in metabolic pathways. Pathways pull components from various genetic tool kits; some of those components evolve independently and others do not. A push in one place can produce unexpected responses in other pathways. And metabolic pathways multiply with modifications, tweaks, and twinges every step of the way.

The 21st century brings new agricultural challenges as populations rise and land quality declines. Improved understanding of metabolic pathways can guide development of the crops and cultivation strategies that will form the foundation of a sustainable and plentiful harvest.

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Plant Metabolism

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Perspectives

See also Perspective p. 1648; Reports pp. 1704, 1708, and 1711; and Science *Careers at http://scim.ag/PlantSci and* Science *Podcast at http://scim.ag/PlantPod*

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