

## Plant Biochemistry

# Plant primary metabolism – From basic research to crop productivity

The domestication of crops was a landmark in the development of human civilisation. Today, most of our food and many of our resources are derived from plants. One of the most fundamental compounds is starch. Starch is the predominant storage carbohydrate in plants and the major constituent of our staple crops (e.g. rice, maize, wheat, potato etc). Despite its importance, our understanding of how plants make and degrade this essential resource is far from complete. Our research team focuses on the metabolic pathways leading to and from starch, and the way in which they are regulated.

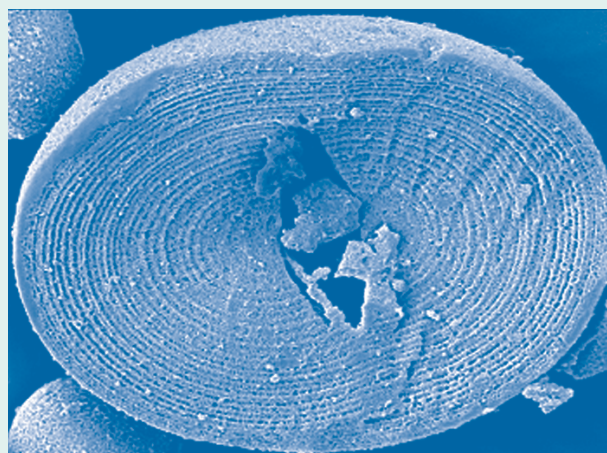
We use the model plant *Arabidopsis thaliana* as our experimental system. This allows us to exploit the complete genome sequence and the array of post-genomic facilities to make rapid progress. Our current understanding suggests that different plants make starch essentially the same way, as the components of the pathway appears to be highly conserved, even in distantly related species. Consequently, the knowledge gained through studying *Arabidopsis* will be transferable to starch-producing crops and enable their future improvement. This is an essential goal as the world population approaches its predicted peak of over 9 billion.

## Research focus

- Carbohydrate metabolism
- Starch biosynthesis and degradation
- Photosynthesis

## Interdisciplinarity

- Plant biochemistry and physiology
- Molecular genetics
- Genomics, proteomics, metabolomics



Egyptian farmers harvesting their starch crops.  
Electron micrograph of a single grain of starch,  
0.02 mm in diameter.



### Contact person

Prof. Samuel Zeeman  
Plant Biochemistry  
Institute of Plant Sciences  
ETH Zurich  
Phone +41 (0)44 632 82 75  
[szeeman@ethz.ch](mailto:szeeman@ethz.ch)  
[www.pbc.ethz.ch](http://www.pbc.ethz.ch)

**Liste 1: Promotionsarbeiten**

Betreuer(in)	Doktorand(in) und Titel	Anzahl der Betreuer
S. Zeeman	M. Stettler, Maltose metabolism during starch breakdown in <i>Arabidopsis thaliana</i> leaves	1
S. Zeeman	H. Reinhold, Sugar Signalling in Plant Carbohydrate Metabolism	1
S. Zeeman	S. Streb, Roles of debranching enzymes in <i>A. thaliana</i> leaves during starch syntheses and breakdown	1
B. Frey, S. Zeeman	N. Regier, Influence of above-ground stress on the metabolism of non-structural carbohydrates in poplar roots	2
S. Zeeman	M. Umhang, Protein complexes involved in starch degradation	1
S. Zeeman	H.-C. Lin, Discovering the mechanism of sucrose export from plant cells	1
S. Zeeman	M. Henriksson	1
S. Zeeman, W. Gruissem	K. Külling	2
W. Gruissem, S. Zeeman	S. Herwig,	2

**Liste 4: Forschungsprojekte**

Projekt-ID	Projektleiter	Titel
1. 12445	Amrhein, Nikolaus	Identification of proteins involved in polyphosphate metabolism in <i>S. cerevisiae</i> .
2. 15518	Zeeman, Samuel	Discovering the role of debranching enzymes in <i>Arabidopsis</i> starch metabolism
3. 15519	Zeeman, Samuel	Discovering the pathway of starch degradation
4. 15520	Zeeman, Samuel	The regulation of starch metabolism
5. 21033	Zeeman, Samuel	Discovering the mechanism of sucrose export from plant cells

### Liste 5: Wissenschaftliche Publikationen

a) Referierte Publikationen			
Publikations-ID	Autoren	Titel	Erschienen in
1. 42463	*Holbein, S., *Freimoser, F. M., Werner, T. P., Wengi, A., Dichtl, B.	Cordycepin-hypersensitive growth links elevated polyphosphate levels to inhibition of poly(A) polymerase in <i>Saccharomyces cerevisiae</i>	Nucleic Acids Research
b) Monografien			
Publikations-ID	Autoren	Titel	Erschienen in
c) Varia			
Publikations-ID	Autoren	Titel	Erschienen in
1. 42279	Fulton, D.C., Stettler, M., Mettler, T., Vaughan, C.K., Li, J., Francisco, P. Gil, M., Reinhold, H., Eicke, S., Messerli, G., Dorken, G., Halliday, K., Smith, A.M., Smith, S.M., and Zeeman, S.C.	$\beta$ -AMYLASE 4, a non-catalytic protein that is required for starch breakdown, acts upstream of three active $\beta$ -amylases in Arabidopsis chloroplasts.	The Plant Cell
2. 42283	Streb, S., Delatte, T., Umhang, M., Eicke, S., Schoderet, M., Trevisan, M., Reinhard, D. and Zeeman, S. C.	Starch granule biosynthesis in Arabidopsis is abolished by removal of all debranching enzymes, but restored by the subsequent removal of an endoamylase	The Plant Cell

### Liste 6: Vorträge vor wissenschaftlichem Publikum

a) Eingeladene Vorträge vor wissenschaftlichem Publikum		
	Redner	Titel
1.	Zeeman, Samuel C.	The metabolism of transitory starch in the chloroplasts of leaves, Taiwan, Taipei, Sept. 25th-26th 2008, Chloroplast Biology Symposium
2.	Zeeman, Samuel C.	The pathways and regulation of starch degradation in Arabidopsis chloroplasts at night. USA, Biddeford, Maine, Aug 10th-15th 2008, Gordon Research Conference 'Mitochondria and Chloroplasts'

3.	Zeeman, Samuel C.	New insight into starch metabolism in plants reveals unexpected parallels with glycogen metabolism in animals. University of Erlangen, Erlangen (Erlangen, Deutschland), Dec 4th 2008.
4.	Zeeman, Samuel C.	New insights into the mechanisms of starch granule biosynthesis and degradation in Arabidopsis. Max-Planck Institute for Molecular Plant Physiology. Germany, Golm, Aug 27th 2008.
5.	Zeeman, Samuel C.	Maltose production, transport and metabolism during starch breakdown in leaves. Germany, Regensburg, Schloss Hirschberg, May 19th 2008, Closing meeting of the Pritoriy Program on Plant Membrane Transport
6.	Zeeman, Samuel C.	The pathways and control of starch breakdown in leaves, Department of Plant Biology, University of Oxford, Oxford, UK, Feb 14th 2008.
7.	Kötting, Oliver	SEX4, a glucan phosphatase, dephosphorylates amylopectin in Arabidopsis leaves, ETH Zurich, Switzerland, 10th-13th Sept 2008, 5th Tri-National Arabidopsis Meeting

b) Sonstige Vorträge und Posterpräsentationen vor wissenschaftlichem Publikum

	Redner	Titel
1.	Zeeman, Samuel C.	What plants do in the dark: the conversion of transitory starch into sucrose in leaves, Japan, Nara, 7th-11th Oct 2008, Photosynthetic Adaptation and Chloroplast Dynamics
2.	Zeeman, Samuel C.	What plants do in the dark: the conversion of transitory starch into sucrose in leaves, Mexico, Merida, June 26th-July 1st 2008, Annual meeting of the American Society of Plant Biologists. Plenary Talk (Charles Albert Shull Awardee [2007] Lecture)
3.	Stettler, Michaela	Metabolism and metabolic regulation; the roles of $\beta$ -amylase proteins in starch breakdown, Finland, Tampere, Aug 17th- 22nd 2008, Conference: FESPB 2008 - XVI Congress of the Federation of European Societies of Plant Biology.
4.	Kötting, Oliver	Reversible starch phosphorylation: a previously unknown mechanism regulating starch metabolism in Arabidopsis thaliana, Switzerland, Les Diablerets, Feb 6th-8th 2008, Swiss Plant Molecular and Cell Biology Conference
5.	Kötting, Oliver	Reversible starch phosphorylation regulates starch metabolism in Arabidopsis thaliana, Finland, Tampere, Aug 17th- 22nd 2008, Conference: FESPB 2008 - XVI Congress of the Federation of European Societies of Plant Biology.
6.	Kötting, Oliver	Reversible starch phosphorylation: A new mechanism regulating starch breakdown in Arabidopsis leaves, Switzerland, Davos, Jun 2nd- 6th 2008, 7th D-BIOL Symposium ETH Zürich
7.	Zeeman, Samuel C.	Understanding starch metabolism for crop improvement and diversification. Joint workshop of the Chinese Academy of Science and the Sino-Swiss Science and Technology Cooperation Programme, ETH Zurich, Zurich, Switzerland, Nov 18th.

8.	Zeeman, Samuel C.	Plant Growth in a Changing Environment. Annual Meeting of the Swiss Initiative for Systems Biology (SystemsX.ch). Congress Centre, Basel, Switzerland, 16th Oct.
9.	Zeeman, Samuel C.	The control of storage carbohydrate metabolism by transient glucan phosphorylation. Switzerland, Davos, Jun 2nd- 6th 2008, 7th D-BIOL Symposium ETH Zurich
10.	Zeeman, Samuel C.	Metabolism and metabolic regulation; the roles of $\beta$ -amylase proteins in starch breakdown, Switzerland, Les Diablerets, Feb 6th-8th 2008, Swiss Plant Molecular and Cell Biology Conference
11.	Freimoser, F. M.	Regulation of phosphate and polyphosphate metabolism by low-affinity phosphate transporters in yeast. Department of Biology at the University of Ottawa, ON, Canada 4th of September, 2008
12.	Freimoser, F. M.	Yeast low-affinity phosphate transporters are allosterically inhibited and regulate phosphate metabolism, Toronto, Canada, July 21st- 27th 2008, Yeast Genetics and Molecular Biology Meeting
13.	Freimoser, F. M.	Regulation of phosphate and polyphosphate metabolism by low-affinity phosphate transporters in yeast. Institute of Cell Biology at the University of Berne, Switzerland, July 21st 2008.
14.	Hürlimann, H.C.	Yeast mutants with altered polyphosphate content respond differently to phosphate availability, Toronto, Canada, July 21st-27th 2008, Yeast Genetics and Molecular Biology Meeting
15.	Glaring M.	Evidence for widespread redox regulation of starch metabolizing enzymes in <i>Arabidopsis thaliana</i> , Tampere, Finland, Aug 17th-22nd 2008, Conference: FESPB 2008 - XVI Congress of the Federation of European Societies of Plant Biology.
16.	Reinhold, Heike	Beyond starch degradation - new roles for $\beta$ -amylases in sugar sensing and gene regulation, ETH Zurich, Switzerland, 10th-13th Sept 2008, 5th Tri-National Arabidopsis Meeting.
17.	Streb, Sebastian	Critical Role of Debranching Enzymes in Starch Granule Synthesis in <i>Arabidopsis thaliana</i> , Switzerland, Davos, Jun 2nd-6th 2008, 7th D-BIOL Symposium ETH Zurich
18.	Henriksson, Maria	Functional characterisation of starch debranching enzymes from <i>Arabidopsis thaliana</i> , Switzerland, Davos, Jun 2nd- 6th 2008, 7th D-BIOL Symposium ETH Zürich
19.	Umhang, Martin	A Proteomic Approach to Understand Starch Metabolism, Switzerland, Davos, Jun 2nd- 6th 2008, 7th D-BIOL Symposium ETH Zürich
20.	Umhang, Martin	Complex Formation Between a $\beta$ -Amylase and a Putative Glucan Phosphatase, Switzerland, Zurich, June 6th 2008, PhD Symposium of the Zurich-Basel Plant Science Center, Mutual Dependence in the 21st Century

21.	Lin, Hsiang-Chun	Sucrose transport processes in Arabidopsis, Switzerland, Davos, Jun 2nd- 6th 2008, 7th D-BIOL Symposium ETH Zürich
-----	------------------	--

### Liste 7: Gutachten

	Gutachter	Art des Gutachtens	Typ der anfordernden Organisation	Sitz der anfordernden Organisation	Anzahl
1.	Zeeman, Samuel C.	Publikationen			12
2.	Zeeman, Samuel C.	Projektanträge	Universität	Nordamerika	1
3.	Zeeman, Samuel C.	Projektanträge	öffentliche	Europa	7
4.	Zeeman, Samuel C.	Projektanträge	öffentliche	Nordamerika	1
5.	Zeeman, Samuel C.	Projektanträge	private	CH	6
6.	Zeeman, Samuel C.	Personen	öffentliche	Europa	2
7.	Zeeman, Samuel C.	Personen	öffentliche	Nordamerika	1
8.	Zeeman, Samuel C.	Diplomarbeit, Master-Arbeit	ETH Zürich / ETH Bereich	CH	2

### Liste 11: Organisierte Kongresse

	Organisator(en)	Titel	Ort	Teilnehmerzahl
1.	Zeeman, Samuel C	„Photosynthetic Adaptation and Chloroplast Dynamics“, Swiss-Japanese Bi-National Meeting of Plant Biology Nara, Japan. 7th-11th October, 2008	Japan, Nara	23
2.	Zeeman, Samuel C	Tri-National Arabidopsis Meeting, Zürich, Switzerland. 10th-13th Sept 2008.	Schweiz, Zürich	300

### Liste 12: Kommissionsarbeit

	Kommissionsmitglied	Neu	Typ Kommission	Typ Organisation	Sitz	Anzahl
1.	Zeeman, Samuel C	Nein	Berufungskommission	ETH Zürich / ETH Bereich	CH	1