# Thomas D. Sharkey

University Distinguished Professor

Michigan State University

MSU DOE Plant Research Laboratory

Plant Resilience Institute

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Education

Michigan State University Biology, Lyman Briggs College B.S. 1974

Michigan State University Botany and Plant Pathology Ph. D. 1980

Australian National University Environmental Biology Post-doctoral Fellow

Academic Positions

5/17 to present - member of the MSU-DOE Plant Research Laboratory

6/15 to present University Distinguished Professor

2/08 to present Professor, Department of Biochemistry and Molecular Biology

3/21 to 6/23 – Interim Director of the Plant Resilience Institute, MSU

4/18 to 2/21 Associate Director of the Plant Resilience Institute, MSU

2/08 to 4/17 Chair, Department of Biochemistry and Molecular Biology

6/04 to 1/08 Director, Institute for Cross-college Biology Education, UW-Madison

1/93 to 5/04 Director, UW-Madison Biotron

9/92 to 6/94 Chair of Department of Botany, University of Wisconsin-Madison

9/91 to 1/08 Professor, Department of Botany, University of Wisconsin-Madison

9/88 to 8/91 Associate Professor, Department of Botany, University of Wisconsin-Madison

8/87 to 8/88 Assistant Professor, Department of Botany, University of Wisconsin-Madison

8/86 to 5/87 Adjunct Associate Professor, Biology Department, University of Nevada-Reno

11/82 to 8/87 Assist. -Assoc. Director/ Assist. -Assoc. Research Professor, Biological Sciences Center, Desert Research Institute, Reno, Nevada

Memberships

American Association for the Advancement of Science (AAAS)

American Society for Biochemistry and Molecular Biology

American Society of Plant Biologists (ASPB)

International Society of Photosynthesis Research

Awards

Kellet Mid-Career Award for Research 1999, UW-Madison ($60,000 research prize)

Fellow of ASPB, 2007 (inaugural class)

Fellow of AAAS, 2011

Outstanding Faculty Award, College of Natural Science, 2014

Beal Outstanding Faculty Award, MSU, 2014

University Distinguished Professor, 2015

ASPB Pioneer Member Award 2022

Anton Lang Lecturer 2022

Professional Activity

*Research*

I study the biochemistry and biophysics that underlie plant-atmosphere interactions, especially photosynthesis and isoprene emission from plants. Significant accomplishments related to photosynthesis include

* measurement of carbon dioxide concentration inside leaves
* measurement of the biophysical resistance to carbon dioxide diffusion within leaves
* explored the use of light-emitting diodes as a light source for photosynthesis research
* elucidation of the biochemical feedback chain that explains how limitations in starch and sucrose synthesis reduce the efficiency of photosynthesis (triose phosphate utilization limitation)
* demonstration that maltose is the primary metabolite exported from chloroplasts at night
* described how oxidative pentose phosphate pathways can bypass the non-oxidative pentose phosphate reactions of the Calvin-Benson-Bassham cycle

Significant accomplishments related to isoprene biosynthesis and emissions from plants include

* measurement of the concentration of isoprene in membranes
* analysis of the evolution of isoprene synthases and enzymes that make the precursor to isoprene
* genomic and transcriptomic analyses related to isoprene in plants,
* analysis of phosphoproteome changes in response to isoprene
* elucidation of the metabolic cause of CO2 suppression of isoprene emission
* discovered cryptic isoprene emission of members of the bean family of plants

<https://bmb.natsci.msu.edu/faculty/thomas-d-sharkey/sharkey-lab/>

<https://prl.natsci.msu.edu/people/faculty/thomas-d-sharkey/>

<https://en.wikipedia.org/wiki/Thomas_D._Sharkey>

*Activities related to research*

* **Current:**
* Area Representative for the International Society of Photosynthesis Research (ISPR) (2016-2024)
* Editorial Board member of *Photosynthesis Research* 1992–present
* **Past:**
* Series Co-Editor for volumes 31 to 44 (with Govindjee, founding series editor, now with Julian Eaton-Rye), Advances in Photosynthesis and Respiration *Including Bioenergy and Related Processes* Volume 47 was published in 2021 by SpringerNature
* *Plant, Cell and Environment* Associate Editor 1992–2001, Senior Editor 2002–2020
* Scientific Advisory Board for the biofuels group at Synthetic Genomics (2018 to 2020)
* Organizer for the between-Congress ISPR meeting “Photosynthesis from Light to Life: an ISPR Meeting Held in Conjunction with Plant Biology 2018” in Montreal, Canada
* Scientific Advisory Board for *International Flavors and Fragrances*, 2011-2016
* Founding Chair, Gordon Research Conference on Biogenic Hydrocarbons and the Atmosphere, 2000
* Gordon Research Conference on Temperature Stress of Plants, Co-Vice-Chair 1999, Co-Chair 2001
* Program committee for International Congress on Photosynthesis, 2004, 2010, 2013
* *Plant Physiology*, Monitoring Editor 1993–1997, 2000–2001
* Editorial Board Member: *Journal of Experimental Botany*, 1994–2011; *Plant Physiology*, 1986–1992
* Panel Member, NSF Physiological Processes, 1988–1991; DOE Equipment, 1994; USDA, Photosynthesis, 1999; DOE Energy Biosciences, 2000; USDA Biochemistry, 2002, 2004, and 2005; NSF Ecological and Evolutionary Physiology, 2003, 2004; NSF Global Change Biology, 2010, DOE ARPA-E, 2011; NSF Plant Processes, Structure and Integrity, 2012; USDA AFRI Biological Mechanisms for Plant Production, 2013, DOE-BES-Biosciences Virtual Panel, 2014; USDA Photosynthetic Efficiency and Nutrient Utilization, 2014, 2017, 2018
* Public Affairs Committee, American Society of Plant Biologists, 1999–2004, Chair 2002–2004
* International Review Committee, Research School of Biological Sciences, Australian National University, 1999–2001, External Reviewer 2009-2010
* International Scientific Advisory Board, Max Planck Institute for Molecular Plant Physiology, 2000–2012

##### Post-Doctoral Associates, current position

Rowan Sage, Prof., Univ. Toronto

Terry Vassey, Golf Course Superintendent, Anaheim CA

Francesco Loreto, Director, Department of Biology, Agriculture, and Food Sciences, CNR, Italy

Charles Delwiche, Professor, Univ. Maryland

Jürgen Schleucher, Professor, Dept. Medical Biochemistry and Biophysics, Umeå, Sweden

Barry Micallef, Assoc. Prof., Univ. Guelph

Marianne Laporte, Assoc. Prof., Eastern Mich. Univ.

Deming Gong, Project Manager, Health Research Council, New Zealand

Xiuyin Chen, Scientist, The New Zealand Institute for Plant and Food Research Limited, New Zealand

Tanya Falbel, Research Scientist, UW-Madison

Dennis Gray, Deceased

Ziru (James) Li, Actuarial

Sean Weise, Assistant Professor FT, Biochemistry and Molecular Biology, MSU

Linus Gog, Analytical Chemist, Green Thumb Industries

Thomas Wieloch, Dept. Medical Biochemistry and Biophysics, Umeå, Sweden

James Santiago, Research and Development Plant Physiologist, Soli Organic, Virginia

Sarathi Weraduwage, Assistant Professor, Bishop’s University, Quebec

Stephanie Schmiege, Assistant Professor, Union College

Mohammad G. Mostofa, current

Abira Sahu, current

*Teaching*

I have a keen interest in teaching at all levels from Freshmen to PhD students. I was among the first adopters of a classroom response system (Clickers) in introductory biology at the University of Wisconsin-Madison. This helped increase the learning experience because the students felt part of a community and took responsibility for the class progress in understanding. It also allowed a shift in focus to deeper understanding by encouraging group discussions during lectures. I also taught fourth-year plant physiology and graduate-level plant biochemistry in Wisconsin. Upon moving to MSU I taught in the fourth-year biochemistry for major’s course and then biochemistry for non-majors in order to gain a clear understanding of the teaching in large courses in the department. I then taught in introductory biology for undergraduates to gain insights for my efforts in curriculum reform. Currently I teach biology for non-scientists. In graduate teaching I have taught plant biochemistry and “Plant Biotechnology for Health and Sustainability.” In all of my teaching I emphasize competency in disciplinary knowledge, competency in the practice of science, and scientific communication. I use ‘clickers’ in larger lecture courses and more interactive methods in small graduate courses.

In addition to teaching, I have been deeply involved in curriculum reform at both UW-Madison and MSU. At UW-Madison I was instrumental in establishing a Biology Major that grew to be the second largest major in the University. I was co-chair of the major and Director of the Cross-College Institute for Biology Education that served as the home for the major. At MSU I have been involved in reforming the introductory biology sequence. To be sure I understood student needs I rearranged my teaching duties to teach in this course. These efforts led to the creation of the College of Natural Science BioInitiative, which was successful in getting over $3MM in new funding for undergraduate biology teaching.

At MSU I have served on 31 PhD committees and hosted 56 undergraduates for research in my laboratory

### Activities related to teaching and service

**MSU:**

* Bioinitiative Executive Committee, 2014-2017
* Bioinitiative Oversight Committee, 2014-2016
* Active participant in “Plant Genomics” an NSF-funded REU program that brings undergraduate students from around the country to campus for summer research experiences. The program has been very successful in bringing in students from underrepresented groups.
* Active participant in “Plant Biotechnology for Health and Sustainability”, an NIH-funded training program (T32) to prepare graduate students for careers in biotechnology.
* Scientific Co-PI of MSU Michigan Translational Research and Commercialization program, a cooperative venture between MSU and the Michigan Economic Development Corporation to accelerate commercial development of university discoveries ($2MM total budget) 2013-2016.
* Search Committee (Chair) for Chair of the Department of Microbiology and Molecular Genetics, 2013-2014
* Department of Physiology Chair search Committee, 2011-2012
* College of Natural Science Dean search committee, 2016-2017
* Other search committees PRL Assist. Prof. 2016-2017; PRI/BMB Assist/Assoc. Prof. 2017-8; PRI/PLB Assist Prof. 2017-8

**UW-Madison:**

* Information Technology Committee, member, 2004–2008
* Council of Associate Deans, member, 2004–2008
* Teaching and Learning Council, member 2004–2008
* Co-Chair, Intercollege Biology Major, 1999–2003
* Member, Tenure Committee of the Biological Sciences Division, 2002–2004
* Member, University Committee (executive committee of the Faculty Senate), 1999–2001, Chair 2000–2001
* Biological Sciences Strategic Planning Committee, 1996–1999, chair 1996–1998
* Chair, Undergraduate Biology Education Committee, 1992–1996
* Co-Chair, Administrative Council for Academic Advising, 1997–1999
* Member, University Academic Advising Committee, 1993–1994
* Member, Executive Committee, Center for Biology Education, 1992–1996

**Graduate Students,** degree,and current position

Barry Micallef, PhD 1994, Assoc. Prof., Univ. Guelph

Daniel Tennessen, PhD 1994, Consultant

Marianne Laporte, PhD 1997, Assoc. Prof., Eastern Mich. Univ.

Eric Singsaas, PhD 1997, Research Director, University of Minnesota Duluth

David Hanson, (Co-Advisor) PhD 1999, Prof., Univ. New Mexico

Sansun Yeh, PhD 2003, Patent Attorney, Novartis Institutes for Biomedical Rersearch

Sean Weise, PhD 2005, Assistant Professor, Mich. State Univ.

Yan Lu, PhD 2005, Assoc. Prof. Western Michigan University.

Stephen Schrader, PhD 2005, Senior Scientist, Corteva

Eunsoo Kim, (Co-Advisor) PhD 2006, Professor, Ewha Woman’s University, South Korea

Amy Wiberly, PhD 2008, Research Plant Physiologist, USDA, Madison WI

Ru Zhang, PhD 2009, Assistant Member and PI, Donald Danforth Plant Science Center

Ziru (James) Li, PhD, 2012, Actuarial

Aparajita Banerjee, PhD, 2015, Technical Support Scientist, Twist Bioscience

Chris Harvey, PhD, 2015, Post-doc, Univ. Illinois

Alexandra Lantz, PhD, 2019, KBI Biopharma

Alyssa Preiser, PhD, 2020

Alan McClain, PhD, 2022

Bianca Serda, PhD, anticipated 2025

External Research Grants

(PI except as noted, current support italicized and in green)

*Funding from DOE for work on photosynthesis*

84–90 DOE $372,000 Gas Exchange Characteristics of Leaves (two 3-year grants)

90–99 DOE $797,000 Feedback Regulation of Photosynthetic Processes (three 3-year grants)

99–04 DOE $440,000 Starch Conversion to Sucrose in Plant Leaves

04–09 DOE $490,000 Maltose Metabolism and Transport in Plant Leaves

12–15 DOE $510,000 Improved Efficiency of Energy Capture and Conversion by Regulating the Interaction between ATP Synthesis and End Product Synthesis

15–17 DOE $350,000 The Calvin-Benson Cycle Glucose 6-phosphate Shunt (folded into the PRL grant below as of 2017)

*13–23 DOE/PRL $1,205,943 Photosynthetic Energy Capture, Conversion and Storage: From Fundamental Mechanisms to Modular Engineering (funds from the PRL core grant to my lab. Total PRL funding $17,100,000)*

*Other grants related to photosynthesis*

84–86 NSF $89,000 Metabolic Limitations of Photosynthesis During Water Stress

84–86 USDA $100,000 Nitrogen Use Efficiency in Photosynthesis: Responses to Irradiance and Water Stress (PI: CB Osmond)

85 NSF $3,000 Phosphate in Chloroplasts (travel grant)

85–87 USDA $ 89,000 Stress Effects on the Functioning and Efficiency of CO2 Fixation (CoPI)

87–90 DOE $140,000 Measurement of Metabolically Active Inorganic Phosphate in Plants

93 Calgene $6,600 Measurement of Yield of Transgenic Tomatoes

01–04 Monsanto $153,000 Photosynthetic Manipulation for Yield Enhancement

07–10 DOE $440,000 GLBRC-1 Manipulation of starch metabolism for biofuels

*Funding from NSF for isoprene studies*

90–92 NSF $75,000 A Study of Isoprene Emissions from Plants

91–97 NSF $489,000 Physiology of Isoprene Emission from Plants (two 3-year grants)

99–01 NSF $223,000 Regulation of the Capacity for Isoprene Synthesis

02–05 NSF $390,405 Molecular Regulation of Isoprene Emission from Plants

07-14 NSF $1,030,625 Physiology of Isoprene Emission from Plants (two 3-year grants)

*20-24 NSF $898,946 IOS - IEP: Isoprene Emission from Plants: An Evolutionary Balancing Act*

*Other isoprene and related grants*

89–90 DOE, NSF $28,000 Workshop on Trace Gas Emissions from Leaves

92–92 LADCo $74,000 Hydrocarbon Emissions from Corn

92–92 EPA $48,000 Improved Isoprene Emission Inventory

93–93 EPA $50,000 Oxygenated Hydrocarbons from Plants

94–98 EPA $416,000 Isoprene Emission Inventory Studies

98 NSF $11,000 Conference: Biogenic Hydrocarbons and the Atmosphere (PI: J. Fuentes)

98–00 USDA $112,000 Temperature and Light Effects on Basal Isoprene Emission Rate

99–00 NSF, EPA $23,000 Gordon Conference on Biogenic Hydrocarbons and the Atmosphere

10 DOD $25,000 Cloning hemiterpene synthases (pass through from UW-Stevens Point)

11–14 ZuvaChem $95,000 Generation of Novel Isoprene Synthases

15–18 SPG $478,000 Engineering Cellular Nanoreactors and Three-dimensional Scaffolds for Isoprene Production (Co-PI, Cheryl Kerfeld PI)

17–21 DOE $559,213 GLBRC-2 Evaluate and optimize the production of common terpene bioproducts in crops and microbes (Aim 4)(PI Tim Donohue)

*Funding for work on heat stress*

98–99 NSF $70,000 Interaction of the Small Chloroplast Heat-Shock Protein with Photosystem II

00–01 NSF $10,000 Gordon Conference on Temperature Stress in Plants

02–04 USDA $167,500 Role of ATP Status in Heat Stress Effects on Photosynthesis

04-10 USDA $410,000 The Sensing and Signaling of Heat Stress in Chloroplasts

18-21 MSU-PRI $205,639 Heat Tolerance of Common Bean Yield

*Institutional grants*

86–87 NSF $100,000 Stimulation of Competitive Research in Biological Sciences at the Desert Research Institute (part of $1.4M EPSCoR Nevada proposal)

88 NSF $95,000 Department of Botany Plant Growth Chamber Facility

93 NSF $50,000 Experimental Lighting in the UW Biotron (Written by Ted Tibbitts)

94–98 HHMI $1,000,000 Biology Education at UW-Madison (PI, CoPI Doug Maxwell)

13–16 MEDC $2,443,000 Michigan Translational Research and Commercialization (M-TRAC)

Abbreviations: EPA, Environmental Protection Agency; GLBRC, Great Lakes Bioenergy Research Center; HHMI, Howard Hughes Medical Institute; LADCo, Lake Michigan Air Directors Consortium; MEDC, Michigan Economic Development Corporation; PRL, MSU-DOE Plant Research Laboratory; MSU-PRI, Plant Resilience Institute; SPG Strategic Partnership Grants from the MSU Foundation

Patent Publications

Gray D. & Sharkey T.D. (2016) Methyl Butenol Synthase. Patent no. US 9,284,578

Sharkey T.D. & Aspland, S.E. (2013) High Efficiency Isoprene Synthases Produced by Protein Engineering. WO/2013/016591

Sharkey T.D. & Weise S.E. (2012) High Starch Accumulation in Plants. US 2012/0054914 A1

Singsaas E L; Wiberley A E; Sharkey T D. (2011) Producing Isoprene Usefully e.g. to Produce Rubber, Comprises Obtaining a Host Transgenic Microorganism Comprising Transgenes Encoding e.g. Isopentenyl Diphosphate Isomerase, and Observing the Production of Isoprene. US2011039323-A1

Publications

*Journal and other publications by year - Books listed at the end*

ORCID 0000-0002-4423-3223; Citation analysis at http://scholar.google.com/citations?user=sstSgW8AAAAJ, Web of Science/Publons Researcher ID B-4032-2009; ISI H-index = 86 Google Scholar H index = 102, > 42,000 citations

***2024***

*Original research papers*

Xu Y, Schmiege SC, **Sharkey TD** (2024) The oxidative pentose phosphate pathway in photosynthesis: A tale of two shunts. *New Phytologist* DOI: 10.1111/nph.19730

Bibik J, Sahu A, Kim B, Unda F, Andersen T, Mansfield S, Maravelias C, **Sharkey TD**, Hamberger B (2024) Engineered poplar for bioproduction of the triterpene squalene. *Plant Biotechnology Journal* DOI 10.1111/pbi.14345

ZhangY, Kaiser E, Dutta S, **Sharkey TD**, Leo F.M. MarcelisLFM, Li T (2024) Short-term salt stress reduces photosynthetic oscillations under triose phosphate utilization limitation in tomato. *Journal of Experimental Botany* DOI 10.1093/jxb/erae089

Weraduwage SM, Whitten D, Kulke M, Sahu A, Vermaas J, **Sharkey TD** (2024) The isoprene-responsive phosphoproteome provides new insights into the putative signaling pathways and novel roles of isoprene. *Plant, Cell & Environment* 47, 1099–1117 DOI 10.1111/pce.14776

Xu Y, Koroma AA, Weise SE, Fu X, **Sharkey TD**, Shachar-Hill Y (2024) Daylength variation affects growth, photosynthesis, leaf metabolism, partitioning, and metabolic fluxes. *Plant Physiology* 194, 475-490 DOI 10.1093/plphys/kiad507

*Original research papers not peer reviewed*

Evans SE, Xu Y, Bergman ME, Ford SA, Liu Y, **Sharkey TD**, Phillips MA (2024) Rubisco supplies pyruvate for the 2-C-methyl-D-erythritol-4-phosphate pathway. *BioRxiv* 10.1101/2024.01.28.577108; (being revised for *Nature Plants*

Bellucci M, Mostofa MG, Werdauwage SM, Xu Y, Abdelrahman M, De Gara L, Loreto F, **Sharkey TD** (2024) The effect of constitutive root isoprene emission on root phenotype and physiology under control and salt stress conditions. *BioRxiv* 10.1101/2024.02.09.579703 (Revision submitted to *Plant Direct*)

Govindjee G, **Sharkey TD**, Melis A (2024) Honoring Hartmut Karl Lichtenthaler, Innovative Pioneer of

Photosynthesis, on his 90th Birthday. *Photosynthetica* in press

*Reviews, chapters, commentaries (peer reviewed)*

**Sharkey TD** (2024) The end game(s) of photosynthetic carbon metabolism. *Plant Physiology* DOI 10.1093/plphys/kiad601

***2023***

*Original research papers*

Stallknecht EJ, Herrera CK, **Sharkey TD**, Lunt RR, Runkle ES (2023) Growth of snapdragon under simulated transparent photovoltaic panels for greenhouse applications. *Journal of Environmental Horticulture* 41, 170-179

Sahu A, Mostofa MG, Weraduwage SM, **Sharkey TD** (2023) Hydroxymethylbutenyl diphosphate accumulation reveals MEP pathway regulation for high CO2-induced suppression of isoprene emission. *Proceedings of the National Academy of Science USA* 120, e2309536120 DOI 10.1073/pnas.2309536120.

Kulke M, Weraduwage SM, **Sharkey TD**, Vermaas JV (2023) Nanoscale simulation of the thylakoid membrane response to extreme temperatures. *Plant Cell & Environment* 46, 2419-2431. DOI 10.1111/pce.14609

Schmiege, SC, **Sharkey TD**, Walker B, Hammer, J, Way DA (2023) Laisk measurements in the non-steady-state: two tests in plants exposed to warming and variable CO2 concentrations. *Plant Physiology*, 193, 1045-1057 DOI 10.1093/plphys/kiad305

Khana D, Tatli1M, Vazquez J, Weraduwage SM, Stern N, Hebert AS, Trujillo EA, Coon JJ, **Sharkey TD**, Amador-Noguez D (2023) Systematic analysis of metabolic bottlenecks in the methylerythritol 4-phosphate (MEP) pathway of *Zymomonas mobilis.* *mSystems* 8 (2), e00092-23 DOI 10.1128/msystems.00092-23

McClain AM, **Sharkey TD** (2023) Rapid CO2 changes cause oscillations in photosynthesis that implicate PSI acceptor-side limitations. *Journal of Experimental Botany* 74, 3163-3173. doi.org/10.1093/jxb/erad084

Stallknecht EJ, Herrera CK, Yang C, King I, **Sharkey TD**, Lunt RR, Runkle ES (2023) Design of plant-transparent agrivoltaics. *Scientific Reports* 13, 1903. DOI 10.1038/s41598-023-28484-5

Weraduwage SM, Sahu A, Kulke M, Vermaas J, **Sharkey TD** (2023) Characterization of promoter elements of isoprene-responsive genes, and the ability of isoprene to bind START domain transcription factors. *Plant Direct*, 7, e483. DOI 10.1002/pld3.483

McClain AM, Cruz JA, Kramer DM. **Sharkey TD** (2023) The time course of acclimation to the stress of triose phosphate use limitation. *Plant, Cell & Environment* 46, 64-75. DOI 10.1111/pce.14476

*Reviews, chapters, commentaries (peer reviewed)*

**Sharkey TD** (2023) The discovery of rubisco. *Journal of Experimental Botany* 74, 510-519 DOI 10.1093/jxb/erac254

**Sharkey TD** (2023) Maximising the efficiency of RuBP (ribulose bisphosphate) regeneration to optimise photosynthesis in crops. In: Understanding and Improving Crop Photosynthesis (ed R. Sharwood) Chapter 9 pp 223-248, ISBN 978-1-80146-129-0. Burleigh Dodds Science Publishing Limited. https://shop.bdspublishing.com/store/bds/detail/product/3-190-9781801467650

Bellucci M, Locato V, **Sharkey TD**, De Gara L, Loreto F (2023) Isoprene emission by plants in polluted environments. *Journal of Plant Interactions.* DOI 10.1080/17429145.2023.2266463

***2022***

*Original research papers*

Weraduwage SM, Frame MK, **Sharkey TD** (2022) Role of guard cell- or mesophyll cell-localized phytochromes in stomatal responses to blue, red, and far-red light. *Planta* 256, 55. DOI 10.1007/s00425-022-03967-3

Bibik J, Weraduwage SM, Banerjee A, Robertson Ks, Espinoza Corral R, **Sharkey TD**, Lundquist P, Hamberger B (2022) Pathway engineering, re-targeting, and synthetic scaffolding improves production of squalene in plants. *ACS Synthetic Biology* 11: 2121-2133. doi.org/10.1021/acssynbio.2c00051

Wieloch T, **Sharkey TD** (2022) Compartment-specific energy requirements of photosynthetic carbon metabolism in *Camelina sativa* leaves. *Planta* 255:103 doi.org/10.1007/s00425-022-03884-5

Xu Y, Wieloch T, Kaste JAM, Shachar-Hill Y, **Sharkey TD** (2022) Reimport of carbon from cytosolic and vacuolar sugar pools into the Calvin-Benson cycle explains photosynthesis labeling anomalies. *Proceedings of the National Academy USA* 119: e2121531119 doi:10.1073/pnas.2121531119

Wieloch T, **Sharkey TD**, Werner RA, Schleucher J (2022) Intramolecular carbon isotope signals reflect metabolite allocation in plants. *Journal of Experimental Botany* https://doi.org/10.1093/jxb/erac028

Dani KGS, Pollastri S, Pinosio S, Reichelt M, **Sharkey TD**, Schnitzler, J-P, Loreto, F (2022) Isoprene enhances leaf cytokinin metabolism and induces early senescence. *New Phytologist* 234(3): 961-974 DOI 10.1111/nph.17833

*Reviews, chapters, commentaries (peer reviewed)*

Weraduwage SM, Rasulov B, Sahu A, Niinemets Ü, **Sharkey TD** (2022) Isoprene measurements to assess plant hydrocarbon emissions and the methylerythritol pathway. In Jez J ed. Methods in Enzymology Vol 676: Biochemical Pathways and Environmental Responses in Plants: Part A. pages 211-237 10.1016/bs.mie.2022.07.020

De-la-Peña C, León P, & **Sharkey TD** (2022) Editorial: Chloroplast Biotechnology for Crop Improvement. Frontiers in Plant Science 13 https://www.frontiersin.org/article/10.3389/fpls.2022.848034

***2021***

*Original research papers*

Gonzalez-Esquer CR, Ferlez B, Wijetilleke SM, Kirst H, Lantz AT, Turmo A, **Sharkey TD**, Kerfeld CA (2021) Validation of an insertion-engineered isoprene synthase as a strategy to improve terpene synthases. *RSC Advances* 11: 29997-30005 <https://doi.org/10.1039/D1RA05710C>

Santiago JP, Soltani A, Bresson MB, Preiser AL, Lowry DB, **Sharkey TD** (2021) Contrasting anther glucose 6-phosphate dehydrogenase activities between two bean varieties suggest an important role in reproductive heat tolerance. *Plant Cell & Environment* 44: 2185-2199 DOI: https://doi.org/10.1111/pce.14057

Osei-Bonsu I, McClain AM, Walker BJ, **Sharkey TD**, Kramer DM (2021) The roles of photorespiration and alternative electron acceptors in the responses of photosynthesis to elevated temperatures in cowpea. *Plant Cell & Environment* 44: 2290-2307 DOI: https://doi.org/10.1111/pce.14026

Xu Y, Fu X, **Sharkey TD**, Shachar-Hill Y, Walker B (2021) The metabolic origins of non-photorespiratory CO2 release during photosynthesis: A metabolic flux analysis. *Plant Physiology* 186: 297-314 <https://doi.org/10.1093/plphys/kiab076>

Poudyal S, Owen JS, **Sharkey TD**, Fernandez RT (2021) Phosphorus requirement for biomass accumulation is higher compared to photosynthetic biochemistry for three ornamental shrubs. *Scientia Horticulturae* 275:109719 DOI: 10.1016/j.scienta.2020.109719

*Reviews, chapters, commentaries (peer reviewed)*

Gregory LM, McClain AM, Kramer DM, Pardo JD, Smith KE, Tessmer OL, Walker BJ, Ziccardi LG, **Sharkey TD** (2021). The triose phosphate utilization limitation of photosynthetic rate: Out of global models but important for leaf models. *Plant, Cell & Environment* 44(10): 3223–3226. https://doi.org/10.1111/pce.14153

**Sharkey TD** (2021) Pentose phosphate pathway reactions in photosynthesizing cells. *Cells* 10: 1547. https://doi.org/10.3390/cells10061547

Yin X, Busch FA, Struik PC, **Sharkey TD** (2021) Evolution of a biochemical model of steady-state photosynthesis. *Plant Cell Environ* 44: 2811-2837 DOI 10.1111/pce.14070

Jagadish KSV, Way DA, **Sharkey TD** (2021) Scaling plant responses to high temperature from cell to ecosystem. *Plant, Cell & Environment* 44: 1987-1991 DOI: https://doi.org/10.1111/pce.14082

Jagadish KSV, Way DA, **Sharkey TD** (2021) Plant heat stress: concepts directing future research *Plant Cell Environ* 44: 1992-2005 DOI: https://doi.org/10.1111/pce.14050

Monson RK, Weraduwage SM, Rosenkranz M. Schnitzler J-P, **Sharkey TD** (2021) Leaf isoprene emission as a trait that mediates the growth-defense tradeoff in the face of climate stress. *Oecologia* <https://doi.org/10.1007/s00442-020-04813-7>

Ely KS, Rogers A, …**Sharkey TD**…Yang D (83 authors) (2021) A reporting format for leaf-level gas exchange data and metadata. *Ecological Informatics* 61:101232 https://doi.org/10.1016/j.ecoinf.2021.101232

**Sharkey T.D.** (2021) Photosynthetic Carbon Dioxide Fixation *Encyclopedia of Biological Chemistry, 3rd Edition*, Jez, J. Ed. p 399-412, ISBN: 9780128194607

***2020***

*Original research papers*

Preiser AL, Banerjee A, Weise SE, Renna L, Brandizzi F, **Sharkey TD** (2020) Phosphoglucoisomerase is an important regulatory enzyme in partitioning carbon out of the Calvin-Benson cycle. *Frontiers in Plant Science* 11:580726 doi: 10.3389/fpls.2020.580726

**Sharkey TD**, Preiser AL, Weraduwage SM, Gog L (2020) Source of 12C in Calvin Benson cycle intermediates and isoprene emitted from plant leaves fed with 13CO2. *Biochemical Journal* 477 (17): 3237–3252 DOI: 10.1042/bcj20200480

Santiago JPM, Ward J, **Sharkey TD** (2020) *Phaseolus vulgaris* SUT1.1 is a high affinity sucrose-proton co-transporter. *Plant Direct* 2020;00:1–11 DOI: 10.1002/pld3.260

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***Books***

**Editor**

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Hikosaka, K. Niinemets, Ü. Anten, N.P.R. eds. *Canopy Photosynthesis: From Basics to Applications,* **Vol 42** of Advances in Photosynthesis and Respiration, Govindjee and **T.D. Sharkey** Series eds. Springer Academic Publications, Dordrecht, 2016

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Bock, R. and V. Knoop eds. *Genomics of Chloroplasts and Mitochondria*, **Vol 35** of Advances in Photosynthesis and Respiration, Govindjee and **T.D. Sharkey** Series eds. Springer Academic Publications, Dordrecht, 2013

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Rebeiz, C.A., C. Benning, H.J. Bohnert, H. Daniell, J.K. Hoober, H.K. Lichtenthaler, A.R. Portis, B.C. Tripathy, eds. *The Chloroplast Basics and Applications*, **Vol 31** of Advances in Photosynthesis and Respiration, Govindjee and **T.D. Sharkey** Series eds. Springer Academic Publications, Dordrecht, 2010

**Seminars and Presentations** (last 10 years)

8/23 “Regulatory mechanisms of the methyl erythritol pathway discovered during isoprene research” Terpnet, Davis California

7/23 “Cytosolic carbon metabolism pathways that support the Calvin-Benson-Bassham cycle” Plenary Speaker, 11th International Conference of Photosynthesis and Hydrogen Energy Research for Sustainability, Istanbul, Turkey

7/22 “Isoprene and the environment” Keynote speaker, Annual Meeting of the Phytochemical Society of North America, Virginia Tech, Blacksburg Virginia

6/22 Discussion leader Emerging Sources and Sinks, Gordon Research Conference on Biogenic Hydrocarbons and the Atmosphere, Oxnard California

6/22 “Hydrocarbon Emissions from Plants: At the Interface of Biochemistry and Ecology” Presentation at the Research Experiences for Undergraduates Program Michigan State University

5/22 “Isoprene signaling and plant resilience to climate change”, Interdisciplinary Plant Group Symposium, University of Missouri

4/22 “Isoprene signaling and plant resilience to climate change” Cornell School of Integrative Plant Science Plenary Seminar

3/21 “Photosynthetic carbon metabolism: Roles of gluconeogenesis and pentose phosphate pathways”, 1 hr lecture, Istanbul University 18th Winter School

2/21 “Shining light on the dark reactions of photosynthesis” Texas Tech University (by Zoom)

11/19 “Will global climate change affect isoprene emission from plants?” Institut für Bio- und Geowissenschaften, Jülich

11/19 “Will global climate change affect isoprene emission from plants?” Heinrich-Heine-Universität Düssedorf

10/19 “Will global climate change affect isoprene emission from plants? Western University, London, Ontario

9/19 “How will global climate change affect isoprene emission from plants?”, John Innes Centre, Norwich

8/19 “Isoprene emission affects growth-defense tradeoffs in plants” ASPB, San Jose

3/19 “Recent Insights into the Calvin-Benson Cycle and Related Metabolism of Photosynthesis” Invited Seminar, Dept. Horticulture, MSU

9/18 “Auxiliary pathways of the Calvin-Benson cycle”, Estonian University of Life Sciences

7/18 “Elaborations of the Calvin-Benson cycle: Historical concerns and new insights”, International Society of Photosynthesis Research 2018 meeting, Montreal

1/18 “Elaborations of the Calvin-Benson Cycle: Historical Concerns and New Insights”, Western Photosynthesis Conference, Biosphere2, Arizona

11/17 “What Gas Exchange Measurements Tell Us About Photosynthesis Metabolism”, Invited talk, Washington State University

10/17 “Carbon Export from the Calvin-Benson Cycle”, Invited talk, Greenhouse Gas Flux Workshop, Potsdam, Germany

10/17 “Carbon Export from the Calvin-Benson Cycle”, Invited talk, Max Planck Institute for Molecular Plant Physiology, Golm, Germany

6/16 Diversity of Sources, Sinks, and Impacts of Atmospheric Organics, Keynote session discussion leader, Gordon Research Conference, Girona, Spain

10/16 “The Calvin-Benson Cycle in a Stochastic Light Environment”, 25 min talk, Montana State University, USDA NC1200 project report

11/15 “The Calvin-Benson Cycle of photosynthesis: historical insights and new hypotheses”, Seminar, Western Michigan University

6/15 “The glucose 6-phosphate shunt around the Calvin-Benson Cycle”. Invited talk, Steven Long symposium, University of Essex, Colchester, UK

6/15 “Building toward an understanding of the mechanism of action of isoprene” Invited talk, Terpnet 2015, Vancouver, Canada

4/15 “Isopentenyl Diphosphate Inhibition of Thiamin Diphosphate Enzymes, Especially Deoxyxylulose 5-Phosphate Synthase” Invited talk, ASBMB national meeting, Boston, MA

3/15 “The glucose 6-phosphate shunt around the Calvin-Benson Cycle: Connecting carbon metabolism and cyclic photophosphorylation.” Invited seminar, Univ. Illinois

10/14 “When photosynthesis becomes insensitive to CO2 – what triose-phosphate-use tells us about photosynthetic metabolism”, Invited speaker, PRL Retreat

7/14 “Exploring chloroplast terpene metabolism using metabolomics of isoprene synthesis” Third International Conference on Plant Metabolism, Xiamen, China

7/14 “Why plants make so much isoprene?” Invited seminar, Nanjing University

6/14 “Control of Carbon metabolism”, Gordon Conference,

5/14 “Molecular and metabolic understanding of isoprene emission from trees” Molecular and Environmental Plant Sciences Symposium. TAMU College Station Texas

6/13 “Isoprene Synthase Genes Form a Monophyletic Clade of Acyclic Terpene Synthases in the Tps-B Terpene Synthase Family” Terpnet, Crete

3/13 “Recent Insights into Isoprene Synthesis” Eurovol Conference on Plant Terpenoids, Florence

11/12 “Engineering End Products of Photosynthesis To Increase Yield and Efficiency” AgBioResearch Brazil workshop, East Lansing

10/12 “High Temperature Effects on Photosynthesis and Protection by Isoprene” Academia Sinica, Tapei, Taiwan

5/12 “Omics of Isoprene Emission from Plants” Interdisciplinary Plant Group, Univ. Missouri, Columbia

12/11 “Novel Isoprene Synthases” ZuvaChem presentation, Baltimore, MD

5/11 “Optimizing End Products of Photosynthesis To Increase Yield and Efficiency” Gordon Research Conference, Les Diableret, Switzerland

8/10 “Leaf Starch Metabolism in C3, C4, and CAM Plants and Molecular Approaches to Engineering” Invited talk, International Photosynthesis Congress, Beijing

8/10 “Biology and Chemistry of Isoprene” Chinese Academy of Science, Shanghai

5/10 “BVOC Research: Past, Present, and Future” Gordon Research Conference *Biogenic Hydrocarbons and the Atmosphere*. Switzerland

1/10 “Improved Isoprene Synthases” Invited talk, ZuvaChem Inc. Baltimore MD

11/09 “Isoprene and Methyl Butenol: Biology, Biochemistry, and Molecular Biology” Invited seminar, Genencor, Palo Alto CA

8/09 “The frustrating biology underlying isoprene emission models” Talk at Gordon Conference on Atmospheric Chemistry

5/09 “The Evolution of Methylbutenol Emission in Pinus” Poster at Terpnet meeting, Tokyo, Japan

5/09 “Increasing the Yield of Starch and other Easily Degraded Polymers in Leaves” Invited talk at GLBRC retreat

2/09 “Leaf Starch Mobilization” Invited seminar, Washington State University