

DOUGLAS ALAN GAGE, Ph.D.

Vice President for Research and Innovation
Michigan State University

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ADDRESSES:

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426 Auditorium Road
East Lansing, MI 48824-1046
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PERSONAL HISTORY:

Place of Birth - Louisville, Kentucky

PROFESSIONAL EXPERIENCE:

7/1/20 – present

Vice President, Research and Innovation (as interim until 6/18/2021)

- Oversight and responsibility over a \$932M research enterprise and diverse organization of 419 FTEs encompassing; the Office of Regulatory Affairs (Environmental Health and Safety, Campus Animal Resources, Human Subjects Protection, Conflict of Interest, Export Control and Trade Sanctions and the University Research Organization), Sponsored Programs Administration, the Innovation Center (intellectual property protection, corporate sponsored research and technology transfer), Research Facilitation, Research Technology Support Facility, Campus Centers and Institutes, Internal Grants and Institutionally Limited Submissions. *The Research Integrity Office has dotted line reporting relationships to the VPRI.*
- Institutional Official. Serves as the individual responsible for regulatory compliance and research integrity.
- Member, Executive Committee for Buildings, Facilities, and Space. Sets strategy for space allocation and new construction on campus with decision making authority for space assignments.
- Chair, Research Committee, Henry Ford Health System-MSU partnership. Leads the group responsible for development of the mechanisms and procedures for faculty appointments, research grant attribution, regulatory compliance, shared research cores, intellectual property, pre-/post-award support and space allocation.
- Member, MSU Strategic Plan Steering Committee and Convener of the Innovation for Global Impact (research) group.

8/16/19 – present

Professor of Biochemistry and Molecular Biology

4/1/14 – 6/30/20

Assistant Vice President OVPRGS (now Research and Innovation)

- Responsible for oversight and central coordination of the Global Impact Initiative to hire 100 new faculty in STEM and Biomedical research areas.
- Academic lead on Interdisciplinary Science and Technology Building project team (building opened 2019).
- Member, Spectrum Health-MSU Alliance Board, managed joint research investments.
- Served on the Executive Committee of the Institute for Quantitative Health Sciences and Engineering (IQ).
- Chair, Provost's Advisory Committee for USAID Afghanistan GRAIN project.
- Academic lead, Co-PI, Michigan Translational Research and Commercialization (MTRAC) Program.
- Co-chair, University Research Space Planning Committee.
- PI, University Autism Spectrum Disorder Project, MDHHS.

3/15/10 – 6/30/20

Director, Interdisciplinary Research and Internal Grants, OVPRGS

- MSU's central administration point of contact for the DOE Great Lakes Bioenergy Research Center. Served on GLBRC Oversight Committee.
- Point person for Government Affairs for Research-related activities.
- Managed Strategic Partnership Grants, Discretionary Funding Initiative, and Humanities and Arts Research Program internal grant programs.
- Managed Institutionally limited proposals selection process.
- Managed Indirect Cost Reduction and Waiver process.
- Academic lead on Molecular Plant Sciences Building project team (building opened 2010).

10/15/07 – 3/14/10

Assistant to the Vice President for Research

Office of the Vice President for Research and Graduate Studies
Michigan State University

- Helped to develop the Management and Operational plan for the DOE Great Lakes Bioenergy Research Center cooperative agreement.
- Served as Director of the Bioeconomy Network to develop academic and corporate research collaborations for MSU in the bioeconomy sector.
- OVPRGS lead for ARRA grant programs, coordinated five research infrastructure applications and helped to develop communication and federal reporting processes.
- Served on the VPR's Team that redesigned MSU's Business Engagement, Technology Transfer and Contracts and Grants organizations.
- Led the Search Committee for the Executive Director of MSU Technologies, the University's intellectual property management organization.
- Served on Provost's team for strategy development for Foundation engagement.

6/15/07 – 9/26/07

Acting Head, Discovery Biology

Pfizer Global Research and Development,
Michigan Labs
Ann Arbor

- Responsible for managing the transfer and exit of the 300 colleagues in Biology from the Ann Arbor site.
- Served on the Leadership team overseeing the completion and transfer of projects to other Pfizer research sites.
- Point of accountability in Discovery to Finance and Global Operations for the transfer of capital assets and the decommissioning of laboratories during the site closure process.

4/16/06 – 9/26/07

Senior Director, Discovery Biomarkers

Mechanistic and Target Biology,
Pfizer Global Research and Development,
Michigan Labs
Ann Arbor

- Led a department of 25 scientists (8 Ph.D.s) with an operating budget of \$5.4 M.
- Responsible for biomarker discovery, assay development, validation, and application to support the Discovery portfolio at the Ann Arbor site.
- Identified safety biomarkers to better understand and predict adverse events.
- Managed a diverse portfolio of biomarker projects from the five Ann Arbor therapeutic areas, Cardiovascular, Inflammation, CNS, Dermatology and Infectious Diseases.
- Provided support for early clinical trials and human methodology studies.
- Served as a member of the Ann Arbor Discovery Leadership Team, with a role in scientific review of projects, performance evaluation of colleagues, budgeting and planning.
- Ann Arbor site representative to the Pfizer Discovery Biomarker Council, active on several global Pfizer teams and task forces on biomarkers, translational medicine and outsourcing strategies.

4/4/2005 – 4/15/06

Director, Discovery Biomarkers Group

Molecular Sciences and Technologies,
Pfizer Global Research and Development,
Michigan Labs
Ann Arbor

- Created a consolidated biomarker group of 20 scientists from several smaller distributed technology groups and biologists working on biomarker assays.
- Provided a centralized source of expertise on biomarkers in Discovery for the first time at any Pfizer site.
- Led effort to fully integrate the use of biomarkers into key go/no go project decisions.
- Member of the Pfizer Ann Arbor Biology Leadership Team, providing scientific review for early-stage projects, capital budget prioritization and colleague performance evaluations.

3/4/2002 – 4/3/2005

Associate Director, Group Leader Biomarker Technologies

Discovery Technologies Department,
Pfizer Global Research and Development,
Michigan Labs
Ann Arbor

- Led a group of eight scientists to provide Discovery project teams with technology support for biomarker discovery.
- Identified metabolic biomarkers of efficacy and safety using NMR and mass spectrometry.
- Characterized proteins for proteomics and structural biology efforts.
- Led the Biomarker Translation Team, with the remit to improve coordination between biomarker efforts in Discovery, Safety, Pharmacodynamics and Drug Metabolism and Clinical Development
- Member of the Protein Biochemistry and Structure Leadership Team.
- Adjunct Assoc. Professor, Biochemistry & Molecular Biology, MSU.

8/15/2000 – 3/1/2002

Associate Professor of Biochemistry & Molecular Biology (tenured), MSU

- Research program on metabolic engineering of compounds to mitigate plant salt and drought stress. Using omics technologies developed an understanding why genetic manipulations in plant biosynthetic pathways often lead to unexpected metabolic phenotypes (funded by NSF).
- Research program on biosynthesis of the algal osmoprotectant compound dimethylsulfoniopropionate, an important component of the global sulfur cycle (funded by Office of Naval Research, NSF).
- Continued collaborative research in biomedical applications of mass spectrometry (e.g., post-translational modifications and protein regulation, proteomics, metabolomics, complex carbohydrate and lipid structure and peptidoglycan modifications in antibiotic resistance).

2000 - 2002

Director, MSU Mass Spectrometry Facility

- Following mandated 30-year sunset of NIH funding, assumed responsibility for overall management and funding of the Facility.
- Obtained \$4M (MI Life Sci. Corridor) for establishing Proteomics Core at MSU as part of Michigan Proteome Consortium.
- Increased emphasis on metabolic profiling at the MSF.

1994 - 2000

Assistant Professor of Biochemistry (tenure track), Michigan State University

- Joined regular faculty to establish independent research program in plant biochemistry.
- Research on biosynthesis and metabolic engineering of dimethylsulfoniopropionate in marine algae and higher plants (funding from the NSF and Office of Naval Research).

1993 - 1994

Research Associate Professor of Biochemistry, Michigan State University

1991 - 2000	Co-Director and Manager, MSU-NIH Mass Spectrometry Facility	
	Responsibility for representing the Facility to funding agency and external reviewers.	
1989 - 1992	Research Assistant Professor of Biochemistry and Facility Manager, MSU-NIH Mass Spectrometry Facility	
	- Responsible for day-to-day management of Facility. - Supervised five staff members and coordinated activities of 15 graduate students. - Expanded collaborative research program with national and international biomedical investigators.	
1987 - 1988	Applications Manager, MSU-NIH Mass Spectrometry Facility.	
	- Developed protein characterization and in vivo stable isotope labeling technology for biological applications at this national research resource (NIH P41-supported facility). - Supported collaborative research for a number of faculty from MSU, US and international institutions.	
1986 - 1987	MSU-DOE Plant Research Laboratory. Postdoctoral Research Associate	
	Elucidated biosynthetic pathways of the plant growth hormones gibberellins and abscisic acid, under Professor Jan Zeevaart (elected to the National Academy of Sciences, 1998).	
EDUCATION:	Ph.D.: University of Texas, Austin, Texas (1986) Botany Dissertation on natural products structure elucidation of biologically active terpenoids from Mexican plants in the genus <i>Piptothrix</i> (Advisor, Prof. Tom Mabry). MS: Florida State University, Tallahassee, Florida (1981) Biological Sci. Thesis on Mechanisms by which the growth and development of herbivorous insects adapt to the natural products of the host plant, <i>Heliconia imbricata</i> (Advisor, Prof. Donald Strong, Jr.). Research Assistant Florida State University, Tallahassee, Florida (1977-1980) Field assistant for ecological studies (Dan Simberloff) Biological Sci. Lab tech for natural products research, plant collector (Werner Herz) Chemistry BS: Florida State University, Tallahassee, Florida (1977) Psychology, Biology	
PROFESSIONAL SOCIETIES AND RESPONSIBILITIES:	American Society for Mass Spectrometry American Chemical Society Member, Long Range Program Planning committee, ACS Analytical Division (2002-2006) Organizer: Symposium on Metabonomics (ACS National Meeting, Phil., PA 2004) Referee for: <i>ACS books and videos, Analytical Chemistry, Analytical Biochemistry, Archives Biochemistry and Biophysics, Biochimica et Biophysica Acta, FEBS Letters, Food Chemistry, Journal of Agricultural and Food Chemistry, Journal of the American Society for Mass Spectrometry,</i>	

Editorial Board Member, *Metabolomics* 2005-2008
 Editorial Board Member, *Analytical Biochemistry* 1994-1997
 Member, Special Study Section, NIH Shared Instrumentation Grant (SIG) Program; June 1996, November 2000; October 2001, Oct 2002, Nov 2003
 Member, Site visit team, NCRR Research Resource, UCSF, Nov. 2006
 Member, Site visit team NIH MS Research Resource, Wash U, Nov 2003, DOE Complex Carbohydrate Research Center, Aug 2001; Ohio State U Core Facilities, Oct. 1998; NIH NICHD Laboratory of Cellular and Molecular Biophysics, Nov. 1999
 Member, Interagency Metabolic Engineering Panel, NSF, Nov. 1999
 Member, Advisory Board Michigan Proteome Consortium 2002- 2006

Peer Reviewed Journal Articles, h-index 67, i10-index 154 (Google Scholar, DA Gage)

<https://scholar.google.com/citations?user=admNvk0AAAAJ&hl=en>

171. Robosky, L.C., Wade, K., Woolson, D., Baker, J.D., Manning, M.L., Gage, D.A. and Reily, M.D.: Quantitative evaluation of sebum lipid components with nuclear magnetic resonance *J. Lipid Research* **49**: 686-692 (2008)
170. Molloy, M.P., Donahoe, S., Brzezinski, E.E., Kilby, G.W., Stevenson, T.I., Baker, J.D., Goodlett, D.R., and Gage, D.A. Large scale evaluation of quantitative reproducibility and proteome coverage using acid cleavable isotope coded affinity tag mass spectrometry for proteomic profiling. *Proteomics* **5**: 1204-1208 (2005)
169. Froehlich, J.E., Wilkerson, C., Ray, K., McAndrew, R.S., Osteryoung, K.W., Gage, D.A., and Phinney, B.S.: Proteomic Study of the *Arabidopsis thaliana* chloroplastic envelope membrane utilizing alternatives to traditional two-dimensional electrophoresis. *J. Proteome Research* **4**: 413-425 (2003).
168. Kocsis, M.G., Ranocha, P., Gage, D.A., Simon, E.S., Rhodes, D., Peel, G.J., Mellema, S., Saito, K., Awazuhara, M., Li, C., Meeley, R.B., Tarczynski, M. Wagner, C. and Hanson, A.D.: Insertional inactivation of the methionine S-methyltransferase gene eliminates the S-Methylmethionine cycle and increases the methylation ratio. *Plant Physiology* **131**: 1808-1815 (2003).
167. Chang, Z. and Gage, D.A.: Extraction, purification and detection by liquid chromatography-electrospray ionization mass spectrometry of tetrahydrofolate metabolites in *Arabidopsis thaliana*. *Nature and Science* **1**: 32-36 (2003).
166. MacLeod K.J., Ponnampalam, R.D., Gage D.A. and Ahn K.: Constitutive phosphorylation of human endothelin-converting enzyme-1 isoforms. *J. Biol Chem.* **277**: 46355-46363 (2002).
165. Hoffmann-Benning S., Gage D.A., McIntosh L., Kende H. and Zeevaart J.A.D.: Comparison of peptides in the phloem sap of flowering and non-flowering Perilla and lupine plants using microbore HPLC followed by matrix-assisted laser desorption/ionization time-of-flight mass spectrometry. *Planta* **216**:140-147 (2002).
164. De Jonge B.L., Gage D.A. and Xu N.: The Carboxyl terminus of peptidoglycan stem peptides Is a determinant for methicillin resistance in *Staphylococcus aureus*. *Antimicrob Agents Chemother.* **46**: 3151-3255 (2002).

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163. Vaz F.M., Melegh B., Bene J., Cuebas D., Gage D.A., Bootsma A, Vreken P., van Gennip AH., Bieber L.L. and Wanders R.J.: Analysis of carnitine biosynthesis metabolites in urine by HPLC-electrospray tandem mass spectrometry. *Clin. Chem.* **48**: 826-834 (2002).
162. Vacratsis P.O., Phinney B.S., Gage D.A., Gallo K.A.: Identification of *in vivo* phosphorylation sites of MLK3 by mass spectrometry and phosphopeptide mapping. *Biochemistry* **41**:5613-5624 (2002).
161. Li W., Scott A.P., Siefkes M.J., Yan H., Liu Q., Yun S.S. and Gage DA.: Bile Acid secreted by male sea lamprey that acts as a sex pheromone. *Science* **296**:138-141 (2002).
160. McNulty, T., Calkins, A., Ostrom, P., Gandhi, H., Gottfried, M.D., Martin, L. and Gage, D.: Stable isotope values of bone organic matter: artificial diagenesis experiments and paleoecology of Natural Trap Cave, Wyoming. *Palaio* **17**: 36-49 (2002)
159. Doorn J.A., Schall, M., Gage, D.A., Talley, T.T., Thompson, C.M. and Richardson, R.J.: Identification of butyrylcholinesterase adducts after inhibition with isomalathion using mass spectrometry: difference in mechanism between (1R)- and (1S)-stereoisomers. *Toxicol. Appl Pharmacol.* **176**: 73-80 (2001).
158. Rivoal, J., Trzos, S., Gage, D.A., Plaxton, W.C. and Turpin D.H.: Two unrelated phosphoenolpyruvate carboxylase polypeptides physically interact in the high molecular mass isoforms of this enzyme in the unicellular green alga *Selenastrum minutum*. *J. Biol. Chem.* **276**:12588-12597 (2001).
157. Johnson R.M., Buck S., Chiu C.H., Gage D.A., Shen T.L., Hendrickx A.G., Gumucio D.L. and Goodman, M.: Humans and old world monkeys have similar patterns of fetal globin expression. *J. Exp. Zool.* **288**: 318-326 (2001).
156. Doorn J.A., Gage D.A., Schall M., Talley T.T., Thompson C.M. and Richardson R.J.: Inhibition of acetylcholinesterase by (1S,3S)-isomalathion proceeds with loss of thiomethyl: kinetic and mass spectral evidence for an unexpected primary leaving group. *Chem. Res. Toxicol.* **13**: 1313-20 (2000).
155. Chern, M.K., Gage, D.A. and Pietruszko, R.: Betaine aldehyde, betaine and choline levels in rat livers during ethanol metabolism. *Biochem. Pharmacol.*, **60**:1629-1637. (2000).
154. Oh, M.-H., Huber, S.C., Asara, J.M., Gage, D.A. and Clouse, S.D.: Recombinant brassinosteroid-insensitive 1 receptor-like kinase autophosphorylates on Ser and Thr residues and phosphorylates a conserved peptide motif *in vitro*. *Plant Physiol.*, **124**: 751-766 (2000).
153. Rathinasabapathi, B., Sigua, C., Ho, J. and Gage, D.A.: Osmoprotectant β -Alanine betaine biosynthesis in the Plumbaginaceae: S-adenosyl-L-methionine dependent N-methylation of β -alanine to β -alanine betaine via N-methyl and N,N-dimethyl β -alanines. *Physiol. Plantarum*, **109**: 225-231 (2000).
152. Ranocha, P., Bourgis, F., Ziemak, M.J., Rhodes, D., Gage, D.A. and Hanson, A.D.H.: Characterization and functional expression of cDNA's encoding methionine-sensitive and -insensitive homocysteine S-methyltransferases from *Arabidopsis*. *J. Biol. Chem.* **275**: 15962-15968 (2000).
151. Suchnya, T.M., Johnson, J.H., Hamer, K., Leykam, J.F., Gage, D.A., Clemo, H.F., Baumgarten, C.M. and Sachs, F.: Identification of a peptide toxin from *Grammostola spatulata* spider venom that blocks cation-selective stretch-activated channels. *J. Gen. Physiol.* **115**: 583-598 (2000). *Erratum J. Gen. Physiol.* **117**: 371 (2001)
150. Hanson, A.D., Gage, D.A., and Shachar-Hill, Y. Plant one-carbon metabolism and its engineering. *Trends Plant Sci.*, **5**: 206-213 (2000).

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149. Ostrom, P.H, Strahler, J.R., Schall, M., Gandhi, H., Shen, T.-L., Hauschka, P.V. and Gage, D.A. : New strategies for characterizing ancient proteins using matrix-assisted laser desorption ionization mass spectrometry. *Geochim. Cosmochim. Acta.*, **64**: 1043-1050 (2000).
148. Boneca, I.G., Huang, Z.-H., Gage, D.A. and Tomasz, A.: The fine structure of *Staphylococcus aureus* cell wall glycan strands: evidence for a new endo- β -N-acetylglucosaminidase activity. *J. Biol. Chem.* **275**: 9910-9918 (2000).
147. Harayama, H., Liao, P.-C., Gage, D.A., Miyake, M., Kato, S. and Hammerstedt, R.: Biochemical characterization of the sialoprotein "Anti-Agglutinin" purified from boar epididymal and seminal plasma by mass spectrometry. *Molec. Reprod. Devel.*, **55**: 96-103 (2000).
146. Shen, T.-L., Huang, Z.H., Laivenieks, M. Zeikus, J.G., Gage, D.A. and Allison, J.: Evaluation of charge derivatization of a proteolytic protein digest for improved MS analysis: De novo sequencing by matrix-assisted laser desorption/ionization postsorce decay mass spectrometry. *J. Mass Spectrom.* **34**: 1154-1165 (1999).
145. Pap, M., Morava, E., Kopcsáyi, Bieber, L.L., Gage, D.A. and Melegh, B.: Cefetamet pivooxil treatment causes carnitine depletion that can be prevented by carnitine administration *J. Nutr. Biochem.***10**: 670-673 (1999).
144. Ma, W., Kamden, D.P., Dawson-Andoh, B.E., Loconto, P., Pan, Y. and Gage, D.A.: Characterization and bioremediation of condensate produced during conditioning of birch (*Betula papyrifera* Marsh) veneer logs. *Wood & Fibre Sci.* **31**: 371-375 (1999).
143. Melegh B., Toth G., Adamovich K., Szekely G., Gage D.A. and Bieber L.L.: Labeled trimethyllysine load depletes unlabeled carnitine in premature infants without evidence of incorporation. *Biol. Neonate* **76**:19-25 (1999).
142. Bourgis, F., Roje, S., Nuccio, M.L., Fisher, D.B., Tarczynski, M.C., Herschbach, C., Rennenberg, H., Pimenta, M.J., Shen, T.-L., Gage, D.A. and Hanson, A.D.: S-Methylmethionine has a major role in phloem sulfur transport and is synthesized by a novel type of methyltransferase. *Plant Cell* **11**: 1485-1497 (1999).
141. Huang Z.H., Shen, T.-L., Wu, J., Gage, D.A. and Watson J.T.: Protein sequencing by matrix-assisted laser desorption ionization-postsorce decay-mass spectrometry analysis of the N-*tris*-(2,4,6-trimethoxyphenyl)phosphonium-acetylated tryptic digests. *Anal. Biochem.* **268**: 305-317 (1999).
140. Barratt, N.M., Dong, W., Gage, D.A., Magnus, V. and Town, C.D.: Metabolism of exogenous auxin by *Arabidopsis thaliana*: Identification of the conjugate indole-3-acetyl-glutamine. *Physiol. Plantarum*, **105**: 207-218 (1999).
139. Xu, Y.-L., Li, L., Gage, D.A. and Zeevaart, J.A.D. Feedback regulation of GA5 expression and metabolic engineering of gibberellin levels in *Arabidopsis*. *Plant Cell* **11**: 927-936 (1999).
138. Savithiry, N., Gage, D.A., Fu, W., and Oriel, P.: Degradation of Pinene by *Bacillus pallidus* BR425. *Biodegradation* **9**: 337-341 (1998).
137. Nuccio, M.L., Russel, B.L., Nolte, K.D., Rathinasabapathi, B., Gage, D.A. and Hanson, A.D. The endogenous choline supply limits glycine betaine synthesis in transgenic tobacco expressing choline monooxygenase. *Plant J.*, **16**: 487-496 (1998).
136. Voitenleitner, C., Rehfuss, C., Hilmes, M., O'Rear, L., Liao, P.-C., Gage, D.A., Ott, R., Nasheuer, H.-P., and Fanning, E.: Cell cycle-dependent regulation of human DNA polymerase α -primase activity by phosphorylation. *Molec. Cell Biol.*, **19**: 646-656 (1998).

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135. Ransom, W.D., Liao, P.-C., Gage, D.A. and Boss, W.F.: Phosphoglycerylethanolamine posttranslational modification of plant eEF-1A. *Plant Physiol.*, **117**: 949-960 (1998).
134. Kocsis, M.G., Nolte, K.D., Rhodes, D., Shen, T.-L., Gage, D.A., and Hanson, A.D.: Dimethylsulfoniopropionate biosynthesis in *Spartina alterniflora*. Evidence that S-methylmethionine and dimethylsulfoniopropylamine are intermediates. *Plant Physiol.*, **117**: 273-281 (1998).
133. Yurewicz, E.C., Sacco, A.G., Gupta, S.K., Xu, N., and Gage, D.A.: Heterooligomerization-dependent binding of pig oocyte zona pellucida glycoproteins ZPB-ZPC to boar sperm membrane vesicles. *J. Biol. Chem.* **273**: 7488-7494 (1998).
132. Trossat, C., Rathinasabapathi, B., Weretilnyk, E.A., Shen, T.-L., Huang, Z.-H., Gage, D.A., and Hanson, A.D.: Salinity promotes accumulation of dimethylsulfoniopropionate and its precursor S-methylmethionine in chloroplasts. *Plant Physiology*, **116**: 165-171 (1998).
131. Owen, D.J., Mander, L.N., Storey, J.M.D., Huntley, R.P., Gaskin, P., Lenton, J.R., Gage, D.A., and Zeevaart, J.A.D.: Synthesis and confirmation of structure for a new gibberellin, 2 β -hydroxy-GA₁₂ (GA₁₁₀), from spinach and oil palm. *Phytochemistry*, **47**: 331-337 (1998).
130. Jones, M.Z., Alroy, J., Boyer, P.J., Cavanagh, K.T., Johnson, K., Gage, D.A., Vorro, J., Render, J.A., Common, R.S., Leedle, R.A., Lowrie, C., Sharp, P., Liour, S.-S., Levene, B., Hoard, H., Lucas, R., and Hopwood, J.J.: Caprine mucopolysaccharidosis-IIIID: clinical, biochemical, morphological and immunohistochemical characteristics. *J. Neuropathol. Exp. Neurol.*, **57**: 148-157 (1998).
129. Rhodes, D., Gage, D.A., Cooper, A.J.L., and Hanson, A.D.: S-Methylmethionine conversion to dimethylsulfoniopropionate: evidence for an unusual transamination reaction. *Plant Physiol.*, **115**: 1541-1548 (1997).
128. Gage, D.A., Rhodes, D., Nolte, K.D., Hicks, W.A., Leustek, T., Cooper, A.J.L., and Hanson, A.D.: A new route for synthesis of dimethylsulphoniopropionate in marine algae. *Nature*, **387**: 891-894 (1997).
127. Xu, Y.-L., Gage, D.A., and Zeevaart, J.A.D.: Gibberellins and stem growth in *Arabidopsis thaliana*: Effects of photoperiod on expression of the GA4 and GA5 Loci. *Plant Physiology*, **114**: 1471-1476 (1997).
126. Chang, F., Li, R., Noon, K., Gage, D.A., and Ladisch, S.: Human medulloblastoma gangliosides. *Glycobiology*, **7**: 523-530 (1997).
125. Boneca, I.G., Xu, N., Gage, D.A., de Jonge, B.L.M., and Tomasz, A.: Structural characterization of an abnormally cross-linked mucopeptide dimer that is accumulated in the peptidoglycan of methicillin- and cefotaxime-resistant mutants of *Staphylococcus aureus*. *J. Biol. Chem.*, **272**: 29053-29059 (1997).
124. Xu, N., Huang, Z.-H., de Jonge, B.L.M., and Gage, D.A.: Structural characterization of peptidoglycan mucopeptides by matrix-assisted laser desorption ionization mass spectrometry and postsource decay. *Anal. Biochem.* **248**: 7-14 (1997).
123. Schwartz, S.H., Tan, B.-C., Gage, D.A., Zeevaart, J.A.D., and McCarty, D.R.: Specific oxidative cleavage of carotenoids by VP14 of maize. *Science*, **276**: 1872-1874 (1997).
122. Nuss, J.S., Guyer, D.E., and Gage, D.A.: Concentration of onion juice volatiles by reverse osmosis and its effects on supercritical CO₂ extraction. *J. Food Process Eng.*, **20**: 125-139 (1997).
121. Dron, A., Guyer, D.E., Gage, D.A., and Lira, C.T.: Yield and quality of onion flavor oil obtained by supercritical fluid extraction and other methods. *J. Food Process Eng.*, **20**: 107-124 (1997).

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120. Barkman, T.J., Beaman, J.H., and Gage, D.A.: Floral fragrance variation in *Cypripedium*: implications for evolutionary and ecological studies. *Phytochemistry*, **44**: 875-882 (1997).
119. Johnson, R.M., Buck, S., Schneider, H., Sampaio, I., Gage, D.A., Shen, T.-L., Schneider, M.P.C. and Goodman, M.: Identification of pre- γ -globin. *Hemoglobin*, **21**: 143-153 (1997).
118. Kang, S., Liao, P.-C., Gage, D.A., and Esselman, W.J.: Identification of *in vivo* phosphorylation sites of CD45 protein-tyrosine phosphatase in 70Z/3.12 cells. *J. Biol. Chem.*, **272**: 11588-11596 (1997).
117. Rossak, M., Schäfer, A., Xu, N., Gage, D.A., and Benning, C.: Accumulation of sulfoquinovosyl-1-O-dihydroxyacetone in a sulfolipid-deficient mutant of *Rhodobacter sphaeroides* inactivated in *sqdC*. *Archives Biochem. Biophys.*, **340**: 219-230 (1997).
116. Kent, U.M., Bend, J.R., Chamberlin, B.A., Gage, D.A., and Hollenberg, P.F.: Mechanism-based inactivation of cytochrome P450 2B1 by *n*-benzyl-1-aminobenzotriazole. *Chem. Res. Toxicol.*, **10**: 600-608 (1997).
115. Melegh, B., Pap, M., Szekely, G., Gage, D.A., Sherry, A.D., and Bieber, L.L.: No replenishment of carnitine from trimethyllysine during pivalate-induced carnitine loss in humans. *Nutr. Biochem.*, **8**: 147-151 (1997).
114. Rathinasabapathi, B., Burnet, M., Russell, B.L., Gage, D.A., Liao, P.-C., Nye, G.J., Scott, P., Golbeck, J.H., and Hanson, A.D.: Choline monooxygenase, an unusual iron-sulfur enzyme catalyzing the first step of glycine betaine synthesis in plants: prosthetic group characterization and cDNA cloning. *Proc. Nat. Acad. Sci.*, **94**: 3454-3458 (1997).
113. Huang, Z.-H., Wu, J., Roth, K.D.W., Yang, Y., Gage, D.A., and Watson, J.T.: A picomole-scale method for charge derivatization of peptides for sequence analysis by mass spectrometry. *Anal. Chem.*, **69**: 137-144 (1997).
112. Xu, N., Huang, Z.-H., Watson, J.T., and Gage, D.A.: Mercaptobenzothiazoles: a new class of matrices for laser desorption ionization mass spectrometry. *J. Am. Soc. Mass Spectrom.*, **8**: 116-124 (1997).
111. Nolte, K.D., Hanson, A.D., and Gage, D.A.: Proline accumulation and methylation to proline betaine in *Citrus*: implications for genetic engineering of stress resistance. *J. Am. Soc. Hort. Sci.*, **122**: 8-13 (1997).
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