

Curriculum Vitae

MARK R. ETZEL, Professor Emeritus

Employment history

University of Wisconsin, Madison, Wisconsin, 4/89 to present

Assistant Professor, 1989 to 1995

Associate Professor, 1995 to 2002

Full Professor, 2002 to 2020

Emeritus Professor, 2020 to present

Affiliate Faculty Member: Department of Chemical and Biological Engineering, Department of Biological Systems Engineering,

Polaroid Corporation, Cambridge, Massachusetts, 9/83 to 3/89

Senior Engineer, 1983 to 1986

Senior Scientist, 1986 to 1989

University of California, Berkeley, California, 9/77 to 6/83

Research Assistant. Thesis: Loss of Volatile Trace Organics During Spray Drying. Advisor: C. Judson King.

Academic training

University of California at Berkeley, Ph.D., 1983, Chemical Engineering

Purdue University, B.S. (honors), 1977, Chemical Engineering

Grants and funding

Center for Dairy Research, 10/89-9/92, \$91,997, "Effect of Processing on Cell Viability, Cell Permeability and Enzyme Activity of *L. helveticus* Cheese Starter Culture Adjunct."

USDA Hatch, 10/89-9/93, \$85,908, "Novel Affinity Methods for Recovery of Enzymes from Agricultural Liquids."

Procter and Gamble Company, 4/90- indef., \$9,914, "The Selective-Diffusion Mechanism in Detergent Drying."

Graduate School, 7/90-6/91, \$15,000, "Effects of Protein-Folding Kinetics in Affinity Bioseparations."

CIBA-GEIGY Corp., 10/90-indef., \$1,650, "Spray Drying of Microorganisms."

Center for Dairy Research, 1/91-6/93, \$53,120, "Mechanisms of Injury to *Streptococcus lactis* During Spray Drying."

FMC Corporation, BioSupport Materials, 4/91-indef., \$6,000 of equipment and labor donated, "Whey Protein Purification Using Ion-Exchange Membranes."

Center for Dairy Research, Scientist Exchange Program, 4/91-7/91, \$6,900, "Differential Inactivation of Intracellular Enzymes During Spray Drying of Starter Cultures."

Bioprocess and Metabolic Engineering Undergraduate Summer Research Fellowship, 6/91-9/91, \$2,700, "Recovery of Food Grade Proteins from Whey Using Ion Exchange Membranes."

National Science Foundation, Research Initiation Award, 7/91-6/94, \$70,000, "Effects of Association Kinetics and Axial Diffusion in Affinity Membrane Bioseparations."

Graduate School and the College of Agricultural and Life Sciences, 7/91-6/94, \$10,000, Matching funds for the National Science Foundation, Research Initiation Award.

Wisconsin Milk Marketing Board, 7/91-6/92, \$23,750, "Production of 90% Pure Whey-Protein Isolate Using Ion-Exchange Membranes."

State of Wisconsin Industrial and Economic Development Research Fund, 7/91-6/94, \$193,202, "Production of Polysaccharide Gums from Whey."

Millipore Corporation, 12/91-indef., \$18,000 of equipment donated, "Fundamentals of Adsorptive Membrane Separations."

Unilever (Van den Bergh Foods), 12/92-12/94, \$63,500, "Use of Spray Dried Cultures as Adjuncts to Improve the Flavor of Reduced Fat Cheddar Cheese."

Baxter Healthcare Corp., 12/92-indef., \$42,000, "Immunoaffinity Membranes for Extracorporeal Treatment of Hypercholesterolemia."

Wisconsin Milk Marketing Board, 11/93-11/96, \$90,800, "Fractionation of Whey Proteins Using Ion-Exchange Membranes."

Baxter Healthcare Corp., 12/93-indef., \$14,400, "Immobilization Chemistry and Kinetic Characteristics of Membrane-Based Affinity Systems."

Center for Dairy Research, 7/94-6/96, \$69,800, "Conversion of Whey Permeate to Propylene Glycol for Food and Non-Food Uses."

Center for Dairy Research, 7/94-6/96, \$70,400, "Process Modification of Starter Cultures for Flavor Enhancement in Low-Fat Cheese."

Baxter Healthcare Corp., 12/94-indef., \$18,000, "Immobilization Chemistry and Kinetic Characteristics of Membrane-Based Affinity Systems."

National Science Foundation, 11/96-10/00, \$219,910, "Competitive Protein Sorption and Affinity Membrane Bioseparations: Experimental Characterization and Mathematical Analysis."

Wisconsin/Hilldale Undergraduate/Faculty Research Award, 3/97-6/98, \$4,000, "Kinetics of Lipid Oxidation in Cheese Powders."

Dairy Management, 7/97-7/99, \$64,700, "Fractionation of Kappa-Casein Macropeptide from Whey for Nutraceutical Uses: Scale Up of the Ion Exchange Membrane Technology."

Kendrick Laboratories, 11/97-indef., \$1,440, "Analytical Methods for Whey Proteins."

Next Nutrition, 8/98-indef., \$6,700, "Glycomacropeptide in Sports Nutrition Beverages."

Amersham Pharmacia Biotech, 9/98-indef., \$5,000, "Chromatographic Purification of Dairy Proteins."

Dairy Management, 1/99-12/01, \$58,100, "Whey Refinery for Producing Proteins for Beverages and Nutraceuticals."

Dairy Management, 12/00-12/02, \$290,251, "Technical and Economic Development of a Milk Refinery."

Dairy Management, 1/01-12/01, \$20,000, "Whey Protein Fractionation -- Pilot Studies."

Graduate School, 1/01-12/01, \$500, Travel Grant.

State of Wisconsin Industrial and Economic Development Research Fund, 7/01-6/02, \$50,000, "Development of a Novel Process for Large Scale Production of High Purity Plasmid DNA."

Graduate School, 7/02-6/03, \$16,350, Chromatographic Fractionation of Medical Proteins from Cheese Whey.

State of Wisconsin Industrial and Economic Development Research Fund, 7/02-6/03, \$3,700, "Production of anti-PLA₂ IgY for Use in Poultry Feed."

Dairy Management, 1/03 to 12/04, \$74,718, "Nutraceutical Protein Recovery from Acid Whey."

Dairy Management, 1/04 to 12/05, \$82,334, "Improving WPI Functionality for Beverage Applications."

Graduate School, 7/02 to 6/03, \$16,350, Research Committee Award.

WARF Draper Award, 9/03 to 9/04, \$30,333, "Assessment of Glycomacropeptide (GMP) for Appetite Suppression During Phenylketonuria (PKU) Therapy."

National Dairy Council, 10/04 to 12/05, \$70,622, "Short-Term Response of Appetite and Food Intake to the Consumption of Dairy Proteins in Young Men – A Pilot Study," (with D. Ney).

Graduate School, 7/05 to 6/06, \$17,772, "Virus-Ligand Interactions in Adsorptive Membrane Bioseparations,"

Dairy Management, 9/05 to 12/06, \$48,656, "Development of Charged Ultrafiltration Membrane Technology for Whey Protein Fractionation."

NIH, 5/05 to 4/07, \$288,209, "Dietary Control of PKU with Glycomacropeptide from Whey," (with D. Ney).

Parental Drug Association, 7/05 to 6/06, \$10,000, "Parental Drug Association Fellowship."

3M, 8/05 to 7/06, \$100,000, "Investigation of Viral Trapping Membranes."

3M, 12/05 to 12/08, \$214,700, "Viral Trapping Membranes."

Michaux Foundation, 8/07 to 12/99, \$58,000, "Nutritional Management of Phenylketonuria Using Dietary Glycomacropeptide from Whey."

Pepsico, 12/07 to 6/08, \$14,700, "Development of a Low pH Protein Fortified Beverage."

Dairy Management, 8/08 to 7/10, \$88,036, "Creation of Whey Protein Enhanced Beverages that are Clear and Heat Stable at Acidic pH."

WARF, 12/08 to indef., \$61,821, "Patent Royalties."

Pepsico, 1/09 to 6/09, \$71,830, "Value Added Protein-Beverages."

Dairy Management, 8/09 to 12/12, \$89,347, "Charged Ultrafiltration Membranes for Fractionation of Milk Proteins."

Dairy Management, 8/09 to 12/12, \$88,347, "Electrostatic Repulsion Enhancement for Heat Stable, Clear Whey Protein Beverages."

Genentech, 12/09 to indef., \$20,000, "Viral Clearance."

USDA, 9/11 to 8/14, \$120,464, "Food Processing & Preservation," (with BH Ingham).

USDA Hatch, 7/12 to 6/14, \$84,502, "Glycomacropeptide-Polysaccharide Conjugates for Improving Phenylketonuria Foods for Overweight and Obese Children."

Cambrooke Foods, 2/16 to indef., \$10,000, "PKU Foods."

National Dairy Council, 2/15 to 12/16, \$70,000, "Next Generation Value-Added Milk Protein Ingredients to Meet Growing International Demand for Clinical Foods."

Dairy Management, 1/17 to 12/19, \$65,000, "Controlled Pilot-Plant-Scale Evaluations of Charged Spiral-Wound Ultrafiltration Membranes."

WARF Accelerator, 2/17 to 6/19, \$51,271, "Charged Ultrafiltration Membranes for Changing the Way Food Proteins Are Manufactured."

USDA Hatch, 10/17 to 9/19, \$62,717, "Improved Glycomacropeptide Foods for Phenylketonuria."

NIH, 7/19 to 6/25, \$235,107, "Targeted Proteomics of MUC16 to Enable Early Detection of Ovarian Cancer Recurrence," (with Patankar MS, Whelan RJ).

Publications

- (1) "Retention of Volatile Components During Freeze Drying of Substances Containing Emulsified Oils," (with C.J. King) *J. Food Technol.*, **15**, 577-588 (1980).
- (2) "Loss of Volatile Trace Organics During Spray Drying," (with C.J. King) *Ind. Eng. Chem. Process Des. Dev.*, **23**(4), 705-710 (1984).
- (3) "A Mathematical Analysis of Affinity Membrane Bioseparations," (with S.-Y. Suen) *Chem. Eng. Sci.*, **47**(6), 1355-1364 (1992).
- (4) "Thermodynamic Mechanisms for the Retention of Aroma Compounds During Drying of Foods," *Am. Inst. Chem. Eng. Symp. Ser.*, **89**(297), 32-38 (1993).
- (5) "Inactivation of Lactic Acid Bacteria during Spray Drying," (with J.A.C. Johnson), *Am. Inst. Chem. Eng. Symp. Ser.*, **89**(297), 98-107 (1993).
- (6) "Sorption Kinetics and Axial Diffusion in Binary Solute Affinity Membrane Bioseparations," (with M. Caracotsios and S.-Y. Suen) *Chem. Eng. Sci.*, **48**(10), 1801-1812 (1993).
- (7) "Injury to *Lactococcus lactis* subsp. *lactis* C2 During Spray Drying," (with W.-Y. Fu and S.-Y. Suen), Proc. 9th Int. Drying Symp., V. Rudolph and R.B. Keey (eds.), August 1-4, 1994, Gold Coast, Australia, pp. 785-792.
- (8) "Competitive Adsorption of α -Lactalbumin and Bovine Serum Albumin to a Sulfopropyl Ion-Exchange Membrane," (with W.F. Weinbrenner) *J. Chromat. A* **662**, 414-419 (1994).
- (9) "Alcohol Precipitation of Xanthan Gum from Pure Solutions and Fermentation Broths," (with J.J. Flahive III and A. Foufopoulos) *Sep. Sci. Technol.*, **29**(13), 1673-1687 (1994).
- (10) "Spray Drying of *Lactococcus lactis* ssp. *lactis* C2 and Cellular Injury," (with W.-Y. Fu) *J. Food Sci.* **60**(1), 195-200 (1995).
- (11) "Evaluation of Sulfopropyl Ion-Exchange Membrane Cartridges for Isolation of Proteins from Bovine Whey," (with M.F. Zietlow) *J. Liq. Chromat.* **18**(5), 1001-1018 (1995).
- (12) "Properties of *Lactobacillus helveticus* CNRZ-32 Attenuated by Spray Drying, Freeze Drying, or Freezing," (with J.A.C. Johnson) *J. Dairy Sci.* **78**(4), 761-768 (1995).
- (13) "Accelerated Ripening of Reduced-Fat Cheddar Cheese Using Four Attenuated *Lactobacillus helveticus* CNRZ-32 Adjuncts," (with J.A.C. Johnson, C.M. Chen and M.E. Johnson) *J. Dairy Sci.* **78**(4), 769-776 (1995).
- (14) "Three Methods for Large-Scale Preservation of a Microbial Inoculum for Bioremediation," (with M.S. Romich and D.C. Cameron), in *Bioaugmentation for Site Remediation*, R.E. Hinchee, J. Fredrickson and B.C. Alleman (eds.), Battelle Press, Columbus, **3**(3), 229-235 (1995).
- (15) "Inactivation of *Lactococcus lactis* ssp. *lactis* C2 and Alkaline Phosphatase During Spray Drying," (with W.-Y. Fu and S.-Y. Suen) *Drying Technol.* **13**(5-7), 1463-1476 (1995).
- (16) "Whey Protein Isolation and Fractionation Using Ion Exchangers," in *Bioseparation Processes in Foods*, R.K. Singh and S.S.H. Rizvi (eds.), Marcel Dekker, New York, Ch. 12 (1995).
- (17) "Enzyme Inactivation in a Droplet Forming a Bubble During Spray Drying," (with S.-Y. Suen, S.L. Halverson and S. Budijono) *J. Food Eng.* **27**(1), 17-34 (1996).
- (18) "Phase Separation of Lactan Gum from Fermentation Broths by Addition of Water Miscible Organic Solvents," (with A. Foufopoulos) *Sep. Sci. Technol.* **31**(6), 757-768 (1996).
- (19) "Purification of Bovine Immunoglobulin G via Protein G Affinity Membranes," (with J.E. Kochan and Y.-J. Wu) *Ind. Eng. Chem. Res.* **35**(4), 1150-1155 (1996).
- (20) "Strong Cation and Anion Exchange Membranes and Beads for Protein Isolation from Whey," (with I.A. Adisaputro and Y.-J. Wu) *J. Liq. Chrom. & Rel. Technol.*, **19**(9), 1437-1450 (1996).
- (21) "Spray Drying, Freeze Drying, or Freezing of Three Different Lactic Acid Bacteria Species," (with B.C.S. To) *J. Food Sci.* **62**(3), 576-578 & 585 (1997).
- (22) "Survival of *Brevibacterium linens* (ATCC 9174) After Spray Drying, Freeze Drying, or Freezing," (with B.C.S. To) *J. Food Sci.* **62**(1), 167-170 & 189 (1997).
- (23) "Mass Transfer Limitations in Protein Separations Using Ion Exchange Membranes," (with F.T. Sarfert) *J. Chromat.* **764**, 3-20 (1997).
- (24) "Fractionation of Lactoperoxidase and Lactoferrin from Bovine Whey Using a Cation Exchange Membrane," (with C. K. Chiu) *J. Food Sci.* **62**(5), 996-1000 (1997).
- (25) "Chemical Engineering for the Food Industry," *Trends in Food Sci. & Technol.* **8**, 387 (1997).
- (26) "In Vitro Characterization of a Membrane-Based Low-Density Lipoprotein Affinity Adsorption Device," (with P.J. Soltys) *Blood Purification* **16**(3), 123-134 (1998).
- (27) "Protein Separation by Ion Exchange in Columns," (with S. Dermawan, M.N. Budiman, V.V. Hendriadi and I. Rosalina) *Int. Dairy Fed. Special Issue* 9804: 66-72 (1998).
- (28) "Equilibrium Adsorption of LDL and Gold Immunoconjugates to Affinity Membranes Containing PEG Spacers," (with P.J. Soltys) *Biomaterials* **21**(1), 37-48 (1999).

- (29) "Analysis of Protein Purification Using Ion-Exchange Membranes," (with H. Yang and M. Bitzer) *Ind. Eng. Chem. Res.* 38(10): 4044-4050 (1999).
- (30) "Affinity Membranes: Competitive Binding of the Human IgG Subclasses to Immobilized Protein G," (with C. Viera and H. Yang) *Ind. Eng. Chem. Res.* 39(19): 3356-3363 (2000).
- (31) "Conversion of Sugars to 1,2-Propanediol by *Thermoanaerobacterium thermosaccharolyticum* HG-8," (with N.E. Altaras and D.C. Cameron) *Biotechnol. Prog.* 17(1): 52-56 (2001).
- (32) "Commercial-Scale Chromatographic Fractionation of Whey Proteins," Proc. 3rd Intl. Whey Conf., Munich, Germany, (2001).
- (33) "Purification of a Large Protein Using Ion Exchange Membranes," (with C. Viera, J. Fischer, and H. Yang) *Ind. Eng. Chem. Res.* 41(6): 1597-1602 (2002).
- (34) "Layered Stacks," in *Monolithic Materials: Preparation, Properties and Applications*, F. Svec, T.B. Tennikova and Z. Deyl (eds.), Ch 10, Elsevier Science, Amsterdam (2003).
- (35) "Evaluation of Three Kinetic Equations in Models of Protein Purification Using Ion-Exchange Membranes," (with H. Yang) *Ind. Eng. Chem. Res.* 42(4): 890-896 (2003).
- (36) "Fractionation of Caseins by Anion-Exchange Chromatography Using Food-Grade Buffers," (with K.N. Turhan and D.M. Barbano) *J. Food Sci.* 68(5): 1578-1583 (2003).
- (37) "Whey Protein Isolate and Glycomacropeptide Recovery from Whey Using Ion Exchange Chromatography," (with S. Daultani and K.N. Turhan) *J. Food Sci.* 68(4): 1389-1395 (2003).
- (38) "Evaluation of an Ion Exchange Membrane for Purification of Plasmid DNA," (with H.N. Endres, J.A.C. Johnson, C.A. Ross, and J.K. Welp) *Biotechnol. Appl. Biochem.* 37: 259-266 (2003).
- (39) "Manufacture and Use of Dairy Protein Fractions," *J. Nutr.* 134(4): 996S-1002S (2004).
- (40) "Fractionation of Proteins from Cheese Whey Using Cation Exchange Chromatography," (with S. Daultani and K.N. Turhan) *Process Biochem.* 39(11): 1737-1743 (2004).
- (41) "Whey Protein Isolate and Alpha-Lactalbumin Recovery from Lactic Acid Whey Using Cation-Exchange Chromatography," (with K.N. Turhan) *J. Food Sci.* 69(2): E66-E70 (2004).
- (42) "Evaluation of a Model for Seeded Isothermal Batch Protein Crystallization," (with M.N. Carbone, R.A. Judge) *Biotechnol. Bioeng.* 91: 84-90 (2005).
- (43) "Effect of Conductivity, pH, and Elution Buffer Salinity on Glycomacropeptide Recovery from Whey Using Anion Exchange Chromatography," (with H.N. Tek, K.N. Turhan) *J. Food Sci.* 70: E295-E300, (2005).
- (44) "Large Pore Size Virus Filter Test Method Recommended by the PDA Virus Filter Task Force," (with Brorson K, Sofer G, Robertson G, Lute S, Martin J, Aranha H, Haque M, Satoh S, Yoshinari K, Moroe I, Morgan M, Yamaguchi F, Carter J, Krishnan M, Stefanyk J, Riordan W, Korneyeva M, Sundaram S, Wilkommen H, Wojciechowski P.) *PDA J. Pharma. Sci. Technol.* 59: 177-186 (2005).
- (45) "Efficacy of Glycomacropeptide in the Nutritional Management of Phenylketonuria." (with Ney DM, Draxler AK, van Calcar SC, Gleason ST, Nelson KL, Lim K) Proceedings of the 4th International Whey Conference, Chicago, IL, September 11-14 (2005).
- (46) "Seeded Isothermal Batch Crystallization of Lysozyme," (with M.N. Carbone) *Biotechnol. Bioeng.* 93: 1221-1224 (2006).
- (47) "Kinetics of Browning During Accelerated Storage of Sweet Whey Powder and Prediction of Its Shelf Life." (with Dattatreya A, Rankin SA.) *Intl. Dairy J.* 17: 177-182 (2007).
- (48) "Solvent Type Affects the Number, Distribution, and Relative Quantities of Volatile Compounds Found in Sweet Whey Powder," (with Prososki RA, Rankin SA) *J. Dairy Sci.* 90: 523-531 (2007).
- (49) "Alternatives to Chromatographic Separations," (with Thömmes J) *Biotechnol. Prog.* 23:42-45 (2007).
- (50) "Membrane Chromatography: Analysis of Breakthrough Curves and Viral Clearance." (with Riordan WT), in "Process Scale Bioseparations for the Biopharmaceutical Industry," Ch. 9, Shukla A, Gadam S, and Etzel MR Editors, CRC Press, Taylor & Francis Group, Boca Raton, FL (2007).
- (51) "Bulk Protein Crystallization – Principles and Methods." in "Process Scale Bioseparations for the Biopharmaceutical Industry," Ch. 5, Shukla A, Gadam S, and Etzel MR Editors, CRC Press, Taylor & Francis Group, Boca Raton, FL, 2007.
- (52) "Process Scale Bioseparations for the Biopharmaceutical Industry," (with Shukla A, Gadam S), CRC Press, Taylor & Francis Group, Boca Raton, FL (2007).
- (53) "Charged Ultrafiltration Membranes for Protein Separation," (with Bhushan S), Am. Soc. Agric. Biol. Engrs., Paper Number 077063 (2007).
- (54) "Small Virus Retentive Filter Test Method Recommended by the PDA Virus Filter Task Force. I. Method Development." (with Lute S, Riordan W, Pease L, Tsai DH, Levy R, Sofer G, Haque M, Moroe I, Sato T, Morgan M, Krishnan M, Campbell J, Genest P, Dolan S, Meyer A, Zachariah M, Tarlov M, Brorson K), *PDA J. Pharm. Sci. Technol.* 62(5): 318-333 (2008).
- (55) "Dietary Glycomacropeptide Supports Growth and Reduces the Concentrations of Phenylalanine in Plasma and Brain in a Murine Model of Phenylketonuria," (with Ney DM, Hull AK, van Calcar SC, Liu X), *J. Nutr.* 138(2): 316-322 (2008).
- (56) "Nutritional Management of PKU with Glycomacropeptide from Cheese Whey," (with Ney DM, Gleason ST, van Calcar SC, MacLeod EL, Nelson KL, Rice GM, Wolff JA, J. Inherit. Metab. Dis., 32(1): 32-39 (2009).

- (57) "Improved Nutritional Management of Phenylketonuria Using a Diet Containing Glycomacropeptide Compared with Amino Acids," (with van Calcar SC, MacLeod EL, Gleason ST, Clayton MK, Wolff JA, Ney DM, *Am. J. Clin. Nutr.*, 89(4): 1068-1077 (2009).
- (58) "Viral Clearance Using Monoliths," (with Riordan WT), *J. Chromat. A*, 1216(13): 2621-2624 (2009).
- (59) "Charged Ultrafiltration Membranes Increase the Selectivity of Whey Protein Separations," (with Bhushan S), *J. Food Sci.*, 74(3): E131-E139 (2009).
- (60) "Design of Salt Tolerant Membrane Adsorbers for Viral Clearance," (with Riordan WT, Heilmann SM, Brorson K, Seshadri K, He Y), *Biotechnol. Bioeng.*, 103(5): 920-929 (2009).
- (61) "Salt Tolerant Membrane Adsorbers for Robust Impurity Clearance," (with Riordan WT, Heilmann SM, Brorson K, Seshadri K), *Biotechnol. Prog.*, 25(6): 1695-1702 (2009).
- (62) "Purification and Use of Glycomacropeptide for Nutritional Management of Phenylketonuria," (with LaClair CE), *J. Food Sci.*, 74(4): E199-E206 (2009).
- (63) "Turbidity and Protein Aggregation in Whey Protein Beverages," (with LaClair CE), *J. Food Sci.*, 74(7): C526-C535 (2009).
- (64) "Ingredients and pH are Key to Clear Beverages that Contain Whey Protein," (with LaClair CE), *J. Food Sci.*, 75(1): C21-C27 (2010).
- (65) "Examination of the Adsorption of Large Biological Molecules to Anion Exchange Surfaces using Surface Plasmon Resonance," (with Riordan WT, Brorson K, Lute S), *Sep. Sci. Technol.* 45:1-10 (2010).
- (66) "Monoliths for the Purification of Whey Protein-Dextran Conjugates," (with Bund, T), *J. Chromat. A*, 1218(17): 2445-2450 (2011).
- (67) "Glycomacropeptide (GMP): A New Option for PKU Diet Management," (with van Calcar SC, Macleod EL, Gleason ST, Rice GM, Ney DM), *Molec. Genetics Metabol.*, 102(3): 262 (2011).
- (68) "Method for Chromatographic Analysis of Whey Protein – Dextran Glycation Products," (with Allelein S, Arunkumar A), *J. Chromat. A* 1270: 330-333 (2012).
- (69) "Chromatographic Purification and Characterization of Whey Protein-Dextran Glycation Products," (with Bund T, Allelein S, Arunkumar A, Lucey JA), *J. Chromat. A*, 1244: 98-105 (2012).
- (70) "Fractionation of α -Lactalbumin from β -Lactoglobulin Using Positively-Charged Tangential-Flow Ultrafiltration Membranes," (with Arunkumar A), *Sep. Purif. Technol.* 105: 121-128 (2013).
- (71) "*In vitro* Infant Digestion of Whey Protein–Dextran Glycates," (with Böttger FB, Lucey JA), *J. Food Digestion* 4: 76-84 (2013).
- (72) "Fractionation of α -Lactalbumin and β -Lactoglobulin from Bovine Milk Serum Using Staged, Positively Charged, Tangential Flow Ultrafiltration Membranes," (with Arunkumar A), *J. Membr. Sci.*, 454, 488-495 (2014).
- (73) "Negatively Charged Tangential Flow Ultrafiltration Membranes for Whey Protein Concentration," (with Arunkumar A), *J. Membr. Sci.*, 475, 340-348 (2015).
- (74) "Dairy Protein Fractionation and Concentration Using Charged Ultrafiltration Membranes," (with Arunkumar A), in *Membrane Processes for Dairy Ingredient Separation*, Hu K, Editor, Wiley-Blackwell, Hoboken, NJ (2015).
- (75) "Home Processing of Acid Foods in Atmospheric Steam and Boiling Water Canners," (with Willmore P, Andress E, Ingham BH), *Food Protection Trends*, 35, 150-160 (2015).
- (76) "Heat Penetration and Thermocouple Location in Home Canning," (with Willmore P, Ingham BH), *Food Sci Nutr*, 3, 25–31 (2015).
- (77) "Comparison of Flat-Sheet and Spiral-Wound Negatively-Charged Wide-Pore Ultrafiltration Membranes for Whey Protein Concentration," (with Arunkumar A, Molitor MS), *Intl. Dairy J.*, 56, 129-133 (2016).
- (78) "Novel Membrane Technologies for Protein Concentration and Fractionation," (with Arunkumar A), in *Innovative Food Processing Technologies*, Juliano P, Smithers G, Sykes R, Editors, Woodhead Publishing, Cambridge, UK (2016).
- (79) "Designing Medical Foods for Inherited Metabolic Disorders: Why Intact Protein Is Superior to Amino Acids," (with Ney DM), *Current Opinion in Biotechnology*, 44, 39-45 (2017).
- (80) "Adsorption of Beta-Lactoglobulin in Anion Exchange Membrane Chromatography Versus the Contacting Mode of the Adsorber," (with Voswinkel L, Kulozik U), *LWT – Food Science and Technology*, 79, 78-83 (2017).
- (81) "Charged Ultrafiltration and Microfiltration Membranes in Antibody Purification," (with Arunkumar A), in *Process Scale Purification of Antibodies*, Gottschalk U, Editor, Wiley, Hoboken, NJ (2017).
- (82) "Inactivation Kinetics of Pathogens during Thermal Processing in Acidified Broth and Tomato Purée (pH 4.5)," (with DuFort EL, Sogin J, Ingham BH), *J. Food. Prot.* 80: 2014-2021 (2017).
- (83) "Thermal Processing Parameters to Ensure a 5-Log Reduction of *Escherichia coli* 0157:H7, *Salmonella enterica*, and *Listeria monocytogenes* in Acidified Tomato-based Foods," (with DuFort EL, Ingham BH), *Food. Prot. Trends* 37: 409-418 (2017).
- (84) "Fractionation of Glycomacropeptide from Whey Using Positively Charged Ultrafiltration Membranes," (with Arunkumar A), *Foods*, 7, 166-175 (2018).
- (85) "Milk Protein Concentration Using Negatively Charged Ultrafiltration Membranes," (with Arunkumar A), *Foods*, 7, 134-143 (2018).
- (86) "Adsorbed Layer Thickness Determination for Convective-Based Media from Pressure Drop Data," (with Podgornik A), *Anal. Chem.*, 90, 4992-4998 (2018).

- (87) "Kinetics of Whey Protein Glycation Using Dextran and the Dry-Heating Method," (with Li N), *Foods*, 8, 528-539 (2019).
- (88) "Hydrolysis of Whey Protein-Dextran Glycates Made Using the Maillard Reaction," (with Li N), *Foods*, 8, 686-692 (2019).
- (89) "Affinity-Free Enrichment and Mass Spectrometry Analysis of the Ovarian Cancer Biomarker CA125 (MUC16) from Patient-Derived Ascites," (with Schuster-Little N, Sokolovsky AD, Gentry A, Anita Saraf A, Patankar N, Javeri S, Patankar MS, Whelan RJ), *Analyst*, 146, 85-94 (2021).
- (90) "Fractionated Whey Protein Ingredients – Glycomacropeptide," Editors: Paul L.H. McSweeney, John P. McNamara, *Encyclopedia of Dairy Sciences (Third Edition)*, Academic Press, 56-60 (2022).
- (91) "Membrane-Processed Liquid Milk," (with Maubois JL) Editors: Paul L.H. McSweeney, John P. McNamara, *Encyclopedia of Dairy Sciences (Third Edition)*, Academic Press, 430-433 (2022).
- (92) "Fractionated Whey Protein Ingredients – α -lactalbumin and β -Lactoglobulin," Editors: Paul L.H. McSweeney, John P. McNamara, *Encyclopedia of Dairy Sciences (Third Edition)*, Academic Press, 50-55 (2022).
- (93) "Chromatography Equipment and Resins," Editors: Paul L.H. McSweeney, John P. McNamara, *Encyclopedia of Dairy Sciences (Third Edition)*, Academic Press, 213-218 (2022).
- (94) "Immunoaffinity-Free Chromatographic Purification of Ovarian Cancer Biomarker CA125 (MUC16) from Blood Serum Enables Mass Spectrometry Characterization," (with Schuster-Little N, Fritz-Klaus R, Patankar N, Javeri S, Patankar MS, Whelan RJ), *Anal. Methods*, 16, 6337-6348 (2024).

Patents

- (1) "Image Recorder with Laser Diode Array," U. S. Pat. 4,978,974 (1990).
- (2) "Production of κ -Casein Macropeptide for Nutraceutical Uses," U.S. Pat. 5,968,586 (1999).
- (3) "Isolating Beta-Lactoglobulin and Alpha-Lactalbumin by Eluting from a Cation Exchanger Without Sodium Chloride," U.S. Pat. 5,986,063 (1999).
- (4) "Production of Substantially Pure Kappa Casein Macropeptide," U.S. Pat. 6,168,823 (2001).
- (5) "Thermal Imaging Medium," U. S. Pat. 6,245,479 (2001).
- (6) "Methods Involving Whey Protein Isolates," US Patent 7,378,123 (2008).
- (7) "Methods for Heat-Stabilizing Proteins with Specific Binding Activities," U.S. Pat. 7,750,117 (2010).
- (8) "Methods Involving Whey Protein Isolates," US Patent 8,071,152 (2011).
- (9) "Methods and Compositions Involving Whey Protein Isolates," U.S. Pat Applic. (2012).
- (10) "Glycomacropeptide Medical Foods for Nutritional Management of Phenylketonuria and Other Metabolic Disorders," U.S. Pat. 8,604,168 (2013).
- (11) "Method for Determining Thickness of Layer of Matter." International Patent Application, WO2013180666-A1, December 5, 2013.
- (12) "Methods and Compositions for Protein Concentration," U.S. Pat Applic., August 21, 2014.
- (13) "Adsorptive Membranes for Trapping Viruses," U.S. Pat. 9,375,499 (2016).
- (14) "Ligand Graft Functionalized Substrates," U.S. Patent 9,492,771 (2016).
- (15) "Diffusion Transfer Functionalized Membrane," U.S. Pat. 11,731,084 B2 (2023).

Courses taught

- (1) FS 328 Food Plant Facilities and Design, 2 cr., 10-15 students, taught 3 yr. (1989-1991)
 - required Food Science undergraduate course
 - an introduction to food process operations: construction materials, clean-in-place, transport equipment, process instrumentation, water treatment, waste disposal, and plant design.
 - course discontinued; incorporated into other courses during curriculum review
- (2) FS 533 Food Processing Laboratory, 2 cr., 10-25 students, taught 3 yr. (1990-2)
 - required Food Science undergraduate course
 - thirty different laboratory topics (120 sessions) illustrating the application of processing principles to the preservation of food
 - course discontinued; incorporated into other courses during curriculum review
- (3) FS 532 Food Processing II (laboratory only), 3 cr., 20-25 students, taught 5 yr. (1993-7)
 - required Food Science undergraduate course
 - twelve different laboratory topics (45 sessions) illustrating the application of processing principles to the preservation of food
- (4) FS/BSE 542 Food Engineering Operations, 4 cr., 15-30 students, taught 17 yr. (1994-2010)
 - required Food Science undergraduate course
 - new course
 - forty-two lectures and twelve laboratory topics (60 sessions) in food engineering operations selected from topics such as: thermodynamics, transport processes, biological kinetics and bioreactor design, thermal process calculations, separation processes, process instrumentation and control, and the use of computers

- (5) ChE 426 Mass Transfer Operations, 3 cr., 55 students, Fall, 1996
 - required Chemical Engineering undergraduate course
 - analysis of chemical engineering operations involving mass transfer: differential and stagewise separation processes; simultaneous heat and mass transfer, mass transfer accompanied by chemical reaction, general design and operation of mass-transfer equipment
- (6) FS/BSE 642 Food and Pharmaceutical Separations, 2-3 cr., 20-30 students, taught 9 yr. (1997-2019)
 - new course
 - alternate-year course
 - basic principles of production-scale separation processes in the food and pharmaceutical industries including gravity sedimentation and centrifugation, extraction, adsorption, chromatography, precipitation, conventional and membrane filtration, crystallization, and drying. Third credit adds a group term project, integrating principles with experiments, defined by students' interests
- (7) ChE 562 Special Topics, Food and Pharmaceutical Separations, 2-3 cr., taught 2 yr. (1997, 1999)
 - meets with FS/BSE 642
 - elective course for Chemical Engineering undergraduates
- (8) FS 440 Principles of Food Engineering, 3 cr., 30-50 students, taught 9 yr. (2009-2018)
 - required Food Science undergraduate course
 - application of engineering principles in the analysis of food process operations: properties of gases and vapors, psychrometrics, material and energy balances, fluid flow, heat transfer, microwave heating, mass transfer, packaging film permeability, dehydration
- (9) ChE 562 Special Topics, Food Manufacture and Preservation, 2 cr., 7 students, taught 1 yr. (2017)
 - new course
 - water activity, moisture migration in food packaging, respiration in food packaging, freezing and thawing of foods, heating and cooling of foods, thermal process calculations, food rheology, residence time distributions, food safety, and microwave heating of foods

Graduate student training

Student	Previous Education	Degree	Dates	Thesis Topic
M.S. Romich	B.S., M.S., C.E.E. Univ. Wisconsin	M.S., Ch.E.	9/88-8/93	Evaluation of Spray-Drying for Preservation of <i>Alcaligenes eutrophus</i> H850 for Use in Bioremediation
S.-Y. Suen	B.S., M.S., Ch.E. Natl. Taiwan Univ.	Ph.D., Ch.E.	9/89-4/94	Sorption Kinetics and the Performance of Multi-Solute Affinity-Membrane Bioseparations
J.A.C. Johnson	B.S., Ch.E. Univ. Wisconsin	M.S., F.S.	6/90-1/93	Spray-Drying of <i>Lactobacillus helveticus</i> Adjuncts for Accelerated Ripening of Reduced-Fat Cheddar Cheese
W.-Y. Fu	B.S., Biochemistry Purdue Univ.	M.S., F.S.	6/91-6/94	Spray Drying of <i>Lactococcus lactis</i> spp. <i>cremoris</i> C2 and Cellular Injury
J.E. Kochan	B.S., Ch.E. Cornell Univ.	M.S., F.S.	9/91-8/93	The Purification of Bovine Immunoglobulin G via Protein G Affinity Membranes
J.J. Flahive III	B.S., Ch.E. Univ. Illinois	M.S., F.S.	9/91-10/93	Alcohol Precipitation of Xanthan Gum from Pure Solutions and Fermentation Broths
A. Foufopoulos	B.S., M.E. Tech. Hochschule Karlsruhe	M.S., Ch.E.	9/92-11/94	Alcohol Precipitation of Lactan Gum from Fermentation Broths
P.S. Soltys	B.S., Biology B.S., M.S., Ch.E. Mass. Inst. Tech.	Ph.D., C.D.	9/93-7/97	Immunoaffinity Membranes for Extracorporeal Treatment of Hypercholesterolemia
B.C.-S. To	B.S., Ch.E. Univ. Wisconsin	M.S., F.S.	6/94-5/96	Process Modification of Starter Cultures for Flavor Enhancement in Low-Fat Cheese
F. Sarfert	B.S., Ch.E. Univ. Stuttgart	M.S., Ch.E.	9/94-12/95	Mass Transfer Limitations in Protein Separations Using Ion Exchange Membranes
C.K.-K. Chiu	B.S., Ch.E. Univ. Wisconsin	M.S., F.S.	9/94-11/96	Fractionation of Whey Proteins Using Ion-Exchange Membranes
C. Viera	B.S., Ch.E.	M.S., Ch.E.	9/94-8/99	Affinity Membranes: Competitive Binding of the

	Univ. Puerto Rico			Human IgG Subclasses to Immobilized Protein G
N.E. Altaras	B.S., Ch.E. McGill Univ.	Ph.D., Ch.E.	9/94-4/99	Metabolic Engineering for the Production of 1,2-Propanediol (co-supervised with D.C. Cameron)
M. Bitzer	B.S., Ch.E. Univ. Stuttgart	Diploma Univ. Stuttgart	9/96-7/97	Mass Transfer Limitations Using Ion Exchange Membranes
C. Rao	B.S., Ch.E. I.I.T. Bombay	M.S., F.S.	9/96-5/98	Mass Transfer in Protein Separations Using Ion Exchange Membranes
S. Dermawan	B.S., Ch.E. Univ. Wisconsin	M.S., F.S.	9/96-4/99	Kappa-Casein Macropeptide Isolation from Cheese Whey Using Ion Exchange Chromatography
J. Fischer	B.S., Ch.E Univ. Stuttgart	M.S., Ch.E	9/99-12/00	Separation of Nanometer-Sized Biological Particles Using Membrane Chromatography: An Analysis of Adsorption Kinetics
S. Doultani	B.S., Ch.E Univ. Bombay	M.S., F.S.	9/00-11/02	Isolation of Whey Proteins Using Ion Exchange Chromatography
H. Tek	B.S., F.E Univ. Gaziantep	M.S., F.S.	1/01-8/03	Purification of Whey Proteins and Use in Model Beverage Solutions
S. Bhushan	M.S., Agric. E IIT Kharagpur	Ph.D., F.S.	9/04-6/08	Charged Ultrafiltration Membranes for Whey Protein Fractionation
W. Riordan	B.S., Ch.E. Penn State Univ.	Ph.D., Ch.E.	9/03-10/08	Analysis and Design of Membrane Adsorbers for Viral Clearance
C. LaClair	M.S., Ch.E. Purdue Univ.	Ph.D., F.S.	9/05-11/08	Purification and Use of Whey Proteins for Improved Health
C. Zhu	B.S., F.S. Univ. Wisconsin	M.S., F.S.	9/08-12/10	Creation of Whey Protein Enhanced Beverages that Are Clear and Heat Stable at Acidic pH
S. Gemili	M.S., Ch.E. Izmir Inst. Technol.	Ph.D., F.S.	5/08-6/12	Membrane Unit Operations for Dairy Protein Concentration and Fractionation
A. Gemili	B.S., F.S. Izmir Inst. Technol.	M.S., F.S.	1/10-12/11	Electrostatic Repulsion Enhancement for Heat Stable, Clear Whey Protein Beverages

A. Arunkumar	B.S., Ch.E. Univ. Bombay	Ph.D., Ch.E.	9/09-12/14	Performance Characteristics of Charged Tangential Flow Ultrafiltration Membranes
J. O'Dell	B.S., Biol. Sys. E. Purdue Univ.	Ph.D., B.S.E. (candidate)	9/09-	Membrane Cascades for Protein Separation
M. Knapp	B.S., Ch.E. Vanderbilt Univ.	M.S., F.S.	6/13-5/15	Glycomacropeptide-Polysaccharide Conjugates for Improving a Fruit Juice Beverage for Patients with Phenylketonuria
N. Li	B.S., Pharm. Sci. Chongqing Med. Univ.	M.S., F.S.	9/14-12/15	The Kinetics of Formation and Hydrolysis of Whey Protein-Dextran Glycates
R. Singh	B.S., Dairy Technol. Nat. Dairy Res. Inst.	M.S., F.S.	9/15-5/17	Integrated Fractionation Techniques to Produce Milk Minerals and Next Generation Proteins
N. Li	M.S., F.S. Univ. Wisconsin	Ph.D., F.S.	1/16-5/21	Charged Polyethersulfone Ultrafiltration Membranes

Post-doctoral and special student training

Student	Previous Education	Appointment	Dates	Topic
S.M. Kim	Ph.D. F.S. Kansas State Univ.	Res. Assoc.	9/89-8/90	Affinity Bioseparations
C. Buijsse	M.S. F.S. Wageningen Univ.	Visiting Sci.	4/91-8/91	Inactivation Kinetics of Lactobacillus helveticus and Its Intracellular Enzymes
E. Bruinink	M.S. F.S. Wageningen Univ.	Visiting Sci.	1/96-7/96	Fermentation of Whey Permeate to 1,2-Propanediol
L. Marschoun	B.S. F.E. Bogor Univ.	Res. Assist.	8/97-5/98	Separation of Whey Proteins by Ion Exchange Chromatography
H. Yang	Ph.D. Ch.E. Univ. Wisconsin	Res. Assoc.	5/98-5/01	Competitive Protein Sorption and Affinity Membrane Bioseparations: Experimental Characterization and Mathematical Analysis
N. Turhan	Ph.D. F.E. Univ. Haccepete	Res. Assoc.	7/01-7/02	Chromatographic Fractionation of Dairy Proteins
Y. Zencir	M.S. F.E. Univ. Haccepete	Visiting Sci.	7/01-7/02	Chromatographic Fractionation of Dairy Proteins
S. Allelein	B.S. N.S. Fraunhofer Institute	Visiting Sci.	8/11-5/12	Whey Protein-Dextran Glycation Products

Service (department, college, university, professional)

Chair, Laboratory Instruction Committee
Chair, Food & Bioprocess Engineering Program Committee
Member, Future Personnel Needs Committee
Member and Chair, Curriculum Committee
Member, Curriculum Certification Committee
Member, Graduate Admissions and Standards Committee
Faculty Senate
Co-developed the Food and Bioprocess Engineering (F&BPE) Program
Created the dual degree and dual major programs in the F&BPE program
Revamped the food processing and food engineering course sequence in response to industry needs for students with stronger food engineering skills
Created a new course FS 542 Food Engineering Operations
Created a new course FS 642 Food and Pharmaceutical Separations
Center for Dairy Research
 Project Area Coordinator -- Whey Research
 Technical Advisory Committee
Dairy Management
 National Technical Advisory Committee -- Whey and Powdered Milk
 Strategic Planning Meeting -- Whey Separation
Department of Civil and Environmental Engineering Review Team
National Science Foundation
 Dilute Solutions Separations Planning Workshop
 CAREER Awards Review Panel
 Strategic Planning Workshop for Food Engineering Research
 SBIR Review Panel
Purdue Chromatographic Workshop Advisory Committee
DuPont Scientific Advisory Board
Treasurer (elected office) of the Food, Pharmaceutical & Bioengineering Division of the American Institute of Chemical Engineers
Editorial Board of the *Journal of Food Engineering* and the *Journal of Food Process Engineering*