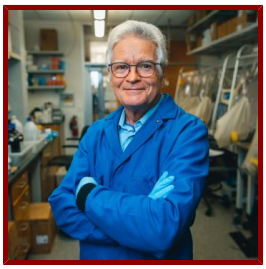
Stanford



# James Swartz

Emeritus Faculty, Academic Council, Chemical Engineering

### CONTACT INFORMATION

- **Administrator**

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## Bio

### BIO

Professor Swartz received his first lessons in resourcefulness and persistence growing up on a farm in South Dakota. After earning a BS in Chemical Engineering with Highest Honors from S. Dak. School of Mines and Technology, he began his professional career with Union Oil Co. of CA in Casper, Wyoming. Serving in the Drilling, Reservoir Engineering, and Production Departments provided an appreciation of the complexity and importance of large scale energy technologies. That experience also strengthened his belief that biological technologies offered the power and versatility to better address evolving societal needs. The MIT graduate programs in chemical engineering (MS) and biochemical engineering (Dsc) helped strengthen his biological training while broadening an appreciation for this emerging field. Following a 3 month exchange visit to the Soviet Union, he gained additional experience at Eli Lilly and participated in the development of the first recombinant DNA pharmaceutical to be approved, rDNA insulin. After two years, he moved to Genentech to help establish their drug production capability, developing the fermentation process for their first product, rDNA growth hormone.

After 17 years at Genentech in various line and project leadership positions, he joined the Stanford Chemical Engineering Department with a focus on an embryonic technology called cell-free protein synthesis (CFPS). Multiple technology breakthroughs from his lab motivated the founding of Sutro Biopharma which now has four promising anti-cancer drugs in clinical trials. A new company called Vaxcyte later spun out of Sutro to focus on complex human vaccines enabled by CFPS. Both companies are now publicly traded. Another company, GreenLight Biosciences, is focusing on inexpensive, large scale RNA production for use against agricultural pests. At Stanford, Professor Swartz is now focusing on expanding the basic capabilities of cell-free bioprocess while also developing technologies for targeted drug development, vaccines, circulating tumor cell assays, the carbon negative production of commodity biochemicals, and for economically attractive photosynthetic hydrogen production.

### ACADEMIC APPOINTMENTS

- Professor, Bioengineering
- Member, Bio-X
- Member, Cardiovascular Institute
- Member, Maternal & Child Health Research Institute (MCHRI)
- Member, Stanford Cancer Institute

### HONORS AND AWARDS

- Founding Fellow, The American Institute of Medical and Biological Engineers (1993)
- James Van Lanen Service Award, Division of Biochemical Technology, American Chem. Soc. (1993)
- Member, National Academy of Engineering (NAE) (1999)
- Amgen Award, Society of Industrial Microbiology (2005)
- Distinguished Alumnus Award, S.Dak. School of Mines and Technology (2005)
- Gaden Award, American Chemical Society (2006)
- The James Bailey Award, Am Inst. of Chem. Eng., Society for Biological Engineering (2007)
- One of 100 Chemical Engineers of Modern Era, Am Institute of Chemical Engineers (2008)
- Inaugural Fellow, American Chemical Society (2009)
- DIC Wang Award for Excellence in Bioch.Eng., AICHE (Society for Biolog. Eng) and Am Chem Soc. (2012)
- DIC Wang Lecture on Frontiers of Biotechn., MIT (2016)
- Fellow, American Institute for Chemical Engineers (2016)
- Marvin Johnson Award in Biochem. Technol., American Chemical Society (2020)

### BOARDS, ADVISORY COMMITTEES, PROFESSIONAL ORGANIZATIONS

- Member, American Institute of Chemical Engineers (1973 - present)
- Member, American Chemical Society (1978 - present)
- Member, National Academy of Engineering (1999 - present)

### PROFESSIONAL EDUCATION

- BS, S. Dak. School of Mines and Technology , Chemical Engineering (1971)
- MS, MIT , Chemical Engineering (1975)
- ScD, MIT , Biochemical Engineering (1978)

### LINKS

- My lab site: https://swartzbiotechnologylab.sites.stanford.edu/

## Research & Scholarship

### CURRENT RESEARCH AND SCHOLARLY INTERESTS

Program Overview

The world we enjoy, including the oxygen we breathe, has been beneficially created by biological systems. Consequently, we believe that innovative biotechnologies can also serve to help correct a natural world that non-natural technologies have pushed out of balance. We must work together to provide a sustainable world system capable of equitably improving the lives of over 10 billion people.

Toward that objective, our program focuses on human health as well as planet health. To address particularly difficult challenges, we seek to synergistically combine: 1) the design and evolution of complex protein-based nanoparticles and enzymatic systems with 2) innovative, uniquely capable cell-free production technologies.

To advance human health we focus on: a) achieving the 120 year-old dream of producing “magic bullets”; smart nanoparticles that deliver therapeutics or genetic therapies only to specific cells in our bodies; b) precisely designing and efficiently producing vaccines that mimic viruses to stimulate safe and protective immune responses; and c) providing a rapid point-of-care liquid biopsy that will count and harvest circulating tumor cells.

To address planet health we are pursuing biotechnologies to: a) inexpensively use atmospheric CO2 to produce commodity biochemicals as the basis for a new carbon negative chemical industry, and b) mitigate the intermittency challenges of photovoltaic and wind produced electricity by producing hydrogen either from biomass sugars or directly from sunlight.

More than 25 years ago, Professor Swartz began his pioneering work to develop cell-free biotechnologies. The new ability to precisely focus biological systems toward efficiently addressing new, “non-natural” objectives has proven tremendously useful as we seek to address the crucial and very difficult challenges listed above. Another critical feature of the program is the courage (or naivete) to approach important objectives that require the development and integration of several necessary-but- not-sufficient technology advances.

## Teaching

### COURSES

**2025-26**

- Biochemical Engineering: BIOE 150, BIOE 250, CHEMENG 150, CHEMENG 250 (Aut)

**2024-25**

- Advanced Biochemical Engineering: BIOE 355, CHEMENG 355 (Spr)
- Biochemical Engineering: BIOE 150, CHEMENG 150, CHEMENG 250 (Win)

**2023-24**

- Advanced Biochemical Engineering: BIOE 355, CHEMENG 355 (Spr)
- Biochemical Engineering: BIOE 150, CHEMENG 150, CHEMENG 250 (Win)
- Foundational Biology for Engineers: CHEMENG 55, ENGR 55 (Aut)

### STANFORD ADVISEES

**Doctoral Dissertation Reader (AC)**

Jenna Ahn, Varun Shanker

## Publications

### PUBLICATIONS

- **The exciting potential of modular nanoparticles for rapid development of highly effective vaccines** *Current Opinion in Chemical Engineering*
  Fogarty, J. A., Swartz, J. R.
  2018; 19: 1-8
- **Escherichia coli-based cell free production of flagellin and ordered flagellin display on virus-like particles.** *Biotechnology and bioengineering*
  Lu, Y., Welsh, J. P., Chan, W., Swartz, J. R.
  2013; 110 (8): 2073-2085
- **Cell-free co-production of an orthogonal transfer RNA activates efficient site-specific non-natural amino acid incorporation** *NUCLEIC ACIDS RESEARCH*
  Albayrak, C., Swartz, J. R.
  2013; 41 (11): 5949-5963
- **Pluripotency transcription factor Sox2 is strongly adsorbed by heparin but requires a protein transduction domain for cell internalization** *BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS*
  Albayrak, C., Yang, W. C., Swartz, J. R.
  2013; 431 (3): 641-645
- **Using E. coli-based cell-free protein synthesis to evaluate the kinetic performance of an orthogonal tRNA and aminoacyl-tRNA synthetase pair** *BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS*
  Albayrak, C., Swartz, J. R.

2013; 431 (2): 291-295

- **Nuclear Resonance Vibrational Spectroscopy and Electron Paramagnetic Resonance Spectroscopy of Fe-57-Enriched [FeFe] Hydrogenase Indicate Stepwise Assembly of the H-Cluster** *BIOCHEMISTRY*
  Kuchenreuther, J. M., Guo, Y., Wang, H., Myers, W. K., George, S. J., Boyke, C. A., Yoda, Y., Alp, E. E., Zhao, J., Britt, R. D., Swartz, J. R., Cramer, S. P.
  2013; 52 (5): 818-826
- **Cell-free production of trimeric influenza hemagglutinin head domain proteins as vaccine antigens** *BIOTECHNOLOGY AND BIOENGINEERING*
  Welsh, J. P., Lu, Y., He, X., Greenberg, H. B., Swartz, J. R.
  2012; 109 (12): 2962-2969
- **New Insights into [FeFe] Hydrogenase Activation and Maturase Function** *PLOS ONE*
  Kuchenreuther, J. M., Britt, R. D., Swartz, J. R.
  2012; 7 (9)
- **A vaccine directed to B cells and produced by cell-free protein synthesis generates potent antilymphoma immunity** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
  Ng, P. P., Jia, M., Patel, K. G., Brody, J. D., Swartz, J. R., Levy, S., Levy, R.
  2012; 109 (36): 14526-14531
- **Simplifying and streamlining Escherichia coli-based cell-free protein synthesis** *BIOTECHNOLOGY PROGRESS*
  Yang, W. C., Patel, K. G., Wong, H. E., Swartz, J. R.
  2012; 28 (2): 413-420
- **Generation of hydrogen from NADPH using an [FeFe] hydrogenase** *INTERNATIONAL JOURNAL OF HYDROGEN ENERGY*
  Smith, P. R., Bingham, A. S., Swartz, J. R.
  2012; 37 (3): 2977-2983
- **Evolution of an [FeFe] hydrogenase with decreased oxygen sensitivity** *INTERNATIONAL JOURNAL OF HYDROGEN ENERGY*
  Bingham, A. S., Smith, P. R., Swartz, J. R.
  2012; 37 (3): 2965-2976
- **Transforming Biochemical Engineering with Cell-Free Biology** *AICHE JOURNAL*
  Swartz, J. R.
  2012; 58 (1): 5-13
- **Solubility partner IF2 Domain I enables high yield synthesis of transducible transcription factors in Escherichia coli** *PROTEIN EXPRESSION AND PURIFICATION*
  Yang, W. C., Welsh, J. P., Lee, J., Cooke, J. P., Swartz, J. R.
  2011; 80 (1): 145-151
- **Discovery of Improved EGF Agonists Using a Novel In Vitro Screening Platform** *JOURNAL OF MOLECULAR BIOLOGY*
  Lui, B. H., Cochran, J. R., Swartz, J. R.
  2011; 413 (2): 406-415
- **A filter microplate assay for quantitative analysis of DNA binding proteins using fluorescent DNA** *ANALYTICAL BIOCHEMISTRY*
  Yang, W. C., Swartz, J. R.
  2011; 415 (2): 168-174
- **Localization of BiP to Translating Ribosomes Increases Soluble Accumulation of Secreted Eukaryotic Proteins in an Escherichia Coli Cell-Free System** *BIOTECHNOLOGY AND BIOENGINEERING*
  Welsh, J. P., Bonomo, J., Swartz, J. R.
  2011; 108 (8): 1739-1748
- **Efficient disulfide bond formation in virus-like particles** *JOURNAL OF BIOTECHNOLOGY*
  Bundy, B. C., Swartz, J. R.
  2011; 154 (4): 230-239
- **Cell-free H-cluster Synthesis and [FeFe] Hydrogenase Activation: All Five CO and CN- Ligands Derive from Tyrosine** *PLOS ONE*

Kuchenreuther, J. M., George, S. J., Grady-Smith, C. S., Cramer, S. P., Swartz, J. R.
2011; 6 (5)

- **Binding of a cationic protein to the cell surface is insufficient for cellular uptake and bioactivity: Arginine-rich sequences are necessary** *241st National Meeting and Exposition of the American-Chemical-Society (ACS)*
  Yang, W. C., Lee, J., Albayrak, C., Cooke, J. P., Swartz, J. R.
  AMER CHEMICAL SOC.2011
- **Surface Functionalization of Virus-Like Particles by Direct Conjugation Using Azide-Alkyne Click Chemistry** *BIOCONJUGATE CHEMISTRY*
  Patel, K. G., Swartz, J. R.
  2011; 22 (3): 376-387
- **Escherichia coli-based production of a tumor idiotype antibody fragment - tetanus toxin fragment C fusion protein vaccine for B cell lymphoma** *PROTEIN EXPRESSION AND PURIFICATION*
  Patel, K. G., Ng, P. P., Levy, S., Levy, R., Swartz, J. R.
  2011; 75 (1): 15-20
- **Development of an In Vitro Compartmentalization Screen for High-Throughput Directed Evolution of [FeFe] Hydrogenases** *PLOS ONE*
  Stapleton, J. A., Swartz, J. R.
  2010; 5 (12)
- **High-Yield Expression of Heterologous [FeFe] Hydrogenases in Escherichia coli** *PLOS ONE*
  Kuchenreuther, J. M., Grady-Smith, C. S., Bingham, A. S., George, S. J., Cramer, S. P., Swartz, J. R.
  2010; 5 (11)
- **Comparing the functional properties of the Hsp70 chaperones, DnaK and BiP** *BIOPHYSICAL CHEMISTRY*
  Bonomo, J., Welsh, J. P., Manthiram, K., Swartz, J. R.
  2010; 149 (1-2): 58-66
- **A Cell-Free Microtiter Plate Screen for Improved [FeFe] Hydrogenases** *PLOS ONE*
  Stapleton, J. A., Swartz, J. R.
  2010; 5 (5)
- **High-yield production of transducible transcription factors for non-viral modulation of gene expression**
  Yang, W. C., Welsh, J. P., Cooke, J. P., Swartz, J. R.
  AMER CHEMICAL SOC.2010
- **Cell-free incorporation of non-natural amino acids in proteins enables the production of complex protein bioconjugates**
  Patel, K. G., Swartz, J. R.
  AMER CHEMICAL SOC.2010
- **Effective site-specific incorporation of non-natural amino acids via simultaneous cell-free synthesis of the orthogonal tRNA and the product protein**
  Albayrak, C., Swartz, J. R.
  AMER CHEMICAL SOC.2010
- **Site-Specific Incorporation of p-Propargyloxyphenylalanine in a Cell-Free Environment for Direct Protein-Protein Click Conjugation** *BIOCONJUGATE CHEMISTRY*
  Bundy, B. C., Swartz, J. R.
  2010; 21 (2): 255-263
- **Cell-free production of Gaussia princeps luciferase - antibody fragment bioconjugates for ex vivo detection of tumor cells** *BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS*
  Patel, K. G., Ng, P. P., Kuo, C., Levy, S., Levy, R., Swartz, J. R.
  2009; 390 (3): 971-976
- **Cell-Free Production of Transducible Transcription Factors for Nuclear Reprogramming** *BIOTECHNOLOGY AND BIOENGINEERING*
  Yang, W. C., Patel, K. G., Lee, J., Ghebremariam, Y. T., Wong, H. E., Cooke, J. P., Swartz, J. R.
  2009; 104 (6): 1047-1058

- **Multiply mutated Gaussia luciferases provide prolonged and intense bioluminescence** *BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS*
  Welsh, J. P., Patel, K. G., Manthiram, K., Swartz, J. R.
  2009; 389 (4): 563-568
- **Novel Anti-CD19/Idiotype Bispecific Diabody Vaccine for B-Cell Lymphoma** *51st Annual Meeting and Exposition of the American-Society-of-Hematology*
  Ng, P. P., Jia, M., Virrueta, A., Patel, K., Swartz, J. R., Levy, S., Levy, R.
  AMER SOC HEMATOLOGY.2009: 1062–62
- **Tyrosine, Cysteine, and S-Adenosyl Methionine Stimulate In Vitro [FeFe] Hydrogenase Activation** *PLOS ONE*
  Kuchenreuther, J. M., Stapleton, J. A., Swartz, J. R.
  2009; 4 (10)
- **Cell-Free Synthesis of Functional Aquaporin Z in Synthetic Liposomes** *BIOTECHNOLOGY AND BIOENGINEERING*
  Hovijitra, N. T., Wuu, J. J., Peaker, B., Swartz, J. R.
  2009; 104 (1): 40-49
- **Universal cell-free protein synthesis** *NATURE BIOTECHNOLOGY*
  Swartz, J. R.
  2009; 27 (8): 731-732
- **High-Level Cell-Free Synthesis Yields of Proteins Containing Site-Specific Non-Natural Amino Acids** *BIOTECHNOLOGY AND BIOENGINEERING*
  Goerke, A. R., Swartz, J. R.
  2009; 102 (2): 400-416
- **Continued Protein Synthesis at Low [ATP] and [GTP] Enables Cell Adaptation during Energy Limitation** *JOURNAL OF BACTERIOLOGY*
  Jewett, M. C., Miller, M. L., Chen, Y., Swartz, J. R.
  2009; 191 (3): 1083-1091
- **An integrated cell-free metabolic platform for protein production and synthetic biology** *MOLECULAR SYSTEMS BIOLOGY*
  Jewett, M. C., Calhoun, K. A., Voloshin, A., Wuu, J. J., Swartz, J. R.
  2008; 4
- **BIOT 10-Cell-free protein synthesis of complex proteins and protein assemblies containing posttranslational modification** *236th National Meeting of the American-Chemical-Society*
  Goerke, A. R., Wuu, J. J., Ebina, W., Bundy, B. C., Swartz, J. R.
  AMER CHEMICAL SOC.2008
- **BIOT 496-Activating and evolving hydrogenases for solar hydrogen production** *236th National Meeting of the American-Chemical-Society*
  Swartz, J. R., Stapleton, J. A., Kuchenreuther, J. M., Smith, P.
  AMER CHEMICAL SOC.2008
- **BIOT 143-Development of in vivo and in vitro systems for studying the expression and activation of [FeFe] hydrogenases and their required maturases** *236th National Meeting of the American-Chemical-Society*
  Kuchenreuther, J. M., Boyer, M. E., Stapleton, J. A., Swartz, J. R.
  AMER CHEMICAL SOC.2008
- **BIOT 482-Enhancing production of complex mammalian proteins using E-coli based cell-free protein synthesis** *236th National Meeting of the American-Chemical-Society*
  Welsh, J. P., Swartz, J. R., Bonomo, J.
  AMER CHEMICAL SOC.2008
- **Escherichia coli-based cell-free synthesis of virus-like particles** *BIOTECHNOLOGY AND BIOENGINEERING*
  Bundy, B. C., Franciszkowicz, M. J., Swartz, J. R.
  2008; 100 (1): 28-37
- **High yield cell-free production of integral membrane proteins without refolding or detergents** *BIOCHIMICA ET BIOPHYSICA ACTA-BIOMEMBRANES*
  Wuu, J. J., Swartz, J. R.

2008; 1778 (5): 1237-1250

- **Cell-free metabolic engineering promotes high-level production of bioactive Gaussia princeps luciferase** *METABOLIC ENGINEERING*
  Goerke, A. R., Loening, A. M., Gambhir, S. S., Swartz, J. R.
  2008; 10 (3-4): 187-200
- **Development of cell-free protein synthesis platforms for disulfide bonded proteins** *BIOTECHNOLOGY AND BIOENGINEERING*
  Goerke, A. R., Swartz, J. R.
  2008; 99 (2): 351-367
- **Cell-free synthesis and maturation of [FeFe] hydrogenases** *BIOTECHNOLOGY AND BIOENGINEERING*
  Boyer, M. E., Stapleton, J. A., Kuchenreuther, J. M., Wang, C., Swartz, J. R.
  2008; 99 (1): 59-67
- **A sequential expression system for high-throughput functional genomic analysis** *PROTEOMICS*
  Woodrow, K. A., Swartz, J. R.
  2007; 7 (21): 3870-3879
- **BIOT 345-High yields of complex proteins with site-specific posttranslational modification using cell-free protein synthesis**
  Goerke, A. R., Wuu, J. J., Ebina, W., Swartz, J. R.
  AMER CHEMICAL SOC.2007
- **BIOT 106-"Seeing the light" with cell-free protein synthesis**
  Goerke, A. R., Loening, A. M., Gambhir, S., Swartz, J. R.
  AMER CHEMICAL SOC.2007
- **Cell-free synthesis of proteins that require disulfide bonds using glucose as an energy source** *BIOTECHNOLOGY AND BIOENGINEERING*
  Knapp, K. G., Goerke, A. R., Swartz, J. R.
  2007; 97 (4): 901-908
- **Cell-free production of scFv fusion proteins: an efficient approach for personalized lymphoma vaccines** *BLOOD*
  Kanter, G., Yang, J., Voloshin, A., Levy, S., Swartz, J. R., Levy, R.
  2007; 109 (8): 3393-3399
- **Evidence for an additional disulfide reduction pathway in Escherichia coli** *JOURNAL OF BIOSCIENCE AND BIOENGINEERING*
  Knapp, K. G., Swartz, J. R.
  2007; 103 (4): 373-376
- **Energy systems for ATP regeneration in cell-free protein synthesis reactions.** *Methods in molecular biology (Clifton, N.J.)*
  Calhoun, K. A., Swartz, J. R.
  2007; 375: 3-17
- **Rapid expression of functional genomic libraries** *JOURNAL OF PROTEOME RESEARCH*
  Woodrow, K. A., Airen, I. O., Swartz, J. R.
  2006; 5 (12): 3288-3300
- **BIOT 364-Expressing high yields of membrane proteins using cell-free synthesis**
  Wuu, J. J., Swartz, J. R.
  AMER CHEMICAL SOC.2006
- **BIOT 70-Avoiding mass transport limitations in hydrophobic biotransformations by efficient cell localization**
  Yancey, D. D., Robertson, C. R., Swartz, J.
  AMER CHEMICAL SOC.2006
- **BIOT 396-Escherichia coli-based cell-free protein synthesis of empty viral capsids**
  Bundy, B. C., Swartz, J. R.
  AMER CHEMICAL SOC.2006
- **BIOT 388-Extending cell-free protein synthesis to complex targets: Expression and maturation of FeFe-hydrogenases**
  Boyer, M. E., Stapleton, J. A., Kuchenreuther, J. M., Wang, C., Swartz, J. R.

AMER CHEMICAL SOC.2006

- **BIOT 4-Developing a cell-free protein synthesis platform for producing proteins requiring disulfide bonds**
  Goerke, A. R., Knapp, K. G., Swartz, J. R.
  AMER CHEMICAL SOC.2006
- **BIOT 22-Directed evolution of oxygen-tolerant hydrogenases for photobiological hydrogen production**
  Stapleton, J. A., Boyer, M. E., Swartz, J. R.
  AMER CHEMICAL SOC.2006
- **Effects of growth rate on cell extract performance in cell-free protein synthesis** *BIOTECHNOLOGY AND BIOENGINEERING*
  Zawada, J., Swartz, J.
  2006; 94 (4): 618-624
- **Developing cell-free biology for industrial applications** *Annual Meeting of the Society-for-Industrial-Microbiology*
  Swartz, J.
  SPRINGER HEIDELBERG.2006: 476–85
- **Total amino acid stabilization during cell-free protein synthesis reactions** *JOURNAL OF BIOTECHNOLOGY*
  Calhoun, K. A., Swartz, J. R.
  2006; 123 (2): 193-203
- **Simultaneous expression and maturation of the iron-sulfur protein ferredoxin in a cell-free system** *BIOTECHNOLOGY AND BIOENGINEERING*
  Boyer, M. E., Wang, C. W., Swartz, J. R.
  2006; 94 (1): 128-138
- **Quantitative polysome analysis identifies limitations in bacterial cell-free protein synthesis** *BIOTECHNOLOGY AND BIOENGINEERING*
  Underwood, K. A., Swartz, J. R., Puglisi, J. D.
  2005; 91 (4): 425-435
- **Efficient and scalable method for scaling up cell free protein synthesis in batch mode** *BIOTECHNOLOGY AND BIOENGINEERING*
  Voloshin, A. M., Swartz, J. R.
  2005; 91 (4): 516-521
- **An economical method for cell-free protein synthesis using glucose and nucleoside monophosphates** *BIOTECHNOLOGY PROGRESS*
  Calhoun, K. A., Swartz, J. R.
  2005; 21 (4): 1146-1153
- **Energizing cell-free protein synthesis with glucose metabolism** *BIOTECHNOLOGY AND BIOENGINEERING*
  Calhoun, K. A., Swartz, J. R.
  2005; 90 (5): 606-613
- **Maintaining stable amino acid concentrations during cell-free protein synthesis.** *229th National Meeting of the American-Chemical-Society (ACS)*
  Calhoun, K. A., Michel-Reydellet, N., Swartz, J. R.
  AMER CHEMICAL SOC.2005: U229–U229
- **Metabolic modeling of cell-free protein synthesis reactions.** *229th National Meeting of the American-Chemical-Society (ACS)*
  Calhoun, K. A., Varner, J., Jewett, M. C., Swartz, J. R.
  AMER CHEMICAL SOC.2005: U194–U194
- **Functional genomic analysis using in vitro protein expression and folding.** *229th National Meeting of the American-Chemical-Society (ACS)*
  Woodrow, K. A., Swartz, J. R.
  AMER CHEMICAL SOC.2005: U190–U191
- **Cell-free synthesis enables patient-specific vaccine production.** *229th National Meeting of the American-Chemical-Society (ACS)*
  Swartz, J. R., Levy, R., Kanter, G., Yang, J. H., Voloshin, A.
  AMER CHEMICAL SOC.2005: U202–U203

- **Economic cell-free protein synthesis system energized with glucose metabolism and NMPS.** *229th National Meeting of the American-Chemical-Society (ACS)*
  Calhoun, K. A., Swartz, J. R.
  AMER CHEMICAL SOC.2005: U180–U180

- **Rapid expression of vaccine proteins for B-cell lymphoma in a cell-free system** *BIOTECHNOLOGY AND BIOENGINEERING*
  Yang, J. H., Kanter, G., Voloshin, A., Michel-Reydellet, N., Velkeen, H., Levy, R., Swartz, J. R.
  2005; 89 (5): 503-511

- **Streamlining Escherichia coli S30 extract preparation for economical cell-free protein synthesis** *BIOTECHNOLOGY PROGRESS*
  Liu, D. V., Zawada, J. F., Swartz, J. R.
  2005; 21 (2): 460-465

- **Maintaining rapid growth in moderate-density Escherichia coli fermentations** *BIOTECHNOLOGY AND BIOENGINEERING*
  Zawada, J., Swartz, J.
  2005; 89 (4): 407-415

- **Increasing PCR fragment stability and protein yields in a cell-free system with genetically modified Escherichia coli extracts** *JOURNAL OF MOLECULAR MICROBIOLOGY AND BIOTECHNOLOGY*
  Michel-Reydellet, N., Woodrow, K., Swartz, J.
  2005; 9 (1): 26-34

- **A novel method for producing custom-made idiotype vaccines for lymphoma immunotherapy using a cell-free expression system.** *46th Annual Meeting of the American-Society-of-Hematology*
  Kanter, G., Yang, J. H., Voloshin, A., Swartz, J. R., Levy, R.
  AMER SOC HEMATOLOGY.2004: 395A–395A

- **Expression of active murine granulocyte-macrophage colony-stimulating factor in an Escherichia coli cell-free system** *BIOTECHNOLOGY PROGRESS*
  Yang, J. H., Kanter, G., Voloshin, A., Levy, R., Swartz, J. R.
  2004; 20 (6): 1689-1696

- **Substrate replenishment extends protein synthesis with an in vitro translation system designed to mimic the cytoplasm** *BIOTECHNOLOGY AND BIOENGINEERING*
  Jewett, M. C., Swartz, J. R.
  2004; 87 (4): 465-472

- **Amino acid stabilization for cell-free protein synthesis by modification of the Escherichia coli genome** *METABOLIC ENGINEERING*
  Michel-Reydellet, N., Calhoun, K., Swartz, J.
  2004; 6 (3): 197-203

- **Enhancing multiple disulfide bonded protein folding in a cell-free system** *BIOTECHNOLOGY AND BIOENGINEERING*
  Yin, G., Swartz, J. R.
  2004; 86 (2): 188-195

- **Mimicking the Escherichia coli cytoplasmic environment activates long-lived and efficient cell-free protein synthesis** *BIOTECHNOLOGY AND BIOENGINEERING*
  Jewett, M. C., Swartz, J. R.
  2004; 86 (1): 19-26

- **Protein expression and engineering for structural studies.** *227th National Meeting of the American-Chemical Society*
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