

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors in the order listed on Form Page 2.

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NAME U. Subrahmanyeswara (U.S.) Rao	POSITION TITLE Professor and Director of Research Appalachian College of Pharmacy Oakwood, VA 24631
eRA COMMONS USER NAME (credential, e.g., agency login) URAO79430	

EDUCATION/TRAINING (*Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable.*)

INSTITUTION AND LOCATION	DEGREE (if applicable)	MM/YY	FIELD OF STUDY
Department of Biochemistry, Indian Institute of Science, Bangalore, India	Ph.D.	1987	Biochemistry of enzymes
Univ. North Carolina at Chapel Hill, NC USA	Postdoc	1987-92	Biochem. H ⁺ -ATPase
Univ. North Carolina at Chapel Hill, NC USA	Res.Asst. Professor	1992-1998	Cancer Multidrug Resistance
University of Nebraska Medical Center, Omaha, NE 68198	Asst. Professor	1998-2005	Amiloride-sensitive sodium channels in cystic fibrosis and renal function
Texas Tech Univ. Health Sci. Cen. Amarillo, TX 79106	Associate Professor	2005-2012	Multidrug resistance in cancer; galectins in gastrointestinal physiology and GI cancers
Appalachian College of Pharmacy, Oakwood, VA 24631	Professor	2012-present	Galectin-4 in inflammation and cancer; Cancer biomarker discovery; Anticancer drug discovery and validation

Please refer to the application instructions in order to complete sections A, B, C, and D of the Biographical Sketch.

A. Personal Statement.

I have broad background in biochemistry, cell biology, molecular biology and analysis of enzymes, transporters and proteins in cancers. My long term interest is to elucidate the molecular mechanisms of multidrug resistance in cancer, specifically the P-glycoprotein-mediated drug resistance in breast cancer.

I am also interested in understanding the mechanisms of galectin-4 in inflammation and cancer of colon. My current focus on training PharmD students in laboratory research in pharmacogenomics field.

B. Membership

1998-present: Member, American Association for Cancer Research (AACR).

1998-present: Member of AAAS.

C. Publications

1. Rao, P.S., Endicott, R., Mullins, R. and **Rao, U.S.** A six-week laboratory research rotation in pharmacogenomics: A model for preparing pharmacy students to practice precision medicine. (Under review).
2. Rao, P.S. and **Rao, U.S.** (2017) Surface-bound galectin-4 regulates gene transcription and secretion of chemokines in human colorectal cancer cell lines. *Tumor Biology* 39: March 2017. (<https://www.ncbi.nlm.nih.gov/pubmed/28345468>)
3. Rao, U.S. and Pugh, K. (2016). Sweet are the incentives of medication adherence. ***American Association of Pharmaceutical Sciences*** Blog discussion. Current Perspectives. <https://aapsblog.aaps.org/2016/01/07/sweet-are-the-incentives-of-medication-adherence/>
4. Krause, Keith M. and **Rao, U.S.** (2015). Painful drugs for abuse. ***American Association of Pharmaceutical Sciences*** Blog discussion. Current Perspectives. <http://aapsblog.aaps.org/2015/08/06/painful-drugs-for-abuse/>
5. Hovasapyan, V. and **Rao, U.S.** (2015). Deadly Precision. ***American Association of Pharmaceutical Sciences***. Blog discussion, Current Perspectives. <http://aapsblog.aaps.org/2015/04/02/deadly-precision/#more-5843>
6. **Rao, U.S.**, Mayhew, S.L. and Rao, P.S. (2015). Strategies for Implementation of an Effective Pharmacogenomics Program in Pharmacy Education. ***Pharmacogenomics***. 16:905-911.
7. Rao, P.S., Labhart, M., Mayhew, S.L., Thirumala, S. and **Rao, U.S.** Heterogeneity in the expression of receptors in the human breast cancer metastasized to the brain. (2014) ***Tumor Biology***. 35:7267-7273 (<http://www.ncbi.nlm.nih.gov/pubmed/?term=24777335>)
8. **Rao, U.S.**, N. S. Hoerster, S., Thirumala and P. S. Rao. The influence of metastatic site on the expression of CEA and cellular localization of β -catenin in colorectal cancer. (2013) ***J. Gastroenterology and Hepatology*** 28: 505-512 (<http://www.ncbi.nlm.nih.gov/pubmed/23216017>).
9. Rao, P.S., Satelli, A., Moridani, M., Jenkins, M. and **Rao, U.S.** (2012) Luteolin induces apoptosis in multidrug resistant cancer cells without affecting the drug transporter function: involvement of cell line-specific apoptotic mechanisms ***International Journal of Cancer*** 130: 2703-2014 (<http://www.ncbi.nlm.nih.gov/pubmed/21792893>).
10. Satelli, A., Rao, P.S., Thirumala, S. and **Rao, U.S.** (2011) Galectin-4 functions as a tumor suppressor of human colorectal cancer. ***International Journal of Cancer***, 129: 799-809. (<http://www.ncbi.nlm.nih.gov/pubmed/21064109>).
11. Satelli, A. and **U.S. Rao** (2011) Galectin-1 is silenced by promoter hypermethylation and its re-expression induces apoptosis in human colorectal cancer cells. ***Cancer Letters***, 301: 38-46. (<http://www.ncbi.nlm.nih.gov/pubmed/21122983>)
12. Zheng, H., Liu, X., **U.S. Rao** and Patel, K.P. (2011) Increased Renal ENaC Subunits and Sodium Retention in Rats with Chronic Heart Failure. ***Am. J. Physiol. Renal Physiol.*** 300: F641-9 (<http://www.ncbi.nlm.nih.gov/pubmed/21159737>).
13. Rao, P.S., Satelli, A., Zhang, S., Srivenugopal, K. S. and **U.S. Rao** (2009) RNF2 is the target for phosphorylation by the p38 MAPK and ERK signaling pathways. ***Proteomics***, 9: 2776-2787. (<http://www.ncbi.nlm.nih.gov/pubmed/19405034>).
14. Satelli, A., Rao, P.S., Gupta, P.K., Srivenugopal, K.S., Lockman, P., and **U.S. Rao** (2008). Varied expression and localization of multiple galectins in different cancer cell lines. ***Oncology Reports*** 19, 587-594 (<http://www.ncbi.nlm.nih.gov/pubmed/18288388>).
15. Rao, P.S., Bickel, U., Srivenugopal, K.S. and **U.S. Rao** (2008). Bap29varP, a variant of Bap29, influences the cell surface expression of the human P-glycoprotein. ***International Journal of Oncology***, 32: 135-144 (<http://www.ncbi.nlm.nih.gov/pubmed/18097552>).
16. Adebamiro, A. Cheng , Y., **U.S. Rao**, Danahay, H. and Bridges, R.J. (2007). A segment of gamma ENaC mediates elastase activation of Na⁺ transport. ***Journal of General Physiology***, 130: 611-229 (<http://www.ncbi.nlm.nih.gov/pubmed/17998393>).
17. Niture, S.K., **U.S. Rao** and Srivenugopal, K.S. (2006). Chemopreventative strategies targeting the MGMT repair protein: augmented expression in human lymphocytes and tumor cells by ethanolic and aqueous extracts of several Indian medicinal plants. ***International Journal of Oncology***, 29: 1269-1278 (<http://www.ncbi.nlm.nih.gov/pubmed/17016661>).

18. Rao, P.S., Mallya, K.B., Srivenugopal, K.S., Balaji, K.C. and **U.S. Rao** (2006). RNF2 interacts with the linker region of the human P-glycoprotein. *International Journal of Oncology*, **29**: 1413-1419 (<http://www.ncbi.nlm.nih.gov/pubmed/17088979>).
19. Rao, P.S., Govindarajan, R., Mallya, K.B., West, W. and **Rao, U.S.** (2005). Characterization of a new antibody raised against the NH2-terminus of P-glycoprotein. *Clinical Cancer Research* **11**: 5833-5839 (<http://www.ncbi.nlm.nih.gov/pubmed/16115923>).
20. **Rao, U.S.**, Baker, J.M., Pluznick, J.L. and Balachandran, P. (2004). Role of intracellular Ca²⁺ in the expression of the amiloride-sensitive epithelial sodium channel. *Cell Calcium*, **35**: 21-28 (<http://www.ncbi.nlm.nih.gov/pubmed/14670368>).
21. **Rao, U.S.** and Nuti, S.L. (2003). Identification of two different states of P-glycoprotein in its catalytic cycle. Role of the linker region in the transition between these two states. *Journal of Biological Chemistry* **278**: 46576-46582 (<http://www.ncbi.nlm.nih.gov/pubmed/12968025>).
22. **Rao, U.S.** (2003). Expression of oligomeric amiloride-sensitive sodium channel in Sf9 insect cells. *Methods in Molecular Biology* **228**, 65-72 (<http://www.ncbi.nlm.nih.gov/pubmed/12824544>).
23. Nuti, S.L. and **Rao, U.S.** (2002). Proteolytic cleavage of the linker region of the human P-glycoprotein modulates its ATPase function. *Journal of Biological Chemistry* **277**: 29417-29423 (<http://www.ncbi.nlm.nih.gov/pubmed/12055198>).
24. **Rao, U.S.**, Steimle, R.E. and Balachandran, P. (2002). Activation of large conductance cationic channels upon expression of amiloride-sensitive sodium channel in Sf9 insect cells. *Journal of Biological Chemistry*. **277**: 4900-4905 (<http://www.ncbi.nlm.nih.gov/pubmed/11733494>).
25. **Rao, U.S.**, Mehdi, A. and Steimle, R.E. (2000). Expression of amiloride-sensitive sodium channel: A strategy for the coexpression of multimeric membrane protein in Sf9 insect cells. *Analytical Biochemistry* **286**: 206-213 (<http://www.ncbi.nlm.nih.gov/pubmed/11067742>).
26. Nuti, S.L., Mehdi, A., and **Rao, U.S.** (2000). Activation of the human P-glycoprotein ATPase by trypsin. *Biochemistry* **39**: 3424-3432 (<http://www.ncbi.nlm.nih.gov/pubmed/10727237>).
27. **Rao, U.S.** (1998). Drug binding and nucleotide hydrolyzability are essential requirements in the vanadate-induced inhibition of the human P-glycoprotein ATPase. *Biochemistry* **37**: 14981-14988 (<http://www.ncbi.nlm.nih.gov/pubmed/9778376>).
28. Scala, M.; Akhmed, N., **Rao, U.S.**, Paul, K., Lan, L.B., Stein, W.D., Bates, S.E. (1997). P-glycoprotein substrates and antagonists cluster into two distinct groups. *Molecular Pharmacology* **51**: 1024-1033 (<http://www.ncbi.nlm.nih.gov/pubmed/9187269>).
29. Lanning, C.L., Fine, R.L., Sachs, C.W., **Rao, U.S.**, Corcoran, J.J., Abou-Donia, M.B. (1996). Chlorpyrifos oxon interacts with the mammalian multidrug resistance protein, P-glycoprotein. *J Toxicol Environmental Health* **47**: 395-407 (<http://www.ncbi.nlm.nih.gov/pubmed/8600291>).
30. **Rao, U.S.** (1995). Mutation of glycine 185 to valine alters the ATPase function of the human P-glycoprotein expressed in Sf9 insect cells. *Journal of Biological Chemistry* **270**: 6686-6690 (<http://www.ncbi.nlm.nih.gov/pubmed/7896810>).
31. **Rao, U.S.** and Scarborough, G.A. (1994). Direct demonstration of high affinity interactions of immunosuppressant drugs with the drug binding site of the human P-glycoprotein. *Molecular Pharmacology* **45**: 773-776 (<http://www.ncbi.nlm.nih.gov/pubmed/7514263>).
32. **Rao, U.S.**, Fine, R.L. and Scarborough, G.A. (1994). Antiestrogens and steroid hormones: Substrates of the human P-glycoprotein. *Biochemical Pharmacology* **48**: 287-292 (<http://www.ncbi.nlm.nih.gov/pubmed/7914405>).
33. Mahanty, S.K., **Rao, U.S.**, Nicholas, R.A. and Scarborough, G.A. (1994). High-yield expression of the *Neurospora crassa* plasma membrane H⁺-ATPase in *Saccharomyces cerevisiae*. *The Journal of Biological Chemistry* **269**: 17705-17712 (<http://www.ncbi.nlm.nih.gov/pubmed/8021283>).
34. Fine, R.L., Sachs, C.W., Albers, M.E., Safa, A., **Rao, U.S.**, Scarborough, G.A., Burchette, J., Jorgan, C., and Trump, D.L. (1993). Inhibition of multidrug resistance in human cancer cells by tamoxifen: Laboratory to clinical studies. *The Mechanism and New Approach on Drug Resistance of Cancer Cells* pp323-332, Excerpta Medica, Amsterdam
35. **Rao, U.S.**, Bauzon, D.B.; Scarborough, G.A. (1992). Cytoplasmic location of amino acids 363-440 of the *Neurospora crassa* plasma membrane H⁺-ATPase. *Biochimica et Biophysica Acta* **1108**: 153-158 (<http://www.ncbi.nlm.nih.gov/pubmed/1386255>).

36. **Rao, U.S.**, Hennessey Jr, JP; Scarborough, GA. (1991). Identification of the membrane-embedded regions of the *Neurospora crassa* plasma membrane H⁺-ATPase. *The Journal of Biological Chemistry* **266**: 14740-14746 (<http://www.ncbi.nlm.nih.gov/pubmed/1830591>).
37. **Rao, U.S.**, Murthy, SK. (1991). The effects of β -mercaptoethanol and sodium dodecyl sulfate on the *Humicola insolens* β -glucosidase. *Biochemistry International* **23**: 343-348 (<http://www.ncbi.nlm.nih.gov/pubmed/1907139>).
38. **Rao, U.S.**, Scarborough, GA. (1990). Chemical state of the cysteine residues in the *Neurospora crassa* plasma membrane H⁺-ATPase. *The Journal of Biological Chemistry* **265**: 7227-7235. (<http://www.ncbi.nlm.nih.gov/pubmed/2139659>)
39. **Rao, U.S.**, Murthy, SK. (1988) Purification and characterization of a β -glucosidase and an endocellulase from *Humicola insolens*. *Indian Journal of Biochemistry and Biophysics* **25**: 687-694 (<http://www.ncbi.nlm.nih.gov/pubmed/3151367>).
40. **Rao, U.S.**, Hennessey, Jr, JP; Scarborough, GA. (1988). Protein chemistry of the *Neurospora crassa* plasma membrane H⁺-ATPase. *Analytical Biochemistry* **173**: 251-264 (<http://www.ncbi.nlm.nih.gov/pubmed/2903697>).

D. Research Support

Not funded:

NIH T35 Training grant “Research training for PharmD students in a medically underserved part of rural, southwest Virginia”. Total Budget: \$388,800 (Dec 1, 2015-11-30-2020). Role: Program Director and Principal Investigator. Received Priority Score. JIT was requested. Council meets in October 2015 to make funding decision.

Current Research Support (submitted for Institutional Small Research Grant Applications)

1. **Immunohistochemical analysis of human tumor biopsies.** Small Grant Applications, Appalachian College of Pharmacy. Role: PI
2. **Antidiabetics and statin prescriptions. A post hoc analysis.** Small Grant Applications, Appalachian College of Pharmacy. Role: PI

Research Support (completed)

1. **Infrastructure development for Research.** *Fluorescence laser microscope for biomarker analysis and validation.* **Funding source:** Appalachian College of Pharmacy. Total budget \$85,000. 2013-2014. Role: Director of Research and PI.
2. **Infrastructure development for Research.** *Flow cytometer for cell biology studies and drug discovery and validation.* **Funding source:** Appalachian College of Pharmacy. Total budget \$60,000. 2014-15. Role: Director of Research and PI
3. **Infrastructure development for Research.** *Digital film processor for discovery and validation of cellular changes in the drug discovery studies.* **Funding source:** Appalachian College of Pharmacy. Total budget \$6,000. 2014-15 Role: Director of Research and PI.
4. **NIH RO1** “A novel RING finger protein in cancer drug resistance”. Agency: NIH (4-1-04 to 3-31-08). No Cost Extension till 3-31-10. Role: **PI**
5. **NIH RO1** “Biochemistry of Amiloride Sensitive Na Channels in Cystic Fibrosis” Agency: NIH. 05/01/97-04/30/02 (with no cost extension till 3-30-03). Role: **PI**.
6. **Department of Defense, BC 46411.** Concept Award: “Filling in the gap in galectin-1 export”. Agency: Department of Defense (Total direct cost: \$75,000; August 15, 2005 to Aug. 14, 2006. With No Cost Extension to August 14, 2007), Role: **PI**.
7. **Women’s Health Research Institute at Texas Tech University Health Sciences Center.** “Drug resistance biomarkers in human breast cancers” Agency: Texas Tech Medical Center, Women’s health Research Institute (Total cost: \$25,000; June 1, 2006 to May 31, 2008). Role: **PI**.
8. **The State of Nebraska, LB506** “Proteolytic modulation of multidrug transporter” Agency: State of Nebraska. (Total budget \$40,000; 7-1-2001 to 6-30-02). Role: **PI**

- 9. Univ. Nebraska Medical Center, Minority Health Education Research Office (MiHERO), UNMC Tobacco Settlement Money, (Total budget: \$2,560 (June 14th to August 6th 2004) (for training Ms.Rachael Dickey)). Role: **PI**.**
- 10. Univ. Nebraska Medical Center, Minority Health Education Research Office (MiHERO), UNMC Tobacco Settlement Money, (Total budget: \$2,560 (May 16th to August 5th 2005) (for training Ms. Takiesha Bridger)). Role: **PI**.**
- 11. University of North Carolina at Chapel Hill, Institutional Research Grant #IRG 15-34 "P-glycoprotein ATPase activity" 15-34. Agency: American Cancer Society, Univ. North Carolina, Chapel Hill (1992- 94). Role: **PI****