

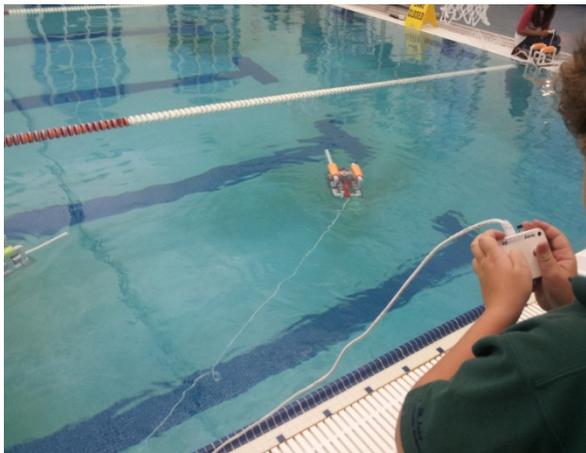
## Cancer Drugs from the Sea

**Principal Investigator:** Thomas I. Manning, Professor, Department of Chemistry

**Number of Undergraduate Student Participants:** 48

Undergraduate students in Marine Chemistry spent 9 days in the Florida Keys studying marine life and marine natural products. The students were addressing an important problem: producing economical and effective medicinal agents from the sea. Undergraduate students in Ocean Science studied deep ocean science and built remotely operated underwater vehicles (ROV) to retrieve sediment samples to test for biologically active compounds in the fight against cancer. They produced ten videos of their activities and presented their work in conferences and in publications (all posted on YouTube). They also incorporated work with ROVs into the Environmental Chemistry curriculum and mentored some middle school teachers on their construction. Recently supplies to build 40 ROVs were purchased for teachers in our area to use as a learning tool.

As a result of this project, five scientific milestones were reached. First, they developed the New Synthesis Approach which is a new Green technology method for synthesizing pharmaceutical agents. Next, the synthesis of a new copper (II) complex cancer drug was discovered. The complex was accepted by the National Cancer Institute (NCI) for testing and it advanced through three levels of testing, revealing better results than a chemotherapeutic drug called Taxol at the same concentration range. Currently, the researchers are awaiting word on whether the NCI will move the compound forward for animal testing. The "pharmaceutical aquaculture" approach has produced approximately 300 mg of an effective but very expensive cancer and Alzheimer's drug (bryostatin). While the scientific community has focused on synthetic, genetic, and live animal production techniques to make the high profile drug, they developed a new technique in which they farm marine bacteria. Thirdly, they developed/synthesized five new cancer drugs that were accepted by the National Cancer Institute for testing. A sixth drug was found but unfortunately was not accepted by the NCI. A patent application was filed to cover this new group of drugs. Next, they developed a new tuberculosis (TB) drug that was accepted by the Infectious Diseases section at the National Institute for Health (NIH) for testing. Lastly, the students developed a second copper based (potential) cancer drug, which was also accepted for National Cancer Institute (NCI) testing.



This research study and educational project advanced both science and practice and served as a cutting-edge educational tool for undergraduate students. It involved innovation in cancer drug synthesis, testing both scientific and educational hypotheses, and had specific measureable outcomes in both endeavors. Further, the Environmental Protection Agency (EPA) has nominated the two patent applications for the "Patents for Humanity" award run by the U.S. Patent Office.

## **Publications in Peer Reviewed Journals (and patent applications)**

### Publications in Peer-Reviewed Journals:

Baum, J.L., Booker, A.L., Burch, W.S., Capland, W.Z., DeBese, M.S., Griner, L.B., Guy, T.P., Jones, R.L., Murphy, M. M., Outlaw, M.D., Patel, J.I., Patel, P.N., Pyles, C.A., Rowe, S.B., Sampson, T. A., West, T.F., Williams, P., and Manning, T. (2012). Kinetics and thermodynamics of solvent evaporation. *Chemical Educator*, 17, 105-111.

Baum, J.L., Jones, R.L., Manning, T.J., Nienow, J., and Phillips, D. (2012). Hemoglobin aggregates studied under static and dynamic conditions involving the formation of nanobacteria-like structures. *Acta Pharm*, 62, 201-209.

Brackin, M.P., Connolly, C.M., Dunham, F.N., Dyson, C.M., Edwards, D.K., Feuser, T.W., Fix, K.M., Fulp, J.P., Fulp, S.R., and Lannon, C. R. (2010). A 24-hour marine science exercise: an up-close, personal and exhausting exercise with the ocean. *Chemical Educator*, 15, 387-391.

Cox, J., Ledwitch, K., Ogburn, R., and Thomas Manning. (2012). Paclitaxel: efficacy against oral squamous cell carcinoma. Invited paper; Mini-reviews in Medicinal Chemistry. In press.

Gokal, R., Hetzel, R., Konda, C., and Manning, T. (2012). Nomenclature system for carbon structures. *Fullerenes, Nanotubes, and Carbon Nanostructures*. In press.

Hetzel, R., Lovingood, D., Manning, T., Strouse, G., and Phillips, D. (2011). Production of fullerenes by microwave synthesis. *Fullerenes, Nanotubes, and Carbon Nanostructures*, 20, 99-108.

Manning, T., and Abadi, G. Successful nanotechnology projects. *Journal of Nano Education*. In preparation.

Manning, T., Hoover, W., Kean, G., Thomas, J., McLeod, B., Ogden, M., Wilbanks, W., Abadi, G., and Phillips, D. (2010). Computational and cell line studies of the iron-taxol complex: improving stability and water solubility. *Technology and Innovation*, 12(2), 153-169.

Manning, T., Jones, R., Little, B., Lannon, C., Kean, G., and Nienow, J. (2010). Development of a green technology approach to marine natural products synthesis: mineral-based microbial amplification system to make bryostatins. *Technology and Innovation*, 12(2), 171-185.

Manning, T.J., Ledwitch, K., Ogburn, R., Lasseter, L., Baum, J., Wylie, G., and Phillips, D. Copper Ion as a delivery platform for pharmaceutical agents. In preparation.

Manning, T.J., Ogburn, R., Ledwitch, K., Wylie, G., and Phillips, D. (2012). Structural studies of the copper (II) - quinine complexes. *Florida Scientist*, 75, 51-62.

Manning, T., Olsen, K., Hardin, L., Purcell, J., and Ogburn, R. (2013). Bulk of degradation of carbon nanotubes by ozone and nitric acid. In press.

### Patent Applications:

Manning, T. (2013). Green chemical process to produce natural products. United States Nonprovisional Utility Patent Application.

Manning, T.J., Ledwitch, K., Ogburn, R., Wylie, G., and Phillips, D. (2012). Copper ion as a delivery platform for pharmaceutical agents.

Presentations:

Baum, J., West, T., Etheridge, A., and Jones, R. (2012). Design, construction and performance of a ROV for sediment collection. 2012 Annual Meeting of the Florida Academy of Sciences, Tampa, FL, March 16-17, 2012. (Awarded best presentation in engineering section).

Baum, J., Booker, A., Burch, W., Capland, W., DeBese, M., Griner, L., Guy, T. et al. (2012). Kinetics and thermodynamics of solvent. Valdosta State University Undergraduate Research Symposium, Valdosta, GA, April 5-6, 2012.

Baum, J., Ledwitch, K., and Ogburn, R. (2012). Cancer drugs from the sea: a comprehensive view. Valdosta State University Undergraduate Research Symposium, Valdosta, GA, April 5-6, 2012.

Baum, J., Etheridge, J.A., Jones, R., and West, T.F. (2012). Designing and building remote operated vehicles to hunt marine natural products. Valdosta State University Undergraduate Research Symposium, Valdosta, GA, April 5-6, 2012.

Bishop, T.M., William, S.B., Desai, S.P., Etheridge, J.A., Farrow, J.K., Furtado, I.L., and Griner, L.B. (2012). Production of aza-fullerenes; synthesis, separation, and detection. Valdosta State University Undergraduate Research Symposium, Valdosta, GA, April 5-6, 2012.

Cox, J., Ledwitch, K., and Ogburn, R.N. (2012). Taxol: efficacy against oral squamous cell carcinoma. Valdosta State University Undergraduate Research Symposium, Valdosta, GA, April 5-6, 2012.

Darrah, J.M., Ford, A.C., Ledwitch, K., Marable, S., and Paulk, S.E. (2012). Improving efficacy of amine containing medicines: a computation approach. Valdosta State University Undergraduate Research Symposium, Valdosta, GA, April 5-6, 2012.

Davis, T., Ledwitch, K., Ogburn, R., Patel, J., Wyche, J. (2012). Synthesis of bryostatins and other natural products using a sand-based microbial system. Valdosta State University Undergraduate Research Symposium, Valdosta, GA, April 5-6, 2012.

Furtado, I., Rozier, R., and Tangar, A. (2012). A facile one-pot synthesis on chiral amines on silica. Valdosta State University Undergraduate Research Symposium, Valdosta, GA, April 5-6, 2012.

Ledwitch, K., and Ogburn, R. (2012). Copper (II) as a drug delivery mechanism taxol and quinine. Valdosta State University Undergraduate Research Symposium, Valdosta, GA, April 5-6, 2012.

Newham, C.B., and Patel, P.P. (2012). Measuring permeability of lipid membranes to h+ acids. Valdosta State University Undergraduate Research Symposium, Valdosta, GA, April 5-6, 2012.

Ogburn, R., and Patel, J.T. (2012). Cancer drugs from the sea. 2012 Annual Meeting of the Florida Academy of Sciences, Tampa, FL, March 16-17, 2012. (Awarded best presentation in chemistry section).

Ogburn, R., Ledwich, K., Baum, J. Green technology to produce drugs from the sea. National Green Technology Expo, National Mall, Washington D.C., April 27-29, 2012.

Parker-Hall, B., and Ogburn, R.N. (2012). Ionization suppression by cations in electrospray ionization-mass spectrometry in analysis of marine natural product. Valdosta State University Undergraduate Research Symposium, Valdosta, GA, April 5-6, 2012.

Patel, J., and Wyche, J. (2012). Cotton balls and mini aquariums for marine microbes. Valdosta State University Undergraduate Research Symposium, Valdosta, GA, April 5-6, 2012.

Ogburn, R., Ledwich, K., and Baum, J. (2012). Green technology to produce drugs from the sea. National Green Technology Expo, National Mall, Washington D.C., April 27-29, 2012.