

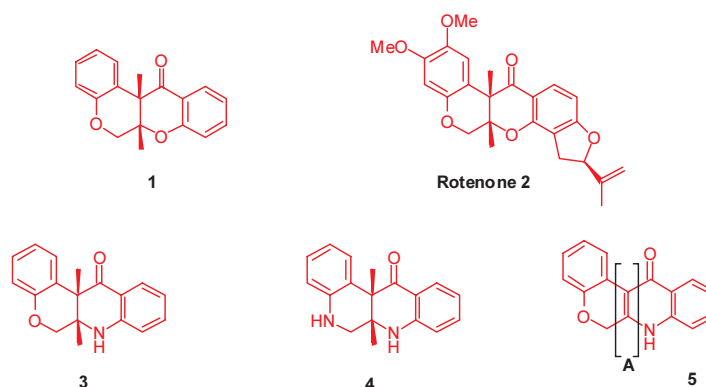


Principal Researcher:  
**Professor Yvette Jackson**  
 Department of Chemistry

Research Fellow:  
**Dr. Norman Townsend**

## The Synthesis of Azarotenoids - Nitrogen Analogues of Rotenoids

**R**otenoids are chemical compounds of general structure 1 (see diagram below), which are isolated from plants of the Fabaceae family. They exhibit a wide range of biological activity, but are most widely known as natural pesticides. Their low toxicity to mammals, and the fact that insects seem not to develop resistance against them, add to their demand as commercial pesticides. Rotenone 2 is the best known rotenoid.



This research project involves making compounds which are structurally similar to rotenoids but which have one or both of the ring oxygen atoms replaced by nitrogen atoms (compounds 3 or 4 respectively - see diagram above). Replacement of oxygen by nitrogen in some compounds has been known to result in increased bioactivity. The study seeks to synthesise compounds 3 and 4 and compare their biological activity with that of rotenoids. Various pathways have been explored, many of which need modification. Through the work of Mr. Andrew Morris, a graduate student in the research group, compound 5 was prepared. However, this compound needs to be altered at the position labeled A (see diagram above) before synthesis of compound 3 can be claimed.



The project has led to the development of some new procedures for carrying out oxidation reactions. The work has also led, serendipitously, to the synthesis of a nitrogen analogue (7) of the natural product eleutherol (6). Eleutherol is a coronary vasodilator which has been used in the treatment of heart diseases such as angina pectoris. Biological testing of compound 7 is currently being conducted. The synthesis of this compound has been outlined in an article submitted to the peer reviewed journal, *Heterocycles*. Other aspects of the work will also be published shortly. •

## Synthesis, Characterization and Reactivity Studies on Novel Oxo-centred Trinuclear Transition Metal Complexes to be used as Biological Models

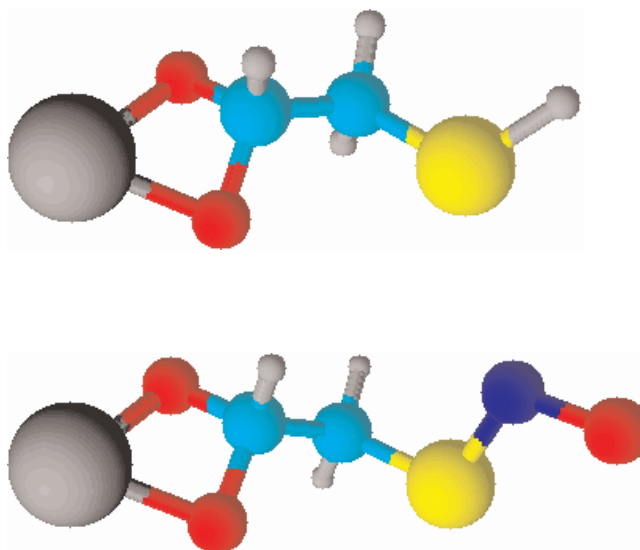
Principal Researcher:  
**Dr. Paul Maragh**  
 Department of Chemistry



The broad goal of this project is to synthesize new and stable compounds which are of biological relevance, particularly in the areas of uptake and transport of nitric oxide (NO). The release of NO in the body by larger carrier molecules causes the relaxation of the muscles in the walls of arteries. This results in the widening of the arteries and a reduction in blood flow, a necessary condition for open heart surgery. S-Nitrosothiols (molecules containing the -S-NO group) are well known as a reliable source and donor of NO, but most are considered unstable in aqueous solution, and are associated with only one molecule of NO.

The study seeks to synthesize stable molecules or complexes which are able to uptake and carry more than one molecule of NO. These carrier molecules would be based on a core structure involving transition metal ions and sulfur containing carboxylic acids. The synthetic route to these new carrier molecules will require modifications to known synthetic procedures, for some similar type compounds. The ideal core for these complexes would be the stable and non-toxic chromium (III) analogue, CrIII<sub>3</sub>-O. The study will entail detailed kinetics and mechanistic investigations on the uptake of Nitric Oxide by the new thio carboxylate complexes. Detailed studies of the transnitrosation process (i.e. the transfer of NO between molecules) between biologically relevant S-nitrosothiols and these new complexes, and between biological thiols and the NO-containing form of the new complexes will also be done. This will give an in-depth view of the intimate mechanism involved in the NO transfer process. After the finer details of the solution chemistry have been worked out, steps will be taken to do in vivo studies.

### A model of the nitric oxide uptake process.



A sulfur-containing carboxylic acid bound to transition metal ion (part structure)  
 Nitric oxide binding to the sulfur atom (part structure)

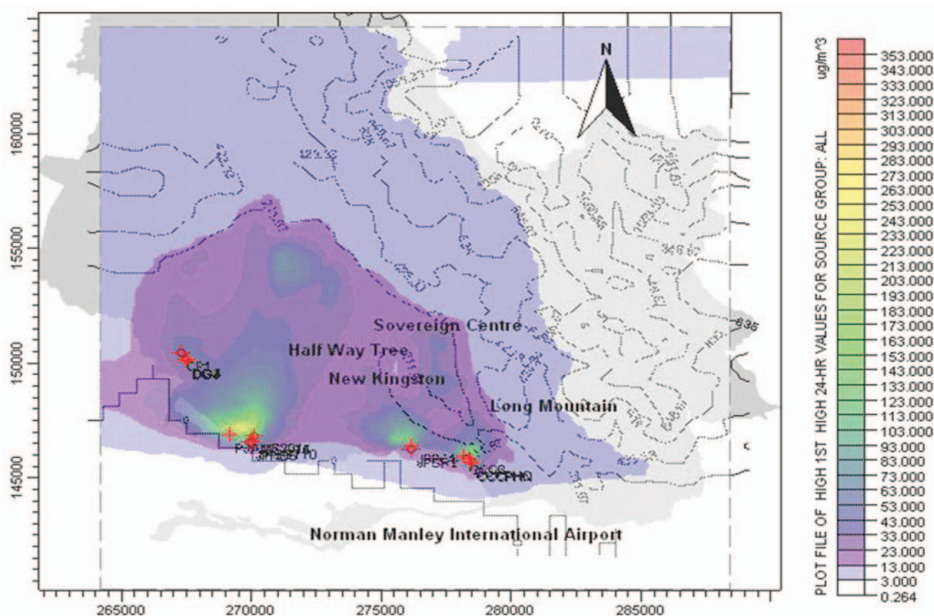
## Sustainable Air Pollution Measurement and Modelling for the Kingston & St. Andrew Conurbation



**Principal Researcher:**  
**Dr. Willard Pinnock**  
Department of Chemistry

**Research Fellow:**  
**Mr. Mark Richards**

There are signs that the incidence of respiratory illnesses are on the increase in the Kingston and St. Andrew Metropolitan area, and this increase has invariably been attributed to a perceived rise in the levels of pollution within the atmospheric environment. Among the factors suggested as being responsible for the rise in the level of pollution are, the significant increase in the number of motor vehicles on the roadways over the last ten years, and the activities of several industrial sites in the city, many of which are located upwind of offices and residential areas. However, attributing the rise in the incidence of respiratory illnesses to increased levels of pollution in the atmosphere is largely speculative, as there is no empirical evidence to support this claim. Furthermore, the cost of the equipment needed to obtain the data required for this analysis, is prohibitive, particularly for developing countries.



Showing AERMOD predictions of SO<sub>2</sub> over the City (from Fixed Source Emissions) for August 2005. Values are in gm<sup>-3</sup>

The aim of this research project is to investigate the feasibility of providing this data through the use of relatively inexpensive passive monitoring devices. These devices would be used along with computer modelling of the dispersion of pollution from known sources. Under the project, passive monitors for some gas pollutants such as SO<sub>2</sub> and CO have been developed, and existing monitors for gas pollutants such as NO<sub>2</sub> and O<sub>3</sub> have been adapted, in order to provide measured data. The challenging task of developing a passive monitor for particulate pollution has also been tackled, using a method which requires microscopic imaging, counting and sizing of particles deposited on exposed glass slides.

For the purpose of modelling, the computer software programme known as ISC-AERMOD, developed by the USEPA, was purchased. The programme is currently being used to predict the dispersion of gas pollutants emitted by the main fixed sources in the Kingston and St. Andrew metropolitan area. These sources include the electricity generating and cement manufacturing plants. Five years of meteorological data have now been obtained and formatted. In addition, land use and elevation data have been acquired and formatted to meet the input requirements of the model, and information was also gathered on the emission of pollutants from the main fixed sources. Analysis of the data obtained to date is currently in progress.

## Sustainable Air Pollution Measurement and Modelling for the Kingston & St. Andrew Conurbation



Research team deploying Passive Monitors at a test site.

The results of this analysis, thus far, show that the level of each pollutant present is largely within World Health Organization (WHO) standards. Only in few cases did the levels exceed WHO standards. Comparison between measured and preliminary model-predicted levels of gaseous pollutants suggests that whereas the model over-predicts to some extent, modelling can provide a useful basis for assessing the impact of any future development that may require the construction of new sources of pollution. •

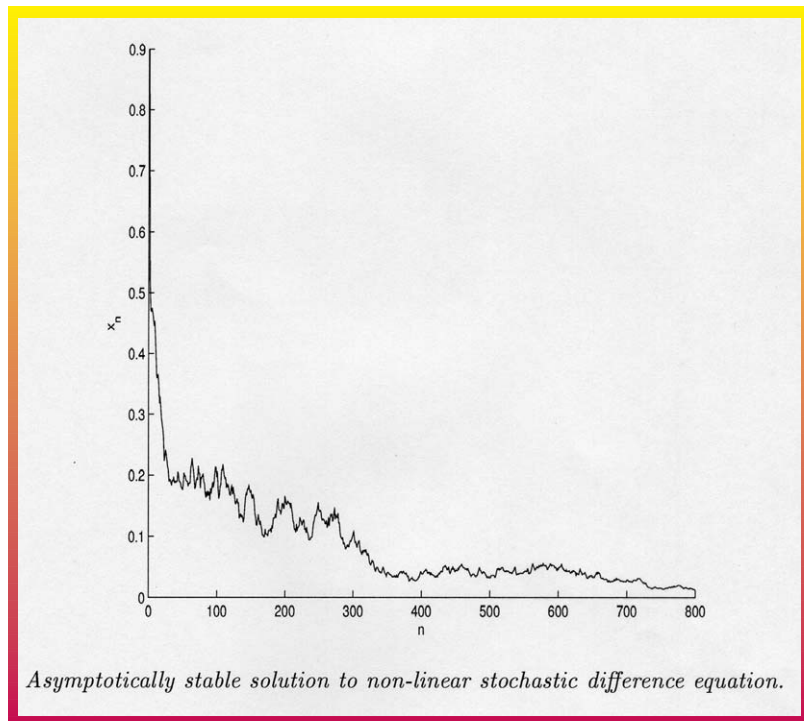
## New Generation of Mathematical Models with Applications in Biology and Finance



**Principal Researcher:**  
**Professor Alexandra Rodkina**  
Department of Mathematics and  
Computer Science

The project looks at analytical and computational methods of nonlinear stochastic dynamical systems with applications in finance, biology and noise-influenced dynamical systems in engineering. The project focuses on finance and biology together, since there are important features within each discipline that bear strong cross-relationships. Among the most important themes that arise persistently in finance and biology, are uncertainty and strong nonlinearities.

The main equations for modelling are nonlinear stochastic differential and difference equations with or without delays. Different types of stability of the solutions, their precise rate of convergence to equilibrium, stabilization and destabilization, oscillations and explosions are under investigation. The project is unified by common techniques: Liapunov's second method in stochastic equations, stochastic semimartingale convergence theorems, the large deviation theory of martingales and other methods.



Many theoretical problems, such as the non-explosion of solutions have practical applications in, for example, the fracturing of metal in solid mechanics, earthquake theory, and inefficient markets. Models of price evolution are based on stochastic delay equations. Stability of the solution in the presence of random noises is relevant to areas such as robotic control, modelling of simulated annealing, and learning in a noisy environment.

## New Generation of Mathematical Models with Applications in Biology and Finance

The project is being conducted together with M.Phil. students, Mrs. Alphonsa Mathew and Mr. Kirk Morgan, as well as, international collaborators. The project will provide comprehensive solutions to some existing questions in financial market models, population dynamics, noise-influenced dynamical systems and stochastic asymptotic theory. It will make substantial inputs to some new areas, both theoretical and applied.

A number of theoretical and applied problems are already under investigation. A paper on the stability of the discrete stochastic Ricker model without delays (population dynamics) was recently published. A paper devoted to the stability of the discrete stochastic equation describing the dynamics of isolated neuron under the influence of stochastic perturbations was recently accepted for publication. The results on the stability of the discrete stochastic Ricker model with multi-steps delays in environmental feedback were obtained together with Mr. Mathew and were presented at the Conference on Mathematics and Applications, held in Trinidad and Tobago, September 2006. The results on local stability for nonlinear difference equations together with simulations were obtained together with Mrs. Morgan. A series of results on almost sure stability, stabilization, and path wise non-exponential decay rates of solutions of scalar, nonlinear, non-homogeneous and polynomial type stochastic difference equation were published between June and September 2006 in the following publications:

- Berkolaiko G. and Rodkina A., Almost Sure Convergence of Solutions to Non-Homogeneous Stochastic Difference Equation. *Difference Equations and Applications*. 12:6 (2006), 535-553.
- Appleby, J. A. D., Mao, X. and Rodkina, A. On stochastic stabilization of difference equations. *Dynamics of Continuous and Discrete System*. (3)15, (2006), 843--857.
- J. A. D. Appleby, A. Rodkina and H. Schurz, Pathwise non-exponential decay rates of solutions of scalar nonlinear stochastic differential equation. *Dynamics of Continuous and Discrete System Ser. B.*, (4)6, (2006), 668-696. •

## Innovative Approaches to Science Education Delivery at the Secondary Level

**Principal Researchers:**

**Dr. Novelette Sadler-McKnight**  
Department of Chemistry

**Dr. Marcia Rainford**  
Department of Educational Studies

The overall goal of this project is to design and develop culturally appropriate curriculum materials for the teaching of science, in order to enhance students' understanding of some fundamental concepts in this area of study. The project will focus on the teaching of Chemistry in the short term, with the hope of expanding into other science subjects, over time.

Specifically, the project will examine:

- i. The factors which influence pupils at the secondary schools to learn and internalize chemical scientific concepts.
- ii. The ways in which aspects of the Jamaican culture and other environmental and institutional factors impact on the learning and teaching of chemical science.
- iii. The prevailing teacher training strategies and the manner in which they affect the ability to foster creativity, competency, and intellectual growth amongst teachers in regards to their ability to inspire and guide the learning process in the Jamaican environment.
- iv. The development of curriculum materials for the teaching of selected chemistry concepts based on the findings of items i to iii above.
- v. Procedures by which the findings from items i to iii can be used to influence programmes for the training and professional development of teachers of science in secondary schools.
- vi. A programme for further designing and building of prototype science teaching materials and equipment.

It is hoped that the findings of this study can be used to prepare chemistry teachers who can cultivate and nurture scientific interest, talents and creativity among our young people. It would also be used for the development of curriculum material for teaching selected concepts in chemistry that would strengthen hands-on teaching and increase student motivation. Such material would give consideration to the diversity in learning styles and life experiences within the context of the Jamaican culture. In addition, a postgraduate programme which focuses on the use of a more effective method for teaching and learning chemistry and by extension, science in Jamaica will be developed. It is also expected that the data gathered will contribute to the development of a National Science Education policy.

Preliminary work is now being undertaken, and this includes the development and the piloting of instruments. •

## Biodiversity Conservation in Jamaica's Remaining Natural Forests: Status Assessments and Impacts of Invasive Species

Principal Researcher:  
**Dr. Byron Wilson**  
Department of Life Sciences

Jamaica is globally recognized as a biodiversity hotspot because the island harbours a vast array of endemic species, many of which are threatened with extinction. The overriding threat to Jamaican diversity is habitat destruction, and make no mistake about it, many species will likely go extinct unless the uncontrolled cutting of trees for agriculture and charcoal production can be reduced or eliminated altogether. Unfortunately, all indications are that the problem is getting worse, not better. Indeed, Jamaica's currently expanding population is putting increasing pressure on the island's natural resources, suggesting that Jamaica could follow in Haiti's footsteps, with the virtual annihilation of all natural habitats.

A major activity being undertaken by the researcher concerns on-going work in the Hellshire Hills that seeks to ensure the persistence of the critically endangered Jamaican iguana.



Cut lignum vitae trees (these had hollow centres, and hence were cut and left since they were not of value for carvings)



Radio tagged Jamaican iguana in the Hellshire Hills

Illegal tree cutting, primarily for charcoal production, has long been a problem in Hellshire; however, the problem has recently become a crisis that threatens the very existence of our research programme. Large commercial charcoal kilns are now operating well within the core iguana conservation zone, and tree cutters have now come within several hundred metres of the iguana's only known nesting sites. Disturbingly, a primary target of the illegal tree cutters is Jamaica's National Flower, the lignum vitae. Reports indicate that the lignum vitae is now being harvested for the production of wood carvings to be sold to tourists on the north coast; that tree cutters are apparently accessing central Hellshire all the way from Trelawny suggests that commercial extinction of the lignum vitae has already occurred in dry forest areas of northwest Jamaica. Because these tree cutters threaten not only the iguana's habitat but the safety of iguana researchers, a new thrust of this research work concerns advocacy for forest protection, that is, the enforcement of tree cutting regulations.

Surprisingly, the lignum vitae is not protected by any national-level laws, only by CITES, which is an international agreement prohibiting the trade in endangered plants and animals. A first step towards saving wild populations of lignum vitae, and by extension, the forest ecosystem in general, would be to make visitors aware that it is illegal to take any lignum vitae products out of the island. The strengthening of national legislation is also warranted, and specifically,



## Biodiversity Conservation in Jamaica's Remaining Natural Forests: Status Assessments and Impacts of Invasive Species

the Wildlife Act of Jamaica should be expanded to include *lignum vitae* as a fully protected species. So, because of the major impact of tree cutting on the iguana's habitat, our survey focus has expanded from the iguana to include a consideration of *lignum vitae* distribution and threat patterns in the Hellshire Hills.



Rick van Veen about to have his banana stolen by an iguana, at camp in the Hellshire Hills

Other recent research and conservation activities have included a radio telemetry study focused on the home range and habitat selection patterns of female iguanas, and continuing efforts to reduce the impacts of alien invasive species. Between June and October 2006, radio transmitters were attached to post-partum female iguanas that were using the known, communal nesting areas in central Hellshire. The primary objective was to determine the non-nesting season habitat use of these individuals; such information is critical to formulating strategies to preserve the most important iguana habitats. Efforts aimed at controlling non-native mammals have expanded to include a more focused removal campaign targeting wild pigs, which represent a major threat to the nests of endangered species such as iguanas and sea turtles. This work has also resulted in the collection of 30 pigs for an analysis of intestinal parasites. That study is led by Professor Ralph Robinson of the UWI, Mona Campus' Department of Life Sciences, and is being conducted primarily by postgraduate student, Chinedu Okoro.



Wilson with a live wild pig

Biodiversity conservation is a challenge in Jamaica, and projects can take unexpected turns that result in unanticipated avenues of exploration. This project is a good example of those challenges, as our initial lizard-focused efforts have now led us to considering endangered trees and wild pigs. •