From uncommon connections in science and political science to the common sense of the distribution of quarks in nucleons and to the science of scents emitted by phytoplankton, the topics covered in this issue of Quest are simply fascinating. The work described in this magazine is at once highly technical, the result of years of education and research, and totally comprehensible to the reader. Each topic has an extremely practical application along with strong intellectual components. Each topic touches our lives in a meaningful fashion.

Most of us have known someone who was injured in a car crash. We have all drawn a deep breath as someone swerved in front of us unexpectedly and slammed on the brakes. Sebastian Bawab’s research in the area of biomechanics, integrating the mechanical and biological aspects of living systems, has a very practical application. He is designing vehicles which will reduce and prevent injury to the passengers. When we hand the keys to our teenaged progeny, we will all thank scientists like Professor Bawab for improved safety conditions.

Every time they tell us to turn off our wireless devices on the airplane, I have always wondered why. Now I know, thanks to Linda Vahala’s work. She explains how the electromagnetic waves emitted by these devices are detected by the radio receiver antennas installed on airplanes and why they can interfere with the planes’ GPS and VHF systems.

Ever since scientists introduced us to quarks, I have also wondered about the patterns of their distribution and their movement inside nucleons. Each part of the atom has a kind of choreography it follows as it moves and reacts to other particles. Now, thanks to Anatoly Radyushkin, we know that the distribution of quarks can be described by a set of mathematical functions. Moreover, we can now obtain a three-dimensional snapshot of the inner structure of the particles comprising the nucleus of the atom. Where is the practical application, you ask? Well, aside from the fact that we will all sleep better knowing this, we have gained access to another stepping stone in the search for meaning and the key to existence. Nothing could be more valuable, more exciting, more promising for our future.

If the world were a jigsaw puzzle, the pieces representing China and India would be among the largest in terms of land mass, population density and economic potential. Shaomin Li and Anil Nair, from our business management department, and Jie Chen, from political science, agreed to discuss for readers of Quest the relationship between the political and economic processes in these very different countries. Understanding these nations is essential in a global marketplace where we compete for the same jobs and products. We have much to learn about them and from them.

If the article on China and India evokes the fable of the tortoise and the hare, the article on our new Engineering and Computational Sciences Building refers to the fabulous shell, the housing we just completed for our researchers. We are extremely proud at Old Dominion University of our environmentally friendly, “green” campus. This new building is our latest initiative and includes the collection of water from the roof to water the surrounding garden, special blinds to allow light but not heat from the sun, special design to disperse outside light throughout the building, motion sensors on the lights, and energy exchange from ground water to run the generator. Fitting in with other environmentally conscious initiatives in teaching, research and campus management, this building is a practical lesson for the students of the future. The campus itself is a laboratory!

Continuing in the environmental mode, we have the fine research conducted by Margaret Muluhand and Greg Cutter who are looking into why phytoplankton produce hydrogen sulfide. When I waved goodbye to these researchers as they sailed off on a recent research voyage aboard a trim vessel filled with test tubes, computers and graduate students, I was inspired by the life of an oceanographer as I imagined sunsets over smooth seas. I did not think of weathering storms, seasickness, or braving the noxious smell of microscopic plants from the ocean’s surface waters. Yet, this is what these researchers did in their quest to track the presence of trace metals in the ocean and to better understand our global climate.

Irish poet W.B. Yeats wrote, “The fascination of what’s difficult/ Has dried the sap of my veins, and rent/ Spontaneous joy and natural content/Out of my heart.” I beg to differ. Quest has fascinated me with difficult topics and made them passionately interesting and genuinely accessible. Of course, Yeats did not have the privilege of reading either this or previous issues of Quest! Had he done so, I believe he might well have written, “The fascination of what’s difficult/ Illumines my every waking thought rendering spontaneous the joy of understanding nature/ and the inestimable boon of discovery.” Eureka!

Sincerely your,
Roseann Runte
President
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The tortoise and the hare?

A tale of two countries in their pursuit of economic development

Quest recently interviewed Shaomin Li and Anil Nair, from the College of Business and Public Administration, and Jie Chen, from the College of Arts and Letters, who are conducting research on recent economic reforms in China and India.
What prompted you to undertake a study comparing economic reform in China and India?

Nair: Several factors. To begin with, the economic adventure these two countries are on is truly exciting. If they are able to implement successfully their economic reforms it may improve the lives of millions of people. Together they represent two-fifths of the world population. In addition to the apparent political and economic implications, from a business perspective we want to understand the implications these reforms have for American companies and managers. Finally, the two countries have different political systems, and partly because of it, have had very different approaches to the reform process that also shows up in their achievements. Simply put, China, which lacks property rights protections and is a country where the Communist Party has a monopoly on power, achieved a higher economic growth and larger market than India, which has representative democracy and the rule of law. So overall, what is going on is really intriguing and interesting.

Chen: This is the paradox we try to examine through our research. There have been instances in the past where authoritarian regimes have achieved high rates of economic growth, such as Chile, South Korea, and Taiwan in the 1970s and 1980s. Yet, it is mostly countries with democratic regimes that adopted free markets that have consistently delivered high economic development. What we try to do in our research is systematically identify the factors that contributed to the differential pace of the reforms in China and India. A better understanding of what made the two countries differ in their rate of economic reforms will not only add to our knowledge of this area, but also help governments and businesses in other countries undertaking similar reforms.

Quest: Your research team seems unconventional. Political science and business management as two separate disciplines usually do not mix. What prompted two business professors to work with a political scientist?

Li: Yes, academic studies tend to be very parochial. One advantage of working at ODU is having the opportunity to conduct such interdisciplinary research. Needless to say, a lot of developments in the world do not fit neatly into single academic disciplines. Economic reform is one such area. Its formulation and implementation involve social, cultural, economic, political and legal issues. Thus, it requires an interdisciplinary approach to study. Anil specializes in strategy and management, Jie contributes his knowledge on the politics of reform, and my expertise in international business provides another leg of the stool. Our diverse backgrounds allow us to develop a richer and more comprehensive analysis of the issues.
Dr. Li, can you talk about some of the recent reforms in China?

Li: Summarizing China's reform of a quarter of a century is not an easy task. The Chinese Communist Party won a 10-year civil war in 1949, and has been ruling China ever since. For nearly the first 30 years after the war, the country was ruled by Mao Zedong, whose extremely revolutionary policy drove China into absolute poverty. In 1976, when Mao died, China was on the verge of a total collapse. The whole country was longing for change. Deng Xiaoping, a practical communist leader who succeeded Mao, seized the opportunity and started economic reform. However, Mao's revolutionary legacy was very strong and any move toward a free market could be termed as "capitalistic," and easily killed on ideological ground for being "anti-socialism." Deng and his associates designed two strategies that proved to be very clever. First, he downplayed the communist ideology and restored the mercantile tradition in China. Two of his most famous dogmas are: "Getting rich is glorious" and "it doesn't matter whether it is a black cat or a white cat; as long as it catches mice, it is a good cat." Second, he allowed foreign investors in China, who not only brought in capital, but also capitalist ways to every aspect of social life: economic governance, business culture, free competition and Western lifestyle. Throughout the period, the Communist Party maintained tight political control and crushed any opposition and challenges, while it allowed people much personal and economic freedom, as opposed to political freedom. This result was phenomenal: from 1978 to 2002, personal income increased 22-fold and foreign direct investment increased from virtually zero to $55 billion. However, in terms of building the infrastructure of a mature market economy, China has a long way to go. Many industries still have high entry barriers, the Chinese currency is not convertible, protectionism is strong, protection of property rights is very weak, and the legal system is not independent and transparent.
Dr. Nair, can you offer an overview of what has happened regarding India's economic reform and development?

Nair: Roughly around the same time that the Chinese Communist Party seized power, India achieved independence from British rule in 1947. Like China, India was a large developing nation seeking its own path of development. However, the similarity stops here. India's quest for development is different from China's in almost every aspect. Although (Mahatma) Gandhi is best known as the founding father of modern India, it was (Jawaharlal) Nehru, another founding figure of modern India, who shaped the developmental path of India. Nehru steered India toward a "Fabian socialist" policy, which advocates the state's playing a dominant role in the economy while maintaining a minimal private ownership. However, the legacy of the British rule left India a well-developed common law system that, according to political economists, provides the best protection of property rights among all legal systems in the world.

From 1950 to 1980, India's economic growth was slow due to the heavy burden of state ownership and bureaucracy, but steady and better than China's under Mao. In the mid-1980s, the Indian leadership began to initiate some reform measures, but they were halfhearted at best because, unlike China, India was never under strong internal pressure, as was China, to start economic reform. Soon a corruption scandal erupted and lack of popular support aborted this first attempt. In the early 1990s, a severe foreign currency reserve crisis, triggered by the Gulf War and the collapse of the Soviet Union, pressured the leadership to undertake a second, and more serious, effort to reform the economy. Despite frequent impasses in the parliamentary democracy, where many small parties could use their votes to swing policies, the reform has produced substantial results and caught the world's attention. Deficits are being cut; privatization is well under way; markets, including the financial market, are more open; tariffs are substantially reduced; and foreign exchange rates float freely.

India is becoming a global hub for software development and is currently one of the largest destination countries for outsourcing. Buoyed by these achievements, the Bharatiya Janata Party-led coalition government decided to hold the national election almost six months ahead of schedule to exploit the perceived economic boom. But the plan backfired. The incumbent BJP was voted out by the rural voters who, according to many analysts, were left behind by the economic reforms.

From the standpoint that academic studies are supposed to extract a general pattern from seemingly random events and offer explanations for their findings, what do you make of the two stories?

Nair: Most studies on India and China have stayed at the storytelling level and failed to offer a general pattern on what determines the pace of reform. In order to systematically analyze the two countries' reform experience, we developed a model using institutional theory, a powerful framework to explain how and why organizational, social or economic practices get taken for granted, persist and change. Our model first examines the initial conditions of the reform. The degrees of crisis that triggered reforms in these countries are very different. The economic crisis in Mao's China was deep and widespread, which made the reform more urgent and easy to show positive results. In contrast, India has never faced such a devastation; the source of crisis that triggered its reform was external (foreign currency reserve), and the expected results of the reform were incremental, making India's reform less radical and more hesitant.

The second issue we identify as important are the risks and incentives faced by the political leaders. Non-democratic regimes do not need to worry about opposition or public opinion – at least while they firmly control the power. Thus, they can more effectively and efficiently design and carry out reforms. In a parliamentary democracy such as India, the incumbent always worries about the support from other parties and the voters when designing and carrying out reforms, thereby sometimes reducing their effectiveness and efficiency.
perplexing question on the research agenda of social science has always been a central yet Chen: The relationship between economic development and also brought capitalistic institutions. In the case of India, the need for foreign investment was less urgent, since there was a domestic capital market and market institutions existed before the reform. The reliance on foreign resources gave China a jump-start.

The final element is institutional arrangements of the two countries. Institutions are the rules by which economic activities are regulated. They include “hard,” or formal, rules, such as laws and regulations, and “soft,” or informal, rules, such as conventions and customs. In order for institutions to function effectively and efficiently, the hard and soft rules must be consistent. For example, a pro-market law coexists with a pro-market culture. Economic reform can be viewed as institutional change, namely, changing anti-free market rules, such as state monopoly, to pro-free market rules, such as free trade policy. In China, a pro-market culture, or soft rules, was being rapidly established by Deng with the influx of capital and lifestyle from the West, consistent with the establishment of hard rules that are pro-market. In India, the anti-foreign culture, as a result of the long-time British rule, and the Hindu culture that repudiates material pleasure may have hindered the reform.

Another aspect is that China was establishing market-oriented institutions from an institutional vacuum, which is relatively easier than India’s effort to incrementally improve existing market institutions. Contrary to the common belief, many of India’s market rules are better developed than China’s, such as the foreign exchange system and the rule of law.

These four elements, to a great extent, determine the pace of economic reform in the two countries. Furthermore, these elements do not act in isolation. They form the so-called “political economy” of a country. China achieved high economic development while maintaining a non-democratic political system and India seems to have gone down a different path.

Quest: Perhaps a more intriguing issue is how China and India’s political systems affect their economic development.

Nair: In terms of the effect of economic development on political change, our study shows that economic development will promote a political democratization in China in a top-down manner, even though the political democratization there has so far lagged behind economic development. Moreover, we believe that the economic reforms result in political changes mainly through new institutions, both formal and informal, that are established by the reforms.

Quest: What are the political ramifications of the economic reforms in China?

Chris: This is a very important question for both China and India. As for the impact of political democracy on economic development, the findings from our study suggest that a democratic system in a developing country is less efficient than an authoritarian system in initiating a major economic reform that could lead to high-speed economic development. This is because in a democracy such as India, a major policy to initiate economic reform is often constrained and dragged by multiple sociopolitical forces. In an authoritarian society such as China, this kind of policy is often made swiftly by a small group of political leaders who are not constrained directly by the public. Yet, after the initial stage of economic reform, a democratic system tends to have a more positive and
lasting effect on economic development than an authoritarian system, since the former is more likely to encourage, protect and institutionalize free competition and property rights. These findings explain why, in the early stage of economic reform, India is behind China, and it is quite likely that India will be ahead of China in the long run unless there is a major change in the nature of each country’s political system.

Quest: You have provided some thoughtful insights about economic reforms in these countries, and with regard to their different experiences, the story of the tortoise and the hare comes to mind. Is there a comparison to be made here?

Li: This is an interesting, but tricky, metaphor. As always, reality rarely conforms to popular folklore. We find that China has been racing ahead like a hare without frequently taking naps, while India, on the other hand, has been lumbering ahead like a tortoise, taking frequent pauses because of the inherent delays in building consensus in a democratic system. However, China’s fast economic pace has suffered major setbacks, due to political crises such as the 1989 Tiananmen Square demonstration. We believe the gap between the political structure and economic development will generate punctuations or pauses in the future in China. Because India’s political system is aligned with its economic policies, it should continue to lumber on without major pauses. Yet, we qualify our observation by noting Yogi Berra’s dictum that “prediction is difficult, especially about the future.” The purpose of our study is aimed more at understanding the relationship between the political and economic factors and their interplay in economic reform, than of predicting the exact pace of the reforms in the two countries. Such an understanding will help policy makers and corporate executives in formulating their reform and business strategies.

Old Dominion faculty members Jie Chen, from the College of Arts and Letters, Shaomin Li and Anil Nair, from the College of Business and Public Administration.
Exploring Ways to Prevent Injuries During Vehicular Crashes

By Elizabeth S. Cooper
Dale Earnhardt’s death in a last-lap crash during the 2001 Daytona 500 devastated millions of racing fans, but an Old Dominion University faculty member believes the NASCAR driver could have survived the accident had he been wearing a specially designed helmet.
Crashworthy Vehicle Design

Bawab is the first Old Dominion mechanical engineer to pursue a research focus in biomechanics, which integrates the mechanical and biological aspects of living systems. In biomechanics, engineering methods are used to measure and understand how the body moves, how movement is controlled and how forces act on biological tissues during movement. Bawab’s research focuses on crashworthy vehicle design or a vehicle’s capability to prevent injury to the occupants during a collision. In a collision, occupants collide against the vehicle’s interior as they are subjected to forces that can lead to injury. Vehicles that are crashworthy are able to disperse those forces over a large period of time and distance as possible and direct those forces to parts of the body that are better able to survive them. The best-known crashworthy features include seatbelts and airbags. Bawab and his students are also analyzing the brain’s behavior when it is subjected to force emanating from a rear-end collision. With this study, they are comparing brain injuries from rear-end collisions.

Brain Injuries from Rear-End Collisions

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Knee Bolsters and Hip Injuries

Bawab and his students are also studying the relationship between knee bolsters and lower extremity injuries. Installed under vehicles’ dashboards and glove compartments for about two decades, knee bolsters are basically plates covered with foam. Although they have reduced knee fractures, the bolsters have also led to an increase in hip fractures or dislocations during a collision. Bawab’s recent research studies the effect of placing an airbag in the knee bolster, asserting that airbags would protect motorists and front-seat passengers by redistributing the forces against their bodies and helping to maintain them in upright positions. An airbag used with knee bolsters would be smaller than a standard-size airbag but would still be large enough to cover the area of impact. Using the MADYMO software to design the airbag and simulate its effect on the hip, femur and knee joint loads during frontal collisions, Bawab has determined that airbags would result in fewer hip injuries.

Brain Injuries from Rear-End Collisions

Bawab and his students are also analyzing the brain’s behavior when it is subjected to force emanating from a rear-end collision. With this study, they are comparing brain injuries from rear-end collisions.
to the brain during all different sorts of sports impact such as boxing and football.

Head and neck injuries, also known as whiplash, can occur as a result of gravitational forces on the headrest during a collision. “We’re trying to study the effect of the headrest on whiplash in a rear impact to see what type of impact gravity would have,” Bawab explains. “We’re using various types of headrests to see if a person should sit in a normal position or if it is riskier if he’s leaning forward.”

Making the A-Pillar Safer

Bawab and colleagues Gene J. Hou, professor of mechanical engineering; Steven A. Hans, a Ph.D. student in mechanical engineering; and Michael L. Woodhouse, a retired Norfolk State University professor, additionally are embarking on a new frontier in crashworthy vehicle design by reconstructing a vehicular roof deformation (crush) using prescribed nodal motion. They prescribe the nodal displacement of the roof being crushed during a rollover to determine how much the roof was deformed, what it looked like before the impact and how the roof deformation took place in a rollover. This is an extremely uncertain phenomenon because the compartment intrusion into the passenger area creates all types of injury that are typically very difficult to predict. The researchers use a FARO Gold Arm digitizer to scan the actual crushed vehicle and model of it. These two surfaces are meshed and correspondingly mapped. The roof deformation is then prescribed as a function of time where it starts at the non-deformed roof and ends at the deformed one.

“We want to see how the collapse of the roof affects the motion of the occupants and the types of injury that can typically occur,” Bawab says. “In the case of unbelted occupants, we should be able to determine the exit point out of the vehicle compartment.”

He adds that the various elements to make a vehicle more crashworthy must work in tandem to best protect the vehicle’s occupants. “People think if you have an airbag, you don’t need a seatbelt, but you can still have injury to the neck. The lap belt alone is also extremely dangerous, especially for children. They can die of liver laceration.”

Working with crashworthy vehicle design has made Bawab more safety conscious when he gets behind the wheel or even when he’s climbing into one of the passenger seats. “As an adult, I never wore a seatbelt in the back seat because it is not the law,” he says, “but I’ve studied enough simulations that I wear it automatically now.”
rowing up in the former Soviet Republic of Kyrgyzstan, Anatoly V. Radyushkin was fascinated with geography and dreamed of one day exploring remote, uninhabited islands. Then his uncle set him on the path that would eventually become his career and gain him international recognition.

“I was reading books about sea adventures and remote countries,” recalls Radyushkin, eminent professor of physics at Old Dominion and senior scientist at the Thomas Jefferson National Accelerator Facility. “My uncle came from Moscow to visit our family and looked at my maps. He told me that all those islands were already discovered, so if I wanted to discover something new, I should go into physics.”

To further encourage his nephew, Radyushkin’s uncle sent him a set of advanced physics books for children. Radyushkin was hooked. “Since the age of 12, I knew I wanted to be a theoretical physicist,” he says, adding that children in the former Soviet Union were required to study physics beginning in the sixth grade.

Entering Moscow University at the age of 17, he received his master’s and doctoral degrees in physics. During his final year at the university in 1974, Radyushkin was working on his thesis at the Joint Institute for Nuclear Research when his adviser, Anatoly Efremov, introduced him to quantum chromodynamics (QCD), a theory that would lead him to cutting-edge research and to the United States. QCD is a fundamental theory that addresses the core structure of nucleons—the protons and neutrons that comprise the nucleus of the atom—according to their more elementary components. Nucleons are made up of quarks and gluons, which are elementary particles known as partons.

“The theory of quantum chromodynamics was proposed as an alternate explanation of strong interactions,” Radyushkin recalls. “We were all excited about the new theory. We were exposed to new ideas and developments and began to work with quarks. When something is already established, it is not easy for students to participate in it, but when something starts, there are many new directions in which to go.”
Breaking New Ground with Generalized Parton Distributions

Thirty years after he first delved into quantum chromodynamics, Radyushkin is an internationally recognized nuclear theorist and a pioneer in the development of generalized parton distributions (GPDs). GPDs are a set of mathematical functions describing how quarks are distributed and move inside the nucleon. Radyushkin’s research allows physicists to probe the quark and gluon structure of the nucleon, which is the fundamental building block of matter. Radyushkin explains, “The nucleon gets energy from the inner structure of the particles comprising the nucleus of the atom. Physicists can use GPDs to plot the location and momentum of the quarks and gluons inside a nucleon.”

“These guys are always moving,” Radyushkin says of the quarks. “GPDs describe the velocity with which quarks are moving.” The mathematical functions of GPDs are being studied with data obtained from electron-neutron collisions in which physicists use an accelerator to propel a beam of electrons to speeds approaching that of light. When the electrons hit a target, many of them collide with particles in the nucleus of atoms, scattering the particles. GPDs can be applied to those collisions that result in a scattered electron, proton, and a photon, known as “deeply virtual Compton scattering.” This application provides information about the structure of the nucleus before the collision.

Radyushkin’s interest in GPDs started in 1996 after he heard Xiangdong Ji of the University of Maryland discuss GPDs at a conference. Ji contended that “deeply virtual Compton scattering” was the best tool for a more detailed study of the structure of nucleons. Charles E. Hyde-Wright, professor of physics at Old Dominion and a member of the university’s experimental nuclear physics group, Bogdan Wojsekhowski of Jefferson Lab, and Alan Nathan of the University of Illinois-Urbana-Champaign, were planning to investigate Compton scattering, and Hyde-Wright urged Radyushkin to apply quantum chromodynamics to study the phenomenon.

“I was very enthusiastic about it,” Radyushkin recalls. “He attracted my attention to Compton scattering a few years before 1996, but I had no idea how to proceed. Then I heard Ji’s talk and realized that quantum chromodynamics can be applied to Compton scattering.” Radyushkin and other theorists derived a set of formulas for GPD to predict possible outcomes depending on how quarks composed the nucleon structure. The lab’s accelerator is testing his hypothesis. If the accelerator’s high-energy electron beam identifies quarks and isolates them to determine how they cause protons and neutrons to spin.

“Or our accelerator hits nucleons in bulk matter,” Radyushkin explains. “The nucleon gets energy from the electron and releases energy in the form of one photon. Normal microscopes use light, i.e. only photons, to look deep inside the matter. Electron microscopes study the matter by scattering electron beams, i.e. they use electrons only. The virtual Compton scattering is a combination of an electron microscope and a conventional microscope because both electrons and photons are detected in the final state. This combines the strengths of two ways of study. We observe the structure of the nucleus using tools to decipher the internal structure of the nucleon.”

As one of the first physicists to study GPDs, Radyushkin says he was “preparing for this business starting from the time I was a graduate student.” One of his first research papers on quarks, written in 1977, delineated some important ingredients necessary for developing GPDs. “At the time, there were no accelerators which could really approach the full content of GPDs,” he notes. “There were some studies on limiting cases where we studied the simpler functions of quarks. I was lucky enough that the mathematical tools necessary for the development with GPDs were very similar to what I started to use in 1977.”

Virginia Outstanding Scientist of the Year

Radyushkin’s work with GPDs earned him recognition as the Virginia Outstanding Scientist of 2004. The award honors scientists who recently contributed to basic scientific research that extends the boundaries of a field of science. Radyushkin is the third Old Dominion faculty member to receive this award, following in the footsteps of Cynthia Jones, professor of biological sciences (2003), and Daniel Sonenshine, professor of biological sciences 1994.

Despite his own efforts to advance GPDs, Radyushkin emphasizes that the Outstanding Scientist Award is not exactly a personal honor. “Many people from the university and the lab participate in this reward,” he says. “This award is not only for me, but also for my collaborators and friends. This is a result of the combined efforts of Old Dominion, other local universities and the Jefferson Lab to build the theory group. It would be impossible without important decisions by Old Dominion to make a major contribution to develop the theory group at Jefferson Lab.” Old Dominion is a member of the Southeastern Universities Research Association, a consortium of more than 60 universities which operates Jefferson Lab on behalf of the U.S. Department of Energy.

Old Dominion’s Partnership with Jefferson Lab

The groundwork for Radyushkin’s relationship with Old Dominion and Jefferson Lab was laid in 1984 when he met Franz Gross at a conference in Georgia, then a republic of the former Soviet Union. Gross was the key theorist forming the scientific program for the Continuous Electron Beam Accelerator Facility (CEBAF), the name Jefferson Lab used when it first opened. Six years later, Radyushkin was in the
United States to speak at an international conference in Cambridge, Mass. Gross suggested he give a seminar at CEBAF, where he met Nathan Isgur, CEBAF’s first nuclear particle theory group leader. Isgur, who later became the chief scientist at Jefferson Lab, was especially interested in Radyushkin’s work in quantum chromodynamics and realized that the lab’s accelerator was the perfect venue in which to test his ideas. In 1992, Radyushkin accepted a joint position at Old Dominion and the lab.

Today, in addition to Radyushkin, there are four other nuclear theorists at Jefferson Lab who hold joint positions with Old Dominion: Ian Balitsky, associate professor of physics; Winton Roberts, professor of physics; Rocco Schiavilla, professor of physics; and J. Wallace Van Orden, professor and eminent scholar of physics. Radyushkin and Balitsky focus their research efforts on GPDs.

“There’s been a big effort on the part of Old Dominion University to create a nuclear theory and experimental group which is one of the largest in the country. Together, we are a rather diversified group, and this is very important,” Radyushkin says. “When you do something new, you never know if it’s correct or wrong. You should try it on somebody who would criticize you. That’s a good characteristic of a theorist. If somebody always agrees with you, he should not be trusted.”

Jefferson Lab recently obtained support from the U.S. Department of Energy for a $225 million upgrade that will double the energy of its central electron accelerator from 6 billion to 12 billion electron volts and add a fourth experimental hall to the facility. Radyushkin says the upgrade will lead the lab in new directions: further study of GPDs, and advanced study of the physical confinement of quarks and how the “glue” holding them together works. “You can’t separate quarks from each other,” he explains. “They are glued to each other. You can pull them, and the glue becomes a string that contains energy. If the string is long enough, it breaks, and the released energy generates pairs of quarks in the form of usual particles.”

As for GPDs, Radyushkin says the facility upgrade would allow additional experiments. “What’s easy to do theoretically is difficult to test with experiments. Every experiment requires big manpower preparations. There’s a line of people that’s like several years waiting to do experiments here. There are several proposed experiments at Jefferson Lab on GPDs, and that’s one of the priorities for future studies at the lab.”

The theory group at Jefferson Lab is all about fundamental science. “To make good fundamental science, you should not start with thinking about applications,” Radyushkin says. “That’s for future generations to think how our results will be practically applied. To be able to use something, you should know its structure. If you don’t know the structure of a nucleon, how can you use it? We are on the frontier of nucleon study.”

Even without the upgrade, Radyushkin asserts that Jefferson Lab is the top facility of its kind in the world, with no visible competitors. “You cannot build installations like that in one year. This was an opportunity for Old Dominion to be associated with an internationally prominent organization. Jefferson Lab understands the significance of support from Old Dominion University.”

“To make good fundamental science, you should not start with thinking about applications. That’s for future generations to think how our results will be practically applied.”

—Anatoly V. Radyushkin
How to Welcome Wireless Devices in the Friendly Skies
You’re sitting aboard a 737 awaiting takeoff when the pilot announces that the aircraft cannot go anywhere because someone’s portable electronic device is wreaking havoc with the navigational equipment. Passengers begin to check their laptops, cell phones and other electronic devices, and you’re shocked to discover that your cell phone, which you had accidentally left on, is the culprit.

ELECTRICAL AND COMPUTER ENGINEERING PROFESSOR STUDIES HOW WIRELESS COMPUTERS INTERFERE WITH AIRPLANE COMMUNICATION SYSTEMS

BY ELIZABETH O. COOPER
Airplanes
Wave Propagation On Measuring Electromagnetic

The research conducted by Vahala and a group of Old Dominion graduate engineering students is especially pertinent in an age where an increasing number of passengers want to use wireless technologies while flying the friendly skies. While cell phones, wireless local area networks and other portable electronic devices (PEDs) have improved travelers' accessibility and productivity, they can also inadvertently cause electromagnetic interference to aircraft navigation and communication radio systems, thereby potentially endangering all on board. According to Vahala, PEDs may emit electromagnetic waves, with their signals detected by the various radio receiver antennas installed on the airplane. Electromagnetic waves, in certain frequency windows, can interfere with the GPS position detailing the plane's position and direction, as well as its VHF system used for communication.

"Phones, computers and other electronic devices must be turned off within 10,000 feet of the ground," Vahala notes. "Antennas on top of the plane are important for take-off and landing and can be affected by radiation coming from those devices. Wireless cards inside a computer or personal electronic devices interfere with antennas on the plane." While cell phones cannot be used on board planes at all, some companies in the United States and other countries are trying to find ways to install wireless computers on planes.

Measuring Electromagnetic Wave Propagation On Airplanes

Vahala and Old Dominion electrical and computer engineering Ph.D. students Madiha Jafri, Mahmoud El-Monatwallah, Yousef and Genevieve Hankins have worked with NASA researchers to collect Interference Path Loss (IPL) data on out-of-service Boeing 737 and 757 airplanes since 2001. IPL data can interfere with the GPS position detailing the plane's position and reflect off different objects the people in certain seats were using," Vahala says. "Electromagnetic waves propagate around the cabin and reflect off materials such as seats and other structures in the cabin. Waves reflect off metal objects and hit the antenna after propagating through the window." Vahala and her students found that electromagnetic propagation of waves with different frequencies, and 16 C, those exact circumstances must be reproduced for measuring PED emission levels. Known as modeling, the research involves placing boundary conditions - the mathematical contingencies to which physical laws apply - on a set of electromagnetic wave equations.

"It's easier to check using theoretical models since these models are designed to apply to large frequency regions and conditions," Vahala notes. "From these models, we plot the intensity of the radiation and have found that radiation is more intense around the planes windows. This helps the industry as they build planes, to determine where they need to put more shielding against electromagnetic waves that could leak out and affect antennas or the pilot's controls." Other students working with Vahala have placed wireless transmitters on these commercial aircraft to determine if the transmitters model the trends found in experimental data for the plane's size, number of passengers and seating arrangements. "If the plane is a 737, you would not expect the data to fit all types of planes," she notes.

If a plane has encountered problems with radiation produced from PEDs, the same scenario of passengers must be replicated in testing in order to accurately reproduce the problem. If passengers using PEDs are seated in 18A, 17B and 16 C, those exact circumstances must be reproduced during testing on an idle airplane. "You could have reflections off different objects the people in certain seats were using," Vahala says. "Electromagnetic waves propagate around the cabin and reflect off materials such as seats and other structures in the cabin. Waves reflect off metal objects and hit the antenna after propagating through the window." Vahala and her students found that electromagnetic propagation of waves within buildings are applicable to those within an aircraft. The building models are designed for square spaces with flat surfaces, and the students have to convert the electromagnetic boundaries to the curved areas found in an aircraft by appropriate transformations," she explains. "We did see that the data fits the experimental results and the maximum boundary conditions on electromagnetic power."
Random Wave Motion

The group also studied random wave propagation. “Research indicates that these waves fit some of the hot spot patterns seen in planes,” Vahala notes. “Waves bouncing back and forth off different objects have a higher intensity of electromagnetic power. There is also a higher intensity by windows where you find more waves.”

Plus, there are constant random changes within the cabin, making it an important medium for studying the effects of wave propagation. “People can affect the wave propagation as well as whatever it is they are holding. We changed the density across the rows and down the aisles so that puts a random effect into how the waves propagate.”

Vahala believes wireless radiation effects could be overcome by placing shielding made of a fine, virtually invisible mesh on a plane’s windows and insulating the doors between the cockpit and the cabin. The insulation would prevent electromagnetic waves from taking a direct path from the cabin to the pilot’s controls. The waves would then be routed outside the plane’s windows where they would lose intensity before hitting the antennas connected to the controls.

Wireless Antennas Used on European Airlines

The number and type of controls on the plane help determine the maximum number of wireless antennas that could be placed on an aircraft. No U.S. airplanes currently in operation have been fitted with wireless antennas; however, two European airlines – Lufthansa and Scandinavian Airlines System – recently began using wireless LANs to deliver Internet service to passengers. During three months of Internet testing on Lufthansa planes, researchers determined that the LAN did not interfere with this particular plane’s systems.

Financial constraints and continuing questions concerning interference with the airplane systems have kept U.S. airlines from jumping on board the wireless bandwagon, although Vahala believes that may change as more and more passengers clamor to surf the net.

“A lot of people want to use wireless computers. There’s no question of that, but we’re very safety conscious here. We want to make sure that something is not going to affect the plane’s function. In the next several years, a company may start coming out with something because wireless computers are very popular. Over the next 10 years, we expect to see more long-term solutions.”

“People have just started looking at the effects of wireless systems added to current aircraft. The airlines want models that predict things because the incidents they’ve been having with wireless computers are not very predictable.”

— Linda Vahala
ENVIRONMENTALLY FRIENDLY
Old Dominion University’s Engineering and Computational Sciences Building, which opened last fall, is the first LEED-certified higher education building in Virginia. The LEED (Leadership in Energy and Environmental Design) certification recognizes buildings designed to meet environmentally friendly standards set by the U.S. Green Building Council.

The $19.6 million, 84,000 square-foot facility has four floors and houses research programs and office space for ODU’s new Center for Computational Sciences, aerospace engineering, mathematics and statistics, computer science, modeling and simulation, and the Office of Computing and Communications Services.

Designed by Moseley Architects, the Engineering and Computational Sciences Building mixes a traditional academic look with technology-accented touches, such as aluminum sunscreens outside the windows that cut air conditioning costs and reflect natural lighting, and incorporates recyclable materials and products bought from vendors that meet environmental requirements.

At the entrance is a four-story “E-glass” window, which is dark on the outside and light on the inside, that filters UV rays so more usable light and less excess heat enter the lobby. The second, third and fourth floors feature a student lounge and office space that benefit from the spectacular “E-glass” window view.

But the most impressive technology is located inside the L-shaped facility. An 8-foot-by-8-foot video wall greets visitors in the lobby and showcases the work being done in the building’s laboratories. The university’s modeling and simulation research will be furthered by the Cave Automated Virtual Environment (CAVE) and a virtual reality demonstration theater, capable of immersing a group of 103 students in a virtual research project. Additionally, Old Dominion’s high-speed computing research, which is helping to build a regional link to the national LambdaRail high-speed network, will be housed in the building.

LEED certification is determined by a point system covering five categories. ODU’s new building meets each category in the following ways:

- Sustainable site – No parking lots were paved for the new building, which integrates bicycle storage areas and electric vehicle charging stations for vehicles. Rainwater collected on the roof filters through on-site rock and plant gardens.
- Water efficiency – Native, drought-resistant plants and drip irrigation reduce the amount of water needed for landscaping. Efficient plumbing systems are expected to cut water use inside the building by 20 percent.
- Energy and atmosphere – Increased insulation, external sun-shading, windows that increase day-lighting and other innovations that increase the efficiency of mechanical systems should cut the building’s energy demands by 20 percent.
- Materials and resources – The facility was constructed with increased amounts of salvaged, certified, recycled and rapidly renewable materials. The university has recycled 50 percent of the construction debris.
- Indoor environmental quality – Air quality management controls keep contaminants out of the heating and air conditioning systems. The building is smoke-free.

First LEED-Certified Higher Ed. Building in Virginia

Photos courtesy of Moseley Architects
Getting past THE SMELL

Studying the linkages between phytoplankton, hydrogen sulfide and trace metal cycling

BY MARGARET MULHOLLAND AND GREG CUTTER
Why would anyone want to study hydrogen sulfide, the smelly gas that most people associate with rotten eggs or mud flats? Actually, scientists are quite interested in this gas which is released by microscopic plants, or algae, called phytoplankton that live in the ocean’s surface waters. The National Science Foundation (NSF) is funding such a study to find out how and why phytoplankton produce this stinky product.

It turns out that hydrogen sulfide reacts with many trace metals that can be essential (like iron or zinc) or toxic (like copper or mercury) to phytoplankton. These reactions can make trace metals unavailable to phytoplankton or even make them insoluble in seawater and cause them to precipitate. This not only affects the way some metals are cycled in the ocean, but also could be a way that phytoplankton affect and even control their chemical environment. Phytoplankton processes can also affect another gas, carbonyl sulfide, which is associated with the production of hydrogen sulfide. This gas affects the radiation balance of the planet by diffusing into the stratosphere and producing particles that block radiative energy from reaching the Earth’s surface.

Our research seeks to determine whether hydrogen sulfide production by phytoplankton in the surface ocean is a significant factor in trace metal cycling and in the planetary sulfur cycle. We are conducting laboratory experiments and fieldwork to test more specific hypotheses. In the laboratory, phytoplankton can be grown under controlled conditions to determine which species of these algae can produce hydrogen sulfide. This work provides a “yardstick” with which field results in the real world can be interpreted.

During laboratory studies to date, phytoplankton from almost all taxonomic groups found in the ocean produce H2S (hydrogen sulfide) to some extent. These include species that occur in the Chesapeake Bay, where there is a broad range of nutrient and trace metal concentrations, and the open ocean, where nutrients and trace metals are often at the limits of analytical detection and where they are thought to limit biological productivity, or growth. In general, the lab results show that the small sizes of the small phytoplankton, the “blue-green algae,” or cyanobacteria, produce the most, while the diatoms that make skeletons out of biogenic silica (also known as opal) and are 100 times as large as the cyanobacteria, produce the least. Adding more metals such as zinc to the culture solutions also increases the relative amounts of hydrogen sulfide produced.

Laboratories at Sea

To put these lab results in context, we conducted two major field expeditions during contrasting seasons, August 2003 and March 2004. Both trips followed the same route, leaving Norfolk to sample waters at the edge of the continental shelf where nutrients, phytoplankton and trace metals are abundant. Our science team then traveled out into the Sargasso Sea (western North Atlantic) near Bermuda, where there are low nutrient, trace metal and phytoplankton concentrations for a temperate open ocean station. Finally, we transected approximately 1,500 miles southwest (800 miles east of Barbados) and repeated sampling experiments in warmer subtropical and tropical seas where the types and species of phytoplankton are different, but where nutrient, trace metal and phytoplankton concentrations remain low. Measurements were made in the uppermost portion of the water column (to 500 meters), where phytoplankton are abundant, and the concentrations and distributions of metals, hydrogen and carbonyl sulfide, and phytoplankton species in these waters were determined.

During August 2003, we used the R/V Cape Hatteras, a member of the NSF research fleet and operated by Duke University and the University of North Carolina, for our fieldwork. We had 12 scientists aboard from Old Dominion University (graduate students, technicians and three faculty), the University of M aryland (graduate student, postdoctoral researcher and a faculty member). We focused on obtaining data on the concentrations of trace metals and hydrogen sulfide in the water column and their interactions. Although John Donat, ODU associate professor of chemistry and biochemistry, is still analyzing the collected trace metals in his lab at the university, one interesting on-board finding was that hydrogen sulfide and mercury strongly interact, and much of the dissolved mercury in the Sargasso Sea appears to be complexed, or bound, by hydrogen sulfide, which affects its cycling and even toxicity.

Other “highlights” of the August expedition were the two major hurricanes we had to avoid. One was Fabian, which caused us two days of lost ship time and went on to inflict substantial damage to Bermuda. The other “missed” hurricane on our way south was Isabel, which hit Norfolk after we returned.

Research Team Tries Something New

In March 2004, we went out on the R/V Endeavor, another NSF research vessel, operated by the University of Rhode Island. This time, graduate students from the University of Southern California and Scripps Institution of Oceanography joined our group. While no hurricanes bothered us, strong winter storms whipped the seas, making work aboard the ship challenging. The scientific focus of this trip was on performing field incubations of resident phytoplankton to determine the rates of hydrogen sulfide production and to examine the effects of trace metal additions. The
Cutter group also brought along a newly developed automatic system to measure hydrogen sulfide concentrations in the surface ocean every 25 minutes, something never before attempted because it requires a group of analysts working in shifts to cover 24 hours a day for days at a time. Such a “time series” allows the integration of all the processes producing and removing hydrogen sulfide to be observed, which cannot be easily duplicated in the laboratory on land.

In the ocean waters east of Barbados, we found that hydrogen sulfide concentrations were maximal in the early morning after sunrise, but then decreased through the day and into the night. This is consistent with production by phytoplankton as part of photosynthesis (which requires energy from sunlight).

Hydrogen Sulfide’s Role in Our Changing Global Climate

The field incubation work obtained data that are spurring new efforts for the Old Dominion lab studies. Surprisingly, the phytoplankton that produced the most hydrogen sulfide in the field were the larger diatoms and not the very small cyanobacteria – exactly the opposite of previous lab results. Furthermore, the addition of metals seemed to have little effect on phytoplankton growth and their production of hydrogen sulfide. This is consistent with what has been found by other researchers working in the North Atlantic (i.e., metal additions do not stimulate the growth of larger phytoplankton), but its relevance to the hydrogen sulfide-phytoplankton connection will have to remain a puzzle for the moment. Nevertheless, further laboratory experiments are being done to confirm that these species produce hydrogen sulfide in a controlled, unialgal laboratory setting.

Why is this important? As noted, hydrogen sulfide can play an important role in trace metal availability in the oceans, and as such, act as an intermediary between the phytoplankton producing it and the trace metals affecting them (pro and con) in their aquatic habitat. In our changing global climate, we are already observing changes in algal species distributions in the coastal and open oceans around the world as a result of man-made nutrient and trace metal inputs. Changes in ocean temperature and pH (acidity from atmospheric carbon dioxide entering surface seawater) will also elicit changes in species composition and the resultant cycling of bioreactive elements in the sea. Hydrogen sulfide will have a role in these global changes, ameliorating some effects, while exacerbating others.
Cynthia Jones, professor of ocean, earth and atmospheric sciences, was honored Nov. 17 as the 2004 Virginia Professor of the Year by the Carnegie Foundation for the Advancement of Teaching and the Council for Advancement and Support of Education (CASE) during a ceremony in Washington, D.C.

She joins Karen Pelonko, professor of sociology and criminal justice, and Robert Lee Kernell, professor emeritus of physics, as the third ODU faculty member to receive this honor.

"Dr. Jones is a scholar of national reputation and representative of the outstanding faculty we have throughout the commonwealth of Virginia," said Gov. Mark R. Warner. "As the 2003 Virginia Scientist of the Year, Dr. Jones and her research contributions and teaching excellence at Old Dominion University are well known to me. She is an invaluable member of the academic community."

The purpose of the awards program is to recognize the most outstanding undergraduate instructors in the country. This year there were winners in 47 states chosen from a group of nearly 400 of the nation's top professors.

Jones, an eminent scholar and director of the Center for Quantitative Fisheries Ecology, joined Old Dominion in 1986. In addition to teaching and advising students in five courses, she is an international pioneer in fisheries ecology. She developed new techniques to accurately determine the age of fish by studying their ear bones, or otoliths, which have daily and annual rings similar to trees. She also pioneered a chemical analysis technique that can determine where a particular fish was hatched and what waters it has inhabited since. Because of her work, scientists can now identify essential fish habitats and determine which ones provide better living conditions.

A Fulbright scholar, Jones is a member of the Virginia Marine Resources Commission, and the first fisheries scientist to serve on the commission in its 125-year history. She was named one of Virginia's Outstanding Scientists of 2003 by Gov. Warner. She recently received a nearly $200,000 Virginia Sea Grant to work on a project titled "How Essential Fish Habitat Influences Population Structure for Spotted Seatrout, Cynoscion Nebulosus, with Special Emphasis on Chesapeake Bay."

CASE established the Professors of the Year program in 1981 and the Carnegie Foundation became a co-sponsor a year later.
Old Dominion University

SECOND ANNUAL RESEARCH DAY

WEDNESDAY, APRIL 6, 2005

For more information: www.odu.edu/research