FACULTY OF ENGINEERING | FALL 2011

Dean's Report

Bioengineering is booming at McGill

Bioengineering is one of the fastest-growing fields in engineering and McGill is moving on several fronts to establish itself as a leader.

A new undergraduate program has been approved by the University and is now under consideration by the Quebec Ministry of Education, planning is underway to establish a Department of Bioengineering and a search has started to hire McGill Engineering's first endowed chair in bioengineering — the result of a major gift from a generous donor.

Bioengineering has played an important role in McGill Engineering research for at least two decades, and our professors' expertise spans the entire field — including exploring ways to use bacteria to break down environmental pollutants, creating new materials (such as bioplastics and biodiesel) and developing neural prosthetics that respond to messages from the brain.

The new BEng program will reflect McGill Engineering's considerable depth in the field and offer undergraduate students an unparalleled interdisciplinary education. The first students are expected to enter the program next fall.

In this issue, we shine the spotlight on some of the professors on our Faculty's bioengineering team. *(see Bioengineering page 3)*

OWEN EGAN

Bioengineering Professor Marta Cerruti and Mining and Materials PhD student Hesameddin Mahjoubi monitor how molecules found in the body interact with the surfaces of sample biomaterials. Their work has multiple applications, such as reconstructive surgery. *(see page 5 for details)*

Andrew Kirk appointed interim dean

Dean Christophe Pierre leaves for new position in United States

A change in leadership is underway at our Faculty. Dean Christophe Pierre stepped down at the end of September to become Vice President for Academic Affairs at the University of Illinois.

Professor Andrew Kirk was named interim dean and a search committee has been struck to recommend a permanent successor.

Professor Kirk played an important role in our Faculty's recent growth and development as a member of the outgoing dean's management team. He served as Associate Dean, Research and Graduate Education between 2006 and 2011, and this past June was appointed chair of McGill Engineering's largest department, Electrical and Computer Engineering. He is an award-winning teacher, an accomplished researcher and, among his other responsibilities, director of the McGill Institute for Advanced Materials (MIAM).

Christophe Pierre was appointed dean in July 2005. A statement by McGill Provost, Anthony Masi, when Professor Pierre's departure was announced, praised his many contributions to *(cont'd on page 2)*






McGill Faculty of Engineering

Dean's Message

The page one article about a change in leadership at McGill Engineering alludes to our Faculty's considerable strength and excellent competitive position.

Reaching that level of distinction required determination and hard work over many generations. Former dean Christophe Pierre rightly deserves high marks for some of our more recent accomplishments, but he would be the first to credit ongoing alumni support for creating many of the conditions that enable our students and professors to shine.

As the person entrusted with guiding our Faculty until a permanent dean is named, I am relying on you to continue that long tradition of engagement and generosity.

Staying the course

My intention is to build on the momentum generated in recent years to solidify the gains made in teaching, research and student services. I refer here to:

- aggressive international recruitment strategies for students and professors;
- improved career counselling and professional development services to ensure that graduates are fully equipped for employment in the global economy;
- expanded partnerships with industry and adequate resources to ensure that students and professors can use their knowledge and skills to the fullest.

My colleagues and I will continue to develop new, cutting-edge teaching and research initiatives, as well, and wholeheartedly endorse the many creative interdisciplinary projects underway at our Faculty.

The departure of our former dean has not slowed McGill Engineering's remarkable growth and development. The search committee established to recommend a permanent dean is already hard at work and you will be kept abreast of its findings.

In the meantime I pledge to work with you, our students, our professors and our technical and support staff to keep our Faculty humming.

Andrew Kirk
Faculty of Engineering

Alumnus C.K. Chen — a Renaissance man

"Without integrity, nothing else matters. I learned that at McGill."

Student recruiters like to highlight four points about life at McGill: the quality of our students, the commitment of our professors, the special ambiance that only Montreal can provide and the international character of our University.

In talking to alumnus Choong Kong Chen, BEng'67, MEng'69 and PhD'72, you realize that those descriptives were equally valid back in the mid-'60s and early '70s.

A highly successful food industry executive, property developer and environmental engineering consultant in Australia, the Malaysia-born, Singapore-raised Chen is a true Renaissance man who combines professional interests with a passion for music, painting and sculpture.

And he says he owes it all to the professors and classmates he got to know during seven years studying Civil Engineering and Applied Mechanics at McGill. "The man that I became was shaped to an incredible degree by my time there."

In a telephone interview from his home in Toowong, near Brisbane, Chen vividly recalls listening to chamber music for the first time at the McGill Faculty of Music, visiting the Montreal Museum of Fine Arts and experiencing his first opera — La Bohème.

Choong Kong Chen

(cont'd on page 6)

Dean Pierre leaves McGill (cont'd from front page)

the Faculty during the past six years.

He raised the standard of excellence at McGill Engineering, the provost said, and he leaves the Faculty in a strong position, well-placed for continued advancement.

Educated at Duke, Princeton and the École Centrale des Arts et Manufactures de Paris, Professor Pierre spent two decades as a teacher, researcher and university administrator in the U.S. before McGill lured him north. At the time he was Associate Dean for Academic Initiatives at the University of Michigan's Horace H. Rackham School of Graduate Studies.

DARIA MARCHENKO

Interim Dean Andrew Kirk (right) presents Christophe Pierre with a plaque announcing that our Faculty's annual research prizes have been renamed in his honor.

His new position as Vice President for Academic Affairs at the University of Illinois includes responsibility for educational policy, academic programs, personnel actions and capital and operating budget items relating to academics on all three University of Illinois campuses: Urbana-Champaign, Chicago and Springfield.

At a farewell reception on Dean Pierre's last day in office, Interim Dean Kirk announced that the Faculty of Engineering's annual research prizes have been renamed the "Christophe Pierre Research Excellence Awards". The recognition honors our former dean's investment, support and promotion of the research enterprise at the Faculty of Engineering.

Bioengineering – the application of biological knowledge an

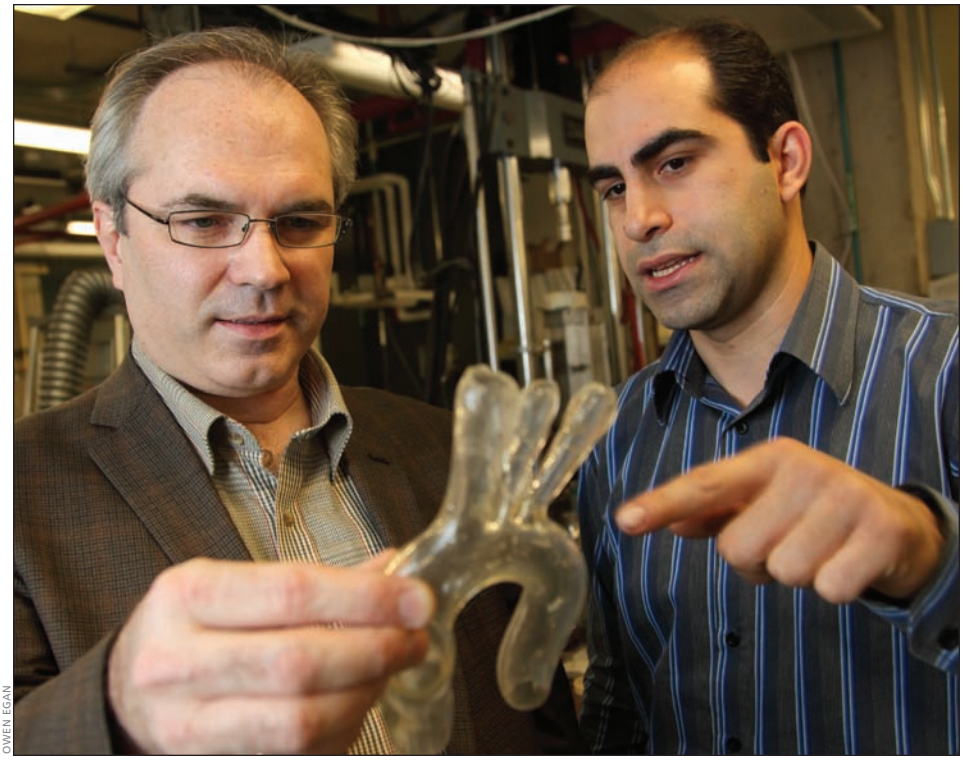
BY PATRICK McDONAGH

Bioengineering's versatility — applications span improving health care, addressing environmental concerns and developing safe and sustainable materials — has elevated its profile in recent years. The U.S. Department of Labor has picked bioengineering as the fastest-growing engineering discipline over the coming decade.

Up until now, McGill undergraduates have explored the field through minors in biotechnology and biomedical engineering, or via the Summer Undergraduate Research in Engineering (S•U•R•E) program (see the Fall 2009 issue of the *Dean's Report*). With the new BEng program more students than ever will be free to pursue studies in bioengineering.

"The Faculty is well poised for this latest step in its bioengineering evolution," says Mechanical Engineering Professor Rosaire Mongrain, who has collaborated for more than 20 years with cardiologists and heart surgeons in designing and building cardiovascular implants, such as heart valves, stents (a small tube for inserting into blocked vessels), and artificial vessels.

Professor Mongrain is one of a core of 29 professors either working primarily in bioengineering or doing significant research in the field, and McGill Engineering will be hiring six more professors working mainly in bioengineering. "So, with high student interest, a strong research core and many partnerships with industry, we have had a lot of potential energy. The new BEng program will convert part of that energy into something concrete."



OWEN EGAN

Professor Rosaire Mongrain examines a silicon model of a human aorta developed with the assistance of PhD Biomedical Engineering student Soroush Nobari (right). This particular 3D model duplicates the aorta of a 63-year-old woman.

Diversity is unique

"Our philosophy is to draw on our wide-ranging research to teach principles that will give students the knowledge base to move between bioengineering clusters — environmental, materials, biomedical and so forth," says Civil Engineering and Applied Mechanics Professor Subhasis Ghoshal, who is also Associate Dean for Undergraduate Education.

"Most other university programs focus on biomedical engineering or biotechnology, so this diversity is unique to McGill Engineering. And it reflects our Faculty's strengths."

In addition to a general "Introduction to Bioengineering" and courses in fundamental engineering skills, students will also select from options including "Electrical Circuits for Bioengineers," "Molecular, Cellular and Tissue Biomechanics," and "Biosystems and Control."

Many will undertake industry internships, and all final-year students will carry out a bioengineering design or research project. The result, says Professor Ghoshal: "a graduate with solid interdisciplinary skills and the ability to move across bioengineering fields."

Professor Ghoshal knows of what he speaks. He is exploring how bacteria can be used to break down petroleum hydrocarbon contaminants, used heavily as industrial solvents.

"People have long believed that bacteria wouldn't work below zero degrees," he says. And that is a problem for Canada, given the oil exploration and other industrial activities occurring in northern regions, creating the potential for environmental damage.

Producing biomaterials

However, Professor Ghoshal and his team have discovered bacteria that do work at temperatures below zero if managed well. "And that is the engineering contribution: we are learning how to tweak things so bacteria work efficiently under sub-zero conditions, giving us longer treatment seasons."

As other faculty research shows, bacteria do more than break down contaminants. "Not only can we develop bacterial systems to de-pollute wastewaters, we can also use this waste to create new biomaterials," says Civil Engineering and Applied Mechanics Professor Dominic Frigon.

Like humans, microorganisms can accumulate fat: in their case, in the form of polyhydroxyalkanoate (PHA) or triglyceride compounds, which can then be used to produce bioplastics or biodiesel fuel, respectively. Currently, industrial facilities generate bioplastics by following precise recipes using specific bacteria to produce these compounds, which can then be harvested. But this is an expensive, time-consuming process that demands a sterile environment.

Professor Frigon, on the other hand, uses the wastewater itself as a source to produce PHAs, even though the precise

mix of organisms is unknown.

"Think of wastewater as an ecosystem. We are trying to manipulate this ecosystem to encourage the growth of microbial strains that would produce what we want," he says. "Because we don't require a sterile environment, it isn't costly. In fact, we're using something that people pay to dispose of, while aiming to create something that people will purchase."

Professors Ghoshal, Frigon and Chemical Engineering's Nathalie Tufenkji are among a number of researchers working in environmental engineering and biomaterials. Professor Tufenkji's research with cranberries (see below) has also taken her into biomedical engineering, which itself encompasses many diverse activities.

OWEN EGAN

This highly sophisticated bioreactor in Professor Dominic Frigon's Environmental Community Engineering Laboratory is a miniature version of a municipal wastewater treatment plant. Built on a scale of 1 to 30-million, the apparatus helps him develop technologies to transform liquid waste into valuable industrial by-products. Located in the Macdonald Engineering Building, the laboratory forms part of the Benedek Integrated Laboratories in Environmental Engineering.

Exploring brains and bodies

For example, imagine a paralyzed individual who wants to move a computer cursor from one point to another. Sam Musallam, a Professor of Electrical and Computer Engineering and the Canada Research Chair in Bioengineering, is hoping to transform such dreams into reality.

His explorations into cognitive neural prosthetics demand two closely coordinated labs — one in the Electrical and Computer Engineering Department, the other in the Faculty of Medicine's Department of Physiology — that study how intentions (like the desire to move the cursor) are encoded as electrical and chemical signals in the brain, how to build implants that will detect these signals, how to develop algorithms to decode them and, finally, how to design prosthetic devices that can translate intentions into actions.

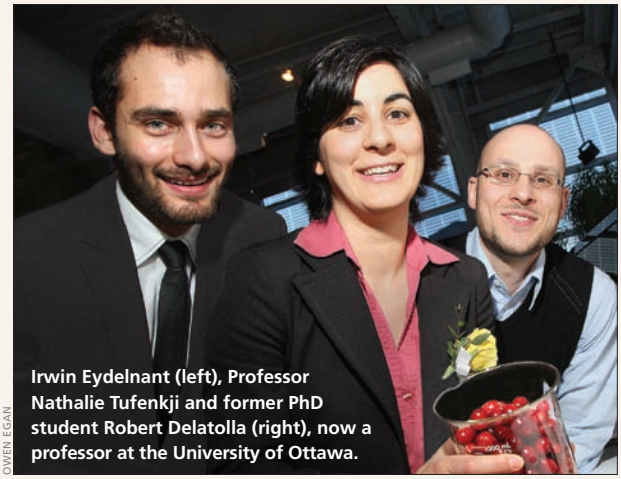
Professor Musallam's laboratory is distinct in many ways: while others focus on decoding motor signals needed to move the cursor through each point along a trajectory, his team focuses on signals representing the intent to move the mouse from one point to another. And, rather than adapting their mechanism to the brain, (cont'd on page 5)

Irwin Eydelnant was an undergraduate student hoping to carry out a research project when he approached Chemical Engineering Department Professor Nathalie Tufenkji, the Canada Research Chair in Biocolloids and Surfaces and Associate Director of the Brace Research Center for Water Resources Management.

"Irwin wanted to do a bioengineering project with a medical slant. I normally study bacteria and pathogens in the environment, but because I'm interested in adhesion and surface interactions, I directed him toward bacteria buildup in catheters," recalls Professor Tufenkji.

"Bacteria can multiply to form a biofilm in catheters, and eventually they can swim up the urinary tract to infect the bladder or kidneys."

Eydelnant had read a study on the impact of cranberry juice, a long established folk treatment for urinary tract problems, and a research project was born.



OWEN EGAN

Irwin Eydelnant (left), Professor Nathalie Tufenkji and former PhD student Robert Delatolla (right), now a professor at the University of Ottawa.

Working through the term (and, after that, through a master's degree), Eydelnant and Tufenkji discovered that when one type of infection-causing bacterium is exposed to the cranberry extract proanthocyanidin (or C-PAC), its capacity to adhere to catheter tubing is inhibited.

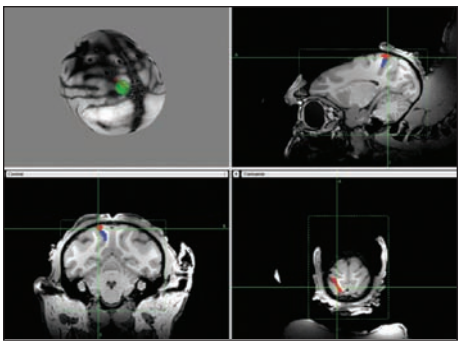
Further research by postdoctoral fellows Che O'May and Gabriela Hidalgo revealed that C-PAC impairs mobility of different infectious bacteria by affecting the gene responsible for the flagella that allow bacteria to move about.

Professor Tufenkji has continued to pursue the cranberry research, and a recent collaboration with McGill Microbiology and Immunology Professor Samantha Gruenheid suggests that the extract may also reduce gastrointestinal infections.

Bioengineering (cont'd from page 4)

they hope to teach the brain to learn their algorithms.

"The brain has extremely powerful learning capacities, so we want it to optimize itself to use our prosthetic devices," he says. "We are using novel ideas where we have started from scratch, so our research is covering a lot of new ground."



Professor Sam Musallam's team implants sensor arrays into the brains of lab monkeys to detect electrical and chemical neural signals that could be translated to operate prosthetic devices. The images above provide a guide for implanting the arrays.

Similarly, Mining and Materials Engineering Department Professor Marta Cerruti's research has a wide range of potential applications. Professor Cerruti is developing "scaffolds" to help the body rebuild tissue lost to disease or accident, or accept prosthetic implants.

The scaffolding materials must encourage the growth of the correct type of cells: either mineralized tissues, like bone or teeth, or soft tissues. To this end, she and her team are studying how proteins regulate this mineralization process so they can construct molecules mimicking these functions and then attach them to the scaffold's porous surfaces. "Scaffolds with these molecules would then be able to direct cells whether or not to promote mineralization," explains Professor Cerruti, who was named the Canada Research Chair in Biosynthetic Interfaces in October 2011.

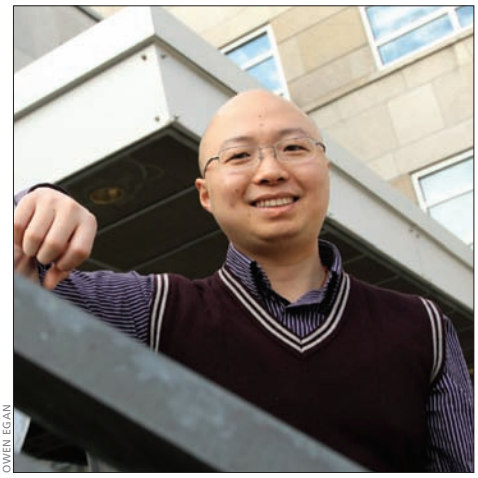
The benefits are many: the scaffolding, made from biodegradable polymers, could be used in reconstructive surgery to prompt the body to generate the appropriate tissue — (cont'd on page 6)

OWEN EGAN

Inter-department cooperation is a major feature of bioengineering at McGill. Mechanical Engineering Professor Rosaire Mongrain is seen here with Mining and Materials Engineering (MME) master's student Bandar Al-Mangour working with a Tensile Tester in the MME Department's Hot Deformation Laboratory. The facility is located in the W. H. Wong Building.

Rapid growth in professoriate spurs advances across the Faculty

The number of professors teaching at McGill Engineering has grown considerably in recent years. The current complement is 152 — up 19% from the 128 professors on staff in 2005 — and the number is expected to rise by nine during the next two years.



OWEN EGAN

Professor Jun Song — a new face in nanomaterials research

Bioengineering is one area that has benefited from the infusion of new blood, but the hiring blitz has provided new talent and potential for growth across the entire Faculty.

"The presence of larger numbers of bright, young, enthusiastic scientists has helped our Faculty develop in all its areas of strength," says Lawrence Chen, Associate Dean Academic Affairs.

"Tremendous headway has been made in materials engineering and nanotechnology, for example, and we continue to enjoy much success in broadband communications, but the reality is these new faculty members bring expertise to virtually all priority fields, including aerospace engineering and engineering and design for sustainability."

Next-generation devices

As indicated in the adjoining articles on bioengineering, many of the Faculty's rising stars have close ties with units outside their particular department or field of specialization. "This interdisciplinary aspect of the work provides additional, substantial impact," Professor Chen says.

One of the Faculty's most recent hires is Mining and Materials Engineering Department Professor Jun Song. After earning his doctorate at Princeton and doing postgraduate work at Brown, Professor Song came to McGill last summer, in part, he says, "because I knew I would find top-notch faculty colleagues and a collaborative environment."

The young researcher and his team use state-of-the-art modelling and simulation techniques to reveal the fundamental deformation and failure mechanisms that dictate how materials behave across time and space — both at the nanoscale and at larger scales.

The objective is to enable precise engineering of the properties of nanomaterials to assist in the design of robust, next-generation devices and appliances.

The technology applies to structures ranging from large-scale constructions to microcircuits. Two particular thrusts Professor Song is pursuing are direct routes to increased energy efficiency and reduced carbon emissions.

The first is designing strong, tough and lightweight structural metals for aerospace and automobile applications. The other is extending the lifetime and improving the power capacity of renewable energy materials (such as rechargeable batteries for electric cars or high-capacity energy storage for the electrical grid).

Bioengineering (cont'd from page 5)

either hard, as in the case of bone, or soft, as with skin and muscle tissues — and then to provide support as the tissue grows. And if used for prosthetic implants, they would integrate with the body and biodegrade as it generates new tissue, so that no artificial materials remain within the body.

Professor Cerruti's work, like the other research described in this issue, has attracted a steady stream of undergraduate students pursuing research experience, which forecasts an enthusiastic response to the Faculty's new bioengineering program. Initial plans are to accept between 30 and 50 students, increasing enrolment as new professors are hired and laboratories develop.

"We anticipate tremendous student interest and we already have a great deal of research activity," Professor Ghoshal says. "So my guess is that the bioengineering program will grow rapidly, like the field itself."

OWEN EGAN

"Bioengineering is one area that has benefited.... but the presence of larger numbers of scientists has helped our Faculty develop in all its areas of strength."

Associate Dean Lawrence Chen

Integrity (cont'd from page 2)

"They were all little things, in a way, but they grounded me, particularly during my graduate years, and taught me the importance of maintaining a balance in life. It is a precept I have tried to respect ever since."

The philosopher in Chen comes to the fore when he says that engineering can be a powerful bridge between nations and the more rounded engineering graduates are, the easier it will be for them to connect people and nations.

As the memories flood back, Chen recounts how concerns he had about leaving Singapore to study in far-off Canada were quickly brushed aside. "I was never made to feel like an outsider. My classmates were all wonderfully welcoming — fellows like Paul Janiga, Dick Williams and George How. There were students from right around the globe — Nigerians, Brits, Australians, Trinidadians and you name it.

First job

"They had a bit of trouble with my accent at first, but they accepted me for what I am."

More than anything, it was Chen's teachers who had the greatest impact on him, and he has kept in touch with several professors over the years. "People like Stuart Savage and Dan Selby, the man who welcomed me warmly on registration day, helped me choose my options and later arranged summer employment with an engineering firm that worked on the monorail system for Expo '67," the World's Fair that Montreal held to celebrate the Centennial of Canadian Confederation.

"That job was my first hands-on experience with a real engineering project, and I've never looked back.

Intellectual honesty

"All of my profs were impressive and all were incredibly helpful," but the individual he cherishes most is Emeritus Professor Raymond N. Yong, MEng'58, PhD'60.

"Raymond, who now lives in Sidney, BC, was a man ahead of his time in many ways. Pollution and environmental concerns were only starting to enter the public consciousness back then, but Professor Yong was a superb and committed environmental engineer.

"On a personal level, he and his wife, Florence, were the most caring and supportive of people. They would invite grad students to their home time and time again for absolutely delicious meals. There was never any formality. We were encouraged to relax and enjoy ourselves — a big plus when you're facing research deadlines. Mrs. Yong made the best fruit cake I ever tasted!

"More importantly," Chen says, "Professor Yong taught us the importance of intellectual honesty. He made us realize that engineers, as true professionals, must always follow the highest moral and ethical standards. That lesson has stayed with me in everything I have done since."

Appreciation for life

Chen chose to honor his mentor recently by establishing the Dr. Raymond Yong Scholarships in Engineering. It is the first time an alumnus in Australia has provided such a major gift to the Faculty of Engineering.

"My success in life would not have been possible if I had not benefited from others' kindness and support," Chen says, and he hopes his scholarships will help future students learn what he did four decades ago about combining expert training with a broad appreciation for life.

"Young people are fed a lot of information these days, but that doesn't equal knowledge. I hope the Dr. Raymond Yong Scholarships in Engineering will encourage students to take a little time to discover thinkers and ideas outside their areas of specialization.

"Over and above academic training, society should enable and empower every human being to reach his or her full potential," Chen says, "so I hope and pray that McGill Engineering continues to be a leading light in education by imparting to students a full range of values."

McGill Engineering's Alma Mater Fund goal is $1-million. Thank you for your past and future support.

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