The Institute of Biological Engineering

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President's Message

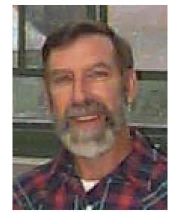
by IBE President, Jerry Gilbert

I am honored to be serving as president of IBE in a period in which there has never been more potential for the society. Biological Engineering as a discipline is expanding and will eventually take its place among the major engineering disciplines. The approval of a new curriculum of Biological Engineering at MIT in February of 2005 marked a milestone in the recognition of the discipline. All of the major engineering disciplines are incorporating some aspect of biology into their programming as we begin the twenty-first century which many are calling the Century of Biology.

We saw considerable excitement and enthusiasm about the future at the 2005 annual meeting of IBE. This meeting was the 10th annual meeting of IBE and it was held in Athens, Georgia on March 4-6, 2005. The meeting brought together a very broad group of people, representing the breadth of the field of Biological Engineering. The diversity of the group and the wide variety of the topics attest to the fact that IBE is an inclusive and dynamic organization that is ready to embrace all that is biological engineering

The theme for the 2005 Meeting was "Biology-Inspired Engineering Frontiers," and Dr. Robert Ulanowicz of the University of Maryland delivered a keynote address focused on ecosystems but touching on our whole view of and approach to biology. Dr. Ulanowicz challenged us to draw ourselves out of the reductionism view of biology and to be inspired by biology's complexity and its dynamic nature. Immediately following the keynote address, we had representatives from a number of major professional societies address the impact that biology is having on the disciplines of engineering. These included talks from representatives of ASME, ASAE, AIChE's Society of Biological Engineering, BMES, ABET, and IBE. It was clear that the biological sciences were influencing all of the traditional engineering disciplines.

Technical sessions at the 2005 meeting included the following biology-inspired topics: engineering education, nanotechnology, biotechnology, computational methods, industrial trends, systems and engineering ecology, tissue/cellular mechanics, materials, bioprocessing/biocatalysis, thermodynamics and transport,



Editor, Art Johnson

Biology Should Not Be Divided

We recently had a faculty meeting where some of the specialists in ecological engineering were expressing discomfort about answering questions from advisees interested mainly in biomedical engineering. From their comments, it was clear that they would prefer to narrow the focus of their own academic lives to wetlands, restoration ecology, and energy. I have heard the obverse from faculty particularly keen on biomedical engineering.

Whereas it is clear that in our own research we must focus on specific topics that usually, although not always, deal with narrow segments of the biological realm, we often forget that the burden of the Biological Engineer is to have some level of understanding of all of biology, just as we must be familiar with general engineering approaches to problem-solving. This generalized approach to understanding of biology sets Biological Engineers apart from others such as biomedical engineers and biochemical engineers.

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sensors and controls, and engineering design. There were 114 separate podium presentations available from which the 158 meeting attendees could chose. In addition to the technical sessions, a student poster session contained 37 excellent poster presentations.

Also at the annual meeting, I had the chance to present my vision and goals for IBE. It is my hope that IBE can become the society of choice for professionals, faculty members, and students in biological engineering. To assist in the development of IBE, I outlined the following specific goals for 2005:

- Increase membership in IBE by 50 to 100% with each member attempting to bring in at least one new member;
- Solidify relationships with other professional societies with emphases on biological engineering and related areas. An effort was started in 2004 to reach out to other societies such as IEEE/EMB, SFB, ASME, and AIChE/SBE, and I hope that we can establish agreements with these and other groups to advance the discipline of biological engineering;
- Continue efforts to plan and deliver a core competencies conference to outline the essential elements of a biological engineering education. Past President Roy Young is taking the lead in contacting interested societies and groups with the goal of funding such a conference in the fall of 2005 or early 2006.
- Establish a quarterly email communiqué with the members of IBE to keep them abreast of topics of interest related to IBE and the discipline of biological engineering;
- Revise the IBE brochure. A task force was named at the Athens meeting to begin this assignment immediately. Brahm Verma and Steve Walker will be leading this effort;
- Convene a mid-year meeting of the governing board of IBE, the IBE Council, in early fall at a major airport hotel. This will allow the Council to better plan activities of IBE throughout the year, rather than relying solely on the meetings at the annual meeting;
- Work with the undergraduate and graduate councilors to create additional and stronger student chapters; and
- Help the students plan a new competition event for the 2006 meeting to add to the student poster competition. One suggestion was to have an essay competition on a bioethics topic.

I extend my thanks to Past-Presidents Brahm Verma and Roy Young and to immediate Past-President Lalit Verma and the 2004 IBE Council for setting the stage for a great 2005, and I look forward to working with President-Elect Vince Bralts and the Council in the current year as we carry out the goals for IBE.

IBE is poised to grow and become a leading society for the field of biological engineering. I ask you to join with the other members and become more active in 2005 and to help shape the future of IBE. There are three specific things that you can do to help: 1) recruit at least one other colleague into joining IBE; 2) join one of the IBE committees and participate in the activities that they have planned for 2005; and 3) make plans to attend and participate in the 2006 annual meeting in Tucson. IBE is ready to move forward, and I invite you to be a part of its future.

IBE members listen attentively while panel members offer advice to students asking questions about employment at the student-sponsored dinner during the IBE meeting.

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Too many of us are more comfortable with talking about Biological Engineering than with biology, and that causes some of our hesitance to speak confidently about biological topics outside our areas of specialty. Yet, there are certain principles in biology that are not observed just at one level or another, but instead permeate all of biology.

It is at this general principle level that biology can be understood most easily. Once the general principles are known, it becomes more realistic to expect to be able to transfer knowledge of a familiar biological subject to one which is unfamiliar.

So what are these principles? Unfortunately, they have not yet been written down. They are waiting for Biological Engineers, such as you and me, to articulate them. I have tried to start this process in my Biology for Engineers book (www.bre.umd.edu/johnson.htm), but it will take many of us to get it right. One principle, however, is clear: the genetic foundation of a population does not change unless there is a reproductive advantage to doing so. "Desirable" genes are not selected for, and "undesirable" genes are not selected against unless there is a selective process going on to begin with. You can bet on it.

Brian Hayes, writing in the July-August 2004 issue of American Scientist, describes a time when all knowledge was classified together as *natural science*. Every kind of knowledge and understanding, from chemistry and physics, mathematics, and biology to philosophy, metaphysics, and religion were taught as one. As time went on, these fields gradually split, each developing appropriate methods and terminology, and this reductionistic trend continues today. In the subdiscipline of biomaterials, for instance, we have specialists in polymers, in ceramics, and in metals. Some day, it seems, we may even see one specialty per specialist, and no one will understand anything anyone else has to say.

Stepping back a bit, we explore our own selves and find that we have some understanding of science, engineering, philosophy, music, art, social graces, religion, and countless other things. In other words, as biological beings, we integrate knowledge about many specialties all the time.

A Biological Engineering design to produce a product or process intended for you and me can only be successful if all these areas of knowledge are considered. A design that fails in one critical area will be unsuccessful even if all else is perfect. The same would be true no matter what biological system is involved.

I conclude from all this that a basic understanding of the entire field of biology is necessary for the Biological Engineer. We can not chop off pieces of biology and ignore the rest; we cannot fail to recognize biology as entirely integrative and unified.

So, while my fellow faculty members may not be able to give specific answers to job possibilities outside their own fields of specialization, they ought to at least have some understanding of the broad opportunities that exist. And, when it comes to answering questions about biology or engineering, they should be confident in the answers they dispense. After all, biology is biology is biology. Right?

Highlights of the IBE Council Meeting

David Jones

Treasurer's Report – Tom Richard distributed budget. 2004 deficit -$4,028

2005 Meeting Report 158 registered , 153 attended

President's Update – Lalit Verma

Roy Young, Lalit Verma, Brahm Verma, and Jerry Gilbert met with various groups including SBM, EMB, AIChE, SBE, BMES, ASEE and others to work toward joint meetings, associate memberships, and other areas of collaborations. Roy Young worked on development of core competencies. Idea is to look at finding sponsorship for a conference (Gordon Style) to develop these competencies. AIChE, and SBM have been the most conversant on these issues.

President's Report – Jerry Gilbert

Jerry Gilbert will be providing a quarterly communication to the membership. Jerry Gilbert, Vince Bralts, and Roy Young will visit ARDEL in Minneapolis in June 2 and 3, 2005 with the Intent to meet with students and faculty. The visit is an opportunity to that will enhance stature and provide a significant connection for MIT. Intend to update, redesign and reproduce the IBE brochure.

Nominations/Elections – Roy Young

- Those elected for the coming year are: President Elect: Vincent Bralts; Secretary: David Jones; Graduate Student Councilor: Praveen Kolar; Undergraduate Student Councilor: Katherine Cleveland; Councilors-At-Large: Doug Cameron, Timothy Fisher, Shelia Grant, George Meyer, Terry Walker. Vince Bralts, by assuming the presidency, leaves a vacant position in the council membership. A person to fill this void will be identified.

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News Release

MIT Establishes Groundbreaking Biological Engineering Major

The Massachusetts Institute of Technology faculty yesterday approved a new course of study for undergraduates, in biological engineering, the first entirely new curriculum established at the Institute in 29 years.

MIT is the first university in the nation to take the step of fusing molecular and cellular bioscience with engineering to create a new biological engineering discipline. Many other universities and medical schools offer biomedical engineering (or bioengineering) programs aimed at applying engineering to medicine, and there are biological engineering programs that have an entirely different focus—generally mainly on agriculture. But an engineering discipline grounded in molecular and cellular biology, enabling a broad spectrum of applications, including but not focused on medicine, has not been established before now. Other universities are expected to be influenced by MIT's approach.

"MIT's program is pioneering the premise of doing engineering analysis, design and synthesis based in modern molecular life sciences with the aim of impacting a diverse set of application areas and industries ranging from microelectronic materials to ocean ecology," said Linda Griffith, professor of mechanical and biological engineering and chair of the biological engineering undergraduate program committee at MIT.

The MIT program is different because the engineering will be taught from the beginning entirely in the context of biology, rather than in the context of machines or chemistry or materials. By contrast, the curricula in biomedical engineering programs typically have students take their engineering courses in various other engineering departments, then learn to apply engineering to medicine and physiology.

Nine new subjects at MIT have been developed for the course of biological engineering, in addition to advanced subjects in math, chemistry and biology. Core subjects include Thermodynamics of Biomolecular Systems; Fields, Forces and Flows of Biological Systems; Molecular, Cell and Tissue Biomechanics; Biomolecular Kinetics and Cell Dynamics; and two laboratory subjects in biotechnology and biological instrumentation. The math and science core will include organic chemistry, genetics, cell biology, biochemistry and differential equations.

MIT Provost Robert Brown described the establishment of the new program as "a tremendously important step in the development of the academic interface between biology, health science and engineering. It is wonderful to see MIT's leadership on this important frontier propelled by such a wonderful group of faculty colleagues."

The last new course of study established at MIT before today was Linguistics and Philosophy in 1976. Since then, other departments have added different "flavors" to their undergraduate degree programs. For instance, the Department of Mathematics now offers a bachelor of science in mathematics with an emphasis on computer science. A number of new graduate programs have been developed, most notably the Computational Systems and Biology program that started in 2004. But yesterday's faculty vote in favor of the new biological engineering course is the first new course of study in 29 years.

Best Poster Awards Announced

1st Place An Undergraduate Biomechanics Module for Modeling the Development of Neuromuscular Disorder Impact of Static Flexion Duration
R. LaBray, M. Solomonow, W.T. Monroe, LSU

2nd Place Development of a Microcounterlever Sensor Array
M. Taveras, Stan Stolpe, David Britt, Utah State University

3rd Place Primary Recovery of Human Lysozyme from Rice Flour
L.R. Wilken, Z.L. Nikolov, Texas A&M University

Student Chapter Activities
University of Georgia
Praveen Kolar

We at university of Georgia are in the process of revamping our student chapter. In addition to our team, there are 8 new graduate students who are keen to get involved. We also had an opportunity to host a dinner at the recently concluded tenth annual IBE conference at Athens, GA. Presently we are working to restructure our graduate student lounge. Our plans for this year include collaboration with students from other departments like physics, biology, chemistry etc, and organizing a faculty-student mixer.

One of our long term goals is to initiate an IBE student chapter interaction. For example, we love to interact with the student chapter at Clemson University or Mississippi State University. As these are located within a few hours drive, we could take a day off and visit these student chapters.

Update on the University of Maryland Biological Resources Engineering

As announced at the IBE meeting, the BRE department faculty voted to petition the Provost to move the BRE Department and the BRE undergraduate and graduate programs to the College of Engineering from the College of Agriculture and Natural Resources. As part of that petition, the following provisions were requested:

1. BRE faculty members and other faculty from other departments would form a new department dedicated to the application of engineering related to biology, including medicine.
2. Some faculty could retain partial or whole appointments in the College of Agriculture.
3. Facilities and support personnel would remain with BRE.
4. No faculty salaries would decrease if appointments went from 12 mos. to 9 mos.
5. Departmental budgets should not decrease.

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Synthetic Biology
Arthur T. Johnson

One of the biggest buzzes at the most recent IBE meeting was about synthetic biology, or artificial life. There are estimates of about 100 labs worldwide attempting to create life forms that never existed before, including ones that are nothing like any other living thing (Stroh, 2005).

Steen Rasmussen and Liaohai Chen are attempting at Los Alamos National Laboratory to create life from the bottom up. They are locating the molecular machinery for their protocell on the outside, where a membrane is not needed. A clump of hydrophobic fatty acid molecules glues the thing together as a structure called a micelle.

Genetic material for the protocell will be supplied by peptide nucleic acid, or PNA, which has the same double-helix structure and the same four chemical bases as DNA, but has a peptide backbone. A light-sensitive molecule will be able to provide the energy to convert precursor molecules into new fatty acids and PNA molecules. Newly created fatty acids will be incorporated into existing micelles, making them larger and larger. At some point they become unstable and split into two, as a simple form of binary fission.

A top-down approach to artificial life is being attempted by Craig Venter at the Institute for Biological Energy Alternatives in Rockville, MD. His team starts with a simple 517 gene organism called *Mycoplasma genitalium*, and pares away as many genes as possible while still maintaining a semblance of life. As many as 215 genes may be unnecessary. A substitute genome is to be constructed from scratch and will require 300,000 chemical bases. If successful, the artificial life form could be loaded with genes to perform useful functions.

Reference:

Stroh, M., 2005, *Life Built to Order*, Pop. Sci.:64-70 98-99 (February).

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This petition was signed and delivered on 1 November 2004.

In this interval, the two Deans of Agriculture and Engineering met to discuss means by which this transfer could occur. Resources and sources of support were uppermost in these discussions. Each BRE faculty member was allowed to indicate where she/he wished to locate.

A meeting is scheduled for 22 April 2005 among the Provost, Deans, and BRE faculty. In announcing this meeting, the following principles were stated by the Provost:

1. Faculty members in BRE will choose the college in which they wish to hold their appointment.
2. Those who go to Engineering may be in the new Department of Bioengineering, when formed, or they may choose to join the faculty of other Engineering departments.
3. Those who stay in Agriculture and Natural Resources will be in either the Department of Natural Resources and Landscape Architecture or some other unit, existing or to be created.
4. In either college, those who go to an existing department will have to be accepted by that department's faculty.
5. Appointments for those who go to Engineering will be changed over time to academic year appointments like those now prevalent in Engineering, and Maryland Agricultural Experiment Station and Maryland Cooperative Extension appointments will remain in Agriculture. (Those leaving who have such appointments will have their appointments changed to State instructional funding.)

This drama is still unfolding. Stay tuned.

Biological Engineer at Work

Annette Dixon interviewed Cris Kloss, who graduated form the Biological Resources Engineering program at the University of Maryland in 1996. Chris has been working in bioenvironmental engineering.

How did you choose your major?

I wanted to major in an environmental specialization and originally was in the Environmental Engineering program in the Civil Engineering department. That program wasn't what I was looking for and I was considering changing majors to natural resources management or environmental science when I learned about the Biological Resources Engineering program (which was just getting started when I was an undergraduate in the early 90s). The focus on natural environmental systems with added coursework in biological sciences and chemistry was very appealing to me.

How did you get your job?

A friend of mine in graduate school mentioned me to a co-worker who put me in touch with my current boss. It ended up just being good timing, as my boss was looking for someone with my background. But I wouldn't have obtained this job if my friend hadn't asked around at her office.

What does your job entail?

I work at the Low Impact Development Center, a research-oriented non-profit that specializes in sustainable development and water resource protection. My job responsibilities are varied, ranging from designing sustainable development demonstration projects to writing environmental guidance manuals and documents, and working on collaborative research projects with professional organizations and universities.

Do you feel there is a firm understanding of biological engineering and applications at your job?

Biological engineering is one of the foundations of the Low Impact Development Center. Low impact development methodologies are based on using natural features (or engineered systems mimicking natural features) to minimize storm water runoff and to mitigate its effects. There is a strong belief that environmental systems with decentralized controls such as bioretention cells, grassed swales are perhaps the best approach to dealing with stormwater volume and quality issues.

Does a B.S. limit your career and would an advanced degree help?

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I am a bit biased because I have received a graduate degree in environmental engineering and will receive a second graduate degree in environmental policy this May. For my personal career path, I felt that graduate degrees were very necessary, and they have been an invaluable component of the knowledge base that I attempt to apply to my work. I don't know that a B.S. limits one's career; there are still many job opportunities for those with a B.S., but it is increasingly desirable to have a graduate degree as well.

Are you pursuing a PE certification?

Currently, I am not pursuing a PE. My interests have focused more on policy issues surrounding environmental protection.

How much of what you have learned in school is applicable to your job?

A great deal of what I learned, both in engineering and policy, is related to my job. I am very glad that the Biological Resources Engineering program required additional chemistry and biology coursework. Chemistry and biological sciences are at the foundation of so many environmental specializations.

Is the work you did in college similar to the work you're doing now?

My current work environment is a bit more of an academic setting than some of my prior consulting work experience. Because of this, there are more similarities between my professional work and collegiate work. While I was consulting there were fewer similarities between work and school.

Do you feel the field of biological engineering is up to date in its major requirements?

The program requirements prepared me very well for graduate school and work. Because of the breadth and variety of required program coursework, I felt that I had bit more comprehensive undergraduate background than others with comparable engineering backgrounds in graduate school.

Is there any course or skill you wished you had learned before entering the field?

Although it's not possible with all the requirements of an engineering degree, I would have liked more exposure to social sciences and literature. These aren't exactly needed as professional requirements, but I wish I had had more exposure to non-technical classes while I was in school.

What fields in biological engineering do you see emerging?

I can't give a good answer, because I'm not involved in evolving biological engineering trends at work.

Do you have any advice for the up and coming biological engineers?

Take advantage of the electives available at school. I was exposed to a topic and field of study in an elective course that became and has remained an academic and professional interest.

What types of pre-graduation experiences make a recent grad a more enticing hire?

Although everyone gives this answer, good writing skills are always desired. Being able to convey scientific information to non-technical audiences is a much needed skill for any area of biological engineering. Practical work experience is always a plus, but I wouldn't necessarily take summer jobs for practical experience at the expense of interesting or socially conscious jobs or volunteer experiences. Being a student allows one to volunteer or take certain types of jobs that they won't be able to as a graduate. Employers are able to tell someone who is motivated and a good hire no matter what their employment background.

IBE congratulates Dr. Roy Young for his election as Vice Chair of the AIMBE Council of Societies.

Where Is the Essence of a Human Being?

An excerpt from Biology for Engineers (www.bre.umd.edu/johnson.html):

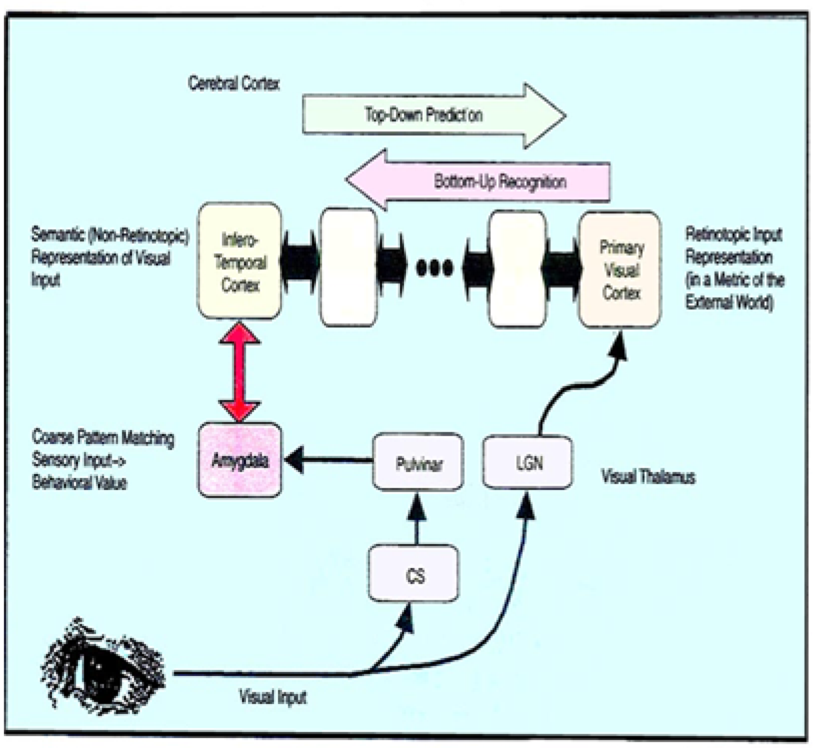
The importance of emotional responses cannot be minimized, even for engineering purposes. Körner and Matsumoto (2002) have attempted to organize an artificial neural network model to analyze visual signals in a manner similar to the efficient parallel processing of the human brain. Many current approaches to this problem, they claim, have not attempted to understand the organization of the brain and its functioning. The current thinking about brain functioning is that relatively new brain structures, such as the neocortex is responsible for defining the parameters of brain function. According to this concept, the processing that goes on in the neocortex is responsible for recognition and plotting of responses. Older areas of the brain, the limbic system responsible for basic functions and emotional responses, are confined in their responses by the neocortex. This top-down idea has the psyche of an individual located in the higher centers of the brain.

Körner and Matsumoto (2002) say this top-down concept is wrong. Who a person is is actually determined by the limbic system. It is the emotional responses of the individual that determine the fears, loves, motivations, joys, and principles at the core of the person. The important self-image of a person is defined by the older structures of the brain. It is these structures that limit the responses of the newer parts of the brain in bottom-up fashion.

Needless to say, this turns the concept of human brain functioning upside down, and removes an important distinction made by some to divide humans from the rest of the animal kingdom. If true, the innate, hard-wired, patterns in the limbic system that make up the basic emotions have much more importance in human brain functioning than was previously thought. It also might lead to vastly improved engineering means to process information with the efficiency of the human brain.

What implications does this have for right-to-life cases when the patient has no activity in the higher centers of the brain, but does have activity in some of the more primitive centers?

In their concept of brain visual function, Körner and Matsumoto (2002) attribute a visual representation of objects to various older structures of the brain (colliculus superior (CS) and lateral geniculate nucleus (LGN)). Higher level processing in the inferotemporal cortex is limited by persona attributes defined by the amygdala (part of the limbic system).



Körner, E. and G. Matsumoto, 2002, Cortical Architecture and Self-Referential Control for Brain-Like Computation, *IEEE Engineering in Medicine and Biology Magazine* 21(5): 121-133 (Sept/Oct).

Biology-Inspired Engineering Design: Report from IBE 2005

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Biological engineering has only recently emerged from an applied science to its current status as a legitimate field of engineering professional practice. Biological systems exhibit a number of properties that challenge our traditional ways of thinking. Among the most dramatic are time and age dependent changes in form, composition and behavior, including evolution, adaptation, competition, emergent properties and others. Many biological processes respond to external stimuli such as light, temperature, pressure, population density, nutrition, etc. in sometimes-unpredictable ways through self-regulation, aggression, and learned or genetically derived anticipatory actions.

Rarely can we design one element of a process without deep connections to surrounding elements. In biology, inclusive systems and interactions tend to produce more robust and sustainable outcomes – in biology the operative word is AND versus the traditional design choice OR in engineering.

In spite of the great advances in biology and biological engineering science, designers are faced with high levels of uncertainty and many unknowns in their design efforts. Chaotic behavior is "normal" in biology. Every day we are surprised by discovery of previously unknown interactions between organisms and their environment, and among organisms in a population. The biological world is constantly affected by environmental and ecological pressures within and beyond what ecologists call the "natural range of historic conditions."

With all this chaos, uncertainty and unknowable stuff, there are fundamental principles that we can use as anchors. Form tends to follow function in biological engineering design. Survivability depends upon minimizing energy consumption and maximizing energy conservation. Interactions and communication is based on minimizing the information content of messages and signals. Structural arrangements and distribution of biological elements in a system maximize system survival in the short term and sustainability over an uncertain long term.

The IBE 2005 panel included leading developers of biological engineering design. Each came to the discipline of biological engineering from very divergent backgrounds and perspectives. Dr. Nam P. Suh from the Mechanical Engineering program at MIT is a former department chair of mechanical engineering and creator of the Axiomatic Design methodology. Dr. Joel Cuello has worked to develop a philosophy and method for design based on his history in agricultural and biological engineering. Dr. Drew Endy received his undergraduate in civil engineering, masters in environmental engineering and PhD in biochemical engineering. Remarkably, although they came from different backgrounds and practice in different areas, their ideas about design in biological engineering share many elements – functional objectives, constraint systems, and hierarchical process models.

Drew Endy http://web.mit.edu/endy/www/index.html was from the Synthetic Biology Group at MIT http://web.mit.edu/synbio/www/ . His talk discussed (i) libraries of standard biological parts (e.g., http://parts.mit.edu/), (ii) part abstraction and an abstraction hierarchy that supports the engineering of many-component integrated genetic systems, and (iii) the decoupling of biological system design from system fabrication. The future of biological engineering design should parallel the "mature" engineering disciplines (e.g., mechanical, chemical, electrical, civil, and software) in that designers should be able to routinely integrate large numbers of well-characterized components to produce many functioning systems. A scaleable development path for biological systems engineering might be inspired by past successful experiences in other engineering disciplines.

Joel Cuello http://ag.arizona.edu/ABE/People/Faculty_Homepages/Cuellos_Homepage/WEBPage.htm presented the latest thinking on his concepts of the duality of biological engineering design as a pair of methods that connect engineering *and* biology, encompassing both "connecting engineering *to* biology" and "connecting biology *to* engineering" in its engineering design process. The first directional case of "connecting engineering to biology" pertains to the application of the engineering design process to regulate and manipulate a given biological system for the purpose of achieving a desired end. The second directional case of "connecting biology to engineering" pertains to employing the knowledge of the attributes of biological systems to inform or guide the engineering design of a physical system for the purpose of achieving a desired end. For "connecting engineering to biology," the object of the design process is a biological system and its design factors are limited by physicochemical principles. Contrastively, for "connecting biology to engineering," the object of the design process is a physical system and its design factors are limited by biological attributes.

Nam Suh http://me.mit.edu/people/personal/npsuh.htm presented an engaging introduction to the application of axiomatic design methods for doing design in the biological arena. Dr. Suh showed how the independence axiom can

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Headquarters Report – Amy Lemon

Membership numbers look good. Web site Stats: 4500 hits since January 1, 2005; 36000 hits in 2004 calendar year; 8200 hits in 2003 calendar year; 2005 Meeting Program — 588 hits (February)

2006 Meeting – Mark Riley

Tucson is the location with March 3, 2006 as the target date.

Meetings – Steve Hall

- Candidates for the 2007 site are: Binghamton University, Binghamton; MIT, Boston; North Carolina State, Raleigh
- Candidates for the 2008 site are: College Park, MD; Penn State, State College; Utah State, Logan

Branches and Chapters – Lalit Verma

Each chapter will be contacted this year. Katherine Cleveland reported that student activities under consideration for the 2006 meeting include: considering ethics essay competition; planned recreational activities; panel discussion; job/internship contacts; undergrad seminars

Membership – Czarena Crofcheck

There are 79 student members and 64 regular members. These data are accurate prior to the 2005 meeting.

IBE Development Fund – Brahm Verma

A contribution of $1050 was received in 2004. A contribution of $100 was received at this meeting.

New Business

Lalit Verma moved, and George Meyer seconded, that the dues for students be reduced from $25 to $15. Discussion ensued. The motion carried. This will go into effect for the 2006 year.

Brahm Verma moved and Roy Young seconded the following resolution…

> *"Be it so resolved that the Institute of Biological Engineering endorses and supports the creation of ABET program criteria for biological engineering. Furthermore, the Institute offers its assistance to the members of ABET as they seek to implement the new criteria."*

The motion passed.

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be used to decouple seemingly intractable problems for subsequent solution. There are several key concepts that are fundamental to axiomatic design: the existence of domains, mapping, axioms, decomposition (by zigzagging between the domains), theorems, and corollaries. For a system to be robust and stable, it must satisfy the Independence Axiom, which states that the functions (i.e., functional requirements, FRs) of the system must always be independent from each other and must always be satisfied by choosing a correct set of design parameters (DPs). In biological systems, we know DPs, but we often do not know FRs. Therefore, FRs must be established based on our understanding the functions of the biological system. It appears that the Independence Axiom is satisfied by many biological systems.

The high-level FRs and DPs are decomposed to the "leaf" level (i.e., the lowest level) through zigzagging between the functional and physical domains so as to achieve the highest FRs in terms of the leaf-level DPs. We must relate FRs and DPs using a design matrix throughout the system design, thereby creating a hierarchy of FRs and DPs. The design matrix enables us to determine how the high-level FRs are related to the molecular behavior (i.e., lower-level DPs). The Information Axiom states that the probability of satisfying the FRs should be maximized. The process of evolution might have eliminated those biological systems that do not satisfy this axiom.

One of the major goals of science and engineering is to reduce complexity. Complexity is defined as a measure of uncertainty in achieving the specified FRs. Complexity can be a function of time or can be completely independent of time, depending on whether or not the system range changes as a function of time. Therefore, complexity can be classified into the following two kinds: *time-dependent complexity* and *time-independent complexity*. The time-independent complexity can further be subdivided into real complexity or imaginary complexity. The information content defined by the Information Axiom is a measure of time-independent real complexity. When the system range moves as a function of time, there are two types of time-dependent complexity: time-dependent *combinatorial complexity* and time-dependent *periodic complexity*. We can reduce time-dependent complexity by transforming a system with combinatorial complexity into a system with periodic complexity. Many biological systems have a functional periodicity (e.g., cell mitosis).

An outcome of the audience response to these three presentations is that IBE will seek to expand the design content of IBE 2006 to be held in Tucson.

2005 IBE Committees

Chapters/Branches	Chair:	Lalit Verma	lverma@uark.edu
	Members:	Dawn Farver	dfarver@uark.edu
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POSITION ANNOUNCEMENT

LABORATORY DIRECTOR FOR HEALTH AND ENVIRONMENTAL SYSTEMS LABORATORY

The Georgia Tech Research Institute (GTRI), the applied research arm of the Georgia Institute of Technology, is initiating a national search for the first director of a newly created laboratory focused on Health and Environmental Systems. This new research laboratory will be an integral component of GTRI and Georgia Tech focusing on emerging and applied research in biomedicine, health and safety, and environmental engineering. This will include the work of existing and future programs in assistive technologies, biophotonics, public health, toxicology, epidemiology, safety, and sustainable engineering.

This challenging position holds equivalent rank to a School Chair in the academic units and requires the ability to nurture and promote collaborative research and education programs across the University. The unique opportunity to help develop a major new operating unit of the Institute will necessitate a person with a flair for developing teams and programs necessary to make this a success. The laboratory should begin operations with approximately $7.5 million in annual awards with the intent to grow. The position reports to Dr. Stephen Cross, Vice-President of Georgia Tech and Director of GTRI, a major unit within the Georgia Institute of Technology focused on client-oriented applied research and professional education. GTRI cooperates fully with the academic schools and colleges of Georgia Tech, and the director of the new laboratory may be offered the opportunity of a joint appointment with one of the academic units of the Institute.

Candidates for the position should have a PhD, MD, DVM, or equivalent degree and experience in engineering, physics, biology, chemistry, applied mathematics, or medicine and an established biomedical, health and safety, or environmental background. Ten or more years of experience in a leadership capacity with a specific technology orientation is essential. Candidates should possess a broad range of management skills in strategic planning, team building, and development of financial support. The candidate selected may be subjected to government security investigation for access to classified information. Experience in a university research environment is a plus. Candidates should possess the ability to relate to both industry and academic environments; strong organizational and communication skills; a strong understanding and vision of the future directions in biotechnology and environmental research and products; an understanding of the requirements related to building large-scale research programs; and personnel and financial management expertise.

Resumes should be submitted to:

Chairman, Search Committee, HESL
Personnel Support Team / GTRI /Georgia Institute of Technology
430 Tenth Street, North Bldg Room 117
Atlanta, GA 30318-0807.

Resumes may also be submitted to employment@gtri.gatech.edu. Please specify “Lab Director-HESL” in the subject heading.

The search will continue until the position is filled. The targeted date for selection is the third quarter of CY2005.

Georgia Tech is an Equal Opportunity Affirmative Action Employer. For more information visit http://www.gtri.gatech.edu