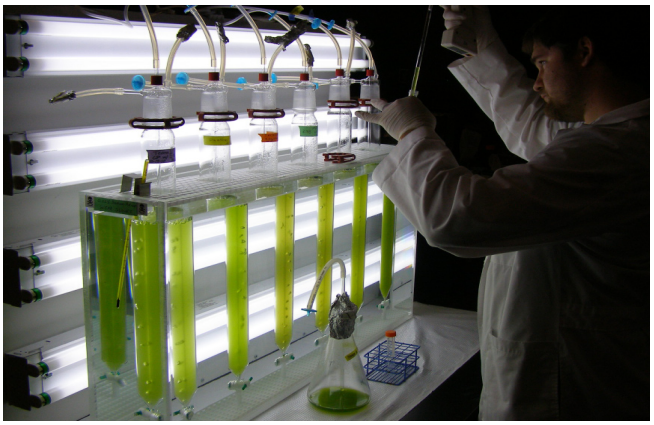
BIOMAN 2011 JOURNAL

MiraCosta College bioreactor trains new biofuel workers

Educators in biomanufacturing from around the nation gathered at MiraCosta College in Oceanside, CA for the **2011 NBC² BIOMAN** conference. Four days of BIOMAN's hands-on laboratories, panel discussions, lectures, and keynotes provide more than enhanced skills and inside industry information for educators. Faculty participants return home inspired, motivated by greater understanding of biomanufacturing. With new NBC² textbooks, manuals and teaching materials in hand, they've gained new ideas and innovative ways to engage students learning in this growing, well-paying field.



Green jobs are coming, biomanufacturing educators and industry join to prepare at BIOMAN conference

The BIOMAN conference concentrates on training America's biomanufacturing workers. With fifty new graduates, the first to complete a new, six-month program to train technicians for biofuel and other "green" jobs, Mira Costa Community College was the perfect site for this year's BIOMAN. "The sustainable bioenergy sector will eventually create millions of new jobs nationwide," said conference keynote speaker, Stephen Mayfield, professor of biology at UC San Diego.

BIOMAN Keynote Speaker Stephen Mayfield: doing a lot to bring people good paying green jobs

Mayfield works hard to create green jobs. He directs an innovative public-private partnership known as the San Diego Center for Algae Biotechnology. It's a prime mover in creating cutting edge curriculum and getting new biofuels programs - like Mira Costa's - up and running. Thirteen graduates have already landed good-paying jobs.

Meeting training challenges is where the EDGE - Educating and Developing Workers for the Green Economy - comes in. Mayfield directs this collaborative effort focused on getting a next-generation workforce ready for the massive scales coming in green technologies.

With unemployment exceeding nine percent and gas prices unpredictable, Mayfield's presentation took on crucial topics of job creation, dependence on diminishing oil, climate change, the real promise of algae-based biofuels and more of the nation's top concerns.

Skills to grow and process energy stored inside photosynthetic marvels such as algae are increasingly needed. Mayfield, who is co-founder and scientific advisor at a powerhouse, pioneering San Diego algal biofuels company - Sapphire Energy - says algae can start to power our cars, planes, and light bulbs - "but only if we have enough smart workers to do it." ***(continued on page two)***

*Register for **BIOMAN 2012***
July 23-26 at Alamance Community College in Graham, NC

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Mayfield: We can manufacture biofuels from algae on a large scale

A renowned expert and leader in the molecular biology and genetics of algae, Stephen Mayfield is a professor at the University of California, San Diego. With research focused on producing new therapeutic proteins and biofuel molecules from algae, Mayfield was awarded his doctorate from the University of California at Berkeley in 1984. An avid surfer, he could often been seen out on the waves not far from the Scripps Research Institute, where he served on the faculty for years.

Goin with the flow - Mayfield is also an avid surfer.

Now he heads a regional consortium working to develop biofuels from algae on larger and larger scales. He is seeing results. His company, Sapphire Energy, is currently building a demonstration facility in New Mexico expected to produce between five and ten thousand barrels of biofuel oil per day by 2018.

In light of the massive climate, economic and security issues involved with hydrocarbon fuels, Mayfield pulled no punches. He started his keynote address at BIOMAN saying "society has a science illiteracy problem. And scientists rarely communicate well." As he spoke, he revealed chilling realities.The end of the hydrocarbon era is approaching, he said, "we will will run out of all energy reserves by 2099." Using slides, Mayfield told the story of how today - more than ever - the world is linked to, and dependent on, fossil fuels. "We burn three hundred billion gallons of petroleum a year," said Mayfield.

The good news is, he said, "while the world consumes fifteen terawatts of energy every year the sun provides 86,000 terawatts of energy every year." The challenge now is how to convert such abundant sunlight into energy that can immediately be used in our existing infrastructures. "Why use algae as the conversion platform?" Mayfield began to answer this question by explaining how algae's power of photosynthesis - the conversion of solar energy into chemical energy - knocks out rates of existing corn and soybean based ethanol production. These plants produce around five thousand liters of fuel per hectare per year. Fast-growing algae can easily double those numbers and can be grown in unused areas; no interference with food production.

View a video of Dr. Mayfield's keynote presentation - click here

Mayfield made a strong case for algae as the world's best energy conversion platform by defining the word "fungible." "This means it fits right in." Indeed, fossil fuels the world's infrastructure is based on are themselves algae-based. Millions of years ago petroleum started out as algae-like living organisms on the floor of the ocean. Fossilization began its conversion into usable fuel. Today, using biotechnology we can cut to the chase and process oil-rich algae for its fuel directly. "Once the oils are processed into green crude it goes directly into existing oil refineries. It can be processed, stored, delivered and burned just like any oil - it's totally fungible," said Mayfield. Such biotechnology advances spell hope for a sustainable future.

Yes, it is still an expensive, energy-intensive operation to grow and harvest algae, extract its oil and process it into a fungible fuel. But now companies use synthetic biology techniques, plus other scientific advances, to bring costs down. Algae is made more efficient by increasing oil content of its cells, changing how it processes light, and improving its efficiency at fuelmaking. Sapphire uses synthetic biology to rapidly survey thousands of genetic manipulations to isolate high-oil producers. It's identified several genes, some from algae and some from other organisms, that, when inserted into lipid biosynthesis pathways, increase oil production. Scaled up, algae can produce up to ten thousand more liters per hectare annually.

Mayfield talked about commercial air flights already use algae jetfuel blends now. He showed a photo of Algaeus, a hybrid vehicle built by Sapphire that's repeatedly crossed the country on algae-based, renewable gasoline or diesel. In conclusion, he spoke about algae reaching world scale production, creating economic viability with a sustainable, fungible fuel product. Many well-trained green job workers will be needed to get us there.

A message from the director

Sonia Wallman, Ph.D.

In partnership with industry, NBC² educators work to make sure tomorrow's biofuels companies have a highly-trained workforce. Because the United States lags in science, technology, engineering and math (STEM) we must inspire and educate people to choose careers in these fields today. Biofuels can help do this because people today are more concerned about global sustainability than ever before. We need public-private partnerships so biofuel companies can provide internships and other opportunities for learning. Such practical experiences lead directly to employment.

One exciting example of such collaboration, in San Diego, is a program called EDGE - Educating and Developing Workers for the Green Economy. This "Green" approach answers our need to develop new domestic sources of clean energy while inspiring people to pursue STEM careers. San Diego's leadership in biofuels provided a local industry focus for BIOMAN 2011; regenerative medicine will be the local focus for BIOMAN 2012 in North Carolina.

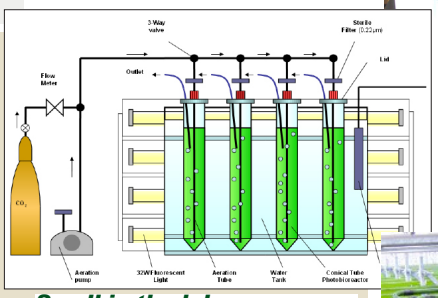
We will publish our industry authored Global Biomanufacturing Curriculum Introduction to Biomanufacturing textbook this fall. We also have a wonderful STEM-strong biofuels textbook and lab manual written by Elmar Schmid at MiraCosta Community College. The biofuels curriculum will be piloted at the University of Hawaii Hilo in spring 2012 with publication slated for fall 2012.

Protein Is Cash workshops help bring awareness of biomanufacturing career paths to teachers and their students in locales with a maturing biotechnology industry throughout the U.S. and Puerto Rico. In two years of workshops we have given 160 high school teachers a hands-on and theoretical understanding of biomanufacturing, knowledge of opportunities for employment at local companies and of educational articulations possible from high school to community colleges to four year colleges and universities. We help create local, sustainable infrastructures to support career pathways in biomanufacturing.

Hands on biomanufacturing industry workshops and labs inspire educators

MiraCosta College biomanufacturing training facilities, especially its bioreactor, were humming all four days of this year's **NBC² BIOMAN** conference. Educators from around the nation experienced hands-on biomanufacturing activities gaining enhanced skills and inside industry information. Learning how sophisticated biomanufacturing operations are run, using new NBC² textbooks, they took away new ideas and innovative means to engage student learning.

Elmar Schmid, Ph.D., gave BIOMAN participants in-depth understanding of the science that drives biomanufacturing through hands-on experiments run on the bioreactor (right)

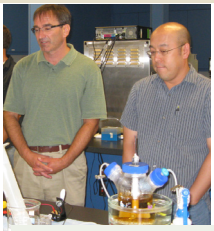


Using diagrams (left) and other aids, Schmid helped educators understand how to control and measure processes.

Microalgae to Biodiesel

This workshop discussed the promise of algae for biofuels and nutriceuticals. These microscopically small, photosynthesizing life forms average in cell size around 5-10 µm. They divide very rapidly under suitable conditions. Doubling times can be on the order of 8 to 36 hours. Algae has a much higher photosynthesis efficiency than plants currently used in large scale ethanol production. Participants used a compound microscope and prepared a hemocytometer. Algae was observed at TM 400x. Cells were counted in 4-16 micro-squares and calculated cell density. Qualitative analysis was also produced in parameters of optical density, biomass production, oil content , oil productivity, photosynthesis rate, aeration rate and solar irradiance.

Small in the lab, processes scale up enormously



Sengyong Lee (right) joins Schmid in the lab observing the bacteria producing hydrogen

Bacteria to Biohydrogen

Attendees learned how hydrogen gas (H2) can be converted into usable heat and electricity with high efficiency and without carbon emissions or soot, using fuel cell technology. H2 has the highest gravimetric energy density (or heating value) of any known fuel. Biohydrogen is produced using life forms found in renewable biomass materials. In this lab session using the bioreactor, participants measured the amount of hydrogen gas produced by a batch culture of a hydrogen-producing bacterium and performed calculations on ithe hydrogen production rate, that is, the amount of hydrogen gas generated per time per volume.

Beginning, intermediate and advanced workshop tracks bring participants tailored experiences

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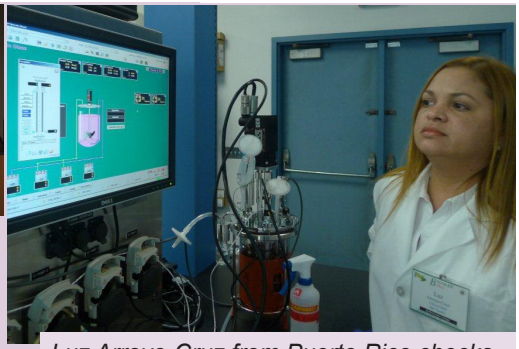
ADVANCED TRACK: Biomanufacturing CHO-tPA with Mike Fino, MiraCosta College

This workshop focused on tissue Plasminogen Activator (tPA) secreting CHO cells. Hands-on equipment and processes were covered in a three-day model of actual biomanufacturing industry core production. All the activities were guided by standard operating procedures (SOPs) and batch records (BRs) to understand how such activities would be controlled in the regulated, industry environment.

The upstream process began as participants were provided with a spinner flask culture of CHO cells that had been cultured to a density to inoculate process-controlled bioreactors. Participants sampled the spinner cultures to determine cell density and viability through the automated Trypan Blue dye exclusion assay performed by the Beckman Coulter Vi-Cell. Participants then prepared 3-L bioreactors that had been previously batched with media and established the process controls for DO, pH, temperature, and agitation on the DeltaV-enabled BioNet control systems.

Mike Fino



Luz Arroyo-Cruz from Puerto Rico checks out the computer screen connected to the process-controlled bioreactor for growing CHO cells.

Inoculation of process controlled bioreactor vessel with CHO cell seed culture at BIOMAN 2011 CHO-tPA workshop.

On the second day participants monitored cultures for cell count, viability, and process chemistry levels with the Nova Medical BP400. A portion of the cultures were harvested and processed via tangential flow filtration (TFF) to concentrate and diafilter the process solution for the subsequent chromatographic separation. The GE AktaPrime chromatography systems were used to perform the ion exchange separation. On day three participants continued to monitor their bioreactor cultures and focused on Quality Control methods. Participants performed an SDS-PAGE analysis to assess the purification of the tPA and confirmed the presence and activity of tPA through a spectrophotometric activity assay.

Hands on biomanufacturing industry workshops and labs inspire educators

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Keynote: Lee Landeen, Ph.D., Advanced Biohealing "Engineered Tissues for Wound Healing Applications"

Advanced BioHealing is a leader in regenerative medicine to repair damaged human tissue and enable the body to heal itself. Dermagraft® is a bio-engineered skin substitute that assists in restoring damaged tissue and supports the body's natural healing process. Dr. Landeen described the development of this fibroblast laden membrane that is used extensively in healing diabetic foot ulcers. He described the science behind the mechanism of action of Dermagraft explaining that it delivers normal dividing fibroblast to the wound, which release growth factors such as FGF, IL-8 and VEGF, and acts as a substrate for re-epithelialization.

INTERMEDIATE TRACK

Taq Polymerase Cloning, Expression and Production with Tom Burkett, Community College of Baltimore County

Participant activities forged connections between what happens in the research laboratory, where a protein encoding gene may be cloned, and the manufacturing suite, where the protein is produced. Burkett led a sequence of exercises on the cloning, expression, and purification of Taq polymerase. Arguably the most used enzyme in biotechnology, this enabling event behind the polymerase chain reaction emerges as a theme in recombinant DNA and biomanufacturing courses. The series went through the process of cloning by amplification of the Taq polymerase gene with its subsequent expression and analysis. Attendees took away validated procedures they can bring to their classrooms. Materials and experience also include the PCR amplification, purification, and quality activity assays for the pol I gene and protein from Thermus aquaticus.

BEGINNER TRACK - Introduction to Biomanufacturing

Downstream Processing of GFP with Kevin Lampe, Montgomery County Community College and Mary Jane Kurtz, NBC²

This workshop focused on the Downstream processing aspect of Biomanufacturing. Participants performed protein purification processes on the Green Fluorescent Protein (GFP) including a novel extraction process and column chromatography. The purity of the product was analyzed by polyacrylamide gel electrophoresis.

SDS PAGE analysis of GFP fractions.

Microbiology Tool Kit with John Hasyn, Margaret Bryans and Sheila Byrne, Montgomery County Community College

Microbiological control is a key issue in pharmaceutical manufacturing. This hands-on workshop introduced experiments and techniques used in the industry to prevent microbial contamination of products. Using the Limulus Amebocyte Lysate (LAL) gel clot assay endotoxin levels in cell culture samples were measured. Bacterial Strains were identified using the Gram stain procedure and the API assay, a colorimetric assay for microbe identification. Microbial air monitoring with equipment commonly used in Microbiological Control laboratories such as an Air Sampler and Particle Counter, was demonstrated.

Hands-On Workshop: ELISA with Bill Woodruff, Alamance Community College

The ELISA assay is a widely used immunological assay. The mechanism of action, the theoretical concepts and real-world applications of this useful tool were explored. In a scenario designed to catch the interest of your students, the assay was used to follow a communicable disease as it is passed from individual to individual within a community. In much the same way that epidemiologists investigate epidemics, the trail of infection was followed to determine within two participants the source of the outbreak.

Hands-On Workshop: "Making Biofuels" with Sherri Andrews, Bio-Rad

Panel: "How to Write an NSF ATE Grant and other NSF Opportunities" with Sonia Wallman, NBC²

Interactive Workshop: Best Practices in Hybrid/Blended Learning in Biomanufacturing with Mike Fino, MiraCosta College and Yakov Cherner, ATe

This interactive panel discussion explored courses that blend online with in-person teaching to maximize student value. Moving from in-person contact, traditional lecture and discussion to a flexible, online format helps develop skills quickly for experiential learning. Examples of blended classes include biostatistics and bioprocessing; fully online examples were also shown.

Interactive Workshop: Root Cause Analysis and CAPA with Jim Hewlett, NBC², Finger Lakes CC

Participants were introduced to basics of Root Cause Analysis (RCA) applying tools to real-world case studies. Inadequate investigations continue to be a major GMP deficiency cited during routine and for-cause regulatory inspections of failures in processes, policies, and procedures.

Participant Quotes

The best way to understand BIOMAN - - listen to its participants:

Premeela Kuraguntla, Cecil College
At BIOMAN, we spend the majority of our time together doing hands-on lab activities. This year, the Taq polymerase workshop with Tom Burkett was excellent. It is definitely an activity I can implement at my college because it does not require expensive equipment.

BIOMAN at Mira Costa College, right along the California coast, offered participants moments to relax and socialize.

Bruce Van Dyke, Quincy College
BIOMAN is a great opportunity to network, work on grants, and learn new techniques. Don't miss it next year!

Tom Burkett, Community College of Baltimore County
The value added for having individual tracks this year is immense. Participants come to BIOMAN with different levels of training and experience. Providing introductory, intermediate and advanced tracks allows participants to choose workshops that are applicable to their college and their levels of expertise.

Vivian Ngan-Winward, Salt Lake Community College

BIOMAN provides the perfect opportunity for you to meet other biomanufacturing faculty and industry representatives from around the country. I find it most valuable for the networking opportunities, learning what others are doing in their programs and sharing. This is one of the few conferences that allows you to do it.

Sarah Cote, Ivy Tech Community College
One of the best things about the BIOMAN Conference is the opportunity to network, interact with others and share ideas. Also, it is great to be able learn from industry partners. I don't have an industry background so learning what happens in industry has been very valuable to me over the years.

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Protein is CA $H!

High School Teachers:

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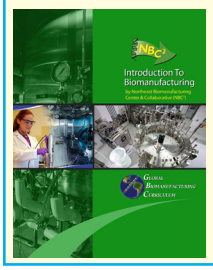

New: ***Introduction to Biomanufacturing*** Textbook

For a sample chapter e-mail swallman@biomanufacturing.org

www.biomanufacturing.org

NBC²

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VISION

To be the nationally recognized center of excellence that develops a world-class sustainable biomanufacturing workforce to improve the quality of life.

MISSION

To coordinate local and regional efforts into a national biomanufacturing education and training system to promote, create, and sustain a qualified workforce.

NSF Awards 0501953 and 0903208