Department of Chemical and Biomolecular Engineering

Senior Design Day 2008
Overview

- Non-traditional projects
- Energy-related projects
- Biotech-related projects
Use of Magnetohydrodynamic Fluids in Manufacturing

Kendra Moreau
Jake Vestal
Christine Watson
Microgravity University

Proposal includes:

• Design of device
  • Functions in microgravity
• Outreach component
  • Magellan Charter School
• Test flight aboard C-9
  • Simulates microgravity
McDonnell-Douglas C-9
EXTRACTING OXYGEN FROM LUNAR SOIL

Team MoonROx

Willie Barton, Laura Blackwell, Jonathon Harding, Daniel Harpham, Eric Hodgden, Patrick McNeely
Motivations and Objectives

- Oxygen for lunar base
- Oxygen fuel for space exploration
- 1 million dollars
<table>
<thead>
<tr>
<th>Components in moon rock</th>
<th>Percent by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon dioxide</td>
<td>46-49</td>
</tr>
<tr>
<td>Aluminum oxide</td>
<td>14.5 - 15.5</td>
</tr>
<tr>
<td>Calcium oxide</td>
<td>10 – 11</td>
</tr>
<tr>
<td>Magnesium oxide</td>
<td>8.5 - 9.5</td>
</tr>
<tr>
<td>Iron (II) oxide</td>
<td>7 - 7.5</td>
</tr>
<tr>
<td>Iron (III) oxide</td>
<td>3 – 4</td>
</tr>
<tr>
<td>Sodium oxide</td>
<td>2.5 – 3</td>
</tr>
<tr>
<td>Titanium dioxide</td>
<td>1 – 2</td>
</tr>
<tr>
<td>Other Components</td>
<td>1.5 - 1.8</td>
</tr>
</tbody>
</table>
Experimental Setup

Hydrogen + Lunar Soil \xrightarrow{\text{Water}} \text{Metal}
Come See Our Poster!

NCSU MoonROx Senior Design Team
Willie Barton, Laura Blackwell, Jonathon Harding, Daniel Harpham, Eric Hodgden, Patrick McNeely

Motivations
- Back to the Moon Initiative
- Establishment of a lunar colony
- Output for further space exploration
- Contest to develop technology

Introduction
- NASA's Centennial Challenges
- MoonROx Challenge to extract oxygen from lunar soil
- Thirteen reactions have been discovered
- More work required to advance technology

Objectives
- Produce oxygen from lunar soil
- Focus on three reactions
- Establish the viability of chosen reactions
- Simulate a feasible reaction scheme

MoonROx Competition Rules
- Produce 2.5 kg of breathable oxygen
- Complete reaction within 4 hours
- Use no more than 10 kW at any time
- Complete apparatus may not exceed 60 kg
- Consume up to 100 kg of lunar soil

<table>
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<th>Component</th>
<th>Percent by Weight</th>
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<tr>
<td>Iron (II) oxide</td>
<td>7.7-8.5</td>
</tr>
<tr>
<td>Iron (II) chloride</td>
<td>3-4</td>
</tr>
<tr>
<td>Sodium oxide</td>
<td>2.5-3</td>
</tr>
<tr>
<td>Titanium dioxide</td>
<td>1.2</td>
</tr>
<tr>
<td>Other Components</td>
<td>1.3-1.8</td>
</tr>
</tbody>
</table>

Lunar Simulant Composition

Experimental Design
- Hydrogen reduction of ilmenite
  - Pass hydrogen gas over lunar soil at 900°C to produce water from ilmenite in lunar soil
  - Ilmenite is titanium dioxide and iron (II) oxide
- Caustic electrolysis
  - Dissolve and electrolyze lunar soil in molten sodium hydroxide at 400°C
- Ion Separation
  - Vaporize lunar soil at 7-10,000°C using a laser

Simulation
- Scale up hydrogen reduction to work on the moon
- Reactor will be 42 cm in diameter and height
- Titanium is ideal material for reactor
- High-temperature electrolysis converts water to oxygen

Conclusions
- Experimental
  - Reaction produces water
  - Better construction and materials
  - Better water collection method
- Simulation
  - Verified successful prototype is possible
  - More work needed for final construction

Acknowledgements
The NCSU MoonROx Senior Design Team would like to recognize the faculty of the NCSU Department of Chemical and Biomolecular Engineering, Orbital Inc., Bobby Cook and Tim Winter of Dicsynthetic Biotechnology Inc., Jim Beawirth of STI Inc., Harold Morton, Kit Young, and Jason Kelly.
Lab on a Chip: 
A Microfluidic White Blood Cell Counting Device

Bessie Bryant, Khalid Kopanski, Justin Smith, Schuyler Wilson
Advisors: Dr. Efimenko, Dr. Velev, Dr. Genzer
Motivations

- HIV, leukemia, neutropenia, lupus
- Fast, accurate test results – no lab needed
- Easy to use – clinics, doctors’ offices
- Relatively inexpensive
Processing a Sample

- **Mixing**
  - Passive mixing structures

- **Separation**
  - Electric fields
  - Cells captured in buckles

- **Detection**
  - Conductivity measurements
Processing a Sample

- **Mixing**
  - Passive mixing structures

- **Separation**
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Processing a Sample

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Processing a Sample

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- **Detection**
  - Conductivity measurements
Come See Our Poster

Lab on a Chip: White Blood Cell Counting Device
Bessie Bryant, Khalid Kopanski, Justin Smith, and Schuyler Wilson

Background
Microfluidics is a growing technology allowing synthesis and analysis of fluids on a micro scale. A device similar to a glucose meter was designed to count the white blood cells in a sample of blood. This device would be useful worldwide for patients with diseases that affect white blood cell levels and require close monitoring.

Process Description
- Sample Introduction
- Mixing, Tetra Structures
- Separation
- Buckled Substrate
- Dielectrophoresis
- Detection: Cell Lysis Impedance Spectroscopy
- Disposal

Mixing
- Mixing not effective in laminar flow
- Tetra structure
- Use of Coanda effect
- Form of passive mixing
- Approximately 30 structures needed
- Achieve near perfect mixing

Buckled Substrate
- Hierarchical buckling
- Angled to facilitate flow and mass transfer
- Used to immobilize the white blood cells
- Sized to fit the dimensions of a white blood cell

Dielectrophoresis
- Primary separation method
- Separates according to dielectric properties
- Attracts white blood cells, repels red blood cells
- AC frequencies induce dipoles on cells

Cell Lysate Impedance Spectroscopy
- Detection method - accurate to 20 cells per microliter
- Releases intracellular ions via lysis
- Correlates ionic conductivity to cellular concentration
- Easily implemented in microfluidic device

Disposal method
- Waste chamber incorporated into device
- Designed to accept more than 10 microliters of fluid
- Entire device can be incinerated to dispose of biohazardous waste

Acknowledgements: Dr. Elmenio, Dr. Veler, Dr. Grezer, Dr. Stallard, and Dr. Pender
What is NanoCool?

NanoCool

Senior Design Project

Uses “Active” heating/cooling

- Reduces package size and shipping costs
- Incorporate temperature control system

Emily Hon
Wran Metzler
Sarah Trexler
Clay Wright
Why Valves?

Summer
Cool package

Winter
Heat package

Package Temperature

- Target Range
  - 45 °F
  - 35 °F

- Current Minimum
  - 32 °F
  - 30 °F

- 60 °F
Stop by our table for more information!
Biodiesel Waste
Water Management

Advisors:  
Dr. Alex Hobbs and Dr. Steven Peretti

Group Members:  
Vanessa Blaylock  
Gabrielle Raymond  
Cindy Wang
Motivations

- **Drought**
- **Importance of renewable energy**
- **Conservation/Environmental**
The Biodiesel Process

Purifies biodiesel of free fatty acids, residual catalyst (KOH), and soap
Objective

• To reduce and treat the water used in the biodiesel water washing process by:
  
  • Designing an efficient washing system that recycles water
  
  • Testing possible water treatments for biodiesel waste water
Conclusions

- Counter current washing dramatically reduced water use.
- Coagulation Flocculation using aluminum salts proved to be effective in removing contaminants.
How Much Water Did We Save?

Stop by our poster and find out!
Design, Control, and Scale-up of an Atomic Layer Deposition Reactor: Deposition on Textiles

Ryan VanGundy

Advisors: Dr. Gregory Parsons, Dr. Lisa Bullard, Dr. G. Kevin Hyde
The next generation of textile technology...
Large-scale production, commercially viable...

or

2000
100-cm² Fabric disks

or

35 T-shirts

... Per Day!
Thank You!
Energy-Related Projects
Projected oil peak worldwide in next 10+ years

World crude reserves

World Crude Oil Reserves, Jan 2000

- Saudi Arabia*: 26%
- United Arab Emirates*: 10%
- Egypt*: 7%
- Iran*: 9%
- Iraq*: 11%
- Kuwait*: 9%
- Venezuela*: 7%
- Nigeria*: 2%
- Libya*: 3%
- Algeria*: 1%
- Qatar*: 0%
- Other Middle East: 1%
- Other Africa: 1%
- China: 2%
- Canada: 0%
- Mexico: 3%
- Othr So America: 1%
- Norway: 1%
- U.K. + other Eur: 1%
- Kazakhstan + Other former USSR: 1%
- Russia: 5%
- Other Far East: 2%
- Othr So America: 1%

5897 Quads
1,016.8 Billion Barrels

Source: Oil and Gas Journal, from the EIA website on International Petroleum Consumption

OPEC Share = 78%
World Coal Reserves - 2005

- Russia: 27%
- US: 24%
- China: 13%
- India: 10%
- Australia: 9%
- Other: 24%

World Total: 1000 Billion Short Tons
19000 Quads

Source: www.eia.doe.gov/pub/international/iea2003/table82.xls
Southeast has relatively cheap power

Risk of dying from coal fired power plant caused particulates

Source: Clean Air Task Force
The new industrial biorefinery

**Biomass Feedstock**
- Trees
- Grasses
- Agricultural Crops
- Agricultural Residues
- Animal Wastes
- Municipal Solid Waste

**Conversion Processes**
- Enzymatic Fermentation
- Gas/liquid Fermentation
- Acid Hydrolysis/Fermentation
- Gasification
- Combustion
- Co-firing

**USES**
- **Fuels:**
  - Ethanol
  - Renewable Diesel
- **Power:**
  - Electricity
  - Heat
- **Chemicals:**
  - Plastics
  - Solvents
  - Chemical Intermediates
  - Phenolics
  - Adhesives
  - Furfural
  - Fatty acids
  - Acetic Acid
  - Carbon black
  - Paints
  - Dyes, Pigments, and Ink
  - Detergents
  - Etc.

**Food and Feed**

From Doug Kaempf - DOE
Sustainable Energy in Africa

Lauren Crumpler
Renee Mitchell
Akin Omófóyè
Christie Reynolds
Una Stone
Sid Subramanian
Chadwick Thompson

Advisor: Dr. Steven Peretti
Scope
Design sustainable energy system:
• Three story building
• 500 students, all year long

Plan
Evaluate:
• Solar-wind hybrid system
• Hydroelectric system
• Stand alone solar system
• Various forms of energy storage
Challenges along the way

- Applying the engineering model to an unfamiliar topic
- Designing a system for an unfamiliar region
- Wind-solar hybrid?
Come find out how you can help provide sustainable energy to schools in Africa!
An original design of a coal to methanol plant with novel options for carbon dioxide removal

Advisors

Dr. Lisa Bullard
Mike Lowder
Dr. Steven Peretti

Design Team

Josh Beatty
Kendall Liner
Brandon Locklear
Dmitri Moundous

Samuel Mootoo
Elizabeth Vara
Brennon Youngblood
Motivations and Goals

Motivations
- Rising oil prices
- Availability of US coal reserves

Goals
- Design a coal to methanol plant
- Determine the business impact of the Carnol process
- Evaluate process economics

http://www.rudrumholdings.co.uk/second_level_pages/ff2.htm
Process Description

Coal to Methanol Plant

- Gasification
- Acid Gas Removal
- Water-Gas Shift
- Methanol Synthesis
- Methanol Refining

Carnol Plant

- Methane Decomposition
- Methanol Synthesis

METHANOL
Results

Coal to Methanol Plant
- 5900 MT/day methanol
- 320 kgal/day ethanol
- Profitable investment

Carnol Addition
- 8000 MT/day methanol
- Reduces 85% of CO$_2$
- Non-profitable investment

<table>
<thead>
<tr>
<th></th>
<th>Coal to Methanol Plant</th>
<th>Carnol Addition</th>
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</thead>
<tbody>
<tr>
<td>Total Capital Investment</td>
<td>$1.3 billion</td>
<td>$179 million</td>
</tr>
<tr>
<td>Raw Materials Cost</td>
<td>$500 million/yr</td>
<td>$1.6 billion/yr</td>
</tr>
<tr>
<td>Operating Cost</td>
<td>$83 million/yr</td>
<td>$450 million/yr</td>
</tr>
<tr>
<td>Revenue</td>
<td>$940 million/yr</td>
<td>$1.0 billion/yr</td>
</tr>
<tr>
<td>Internal Rate of Return</td>
<td>12.4%</td>
<td></td>
</tr>
</tbody>
</table>
Come See Our Poster!

Thank You!
SUPERCRITICAL CO₂

By

Henry Lan
Diana Tysinger
Derek Hernandez
Process Goal
ScCO$_2$ vs. Hexane
Extraction Basics

Solvent

POOF

MIX!!

MIX!!

MIX!!

MIX!!
Does CO$_2$ Compare to Hexane?
Bull City Biodiesel: Production for Shimar Recycling

Advisor: Dr. Steven Peretti
Members: Ahmed Abdel-Rahman
         Matthew Markland
         Erika White
         Bryan Wright
Objective

- Produce a 1,500 gallon per month design for Shimar Recycling in Durham, NC
- Attempt to make cheaper than current biodiesel supplier
- Make process as hands off as possible
- Leave flexibility for future expansion and other chemical options
Accomplishments

- Process size of 500 gallons per batch
- Minimized operator input needed per batch
- 1 week batch process time
  - 3 batches/month
- Capital investment ~$6,000
- Cost of raw materials ~$1.50/gallon
Come see our poster!
Value Added Enzymatic Processing of Waste Glycerol and Low Value Oils

Team Members
Kevin M. Porch, Jose Tan II
James Wright, Ding Shan Yuan

Advisor
Dr. Steven Peretti
MOTIVATIONS

- Increased Biodiesel production = surplus waste glycerol
- Refined waste glycerol = $1.28 - 1.65/gallon
- Glycerol Carbonate = $1.40/gram
- Applications
PROJECT GOALS

- Determine lipase activity for processing
- Design downstream process for glycerol carbonate production
- Analysis (engineering, economic)
- Recommendations
PROCESS DESIGN

Biodiesel Process → Glycerol Carbonate → Enzymatic Reaction

Diagram showing the process design for producing biodiesel through enzymatic reactions involving glycerol carbonate.
Thank you for your time!
Come see our poster!

Value-Added Enzymatic Processing of Waste Glycerol and Low Value Oils

Goals
- Determine if immobilized Canvita amylase lipase Bi is acceptable for the process
- Design downstream process for producing glycerol carbonate
- Evaluate equipment
- Economic analysis
- Provide recommendations

Motivation
- Increased biodiesel production = surplus waste glycerol
- Refined waste glycerol = $1.25-1.65 per gallon
  Glycerol carbonate = $1.40 per gram
- Glycerol carbonate applications: solvent, additive, monomer, chemical intermediate, gas separation membrane applications, and detergents

Economic Analysis
- Capital Costs: $131,000 (equipment purchase cost, installation, process piping, instrumentation, and pumps)
- Manufacturing Costs: $10,000 per batch (utilities, lipase, raw materials, and labor)

Conclusions
- Process:
  - Converts 7,000 gallons of refined waste glycerol to glycerol carbonate
  - 65% conversion of glycerol to glycerol carbonate
- Results:
  - 525 gallons of glycerol carbonate per batch
  - A profit of $21,000 per batch*
- Based on Superpro simulation data

Recommendations
- Experiments:
  - Investigate other solvents
  - Further gas chromatography analysis
- Better understanding of reaction products
- Process:
  - Explore continuous operation options
  - Scale-up considerations beyond pilot plant

Acknowledgements
The authors would like to thank our advisor Dr. Steven W. Peretti, the personnel in Peretti’s lab, and all the ENH staff.
Biodiesel Dry Processing

Michael Akerman
Eli Dawson
Jennifer Gilliam

Advisors:
Alex Hobbs
Steven Peretti
What is it?

• Purifies biodiesel without using water
• Less environmental impact!
• Reduces production cost
What is it?

How do you wash it?

Unwashed  Washed
3 adsorbents
4 designs
Only one survived......
Come see which design succeeded!
Glycerol Burner

Members:
Marc Leyrer
Henryk Orlik
Patrick Johnson

Advisors:
Dr. Steven Peretti
Dr. Alex Hobbs

Photos courtesy of Brian Metzger
Motivations

- Biodiesel production has tripled
  - 2010: 245 US biodiesel plants expected
- 400 million pounds of glycerol produced per year
  - Price of glycerol: $0.06-$0.10 per pound (2007)
Goals

- Construction of burner capable of combusting glycerol
- Glycerol purification through filtration and acidification
- Utilization of heat from combustion
Glycerol Combustion Challenges

- Highly viscous, similar to molasses
- High auto-ignition temperature: 370 °C
- Produces less heat than most other fuels
- Large amount of solids and contaminants
Will it work?

Come see our poster!
Wood to Ethanol: Craven County Facility

Group members
Devin Cribb, Jesse Daystar, Rebekah Howes, & Johnson Scarboro

Advisor
Dr. Med Byrd
Current Facility

- Craven County wood energy facility
  - New Bern, NC
  - 50 MW biomass plant
  - Uses 100% wood and wood waste
  - Burns 530,000 green tons / year
Objectives

- Determine if the addition of an ethanol producing facility to the Craven County wood energy plant will increase profitability
- Process optimization
Design Challenge

How big can we build and still be profitable?

• Determine the ethanol production with the highest incremental rate of return (IRR)

• Must balance:
  – Ethanol production
  – Electricity production
  – Costs

• Constraint: boiler cannot produce any additional steam
Come see our poster!

Wood to Ethanol: Craven County Facility
Devin Cribb, Jesse Daystar, Rebekah Howes, & Johnson Scarboro
Advisor: Dr. Med Byrd
Department of Chemical and Biomolecular Engineering
North Carolina State University

Objective
- To determine if the addition of an ethanol producing facility to the Craven County wood energy facility will be economically feasible and desirable
- Process optimization of the ethanol process
- Economic analysis

Simulation: Proposed Process Model
Cellulosic ethanol production:
- Hydrolysis
- Fermentation
- Distillation
- Taxation

Optimization
- High risk project
- Discount rate = 28%
- Optimal production = 9.35 million gallons of ethanol per year

Process Background
Base case / Current process
- Wood: 530,000 green tons / year
- Water: 2,000,000 gallons / year
- Ash: 6,075 tons / year

Sensitivity Analysis
- Performed to separately evaluate the impact of wood price, ethanol selling price and capital cost.

Assumptions

<table>
<thead>
<tr>
<th>Assumption</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Plant start-up</td>
<td>December 2009</td>
</tr>
<tr>
<td>Ethanol sales revenue</td>
<td>$2.50/gallon in 2009 increases 3% per year</td>
</tr>
<tr>
<td>Power sales</td>
<td>$60 / MWh (held constant throughout the project)</td>
</tr>
<tr>
<td>Subsidy</td>
<td>$1.25/gallon for 2009-2012</td>
</tr>
<tr>
<td>Depreciation schedule</td>
<td>IRS 9461</td>
</tr>
<tr>
<td>Taxes</td>
<td>30%</td>
</tr>
</tbody>
</table>

NC STATE UNIVERSITY
Feasibility of a Greenfield Wood-Ethanol Plant
Pender County – North Carolina

Philip Crawford
Truong Dong
Dionne Kimani
Liam Royce

North Carolina State University
May 5, 2008
Generally I think you have done a very logical treatment of the subject, and the results seem reasonable, with a few points I have inserted in the specific file pages.

Two things that seems to be missing:

1. Explicit identification of the Base price of ethanol distinguished from the subsized price. This would allow the reader to distinguish the price paid for corn ethanol vs cellulosic ethanol. One enjoys a $0.51 per gallon subsidy and the other $1.28.

2. I believe there was a requirement to demonstrate the impact of the accelerated depreciation schedule allowed by IRS 946.

Richard Phillips, 4/19/2008
Why did we do it?

- “Food vs. Fuel”
- Abundant Renewable Resource
- Profitable
Process Flow Diagram

- Chips
  - Acid Hydrolysis: 12 atm, 190°C
  - Sulfuric Acid
- Ammonia
- Yeast CSL
- Fermentation: 30°C, 1 atm
- Distillation: Ethanol, Water
- Ethanol Dehydration: Ethanol
- Extractives
- Lignin
- Turbine: Electricity, Process Steam
- Boiler: Steam, Ash
- Lignin Separation
What we Did!

- Win Gems
- Raw Materials Model
- Financial Model
- Optimization
- Sensitivity Analysis

http://www.ericsons.co.uk/uploaded_images/ethanol-705128.jpg
Will it work?

- Please visit our poster!
Biotech-Related Projects
Fun facts about Biotech in NC

- North Carolina is home to the third largest biotechnology industry in the United States.
- In the RTP region there are 258 life sciences company sites with a total of 24,989 life sciences jobs.
- Over $1 billion in industrial life science R&D funding annually in the Research Triangle region.
Biotech Goals for NC

- 48,000 biotechnology-related jobs by 2013
- BTEC - The Golden LEAF Biomanufacturing Training and Education Center
Carbon Dioxide Conversion to Ethanol via Bacterial Composite Coating

Co-advisors:
Dr. Michael Flickinger
Dr. Kirill Efimenko

Team members:
Lulu Alborno
Robert Crews
Jessica Lisane
Erin Redmond
Heather Ruby
Objectives – Think Air Filters!

- Create a design to implement immobilized bacteria for conversion of carbon dioxide to ethanol
- Scale-up design for cement manufacturers
- Analyze and justify economical feasibility of design and scale-up
Motivations

- Increasing worldwide demand for ethanol
- Steady increase of CO$_2$ in the atmosphere
- Cement plants emit over $\frac{1}{2}$ pound of CO$_2$ for every pound of cement produced
Clostridium ljungdahlii

- Can absorb both CO and CO$_2$
- A gram of cells can absorb 0.28 g of CO$_2$ in one hour
- Produces Acetate and ethanol in a 7:1 ratio
Synthetic Bio-film Coating

Think Paint!

- Pre-coat functions as an adhesive surface
- Cells are metabolically active but not growing
- Top-coat prevents cells from leaching out of coating
Feel the Magic!

Magic Coating

\[ \text{CO}_2(g) \]
\[ \text{CO}(g) \]

Ethanol and Acetate
Bioreactor Design Presentation

Team Members:
Kevin Brown
Abby Lithgo
Michael Perkins
Tracy Sapp

Advisors:
Marcelo Anderson
Dr. Steven Peretti
Andy Stober
Motivation

Biopharmaceutical industry growing rapidly

Trying to optimize manufacturing performance and flexibility

Need innovative bioreactor technologies to generate their products

That's where we come in!!
Project Goals

1. Support Biogen Idec’s current processes and offer flexibility
2. Minimize cell death and foaming
3. Maximize product yield and mass transfer
4. Create two 2000L bioreactor designs: *Conventional* and *Innovative*
Results & Decisions

Disposable Airlift

Antifoaming Net

After 1 minute
After 3 minutes
After 4 minutes
After 5 minutes

ABEC Corporation
Thank you!

Come see us and our bioreactors!
Design of Protein Production Facility for Novozymes

Design Team:
Emily Blackwell
Malonda Bumba
Taylor Loftis
Yorke Reynolds
Lindsey Robinson
Alison Thomas
Danielle Zimmerman

Advisors:
Dr. Steven Peretti – NCSU
Mike Hess – Novozymes
Marcelo Anderson – BTEC
Dr. Gary Gilleskie – BTEC

January 31, 2017
Design Project Motivation

- Expanding biotechnology market
Manufactured Products

- **Food Grade Enzymes:** Environmentally friendly and energy efficient

- **Active Pharmaceutical Intermediates:** Safe and effective vaccines


http://www.sptimes.com/2007/05/04/images/Cheese_KraftSingles.jpg

http://www.time.com/time/health/article/0,8599,1543319,00.html
Project Goals

• Design a **process to produce a total of 500,000 gallons** per week of
  
  • Active Pharmaceutical Intermediates (API)
  
  • Food Grade Enzymes

• Design the **site layout** of the production facility

• **20% ROI** – Food Grade Enzymes

• **50% ROI** – Active Pharmaceutical Intermediates

http://www.varney.biz/images/novozymes.jpg
To learn more about our exciting design, come and visit us!
Disposable Bioreactors for Seed Expansion Fermentation in Biotechnology Manufacturing

Team Members
Graham Gibson
Stephanie Goss
Taylor Kirkland
Derrick Laton
Christopher Smith

Advisors
Dr. Steven Peretti, NCSU
Rick Lawless, BTEC
Terry Burns, Wyeth
Motivation

Money!

Time!

Quality!
Goals

- Equipment Selection
- Process and Lab Design
- Batch Scheduling

- Utility Savings
- Environmental Analysis
- Economic Analysis

- Recommend Fermentation Train
- Time Savings
Is the Disposable Process Practical?

Come see our poster and find out!
Enjoy the posters in the Atrium of Engineering Building I!

Come back at 11:30 for some special presentations!