



# Chemical Engineering





# What is Chemical Engineering?



Chemical processes



Environmental processes



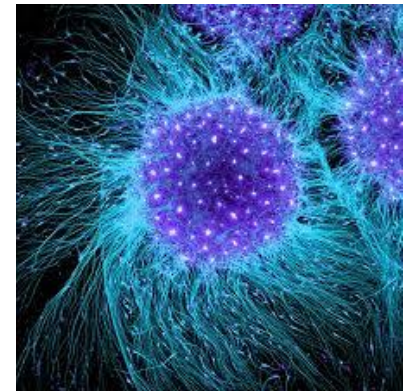
Fuels and Energy



Food manufacturing



Bioprocesses & Pharmaceuticals

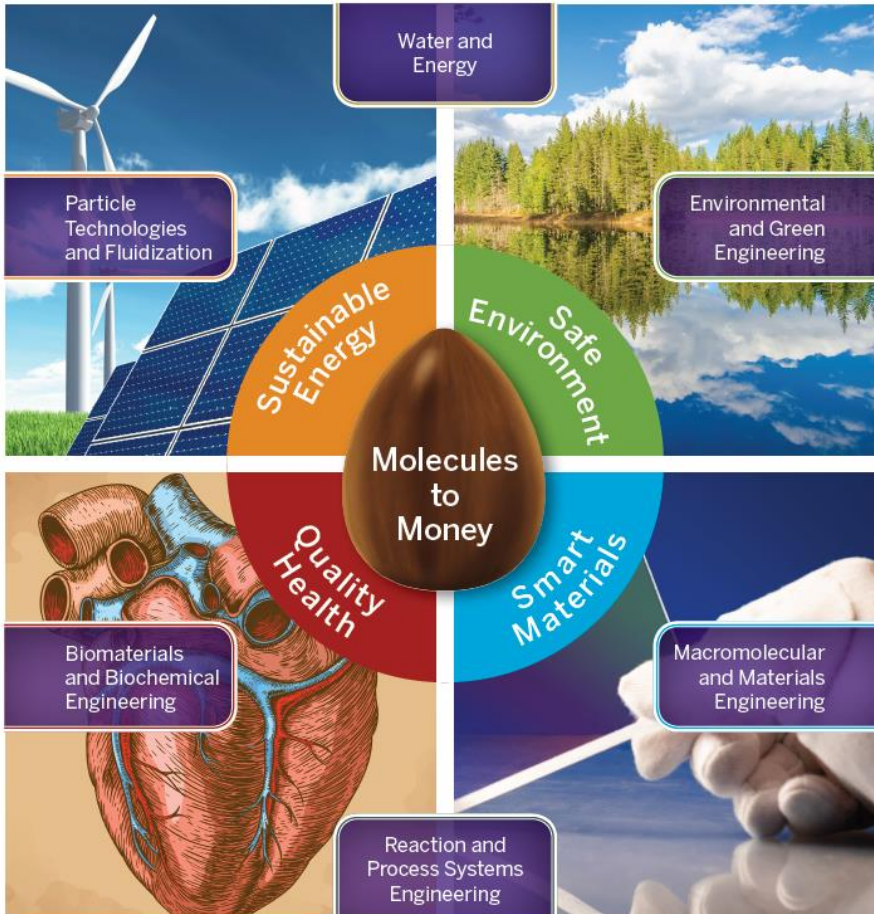


Biomaterials & Regenerative Medicine

# ENGINEERING WITH SCIENCE FOR LIFE



## Areas of Research Specialization



## Chemical Engineering Options:

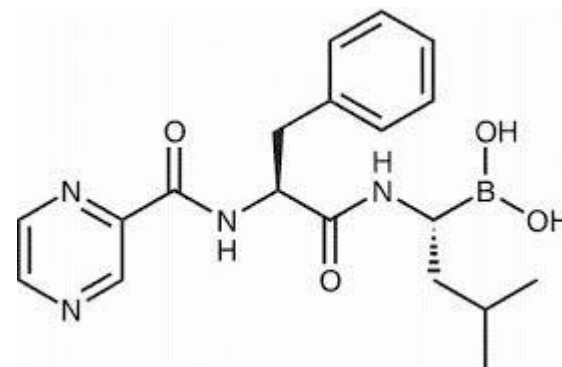
- **General Chemical Engineering**
- **Biochemical and Environmental Engineering**
- Dual degrees (Ivey, Law, BME)
- **28 full-time Faculty members**
- **High flexibility of 4th year technical electives in the curriculum (6 technical electives in year 4)**



# How is Chemical Engineering different from Chemistry?

## A Chemist works with these questions:

- What molecular structure is needed to obtain a desired property?
- How can we make a reaction occur between two different molecules?
- What reaction steps are needed to obtain the desired product from specific reactants?



## A Chemical Engineer works with these questions:

- Which raw chemicals should we use to make a chemical process economically viable and environmentally responsible?
- How can we efficiently and safely produce required quantities (for example: 100,000 tons/year) of our product(s)?
- What processing steps (reactors, heat exchangers, pumps, separators) are needed?



# Job Functions of Chemical Engineers

Improve food **processing techniques**, and methods of producing fertilizers, to **increase the quantity and quality** of available food.



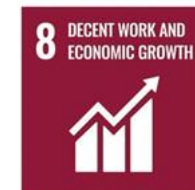
Construct the synthetic fibers that make our clothes more comfortable and water resistant; develop **methods to mass-produce** drugs, making them **more affordable**; and they create **safer, more efficient methods** of refining petroleum products, making energy and chemical sources **more productive and cost effective**.



Develop **solutions to environmental problems**, such as **pollution control and remediation**.



Process chemicals, which are used to make or improve just about everything you see around you.



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Environmental  
processes



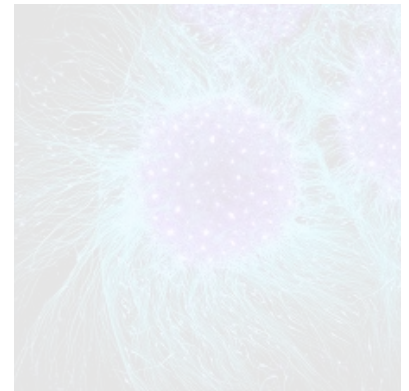
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Pharmaceuticals



Biomaterials &  
Regenerative Medicine



# Chemical Processes

## Chemical Products and Processes

### Commodity chemicals:

- Petrochemicals, solvents
- Gasoline, diesel, natural gas
- Fertilizer (ammonia)



### Polymers:

- Polyethylene (PE, LDPE, HDPE)
- Polyvinyl chloride (PVC)
- Polypropylene (PP)



### Specialty chemicals:

- Purified industrial gases
- Adhesives, sealants, coatings

### Consumer products:

- Detergents
- Synthetic fibers, dyes
- Acids for batteries
- Construction materials

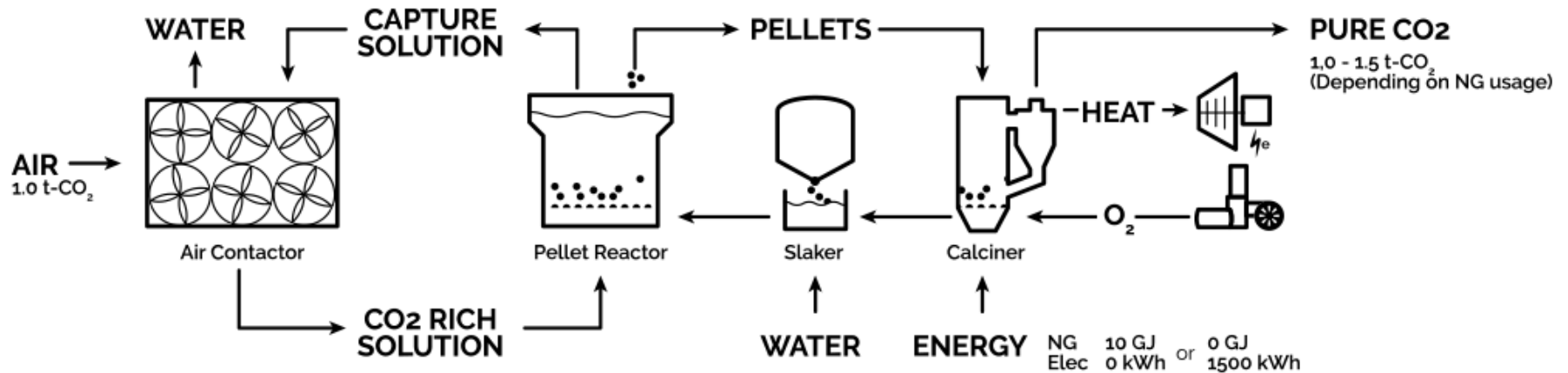


# Next-Generation Chemical Processes



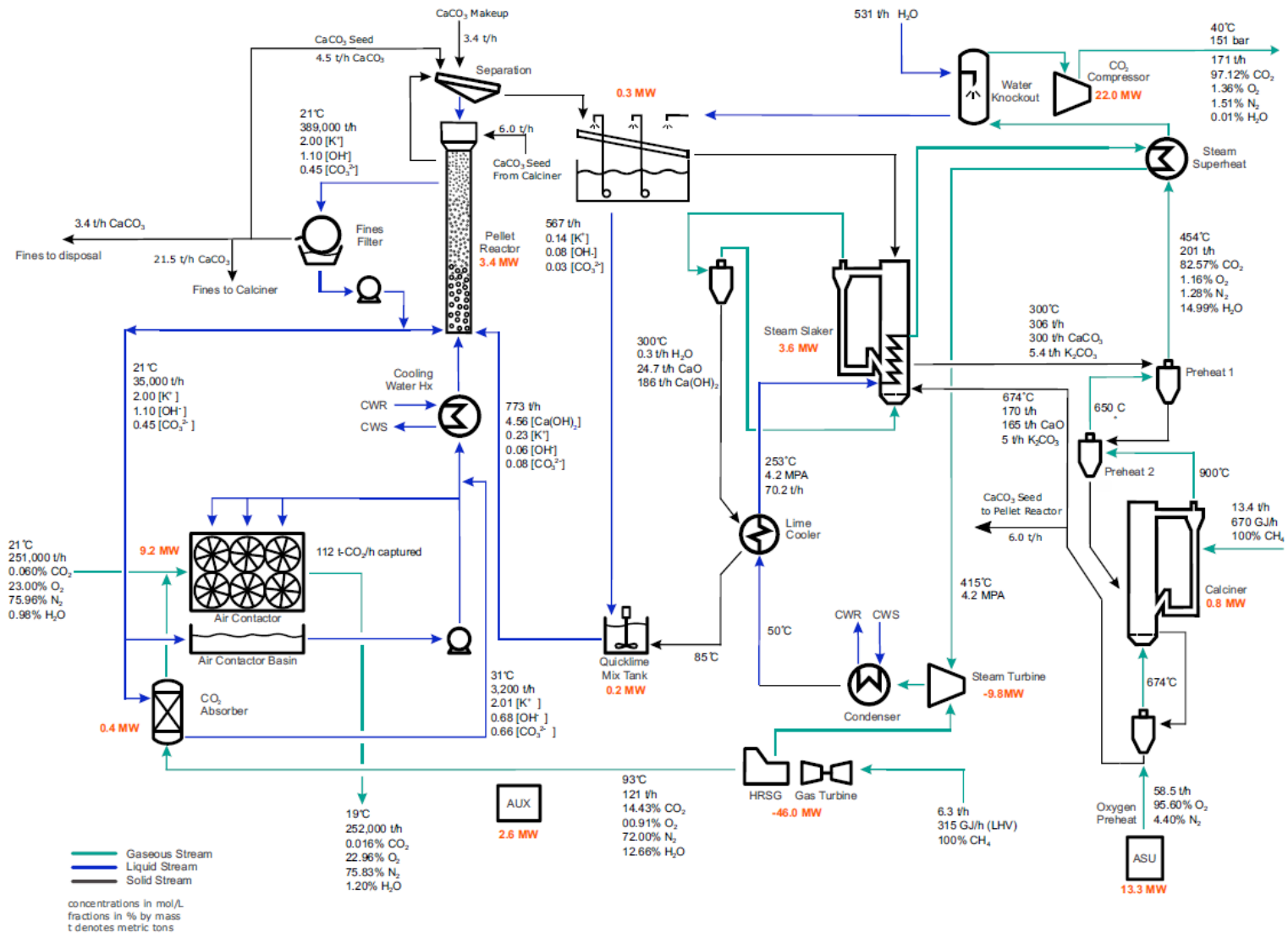
Carbon  
Engineering

Direct air carbon capture





# Next-Generation Chemical Processes



# Chemical Engineering Courses

- CBE 2207 - Industrial Organic Chemistry
- CBE 2221 - Fluid Flow
- CBE 2220 - Chemical Process Calculations
- CBE 3315 - Reaction Engineering
- CBE 3322 - Heat Transfer Operations
- CBE 3323 - Staged Operations
- CBE 3319 - Introduction to Plant Design & Safety
- CBE 3310 - Process Dynamics & Control
- CBE 4497 - Chemical Process & Plant Design
- CBE 4420 - Computer Process Control
- CBE 4417 - Catalytic Processes



# Careers in Chemical Engineering



# What is Chemical Engineering?



Chemical processes



Environmental  
processes



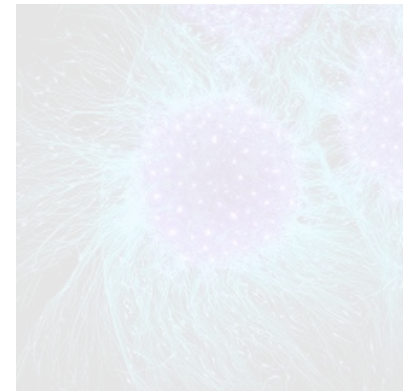
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Bioprocesses &  
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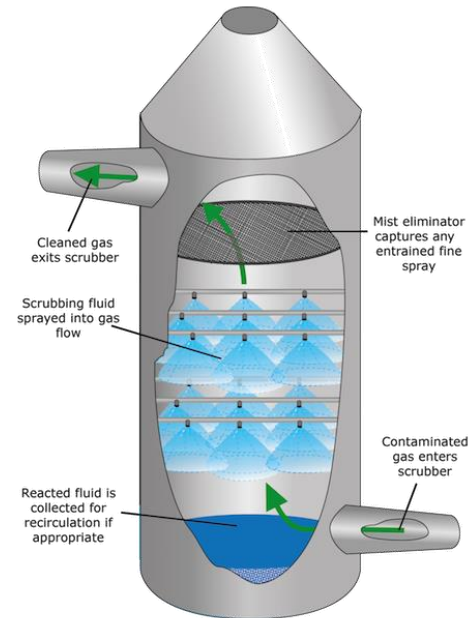
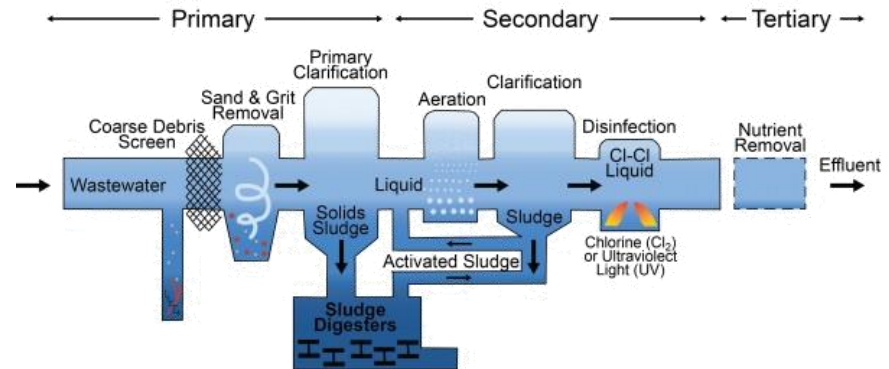
# Environmental Processes

## Study, modelling and design of biochemical environmental processes:

- Domestic wastewater biotreatment (almost all the domestic wastewater in the world is treated biologically)
- Industrial wastewater biotreatment
- Soil and groundwater bioremediation
- Biological removal of toxicity from air

## Study, modelling and process design of chemical environmental processes :

- Physicochemical wastewater treatment
- Physicochemical methods for the treatment of contaminated soil
- Physicochemical contaminated air treatment



# Fuels and Energy

## Chemical Engineering and the Energy sector

### Production of fuels:

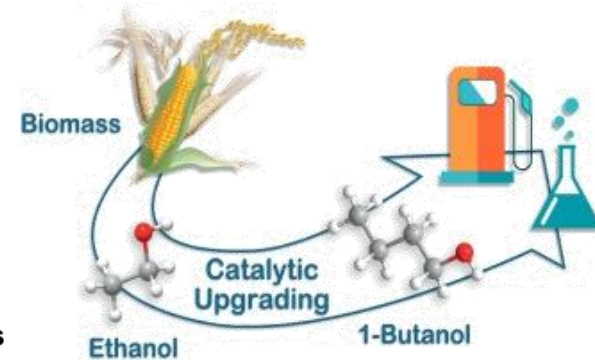
- Bioethanol, biobutanol
- Biogas (methane), Biohydrogen
- Uranium extraction and purification
- Bioelectricity from waste

### Energy storage (The Holy Grail of renewable energy):

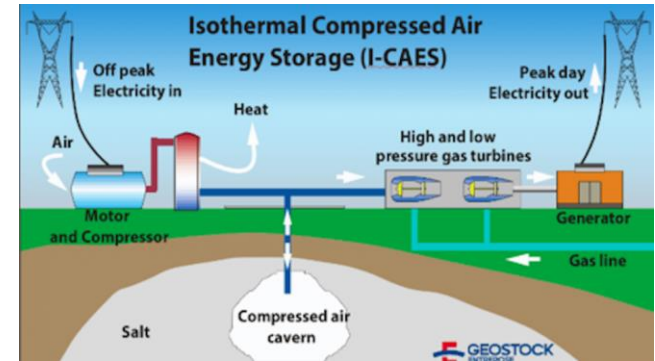
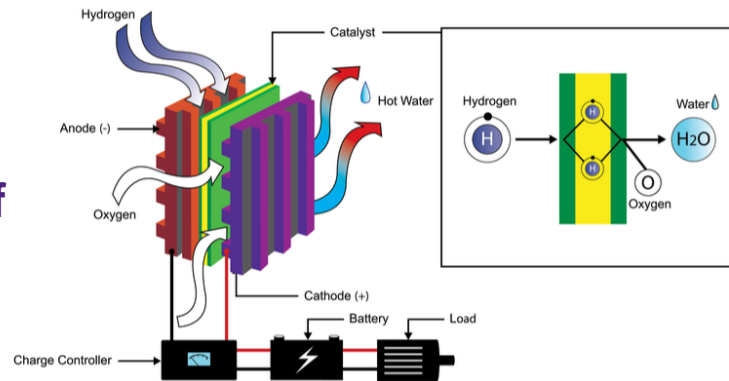
- Redox flow batteries
- Compressed air energy storage
- BioGenerator
- Thermal solar

### Renewable energy and carbon emissions reduction:

- Design of solar panels
- Hydrogen and fuel cells
- Design of low-carbon processes



Hydrogen Fuel Cells





# Environmental, Fuels and Energy Courses

- CBE 2214 - Chemical Engineering Thermodynamics I
- CBE 2224 - Chemical Engineering Thermodynamics II
- CBE 2290 - Fundamentals of Biochemical Environmental Engineering
- CBE 3330 - Bioreaction and Bioprocess Engineering
- CBE 4409 - Wastewater Treatment
- CBE 4485 - Fuel, Energy and Environment
- CEE 4405 - Air Pollution
- CBE 4432 - Energy and Fuel Production Systems
- CBE 4416 - Carbon Footprint and Management
- CBE 4432 - Oil Refining and Processing

# Careers in the Environmental and Energy Sectors

**ONTARIO POWER**  
GENERATION



**BALLARD**<sup>®</sup>





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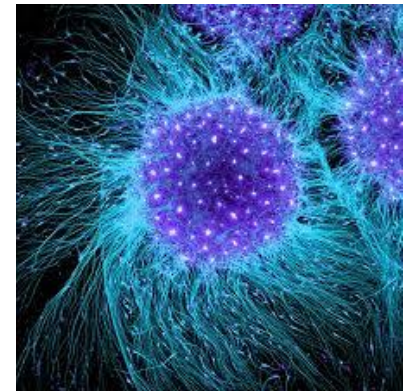
Fuels and Energy



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Bioprocesses & Pharmaceuticals



Biomaterials & Regenerative Medicine

# Bioprocess Engineering

## Microbial Products and Processes

### Industrial Bioproducts:

- Solvents, enzymes
- Biopolymers

### Biofuels:

- Bioethanol, biobutanol, biogas, bio-H<sub>2</sub>

### Medical Products:

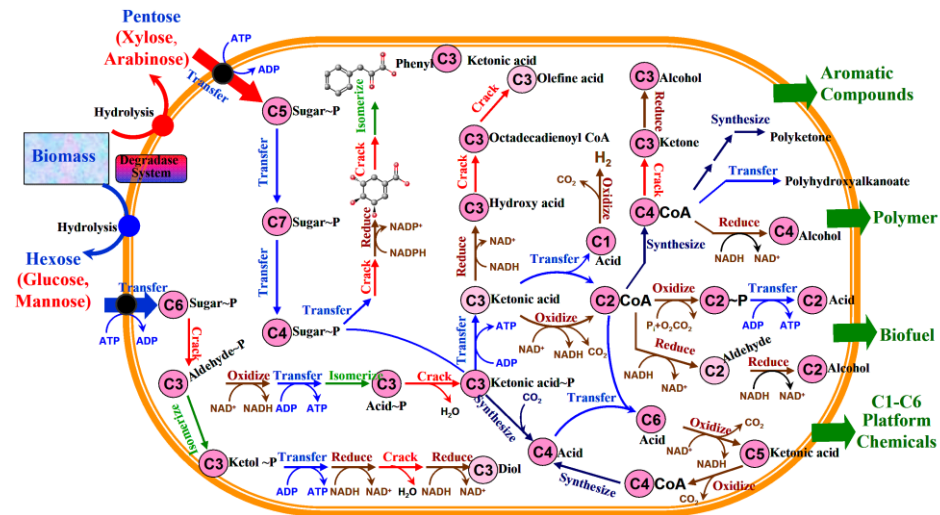
- Biopharma: accounts for 30% of medicines on the market (global sales: \$280 Billion)
- Recombinant DNA technology (e.g. insulin, hormones, protein-based cancer therapies)

### Food Products & Additives:

- Brewing, fermented foods, vitamins, polysaccharides

### Agricultural Products:

- Biopesticides, Biofertilizers
- Genetically-engineered crops

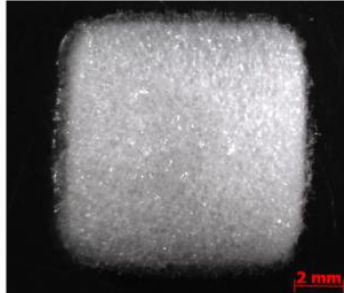
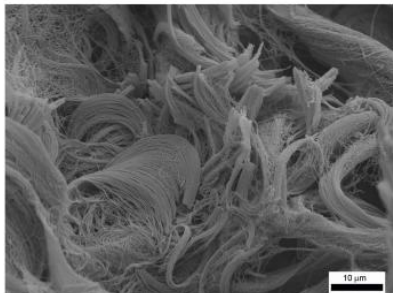
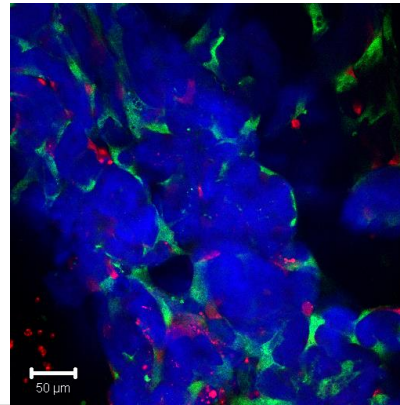


<http://www.intechopen.com/books/progress-in-molecular-and-environmental-bioengineering-from-analysis-and-modeling-to-technology-applications/cofactor-engineering-enhances-the-physiological-function-of-an-industrial-strain>



# Biomedical Engineering

- Stem cells & regenerative medicine
- Bioreactor design
- Biomaterials
- Nanotechnology
- Medical device design
- Drug delivery systems
- Drug screening platforms
- 3-D bioprinting
- Biosensors





# Bio-related Courses

- CBE 2290 – Fundamentals of Biochemical & Environmental Engineering
- CBE 3330 – Bioreaction & Bioprocess Engineering
- CBE 4403 – Biochemical Separation Processes
- CBE 4498 – Biochemical Process & Plant Design
- CBE 4404 – Downstream Processing in Pharmaceutical Manufacturing
- CBE 4433 – Nanobiotechnology
- CBE 4421 – Introduction to Biomaterials Engineering
- CBE 4423 – Tissue Engineering
- CBE 4424 – Biosensor Principles and Applications
- CBE 4425 – Biochemical Engineering Project

# Careers in Bioprocess Engineering



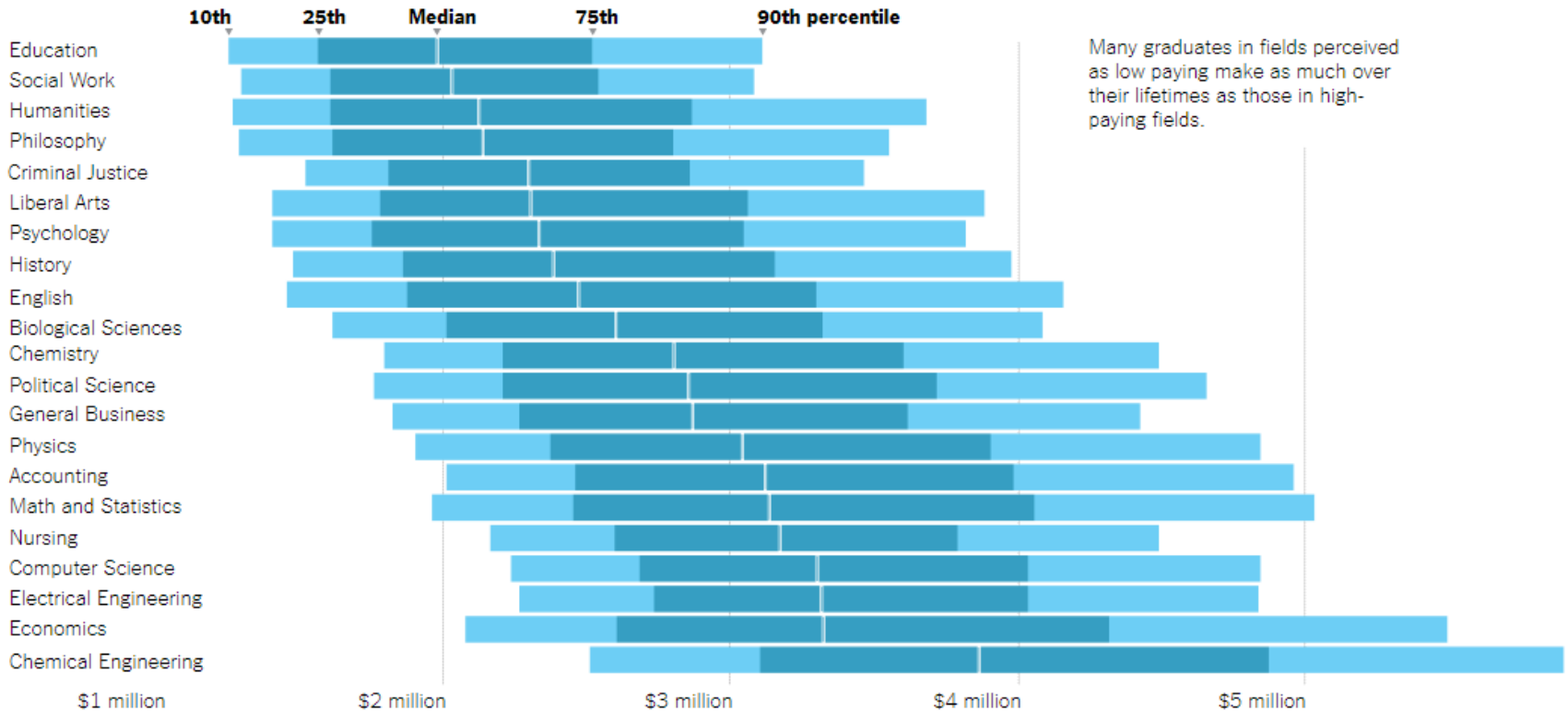
# Careers in Biomedical Engineering





# Projected career earnings

Projected career earnings for college graduates in the ...



"The Lifetime Earnings Premia of Different Majors," 2014 (updated: 2017), by Douglas A. Webber

Jeffrey J. Selingo, **Six Myths About Choosing a College Major**, New York Times, Nov. 2017


# Job outlook - Chemical Engineers


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### Summary


#### Quick Facts: Chemical Engineers

2018 Median Pay 	\$104,910 per year \$50.44 per hour
Typical Entry-Level Education 	Bachelor's degree
Work Experience in a Related Occupation 	None
On-the-job Training 	None
Number of Jobs, 2018 	33,900
Job Outlook, 2018-28 	6% (As fast as average)
Employment Change, 2018-28 	2,100





# Job outlook - Environmental Engineers








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**Summary**


Quick Facts: Environmental Engineers	
2018 Median Pay 	\$87,620 per year \$42.13 per hour
Typical Entry-Level Education 	Bachelor's degree
Work Experience in a Related Occupation 	None
On-the-job Training 	None
Number of Jobs, 2018 	55,400
Job Outlook, 2018-28 	5% (As fast as average)
Employment Change, 2018-28 	2,900





# Job outlook - Health and Safety Engineers

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### Health and Safety Engineers

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### Summary

#### Quick Facts: Health and Safety Engineers

2018 Median Pay 	\$89,130 per year \$42.85 per hour
Typical Entry-Level Education 	Bachelor's degree
Work Experience in a Related Occupation 	None
On-the-job Training 	None
Number of Jobs, 2018 	27,000
Job Outlook, 2018-28 	5% (As fast as average)
Employment Change, 2018-28 	1,400



# Job outlook - Petroleum Engineers

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### Petroleum Engineers

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### Summary

#### Quick Facts: Petroleum Engineers

2018 Median Pay 	\$137,170 per year \$65.95 per hour
Typical Entry-Level Education 	Bachelor's degree
Work Experience in a Related Occupation 	None
On-the-job Training 	None
Number of Jobs, 2018 	33,500
Job Outlook, 2018-28 	3% (Slower than average)
Employment Change, 2018-28 	900

