

## BREAKOUT GROUP #1

### 1. Definition of Biological Engineering?

*Biological engineering is the discipline of engineering that integrates life sciences with engineering principles in the advancement of fundamental concepts of biological systems from molecular to ecosystem levels.*

### 2. What are the essential subjects (core knowledge) to establish biological engineering as a discipline?

- fermentation
- bioprocessing
- introduction to biology
- from inorganic chemistry (one semester) to biochemistry
- physiology
- some persons felt biology should be a “brand” of biology for engineers
- fundamentals sciences broadly
- kinetics
- heat and mass transfer
- biomaterials – particular emphasis on surfaces
- engineering of biological systems with emphasis on quantification (two terms)
- bioinstrumentation
- hands on – problem solving design orientation

### 3. What are the knowledge expectations for a biological engineer entering first employment in industry?

- knowledge of fundamentals
- verbal abilities to describe designs and projects
- an understanding of basic principles
- “how it (one’s work) relates” to the real problem
- a passion about wanting “to do something”

## BREAKOUT GROUP #2

### 4. Definition of Biological Engineering?

*Biological engineering is the biological – based engineering discipline that educates engineers to solve problems in living systems dealing with plants, animals, humans or the environment.*

Biological engineering should include elements of:

- biology – based engineering discipline
- education
- living systems
- from molecular to organism levels
- ecosphere
- design
- problem solving
- integrate systems

What should be the level?

- biological engineering creates solutions to problems in living systems.
- biological engineering is the biological – based engineering of living systems.
- it educates engineers to design solutions to problems including those with plants, animals, humans and the environment from molecular to ecosystems levels.
- key issues are “educate” and “design”

### 5. *What are the essential subjects (core knowledge) to establish biological engineering as a discipline?*

- mathematics, chemistry and physics
- core biology
- introductory courses
- fundamental core courses
- application courses

At the undergraduate level

- biotransport phenomenon
- kinetics
- thermodynamics
- probability and statistics
- bioreactors and unit operations
- biomaterials
- biomechanics
- physiology

- systems analysis
- modeling and simulation
- bioinstrumentation and biosensors
- control systems
- mechanical design
- circuits and electronic design
- bioenvironmental engineering
- medical engineering
- bioinformatics
- information transfer

## BREAKOUT GROUP #3

### 6. Definition of Biological Engineering

A definition must contain the elements of:

- design processes, process systems,
- simulation, modeling, predictive capability,
- design environment,
- design instrumentation,
- controlling living systems, and
- design products

Biological Engineering is the discipline of engineering which integrates biology, physics, chemistry and math with engineering principles in the design of biologically based products and processes from the bio-molecular to organisms to the ecosystem.

*A number of descriptive phrases which add to an understanding of biological engineering were developed:*

- biology adds value to engineering designs for and with biological engineering systems,
- bringing life to engineering,
- integrating engineering and life sciences,
- engineering that puts biology to work,
- bringing biology and engineering together,
- engineering that puts biology first,
- engineering enriched by life science,
- using life sciences to enrich engineering,
- adding life to engineering, and
- enhancing living systems through engineering.

### 7. What are the essential subjects (core knowledge) to establish biological engineering as a discipline?

#### **Core Sciences:**

- biology
- organic chemistry
- inorganic chemistry
- biochemistry
- physics
- applied statistics
- advanced biology as appropriate
- microbiology

#### **Engineering Fundamentals:**

- statics

- fluids
- transport (Mass & Energy)
- thermodynamics
- electrical systems
- biomaterials
- kinetics
- bioenergetics
- locomotion/movement
- populations and ecology
- biochemical synthesis
- design
- bioinstrumentation
- engineering economics/ project management
- ethics
- capstone design
- specialization
- open-ended problems
- biological and engineer materials
- communication skills
- problem solving/framing
- computer use and modern engineering tools
- understanding biological variation
- discipline specific skills
- project management
- design constraints engineering, biology, economic and social

## BREAKOUT GROUP #4

### 1. Definition of Biological Engineering?

*Integrating Biological Science and Engineering Principles to meet societal needs.*

### 2. What are the essential subjects (core knowledge) to establish biological engineering as a discipline?

We decided that using courses was too broad and instead used term “areas” to define what needs to be covered. This would allow department to cover several areas in one course if they felt this was better.

#### **Core knowledge areas in Biological Engineering**

- Statics
- Mechanics of materials
- Properties of materials
- Fluid dynamics
- Transport Phenomena
  - Heat transfer
  - Mass transfer
  - Momentum transfer
- Thermodynamics
- Computer programming
- Statistics (including SQC)
- Bioinstrumentation
- Process control
- Bioprocess Engineering
- Quantification of biological engineering
- Unit operations
- Kinetics
- Modeling and simulation
- Ethics
- Numerical Methods
- Kinetics
- Design

In addition to the engineering requirements basic science courses should include:

#### **Science core courses**

- Biology
- Microbiology
- Cellular biology
- Biochemistry
- Organic Chemistry
- Mathematics through DEQ's
- Physics