Workshop II Summary

- We began with the common themes from Workshop I
  - Biology is a foundation science
  - Agreement that the need for change goes beyond biology
    - Diversity of employment
    - Public perception
    - Recognition of molecular-level understanding
    - Competition for best students
  - Need to engage enabling sciences in change
  - Infuse curriculum with contemporary examples that integrate principles of chemical engineering
  - Chemical engineering involves analysis, design, and synthesis

Workshop I Common Themes continued

- Need to articulate to freshmen the intellectual challenges and professional opportunities
- Chemical engineering includes multi-scale descriptions of materials and phenomena
- Agreement on the desired attributes of the chemical engineering graduate
  - Experience in labs
  - Communication skills
  - Problem solving skills
  - Etc.
- Curriculum should be designed for flexibility

Building Blocks – Areas of Agreement

- The enabling sciences are:
  - biology
  - chemistry
  - physics
  - math
- There is a core set of chemical engineering principles
- Molecular level design is a new core principle
- Chemical engineering contains both product & process design
- There is a need for 1st year chemical engineering experience

Building Blocks

- Proposals
  - case study learning
  - vertical integration
  - molecular-level design as an organizing principle
  - single-room learning
- Other Ideas
  - benefits of alternative terminology in curriculum revitalization
  - student as a customer (or partner, employer as partner, participant, constituent, ally)

Summary Report on Curriculum Ideas

Jim Rawlings
Mike Thien

Conclusions Regarding the Chemical Engineering Profession...

- The Chemical Engineering Profession is very successful
  - has moved in many new directions, pushing the understanding and use of new technologies
  - students are highly sought after by industry
  - this has been made possible by the effective teaching of the fundamentals of chemical engineering

… however...

- Chemical Engineering is facing significant pressure from other disciplines

and

- The Current Curriculum is not well integrated:
  - it is compartmentalized in the subjects presented
  - “tired”
- The Current Curriculum is largely ***not***:
  - exploring transformations at the molecular level
  - embracing complexity and uncertainty
    - closed problems with one answer
  - demonstrating the applicability of multiple scales
  - demonstrating/effectively using systems approaches
  - employing relevant, interesting and topical examples to illustrate principles

Integration of the Curriculum: New Core Organizing Principles

- Molecular Scale Transformations
  - chemical & biological
  - physical: phase change, adsorption, etc
- Multi-Scale Descriptions
  - from sub-molecular through "super-macro"
  - for physical, chemical and biological processes
- Systems Analysis & Synthesis
  - at all scales
  - tools to address dynamics, complexity, uncertainty, external factors

Old core did not integrate molecular concepts

Old core covered only macro to continuum, physical and chemical

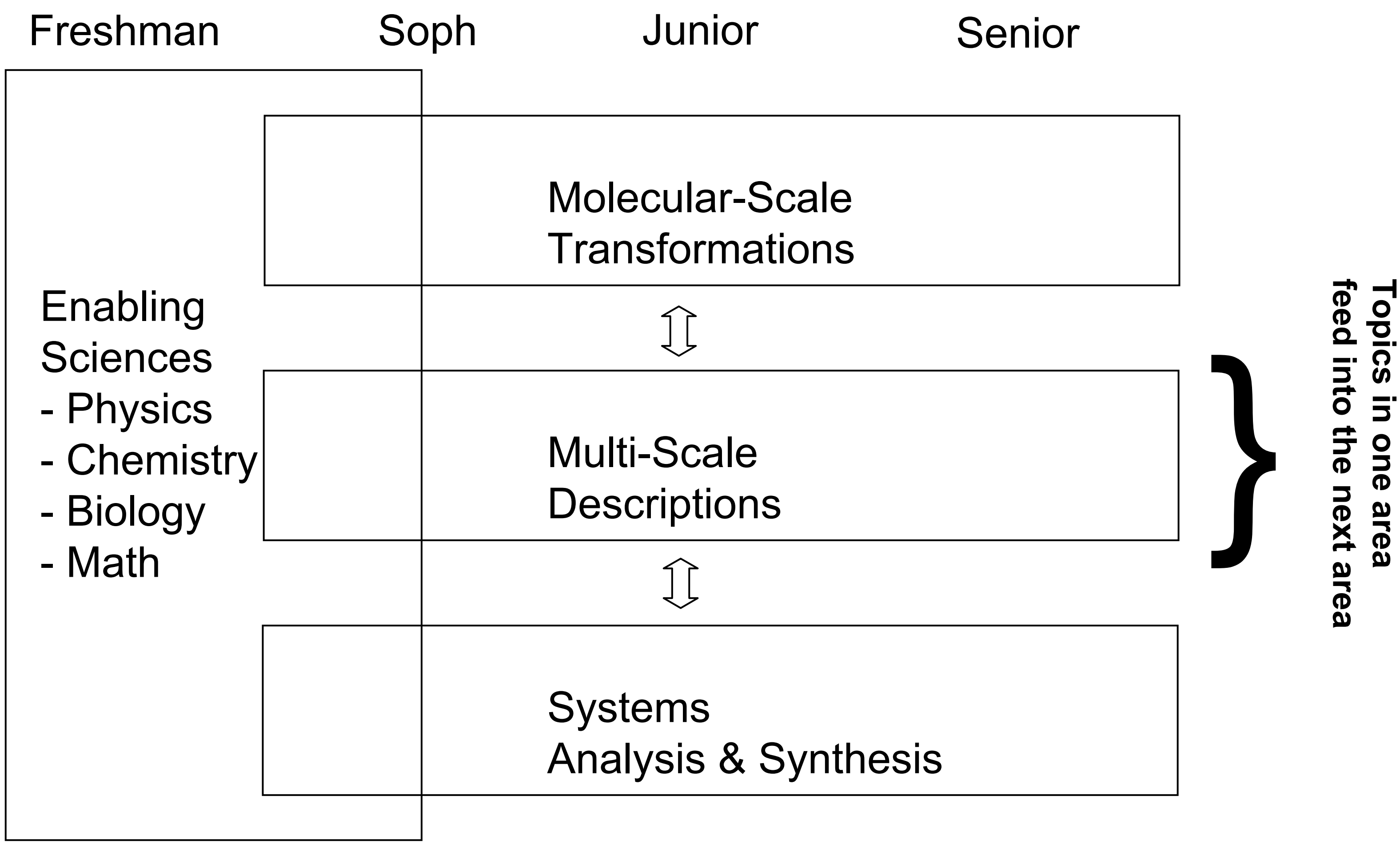
Old core primarily tied to large scale chemical processes

Creation of the New Curriculum: Essential Elements

- Case Studies and Examples
  - Diverse
  - Relevant and topical
  - Integrated into curriculum
    - horizontal integration (over time)
    - vertical integration (between classes at same time)
  - Provide real world context
    - safety, economics, ethics, regulation, IP, market/social needs
  - Provide real world challenge
    - open-ended, complex, incomplete data, rapid generation, and pruning alternatives

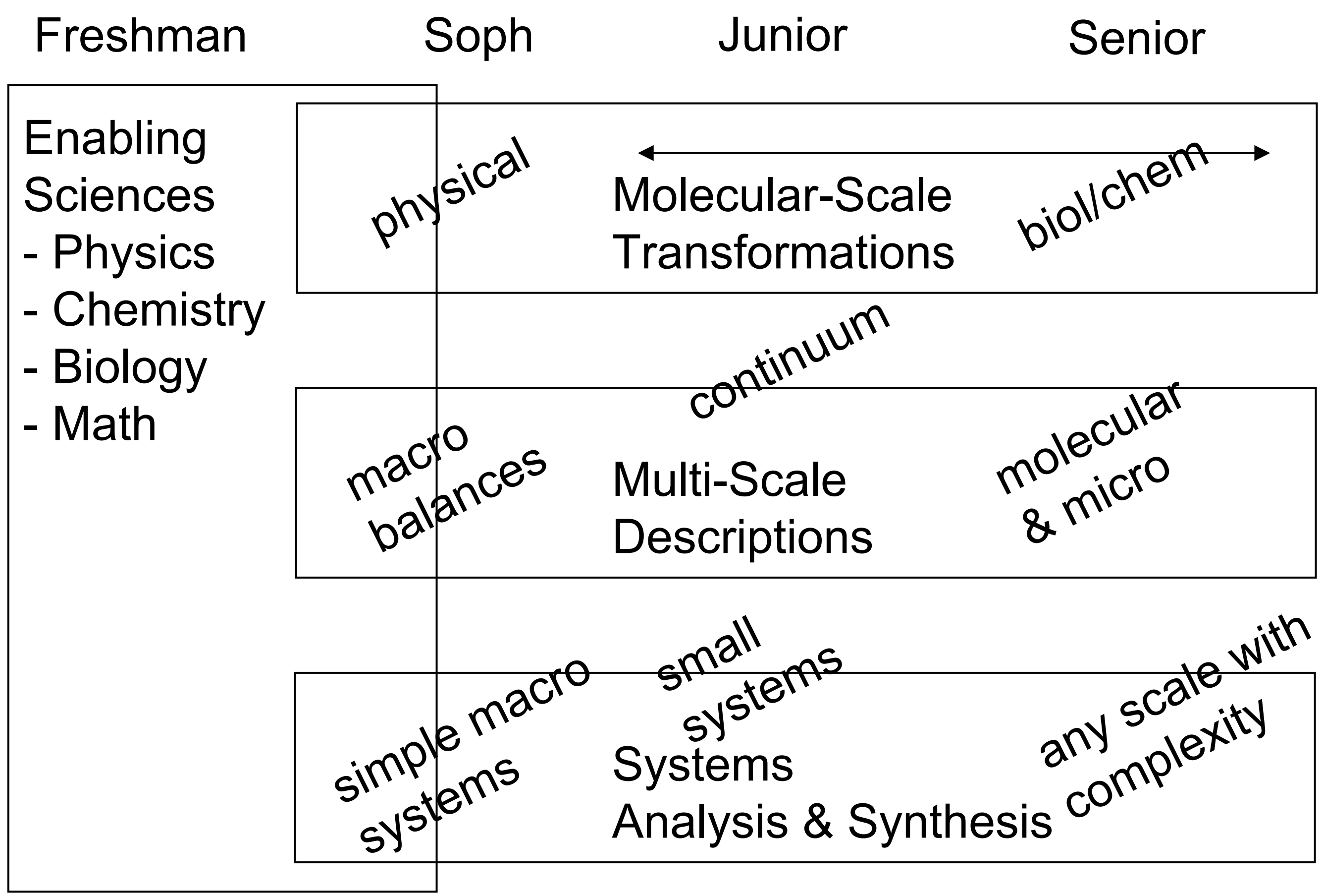
...Essential Elements... (cont.)

- Integrated Curriculum



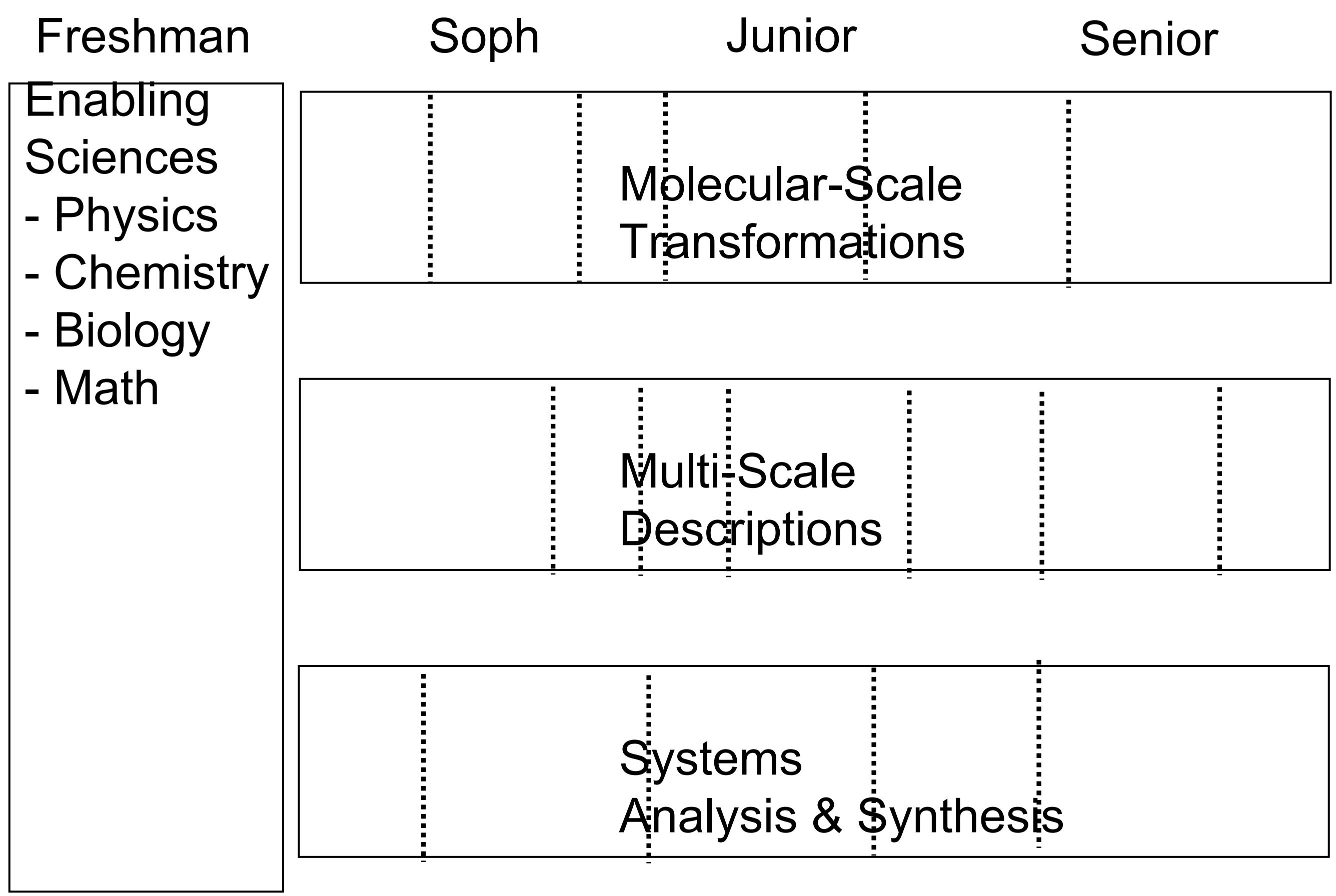
...Essential Elements... (cont.)

- Integrated curriculum: incorporating the fundamentals



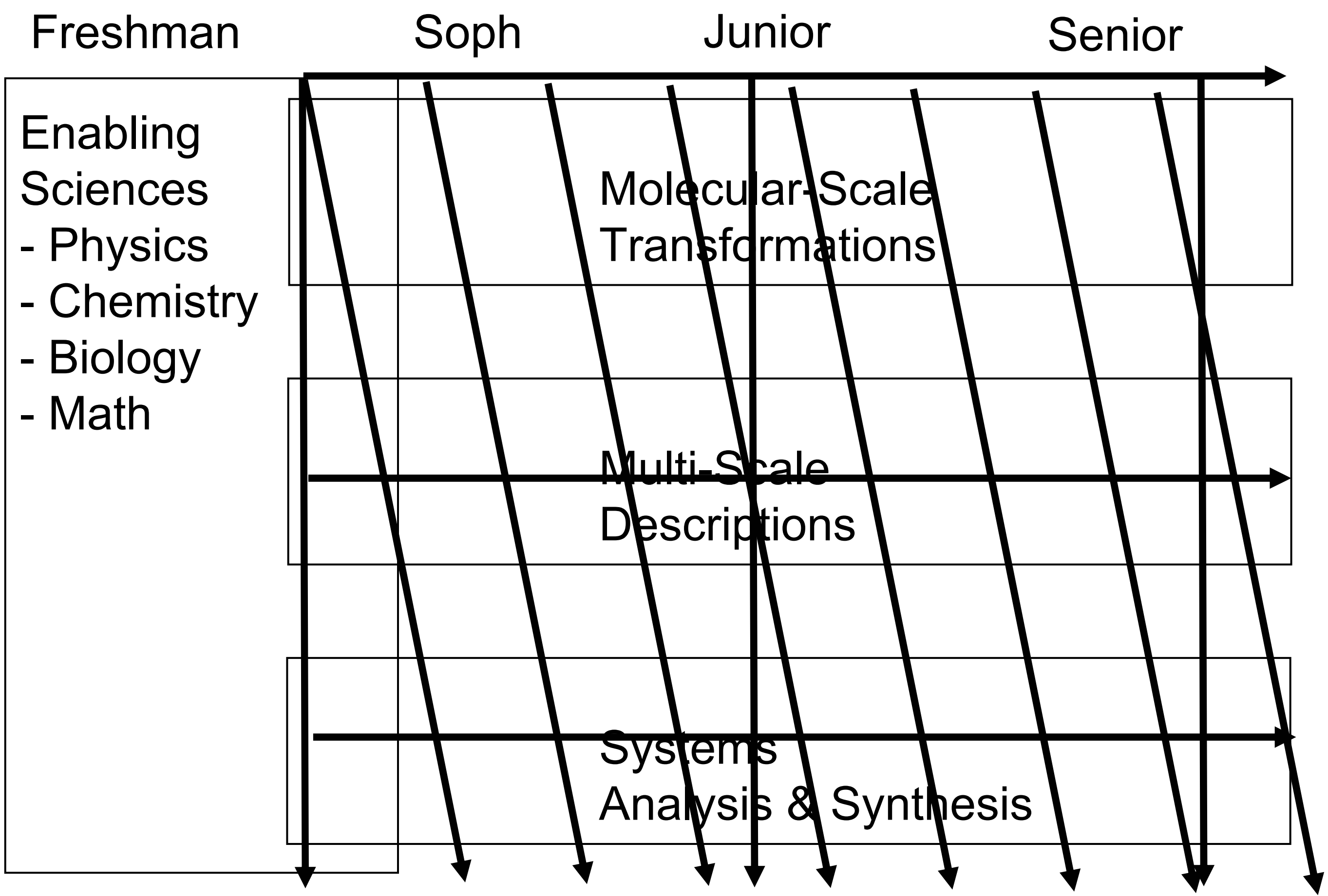
...Essential Elements... (cont.)

- Integrated curriculum: incorporating modules



...Essential Elements... (cont.)

- Integrated curriculum: incorporating examples



The Spectrum of Curriculum Change: from "Tweaks" to "Complete Overhaul"

- The consensus is that we seek large change
  - the science base has dramatically increased
  - this creates new economic opportunity
  - some discipline will emerge to address these new opportunities
  - chemical engineering is well-positioned to be this new discipline...
  - …but it will require a large change to the undergraduate curriculum
- This change may require a 10 year investment
- We must accommodate a diversity of universities

Workshop II Accomplishments

- Excellent summary by Jim and Mike
- Is there a new core?

  - Thermodynamics
  - Transport
  - Reaction engineering

  →

  - Molecular transformations
  - Multiscale
  - Systems
  - Quantitative

- Advantages
  - Foster creative developments in curriculum and discipline
  - Reopen exciting flow of new developments into undergraduate curriculum

Additional Discussion

- Integrating case studies/examples emerge as an important theme
  - Better enable teaching of critical attributes such ability to think critically, to work effectively with uncertainty, to continue to learn beyond the classroom, ….
  - Connect better with evolving industries and research frontiers
  - Reopen the flow of ideas from graduate research to the undergraduate curriculum

…but

- Should we also do this with laboratory subjects/experience
- How do we teach faculty to do this? (or is this not a problem)
- How do we distribute these?
- How do we ensure uniformity/interoperability?
- How do we provide incentives for initial and ongoing work?
  - Credit for contributions
  - Financial incentives – replace book royalties(?!)

Workshop III

- Proposal for construction
- Broader discussion within discipline

Proposal

- Motivation
  - Drivers for change in chemical engineering
  - Educational frontiers for chemical engineering
- Overview of curriculum
  - Goals
  - Structure
  - Versatility
- Proposed curricular development
- Mechanisms for interoperability and sharing
- Use of best practices in teaching
- Evaluation and assessment
- Summary and conclusions

Proposed Curriculum Development

- How do we manage this?
  - Get faculty time – not do this on the margins
    - Money is probably easier than time
  - Should we target teams to ensure integration (molecular, multiscale, systems)
  - How do we ensure full coverage – address gaps
  - Ensure quality control
  - Time scale
    - Proposal to NSF due June 25(?)

Homework for Workshop III

- Present to your faculty, company
- Prepare specific curriculum contributions to present at Ocean Edge
  - Small examples to better illustrate core ideas
  - Large integrative case studies
    - Probably involve multiple faculty
  - New subjects to capture molecular, multiscale, systems, quantitative aspects of discipline
  - New introductory experience
- Communicate your ideas plans to me as soon as possible

A Large Change is Needed

- A Plan for Change
- Proposal to NSF is just the first step
- Need to develop “document” that discipline can use as a rallying point for education
- Need to engage our profession more fully – AIChE?
- Need to engage industry more fully
- Need to communicate to the public
  - Public perception
  - Attract the best students
  - Clarify to stakeholders the nature of our graduates
- How do we best bring new educational methods/technology to our faculty