Individual Working Group Reports

Five working groups were charged to create the building blocks of the curriculum, specifically avoiding the terms “thermodynamics”, “kinetics”, “transport”, “material and energy balances”. They reported Tuesday 2003 Jan 28.

Group 1

- Technical/technology overview (math/science/engineering. based)
- Math/computational
- Physics (through discoveries/revolutions)
- Chemistry/biology (with discovery as theme)
- Engineering/modeling (molecular based chem./bio systems)
- Multiple scale (ChE core) through integration
- Designing/analyzing (Chem/bio systems)
  - Combination of approaches (Engr./Sci)
  - Multiple scales
- Depth/specialization ? BS Degree
  ?
  Advanced Study

Group 2

Goals:

- Corporate leader
- Functioning member of society
- Good citizen
- Versatility

Organize curriculum around goals and building blocks

Attributes:

- Ability to deal with incomplete info
- Managing complexity
- Managing large amounts of messy data
- Willingness to make assumptions
- Ability to formulate and solve problems
- Risk-taker/ personal initiative
- “Armstrong attributes”

(1) Case Study Approach

motif: ? ? ? ? ? ?
--? time

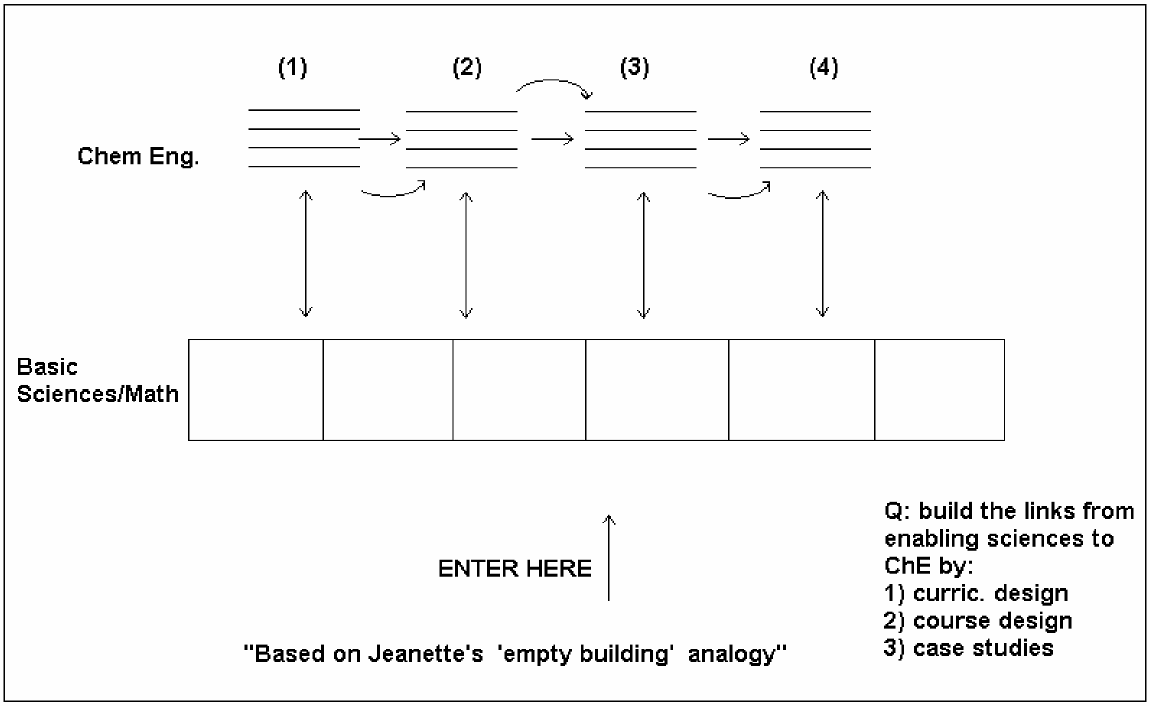
Each arrow above is a ChE principle or application

Sample motifs: polymer, bio, microelectronic
Positives: external expertise, collect like-minded faculty
Negatives: textbooks (can be a positive), coverage of hard topics

(2) ChE Essence Building Blocks

- Enabling Sci/Math
- “ChE essence”
    - ChE principles
    - ChE Applied
- General Education
- Theme (specialization within chemical engineering)
- Lots of electives
- Professional focus, personal development, cultural enrichment

(3) Organizing Paradigm



Develop integration tools:

- Relating molecular structure and function to properties/process/function
- Bond additivity calculations for reactions
- Origin of viscosity
- Tear apart lab helps to motivate
- Energy balance on solar cells
- Synthesis and design

Observation: Two years of math education is a black hole of time

(4)Turn-key Paradigm – focus more on the use of tools instead of the development of tools

Can we judiciously ensure that learning trajectory matches reality of use of turn-key tools?

Group 3

CORE

A. Thermodynamics
   1. enthalpy/entropy
   2. equilibrium/dynamic (phase & reaction)
   3. structure – property
   4. structure – function
   5. EOS, G^{EX}
   6. state functions

B. Kinetics
   1. rates of reaction
   2. catalysis
   3. reaction order
   4. biocatalysis
   5. reaction mechanisms/transition states
   6. reaction networks
   7. metabolic paths

C. Transport phenomena
   1. heat transfer
   2. mass
   3. driving forces/resistances
   4. momentum
   5. turbulence/laminar
   6. multi-phase flow
   7. rheology/solids flow
   8. transport properties
   9. field effects

D. Mass & energy balances
   1. conservation principles
   2. steady state & dynamics

APPLICATIONS

E. Separations
   1. mass transport/dynamic
   2. kinetics
   3. rate processes
   4. equilibrium
   5. staged processes
   6. bioseparation
   7. common separation processes

F. Reaction engineering
   1. reactors/bioreactor
   2. stability
   3. coupled phenomena
   4. homogeneous & heterogeneous
   5. selectivity/yields

6. safety

G. Systems (design, control)
1. process thermodynamics
2. constraint identification
3. equipment
4. assumptions
5. optimization
6. process dynamics & stability
7. modeling
8. safety
9. defining the need & product performance
10. market analysis
11. economics

<u>BASIC SCIENCES</u>

H. Math
1. calculus
2. differential equations
3. statistics
4. numerical methods

I. Chemistry
1. general
2. physical (stat mechanical quantum)
3. organic
4. biochemistry
5. materials chemistry

J. Physics
1. kinematics
2. electromagnetics (optics)
3. quantum

K. Biology
1. biochemistry
2. cell biology
3. molecular biology (tools of manipulation)

<u>TOOLS & SKILLS & EXPERIENCES</u>

L. Communications experiences
1. technical
2. interpersonal

M. Teaming

N. Research skills (lifelong learning) – judging resource credibility

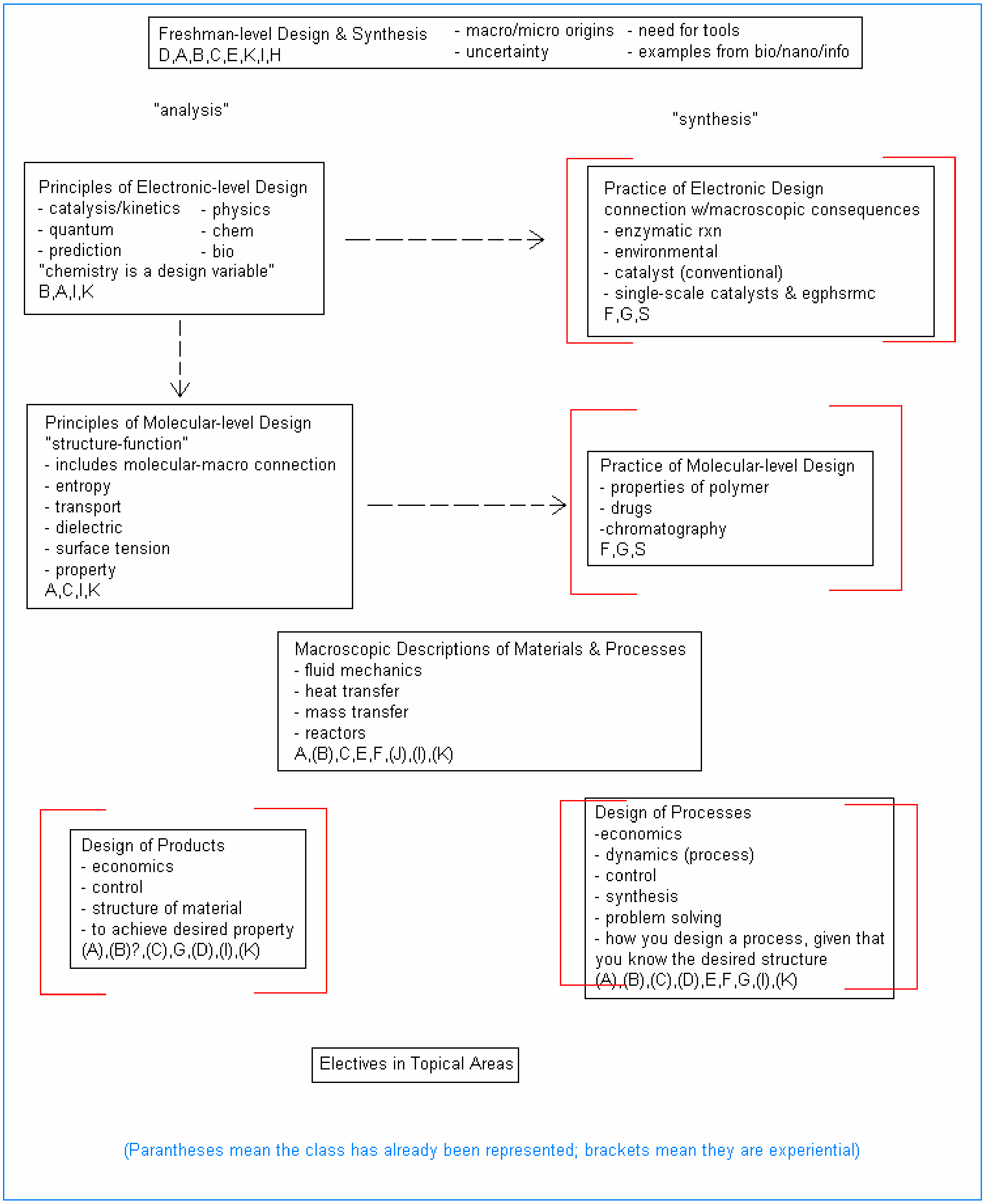
O. Ethics
1. use of Web
2. data integrity
3. accountability

P. Co-op/internship/research exp. (desirable, but not universally required)

Q. Computer literacy
   1. use computer to solve problems
   2. electronic resources

R. Laboratory skills
   1. correct data analysis
   2. experimental design
   3. error analysis
   4. problem definition
   5. troubleshooting

S. Lab experience
   1. assemble & dissemble laboratory apparatus
   2. qualitative & quantitative
   3. practical experience w/open ended problems
   4. varied application
   5. connect to classes but learning more on their own


Freshman-level Design & Synthesis
D,A,B,C,E,K,I,H
- macro/micro origins
- uncertainty
- need for tools
- examples from bio/nano/info
"analysis"
"synthesis"
Principles of Electronic-level Design
- catalysis/kinetics
- quantum
- prediction
- physics
- chem
- bio
"chemistry is a design variable"
B,A,I,K
Practice of Electronic Design
connection w/macroscopic consequences
- enzymatic rxn
- environmental
- catalyst (conventional)
- single-scale catalysts & egphsrmc
F,G,S
Principles of Molecular-level Design
"structure-function"
- includes molecular-macro connection
- entropy
- transport
- dielectric
- surface tension
- property
A,C,I,K
Practice of Molecular-level Design
- properties of polymer
- drugs
-chromatography
F,G,S
Macroscopic Descriptions of Materials & Processes
- fluid mechanics
- heat transfer
- mass transfer
- reactors
A,(B),C,E,F,(J),(I),(K)
Design of Products
- economics
- control
- structure of material
- to achieve desired property
(A),(B)?,(C),G,(D),(I),(K)
Design of Processes
-economics
- dynamics (process)
- control
- synthesis
- problem solving
- how you design a process, given that you know the desired structure
(A),(B),(C),(D),E,F,G,(I),(K)
Electives in Topical Areas
(Parantheses mean the class has already been represented; brackets mean they are experiential)

Group 4

<u>Basic Sciences</u>

- Not only enabling sciences, but important to well-educated students in their own right
- Not necessarily front-loaded in curriculum – possible integrated with ChemEng Science "core"
    - Mathematics
    - Chemistry
    - Physics
    - Biology

<u>Chemical Engineering Science</u>

- Quantitative description of molecules & collections of molecules (including bio-molecules)
- Controlled transformation of molecules and collections of molecules (molecular → macroscopic) (including bio-molecules)
- Critical evaluation of problems with incomplete information and many solutions
- Integration and synthesis
- Implications of chemical change (safety, ethical, environmental, sustainability)

<u>The Engineering Scientist</u>

- Common to all engineering disciplines (may combine engineers in instruction)
- Creative thinking/learning skills
- Oral & written communications
- Use of computational tools
- Team/group problem solving
- Language/foreign culture
- "Hands on" experience
- Engineering economics

Group 5

1. Science and math
    a. Chemistry
        i. Molecular interactions/transformations (some depth)
        ii. Materials science
    b. Physics
        i. Fundamentals (overview)
    c. Biology
        i. Cellular
        ii. Molecular interactions/transformations
    d. Mathematics and computation
2. Processes
    a. Physical
    b. Chemical
    c. Biological
    d. Rate processes
3. Problem analysis and solution
    a. Intuition
    b. Model development/estimation
    c. Open ended problems
    d. Uncertainty/risk
4. Conservation
    a. Balance equation
5. Systems/synthesis
    a. Multiscale
    b. Process & product design
    c. Economics
    d. Compositional control
6. Laboratory skills
    a. Intuition
    b. Design
    c. Data analysis
    d. Integration with lectures
    e. Safety
    f. Critical thinking
    g. Trouble shooting
    h. Analytical skills
    i. Physical intuition/judgment
7. Equilibrium Phenomena
    a. Phase
    b. Reaction
    c. Non-ideal systems
8. Communication
    a. Written
    b. Oral
9. Teamwork

   a. Multidisciplinary (maybe not high priority)

10. Educated human being
11. Humanities

New Ideas – Building Blocks

VERTICAL INTEGRATION

Year	1	…	…	…	…	6,8
Fresh “Project A”						
Soph “Project B”						
Jun “Project C”						
Senior “Project D”						

Intuitive Engineering

1. Teach by immersion
   a. College-wide (all engineering)
   b. Very successful
2. Studio environment
3. Team internship (MIT Practice School)
4. Evolving design
5. Direction repair
6. Entrepreneurship
7. Laptop/use of computers – reinforce ideas immediately after class
8. Learning community