

Transforming Pharmaceutical Technology Education: A Strategic Proposal for Advanced Training

NIPTE Faculty Committee
presented by Lee Kirsch
The University of Iowa

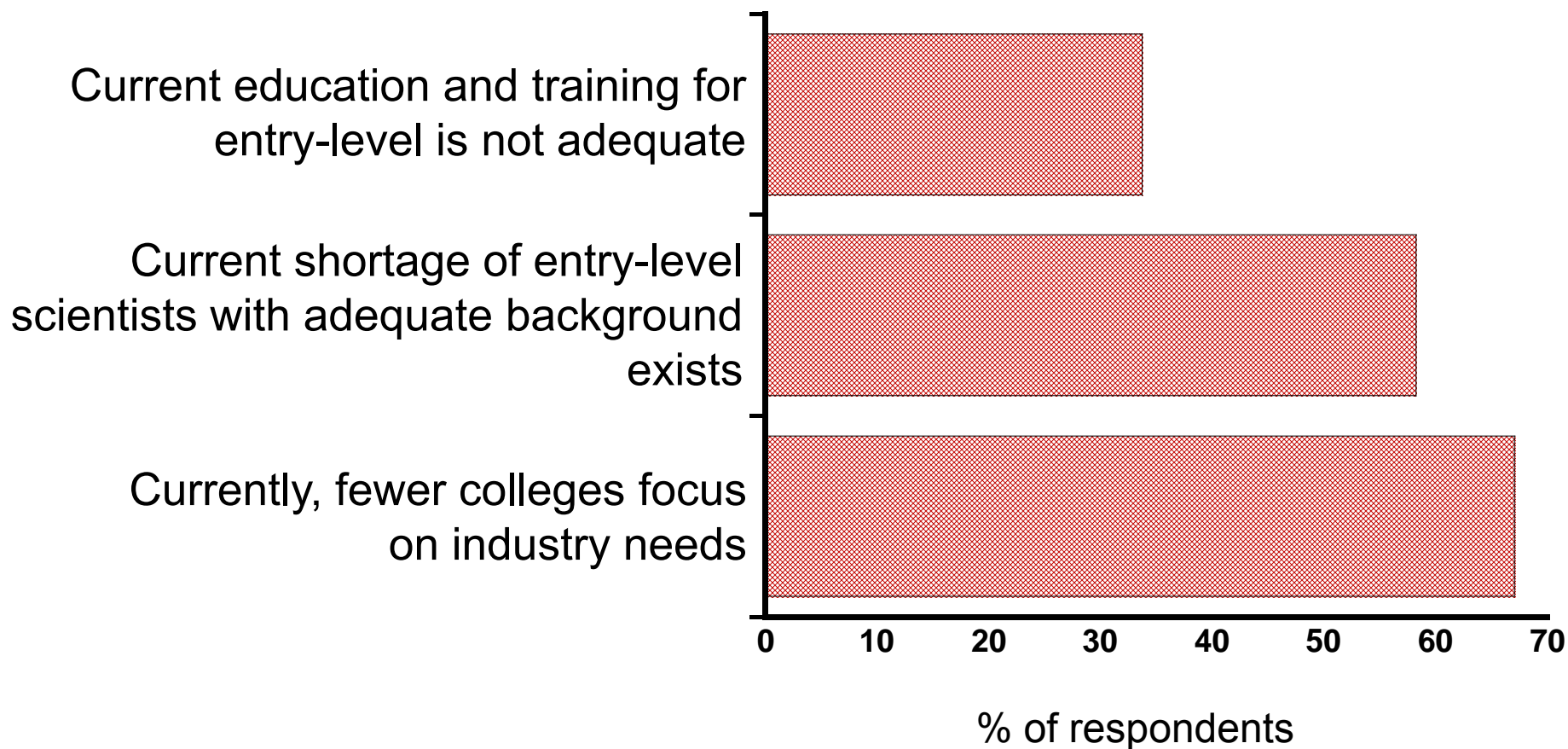
Critical Need

- Decline in availability of new pharmaceutical technologists
- Stagnation of progress in basic sciences underpinning pharmaceutical manufacturing and development
- Potential dangers of outsourcing pharmaceutical development and manufacturing
- Possibility of lost opportunities for capitalizing on biomedical discoveries

Is there a dwindling supply?

Report of the 2004 PT Section Education Committee

AAPS PharmSciTech 2007: 8(1)



Is there stagnation of advances in basic sciences underpinning pharmaceutical technology?

- Current technologies used to develop and manufacture pharmaceuticals largely identical to those use in middle of 20th century
 - notwithstanding the drive to PAT, QbD and GMPs for the 21st century
- NAS Committee on Trends in Federal Spending on Science and Engineering Research (2001)
 - Since early 1990s, support for research/education in physical sciences and engineering declined even within agencies with growing budgets (NIH & NSF)
 - Important report conclusions
 - compelling reasons for federal investment across range of science and engineering disciplines
 - cause for concern regarding stagnation of physical science/engineering funding
 - allocation decisions should take into account need for trained people in a particular field
 - current allocation system doesn't ensure national priorities are taken into account

Potential dangers of pharmaceutical technology outsourcing

- Possible loss of national vitality associated with decline in leadership role
 - NAS report (2007): Rising Above the Gathering Storm
- Potential for patient safety issues given current state of quality control and assurance in emerging industrialization regions
 - EXAMPLE: recent history of diethylene glycol poisoning

Diethylene Glycol in Pharmaceuticals

- **1937** (US manufacturer): Sulfonamide elixir containing DG kills **33** patient
 - Massengill tragedy led to 1938 Federal Food Drug Cosmetic Act that charged FDA with product safety for first time
- **1986** (Delhi manufacturer): **14** patient died of DG containing glycerin
- **1990** (Bangladesh): **236** children died DG-containing pharmaceutical
- **1990** (Nigeria) **40** children died from acetaminophen elixir
- **1996** (Haiti): **88** children died paracetamol elixir
 - Chinese supplier claim glycerol met USP but it contained 20% DG
- **1998** (Calcutta pharmaceutical) **33** children died after ingesting DG-containing cough syrup

Capitalizing on Science/Technology Investments: COSEPUP Report

- Findings
 - Capitalization is national strength: much room for improvement
 - Keys:
 - diverse research investment portfolio
 - facile movement of ideas between people & institutions
 - skilled, flexible science and engineering human resource
 - cooperation between academia, industry and government

COSEPUP Recommendations

- Federal research funding at all stages
 - fundamental research, applied research and fundamental technology development
- Favorable economic & regulatory environment
- Regard education and training of scientists and engineers as an essential ingredient
- Build stronger partnerships between academia, industry and government
 - universities should continue to experiment with partnerships and consortia

The NIPTE Strategy

- Develop and implement a pharmaceutical technology curriculum optimally-designed to provide the highest caliber entry-level scientist/engineer
- Curriculum precepts
 - Interdisciplinary
 - Constructivist

Interdisciplinary

- Cross-cutting fundamentals
 - biological: pharmacology, physiology, toxicology, pharmacokinetics, pharmacodynamics, microbiology
 - chemical: thermodynamics, transport, kinetics, material science, analytical chemistry, interfacial phenomena
 - mathematical: statistics, linear algebra, differential calculus, model-building
- Merging of disciplines
 - Pharmaceutics
 - Engineering
- Partnerships
 - FDA involvement
 - Industrial involvement



Curricular content development
Participation in curriculum delivery
Internship program

Constructivist Approach

- Students explore models based on pharmaceutical systems to formulate foundational understanding of underlying scientific principles
 - computer simulation
 - laboratory exercises
 - internships
- Students provided training in model-building for tasks of designing → predicting → optimizing product/process performance

Curriculum Development

- Faculty committee
 - 11 workshops between 7/05—4/08
 - about 30 participants from all institutions
- Stakeholders meetings
 - 9/06 Rockville (NIPTE/FDA sponsored)
 - 11/07 San Diego (AAPS Annual Meeting)
 - 4/08 Chicago (NIPTE sponsored)
 - about 100 participants from industry, FDA, USP, NSF, non-NIPTE academics

Education Stakeholders Meeting Chicago, April 8-9, 2008



*NIPTE Education
Stakeholders Meeting
April 8-9, 2008*



Meeting Agenda

- Perspectives on current and future state
 - K. Habucky
 - Y. Joshi
 - R. Bogner
 - H. Pedersen
- Starting Point: NIPTE Curriculum
 - Overview
 - Breakout Sessions
- Curriculum Refinements
 - Breakout group reports
- Next Step
 - Delivery ideas and discussion
- Future action plan



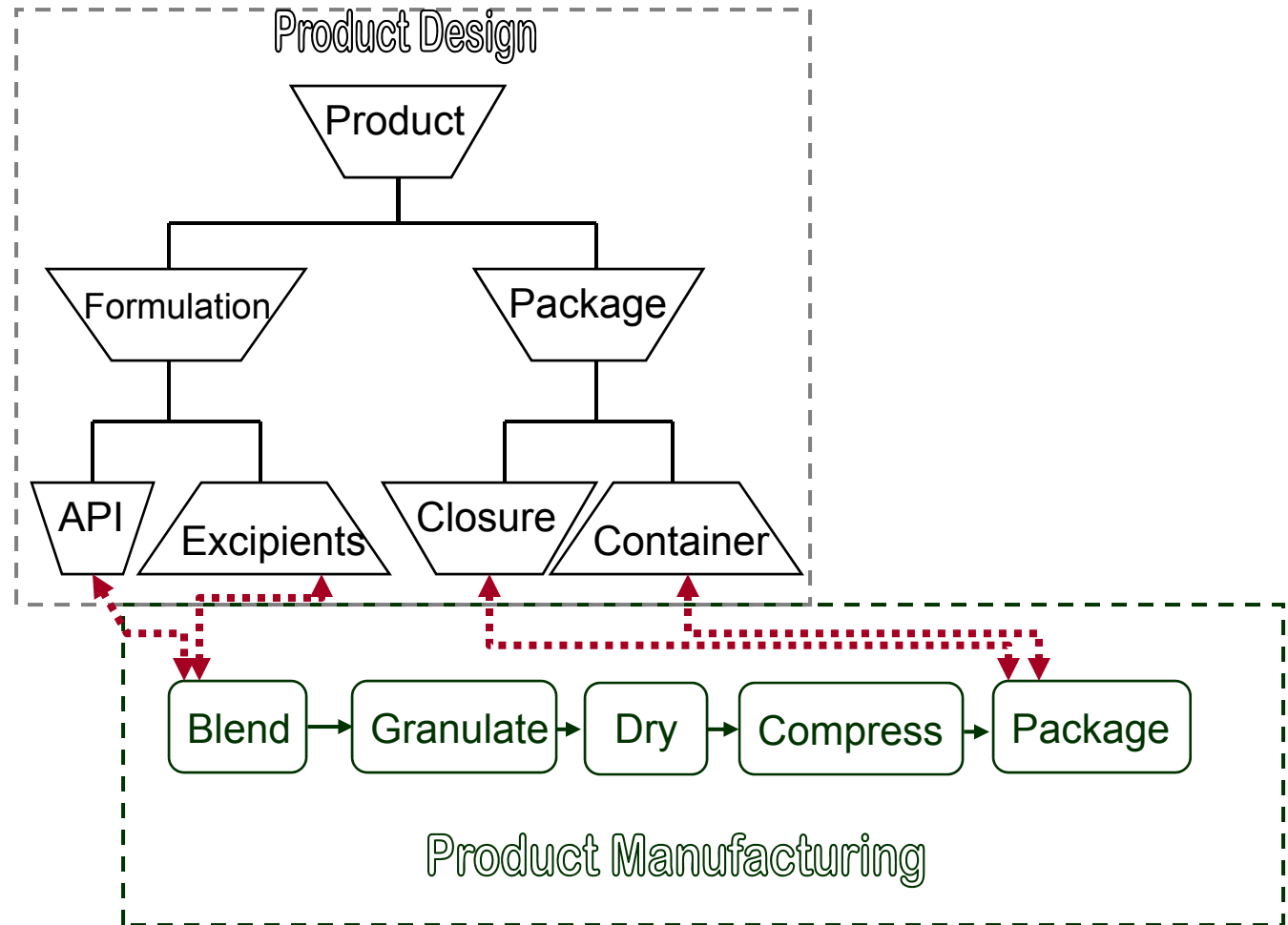
Stakeholder Guest Speakers

- Celeste Carter is a Program Director in the Division of Undergraduate Education at the National Science Foundation.
- Louise Hewitt serves as Director of IIT Online Technology Services including microwave, videoconferencing, Internet-based streaming-video courses and programs and is responsible for implementing and integrating new technologies such as WiMAX into the delivery of programs and courses.
- Karen Habucky, Ph.D. is a Compound Development Team Leader for the Antiinfectives Franchise at Johnson & Johnson Pharmaceutical Research and Development LLC and is currently president of the American Association of Pharmaceutical Scientists.
- Yatindra M. Joshi is Vice President of Generics R&D at Teva, North Wales, PA.
- Michael McLennan joined Purdue in 2004 and became the software architect for both the Network for Computational Nanotechnology (NCN) and the Center for Predication of Reliability, Integrity, and Survivability of Microsystems (PRISM). He is also leader of the Hub Technology Group at Purdue. His latest project is the Rappture Toolkit, a package which accelerates the creation of simulation tools for scientific modeling, available as open source at <http://rappture.org>.
- Steven L. Nail is currently a Senior Baxter Research Scientist in the R&D organization of Baxter Pharmaceutical Solutions, Bloomington, IN.

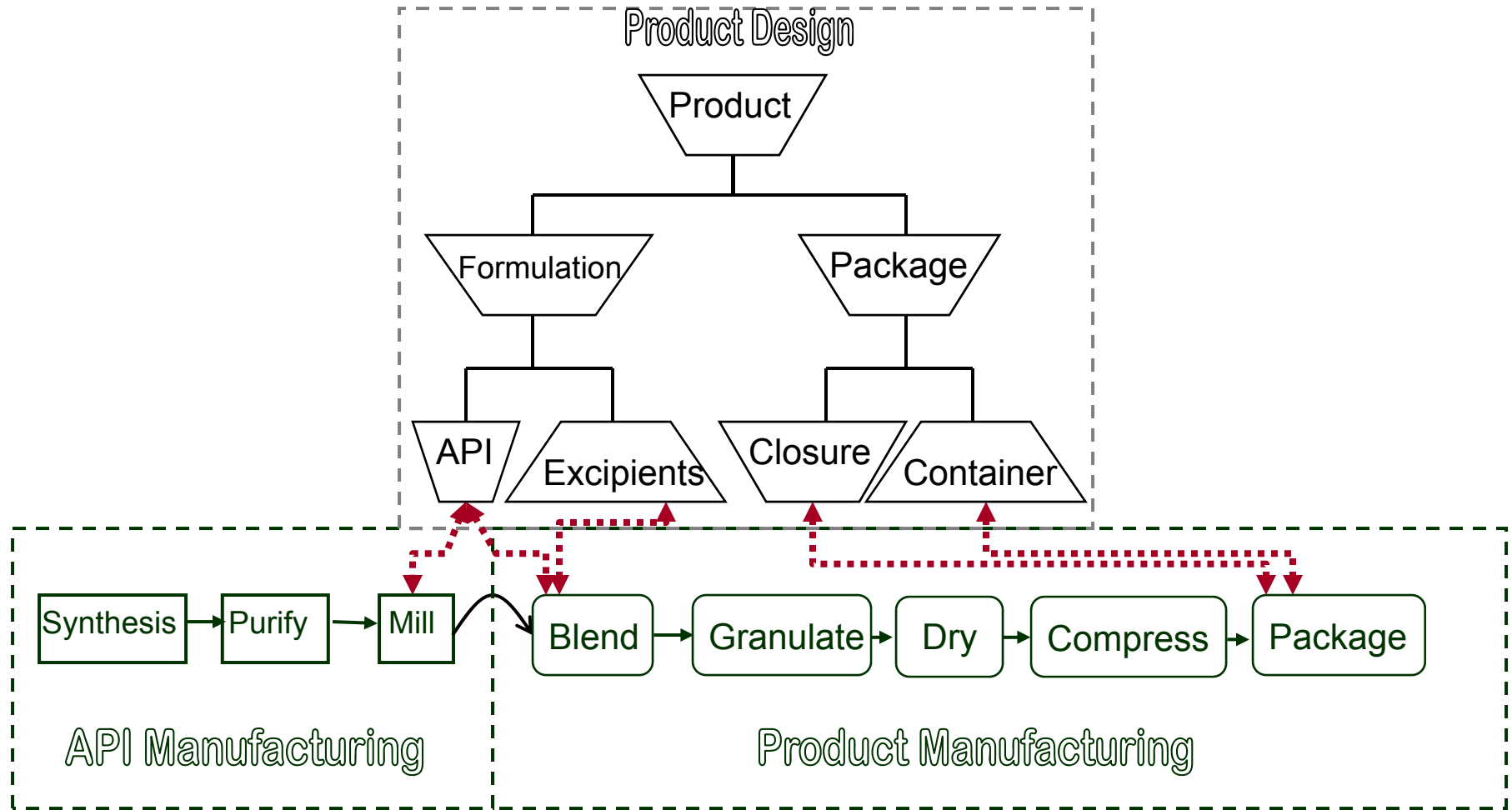
Specific Objectives

- i. Rationally coalesce pharmaceutical science and engineering
- ii. Provide understanding of underlying scientific basis of current and future product and process design, development and quality assurance
- iii. Provide training in the cognitive skills and methodologies needed to invent, develop and trouble-shoot pharmaceutical product and process technologies

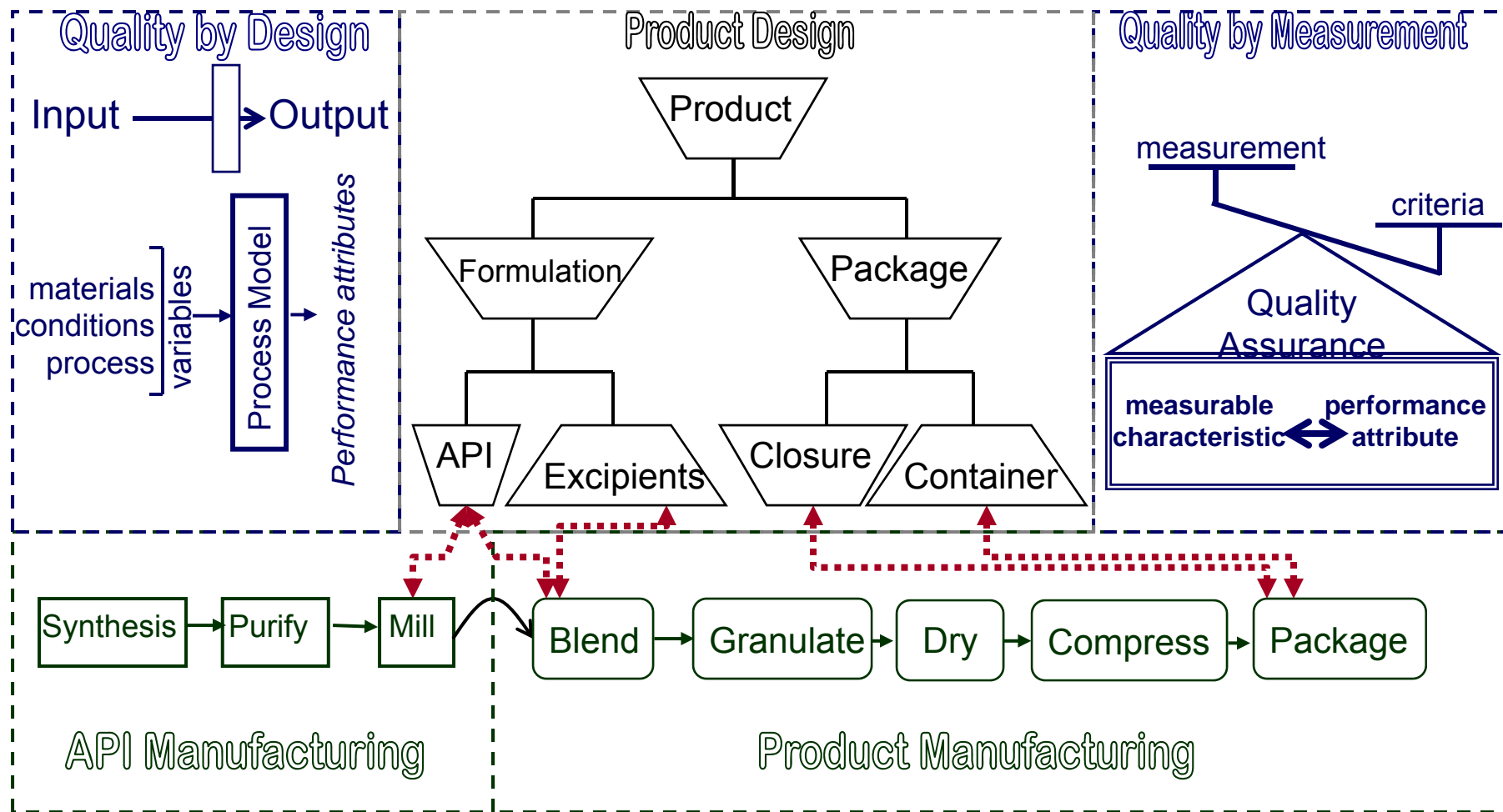
Transforming the education paradigm: 1. combining product/process technology



Transforming the education paradigm: 2. the importance of API processing



Transforming the education paradigm: a holistic view of pharmaceutical technology



Knowledge Domains

List Compiled at NIPTE Stakeholders Meeting (9/06)

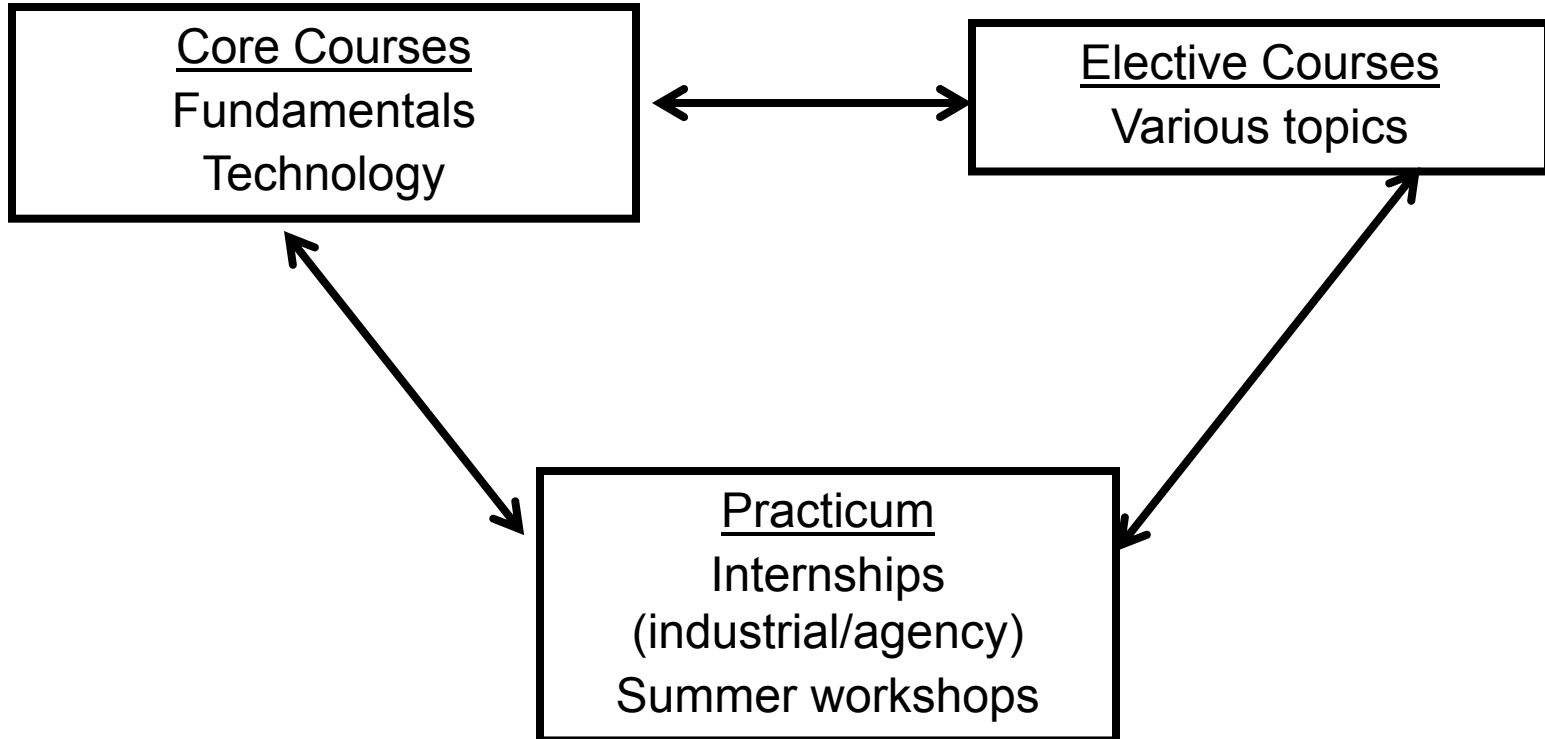
probability theory
 moments
 linear regression
 nonlinear regression
 design of experiments
 statistical quality control
 multivariate analysis
 thermodynamics
 complex equilibria
 solubility
 calorimetry
 complexation
 heat transfer
 mass transfer
 momentum transfer
 ODE & PDE
 chemical stability
 physical stability
 kinetics
 ICH guidelines
 biopharmaceutics
 pharmacokinetics
 physiology/anatomy
 pharmacodynamics
 pharmacology
 spectroscopy
 NMR
 chromatography
 thermal methods
 electrochemistry

material properties
 particle properties
 microstructures
 amorphous dynamics
 composites
 rheology
 granular systems
 solids unit ops
 liquid unit ops
 process design
 aseptic processing
 applied microbiology
 control systems
 regulatory processes
 cGMPs
 oral solids
 solutions
 dispersed systems
 packaging
 excipients
 protein pharmaceuticals
 injectables
 topicals
 API unit ops
 process dynamics
 process control
 optimization

Core Courses

Statistical and Mathematical Modeling
Thermodynamics of Pharmaceutical Materials
Transport Phenomena
Basic Pharmaceutical Material Sciences
Pharmaceutical Stability
Biopharmaceutical Principles
Applied Analytical Methods
Pharmaceutical technologies I
Pharmaceutical technologies II
Pharmaceutical technologies III & IV

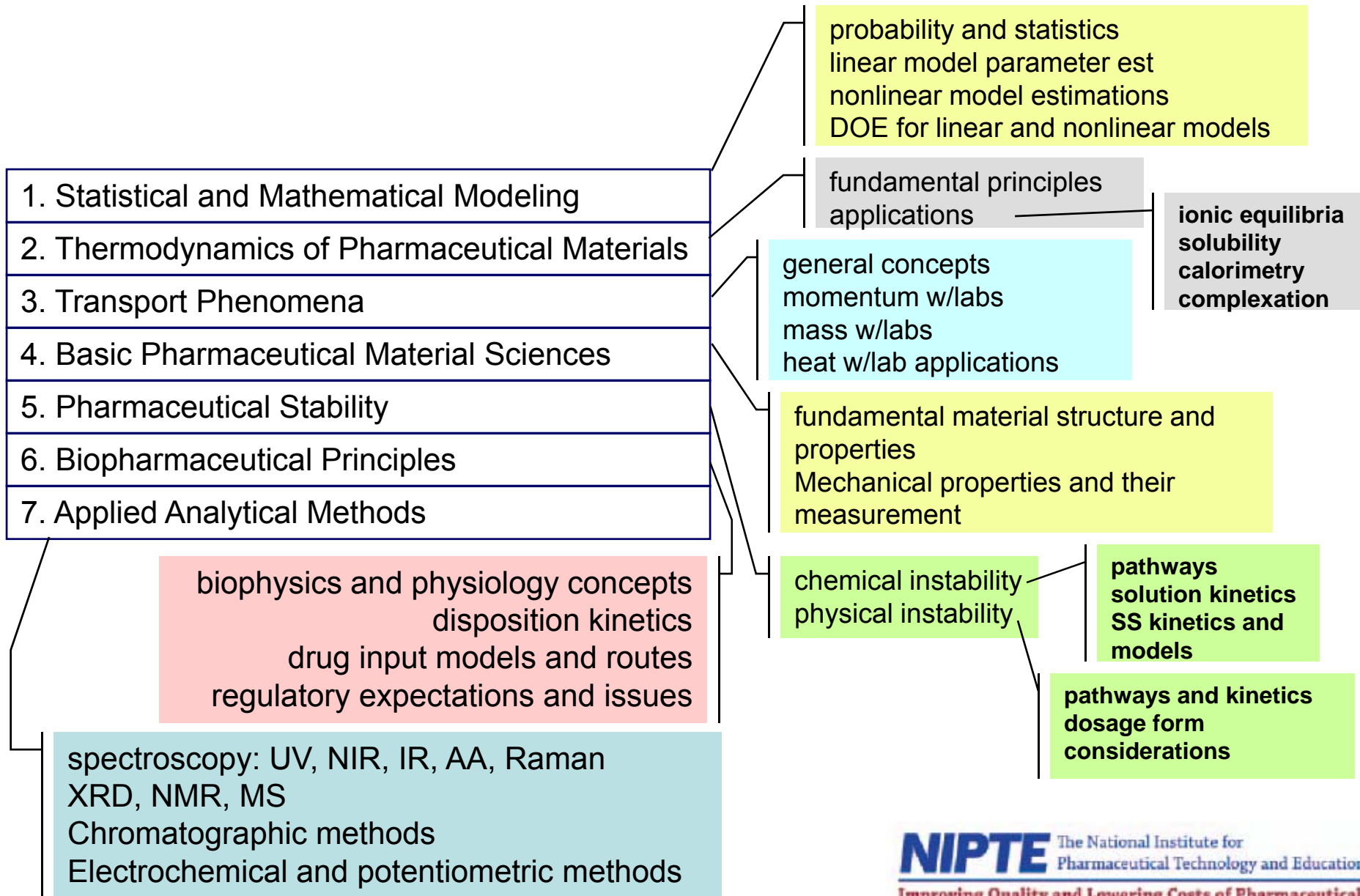
The NIPTE Curriculum



The Core Course

Overview of Drug Development
Math/Statistical Modeling
Thermodynamics of Pharm Materials
Transport Phenomena
Basic Pharm Material Science
Pharmaceutical Stability
Biopharmaceutical Principles
Applied Analytical Methods
PT I: solids
PT II: parenterals
PT III: API manufacturing
PT IV: manufacturing control

Some key course topics



	Course Title	Credit Hours	ESSENTIAL	SECONDARY	SCORE E = 2 PTS S = 1 PT
1	<i>Mathematical and statistical Modeling</i>	3	15	1	31
2	<i>Thermodynamics of Pharmaceutical Materials</i>	3	13	2	28
3	<i>Transport phenomena</i>	4	12	4	28
4	<i>Basic Pharmaceutical Material Sciences</i>	3	12	3	27
5	<i>Pharmaceutical Stability</i>	3	10	6	26
6	<i>Biopharmaceutical principles</i>	3	13	3	29
7	<i>Applied Analytical Chemistry</i>	4	9	4	22
8	<i>Pharmaceutical Technology I: Solids</i>	4	10	4	24
9	<i>Pharmaceutical Technology II: Parenterals</i>	3	2	7	11
10	<i>Pharmaceutical Technology III: API Manufacturing</i>	3	1	6	8
11	<i>Pharmaceutical Technology IV: Manufacturing Control</i>	3	2	8	12
12	Survey of Drug Development Process	1	9	2	20
13	physical organic chemistry and drug degradation mechanisms	2		3	3
14	solid state drug degradation mechanisms	2		1	1
17	engineering of controlled and targeted delivery systems	3		2	2
19	advanced chemometrics	2		1	1
20	processing of biomolecules	2		1	1
21	pharmaceutical biotechnology	2		3	3
25	advanced solids processing and modeling	2		1	1
26	advanced particle engineering	2		2	2
28	scientist survival skills	1		1	1
29	Risk management	1		1	1

Some Potential Electives: courses or modules

1. physical organic chemistry and drug degradation mechanisms
2. solid state drug degradation mechanisms
3. advanced chemometrics
4. freeze-drying
5. pharmaceutical biotechnology
6. vaccines
7. packaging systems and control
8. solid state nmr applications for pharmaceutical systems
9. applied pharmaceutical microbiology
10. advanced solids processing and modeling
11. engineering of controlled and targeted delivery systems
12. advanced particle engineering
13. dissolution models and applications

Development Process

