Crossing the Synapse

Integrating Basic Science and Clinical Medicine at the Cognitive Level to Improve Medical Decision Making

Leslie H. Fall, MD
Professor of Pediatrics
Associate Dean for Faculty Development
Geisel School of Medicine at Dartmouth
MedU Executive Medical Director

CLIPP PEDIATRIC COURSE
fmCASES FAMILY MEDICINE COURSE
SIMPLE INTERNAL MEDICINE COURSE
CORE RADIOLOGY COURSE
WISE-MD SURGICAL MODULES

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- Improved clinical care through basic science understanding
- Student self assessment of basic science knowledge
- Educator tools for integrated teaching sessions
- Mobile tools for bedside teaching and learning

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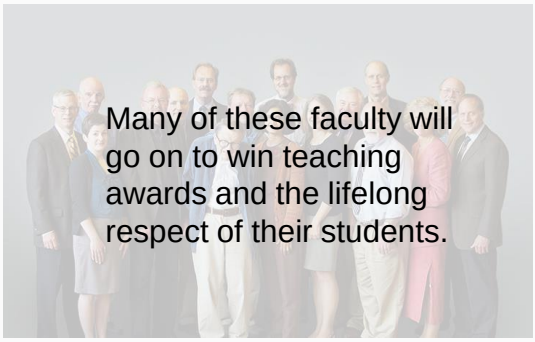
Faculty spend over 1200 hours teaching basic sciences in the average medical school curriculum.



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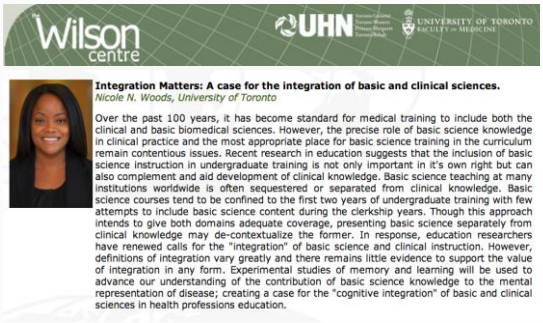
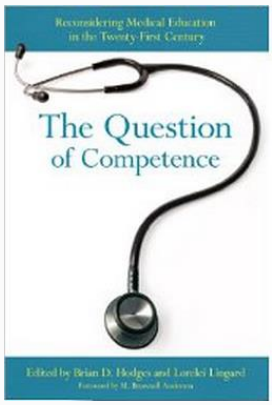
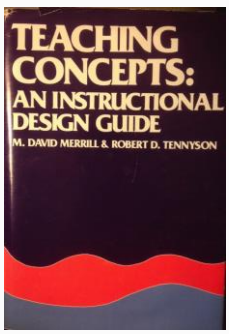
So why are medical students persistently told by clinicians that they will use little of their basic science education in practice?

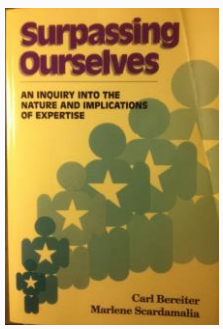


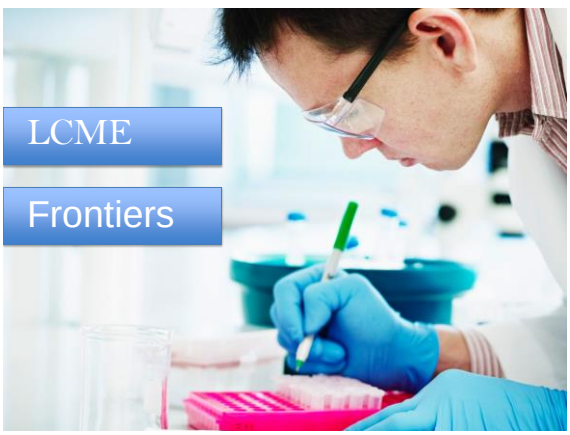


4. Competence as Expertise: Exploring Constructions of Knowledge in Expert Practice
- ***Maria Mylopoulos***

7. The Competent Mind: Beyond Cognition
- Annie S. O. Leung, Ronald M. Epstein, and Carol-Anne E. Moulton







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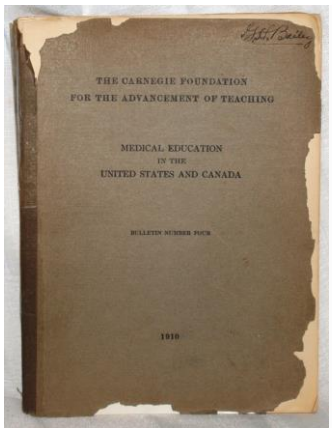
Why are the basic sciences important to the practice of clinical medicine?


THE CARNEGIE FOUNDATION
FOR THE ADVANCEMENT OF TEACHING

MEDICAL EDUCATION
IN THE
UNITED STATES AND CANADA

BULLETIN NUMBER FOUR

1910

Train physicians to practice with a scientific understanding of human anatomy and physiology, employing faculty engaged in medical research

Why are the basic sciences important to the practice of clinical medicine *today*?

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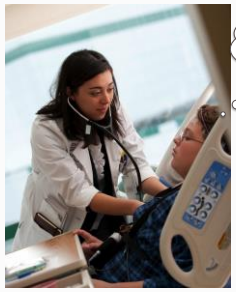
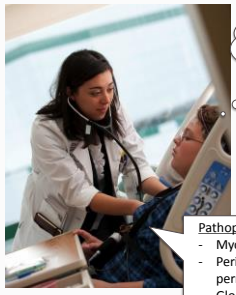


Why are the basic sciences important to the practice of clinical medicine *today*?

Causal Reasoning



?

How can we better integrate basic science understanding into clinical learning?

Perspective: **Deconstructing Integration: A Framework for the Rational Application of Integration as a Guiding Curricular Strategy**

Ellen Goldman, EdD, and W. Scott Schroth, MD, MPH

Abstract

In response to historical criticism, evolving accreditation standards, and recent reports on curricula, medical educators and medical schools have been eagerly pursuing integration as a goal of curricular reform. The general education literature broadly considers integration to be the deliberate unification of separate areas of knowledge, and it provides support for the concept that integration better meets the needs of adult learners in professional education.

The use of integration as a curricular goal is not without its critics, however, nor is it free of difficulties in implementation. In this perspective, the authors propose that most of these difficulties arise from a failure to recognize that integration is a strategy for curricular development rather than a goal in itself, and they argue that adopting a systematic approach to integration offers many potential benefits. They articulate the conceptual and practical issues that they believe are critical to consider in order to achieve successful curricular integration, and they suggest that integration should be approached as a subset of broader curriculum development decisions. They propose a three-level framework for applying integration as a guiding curricular strategy, in which decisions about integration must follow curricular decisions made at the program level, the course level, and then the individual session level.

Academic Medicine, Vol. 87, No. 6 / June 2012

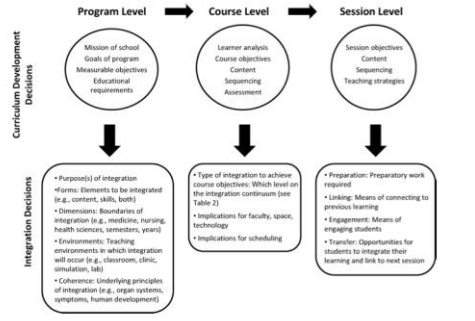
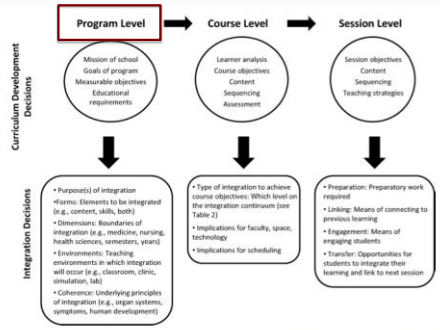


Figure 1 Organizing framework for curriculum development and required integration decisions at the program, course, and session levels of curricular design.



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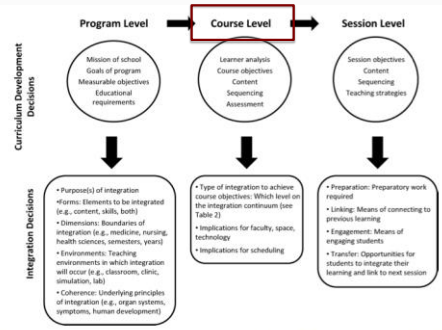

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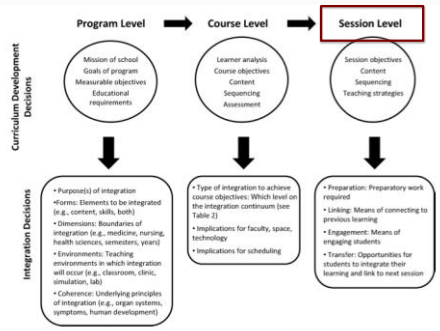

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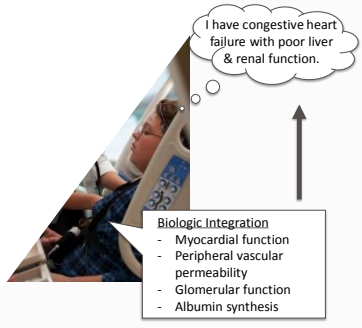
Contextual Integration

http://portals.clevelandclinic.org/cclcm/Academics/Problem-basedLearning/tabid/7615/Default.aspx

?

What are we missing?

Integration begins here . . .



Clinical competency begins here . . .

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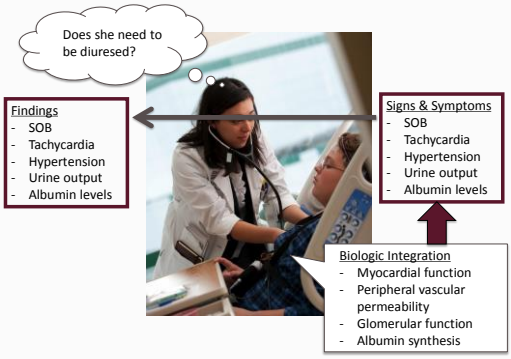
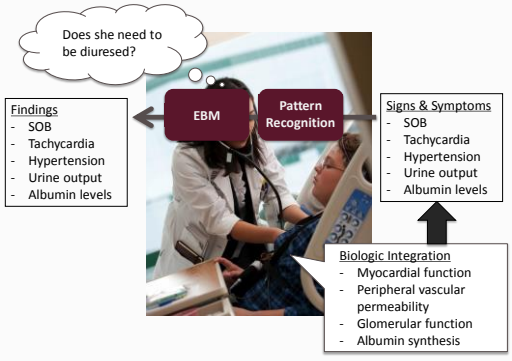
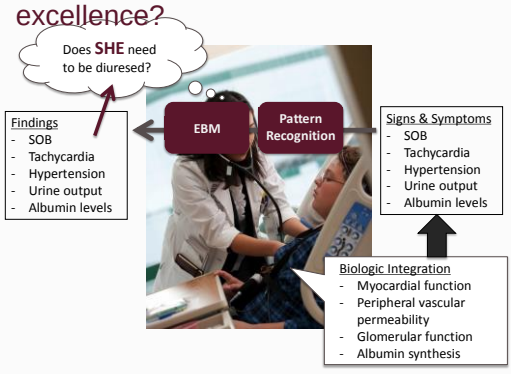


With these tools to help . . .



But is that all there is to clinical excellence?



The Answer: Excellence in Patient Care

It is in the application of principles to individual patients, in the individuality of each clinical decision-making situation, that an understanding of science is essential and takes precedence over pattern recognition and protocols.

Adapted from Lou Pangaro (JIAMSE 2010)

MedU

Cognition Before Curriculum: Rethinking the Integration of Basic Science and Clinical Learning

Kulamakan Mahan Kulasegaram, Maria Athina Martimianakis, PhD, Maria Mylopoulos, PhD, Cynthia R. Whitehead, MD, PhD, and Nicole N. Woods, PhD

Abstract

Purpose
Integrating basic science and clinical concepts in the undergraduate medical curriculum is an important challenge for medical education. The health professions education literature includes a variety of educational strategies for integrating basic science and clinical concepts at multiple levels of the curriculum. To date, assessment of this literature has been limited.

Method
In this critical narrative review, the authors analyzed literature published in the last 30 years (1982–2012) using a previously published integration framework. They included studies that documented approaches to integration at the level of programs, courses, or teaching sessions and that aimed to improve learning outcomes. The authors evaluated these studies for evidence of successful integration and to identify factors that contribute to integration.

Results
Several strategies at the program and course level are well described but poorly evaluated. Multiple factors contribute to successful learning, so identifying how interventions at these levels result in successful integration is difficult. Evidence from session-level interventions and experimental studies suggests that integration can be achieved if learning interventions attempt to link basic and clinical science in a causal relationship. These interventions attend to how learners connect different domains of knowledge and suggest that successful integration requires learners to build cognitive associations between basic and clinical science.

Conclusions
One way of understanding the integration of basic and clinical science is as a cognitive activity occurring within learners. This perspective suggests that learner-centered, content-focused, and session-level-oriented strategies can achieve cognitive integration.

Academic Medicine, Vol. 88, No. 10 / October 2013

Cognition Before Curriculum: Rethinking the Integration of Basic Science and Clinical Learning

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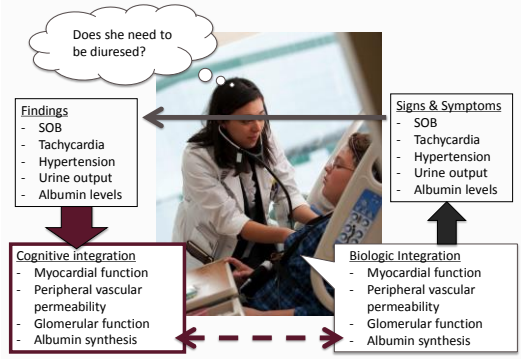
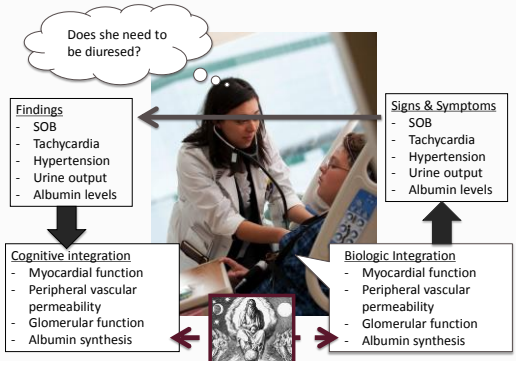
Integration happens here!



and the ultimate goal is omniscience ☺



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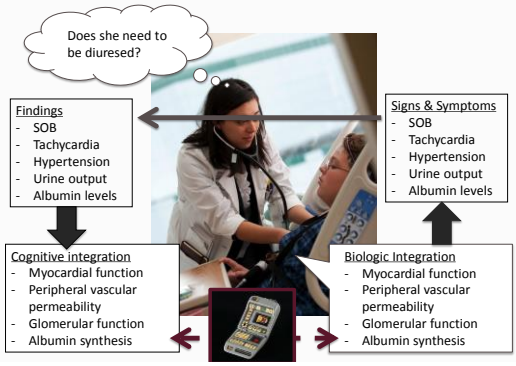
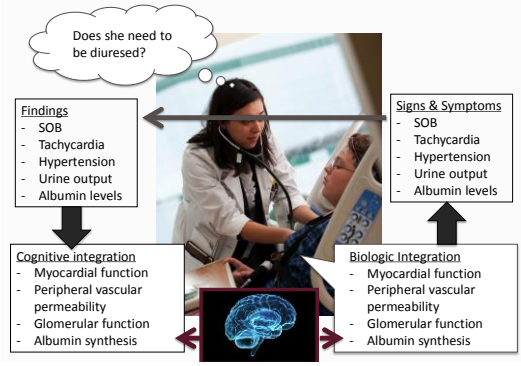
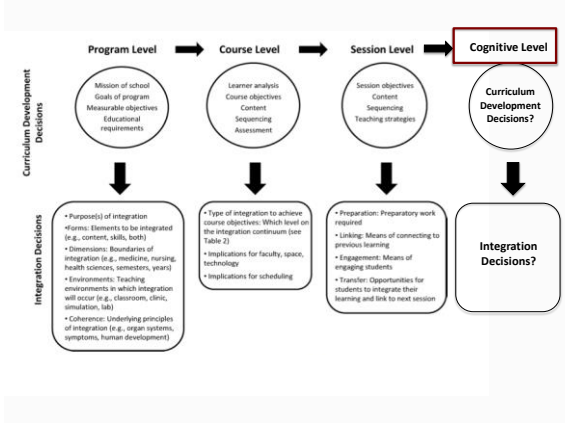
What tools have we given her to help with cognitive integration?

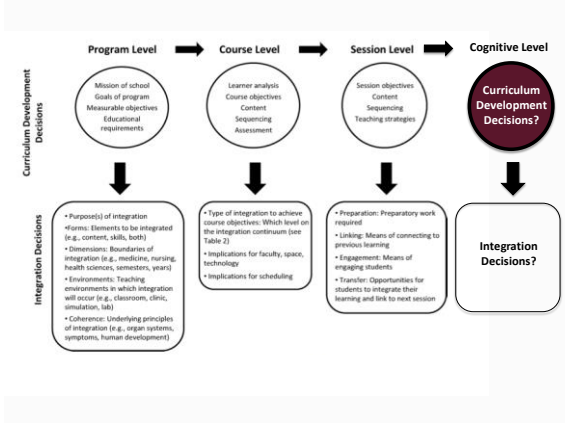
No tricorders (yet) . . .



But we have something better . . .




Program Level
Course Level
Session Level
Cognitive Level
Curriculum Development Decisions
Mission of school
Goals of program
Measurable objectives
Educational requirements
Learner analysis
Course objectives
Content
Sequencing
Assessment
Session objectives
Content
Sequencing
Teaching strategies
Curriculum Development Decisions?
Integration Decisions
• Purpose(s) of integration
•Forms: Elements to be integrated (e.g., content, skills, both)
• Dimensions: Boundaries of integration (e.g., medicine, nursing, health sciences, semesters, years)
• Environments: Teaching environments in which integration will occur (e.g., classroom, clinic, simulation, lab)
• Coherence: Underlying principles of integration (e.g., organ systems, symptoms, human development)
• Type of integration to achieve course objectives: Which level on the integration continuum (see Table 2)
• Implications for faculty, space, technology
• Implications for scheduling
• Preparation: Preparatory work required
• Linking: Means of connecting to previous learning
• Engagement: Means of engaging students
• Transfer: Opportunities for students to integrate their learning and link to next session
Integration Decisions?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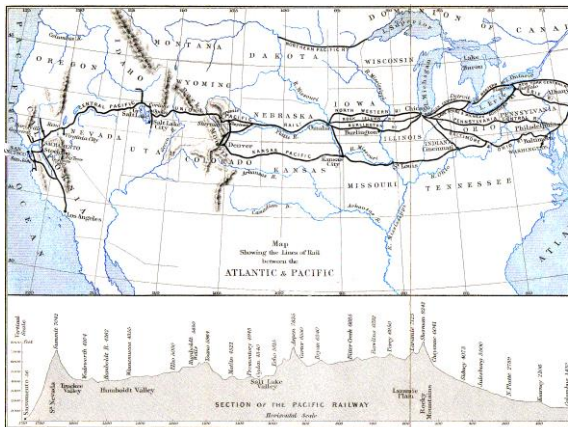
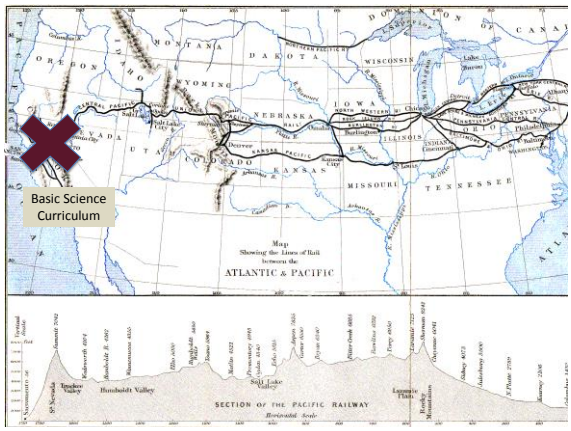
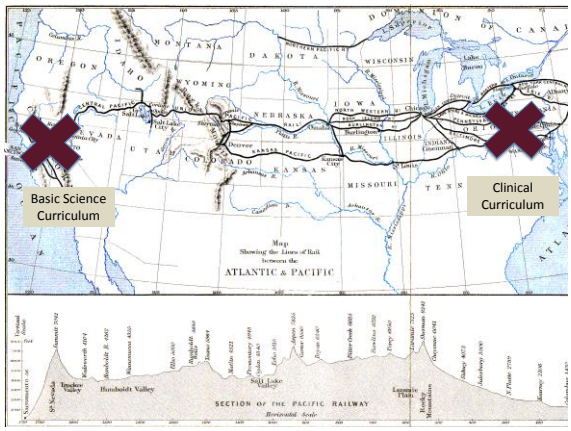

Map Showing the Lines of Rail between the ATLANTIC & PACIFIC
SECTION OF THE PACIFIC RAILWAY


Basic Science Curriculum
Map Showing the Lines of Rail between the ATLANTIC & PACIFIC
SECTION OF THE PACIFIC RAILWAY


Basic Science Curriculum
Clinical Curriculum
Map Showing the Lines of Rail between the ATLANTIC & PACIFIC
SECTION OF THE PACIFIC RAILWAY


DURANGO & SILVERTON
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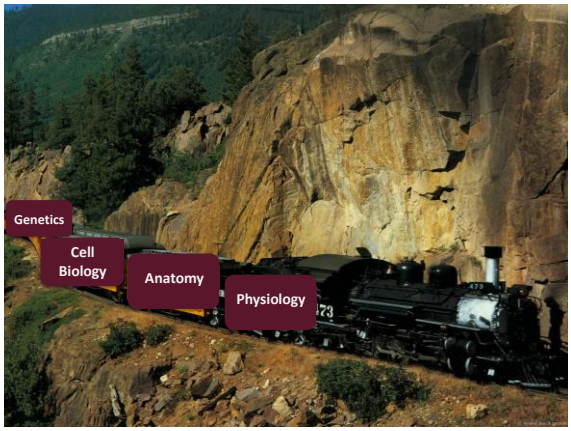
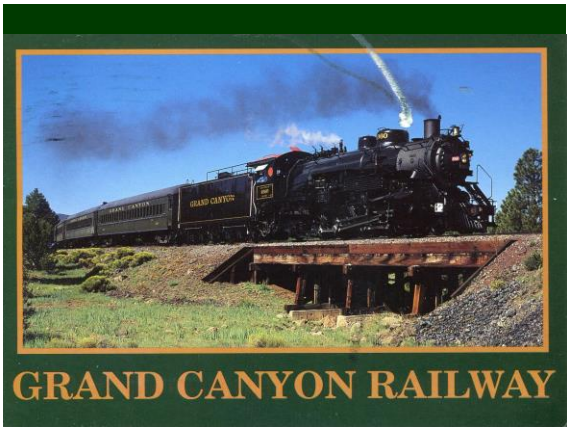

Genetics
Cell Biology
Anatomy
Physiology


Pattern Recognition
EBM



?

How do we package basic science information so it survives the journey?

CORE CONCEPTS – the containers

Information stored as a mental representation of a uniquely related group of objects, symbols, events.

- Name, symbol, image
- Metaphors
- Stories

Do **not** think of a

Do **not** think of a

TREE

Do **not** think of a

TREE

Knowledge Organization – the packaging

A progressively rich and organized semantic network of relationships between concepts that confers meaning.

- Reduced
- Dispersed
- Elaborated
- Encapsulated

Bordage. Academic Medicine, 1994; 11:76.

MedU

Tree
Noun

l **plant**
em, or t ing to a **considerable height**, a lateral **brai**
e ground.

Tree
Noun

A perennial **plant** with an elongated and thick wooden stem, or **trunk**, growing to a **considerable height**, and bearing many large lateral **branches** with leaves at some distance from the ground.

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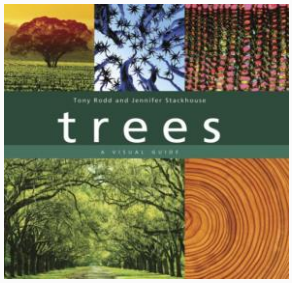
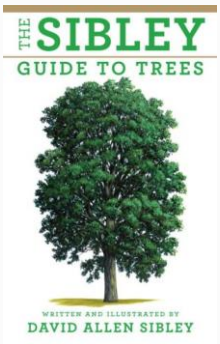
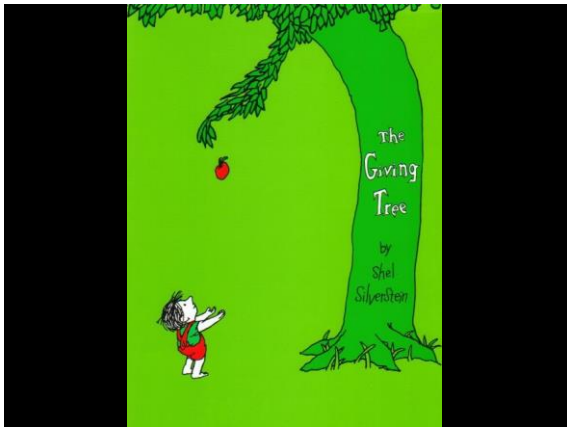
Conceptual understanding allows for:

- Stable, rich and efficient memory
- Categorization
- Inference
- Abstraction
- Learning
- Decision-making
- Creativity


Tony Rodd and Jennifer Stackhouse
trees


THE SIBLEY
GUIDE TO TREES
WRITTEN AND ILLUSTRATED BY
DAVID ALLEN SIBLEY


The Giving Tree
by
Shel Silverstein

?

How do we safely and effectively package biomedical concepts?

Integration of Basic Sciences and Clinical Sciences in Oral Radiology Education for Dental Students

Mariam T. Baghdady, B.D.S., M.Sc., F.R.C.D.(C), Dip. A.B.O.M.R.; Heather Carnahan, Ph.D.; Ernest W.N. Lam, D.M.D., Ph.D., F.R.C.D.(C); Nicole N. Woods, Ph.D.

Abstract: Educational research suggests that cognitive processing in diagnostic radiology requires a solid foundation in the basic sciences and knowledge of the radiological changes associated with disease. Although it is generally assumed that dental students must acquire both sets of knowledge, little is known about the most effective way to teach them. Currently, the basic and clinical sciences are taught separately. This study was conducted to compare the diagnostic accuracy of students when taught basic sciences segregated or integrated with clinical features. Predoctoral dental students (n=51) were taught four confusable intraboony abnormalities using basic science descriptions integrated with the radiographic features or taught segregated from the radiographic features. The students were tested with diagnostic images, and memory tests were performed immediately after learning and one week later. On immediate and delayed testing, participants in the integrated basic science group outperformed those from the segregated group. A main effect of learning condition was found to be significant ($p<0.05$). The results of this study support the critical role of integrating biomedical knowledge in diagnostic radiology and shows that teaching basic sciences integrated with clinical features produces higher diagnostic accuracy in novices than teaching basic sciences segregated from clinical features.

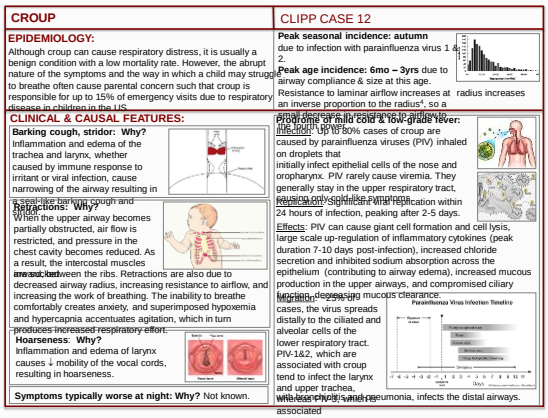
Journal of Dental Education ■ *Volume 77, Number 6 June 2013*

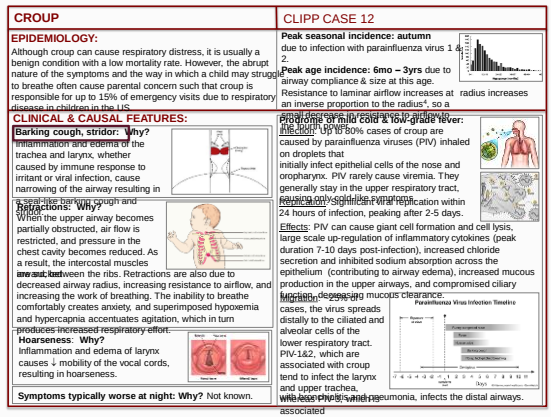
Table 1. Example of the radiographic features of periapical sclerosing osteitis explained in the two learning groups

	SEGREGATED BASIC SCIENCE
Basic Science explanation	The body responds to microbiological injury with inflammation. The inflammatory response destroys or walls off the injurious stimulus and sets up an environment for repair of damaged tissue. Inflammatory lesions are the most common pathological lesions in the jawbones. Normally, bone metabolism represents a balance of osteoclastic bone resorption and osteoblastic bone formation. Inflammatory mediators (cytokines, prostaglandins, etc.) tip this balance either to bone resorption or bone formation. Usually there is a combination of both processes. The initial source of inflammation in periapical inflammatory lesions is necrotic pulp. Toxic metabolites from the necrotic pulp exit through the root apex or the accessory canals causing an inflammatory reaction in periapical structures and the surrounding bone. Sclerosing osteitis is a local response of bone around the apex of a tooth that occurs secondarily to necrosis of the pulp.
Radiographic feature	Location: In most cases, the epicenter of periapical inflammatory lesions is found at the apex of the involved tooth. Less often, such lesions are centered around other regions of the tooth root. Most cases occur in the premolar-molar area in the mandible. Periphery: The periphery of periapicals inflammatory lesions is ill defined with a gradual transition from normal to abnormal bone. Internal Structure: Internally, these lesions may appear either mainly radiolucent (periapical rarefying osteitis) or mainly radiopaque (periapical sclerosing osteitis) or more commonly a mixture of both. Effect on surrounding structures: Periapical inflammatory lesions usually cause loss of lamina dura and widening of the apical portion of the periodontal ligament space.

Table 1. Example of the radiographic features of periapical sclerosing osteitis explained in the two learning groups

INTEGRATED BASIC SCIENCE
The body responds to microbiological injury with inflammation. Normally, bone metabolism represents a balance of osteoclastic bone resorption and osteoblastic bone formation. Inflammatory mediators (cytokines, prostaglandins, etc.) tip this balance either to bone resorption or bone formation. Radiographically, the affected cancellous bone will appear either radiolucent (resorption) or radiopaque (bone formation). Usually there is a combination of the two processes. When most of the lesion consists of increased bone formation, the term "periapical sclerosing osteitis" is used; when most of the lesion is undergoing bone resorption, the term "periapical rarefying osteitis" is used. The initial source of inflammation in periapical inflammatory lesions is a necrotic pulp. Toxic metabolites from the necrotic pulp exit through the root apex or the accessory canals causing an inflammatory reaction in the surrounding bone. Radiographically, the lesion is restricted to a region around the tooth with a center typically located at the apex of the root. However, lesions of pulpal origins also may be located anywhere along the root surface because of the accessory canals. The periphery of periapical inflammatory lesions is ill defined, showing a gradual transition from the surrounding normal trabecular bone into the abnormal bone pattern. Radiographically, there is loss of lamina dura and widening of the periodontal ligament space around the affected tooth, the bone resorption being stimulated by the inflammatory process.





CROUP

EPIDEMIOLOGY:
Although croup can cause respiratory distress, it is usually a benign condition with a low mortality rate. However, the abrupt nature of the symptoms and the way in which a child may struggle to breathe often cause parental concern such that croup is responsible for up to 15% of emergency visits due to respiratory disease in children in the US.

CLINICAL & CAUSAL FEATURES:

Barking cough, stridor: Why?
Inflammation and edema of the trachea and larynx, whether caused by immune response to irritant or viral infection, cause narrowing of the airway resulting in a seal-like barking cough and stridor.

Retractions: Why?
When the upper airway becomes partially obstructed, air flow is restricted, and pressure in the chest cavity becomes reduced. As a result, the intercostal muscles are sucked between the ribs. Retractions are also due to decreased airway radius, increasing resistance to airflow, and increasing the work of breathing. The inability to breathe comfortably creates anxiety, and superimposed hypoxemia and hypercapnia accentuates agitation, which in turn produces increased respiratory effort.

Hoarseness: Why?
Inflammation and edema of larynx causes ↓ mobility of the vocal cords, resulting in hoarseness.

Symptoms typically worse at night: Why? Not known.

CLIPP CASE 12

Peak seasonal incidence: autumn
due to infection with parainfluenza virus 1 & 2.

Peak age incidence: 6mo – 3yrs due to airway compliance & size at this age.
Resistance to laminar airflow increases at an inverse proportion to the radius[4], so a small decrease in resistance to airflow to the fourth power.

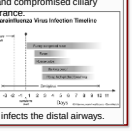
radius increases

Prodrome of mild cold & low-grade fever:
Infection: Up to 80% cases of croup are caused by parainfluenza viruses (PIV) inhaled on droplets that initially infect epithelial cells of the nose and oropharynx. PIV rarely cause viremia. They generally stay in the upper respiratory tract, causing only cold-like symptoms.

Replication: Significant viral replication within 24 hours of infection, peaking after 2-5 days.

Effects: PIV can cause giant cell formation and cell lysis, large scale up-regulation of inflammatory cytokines (peak duration 7-10 days post-infection), increased chloride secretion and inhibited sodium absorption across the epithelium (contributing to airway edema), increased mucous production in the upper airways, and compromised ciliary function, decreasing mucous clearance.

Inflammation: 25% of cases, the virus spreads distally to the ciliated and alveolar cells of the lower respiratory tract. PIV-1&2, which are associated with croup tend to infect the larynx and upper trachea, whereas PIV-3, which is associated with bronchiolitis and pneumonia, infects the distal airways.



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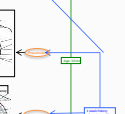
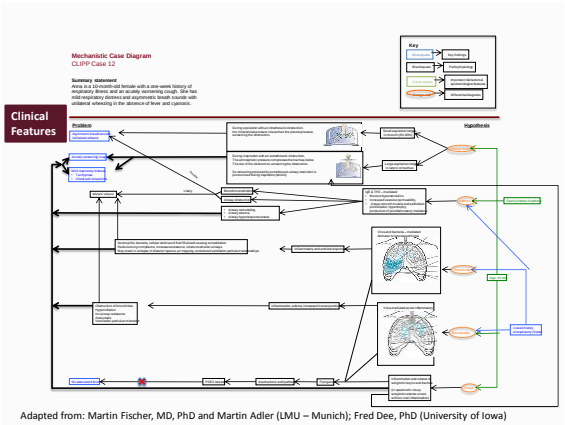


Adapted from: Martin Fischer, MD, PhD and Martin Adler (LMU – Munich); Fred Dee, PhD (University of Iowa)



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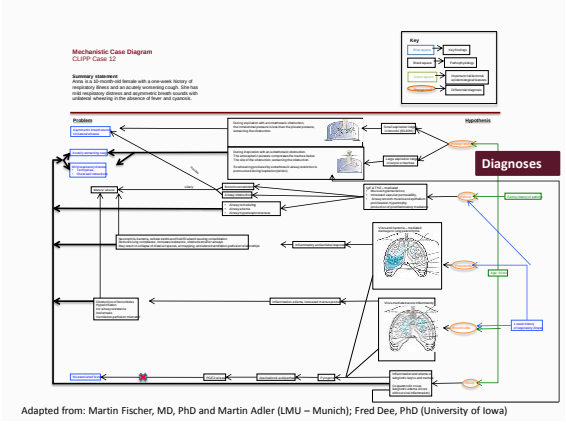

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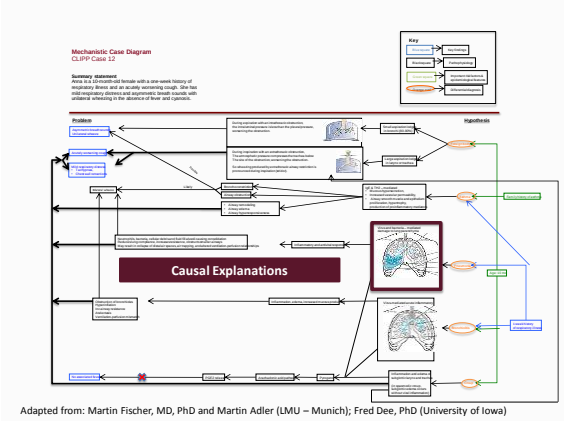

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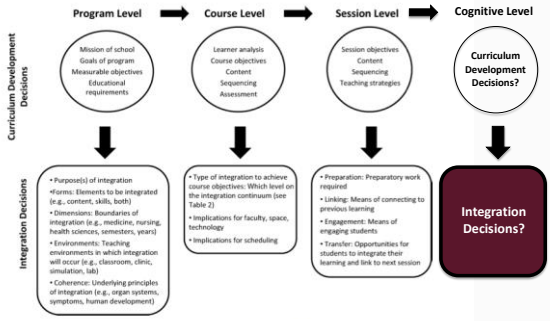
Slowing Down When You Should: A New Model of Expert Judgment

Carol-anne E. Moulton, Glenn Regehr, Maria Mylopoulos, and Helen M. MacRae

Clinical Judgment Review Paper Acad Med. 2007;82(10 Suppl):S109–S116.

?

How do we put the conceptual packages to work once they arrive safely on the clinical side?



From Understanding to Action

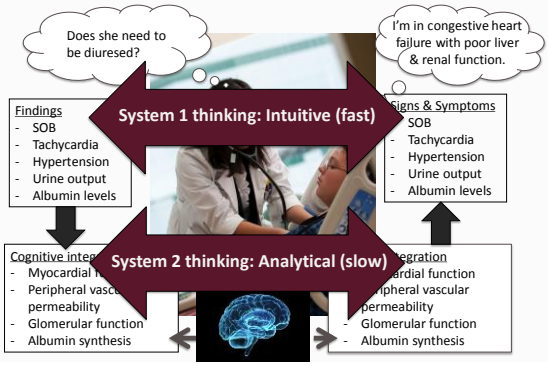
Basic science plays an essential role in the student's progress towards independence - as their responsibilities move from understanding and explaining towards diagnostic and therapeutic decision-making.

The knowledge is not there for its own sake, but to support the responsibilities the student will be given.

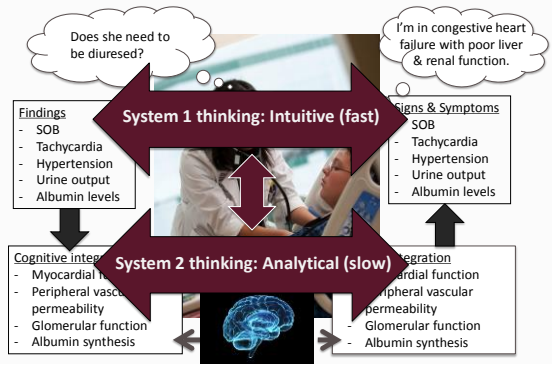
Adapted from Lou Pangaro (JIAMSE 2010)

MedU

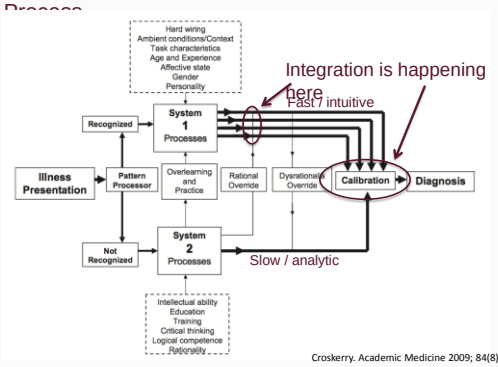
Clinical Decision Making



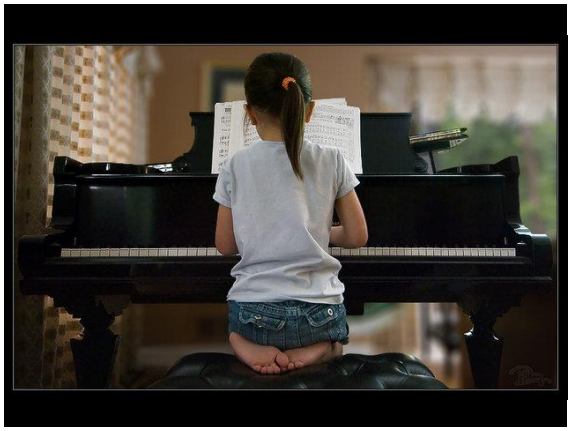
Clinical Decision Making



Clinical Decision Making: A Cognitive Dual Process



Croskerry. Academic Medicine 2009; 84(8):1022



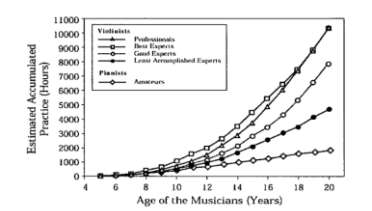


Figure 2. Estimated amount of time for solitary practice as a function of age for the middle-aged *professional* violinists (*triangles*), the best expert violinists (*squares*), the good expert violinists (*empty circles*), the *least accomplished* expert violinists (*filled circles*) and *amateur* pianists (*diamonds*). (From "The role of deliberate practice in the acquisition of expert performance," by K. A. Ericsson, R. Th. Krampe, and C. Tesch-Römer, 1993, *Psychological Review*, *100*(3), p. 379 and p. 384. Copyright 1993 by American Psychological Association. Adapted with permission.)

Deliberate Practice and the Acquisition and Maintenance of Expert Performance in Medicine and Related Domains

K. ANDERS ERICSSON

ACADEMIC MEDICINE, VOL. 79, NO. 10/OCTOBER SUPPLEMENT 2004

Frequent Practice

Relevant Decision-Making

- Diagnosis
- Work-up
- Therapy
- Prognosis

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Relevant Decision-Making

- Diagnosis
- Work-up
- Therapy
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Common Conditions (~300)

- Asthma
- Bronchiolitis
- Depression
- Diabetes
- Gastric reflux disease
- Hypertension
- Influenza
- Multiple sclerosis
- Postpartum infection
- Venous thrombosis

Crohn's Disease – acute presentation; treatment

- Digestion and absorption
- GI secretion
- GI water transport
- Mucosal immunity
- Microbiome
- Systemic inflammation
- Chronic inflammation
- Autoimmunity
- Nutritional immunity
- Acid-base balance
- Individualizing therapeutics
- Toxic drug effects
- Cellular transport mechanisms
- Steady state metabolism
- Nitrogen balance
- Micronutrients
- Whole body energy balance
- Intracellular energy regulation
- Microbial immunology
- Microbial pathogenesis
- Cancer metabolism
- Genetics of drug

MedU Science: Goals for Learners

To understand how the application of their basic science knowledge to the practice of everyday medicine makes them better doctors and improves patient care and improves health care outcomes.

- Improve the accuracy and efficiency of diagnosis
- Improve the accuracy and cost effectiveness of work-up
- Improve the targeted choice and cost effectiveness of therapy
- Routine application of basic science core concepts
- Continuous formative assessment

MedU Science Virtual Patient Cases

- Targeted to late clinical learners
- Appropriate for all core disciplines
- Common presentations and problems
- 20 minute cases
- Focus on decision-making
- Applied core basic science concepts
- Knowledge calibration
- Ongoing formative assessment
- Align with the AAMC's CEPAER project

MedU Science: Goals for Faculty

To meet the needs for better methods and tools to effectively integrate the basic sciences into the clinical curriculum in a meaningful way through cognitive integration and collaboratively developed teaching tools.

- Flexibility in use of cases within the clinical curriculum
- Tools for active learning sessions with robust facilitator guides
- Equally effective for basic science and clinical faculty educators
- Tools for integration into rounds and bedside teaching

Curriculum Authoring Team Leads

Project Leads:
Ann Poznanski, MD, PhD (CNU)
Tracy Fulton, PhD (UCSF)
Amy Wilson-Delfosse, PhD (CWR)

Anatomy:
Virginia Lyons, PhD (Dartmouth)

Embryology:
Anna Edmondson, PhD (MCG-UGA)

Pathology:
James Fishback, MD (Kansas)

Physiology (all systems):
Anthony Paganini, PhD (Michigan State) and David Harris, PhD (UCF)

Pharmacology:

Immunology/inflammation:
Bonny Dickinson, PhD (W. Michigan)

Molecular Biology:
Julie Kerry, PhD (Eastern Virginia)

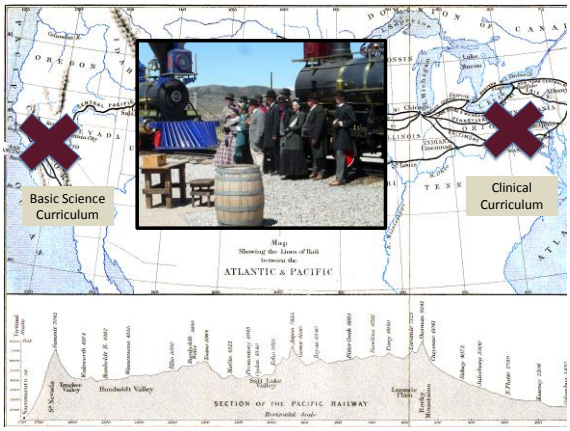
Genetics:
Michael Bradbury, PhD (Alabama COM)

Neuroscience:
Eve Gallman, PhD (GRU-UGA)

Microbiology:
Donna Russo, PhD (Drexel)

Biochemistry:
Tracy Fulton, PhD (UCSF)

Cell Biology & Signaling:
Stephen Everse, PhD (UVM



Lessons for Crossing the Synapse

- Collaborative curriculum engineering
- Core concepts
- Packaged well
- Clerkship practice
- Common problems
- Relevant decision making
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