ADDENDUM TO:

EFFECTIVE PHYSICS KNOWLEDGE FOR DIAGNOSTIC RADIOLOGISTS

Clinically Focused Physics Education

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Emory University, Atlanta
Sprawls Educational Foundation, www.sprawls.org

This is a presentation containing a collection of visuals used in courses on the general topic of medical physics education for medical professionals, especially radiologists and radiology residents.

They are provided here to be used by medical physicists for individual study, group discussions, or in class or conference presentations.

Clinical Medicine

Imaging

Radiation Therapy

Physics

The Foundation Science

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Effective and Safe Clinical Procedures

Imaging

Radiation Therapy

Require an extensive knowledge of Applied Physics and The Associated Technology

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Who needs a knowledge of Physics applied to clinical imaging?

Radiologists, Residents and Fellows

Technologists

Medical Physicists

Each provides unique challenges and opportunities.

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Clinically Focused Physics Education

Classroom

Clinical Conference

Small Group

"Flying Solo"

Learning Facilitator
"Teacher"

Individual
and
Peer Interactive
Learning

Each type of learning activity has a unique value.

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Clinically Focused Physics Education

Classroom

Clinical Conference

Small Group

"Flying Solo"

Learning Facilator "Teacher"

Individual and Peer Interactive Learning

The Goal..

Increase the EFFECTIVENESS of each type of learning activity with the necessary resources and understanding of the process by the Learning Facilators.

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The Barrier

Physics Education

Clinical Imaging

Efficiency

Location, Resources, Human Effort, Cost

Limited Experience

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Why an Evolving Model?

Three Dynamics....

1. Rapidly expanding **NEEDS** for physics knowledge.
2. Expanding availability of educational **RESOURCES.**
3. Better knowledge of the learning and teaching process.

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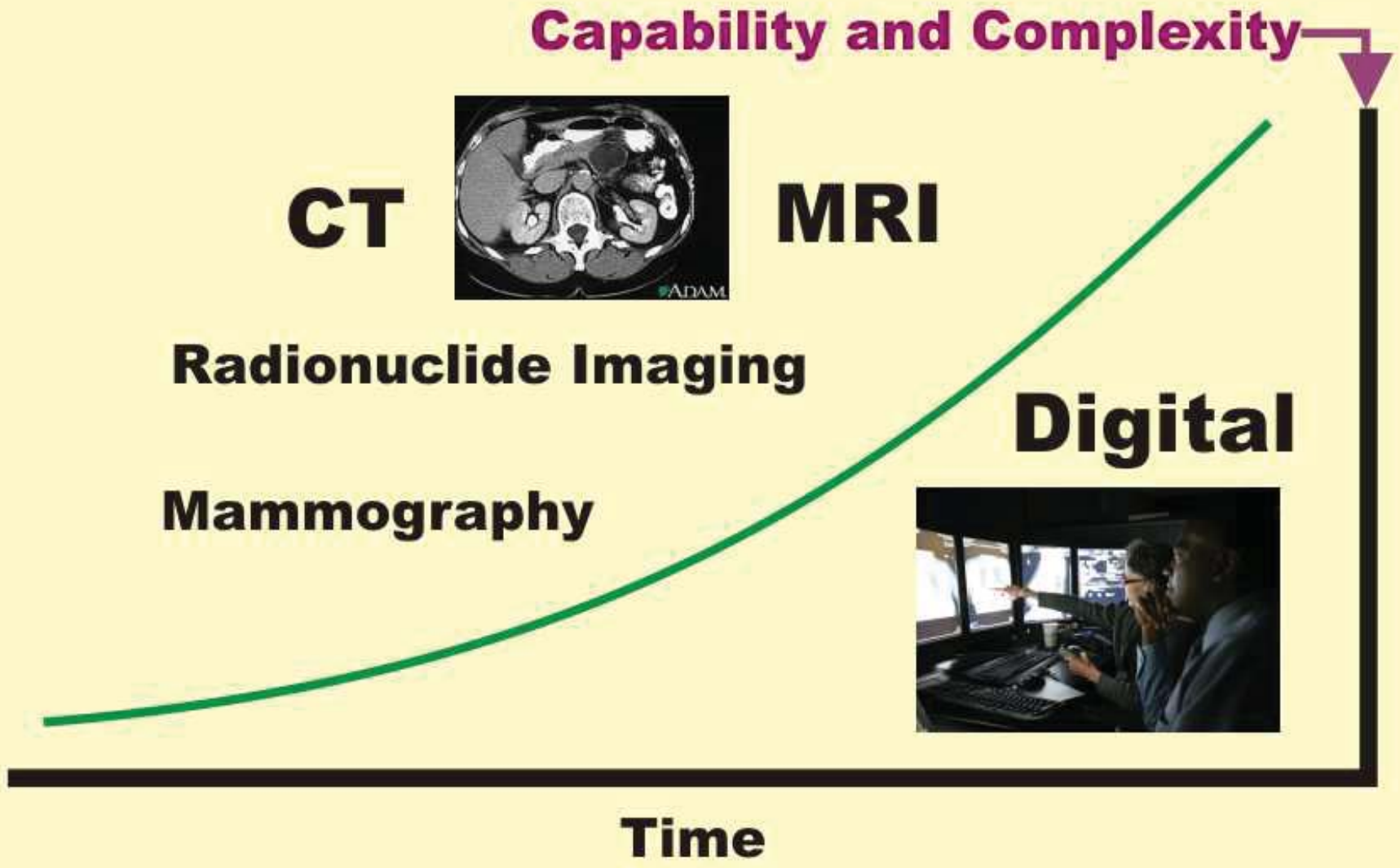
Continuing Growth in the Need for Physics Knowledge



Sprawls

Digital Resources to Enrich Learning Activities

The Web
Connecting and Sharing

Textbooks
Modules

Visuals

Clinical
Images

Modules

References
Teaching Files

Classroom

Clinical
Conference

Small
Group

"Flying Solo"

Sprawls

Physics Learning Objectives for Radiologists

Image Physical Characteristics

- **Identify**
- **Relationship to Visibility** → **Anatomy and Pathology**
- **Evaluate**
- **Control and Optimize** → **Risk**

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LEARNING is...

Building a knowledge structure in the mind

Sprouts

Learning Physics is by..

Encounter and Experience

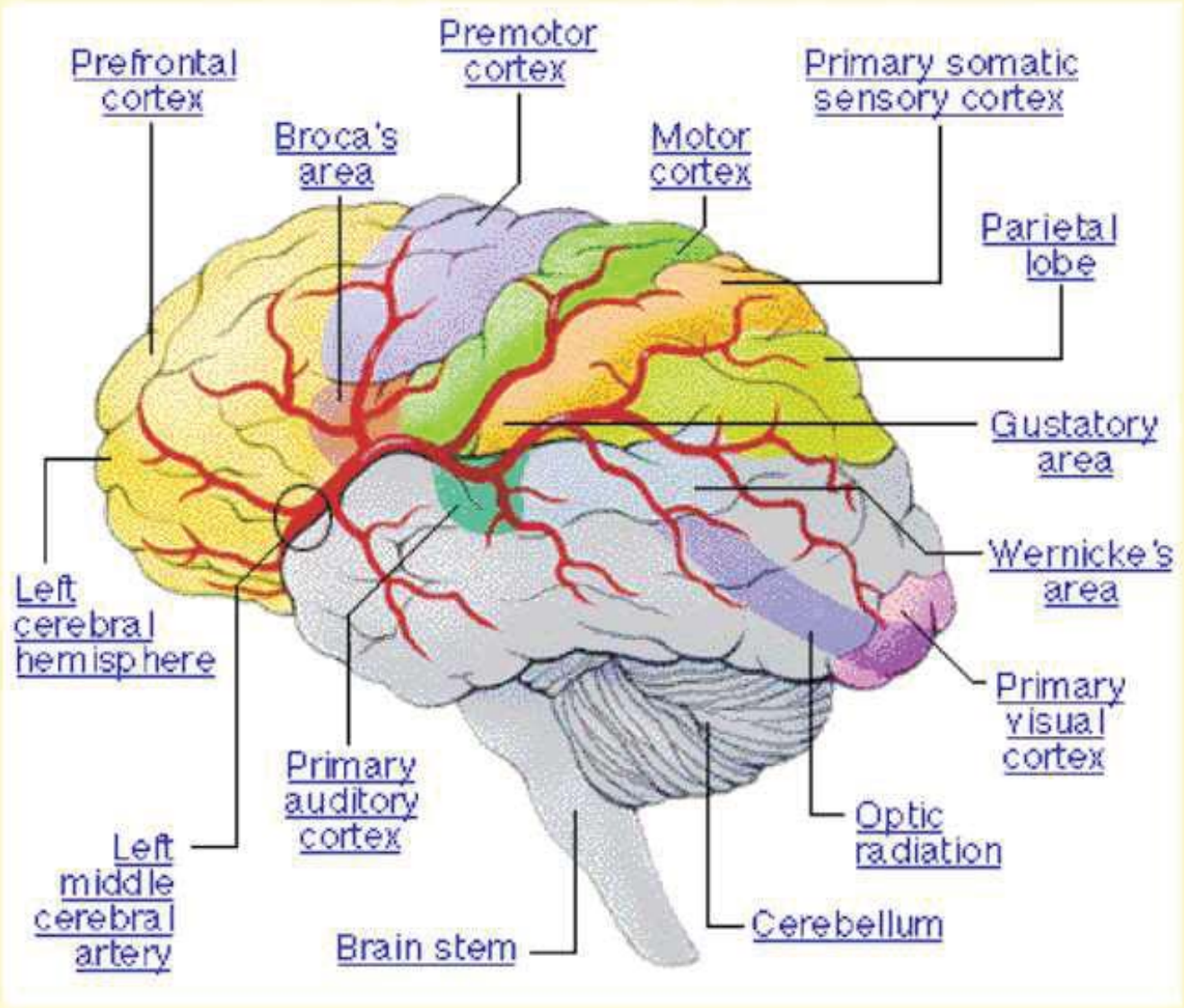
Physical Universe

Brain

Images: BYU and Howstuff works

Sprawls

The Brain...

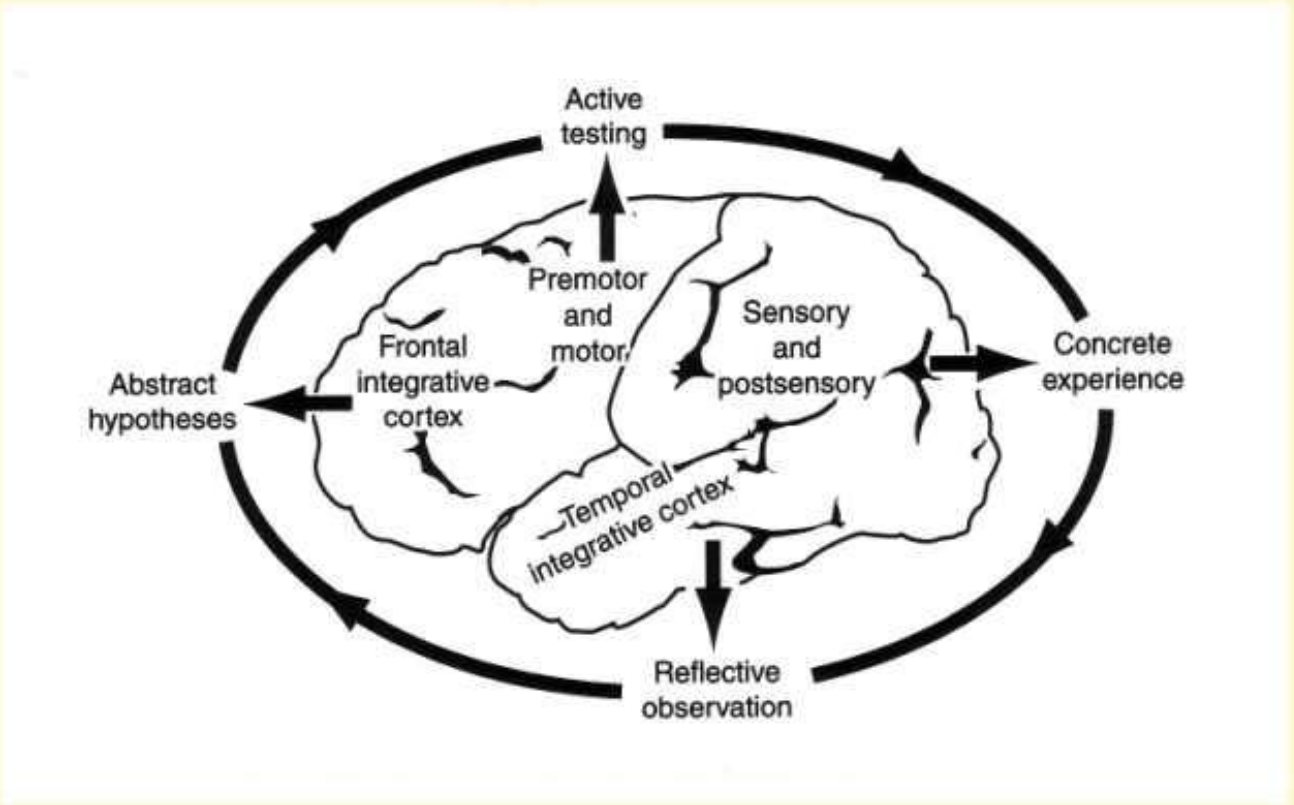


Structure and Function

Image: AMA

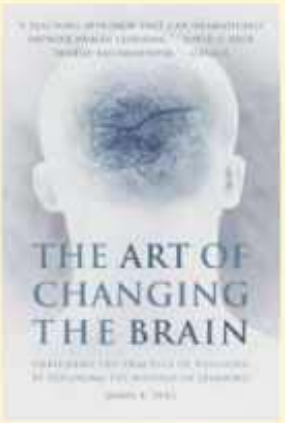
Sprawls

Zull's Model of Brain Function

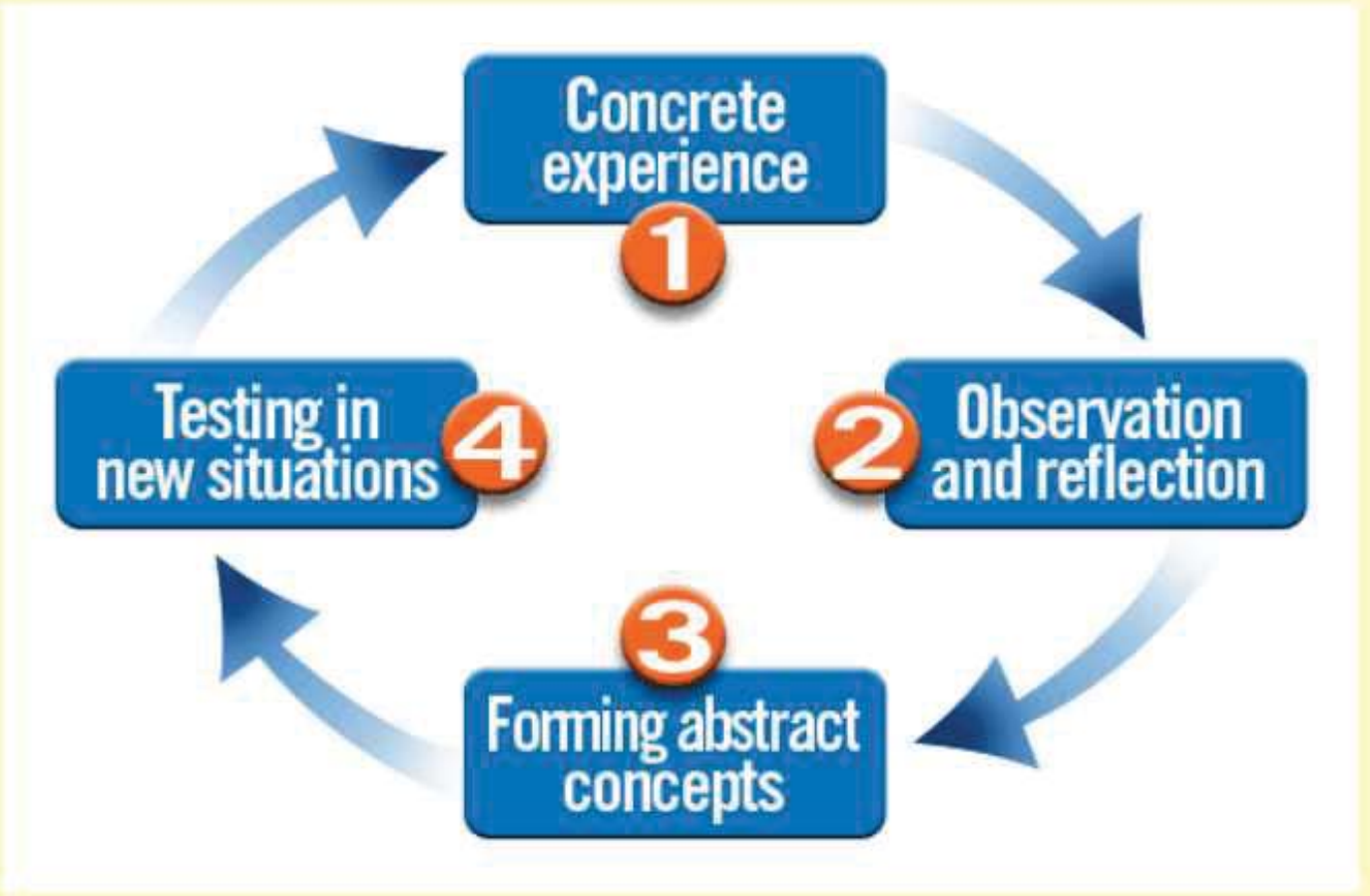


James Zull, Ph.D.
Professor of Biology
Professor of Biochemistry
Director of University Center for Innovation in Teaching and Education
Case Western Reserve

Reference:



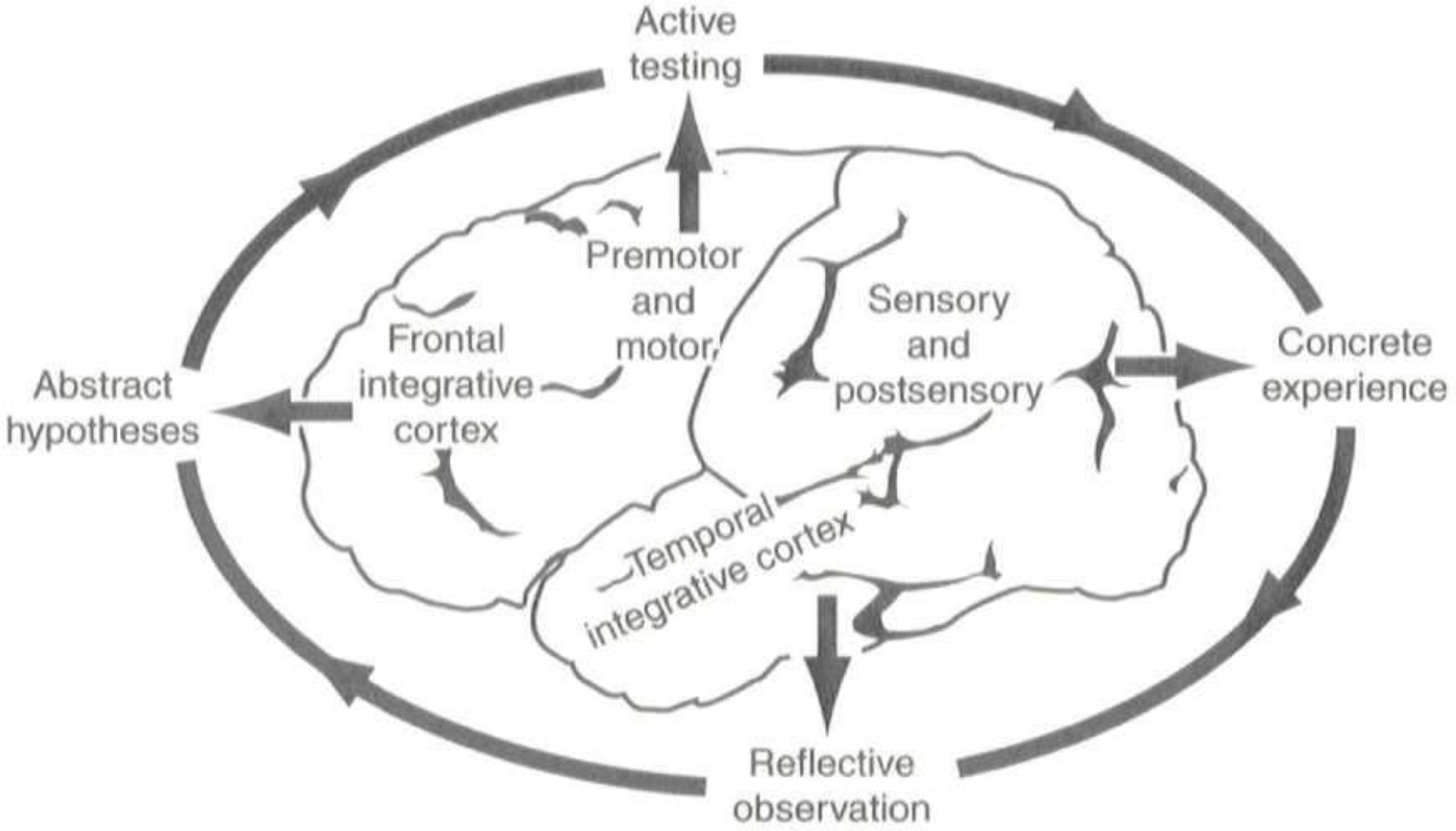
Kolb's Experiential Learning Model



David A. Kolb, Ph.D.
Professor of Organizational Behavior
Case Western Reserve

Website: http://www.learningfromexperience.com

Zull's Model of Brain Function



Brain Functions for Learning Physics

Control

Sensory

Back Integrative Cortex

Where

(Relationships)

(Characteristics)

What

(Identification)

Language

Comprehension

Frontal Integrative Cortex

Making Plans
Evaluating
Problem Solving

Language

Assembly

Motor

Emotions

Sprawls

Brain Functions for Learning Physics

Control

Sensory

Back Integrative Cortex

Records of the Past

Reflection

Frontal Integrative Cortex

Preparation for the Future

Hypotheses

Motor

Emotions

Sprawls

Brain Functions for Learning Physics

Control

Sensory

Back Integrative Cortex

Records of the Past

Knowing

Frontal Integrative Cortex

Preparation for the Future

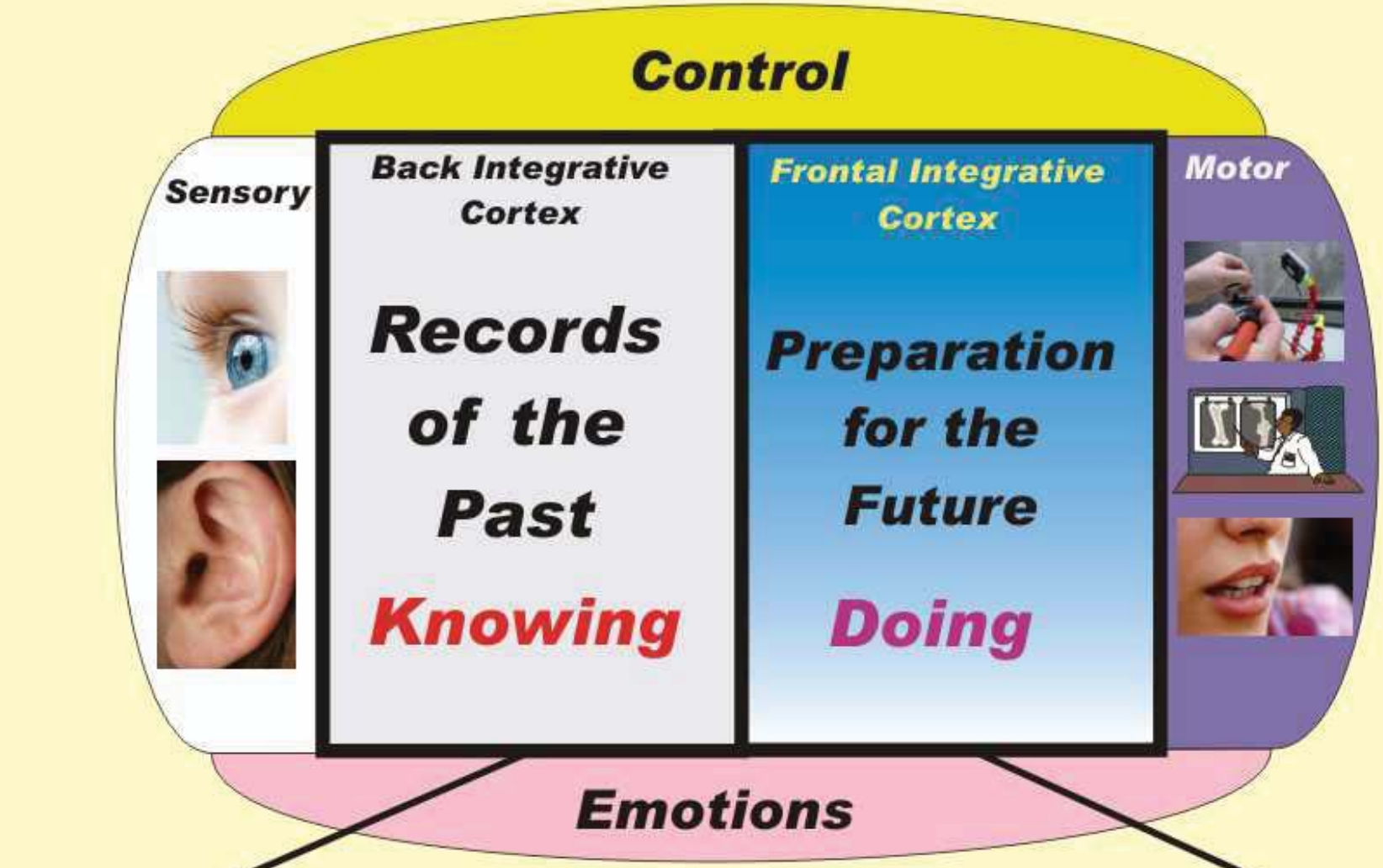
Doing

Motor

Emotions

Sprawls

Brain Functions for Learning Physics



Balanced Education

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Forming Knowledge Structures

Physical Universe

Back Integrative Cortex

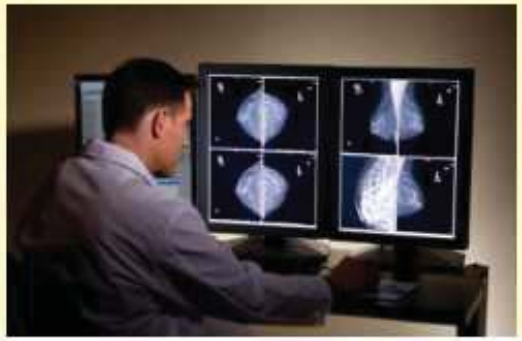
Sensory

Visible Physical Objects

Sprawls

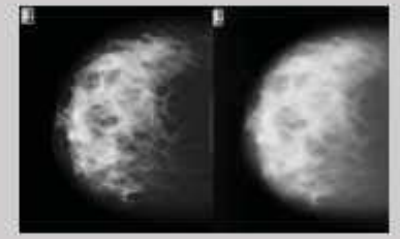
Forming Knowledge Structures

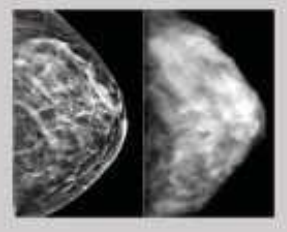
Physical Universe



Sensory

Back Integrative Cortex





Visible Physical Objects

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Forming Knowledge Structures

Physical Universe

Back Integrative Cortex

Sensory

Radiation
Electrons
Magnetic
Atomic
Nuclear

? ? ?

Invisible Physical Objects

Sprawls

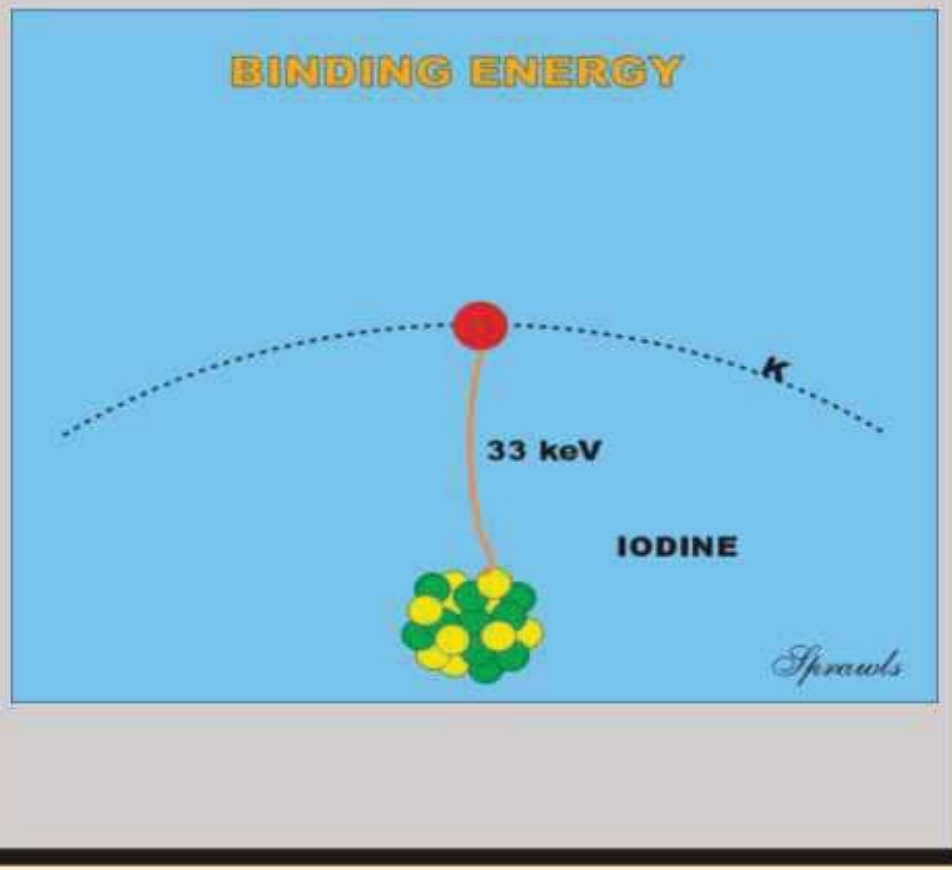
Forming Knowledge Structures

Physical Universe

Back Integrative Cortex

Sensory

Radiation
Electrons
Magnetic
Atomic
Nuclear



Invisible

Physical Objects

Visuals

Sprawls

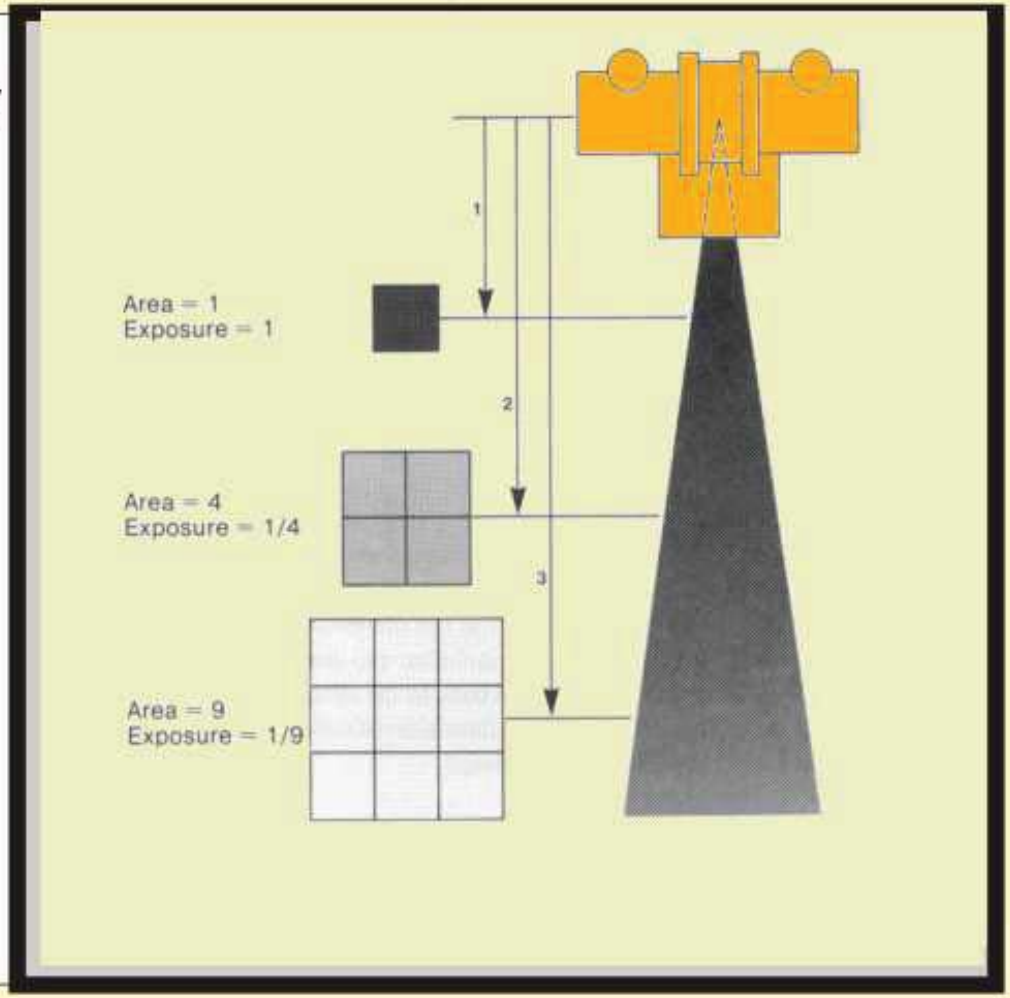
Forming Knowledge Structures

Physical Universe

Back Integrative Cortex

Inverse Square Effect

Sensory



Invisible

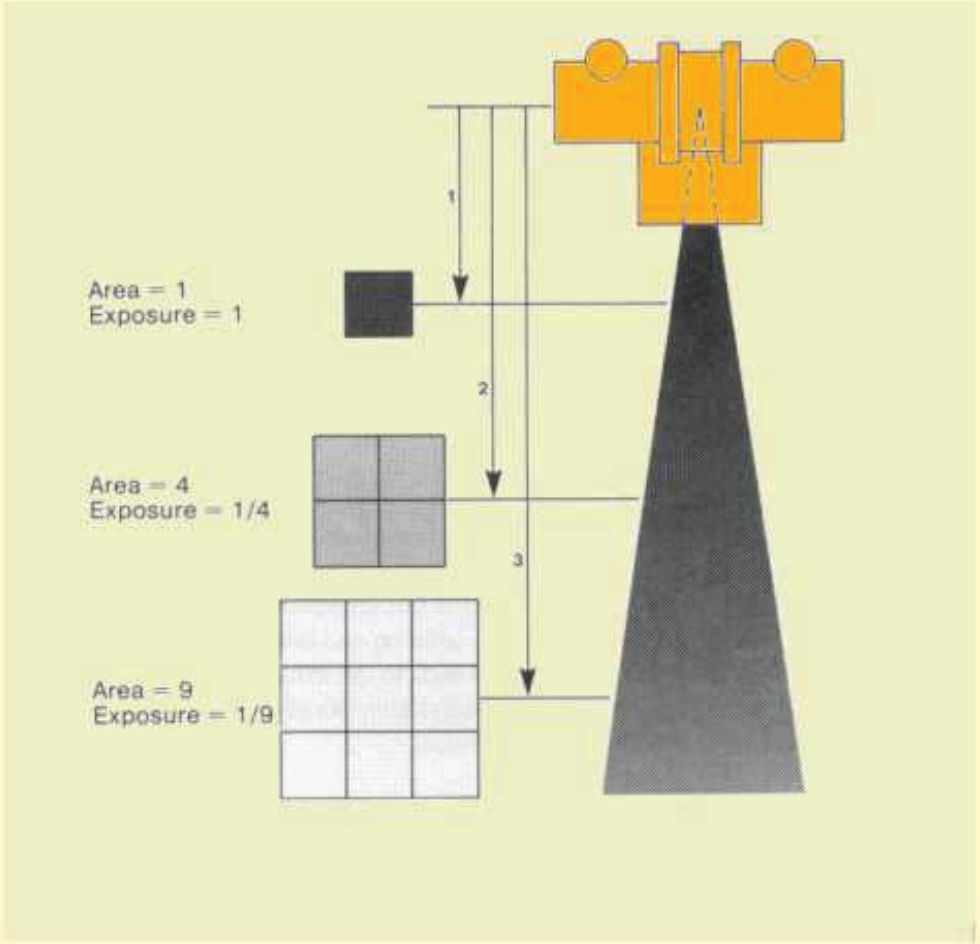
Concepts

Ideas

Visuals

Sprawls

Forming Knowledge Structures



Intensity = Power / Area

Surface area of a sphere = $\frac{4\pi r^2}{3}$

So, the luminous intensity on a spherical surface a distance r from a source radiating a total power P is:

$$I = 3P / 4\pi r^2$$

As P and pi remain constant, the luminous intensity is proportional to the inverse square of distance:

$$I \sim 1 / r^2$$

Visual

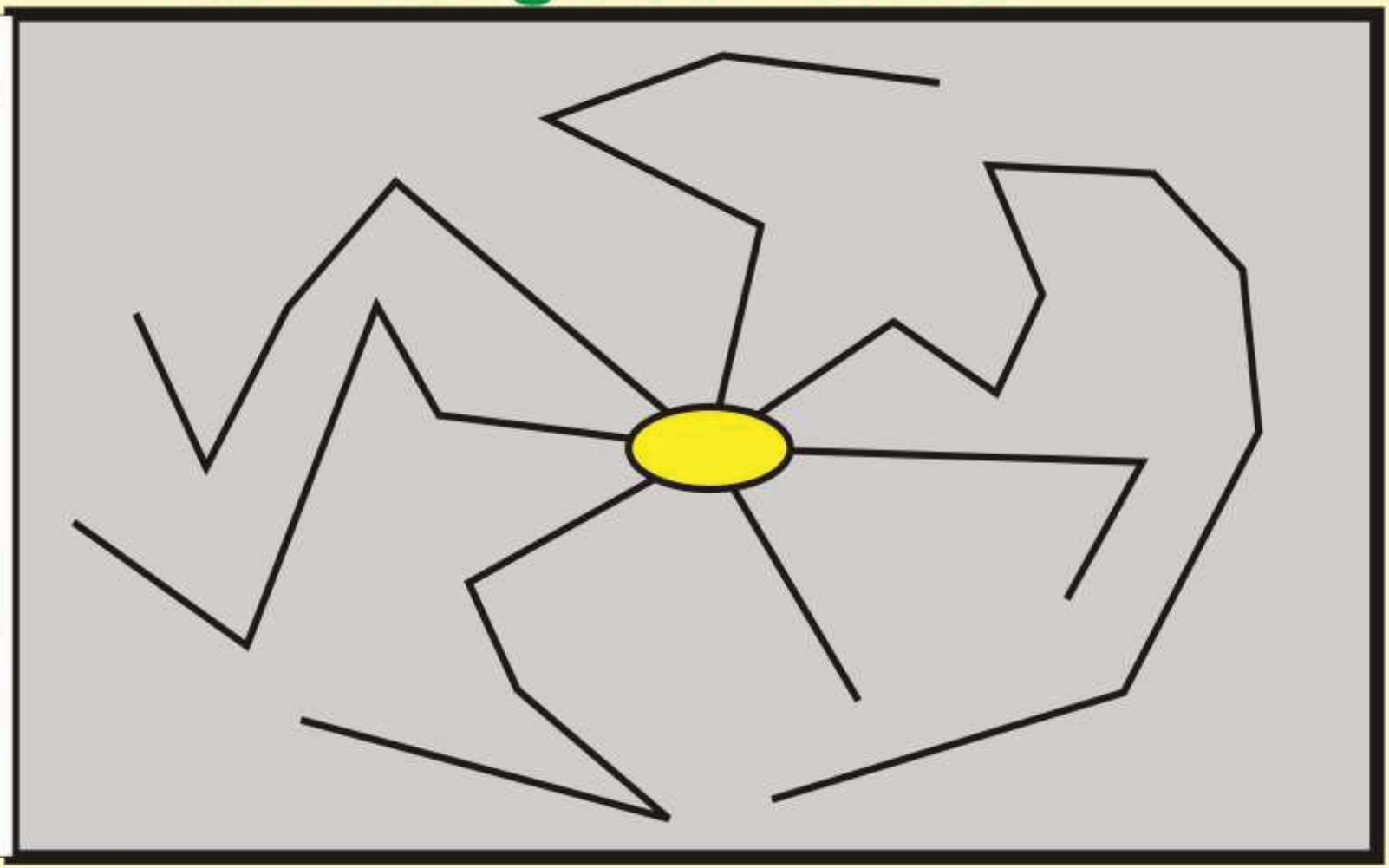
Verbal and Symbolic

Sprawls

Back Integrative Cortex

Integrating experience into existing knowledge structure

Sensory

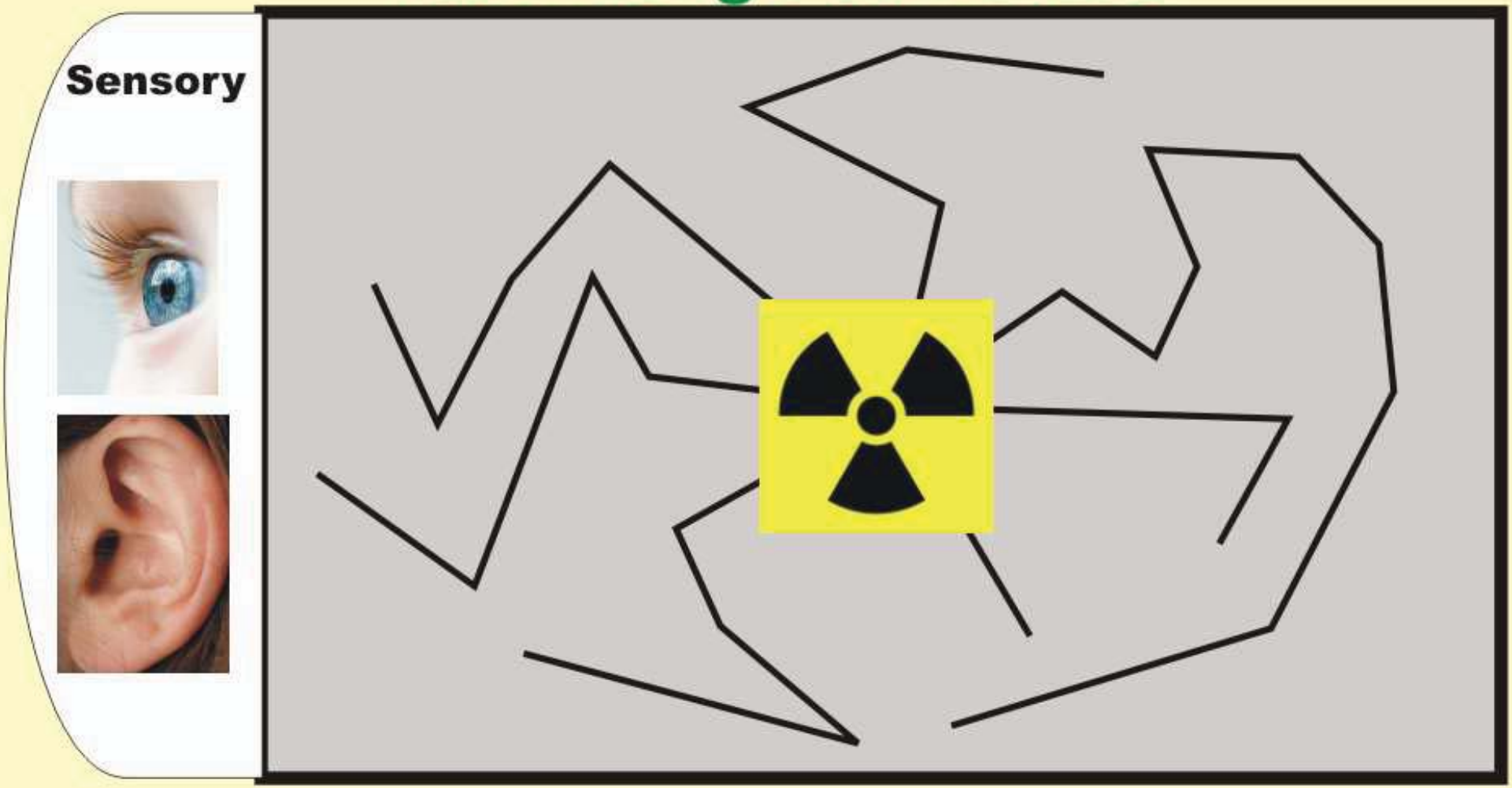


Meaning

Sprawls

Back Integrative Cortex

Integrating experience into existing knowledge structure



Meaning

Sprawls

Back Integrative Cortex

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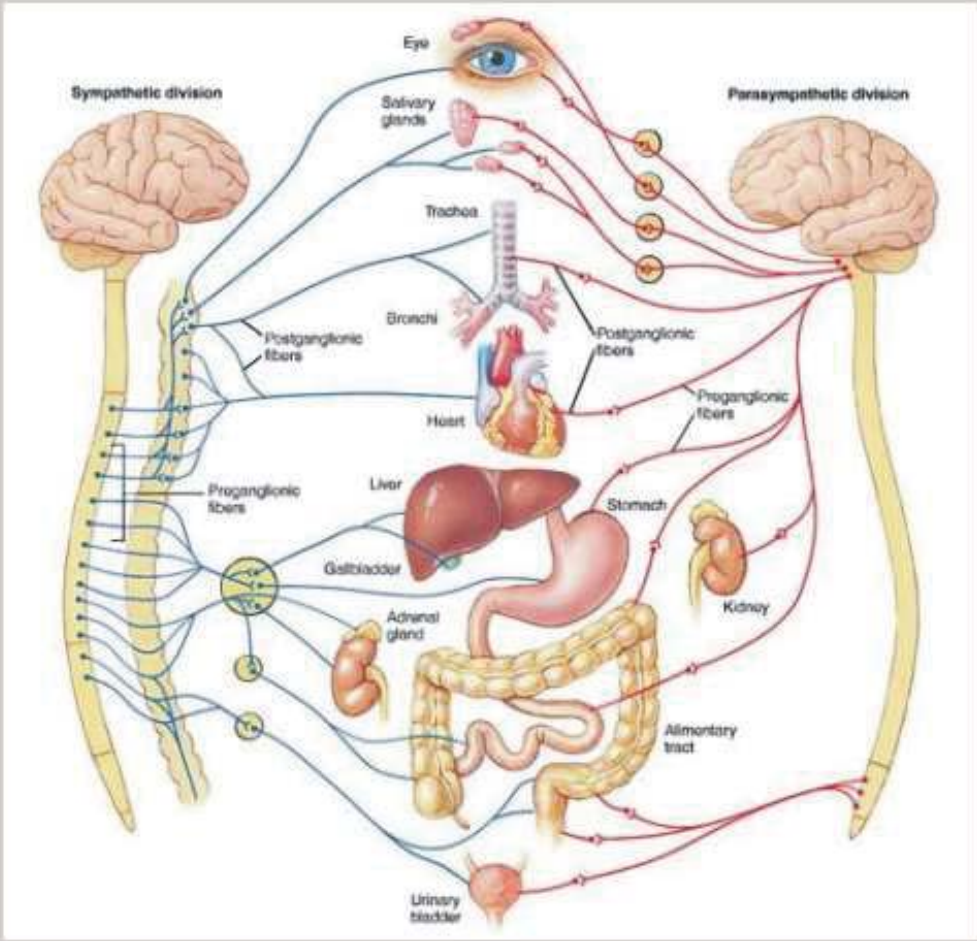


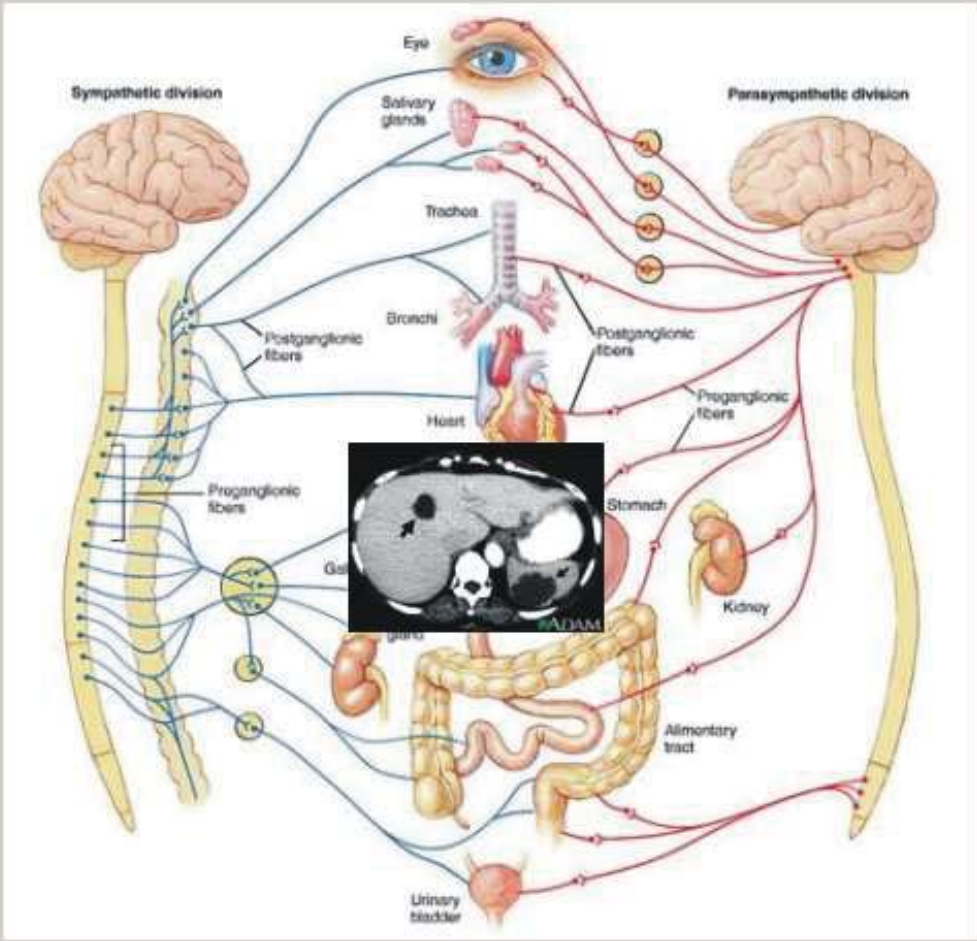
Medical Knowledge

Sprawls

Back Integrative Cortex

Integrating experience into existing knowledge structure

Sensory



The image is the connection

Sprawls

Back Integrative Cortex

Integrating experience into existing knowledge structure

Sensory

The image is the starting point for learning physics

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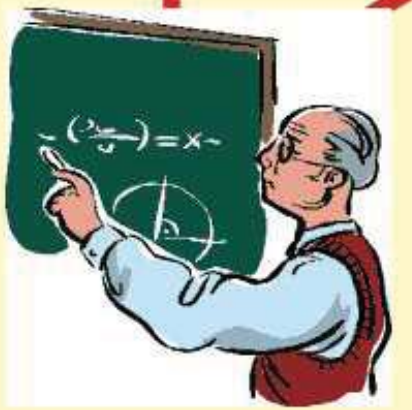
Forming Knowledge Structures

Physical Universe

Inverse Square Effect



Sensory

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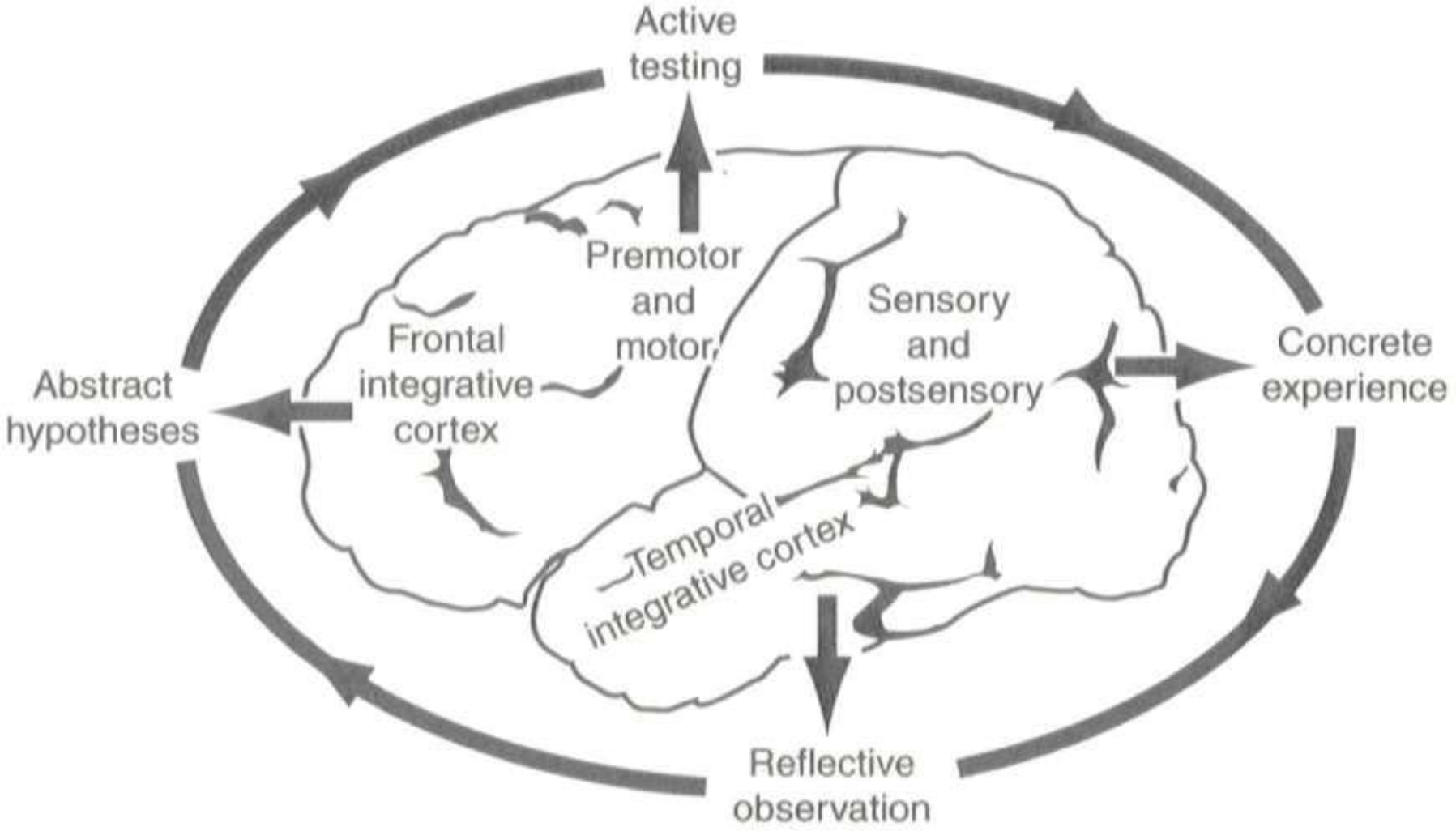
Verbal and Symbolic

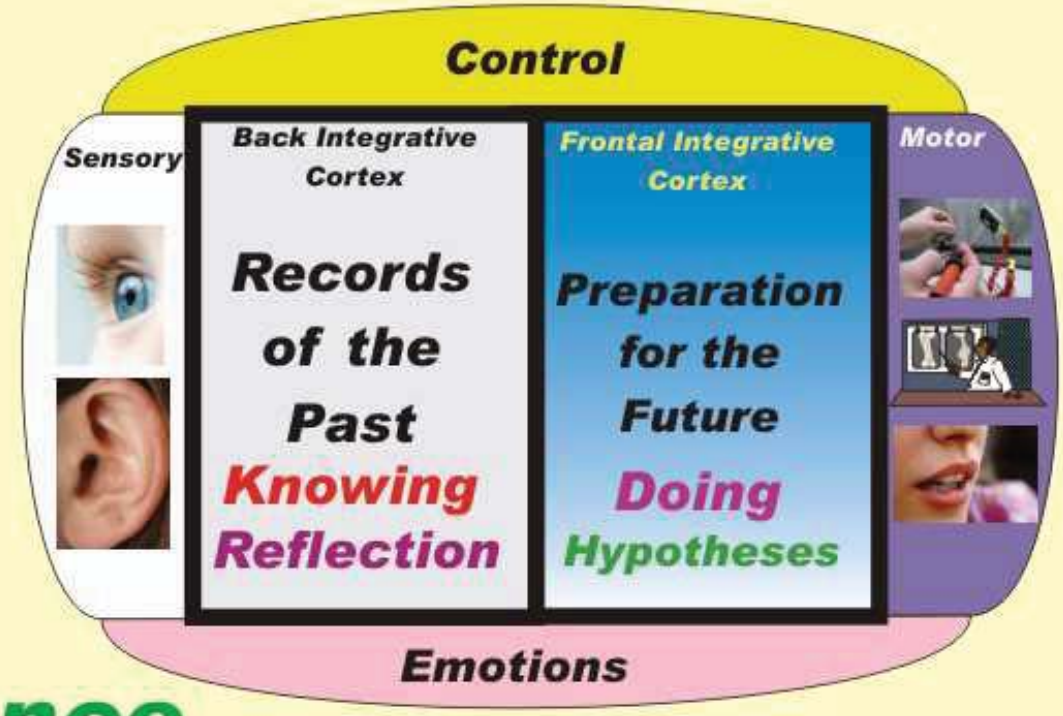
Sprawls

Zull's Model of Brain Function



Brain Functions for Learning Physics

Active Experimentation and Testing



Sense and Experience Observe

Interact and Affect

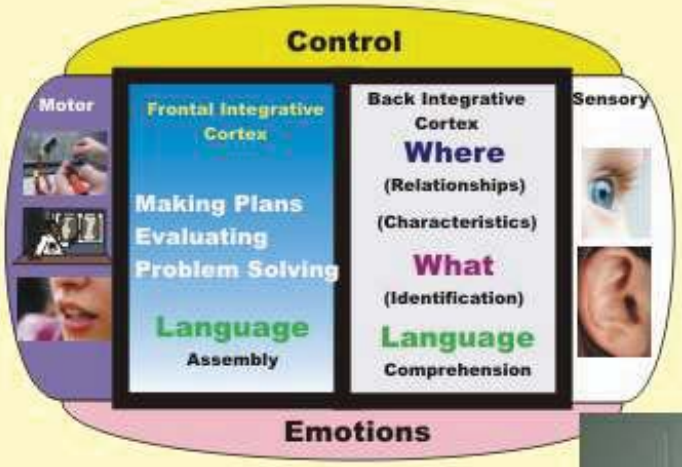
Physical Universe

Sprawls

Brain Functions for Learning Physics

Two brains are better than one!

Collaborative Learning



Views
Perspectives
Experiences

Views
Perspectives
Experiences

Analysis and Evaluation

Image: UGA

Sprawls

Brain Functions for Learning Physics

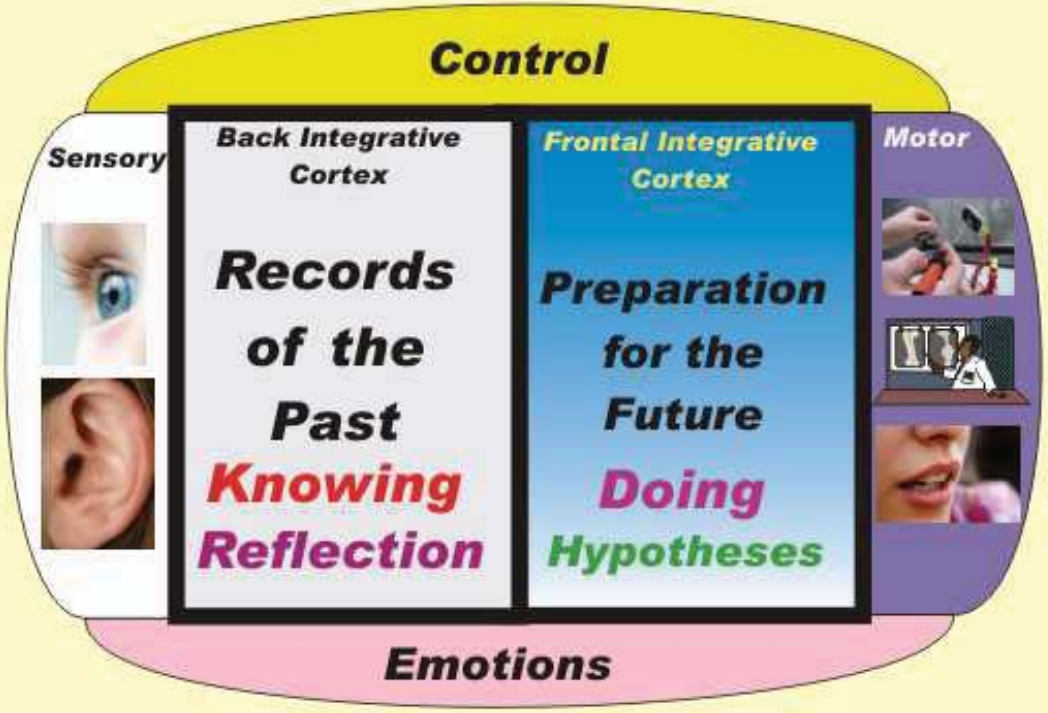
Two brains are better than one!

Collaborative Learning

Problem Solving
Analysis and Evaluation
Developing Plans

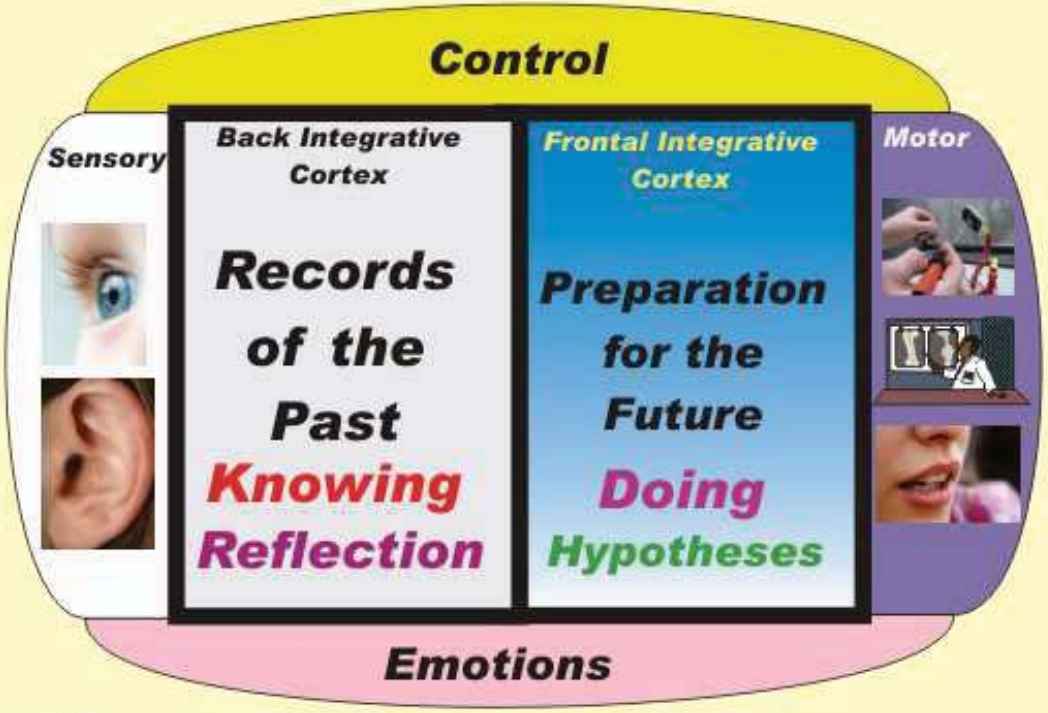
Sprawls

The Learning Environment



Sprawls

Rich Learning Environments



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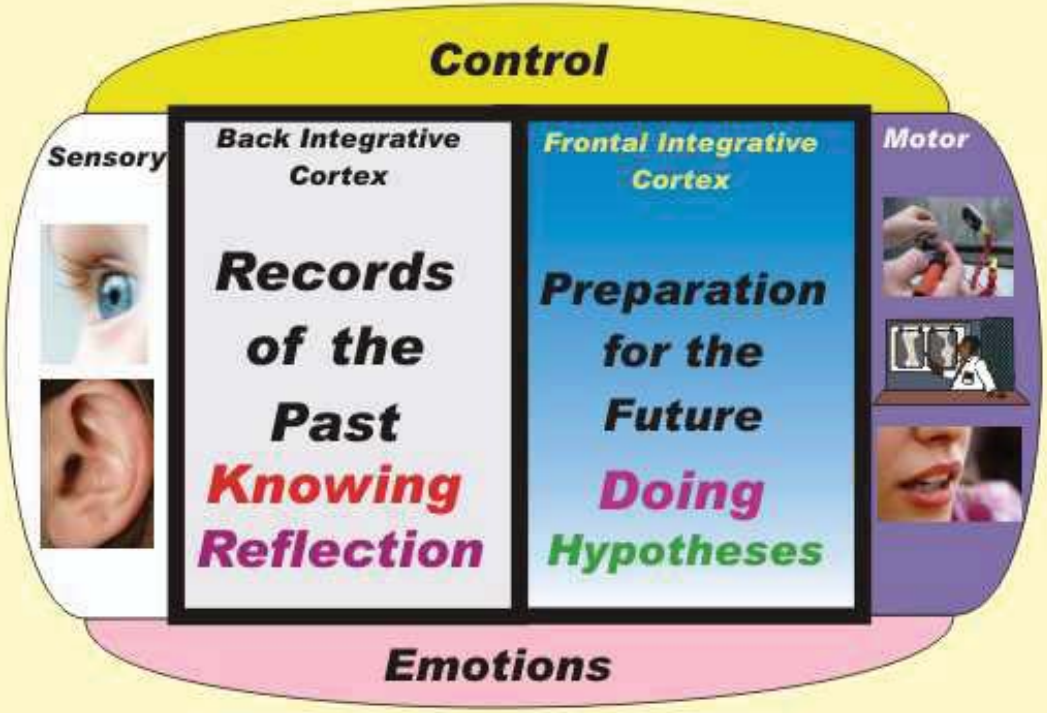
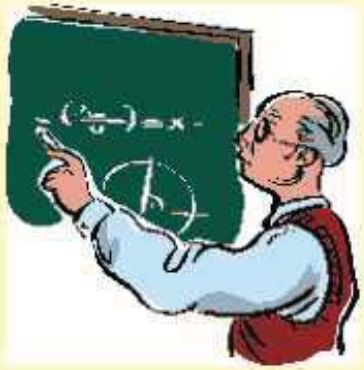
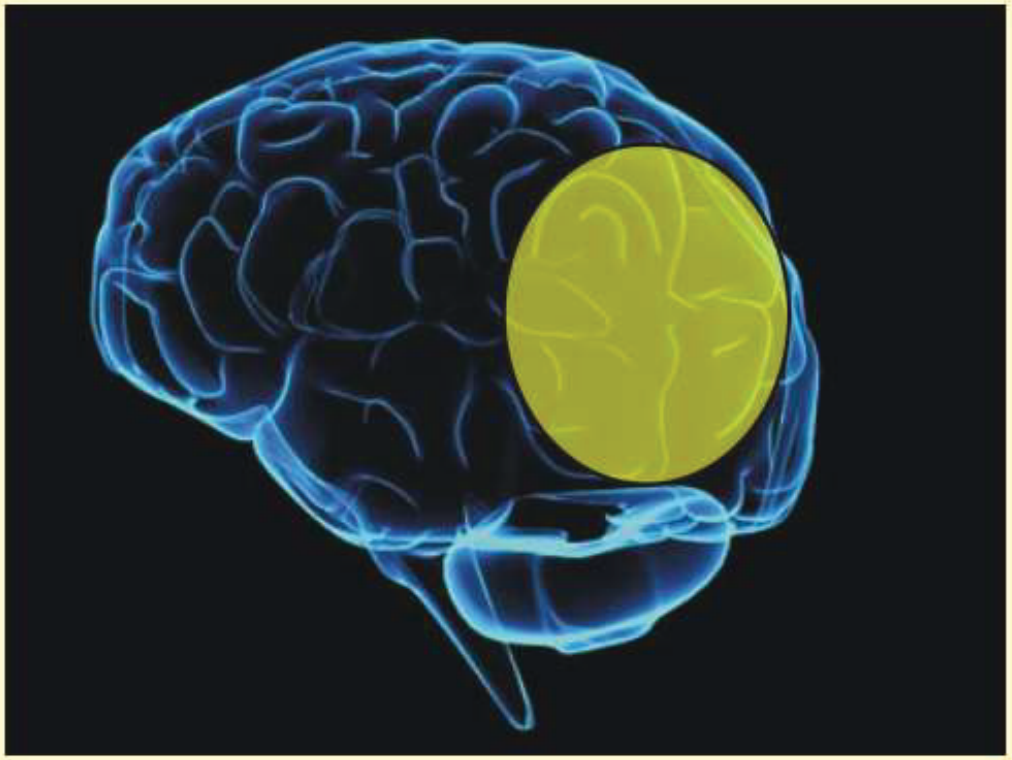
Challenging Learning Environments





Sprawls

Effective Learning



Rich Learning Environment

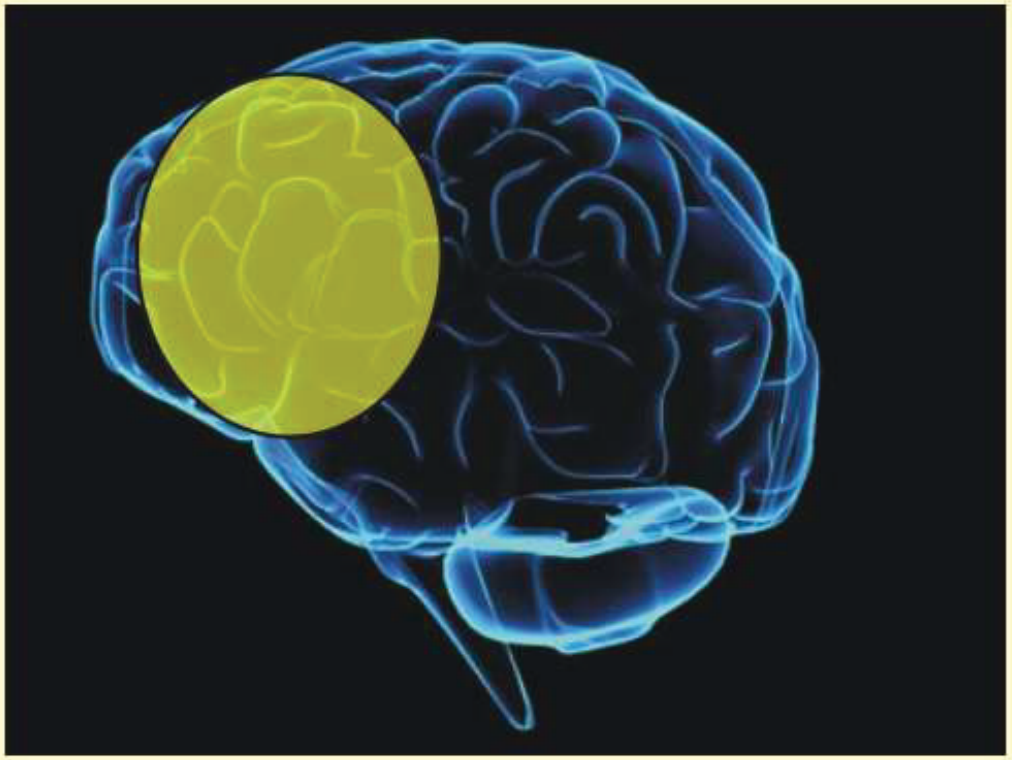
New and Different

Integrate into Existing Knowledge

Reflection →

Sprawls

Effective Learning



Interact **Review** **Reflect**

Developing useful knowledge for the future

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Brain Functions for Learning Physics

Motivation

Organization

Interest

Control

Sensory

Back Integrative Cortex

Records of the Past

Knowing

Reflection

Frontal Integrative Cortex

Preparation for the Future

Doing

Hypotheses

Motor

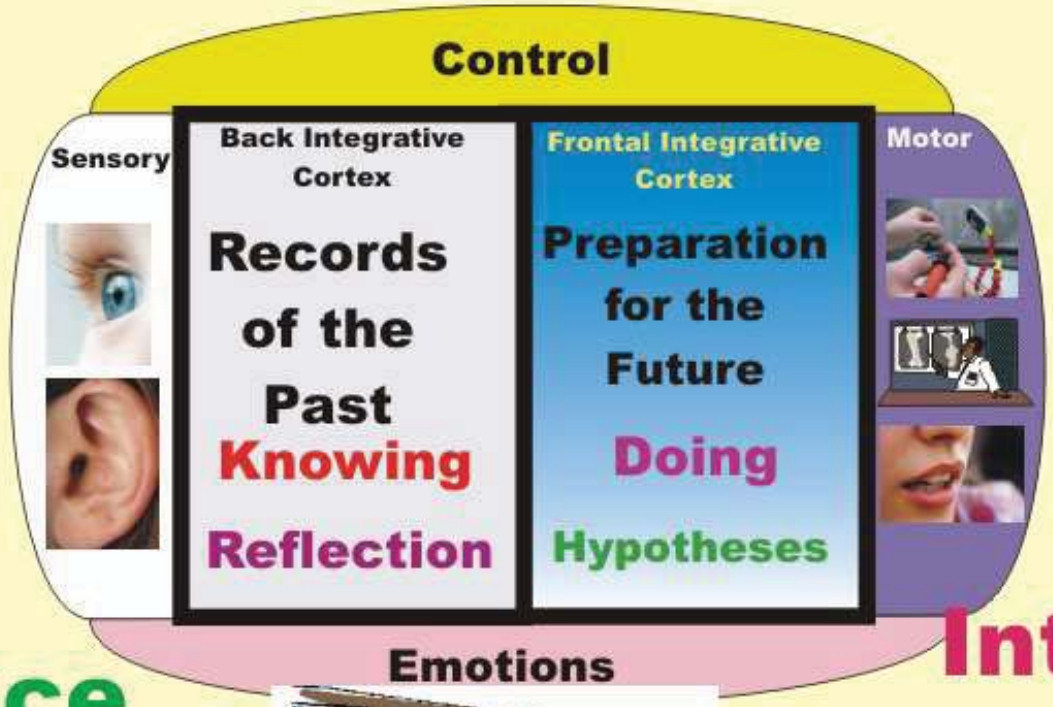
Emotions

Hate ⟷ **Joy**

Sprawls

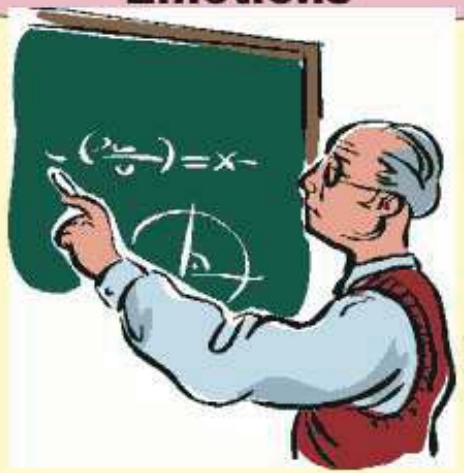
Brain Functions for Learning About

Learning Physics



Sense and Experience Observe

Interact and Affect



Our Teaching

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Robert Gagne (1916-2002)

Best known for his Nine Events of Instruction

The Gagne assumption is that different types of learning exist, and that different instructional conditions are most likely to bring about these different types of learning

Gagné was also well-known for his sophisticated stimulus-response theory of eight kinds of learning which differ in the quality and quantity of stimulus-response bonds involved. From the simplest to the most complex, these are:

signal learning (Pavlovian conditioning)
stimulus-response learning (operant conditioning)
chaining (complex operant conditioning)
verbal association
discrimination learning
concept learning
rule learning
and problem solving.

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Gagne's Hierarchy of Learning

PROBLEM SOLVING

RULE LEARNING

CONCEPT LEARNING

DISCRIMINATION LEARNING

VERBAL ASSOCIATION

CHAINING

STIMULUS RESPONSE

SIGNAL LEARNING

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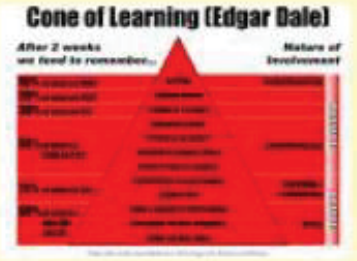
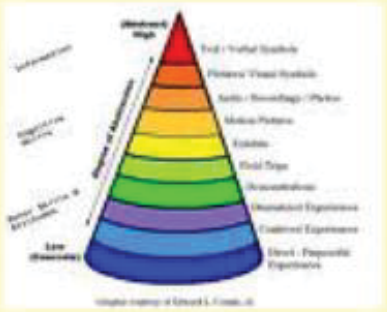
Edgar Dale (1900-1985)

Educationalist who developed the famous

Cone of Experience theory





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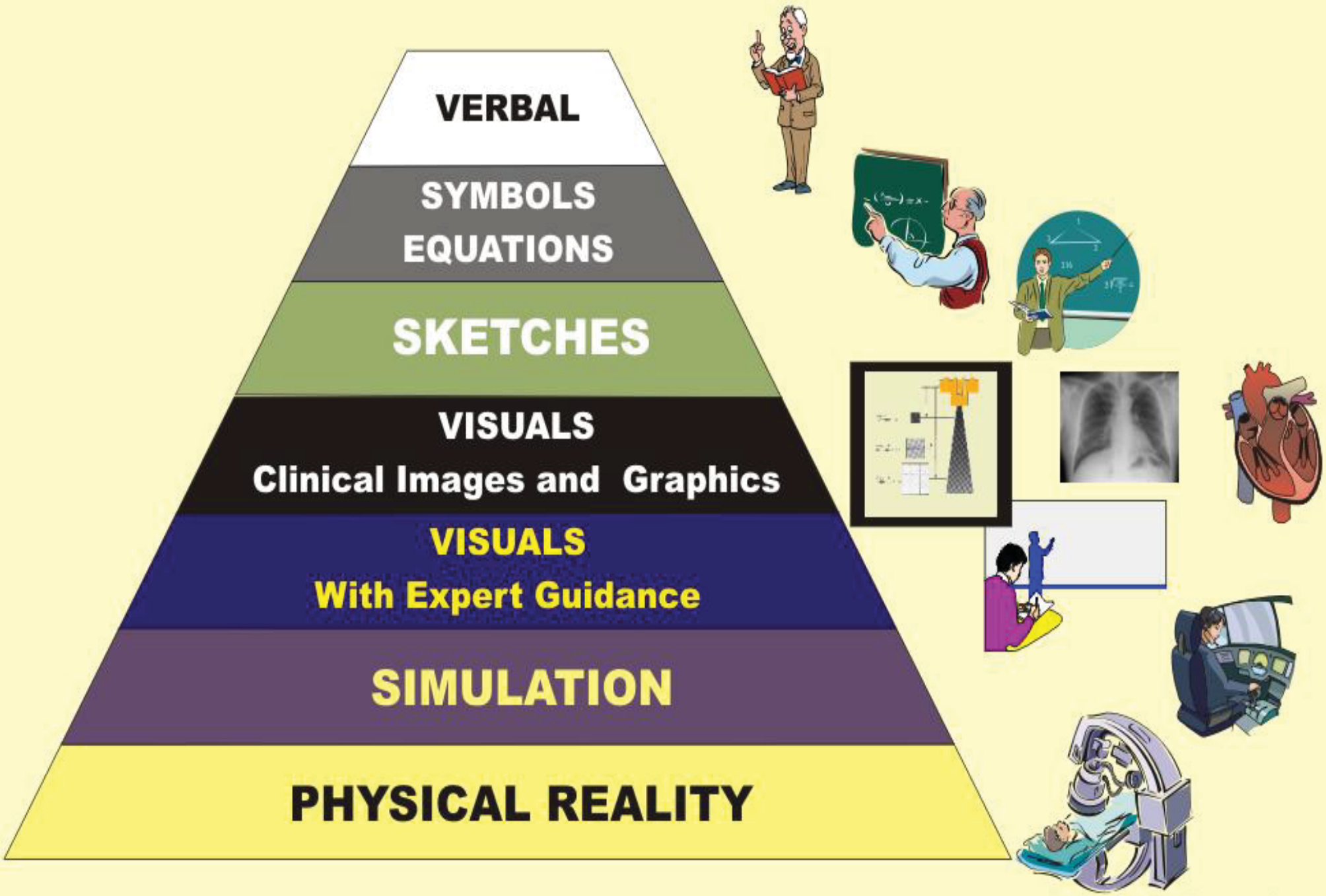
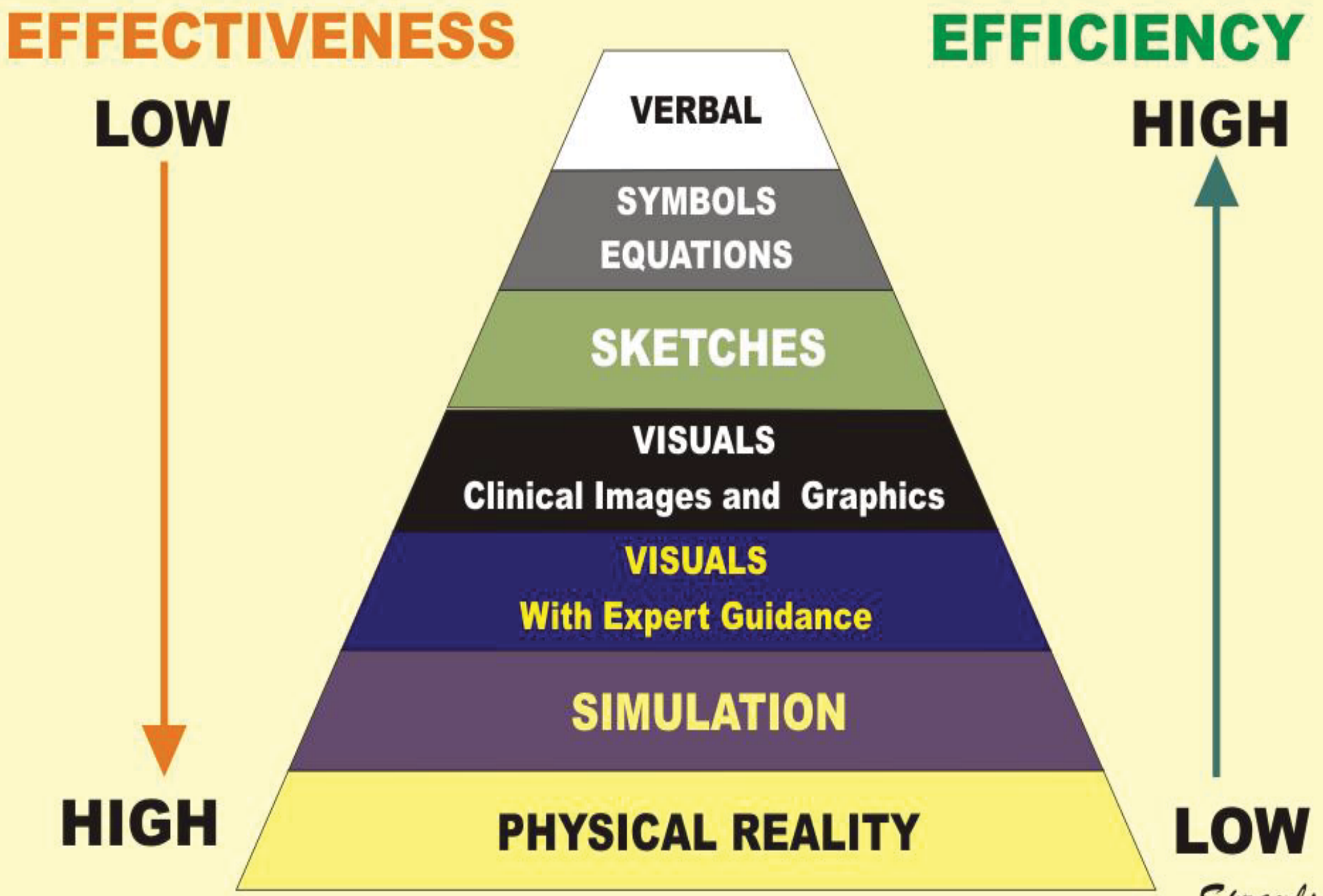
Cone of Experience for Medical Imaging Education



Cone of Experience for Medical Imaging Education



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Cone of Experience for Medical Imaging Education

LEARNING OUTCOMES

VERBAL

SYMBOLS
EQUATIONS

SKETCHES

VISUALS
Clinical Images and Graphics

VISUALS
With Expert Guidance

SIMULATION

PHYSICAL REALITY

Define
List
Describe
Explain

Demonstrate
Apply
Practice

Analyze
Create
Evaluate

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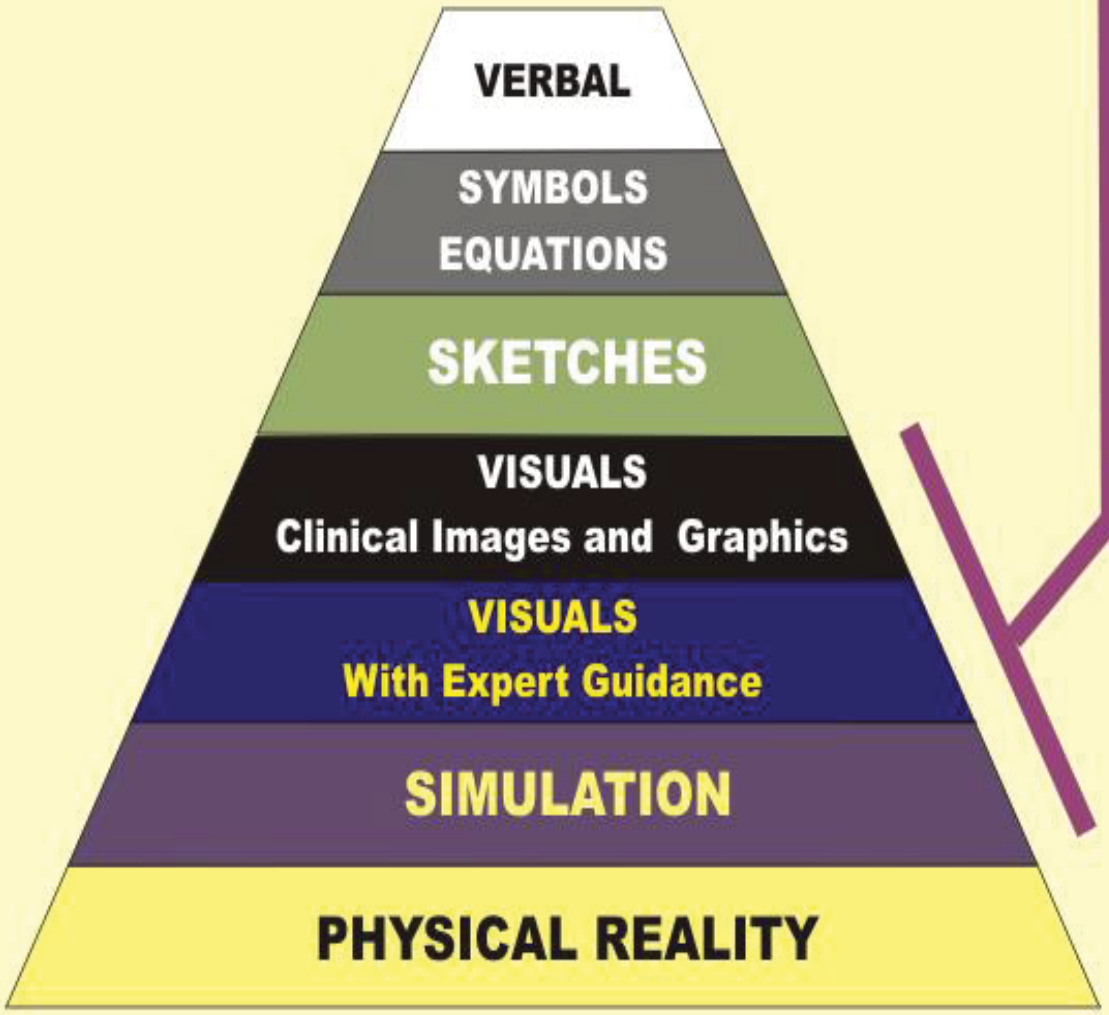
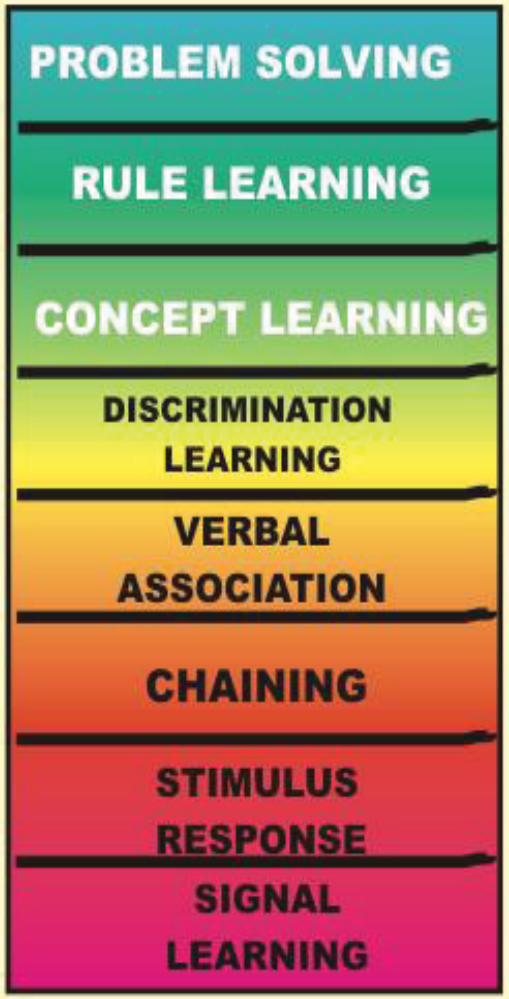
Effective Learning





Experience — **Level**

Learning

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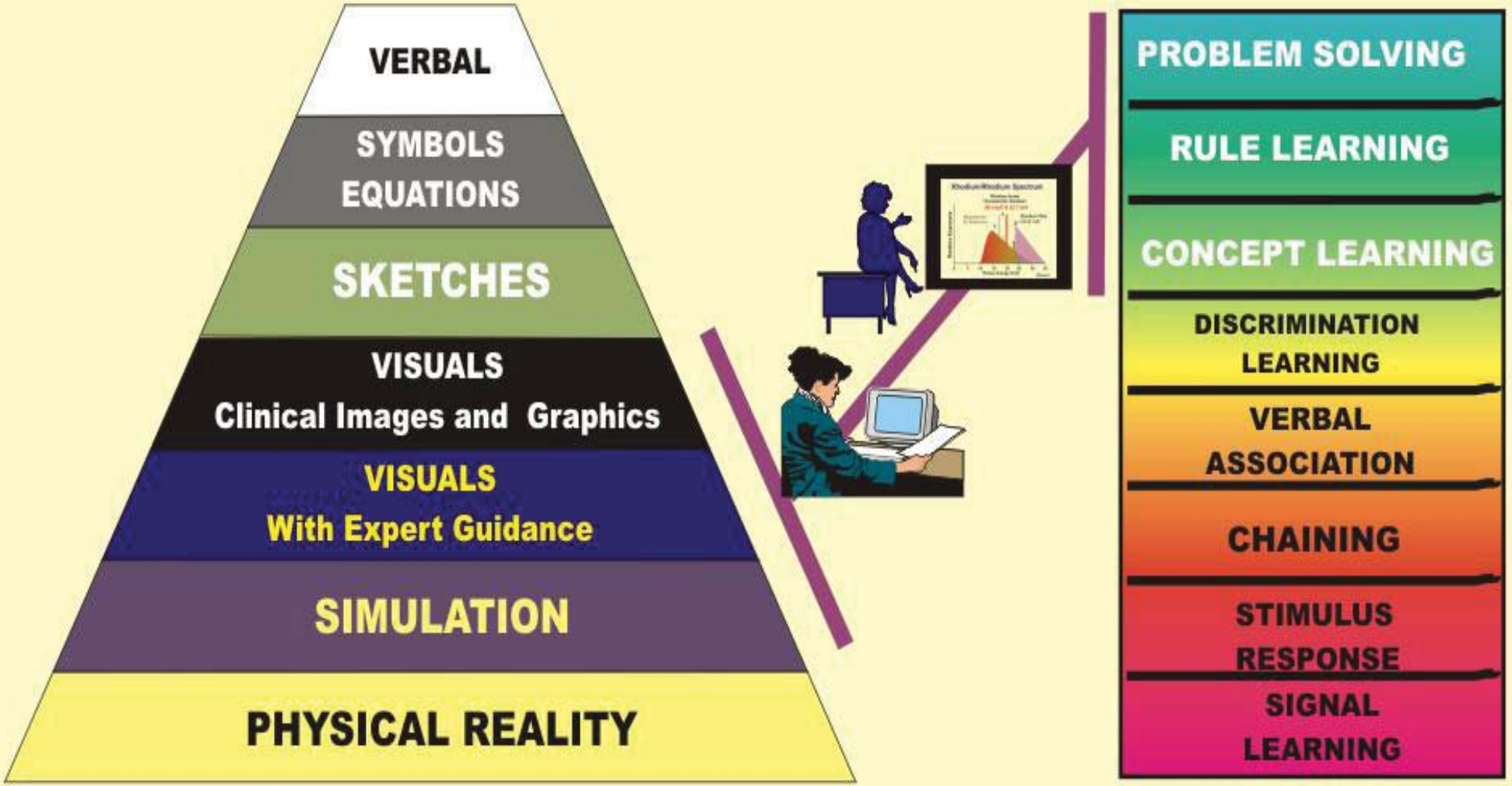
Technology Enhanced

Learning and Teaching



Experience — **Learning** — **Level**

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Clinically Focused Physics Education

Classroom | Clinical Conference | Small Group | "Flying Solo"

Highly Efficient

For General Physics and Related Topics

Highly Effective

Clinically Rich Learning Activities

Visuals **Images** **Online Modules**

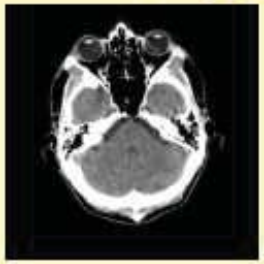
Resources and References

Sprawls

Physics Education

General Basics

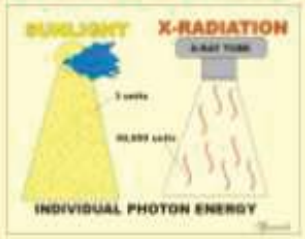
Images



Contrast
Detail
Noise
Artifacts
Spatial

Characteristics and Comparison of Modalities

Radiation



Radiation for Imaging
Quantities and Units
X-Ray Production
Radioactivity
Interactions

Digital Image Structure and Characteristics

Clinical

X-Ray Image Formation
Radiographic Receptors
Radiographic Detail
Fluoroscopic Systems
CT Image Formation
CT Image Quality and Dose Optimization
Radionuclide Imaging, SPECT, PET
MRI
Ultrasound

Radiation Safety

Biological Effects
Personnel Protection
Patient Dose Management

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Rich Classroom and Conference Learning Activities

Learning Facilitator "Teacher"

Visuals

Representations of Reality

- **Organize and Guide the Learning Activity**
- **Share Experience and Knowledge**
- **Explain and Interpret What is Viewed**
- **Motivate and Engage Learners**

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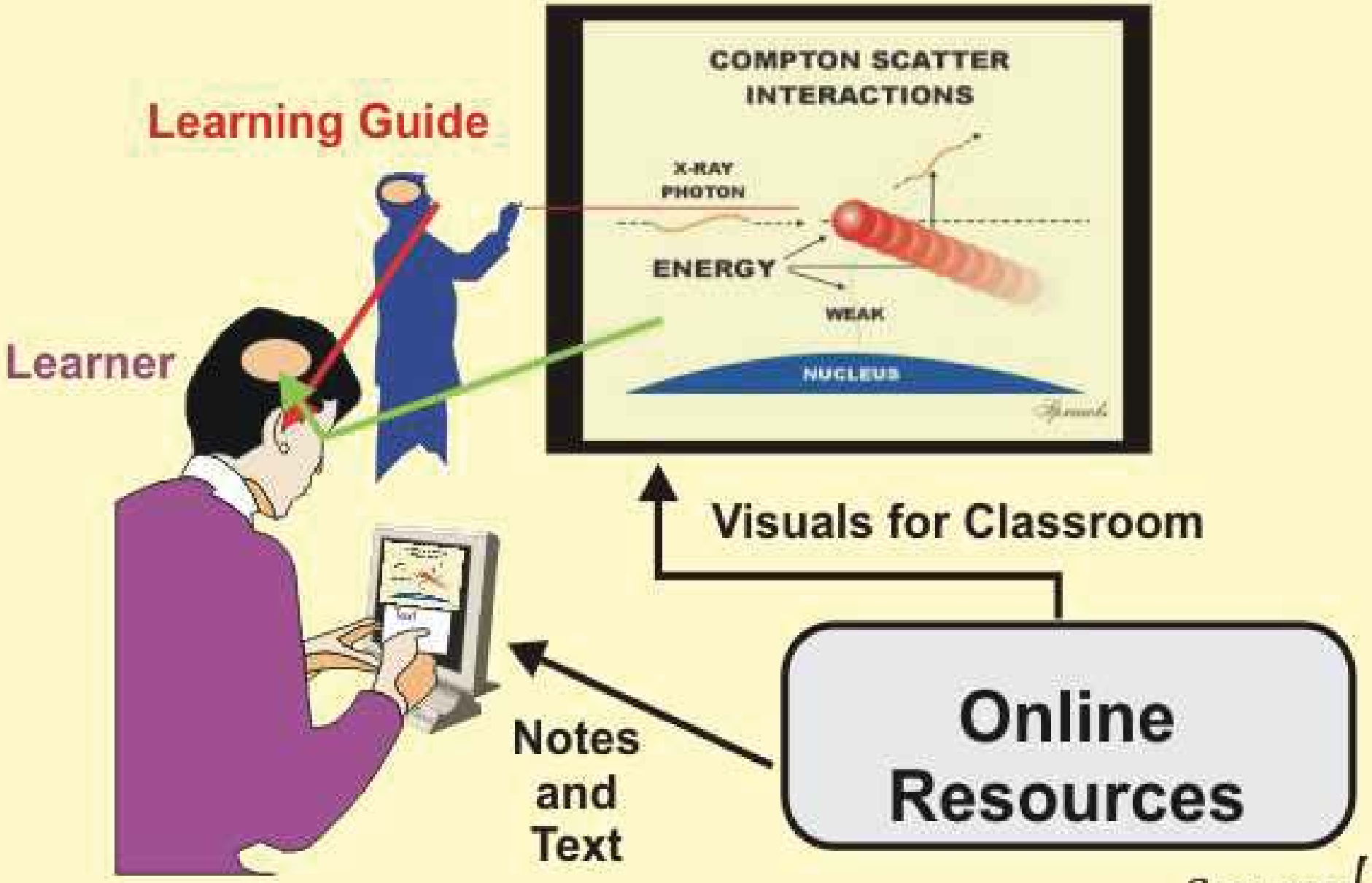
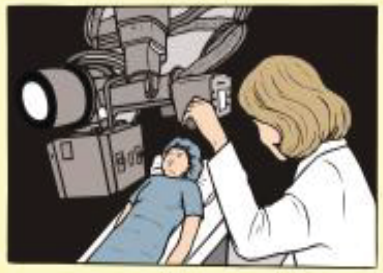
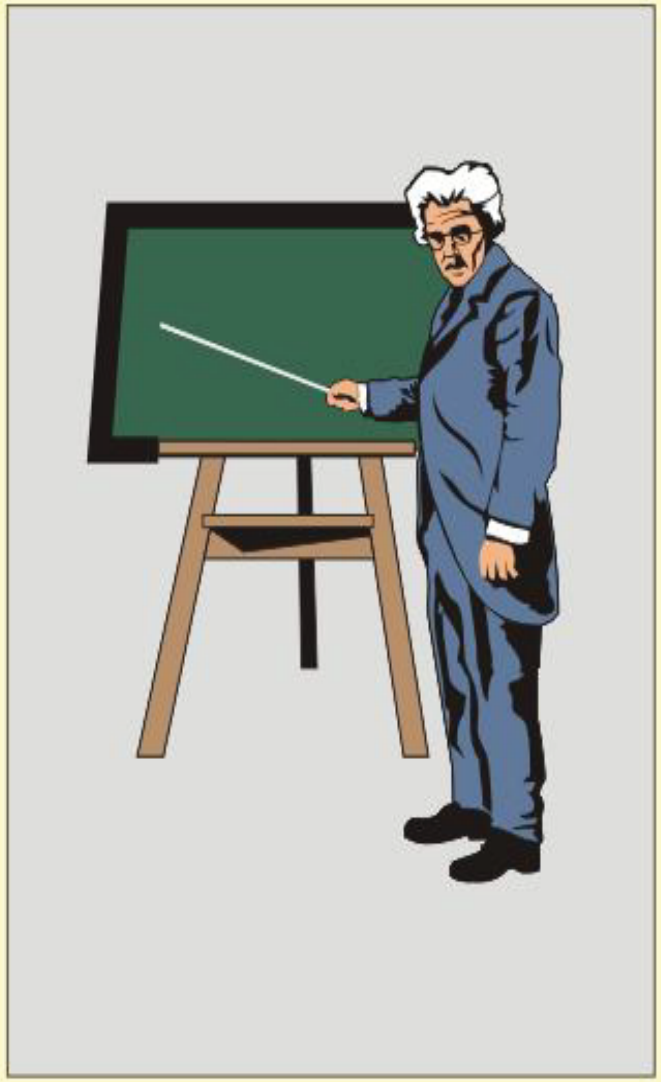
Technology Enhanced Learning



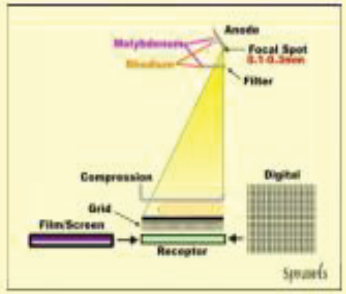
WINDOW
or
BARRIER

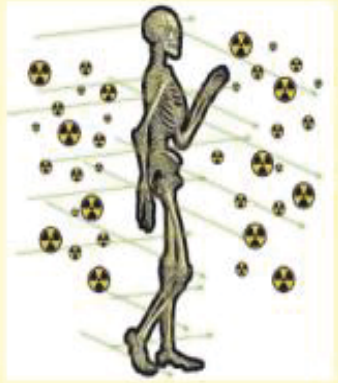
THE LEARNERS





PHYSICAL UNIVERSE





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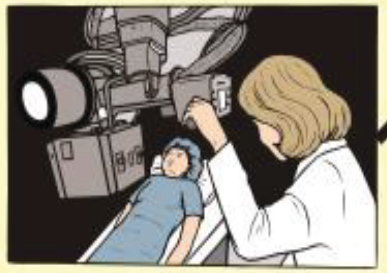
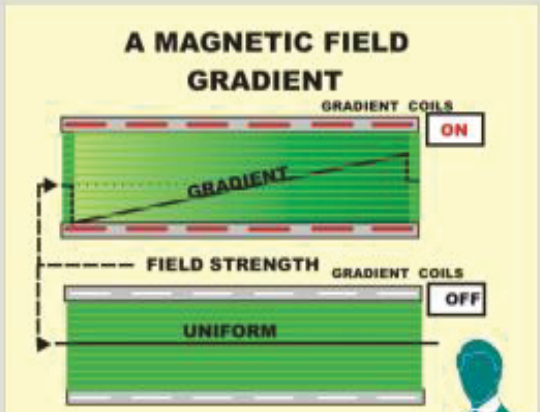
WINDOW or BARRIER

THE LEARNERS

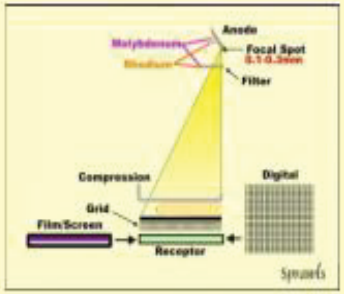


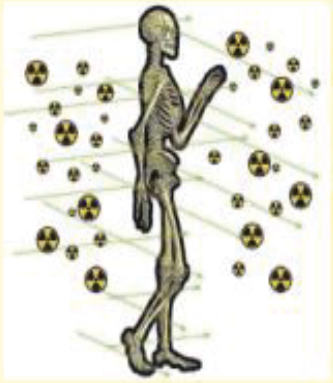
Visuals



Physicists

PHYSICAL UNIVERSE





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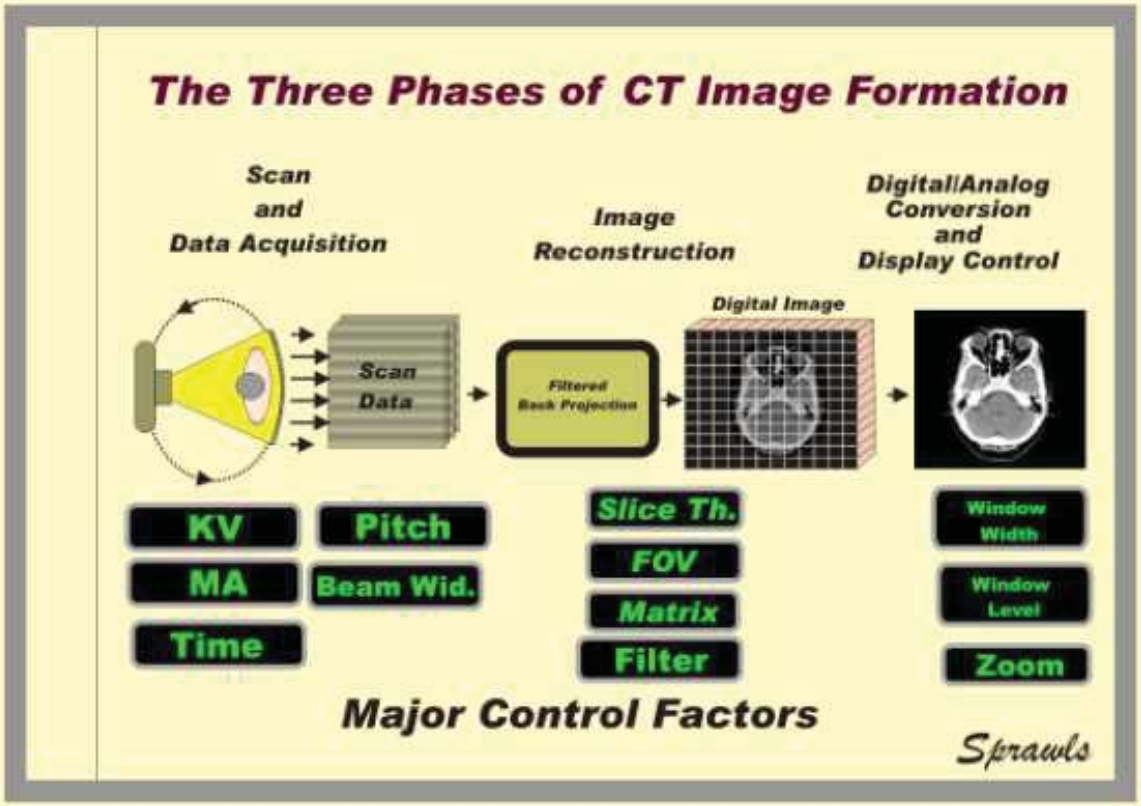
Visuals for Learning and Teaching

The Imaging Process



Clinical Images

Sprawls

Clinically Focused Physics Education

Classroom | Clinical Conference | Small Group | "Flying Solo"

Highly Efficient

For General Physics and Related Topics

Highly Effective

Clinically Rich Learning Activities

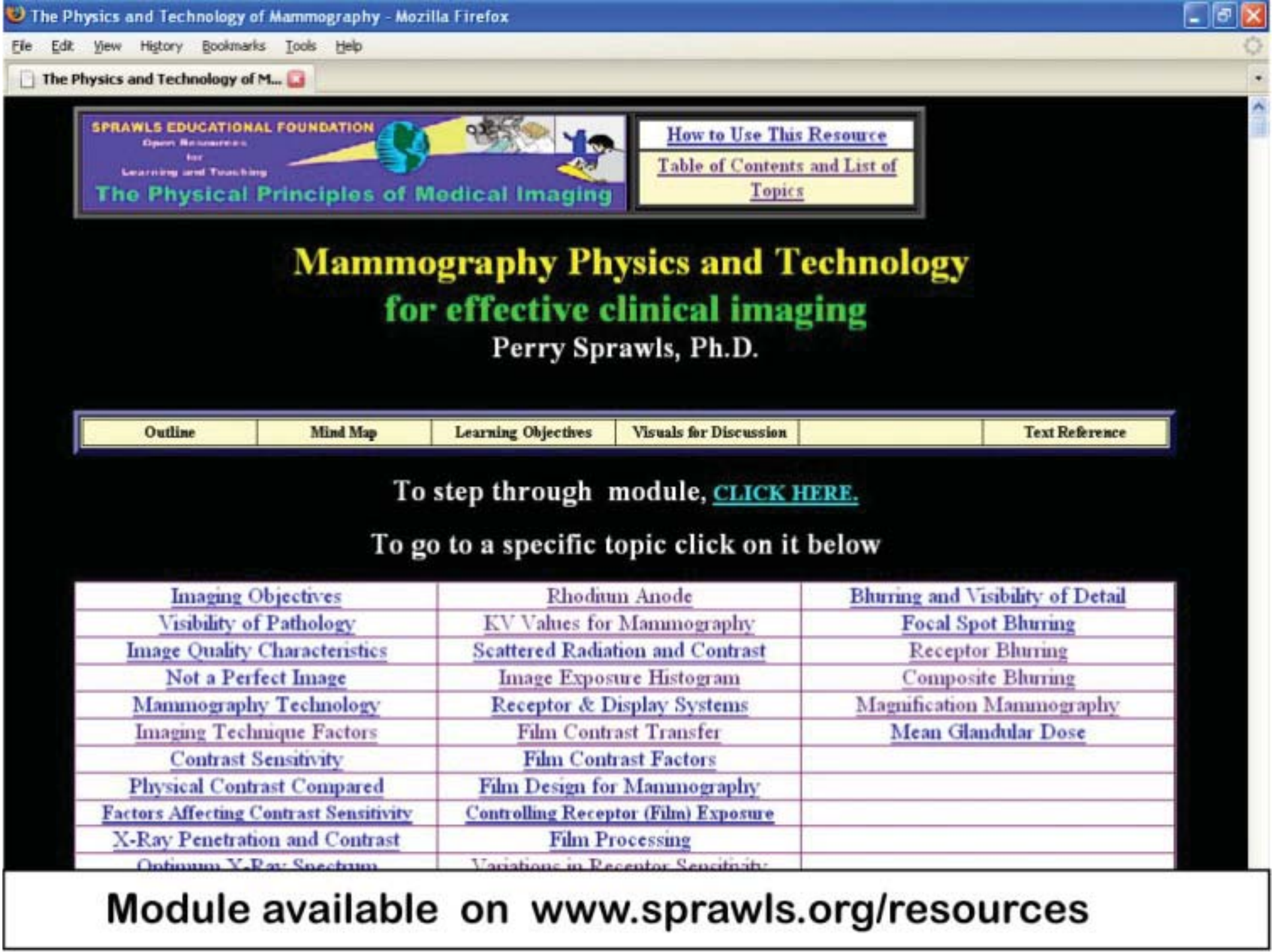
Visuals **Images** **Online Modules**

Resources and References

Sprawls

Radiology resident analyzing a mammogram under the direction of radiologist Dr. Debra Monticciolo who discusses image characteristic and related physics. The monitor in the rear is displaying the mammography physics module.

They then use the module to study topics in more depth or lookup specific information. The resident will continue to use the module to study physics during his mammography clinical clinical rotation.

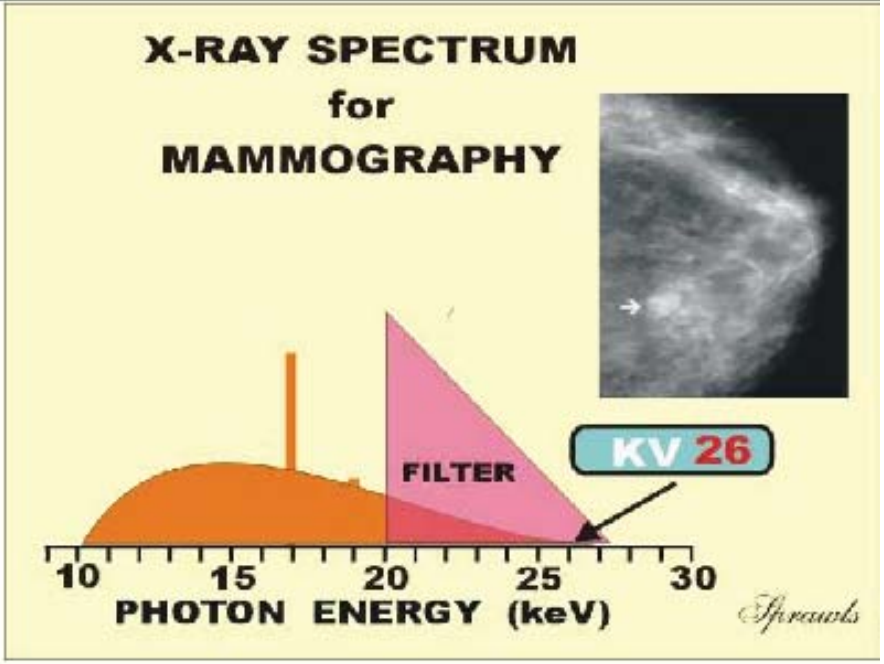

The Physics and Technology of Mammography - Mozilla Firefox
File Edit View History Bookmarks Tools Help
The Physics and Technology of M...
SPRAWLS EDUCATIONAL FOUNDATION
Open Resources for Learning and Teaching
The Physical Principles of Medical Imaging
How to Use This Resource
Table of Contents and List of Topics
Mammography Physics and Technology
for effective clinical imaging
Perry Sprawls, Ph.D.
Outline
Mind Map
Learning Objectives
Visuals for Discussion
Text Reference
To step through module, CLICK HERE.
To go to a specific topic click on it below
Imaging Objectives
Visibility of Pathology
Image Quality Characteristics
Not a Perfect Image
Mammography Technology
Imaging Technique Factors
Contrast Sensitivity
Physical Contrast Compared
Factors Affecting Contrast Sensitivity
X-Ray Penetration and Contrast
Optimum X-Ray Spectrum
Rhodium Anode
KV Values for Mammography
Scattered Radiation and Contrast
Image Exposure Histogram
Receptor & Display Systems
Film Contrast Transfer
Film Contrast Factors
Film Design for Mammography
Controlling Receptor (Film) Exposure
Film Processing
Variations in Receptor Sensitivity
Blurring and Visibility of Detail
Focal Spot Blurring
Receptor Blurring
Composite Blurring
Magnification Mammography
Mean Glandular Dose
Module available on www.sprawls.org/resources

e x-ray beam spectrum is one of the most critical factors that must be
usted to optimize a procedure with respect to contrast sensitivity and dose.

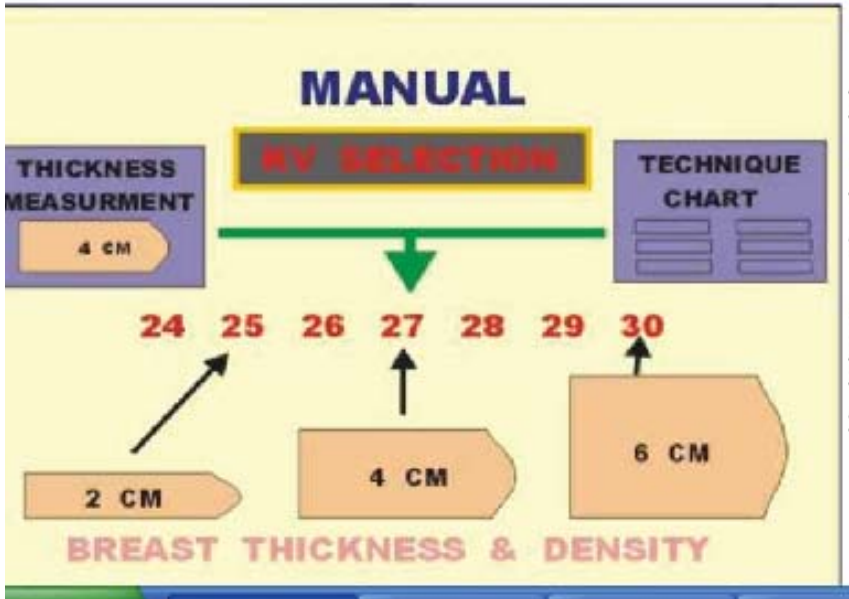
e can think of it as a three-step procedure:

1. Select the appropriate anode (moly or rhodium)
2. Select the appropriate filter (moly or rhodium)
3. Select the appropriate KV (In the range 24 kV to 32 kV)

reasing the KV has two effects on the x-ray beam. It increases the efficiency
l output for a specific MAS value and it shifts the photon energy spectrum
ward so that the beam becomes more penetrating.



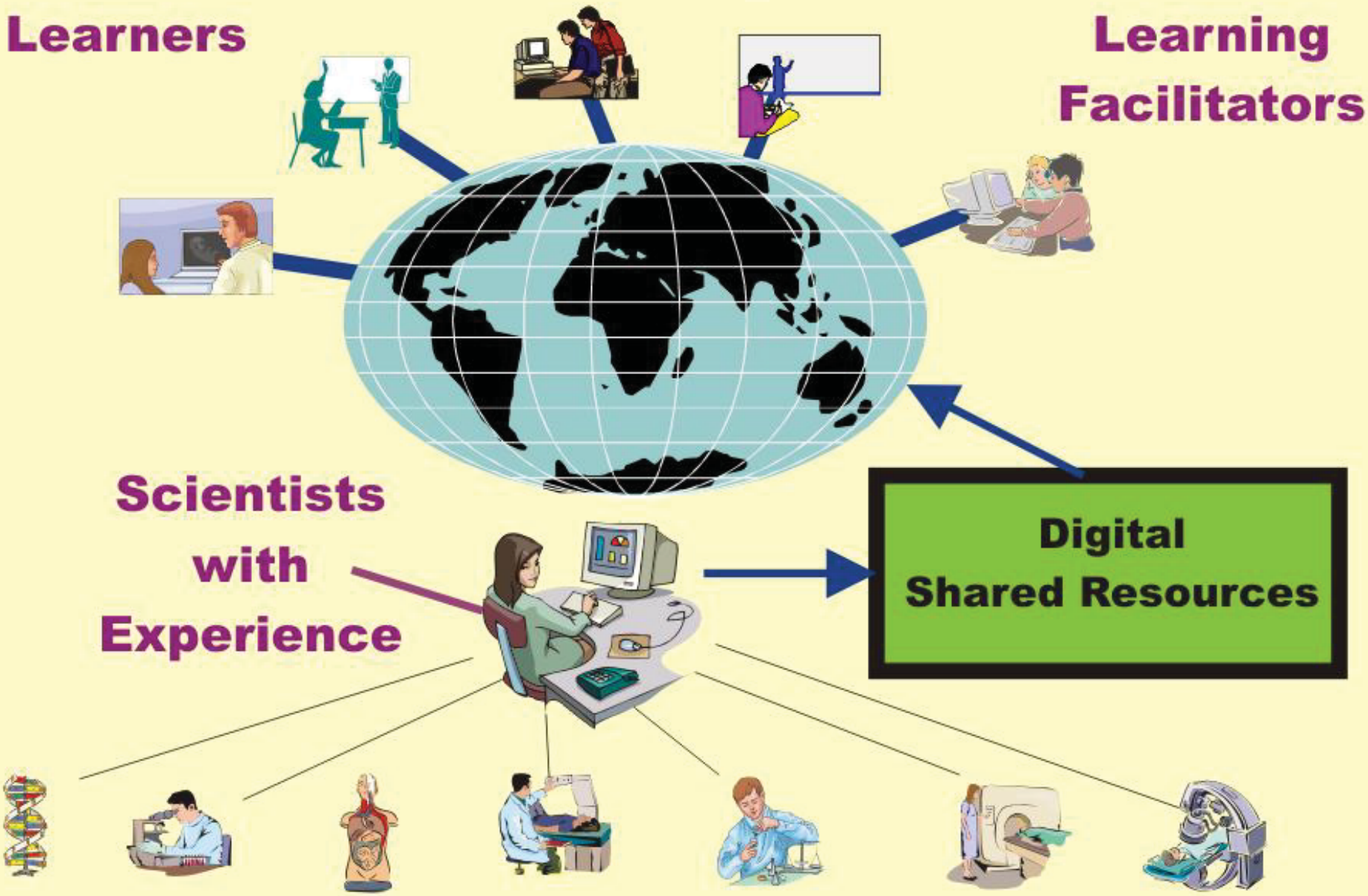
ile a more penetrating beam does reduce contrast sensitivity it is necessary
en imaging thicker and more dense breast. Therefore compressed breast thickness is the principal factor that determines the optimum
.

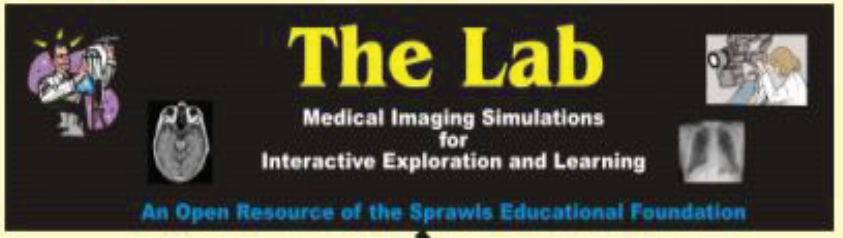


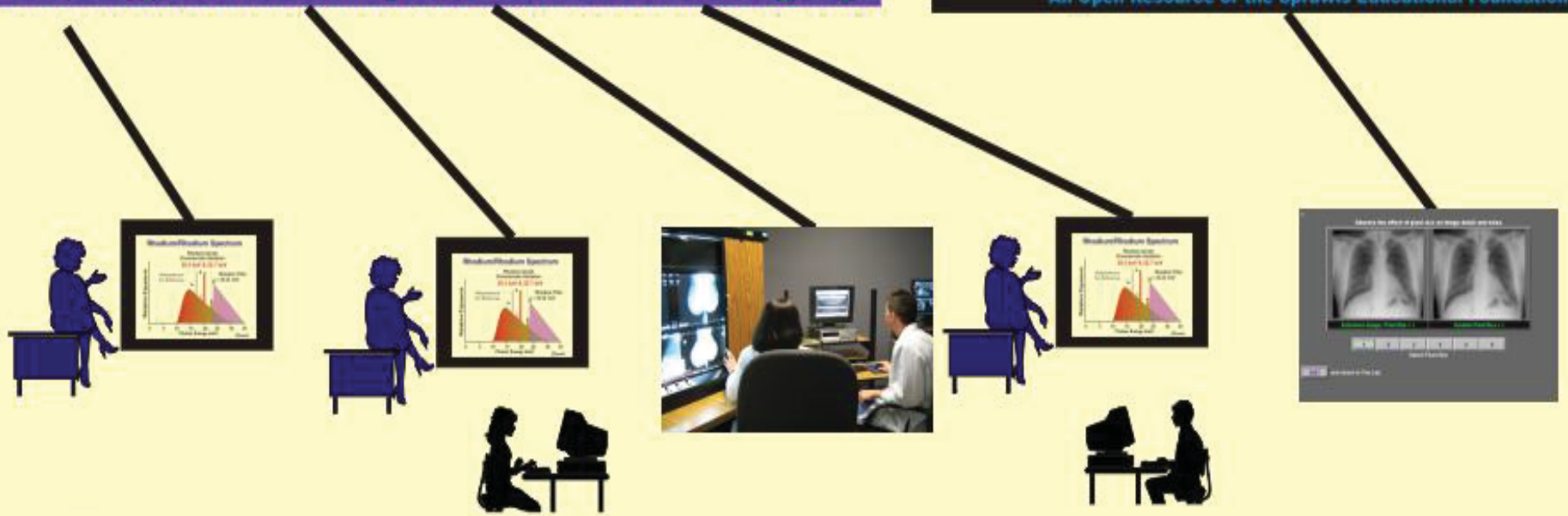
Mammography systems have indicators that display the thickness of the compressed breast. This along with a general assessment of breast density is used to manually select an optimum KV either from experience or an established technique chart.

The general goal is to increase the KV as necessary to keep the exposure time, MAS, and dose to the breast within reasonable limits as breast thickness increases.

Enriched Learning Environments



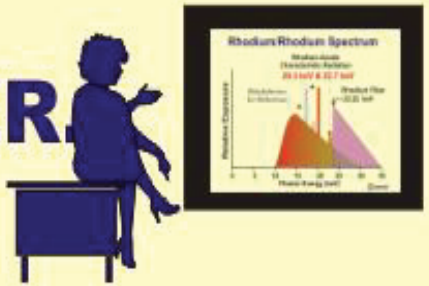




In Partnership with Other Medical Physics Teachers to be More Effective and Efficient in Providing Medical Imaging Education

The Values We Hold

The PHYSICIST is the TEACHER.



TECHNOLOGY is the TOOL that can be used for effective and efficient teaching.

Technology should be used to enhance human performance of both learners (residents, students, etc.) And teachers

Sprawls

Clinically Focused Physics Education

Perry Sprawls, Ph.D.
Emory University, Atlanta
Sprawls Educational Foundation, www.sprawls.org

This is a presentation containing a collection of visuals used in courses on the general topic of medical physics education for medical professionals, especially radiologists and radiology residents.

They are provided here to be used by medical physicists for individual study, group discussions, or in class or conference presentations.