



Clinically Focused Physics Education

The Foundation for Image Quality

and

Effective Dose Management

Perry Sprawls, Ph.D.

Distinguished Emeritus Professor

Emory University

and

Sprawls Education Foundation

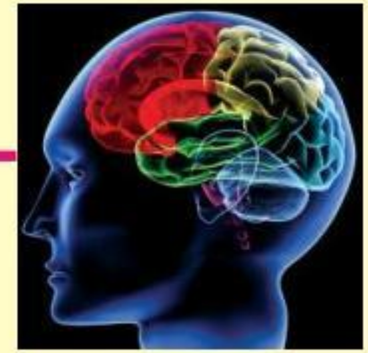
http://www.sprawls.org

Clinically Focused Physics Education

Clinical Radiology

DO

Effective Knowledge Structures

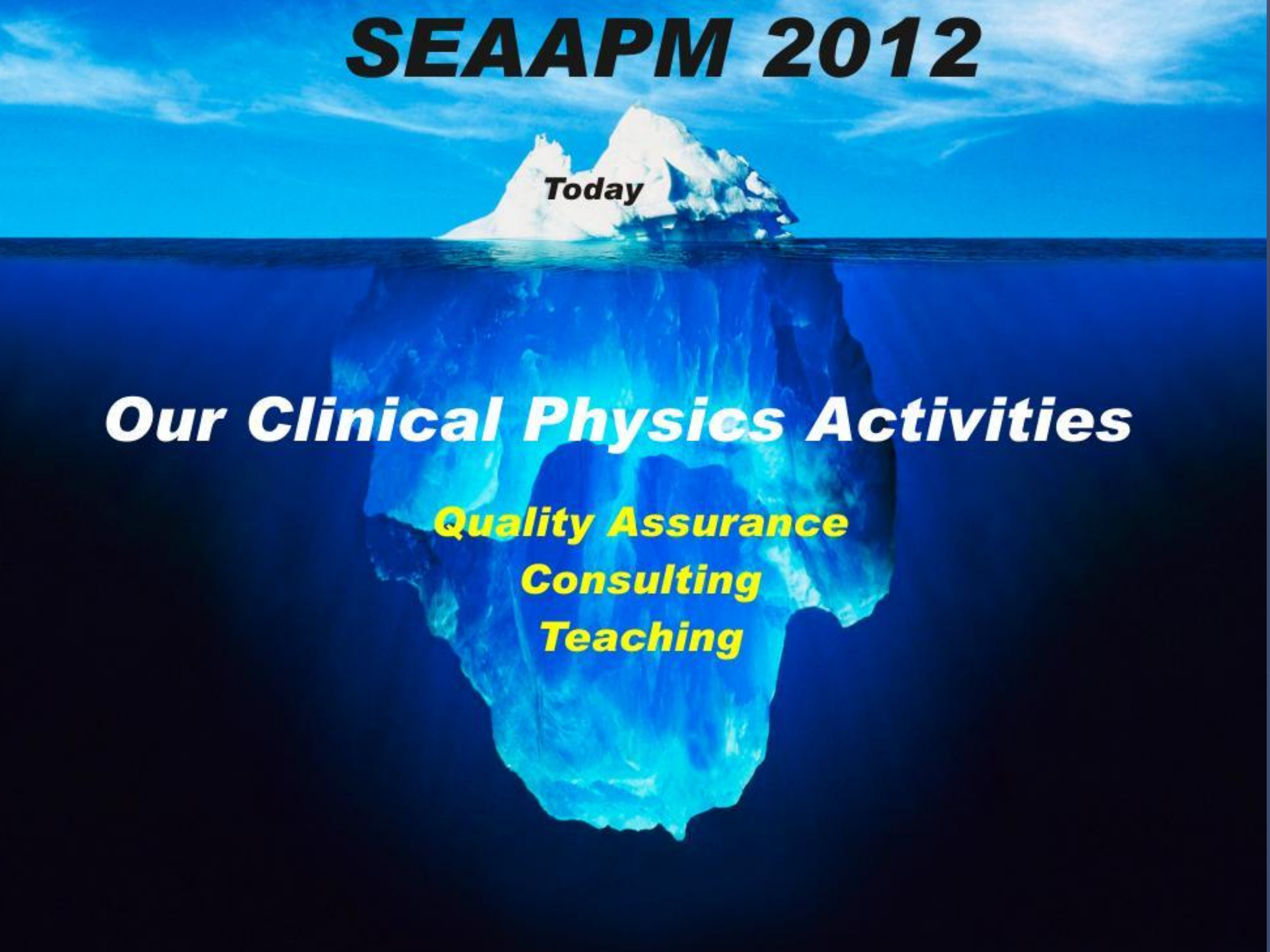


Levels of Learning

LEARN

Learning Activities **Effectiveness** and **Efficienc**

RESOURCES


SEAAPM 2012
Today
Our Clinical Physics Activities
Quality Assurance
Consulting
Teaching

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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Physics Learning Objectives for Radiologists

Image Physical Characteristics

Identify

Relationship to Visibility

Anatomy and Pathology

Evaluate

Control and Optimize

Risk

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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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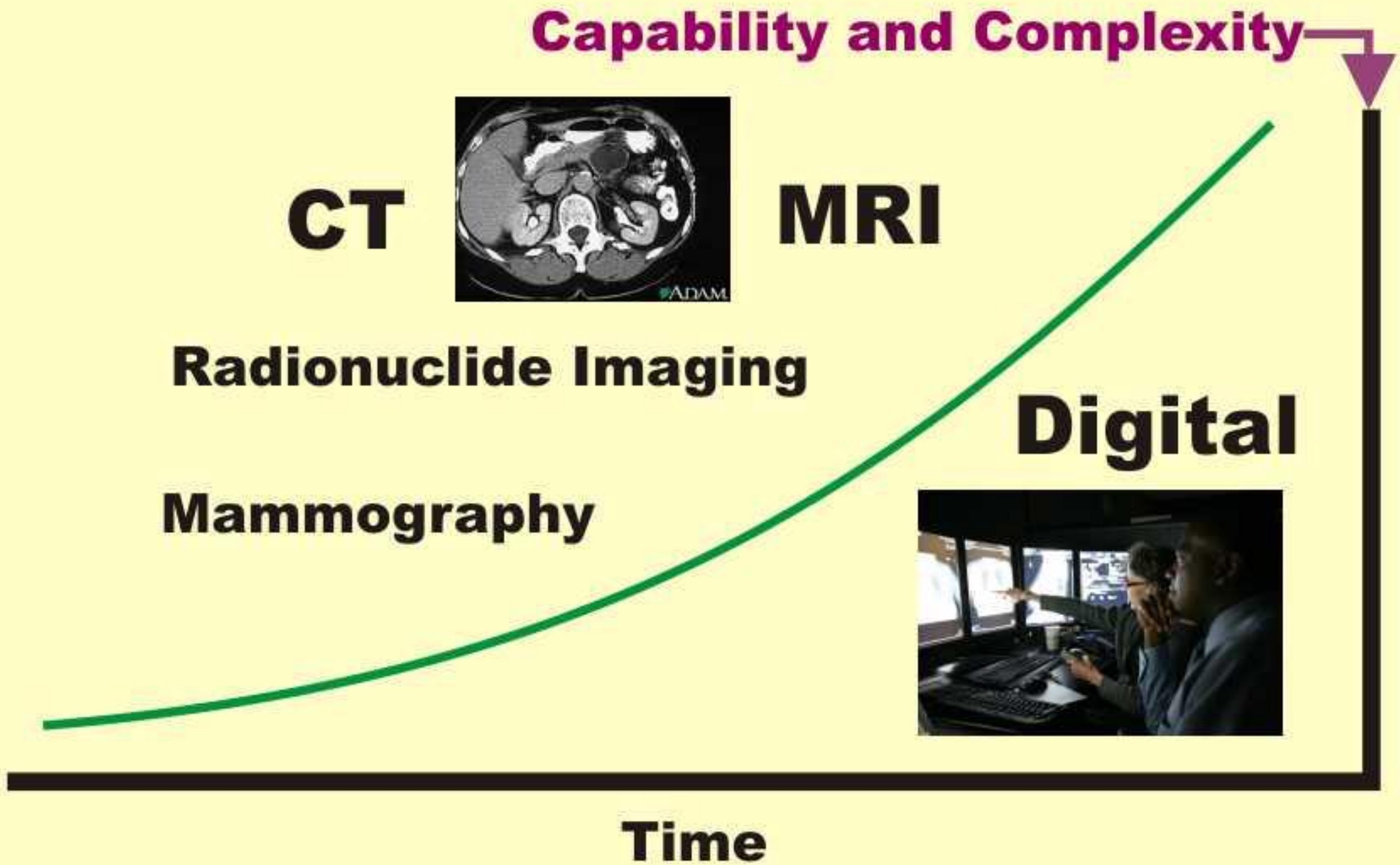
Continuing Growth in the Need for Physics Knowledge



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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"

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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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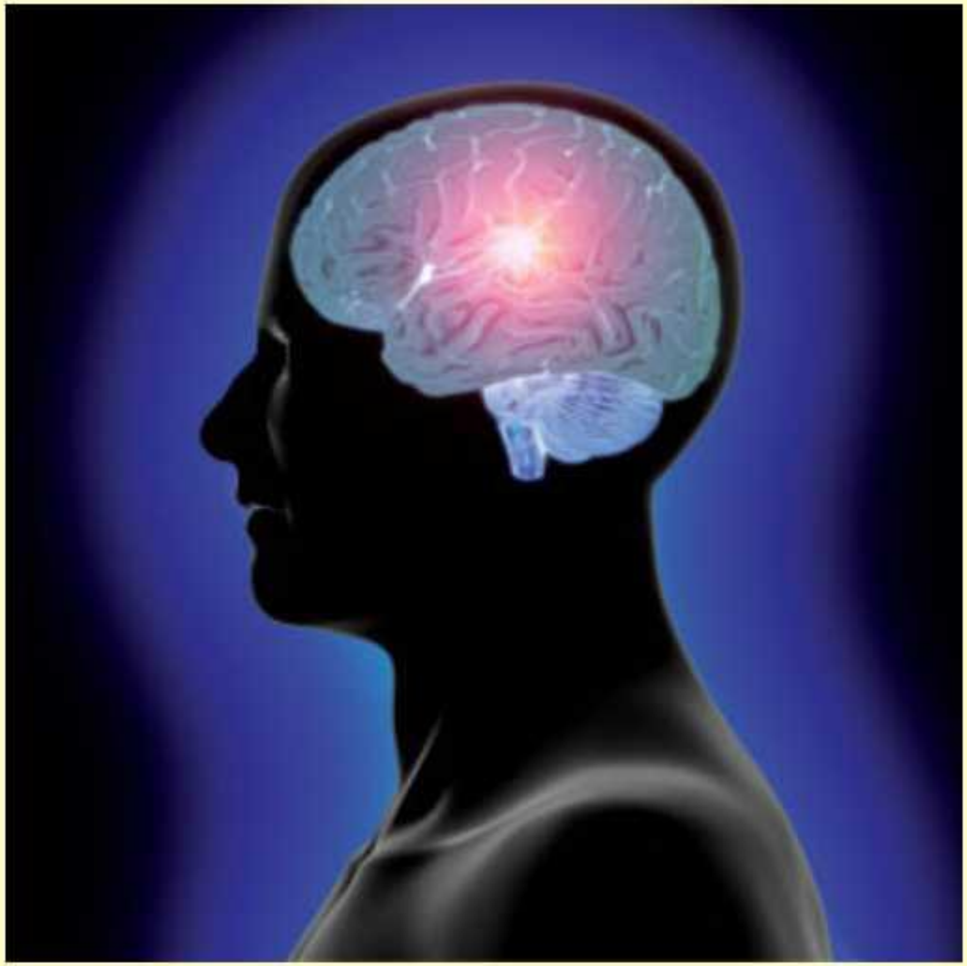
Learning is....



Building knowledge structures in the brain

Image: UCDavis

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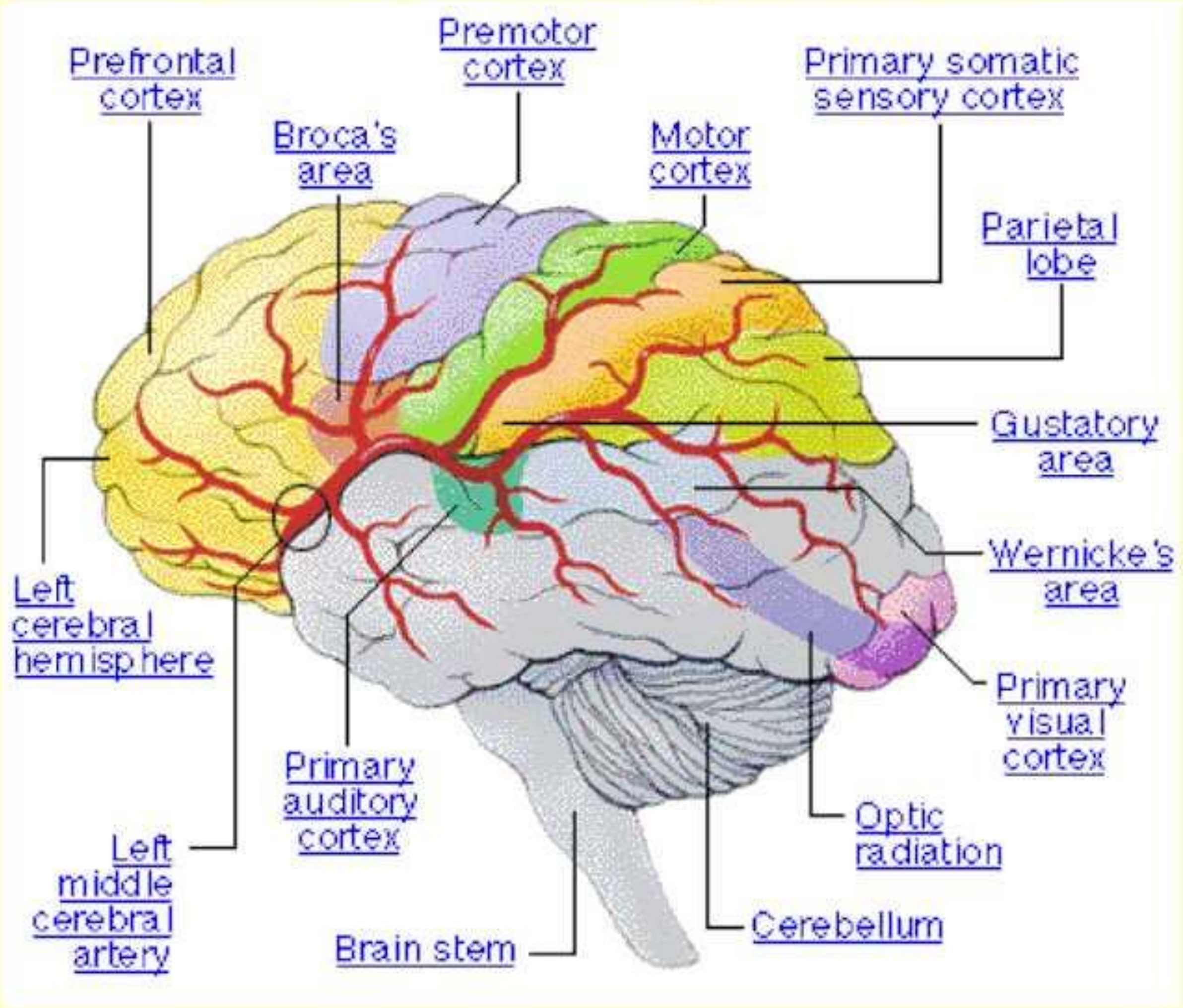
The Brain...



Structure and Function

Image: AMA

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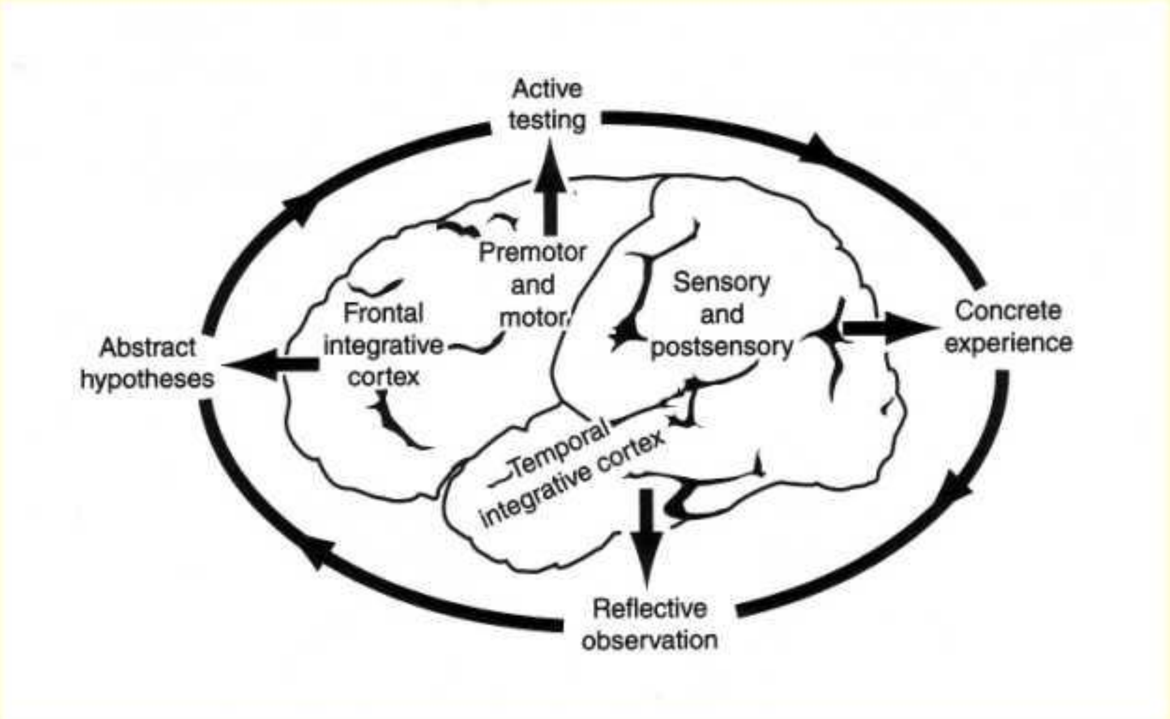
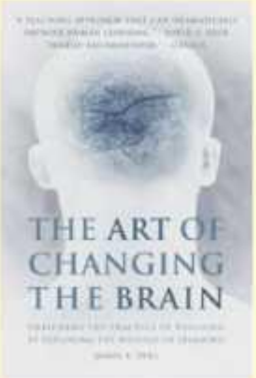
Zull's Model of Brain Function

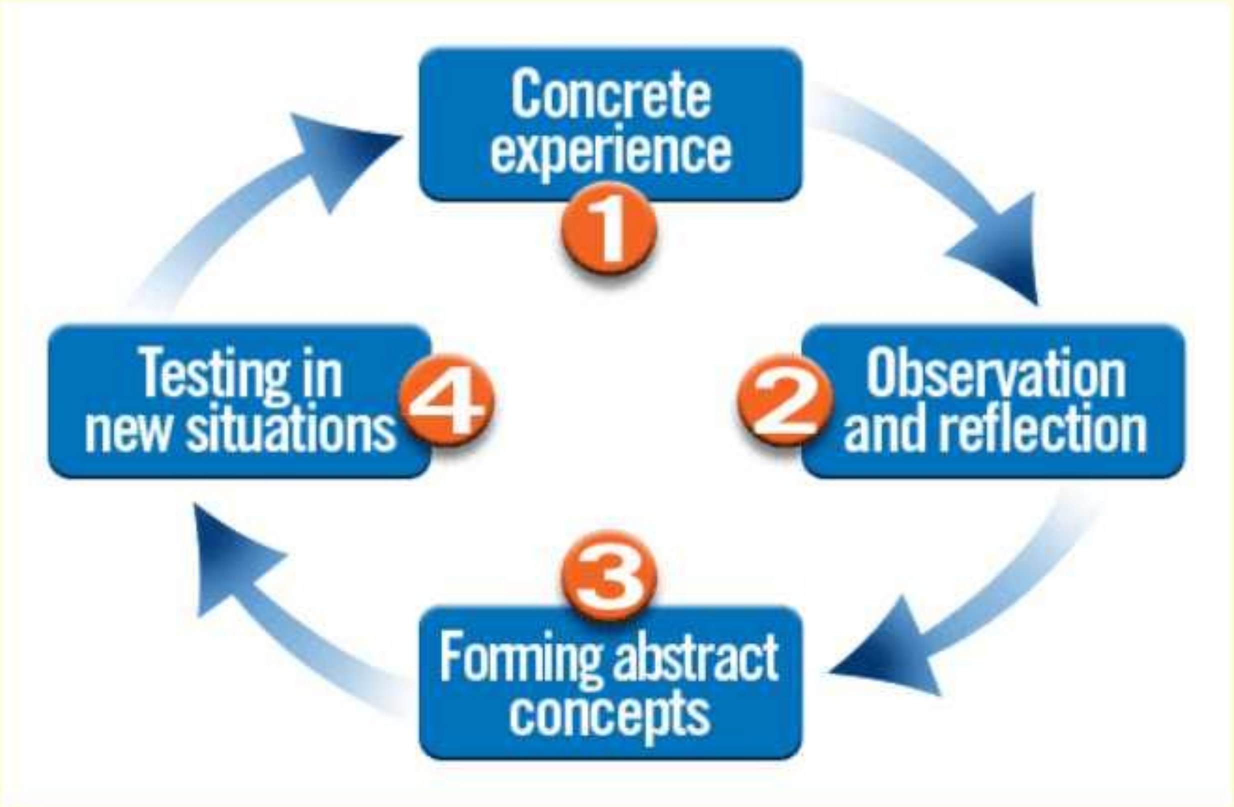


James Zull, Ph.D.
Professor of Biology
Professor of Biochemistry
Director of University Center for Innovation in Teaching and Education
Case Western Reserve

Reference:



Kolb's Experiential Learning Model



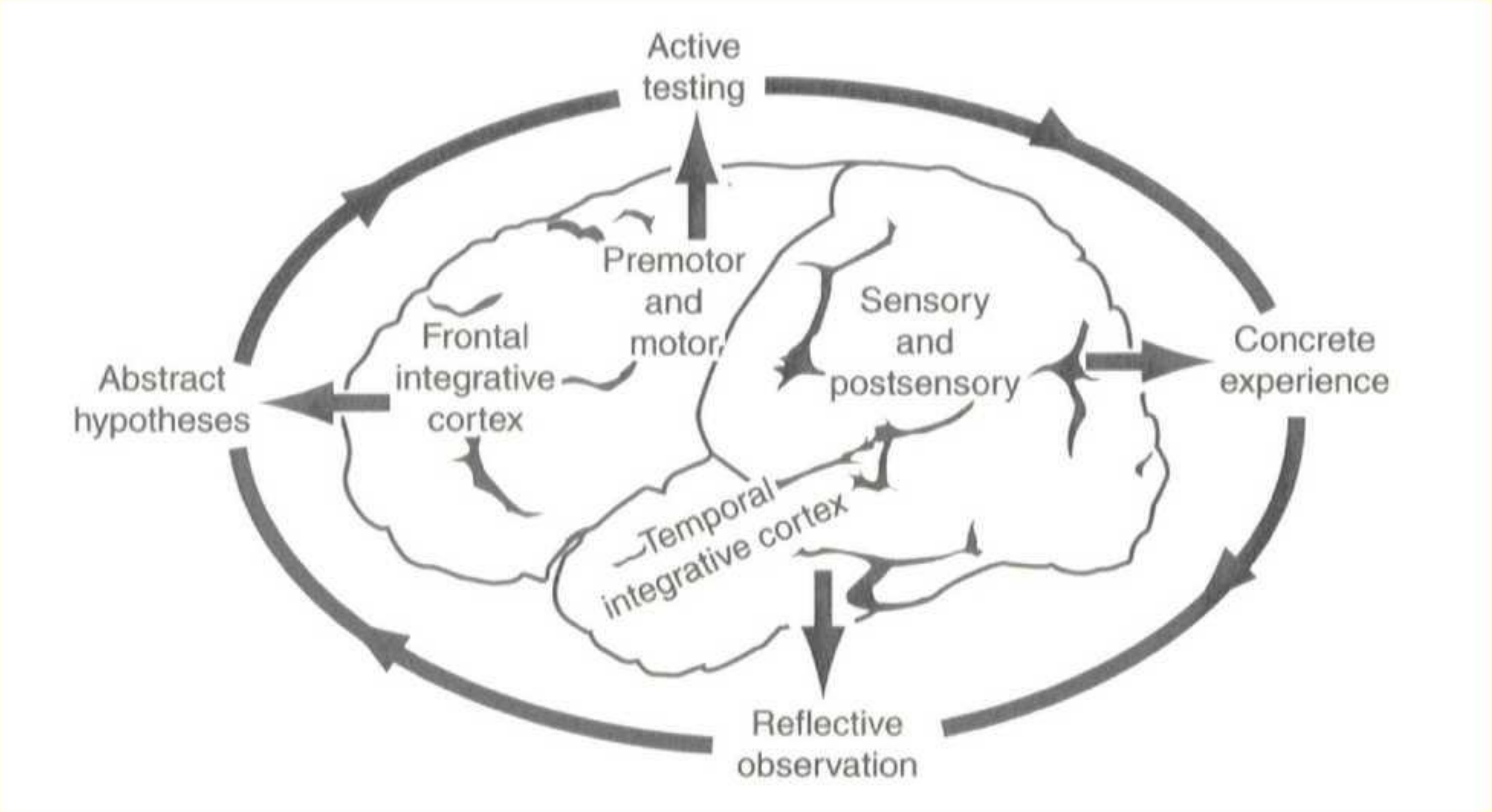
David A. Kolb, Ph.D.

Professor of Organizational Behavior

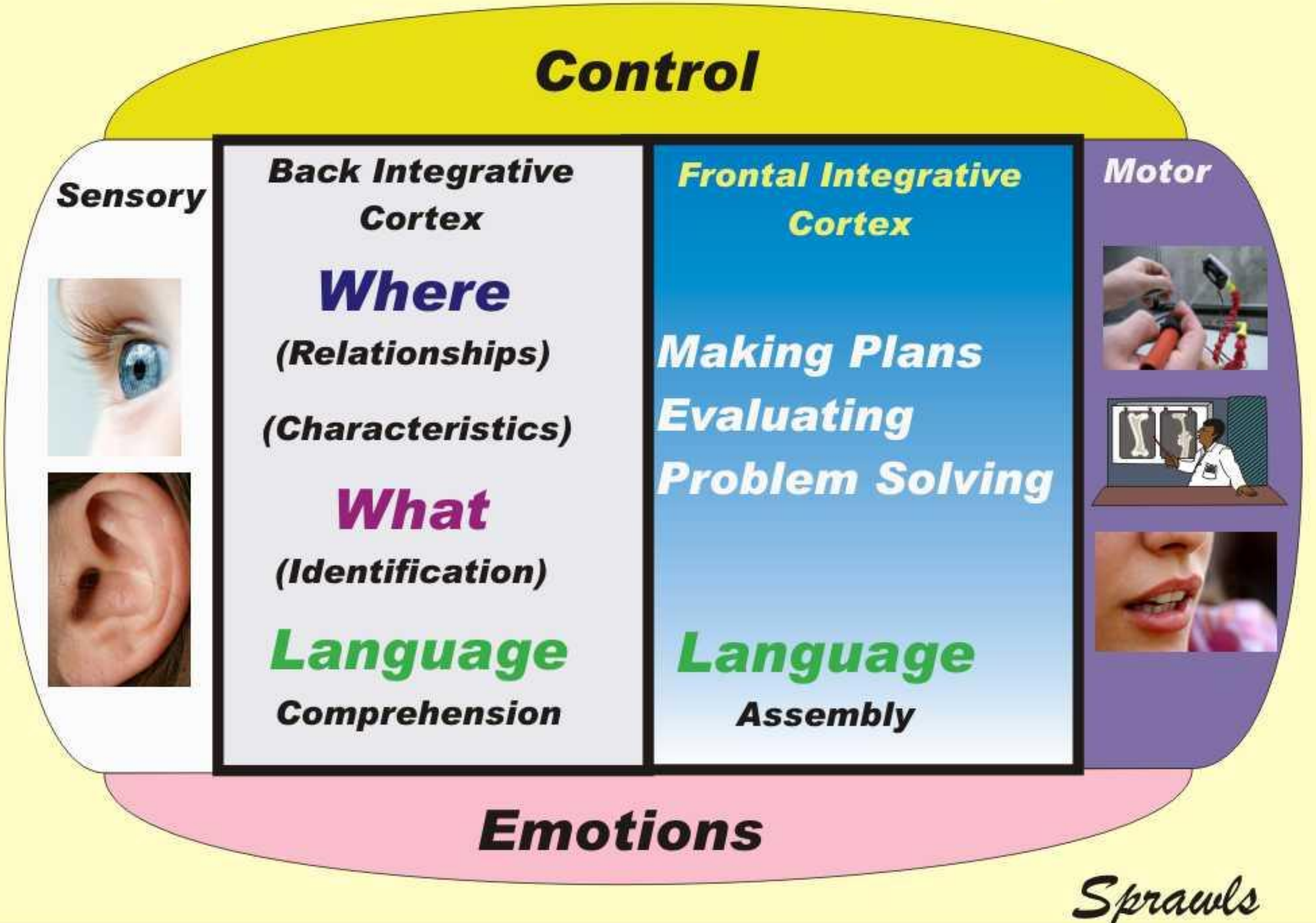
Case Western Reserve

Website: http://www.learningfromexperience.com

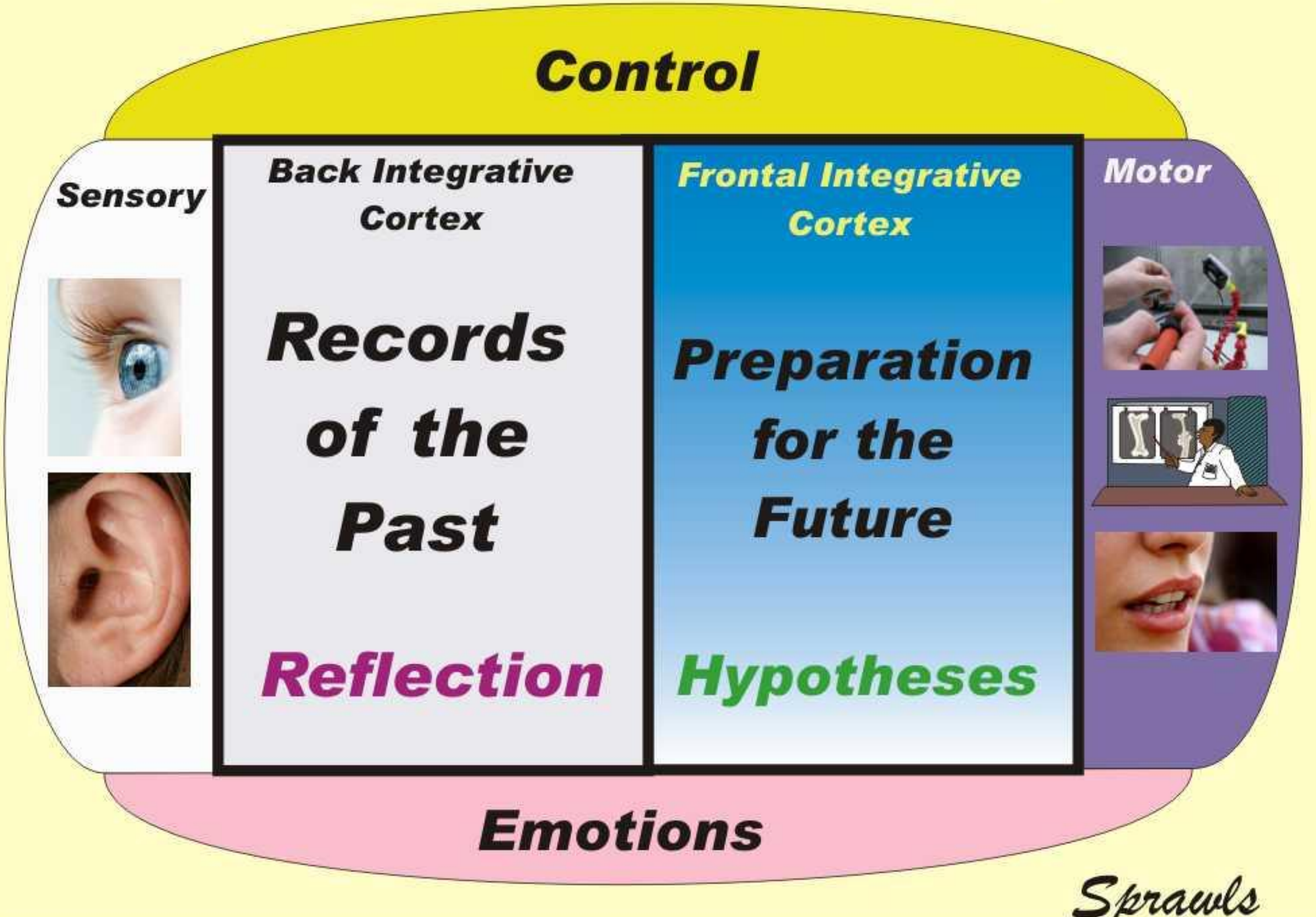
Zull's Model of Brain Function



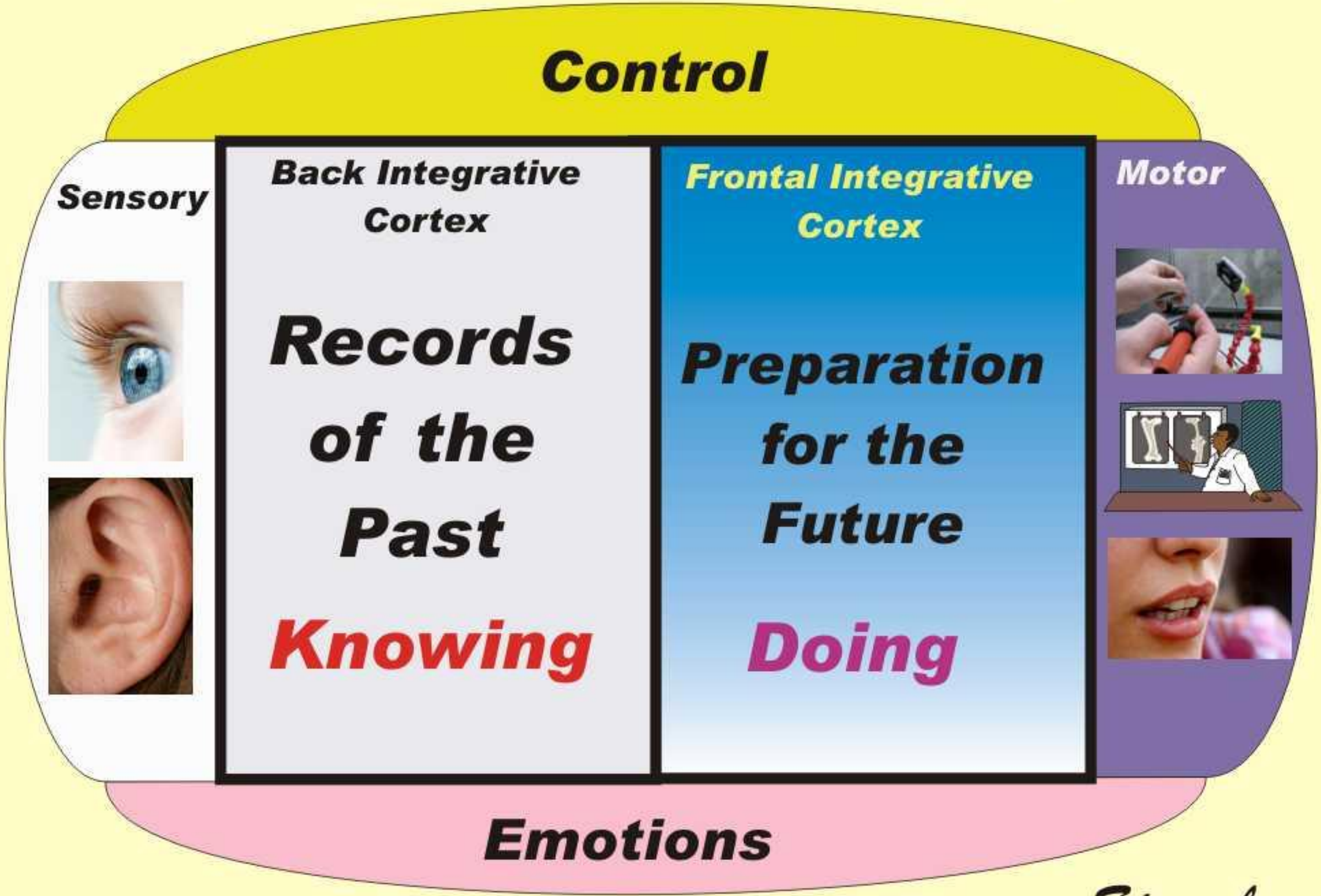
Brain Functions for Learning Physics



Brain Functions for Learning Physics



Brain Functions for Learning Physics



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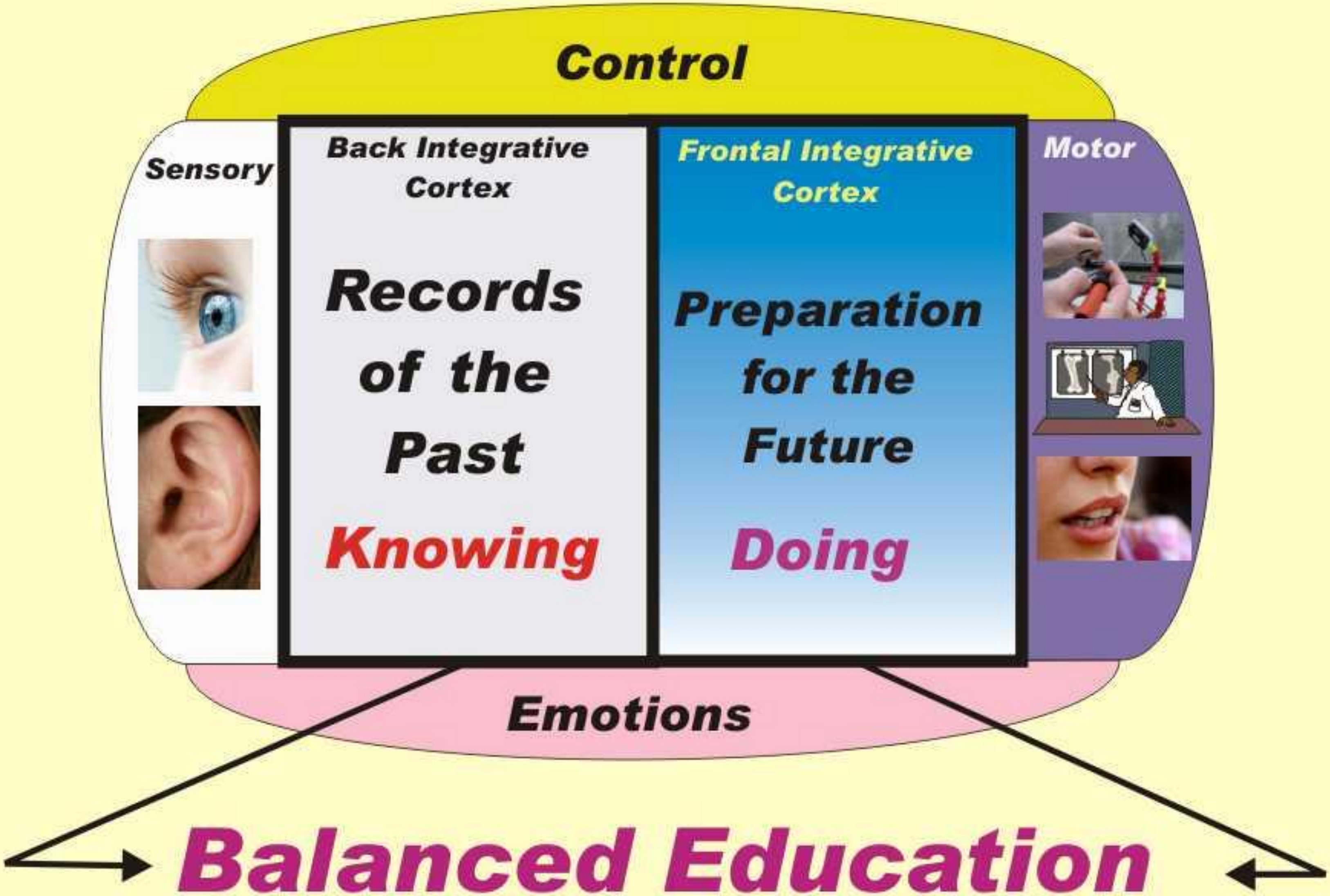
Brain Functions for Learning Physics



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Forming Knowledge Structures

Physical Universe

Back Integrative Cortex

Sensory

Visible Physical Objects

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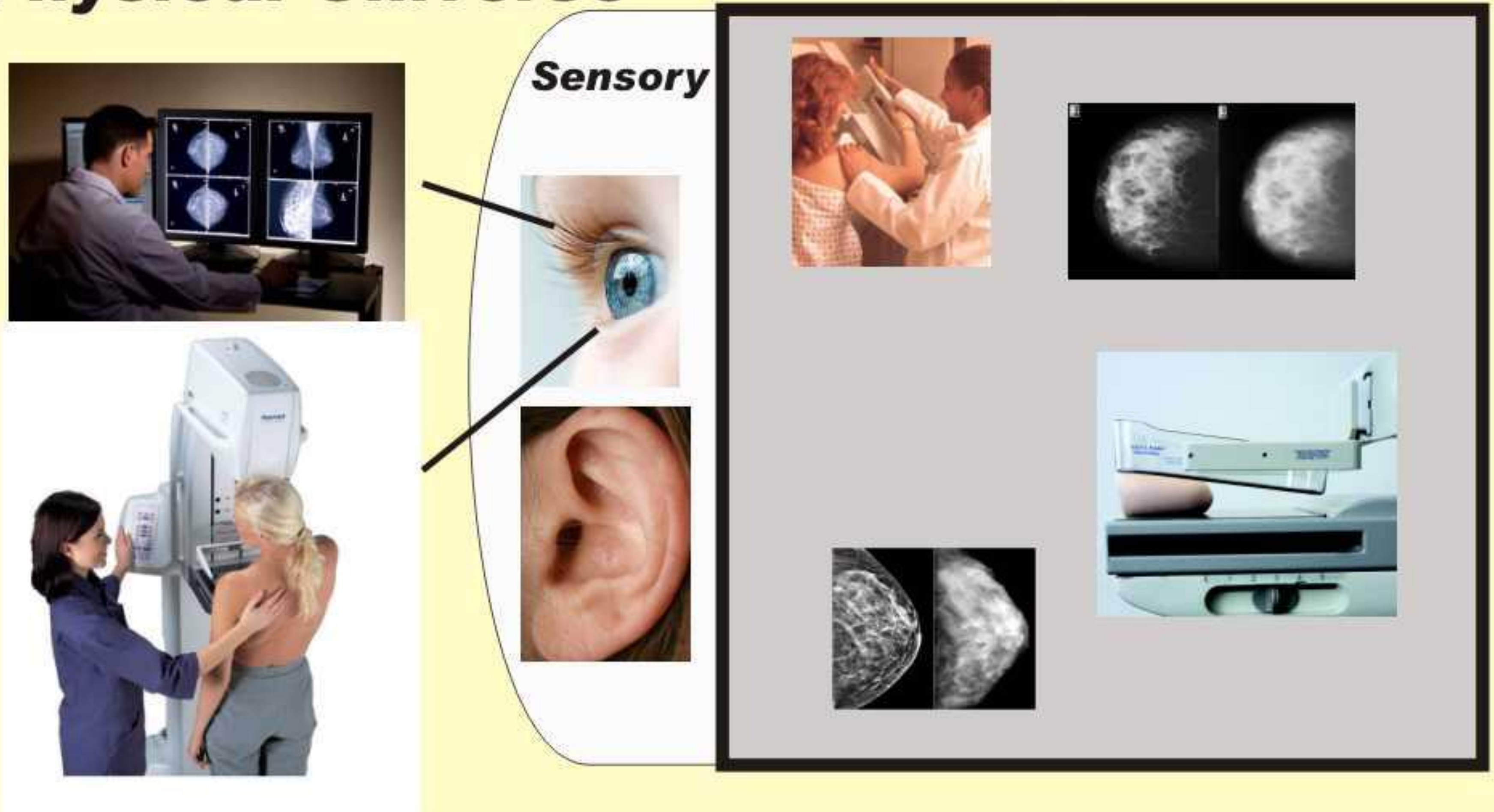
Forming Knowledge Structures

Physical Universe **Back Integrative Cortex**



Visible Physical Objects

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Forming Knowledge Structures

Physical Universe

Radiation
Electrons
Magnetic
Atomic
Nuclear

Sensory

Back Integrative Cortex

? ? ?

Invisible Physical Objects

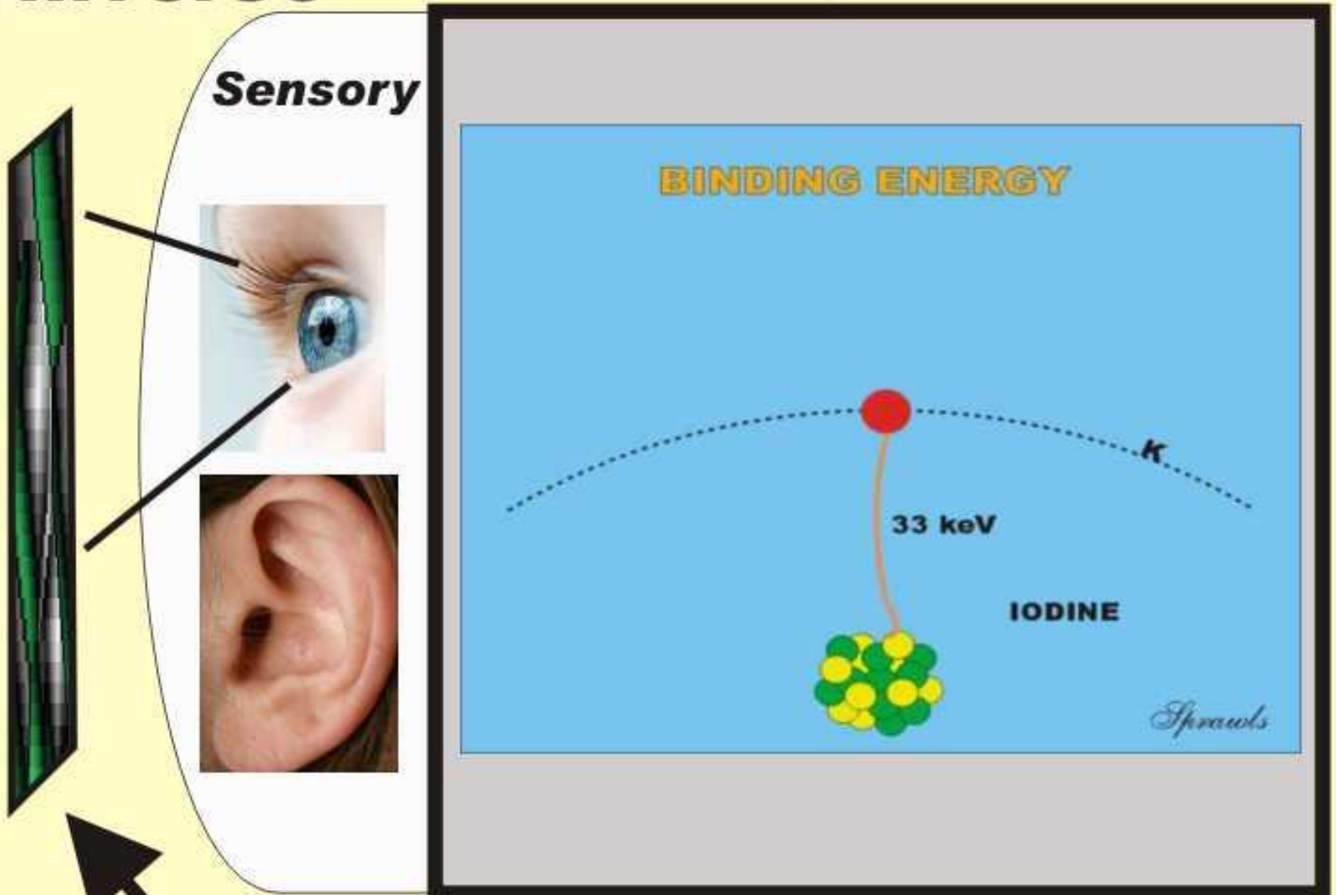
Sprawls

Forming Knowledge Structures

Physical Universe

Back Integrative Cortex

Radiation
Electrons
Magnetic
Atomic
Nuclear



Invisible

Visuals

Physical Objects

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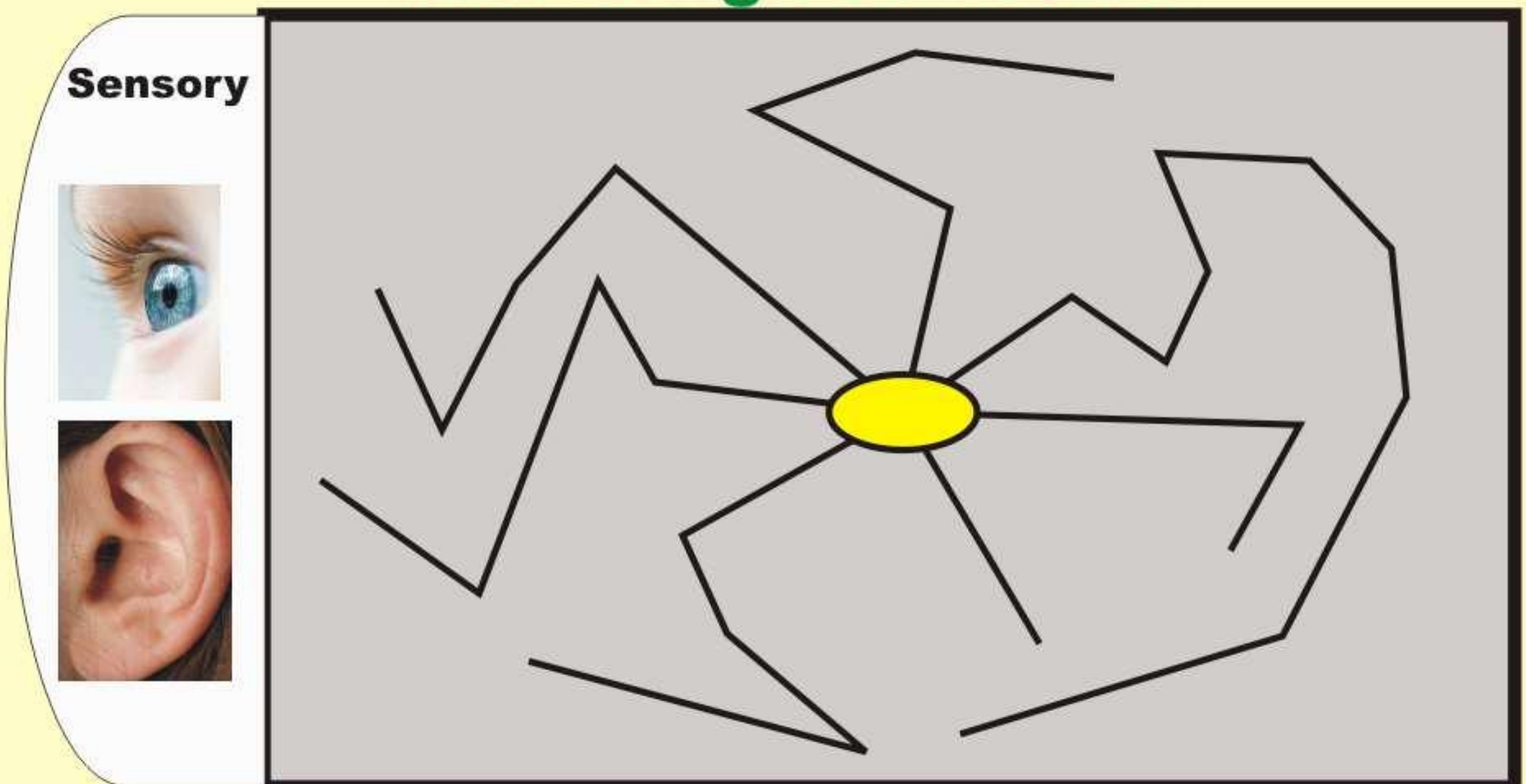
Back Integrative Cortex

Integrating experience into existing knowledge structure



Meaning

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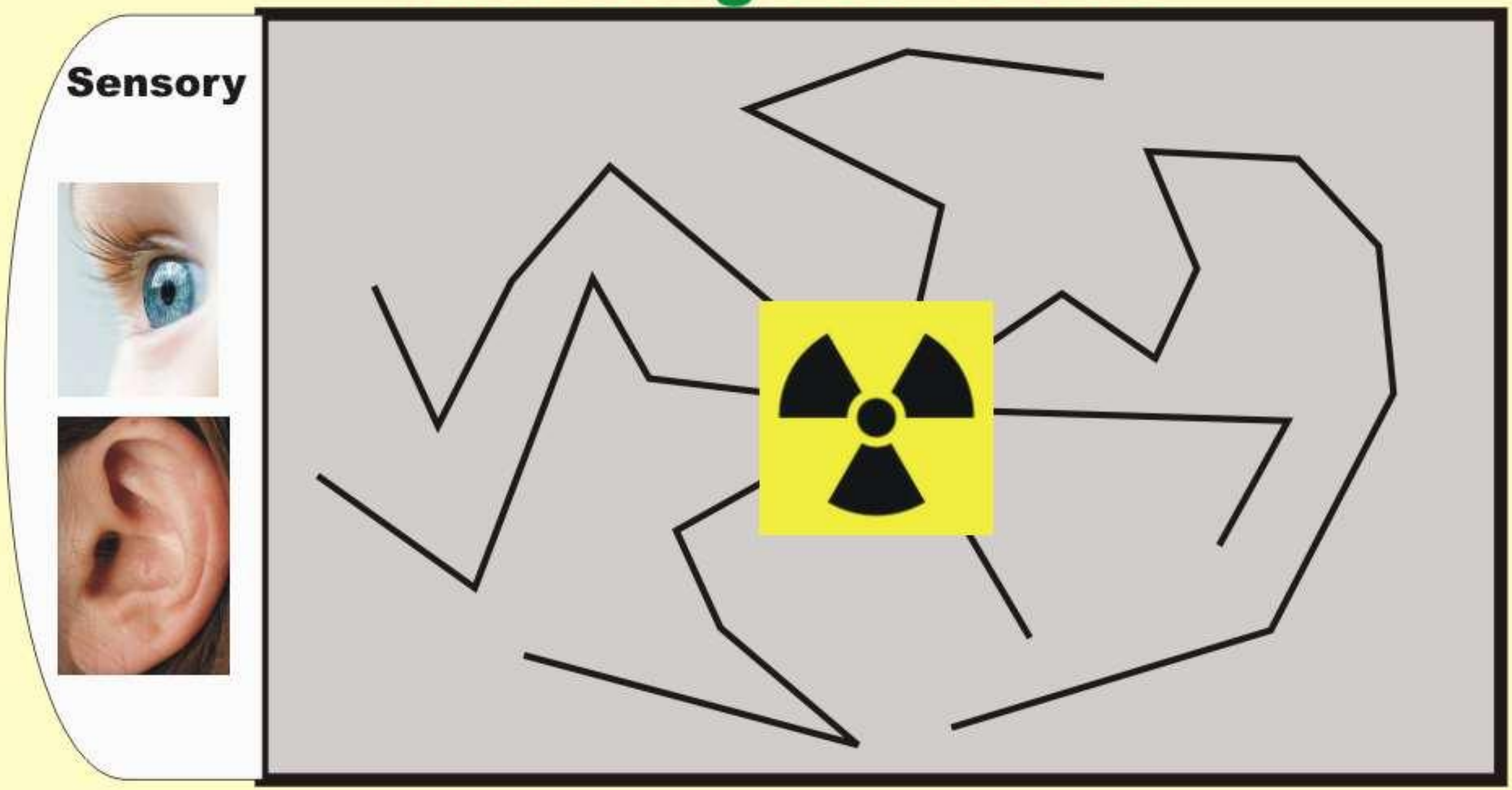
Back Integrative Cortex

Integrating experience into existing knowledge structure



Meaning

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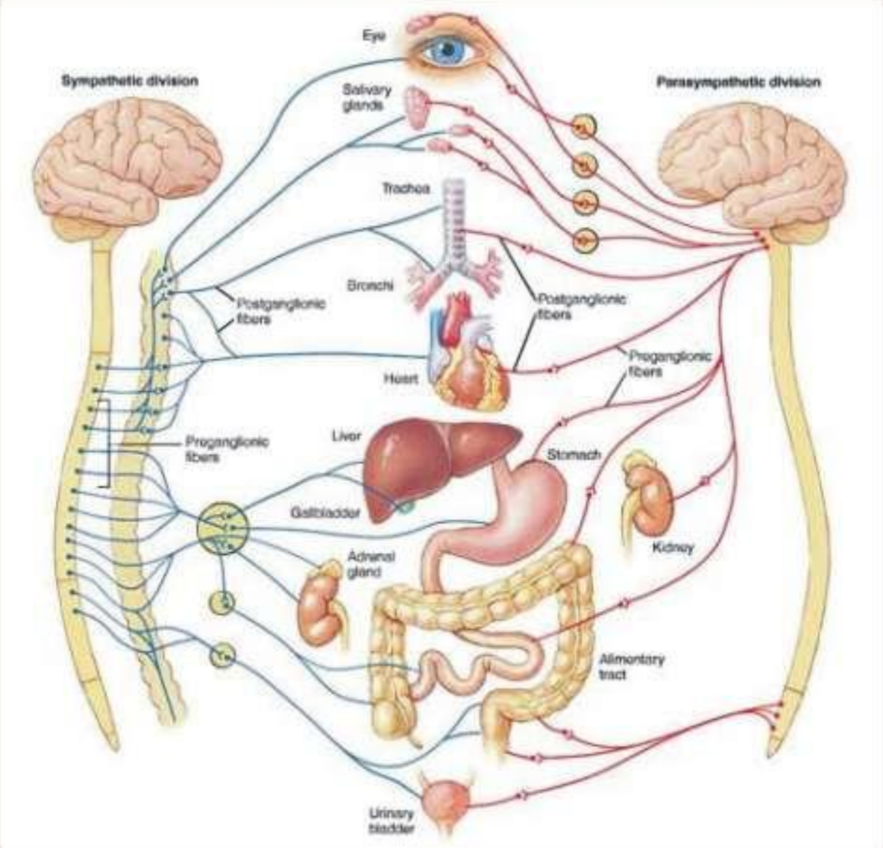
Back Integrative Cortex

Integrating experience into existing knowledge structure

Sensory



Medical Knowledge

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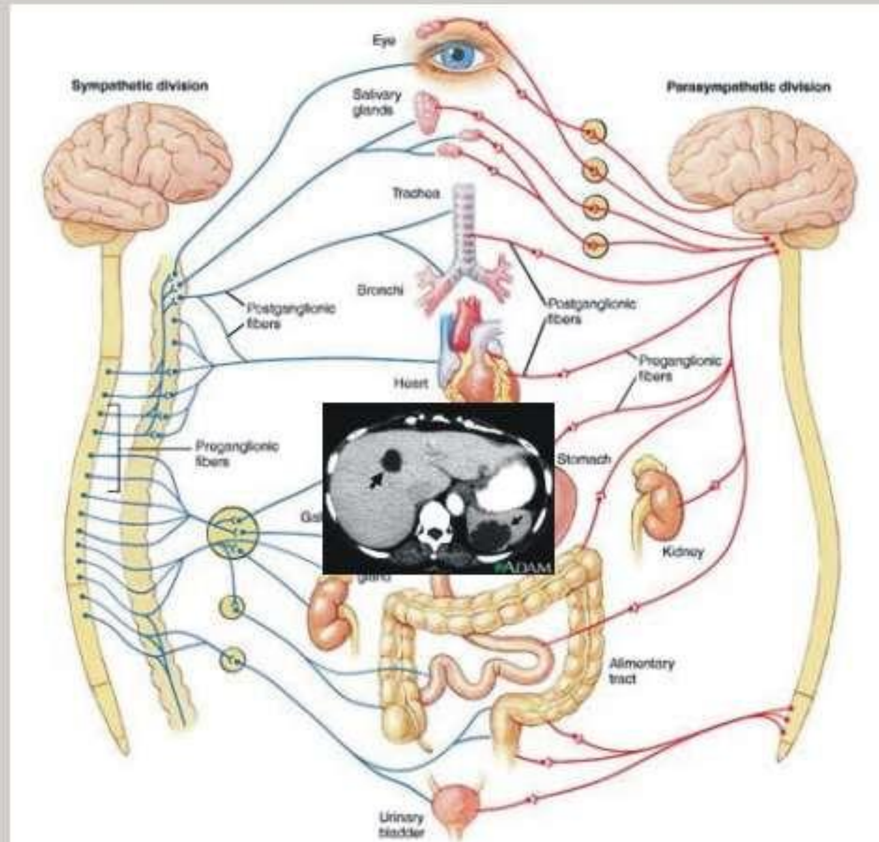
Back Integrative Cortex

Integrating experience into existing knowledge structure

Sensory



The image is the connection

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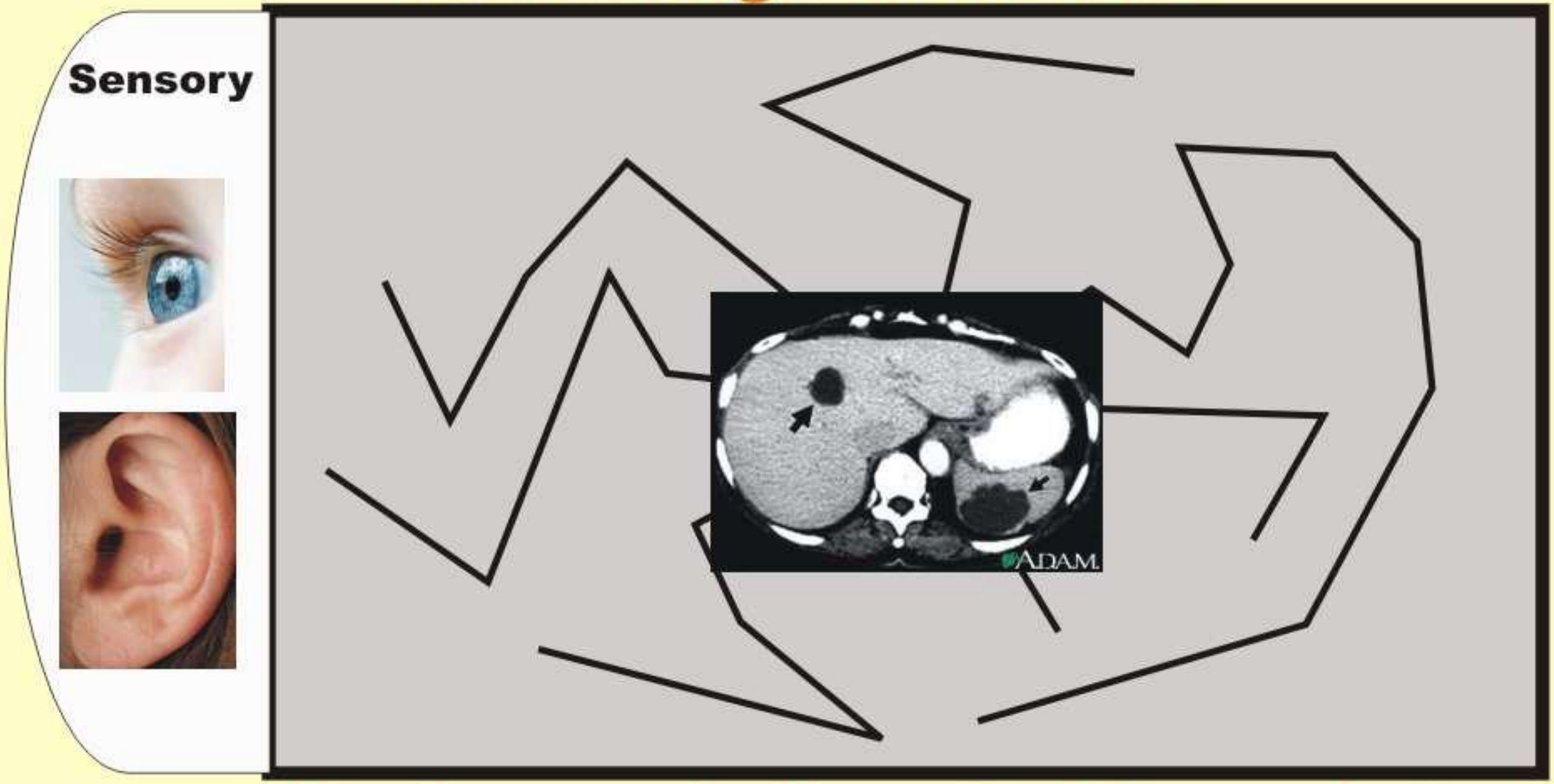
Back Integrative Cortex

Integrating experience into existing knowledge structure



The image is the starting point for learning physics

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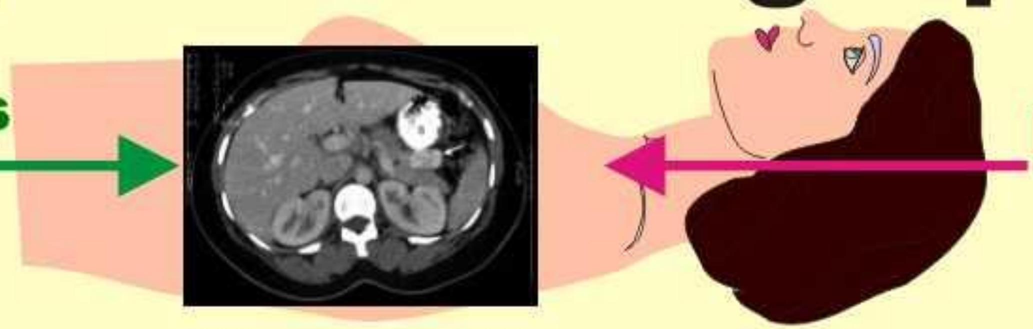
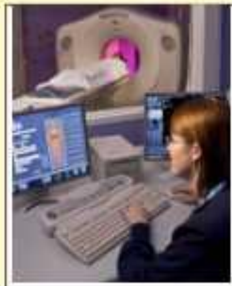
Computed Tomography

Image Characteristics and Quality

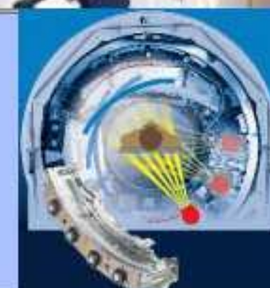


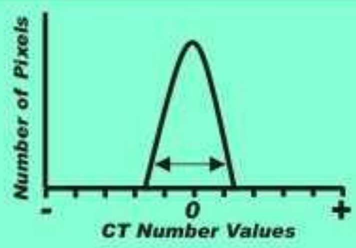
Radiation Dose



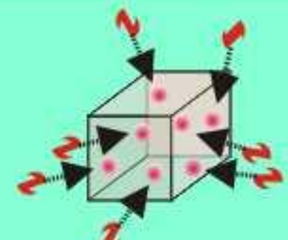
Imaging Protocols

Technology





Science



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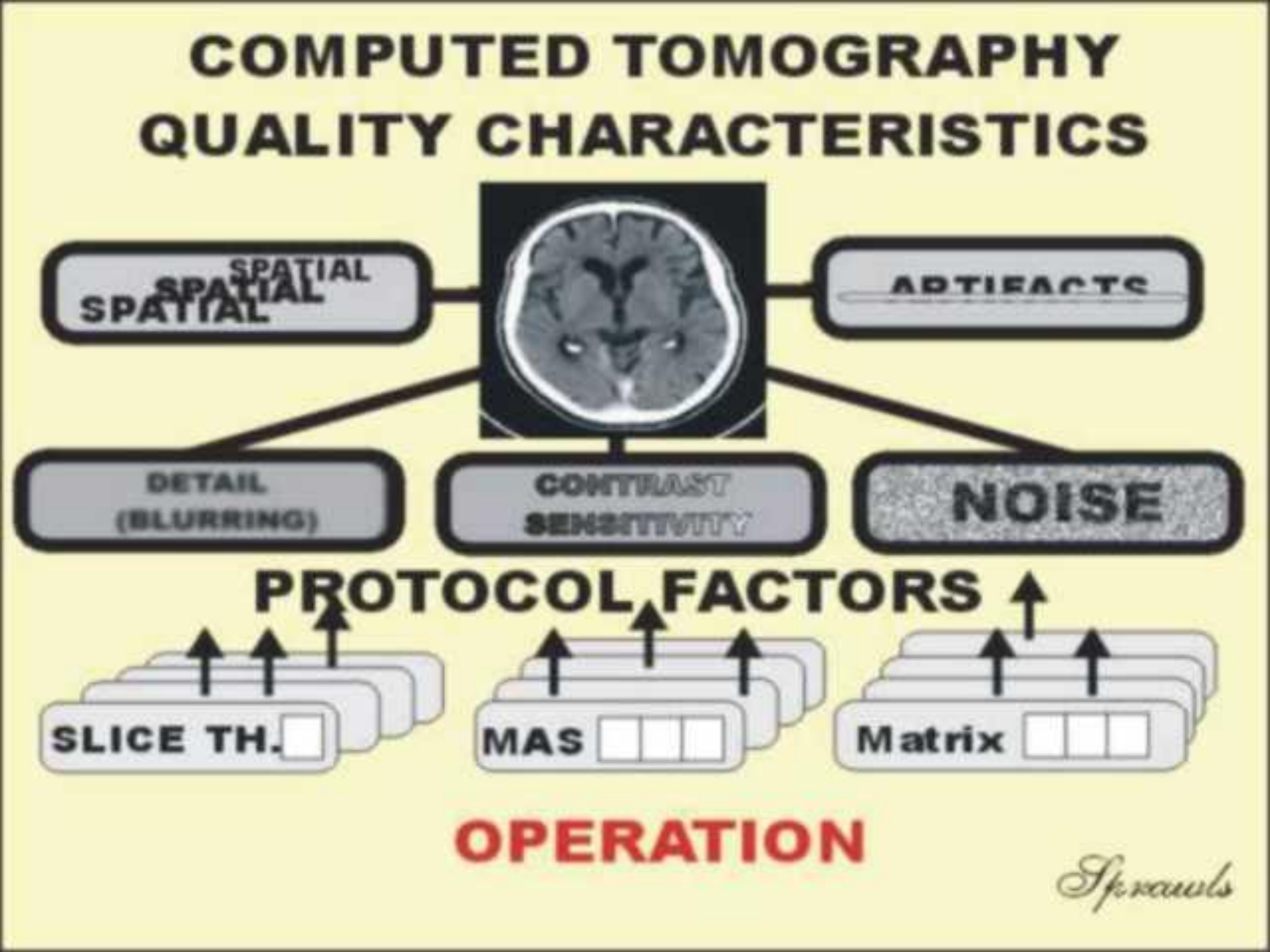
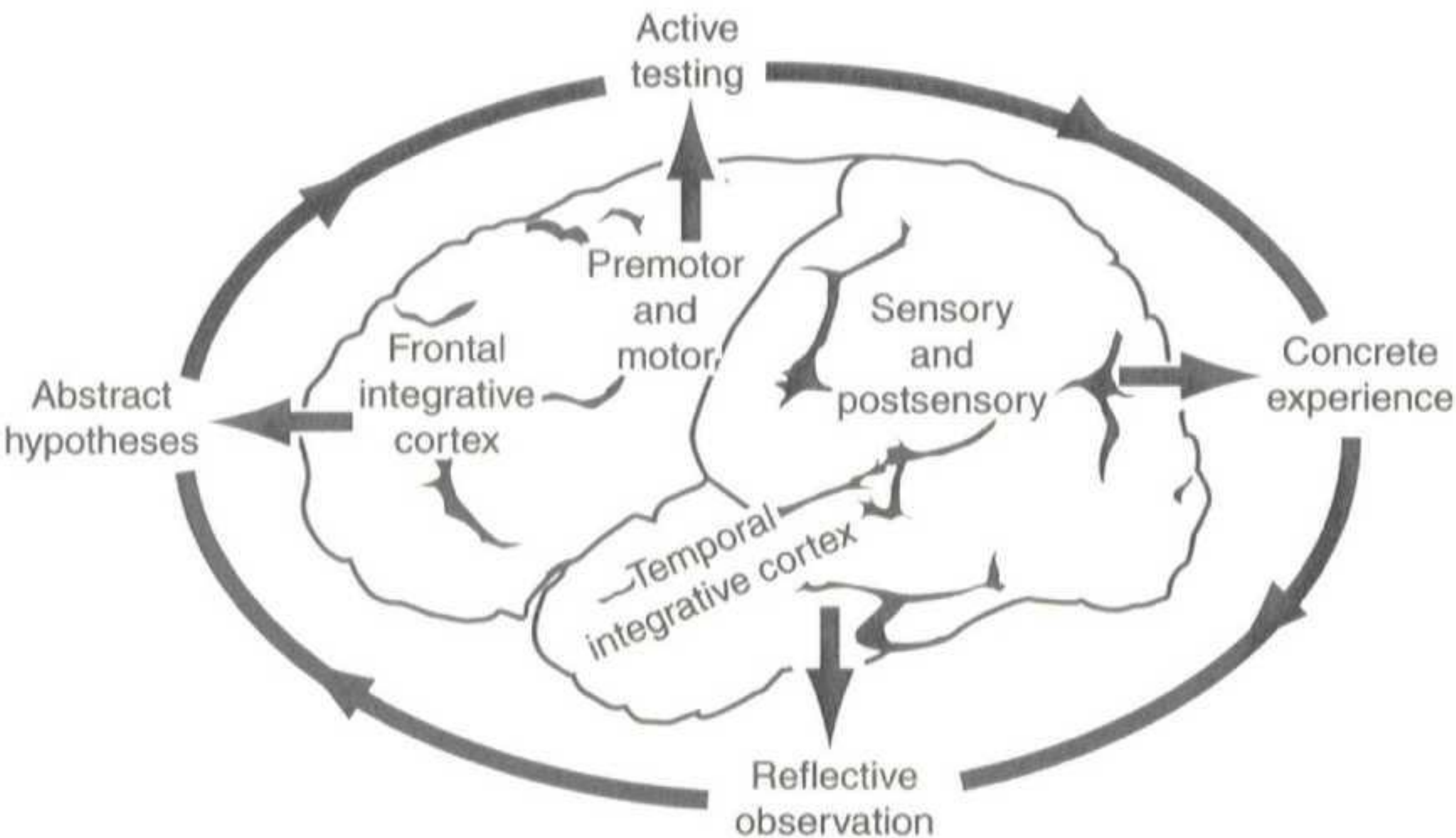
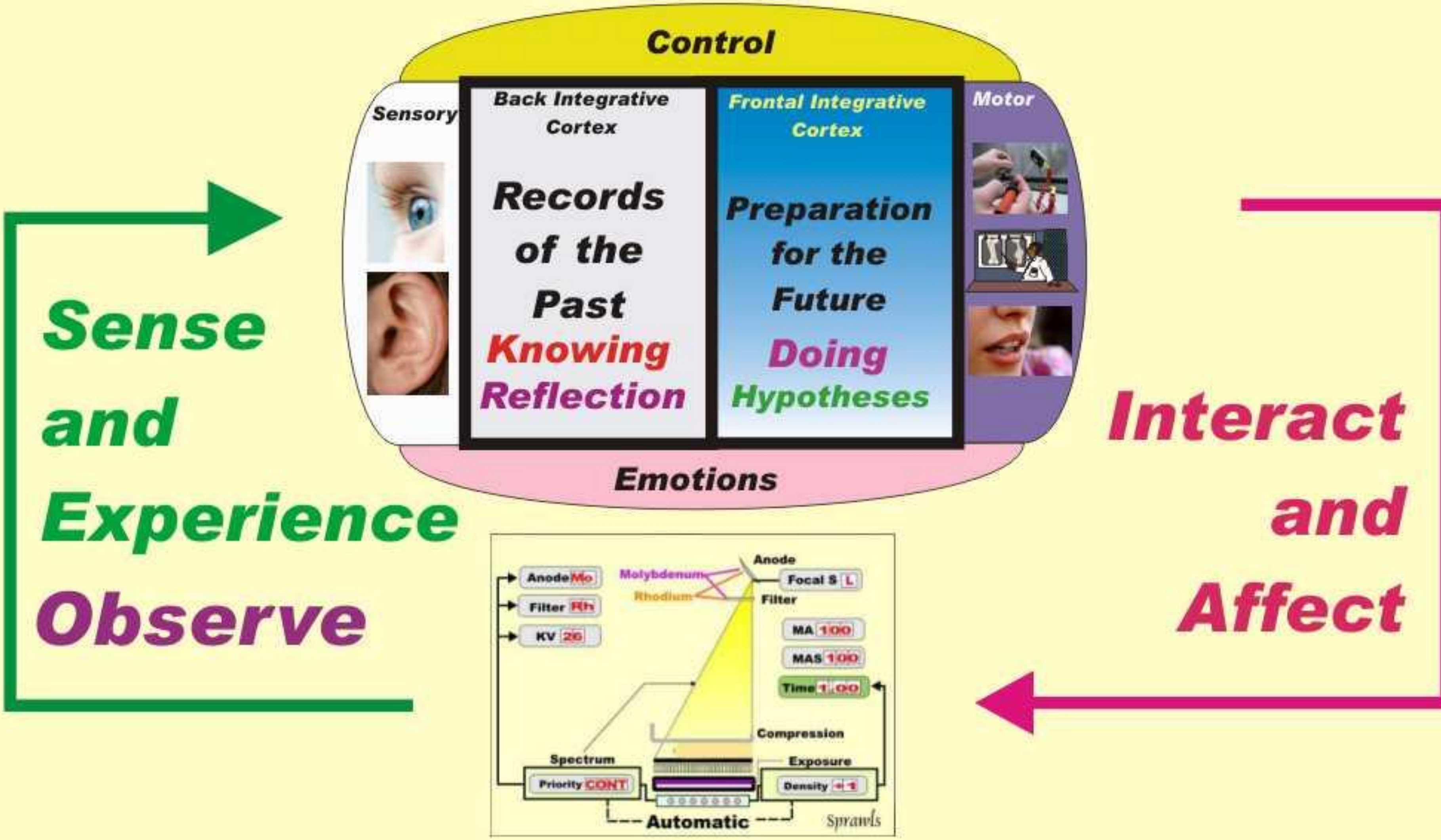

COMPUTED TOMOGRAPHY
QUALITY CHARACTERISTICS
SPATIAL
SPATIAL
SPATIAL
ARTIFACTS
DETAIL
(BLURRING)
CONTRAST
SENSITIVITY
NOISE
PROTOCOL FACTORS
SLICE TH.
MAS
Matrix
OPERATION
Sprawls

Zull's Model of Brain Function



Brain Functions for Learning Physics

Active Experimentation and Testing



Physical Universe

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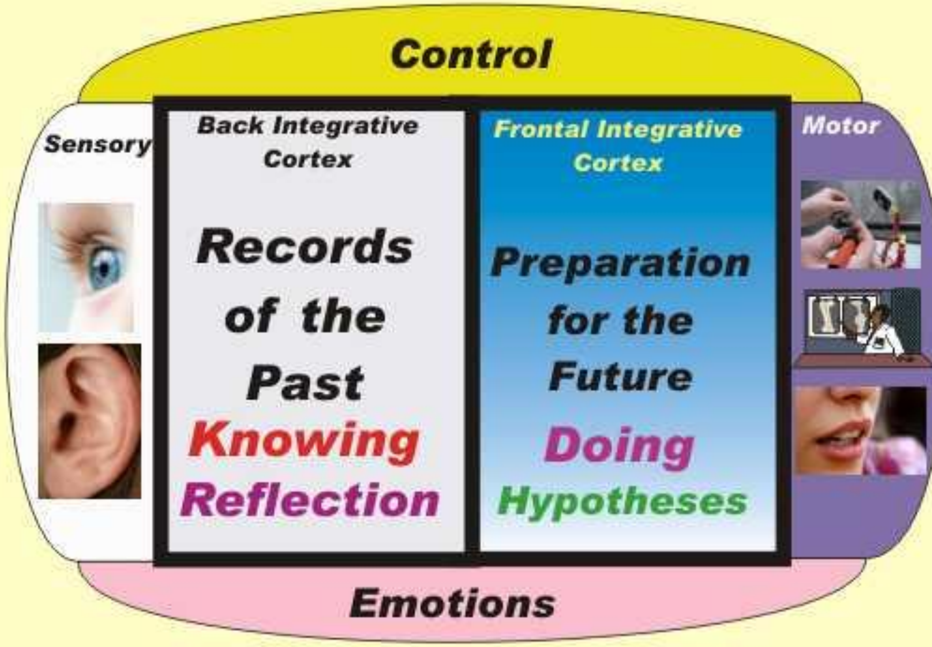
The Learning Environment



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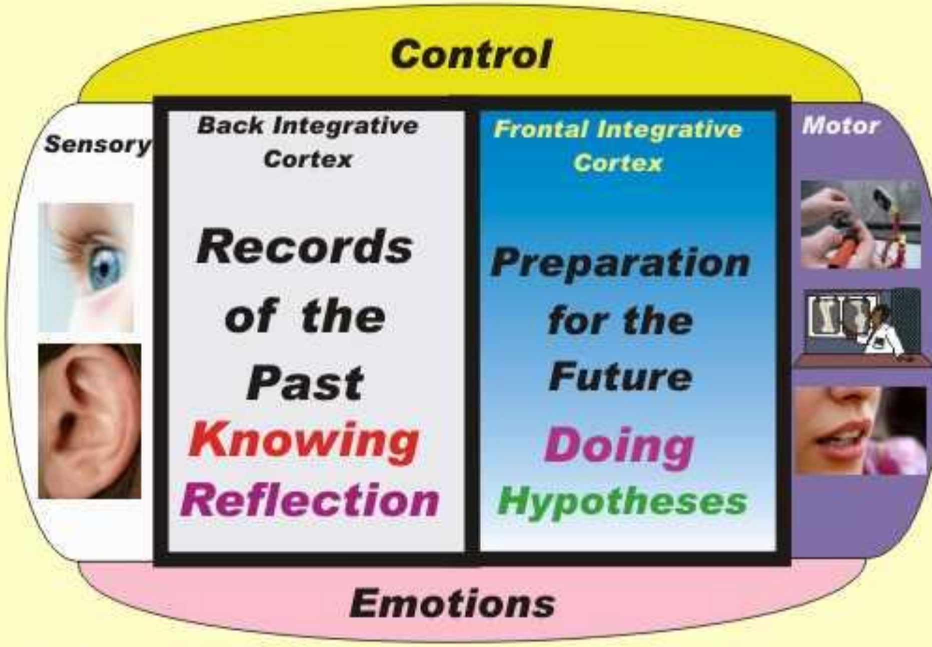
Rich Learning Environments



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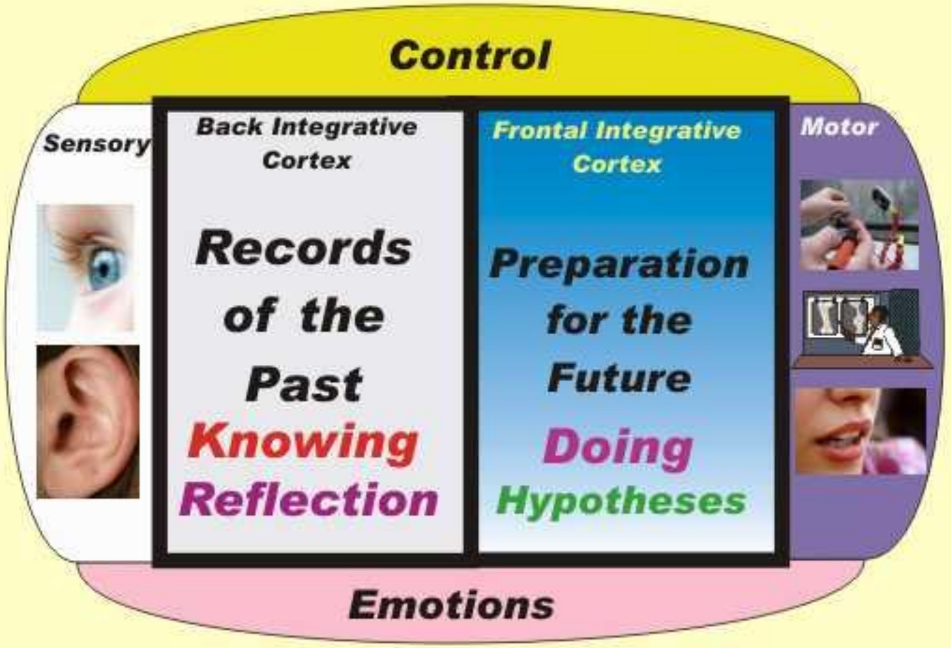
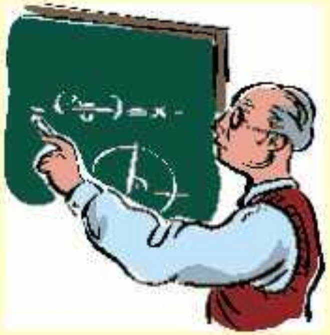
Challenging Learning Environments





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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

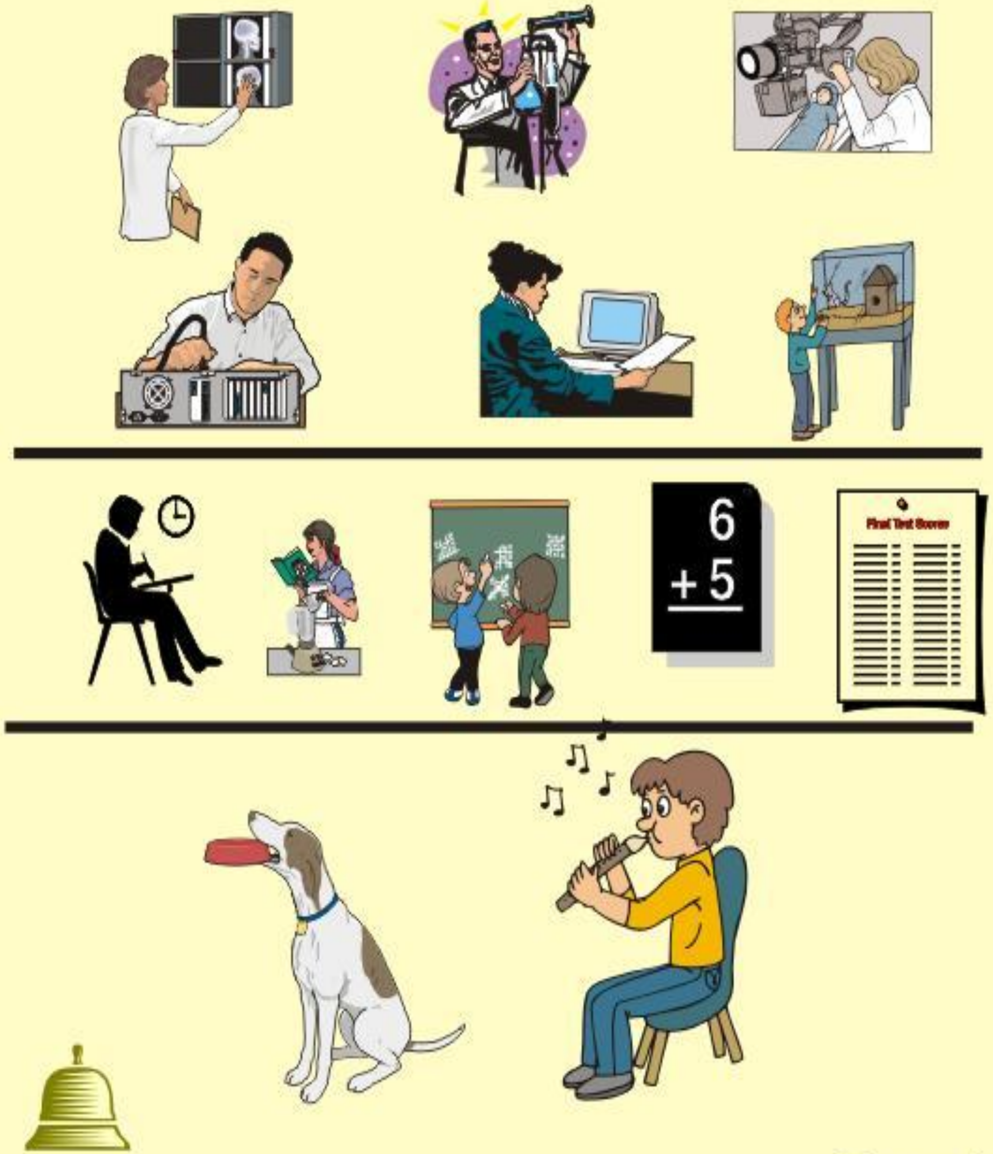
DISCRIMINATION LEARNING

VERBAL ASSOCIATION

CHAINING

STIMULUS RESPONSE

SIGNAL LEARNING



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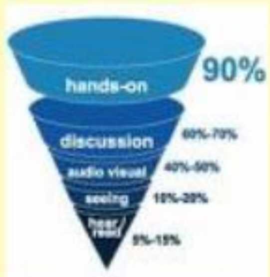
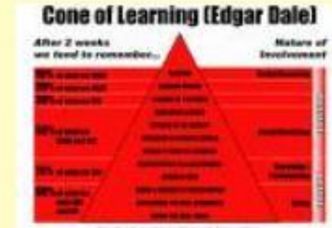
Edgar Dale (1900-1985)

Educationalist who developed the famous

Cone of Experience theory





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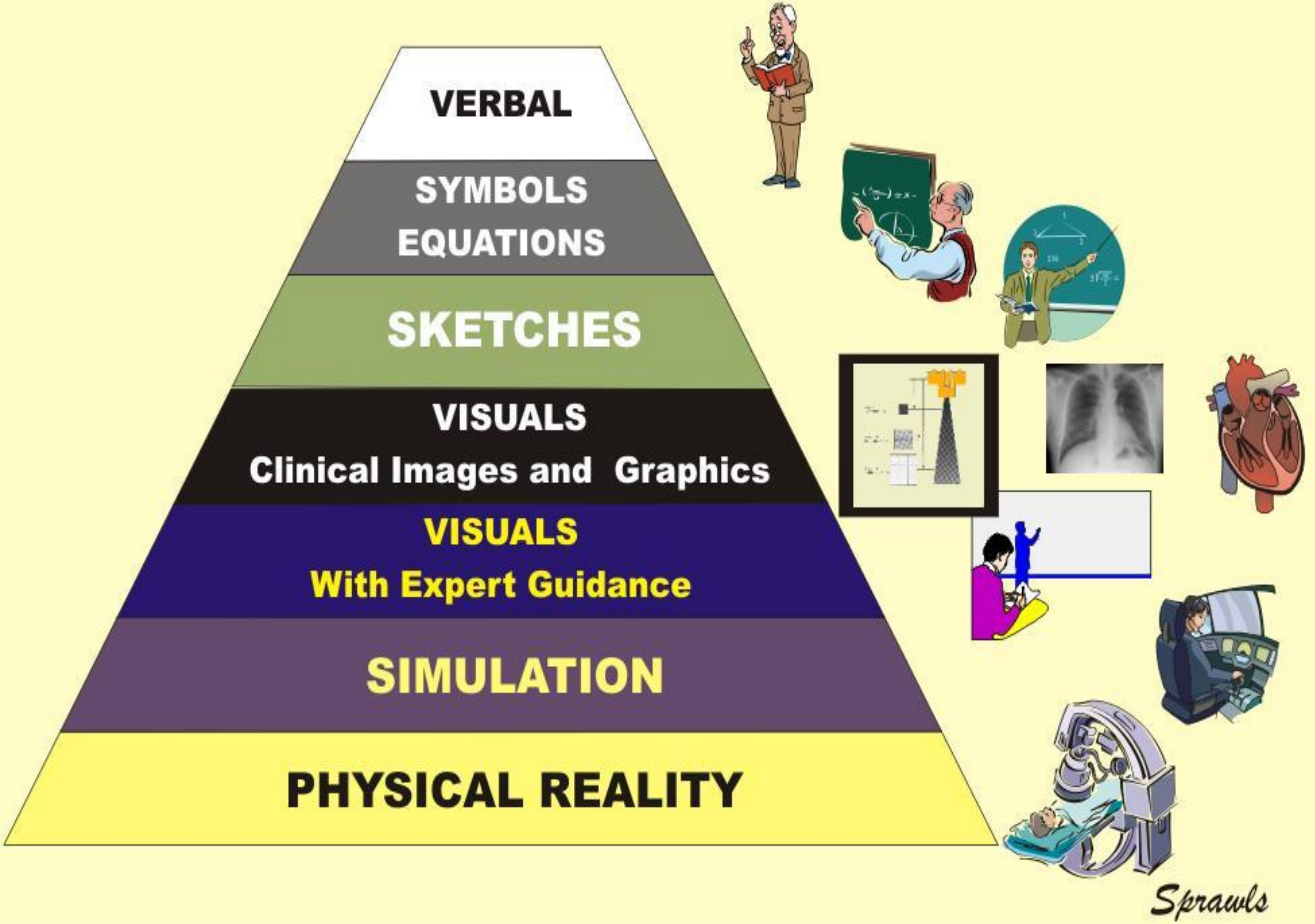
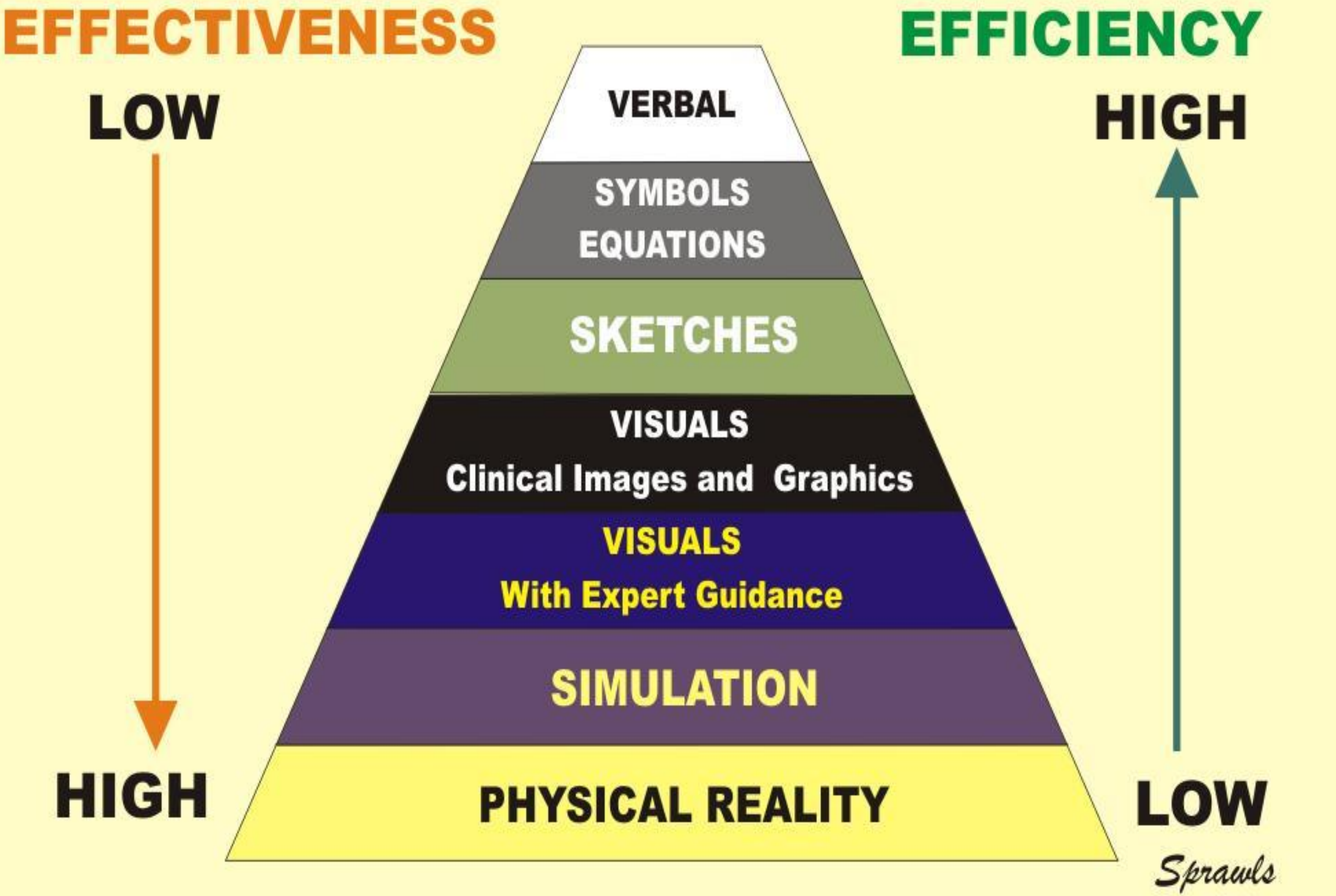
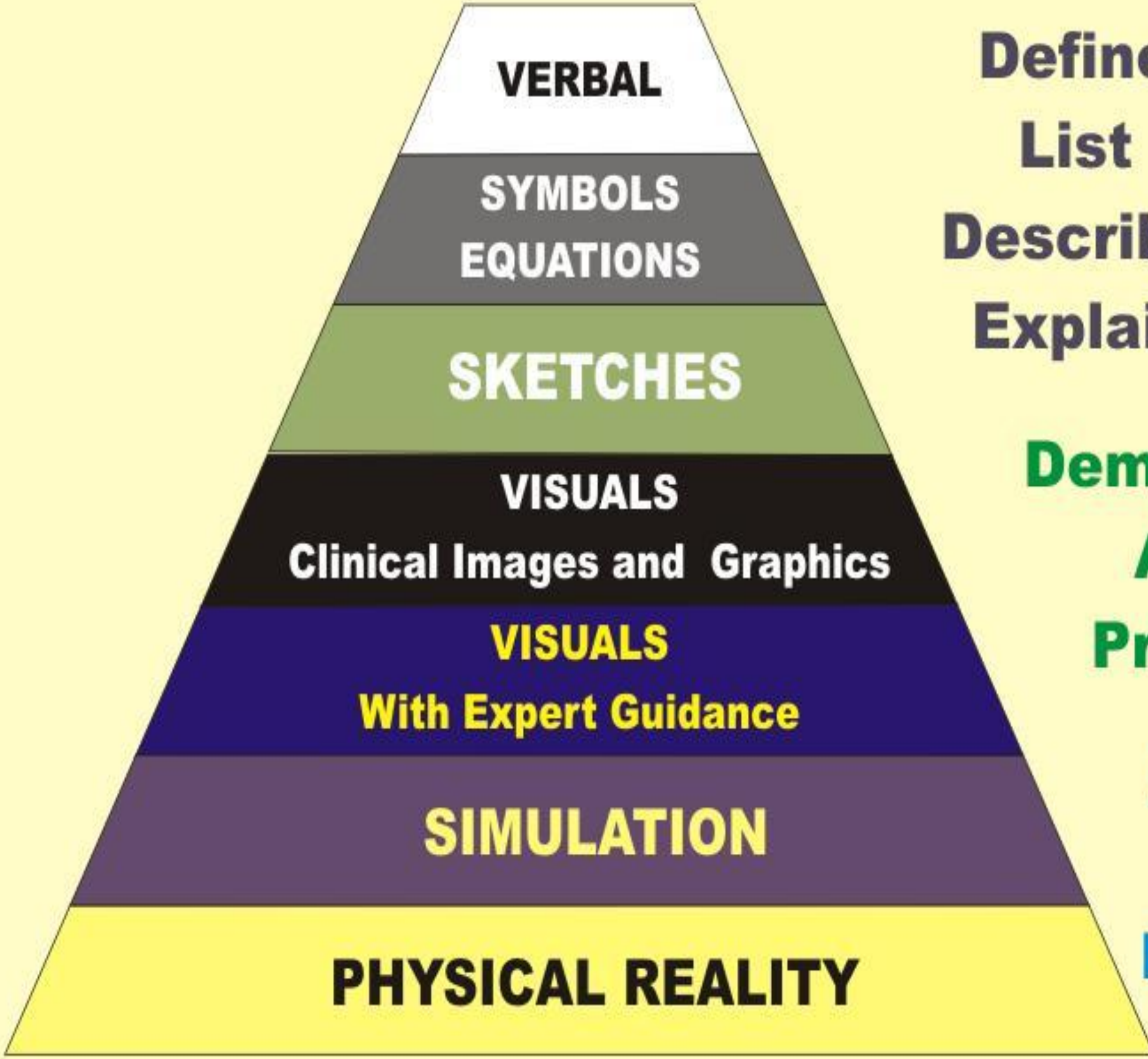
Cone of Experience for Medical Imaging Education



Cone of Experience for Medical Imaging Education



Cone of Experience for Medical Imaging Education



LEARNING OUTCOMES

Define
List
Describe
Explain



Demonstrate
Apply
Practice


Analyze
Create
Evaluate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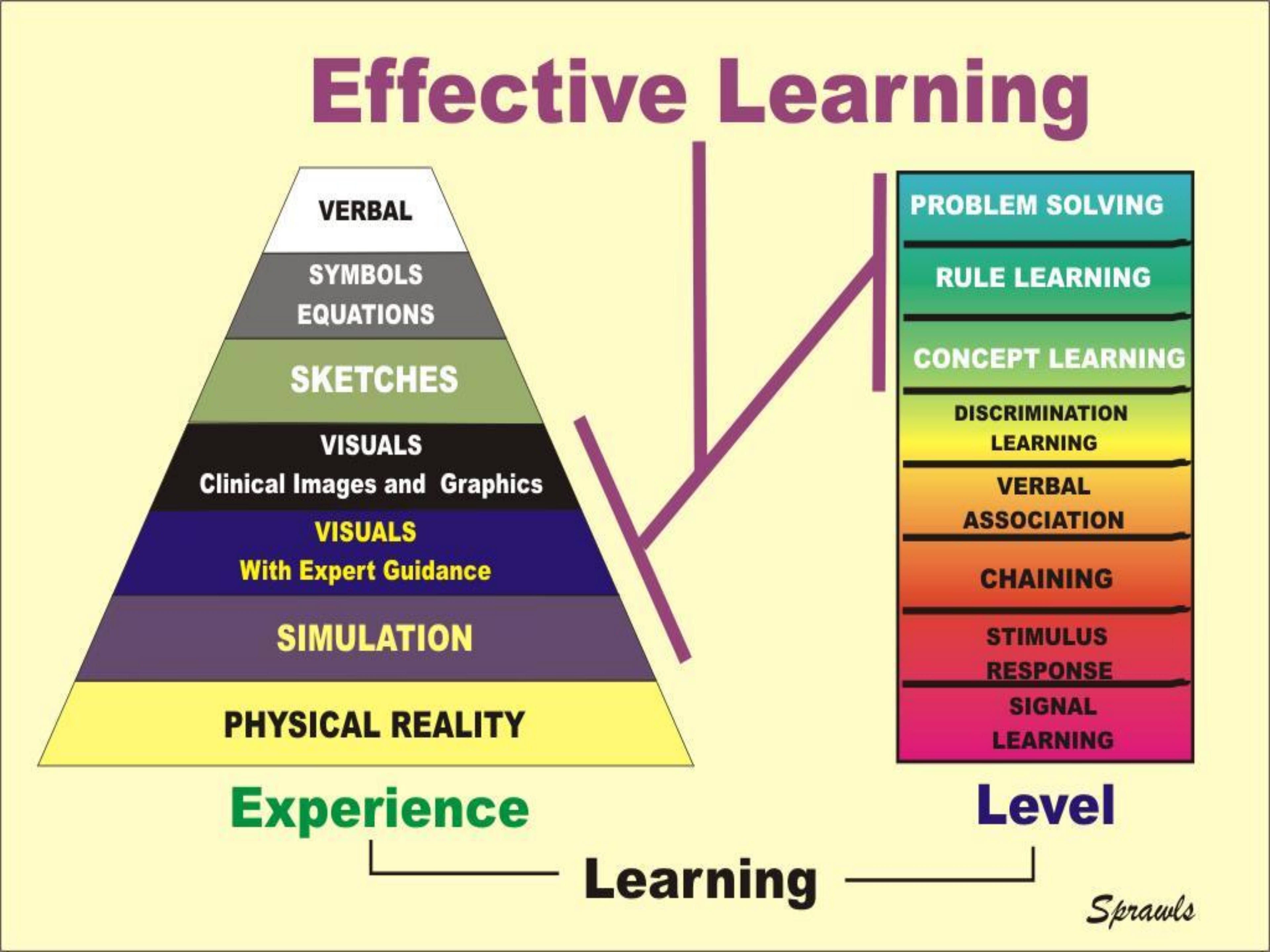
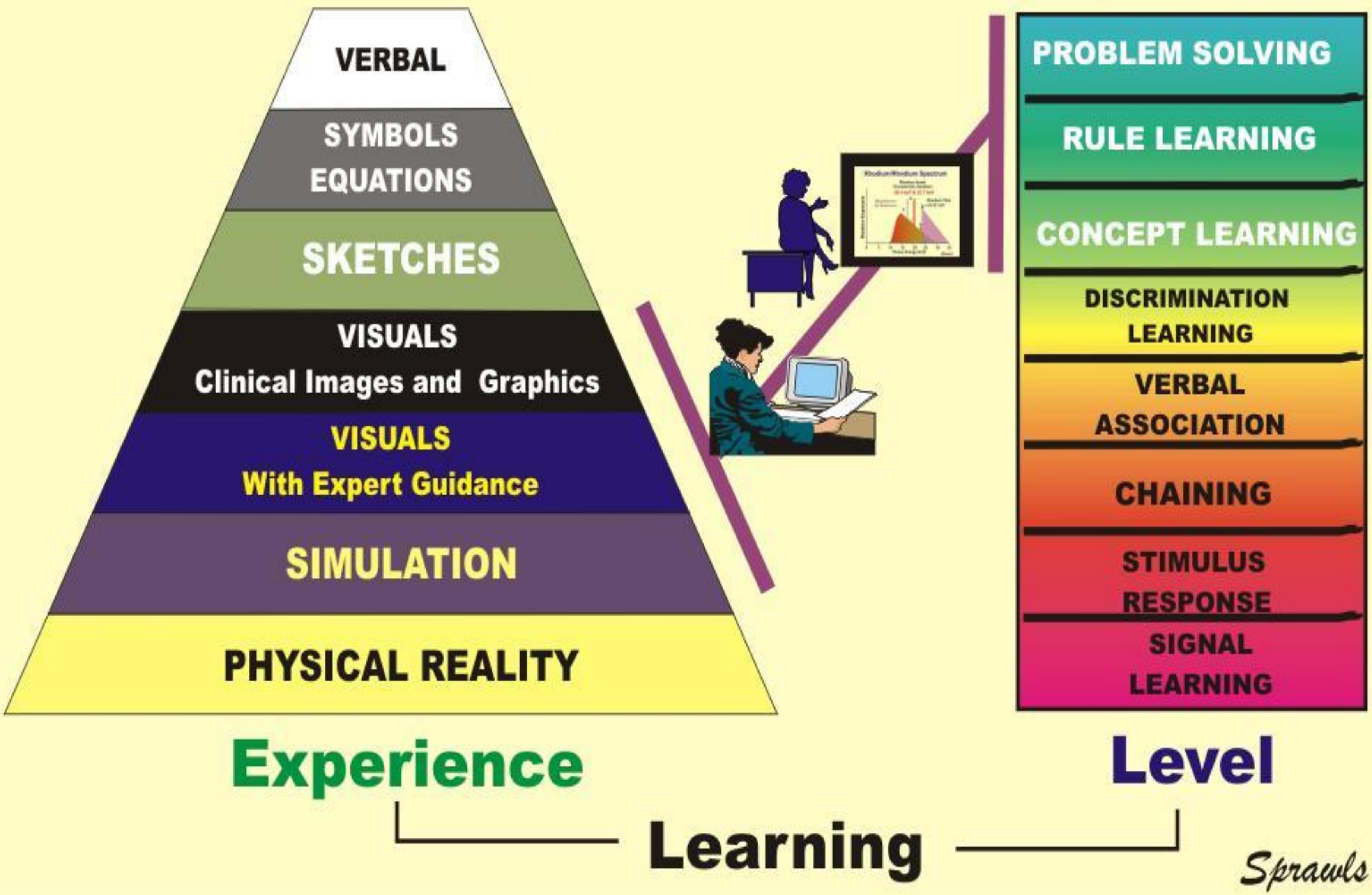


Effective Learning
VERBAL
SYMBOLS
EQUATIONS
SKETCHES
VISUALS
Clinical Images and Graphics
VISUALS
With Expert Guidance
SIMULATION
PHYSICAL REALITY
Experience
PROBLEM SOLVING
RULE LEARNING
CONCEPT LEARNING
DISCRIMINATION LEARNING
VERBAL ASSOCIATION
CHAINING
STIMULUS RESPONSE
SIGNAL LEARNING
Level
Learning
Sprawls

Technology Enhanced
Learning and Teaching



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

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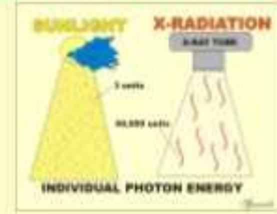
Physics Education

Images

Radiation



General Basics

Contrast
Detail
Noise
Artifacts
Spatial

Characteristics and Comparison of Modalities

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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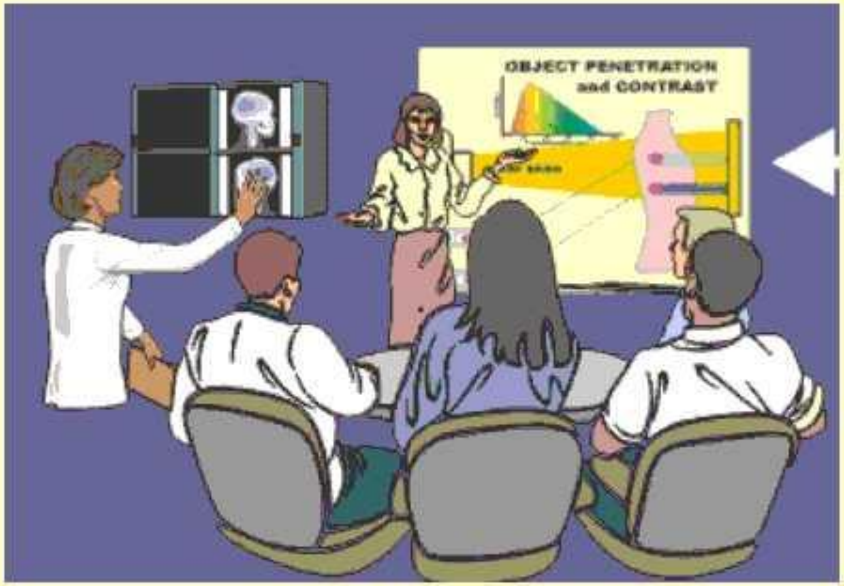
Rich Classroom and Conference Learning Activities

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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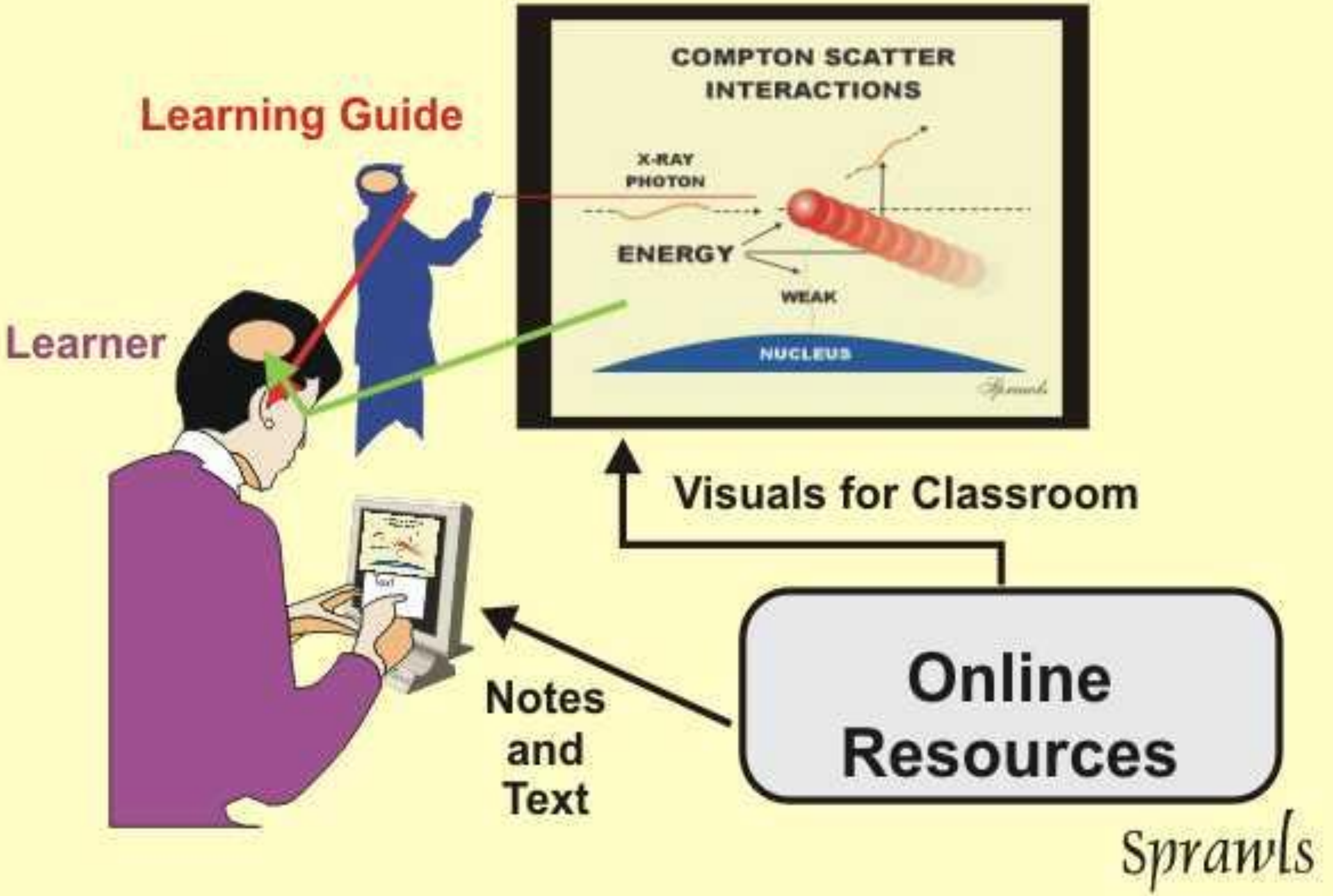
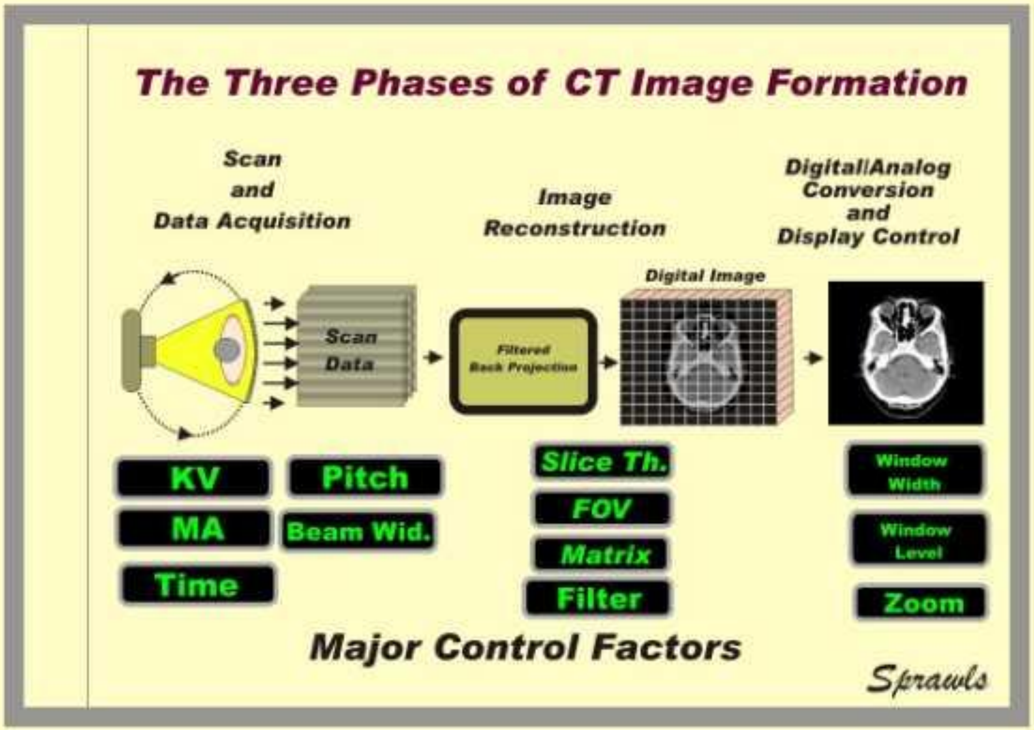
Technology Enhanced Learning

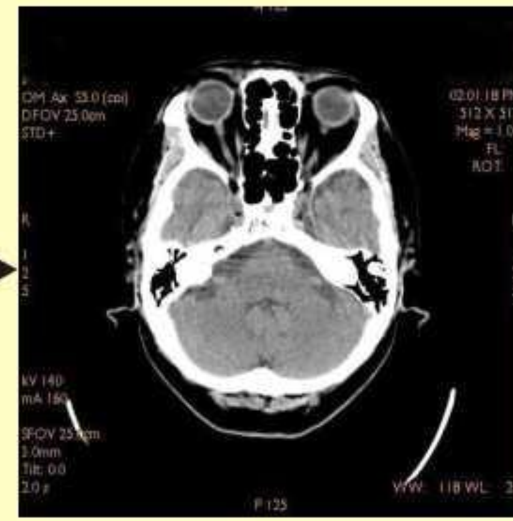


Visuals
for
Learning and Teaching

The Imaging Process



Clinical Images



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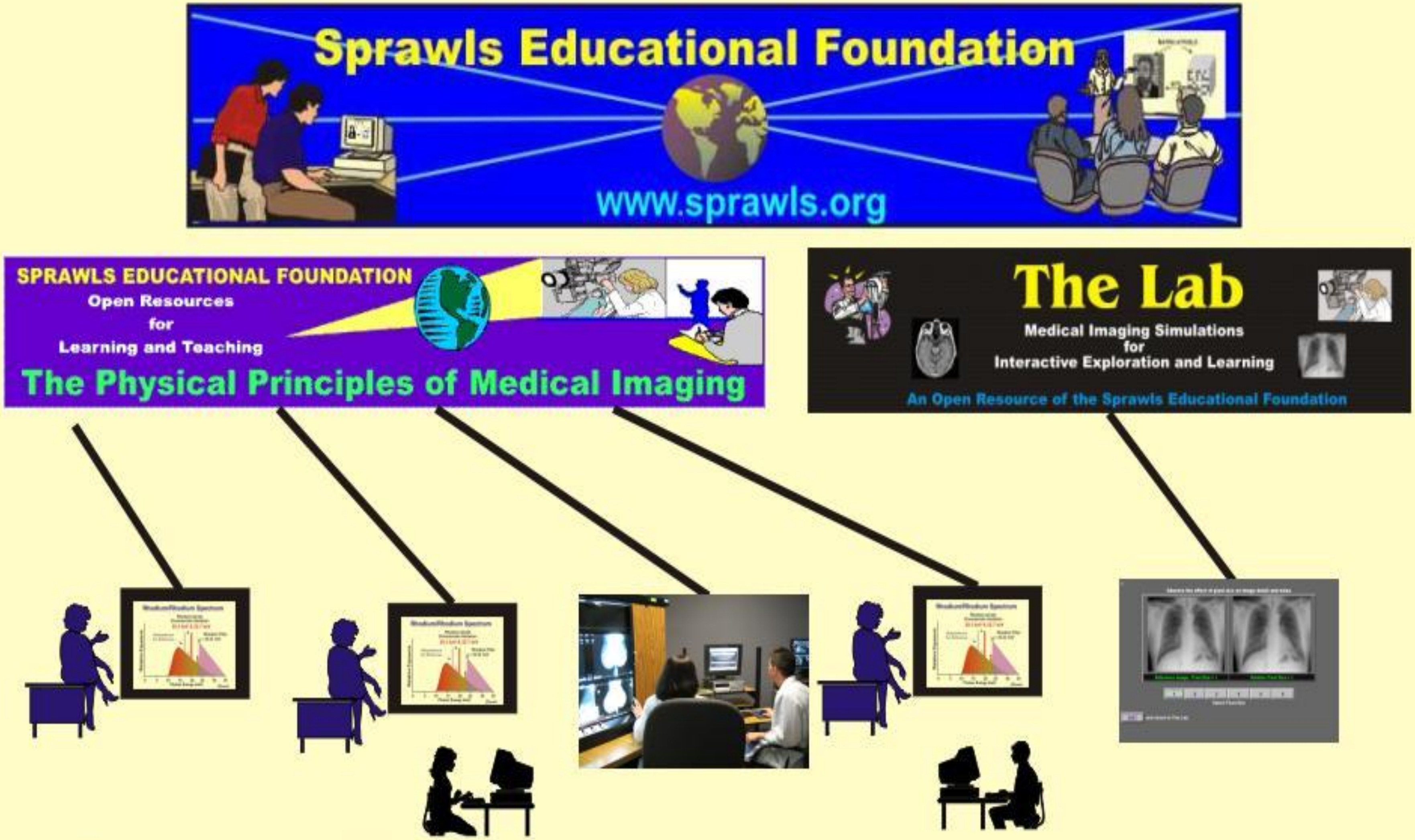
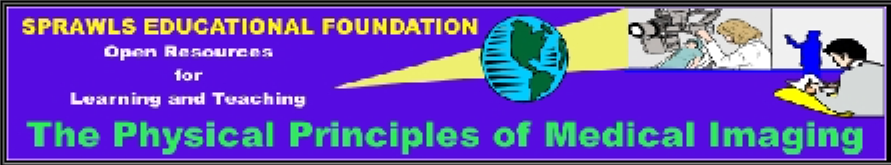


In **Partnership** with Other Medical Physics Teachers

to be More **Effective** and **Efficient** in Providing

Medical Imaging Education



Mammography Physics and Technology

for effective clinical imaging

Perry Sprawls, Ph.D.

To step through module, CLICK HERE.

To go to a specific topic click on it below

Imaging Objectives	Rhodium Anode	Blurring and Visibility of Detail
Visibility of Pathology	KV Values for Mammography	Focal Spot Blurring
Image Quality Characteristics	Scattered Radiation and Contrast	Receptor Blurring
Not a Perfect Image	Image Exposure Histogram	Composite Blurring
Mammography Technology	Receptor & Display Systems	Magnification Mammography
Imaging Technique Factors	Film Contrast Transfer	Mean Glandular Dose
Contrast Sensitivity	Film Contrast Factors	
Physical Contrast Compared	Film Design for Mammography	
Factors Affecting Contrast Sensitivity	Controlling Receptor (Film) Exposure	
X-Ray Penetration and Contrast	Film Processing	
Optimum X-Ray Spectrum	Variations in Receptor Sensitivity	
Effect of Breast Size	Film Viewing Conditions	

Mammography Physics and Technology
for effective clinical imaging
Perry Sprawls, Ph.D.
To step through module, CLICK HERE.
To go to a specific topic click on it below

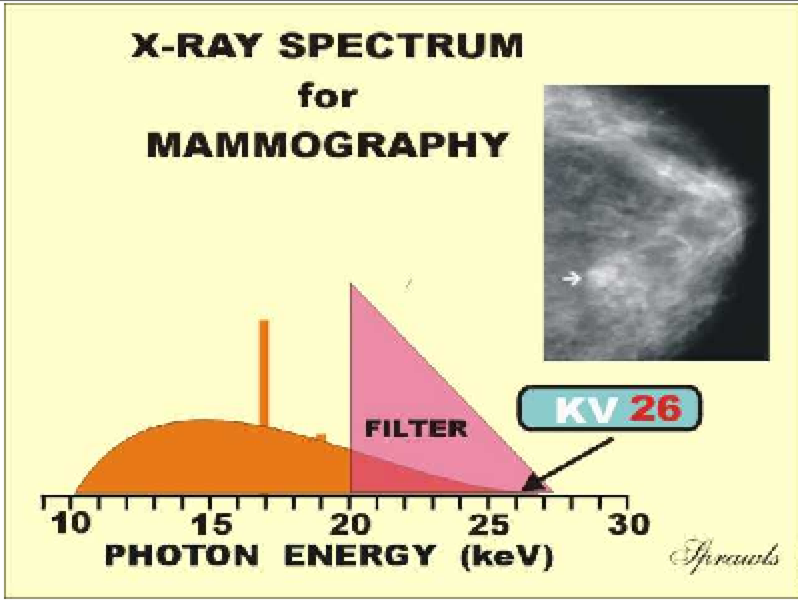

PLANAR
BACK
NEXT
Visibility
Depends on
Image Quality

KV Values for Mammography

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

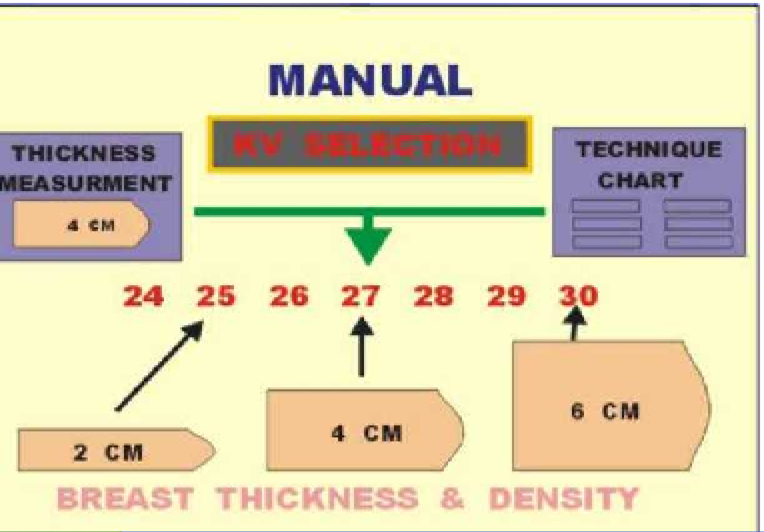
e can think of it as a three-step procedure:

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 d output for a specific MAS value and it shifts the photon energy spectrum ward so that the beam becomes more penetrating.

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

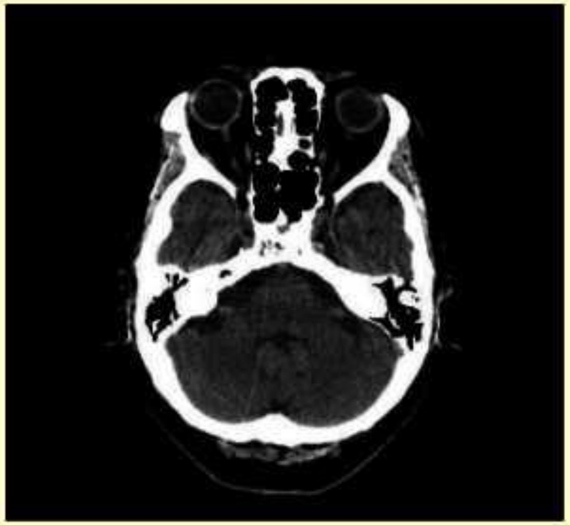


Mammography systems have indicators that display the thickness of the compressed breast. This along with a general assessment of breast density is used to manually select an optimum KV either from experience or an established technique chart.

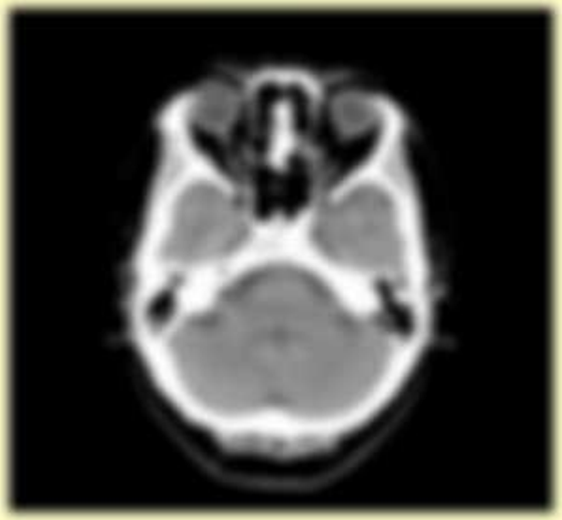
The general goal is to increase the KV as necessary to keep the exposure time, MAS, and dose to the breast within reasonable limits as breast thickness increases.

CT Image Characteristics

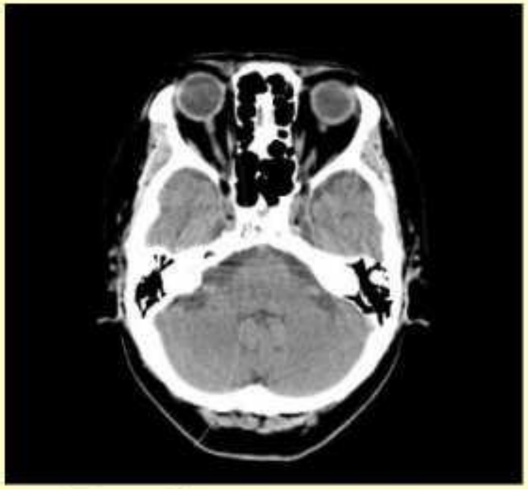
A



B



C

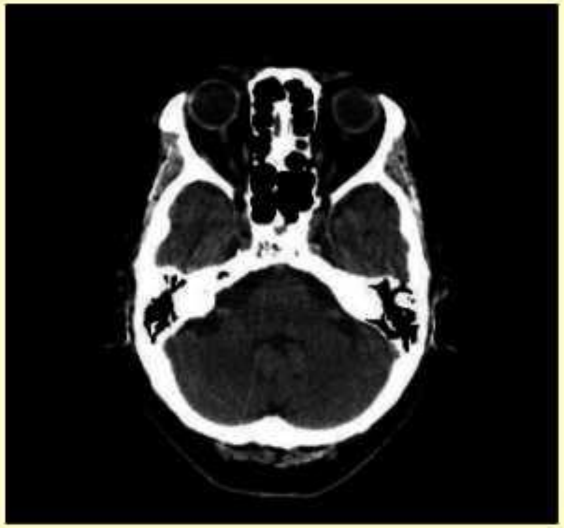


Reference

Sprawls

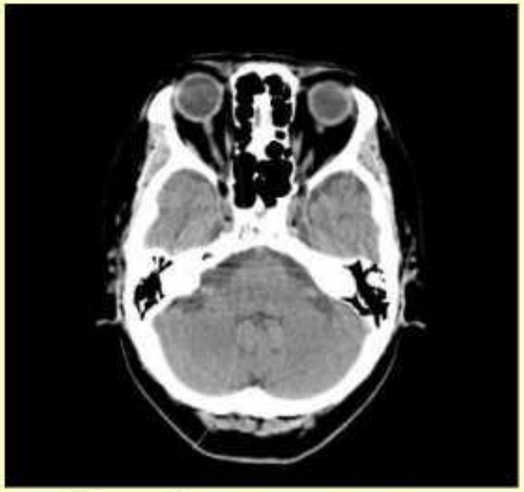
CT Image Characteristics

Contrast



Detail

Noise

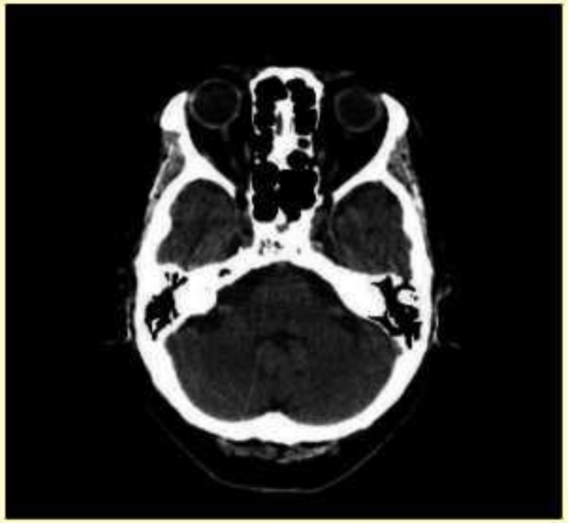


Reference

Sprawls

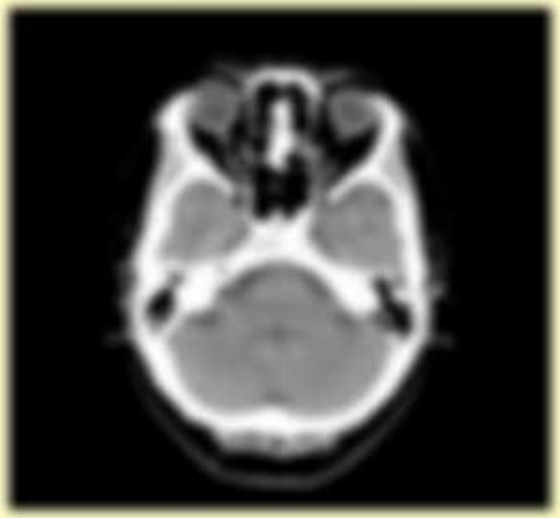
CT Image Characteristics

Contrast



Same

Detail

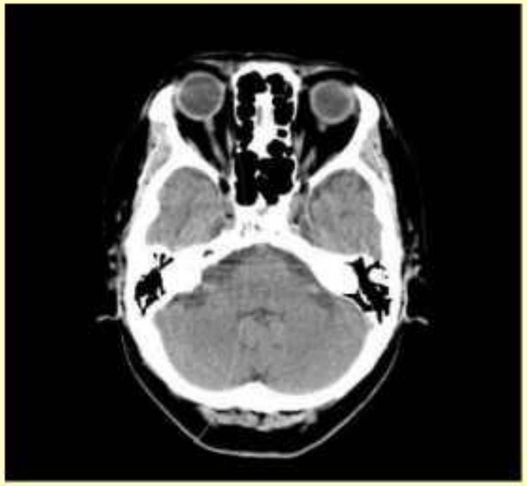


Low

Noise

Low

Reference

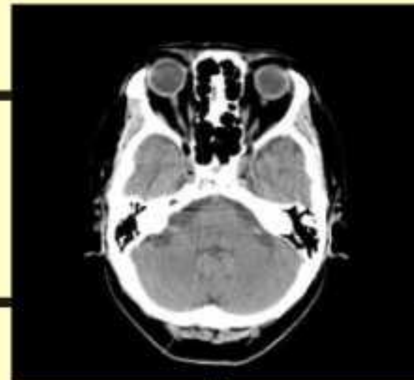


Sprawls

CT Image Characteristics

Spatial

Detail



Artifacts

Noise

Contrast Sensitivity

KV

MA

Time

Pitch

Beam Wid.

Filter

Slice Th.

FOV

Matrix

Window Width

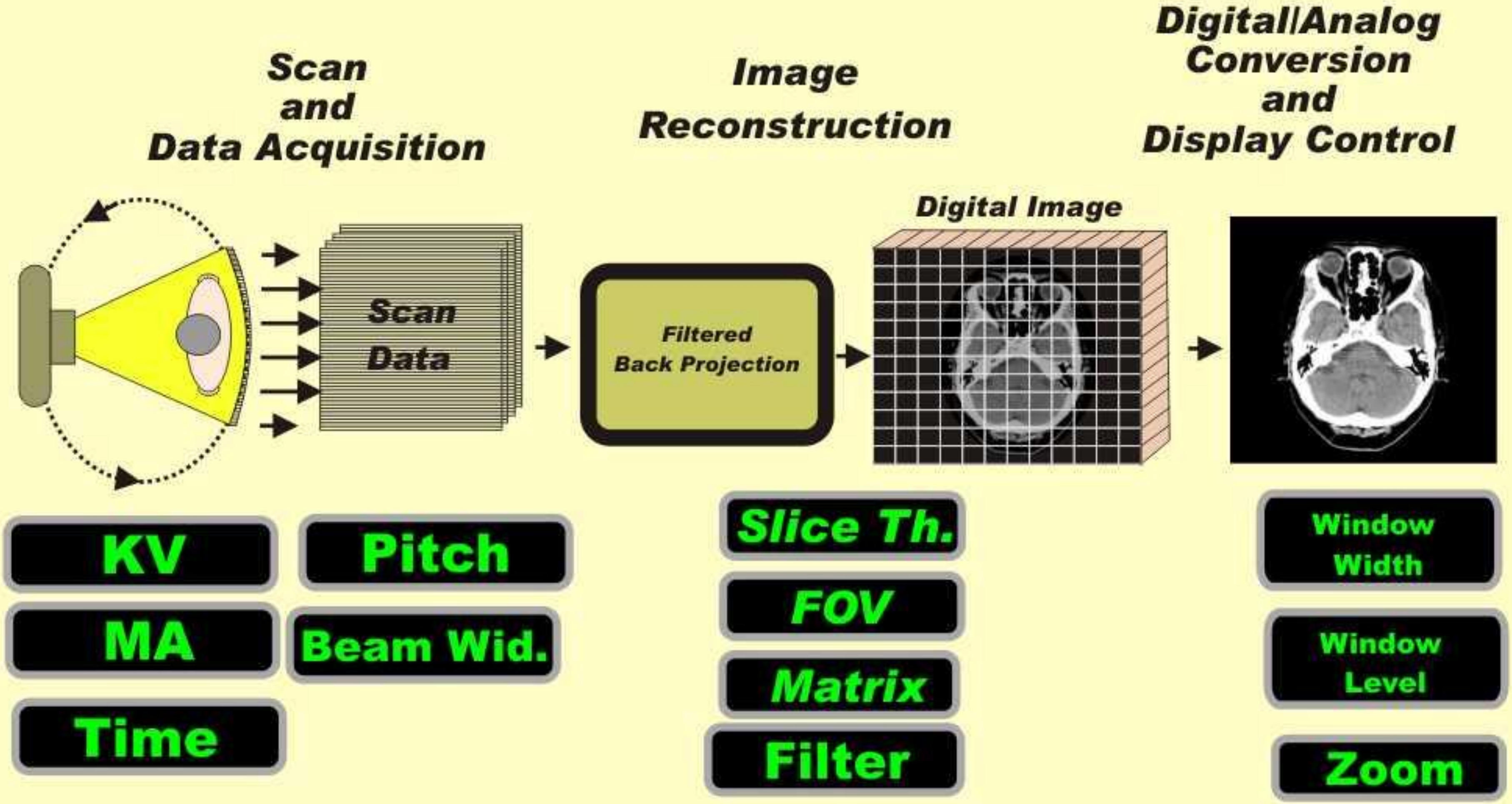
Window Level

Zoom

Major Protocol Factors

Sprawls

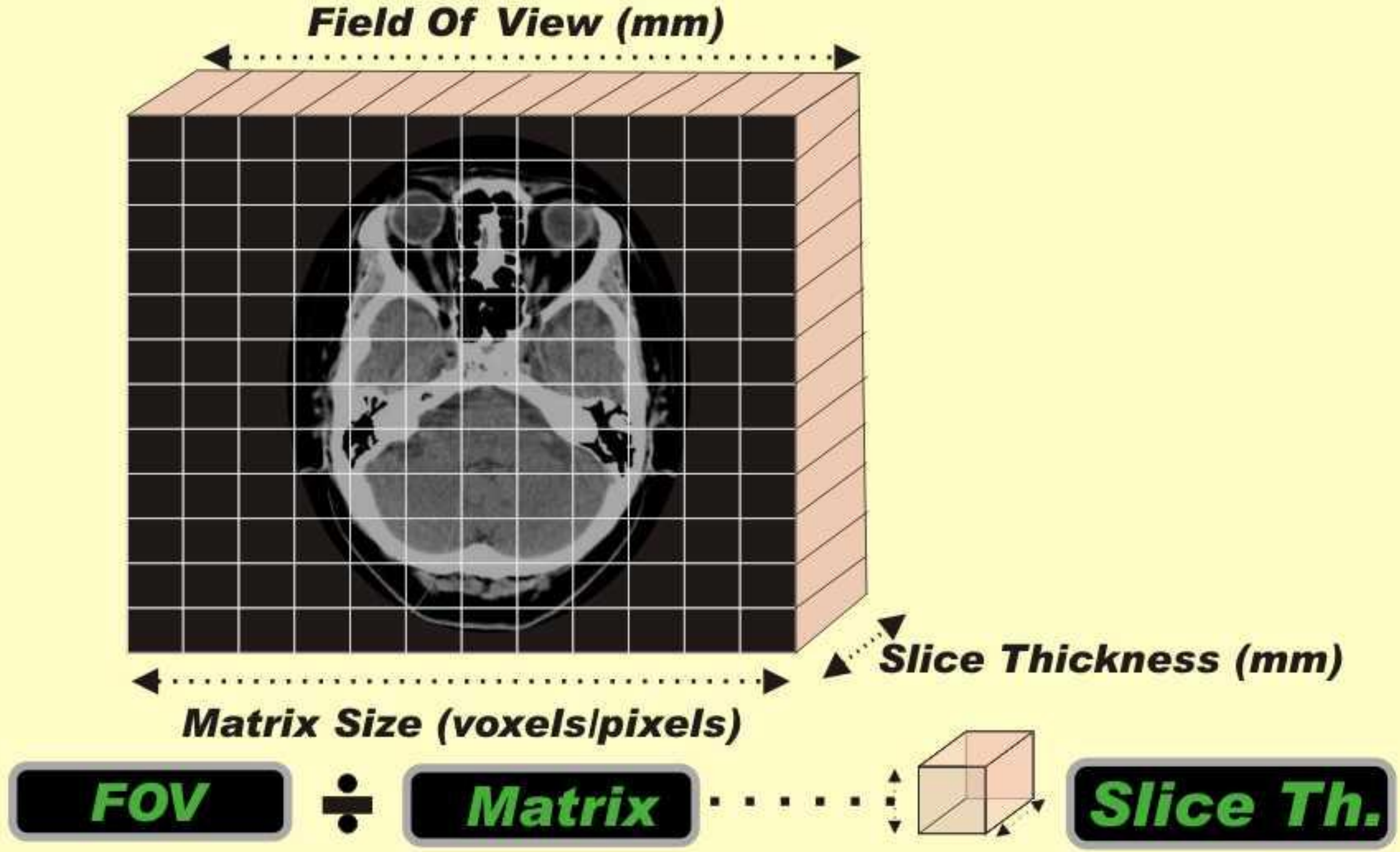
The Three Phases of CT Image Formation



Major Protocol Factors

Sprawls

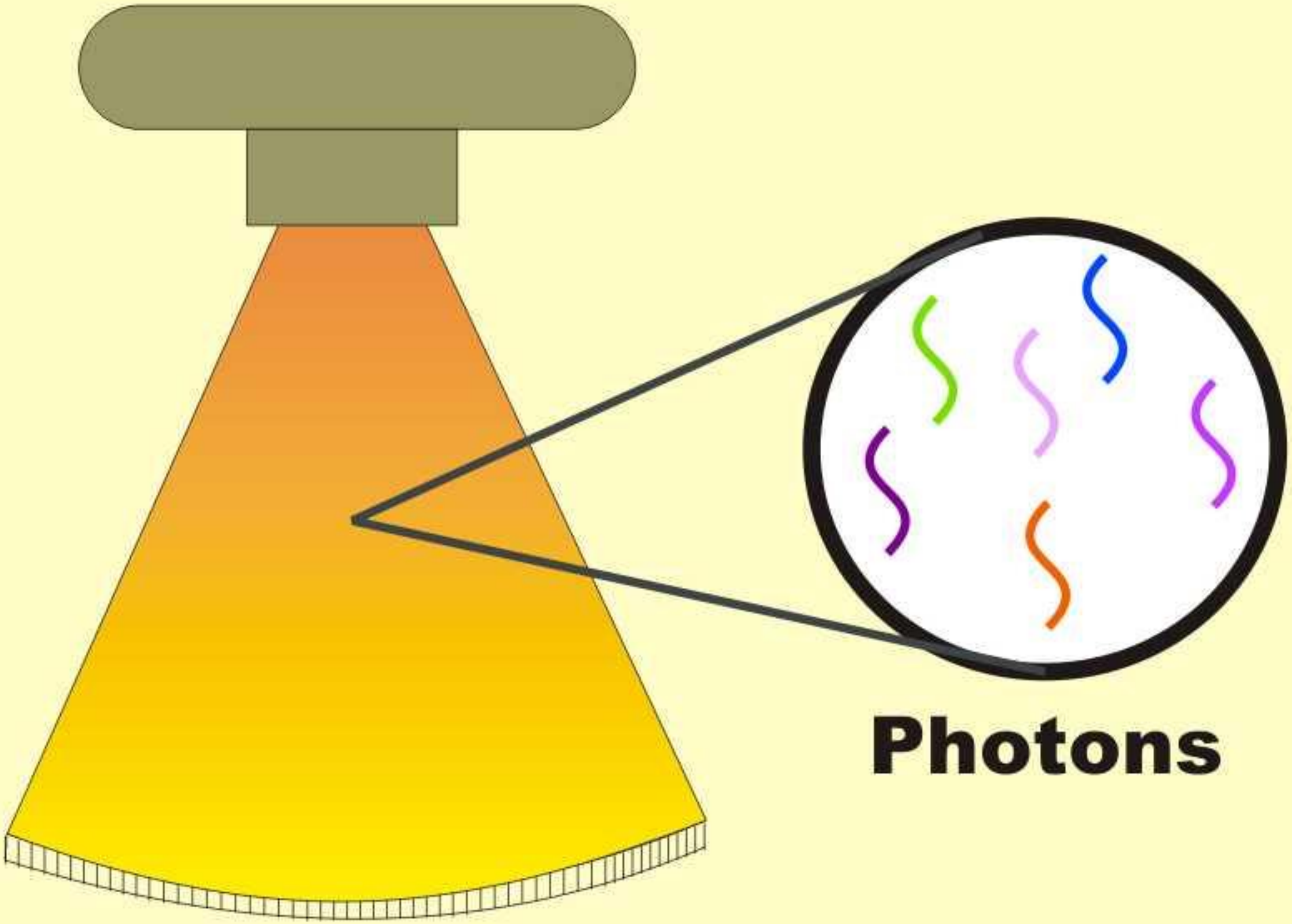
CT Slice Divided into Matrix of Voxels



Voxel Size Controlled By

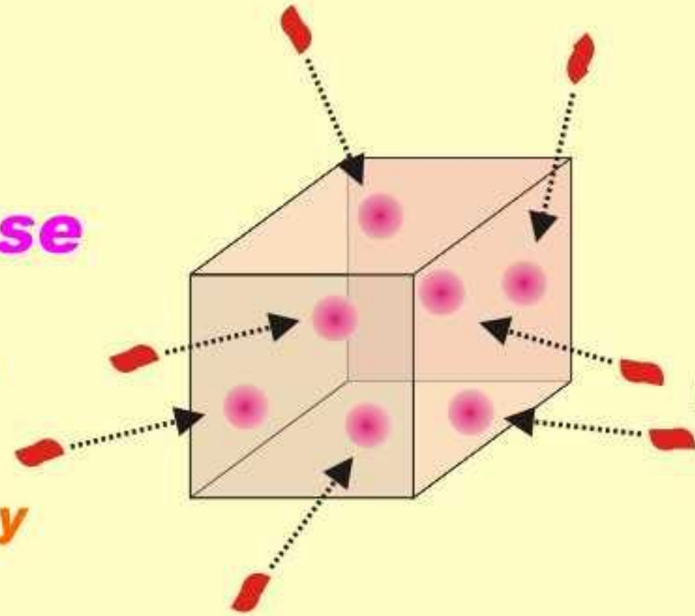
Sprawls

The Quantum Structure of the X-ray Beam



Sprawls

X-ray Photons Interact With Tissue in A Voxel



Radiation Dose

determined by

Concentration

of

Absorbed Energy

per voxel

Image Noise

determined by

Number of Photons

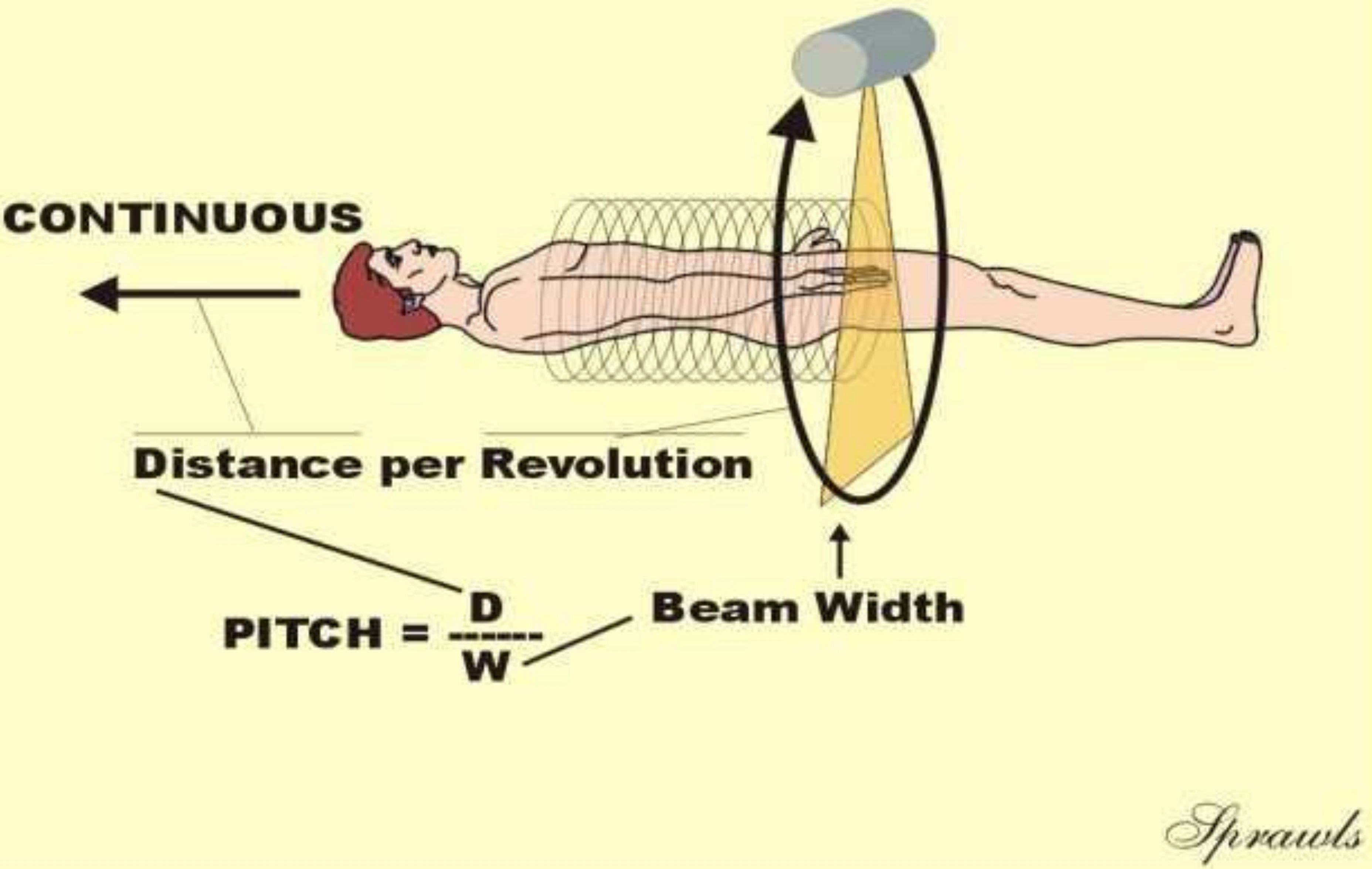
per voxel

Dose is increased
by
increasing number
of photons.

Noise is reduced
by
increasing number
of photons.

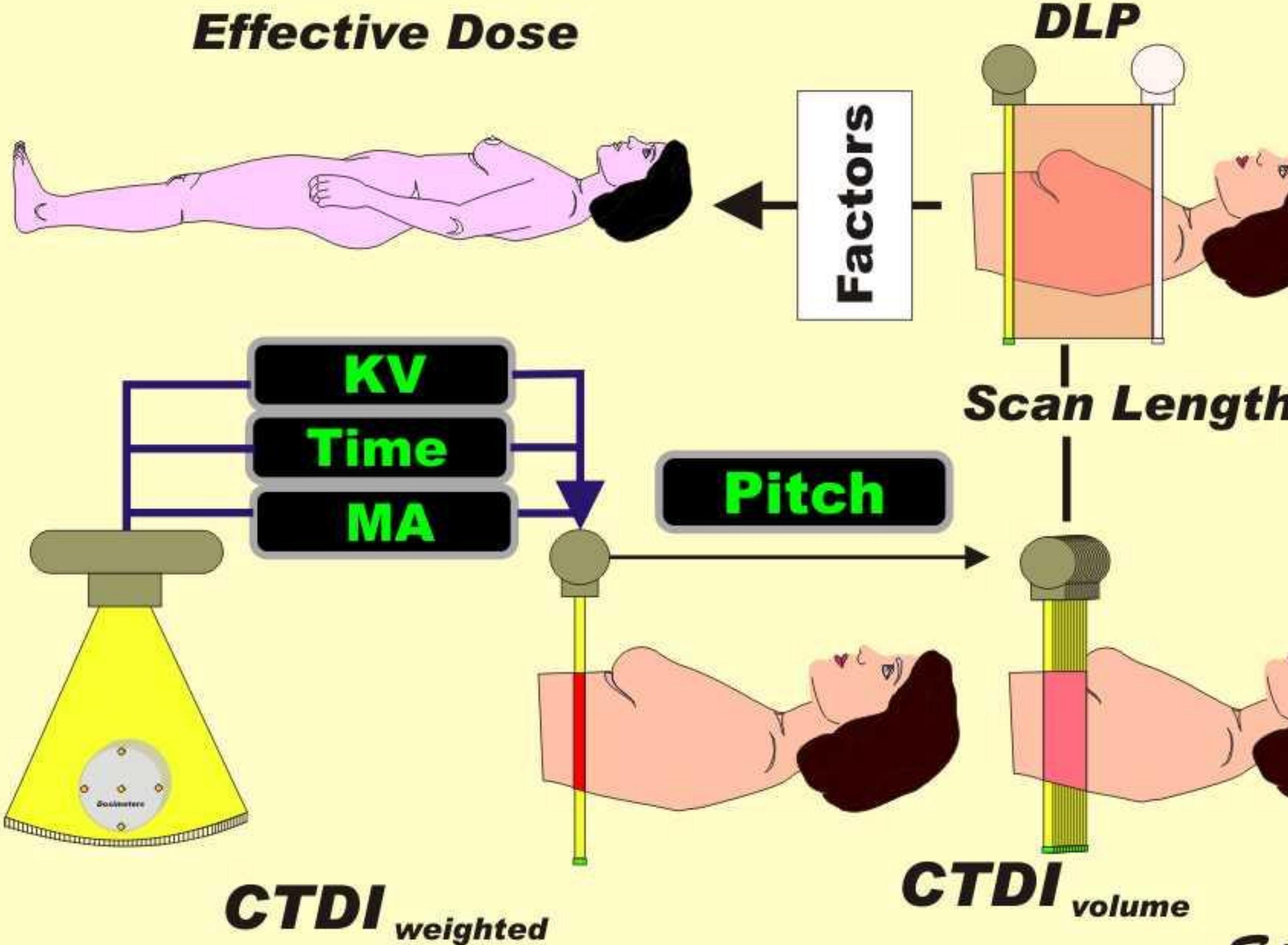
Sprawls

SPIRAL SCAN



CONTINUOUS
Distance per Revolution
Beam Width
PITCH = D / W
Sprawls

CT Dose Quantities



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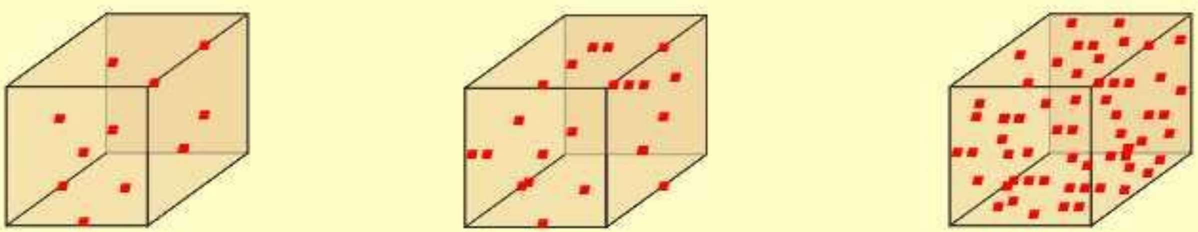
Decreasing Noise

Requires Increased Photons Absorbed Per Voxel



Produces Increasing Dose

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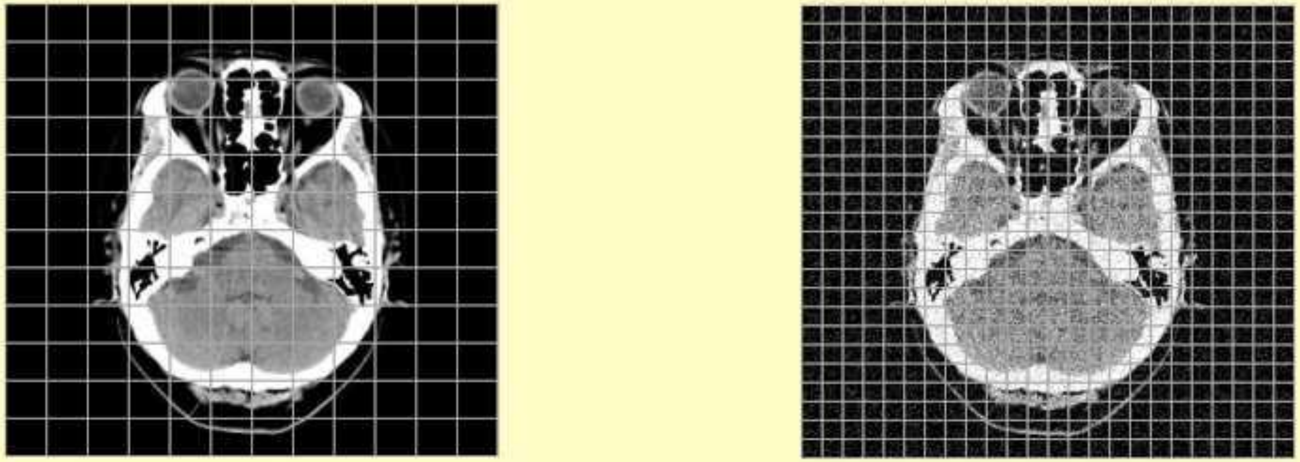
Effect of Matrix Size on Image Noise

Small **Matrix** Large



The same radiation dose for both images.

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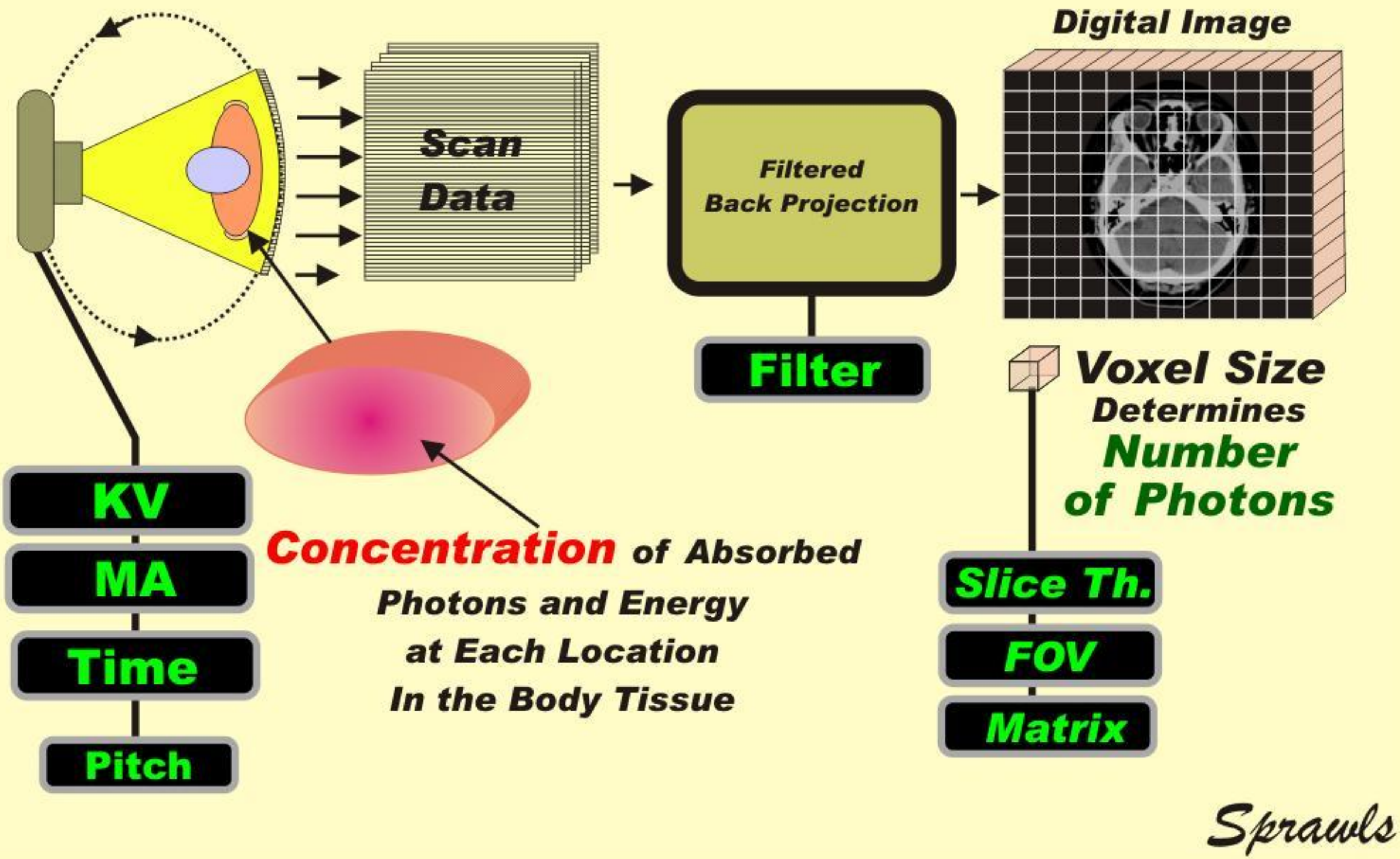
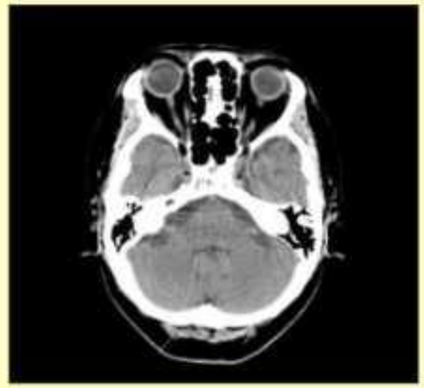
Factors That Determine Image Noise



Two Major Image Quality Goals

High Detail



Low Noise

Small — **Voxel Size** — **Large**

FOV | ***Matrix*** | ***Slice Th.***

Protocol Factors

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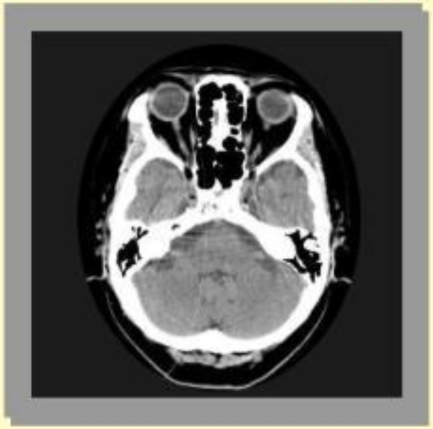
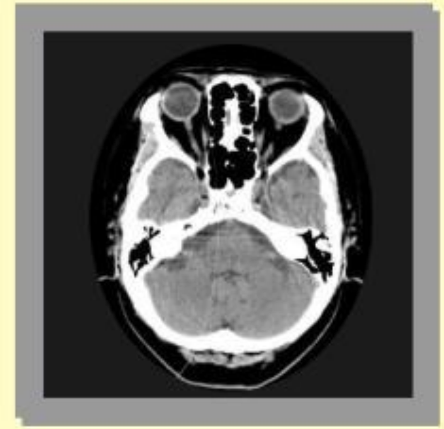
Relationship of Radiation Dose to Image Detail

Lower Dose



Higher Dose



When detail is increased by

Decreasing **Slice Th.**

Increasing **Matrix**

Decreasing **FOV**

Noise Increases

Because of decreased voxel size

Dose must be **increased** to **reduce noise.**

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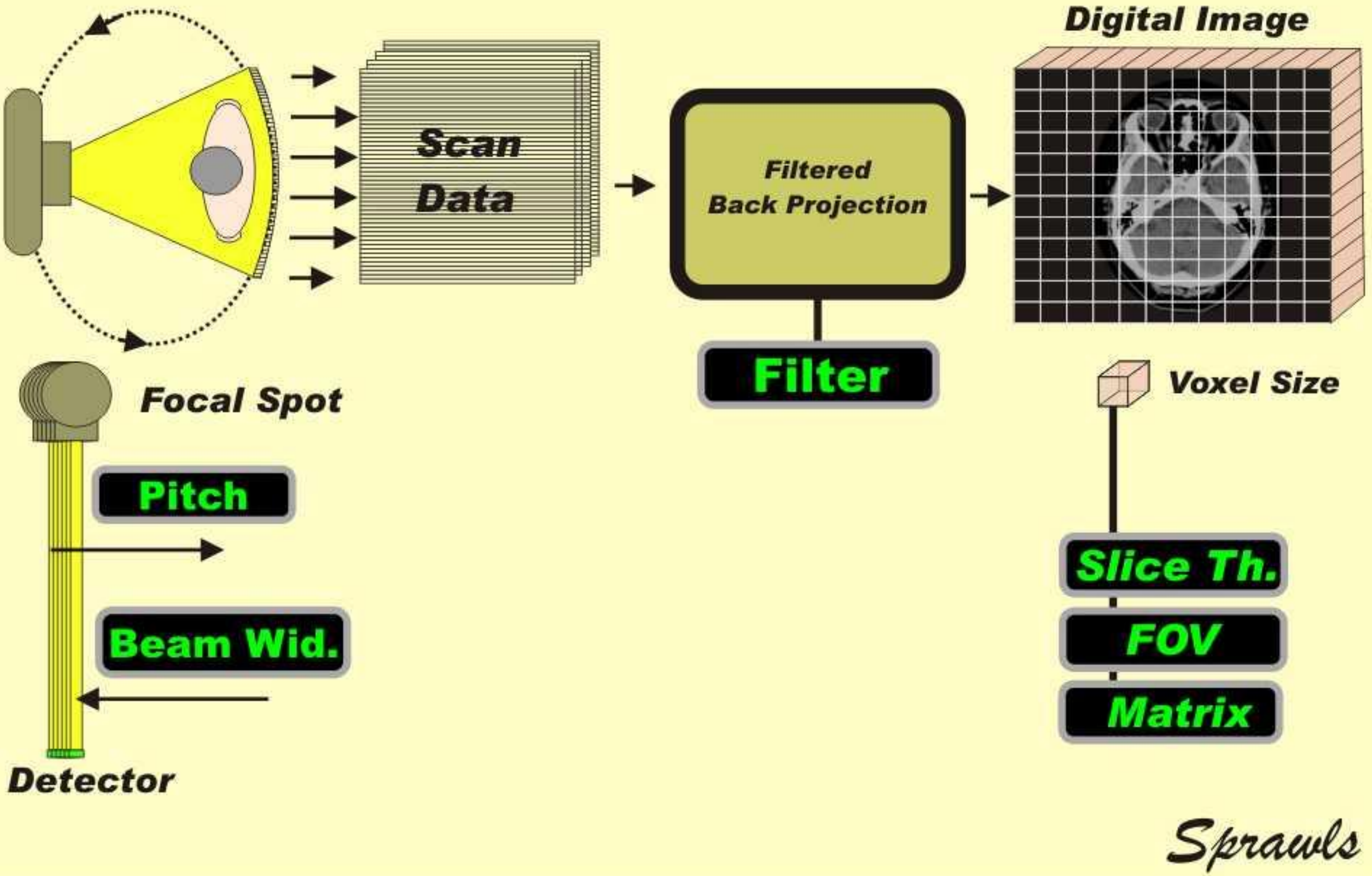
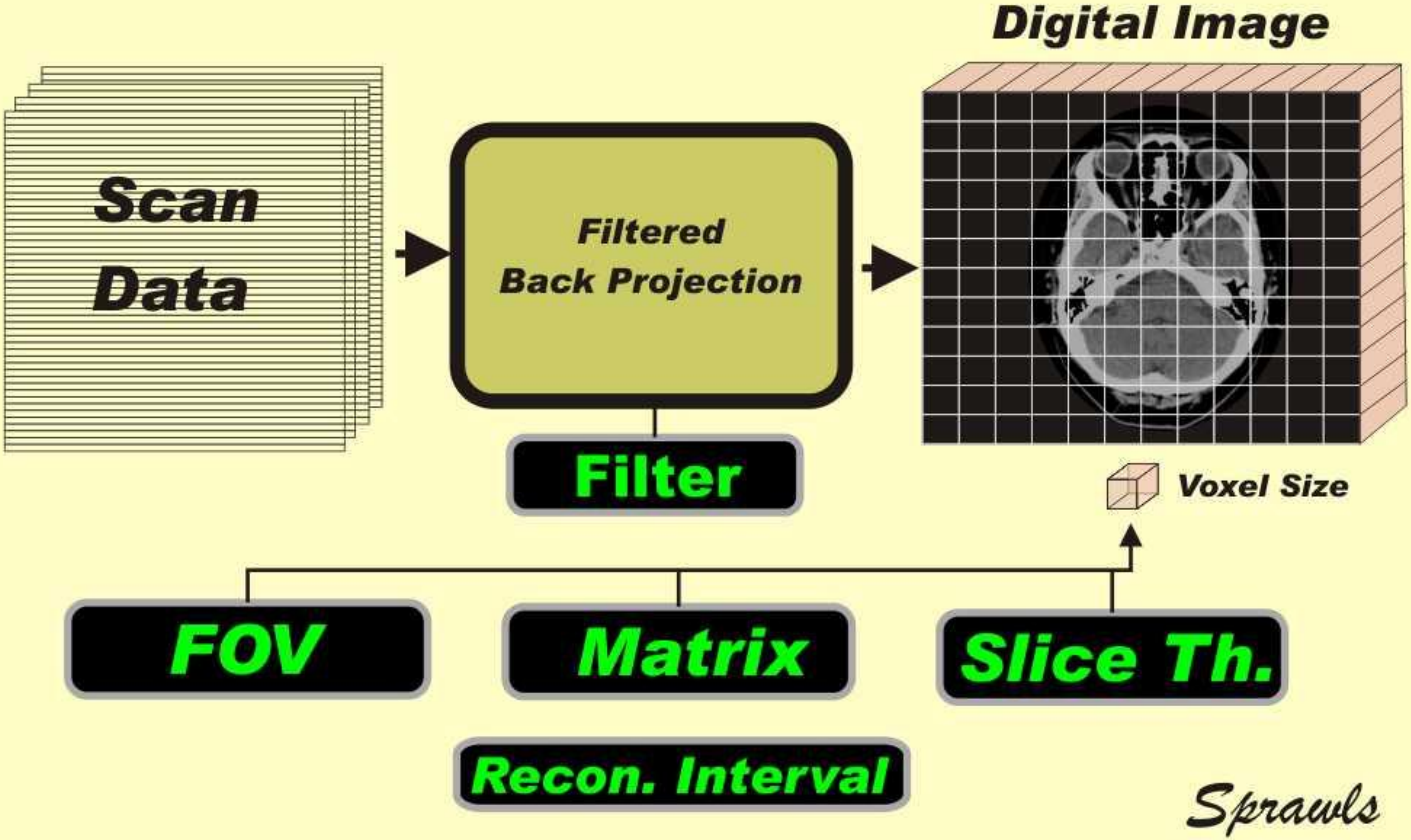
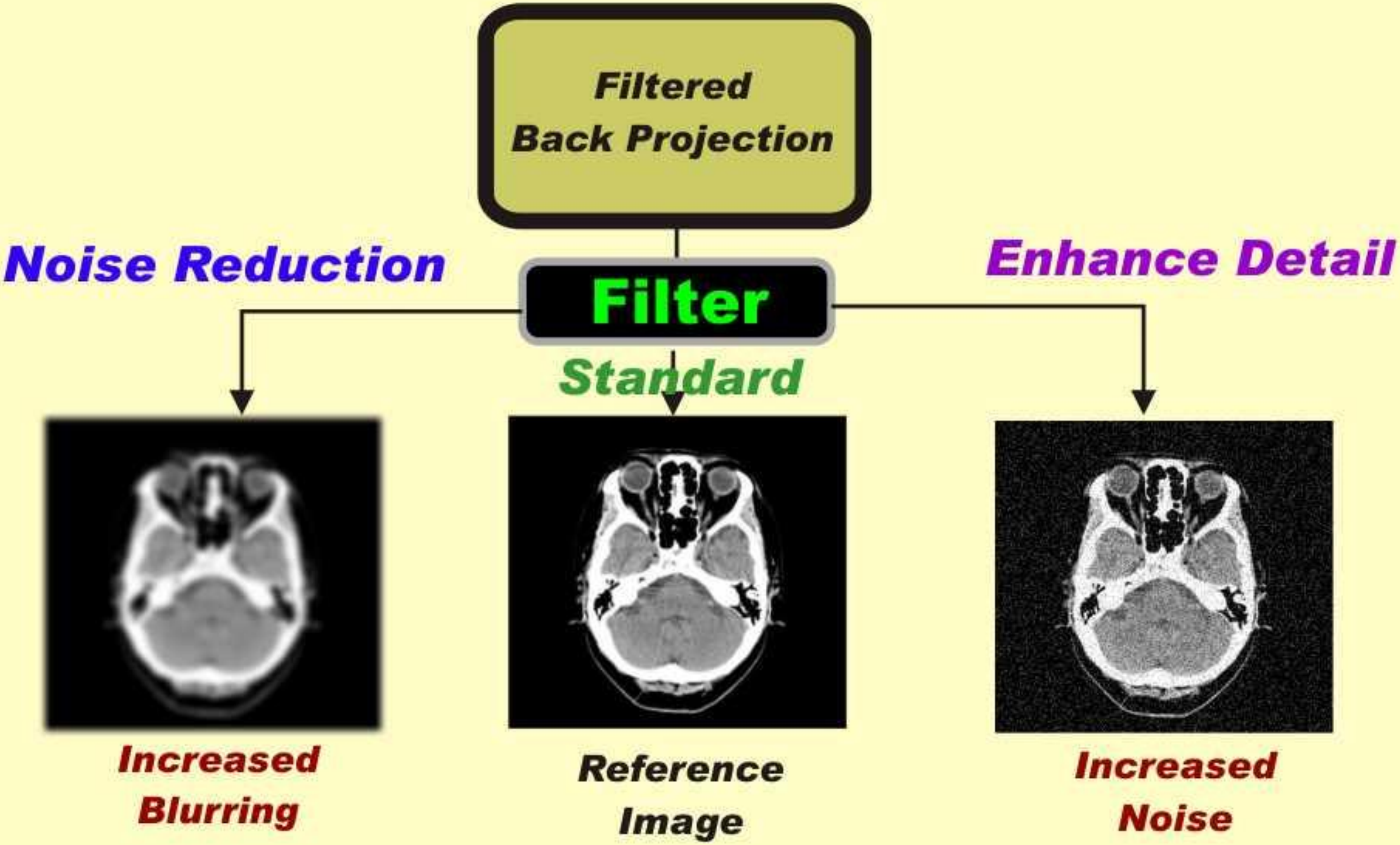
Factors That Determine Image Detail
(Sources of Blurring)



CT Image Reconstruction



Reconstruction Filter Kernels



(Effects exaggerated for illustration here)

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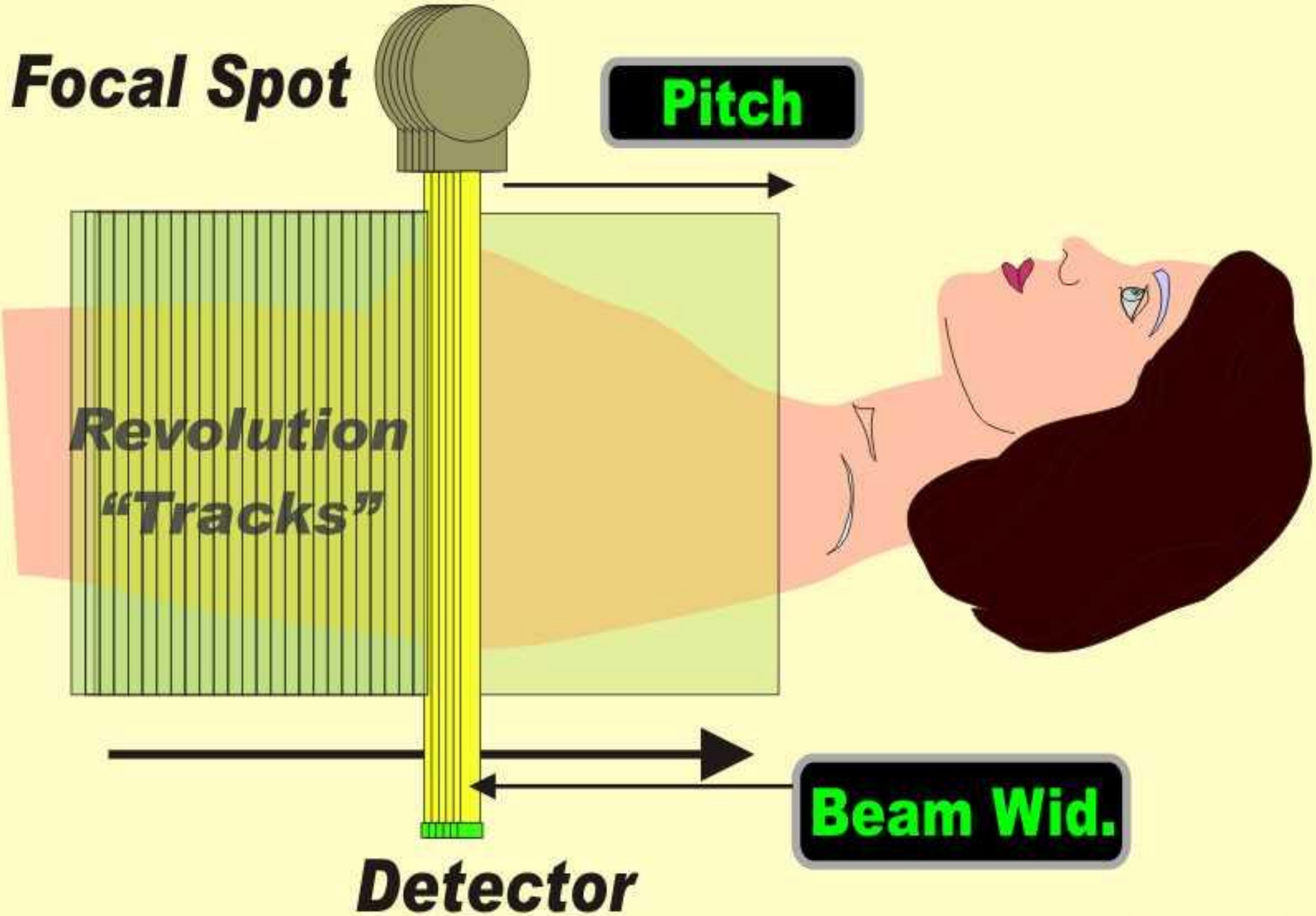
Scan Data Set



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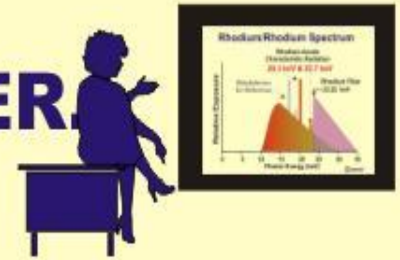
The Values We Hold

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

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Clinically Focused Physics Education

Website

http://www.sprawls.org/clinphys