The Elements of
A Highly Effective Educational Session



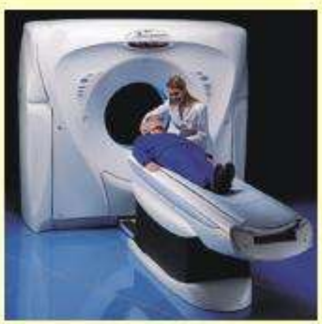
Perry Sprawls, Ph.D.

Department of Radiology and Imaging Sciences

Emory University

and

Sprawls Educational Foundation

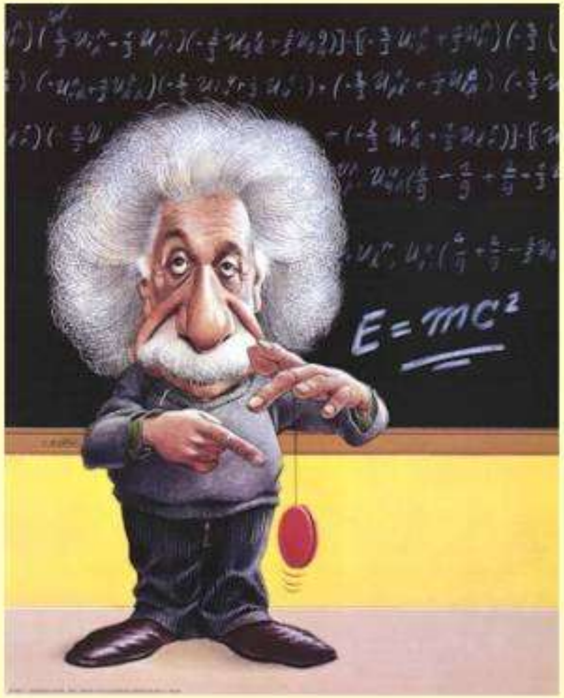



Handouts and Resources
at
http://www.sprawls.org/ipad

The Physicist as an Educator and Teacher

Our Objectives

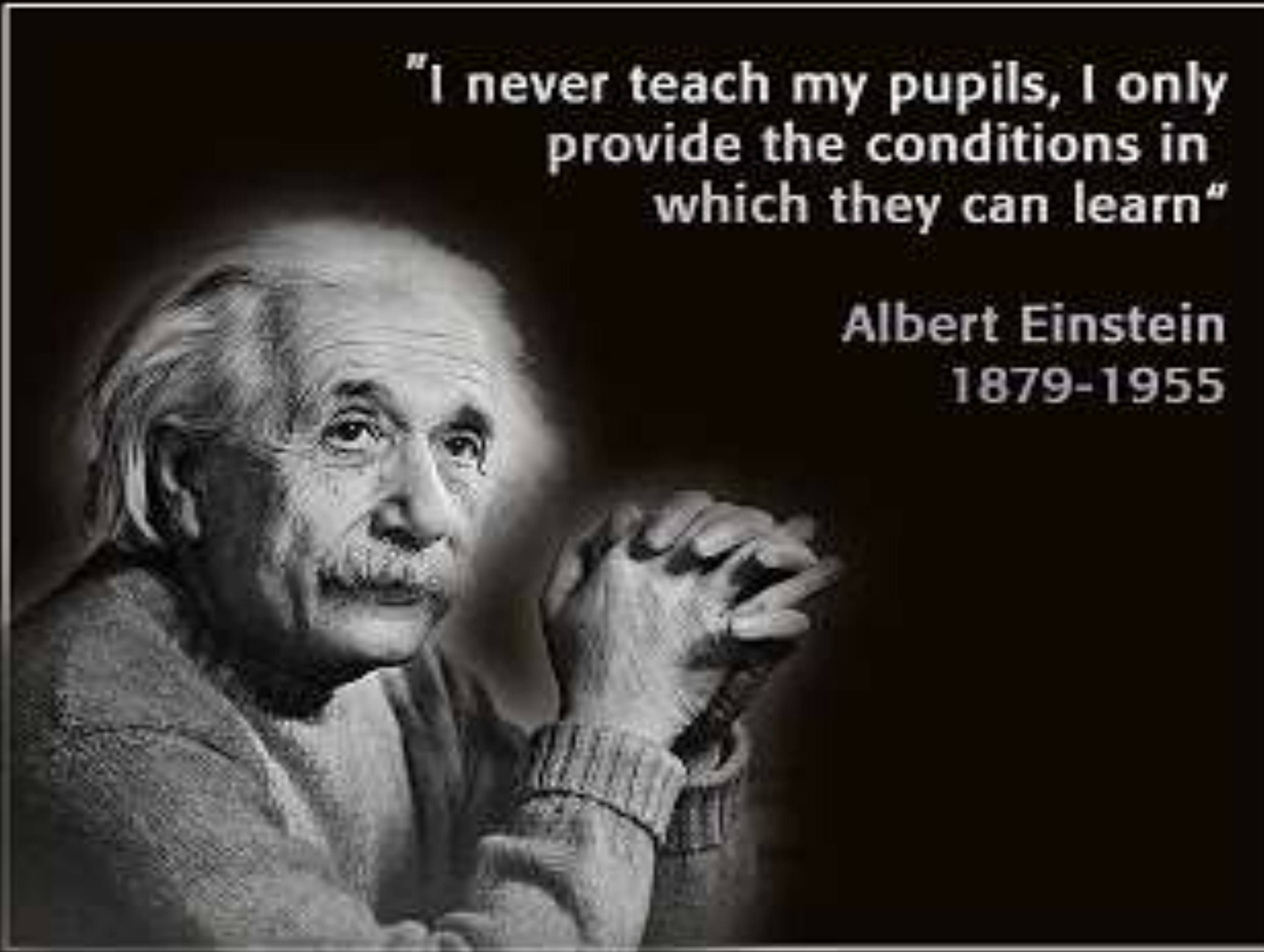
Provide more
EFFECTIVE
learning activities.



Be
EFFICIENT
in our
teaching

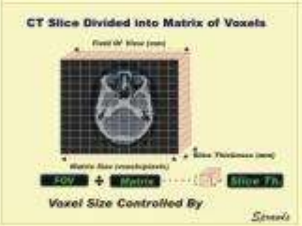
Challenges **Opportunities**

Sprawls


"I never teach my pupils, I only provide the conditions in which they can learn"
Albert Einstein
1879-1955

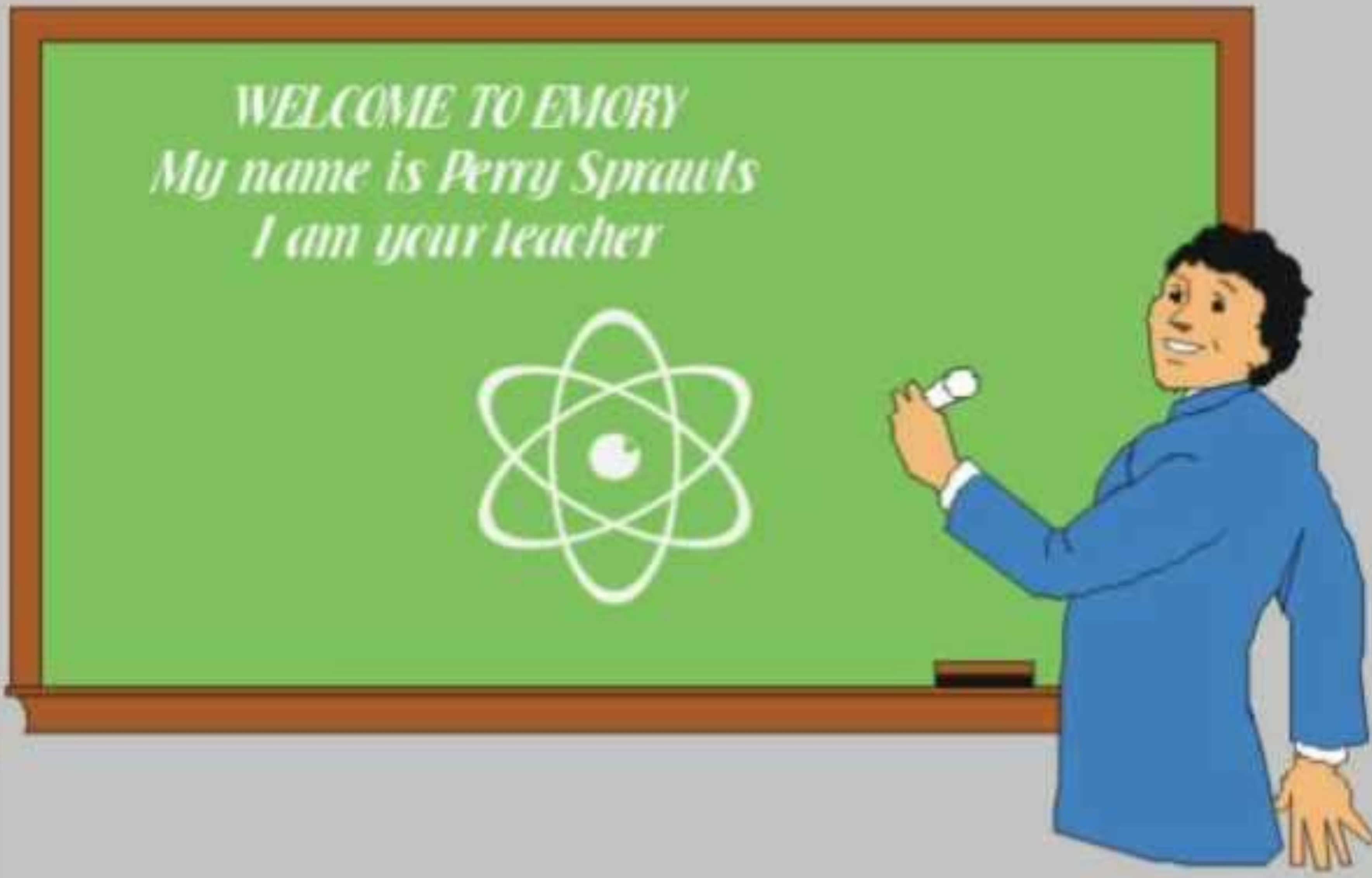
The Traditional Classroom

" A Box for Enclosing Students..."



And hiding them from the world about which they should learning.

1960



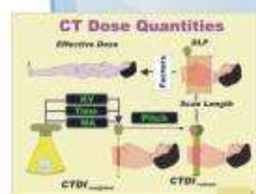
The Sprawls Resources

Sharing the Emory Experience with the World
With Emphasis on the Developing Countries

Emory

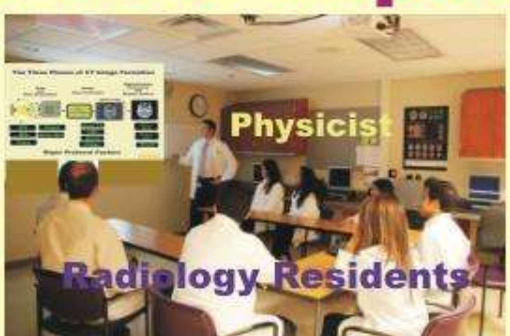
www.sprawls.org/resources

Open Access
Educational Resources



Visuals **Books** **Modules**

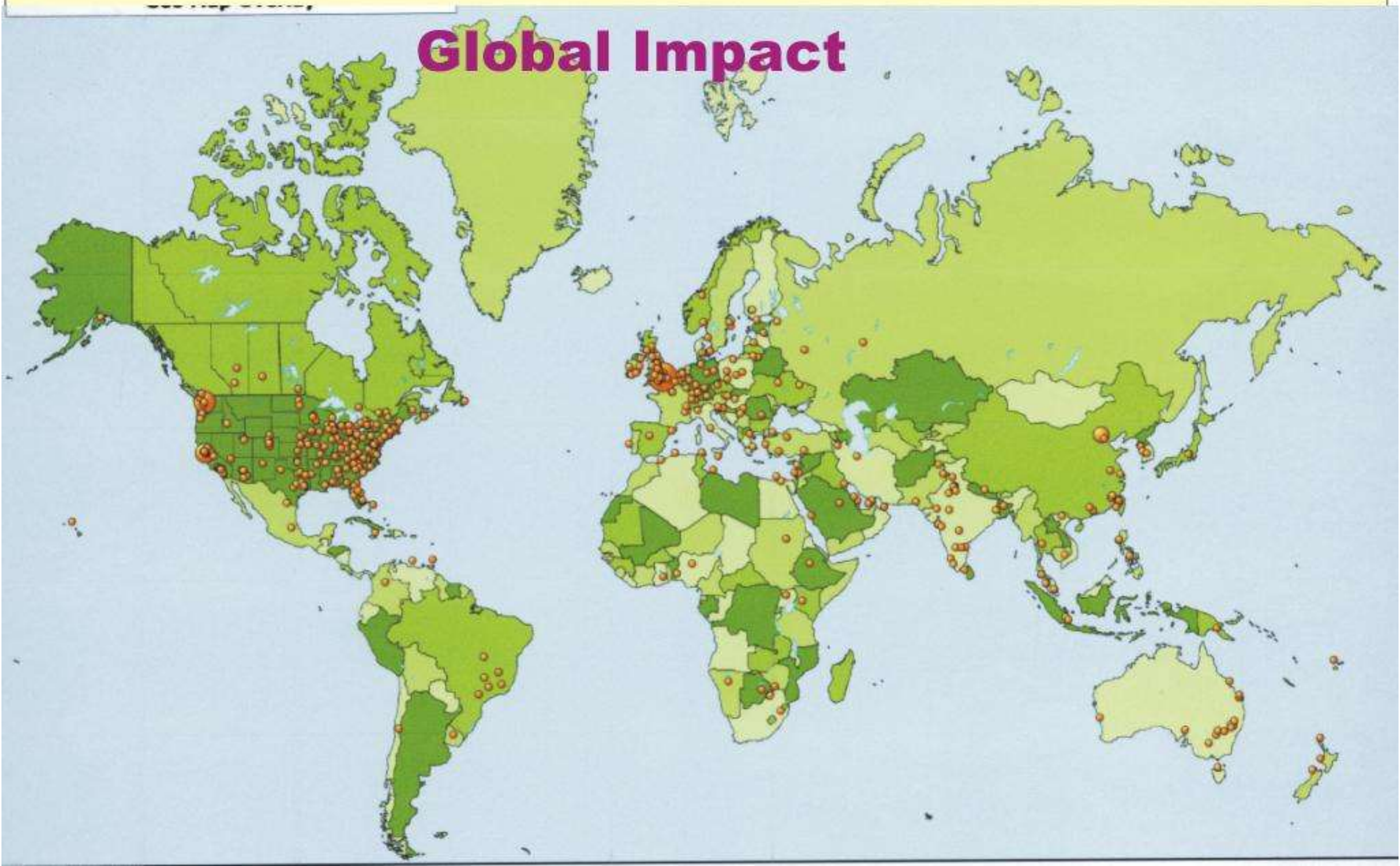
Global Impact



Enhancing Radiology Education in Every Country of the World

The Sprawls Resources

Users, April 2013



The Elements of A Highly Effective Educational Session

The Brain

The Physical Universe

(Physics of Medical Imaging)

Developing a knowledge structure.

Needs Analysis

Learning Objectives

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Clinical Medicine

Imaging

Radiation Therapy

Physics

The Foundation Science

Sprawls

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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Effective
Medical Imaging Physics Education

Goals & Objectives

Medical imaging professionals with a knowledge of physics that will enable them to perform clinically effective imaging procedures with managed risk to both patients and staff.

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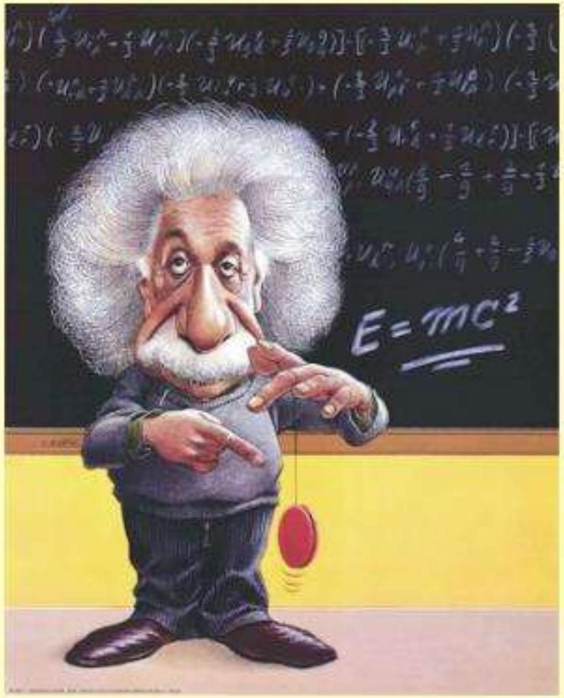
The Physicist as an Educator and Teacher

Our Objectives

Provide more EFFECTIVE learning activities.



Be EFFICIENT in our teaching

Challenges Opportunities

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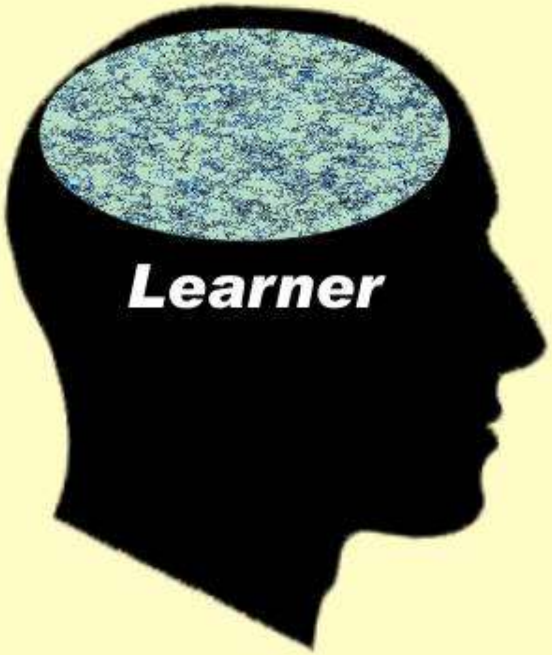
Learning Physics
is
Building a Knowledge Structure
in the Brain



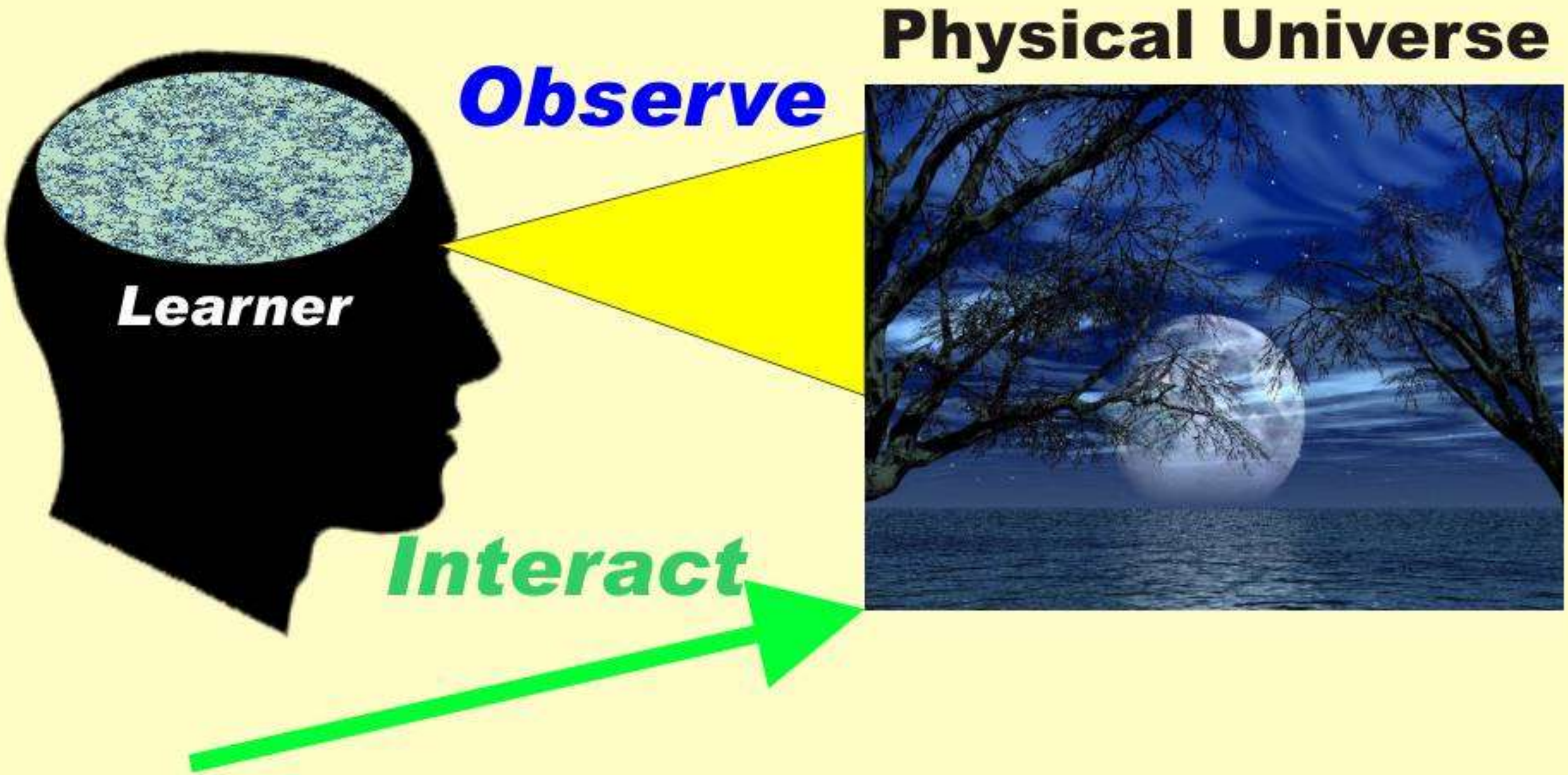
Physical Universe

A mental representation of physical reality

Sprawls

Learning is a Natural Human Process

We Learn by Experience



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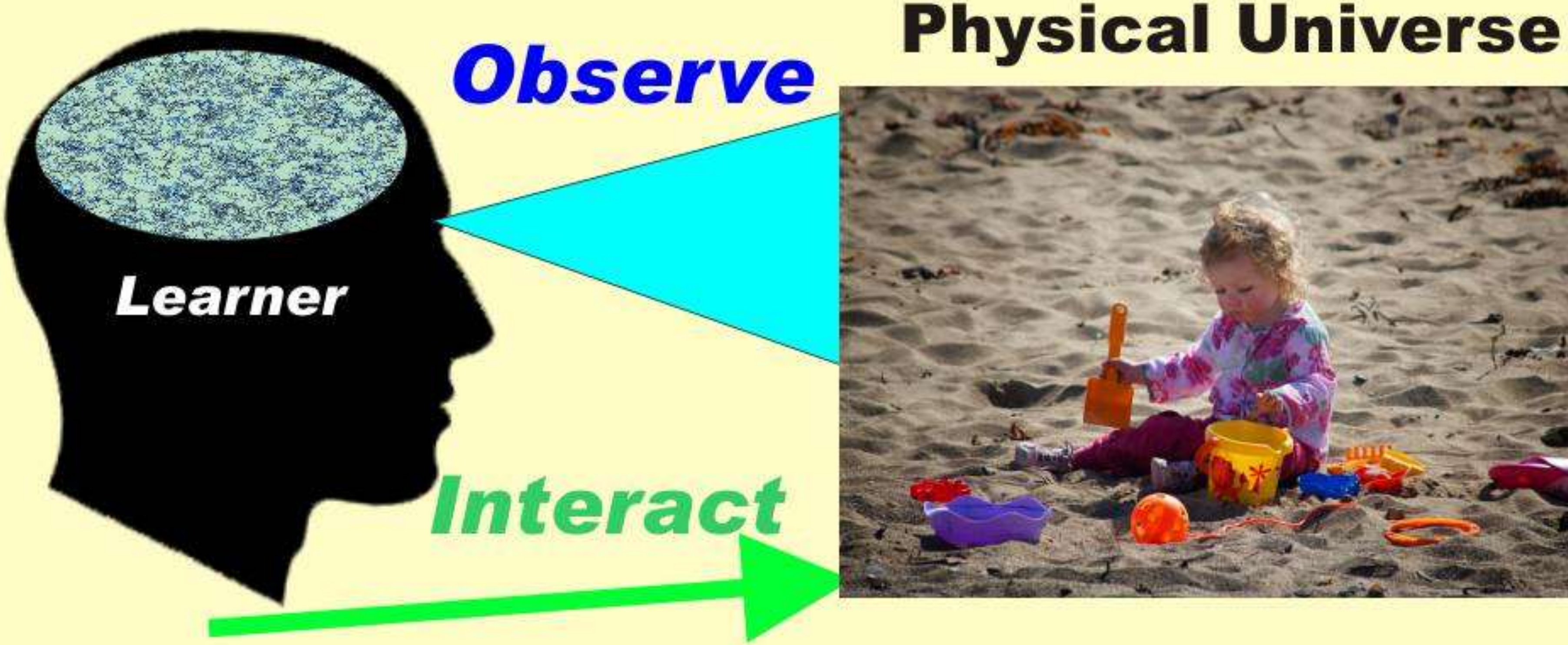

Our Early Physics Learning Activities

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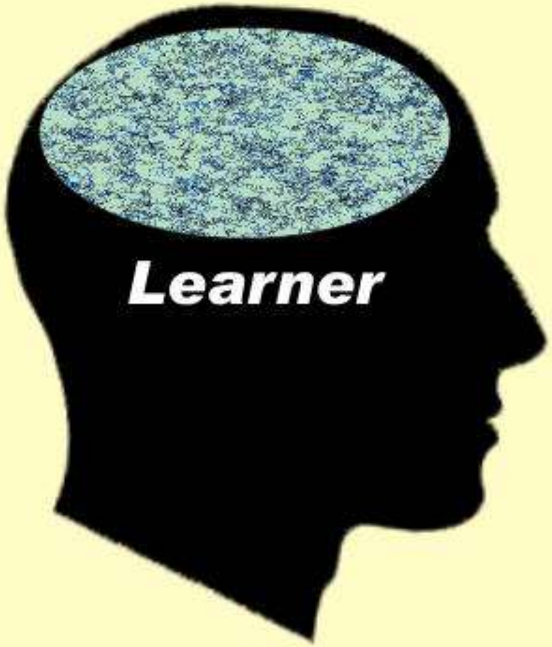
Teaching

is helping someone

Building a Knowledge Structure in the Brain



Physical Universe

A mental representation of physical reality

Connect ***Organize*** ***Guide***

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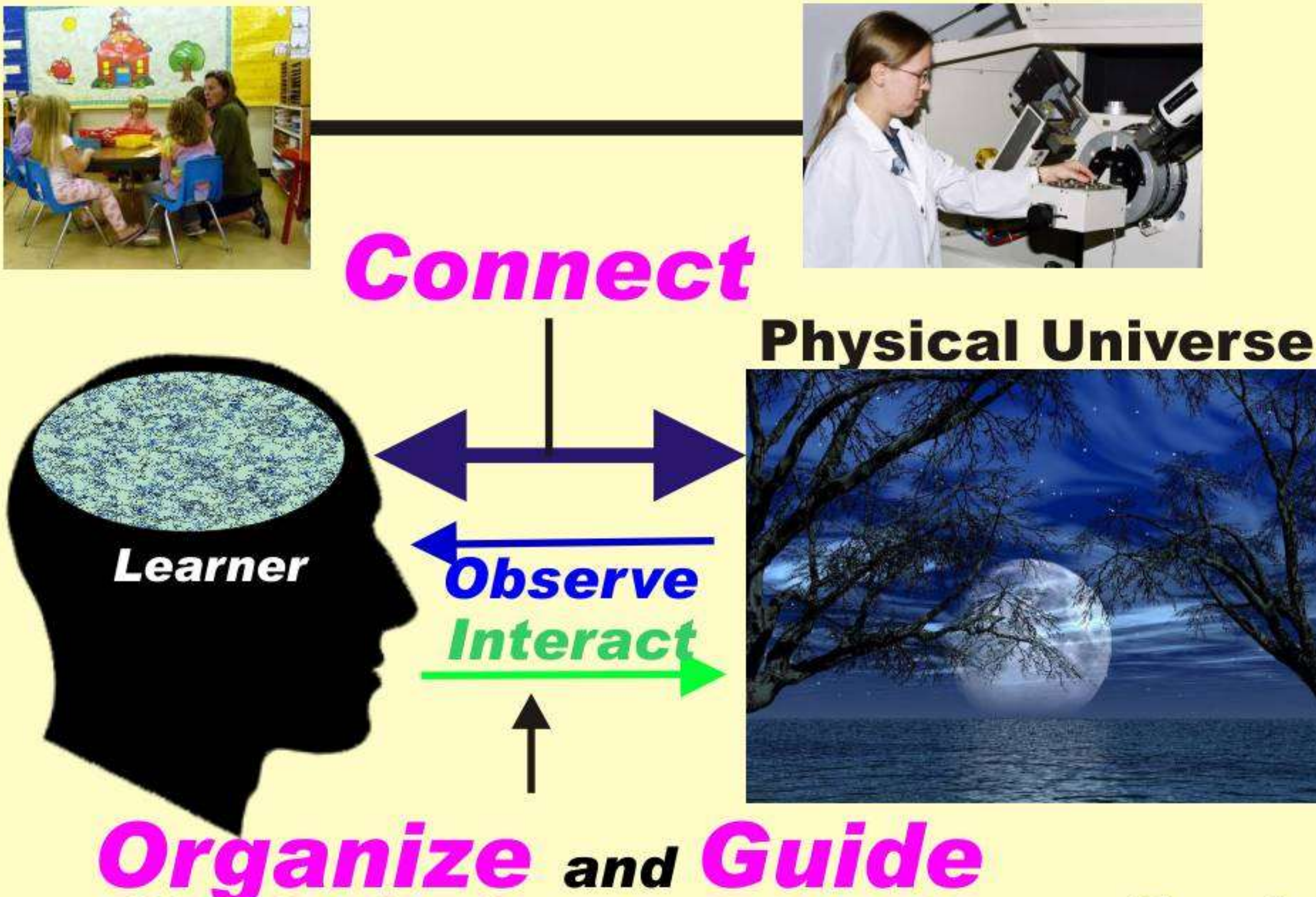
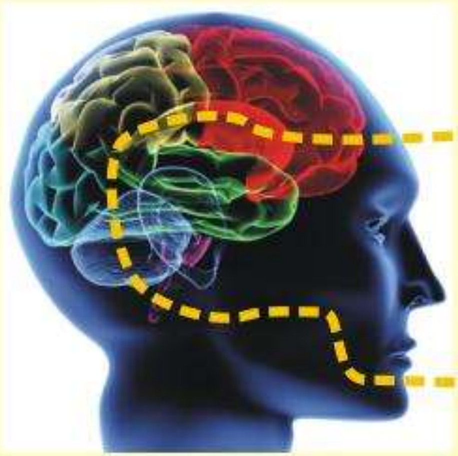
The Role of Formal Education

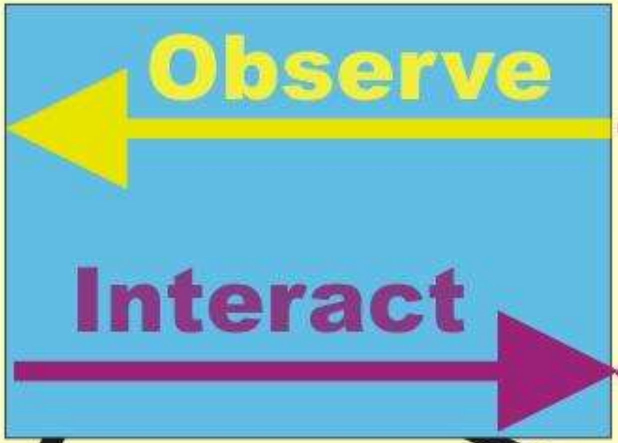


The Elements of
A Highly Effective Educational Session

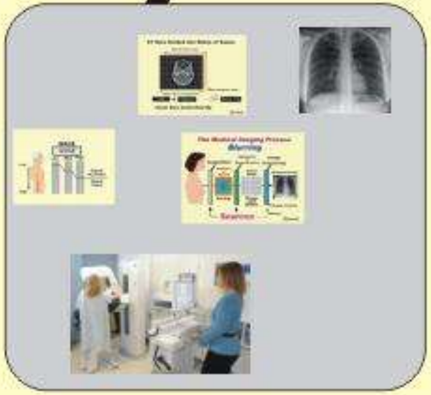
The Brain



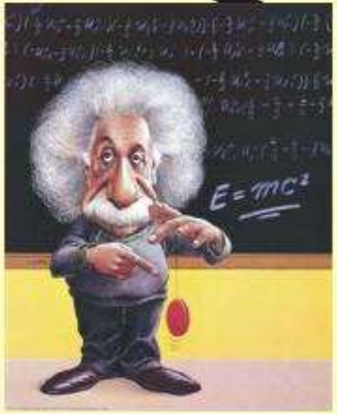
Connection



The Physical Universe
(Physics of Medical Imaging)



"Window"



Teacher /Guide

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Five Dynamics

" It's a new ball game!"

Capability & Complexity

Geographic Dispersion

Learning & Teaching Knowledge

Expanding Educational Resources

Increased Connectivity

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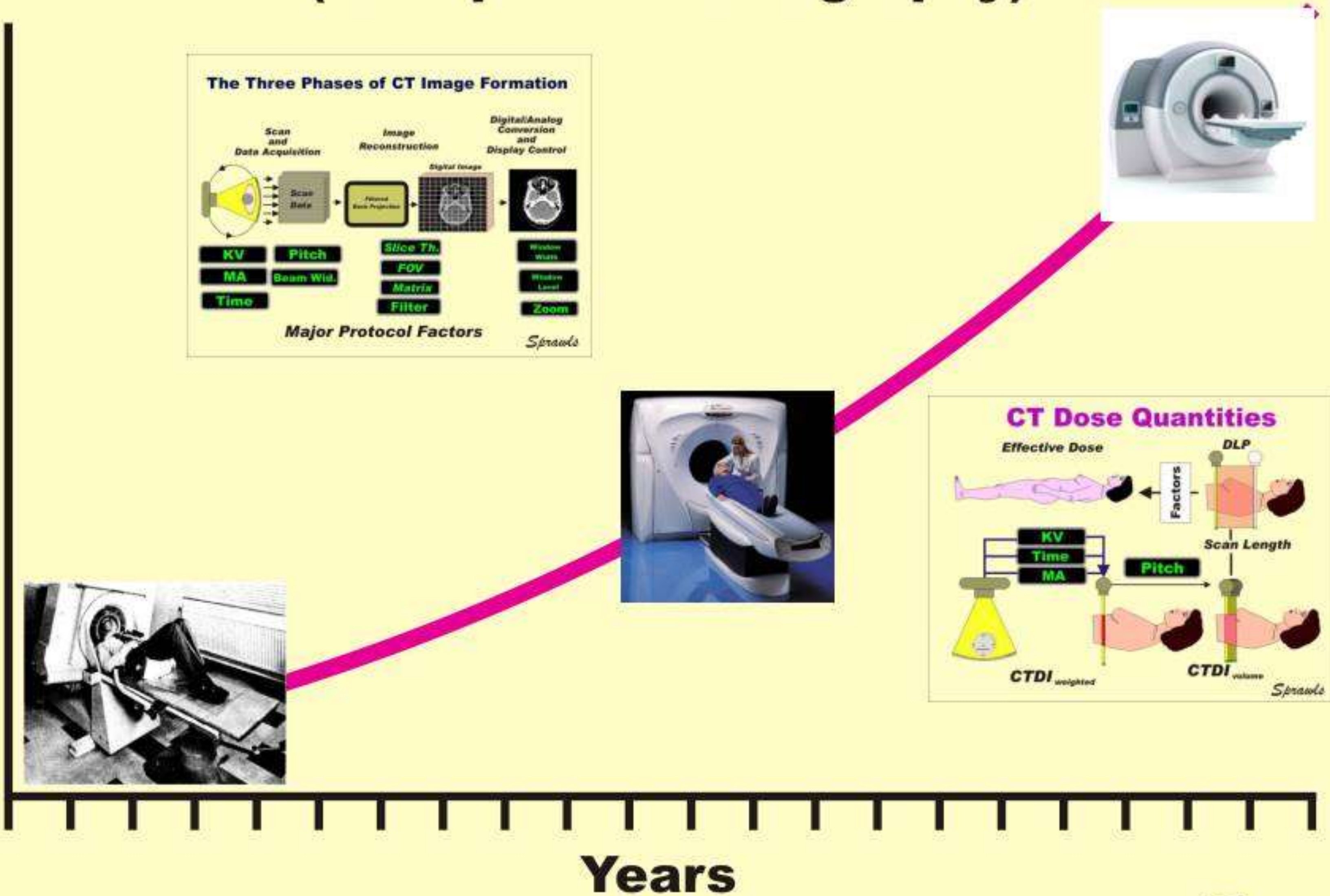
Capability & Complexity

(Computed Tomography)



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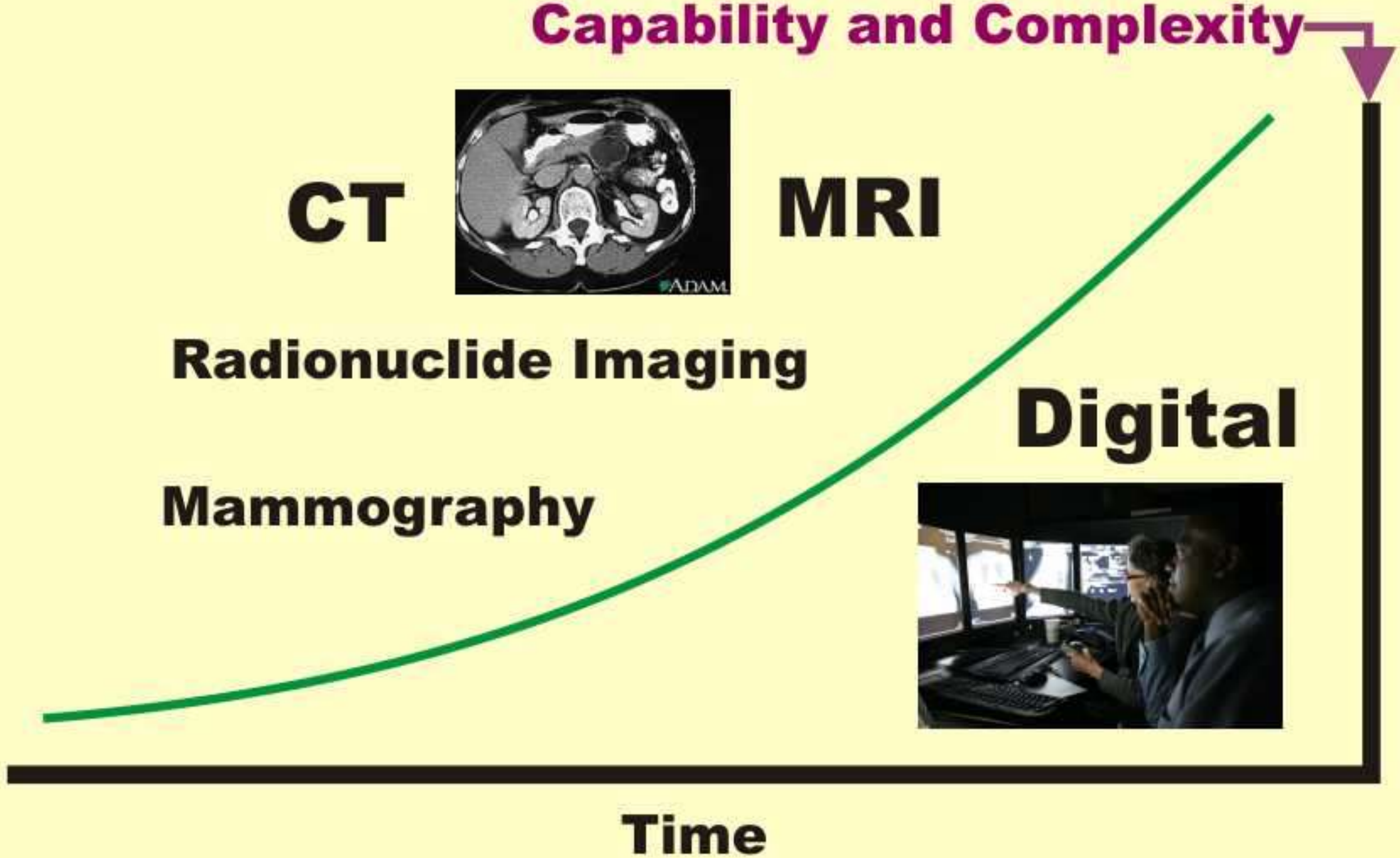
Continuing Growth in the Need for Physics Knowledge



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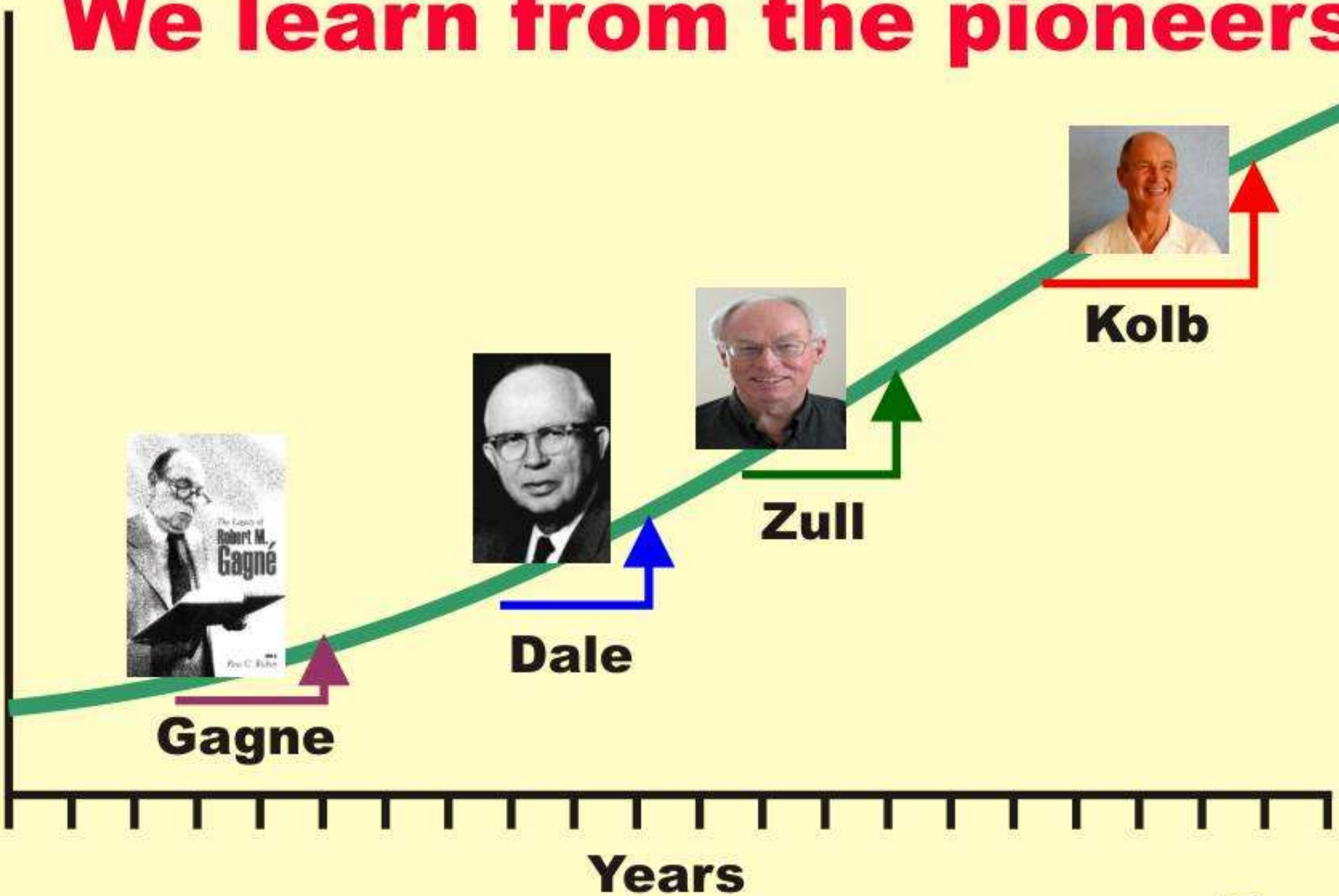
Knowledge of the Learning & Teaching Process

We learn from the pioneers



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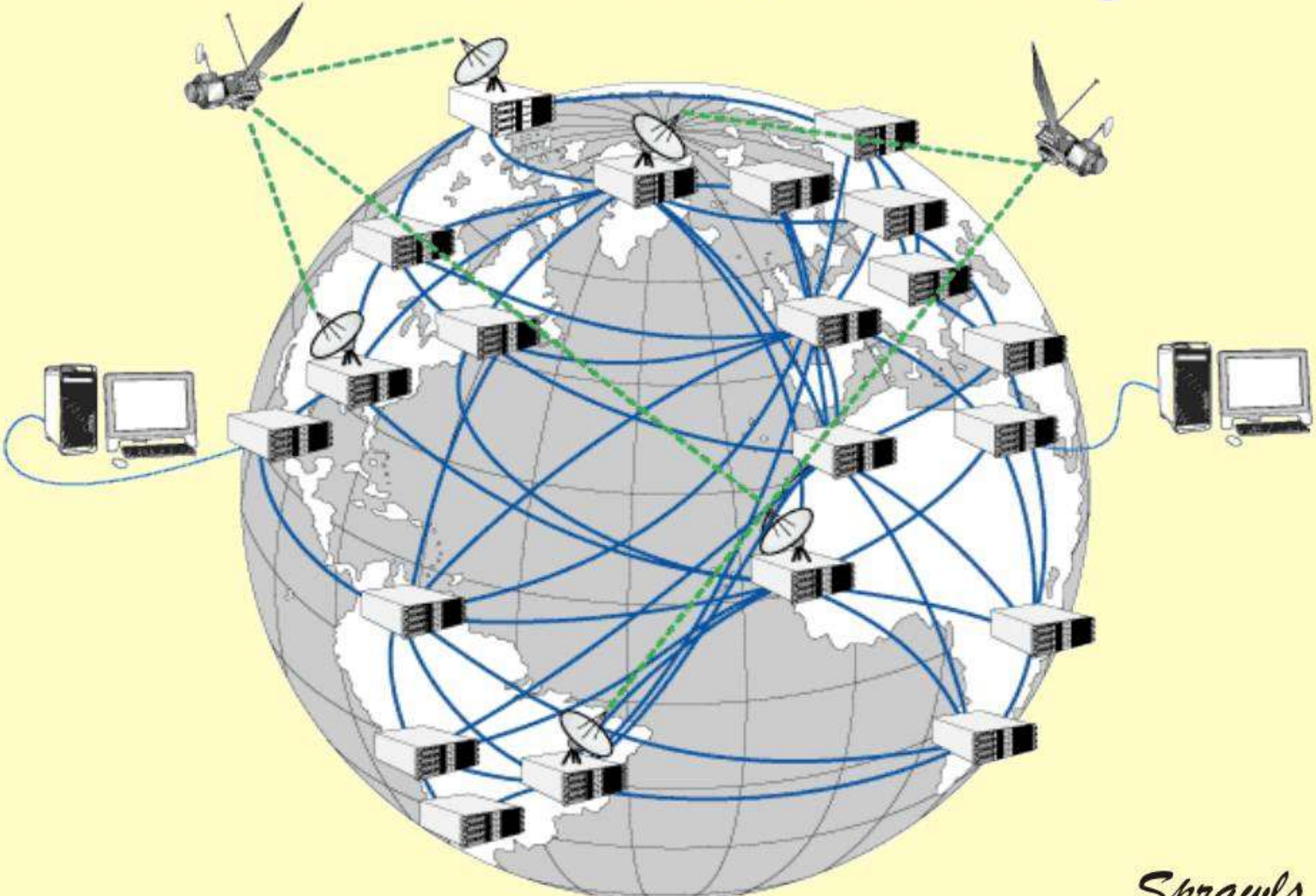
Increased Connectivity



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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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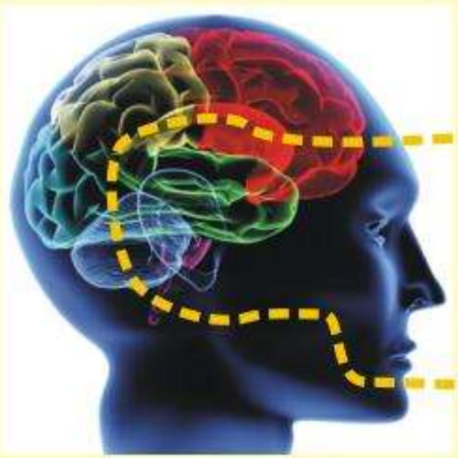
The Elements of A Highly Effective Educational Session

The Brain

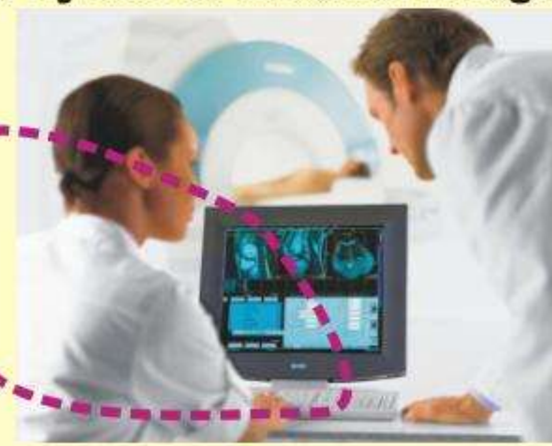


Connection

Observe

Interact

The Physical Universe
(Physics of Medical Imaging)



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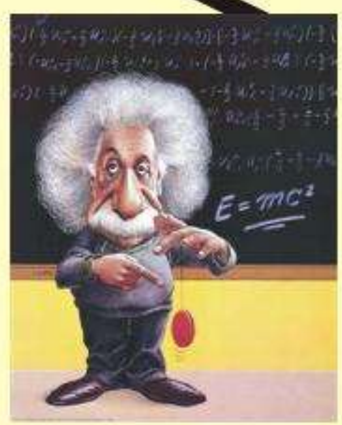

Teacher /Guide

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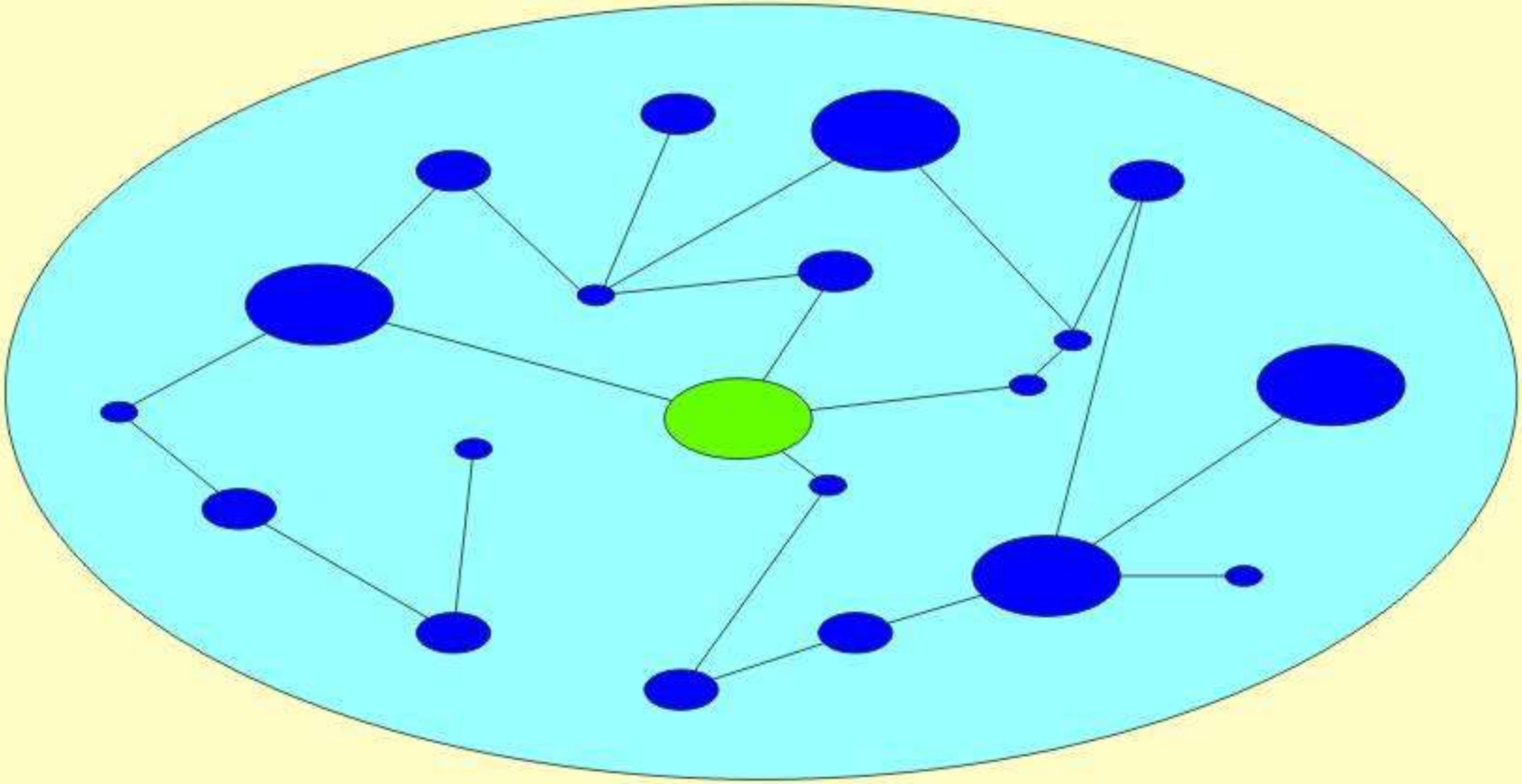
Knowledge Structures in the Brain

A Complex Network



Concepts **Facts**

Images **Language**

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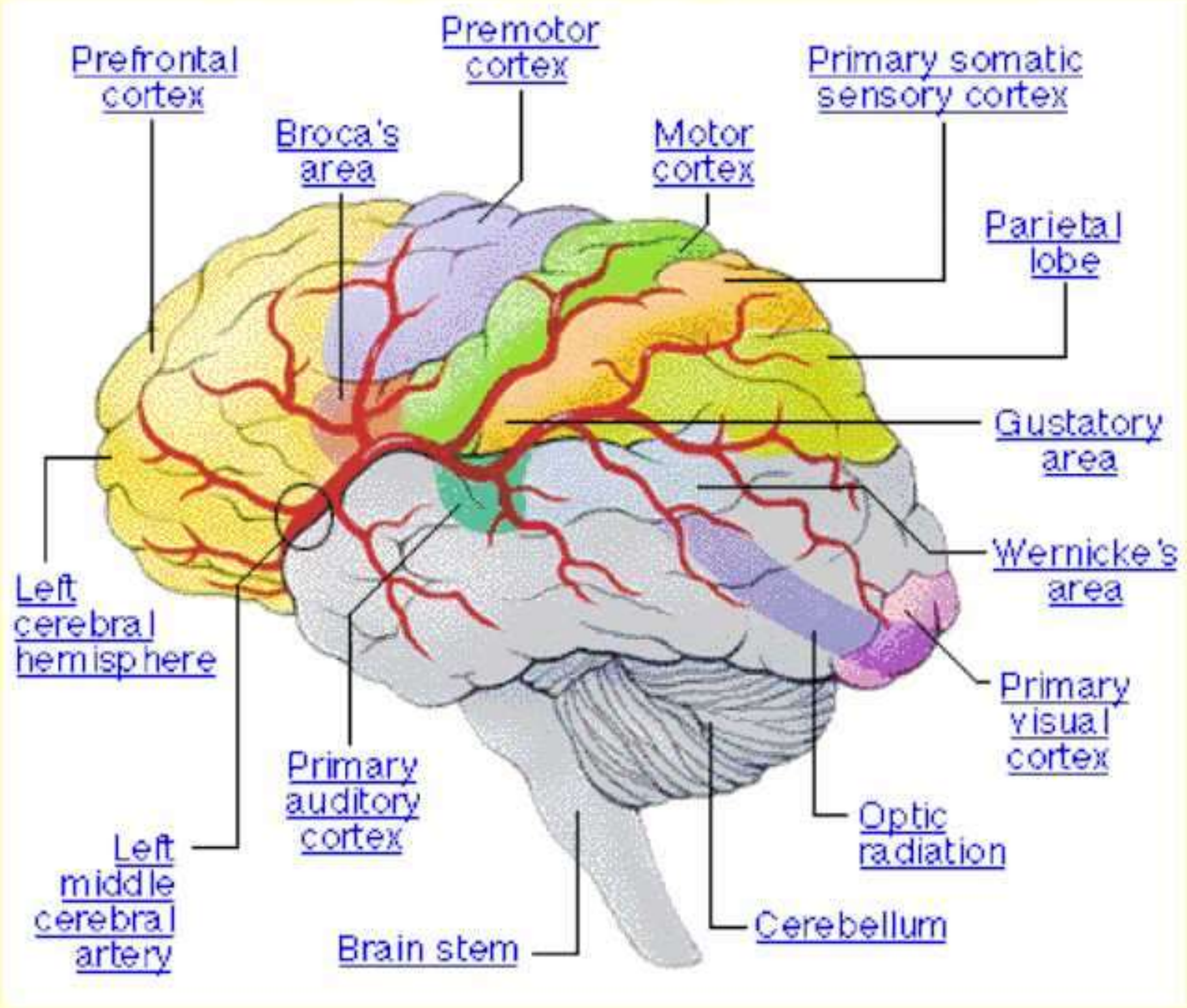
The Brain...



Structure and Function

Image: AMA

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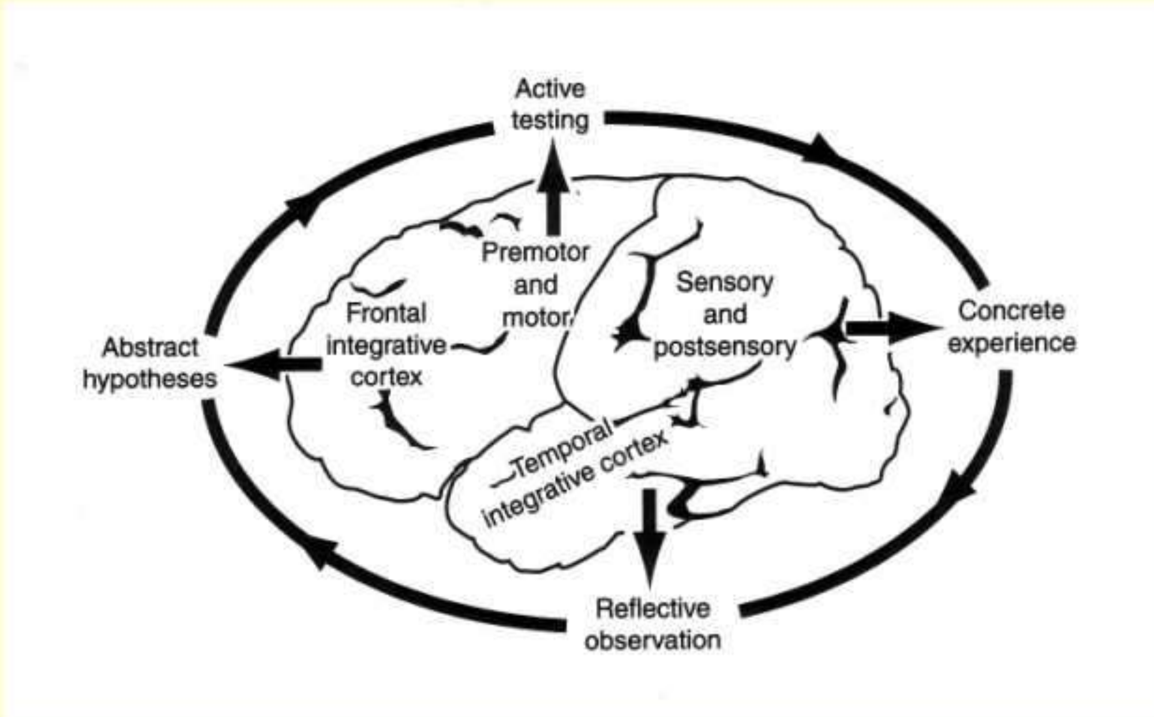
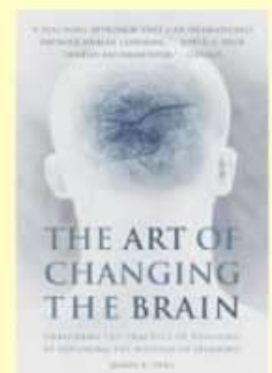
Zull's Model of Brain Function

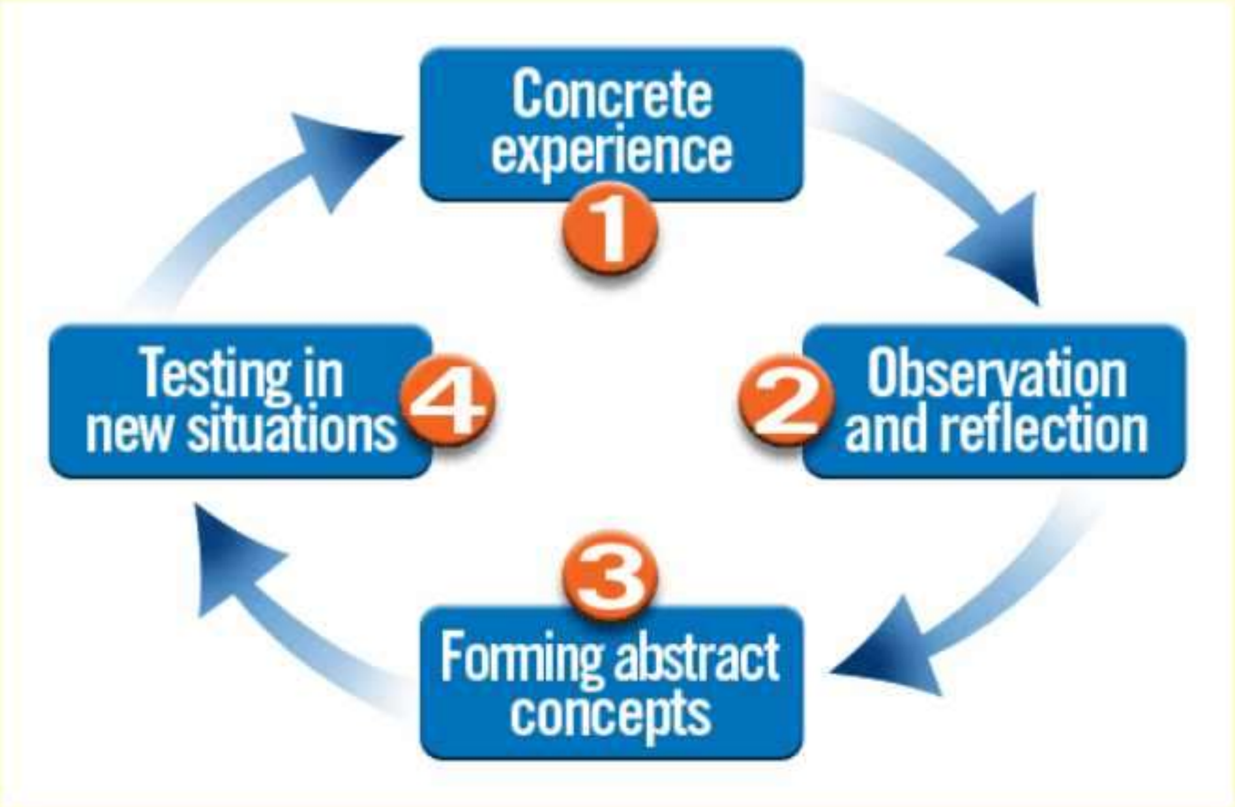


James Zull, Ph.D.
Professor of Biology
Professor of Biochemistry
Director of University Center for Innovation in Teaching and Education
Case Western Reserve

Reference:



Kolb's Experiential Learning Model



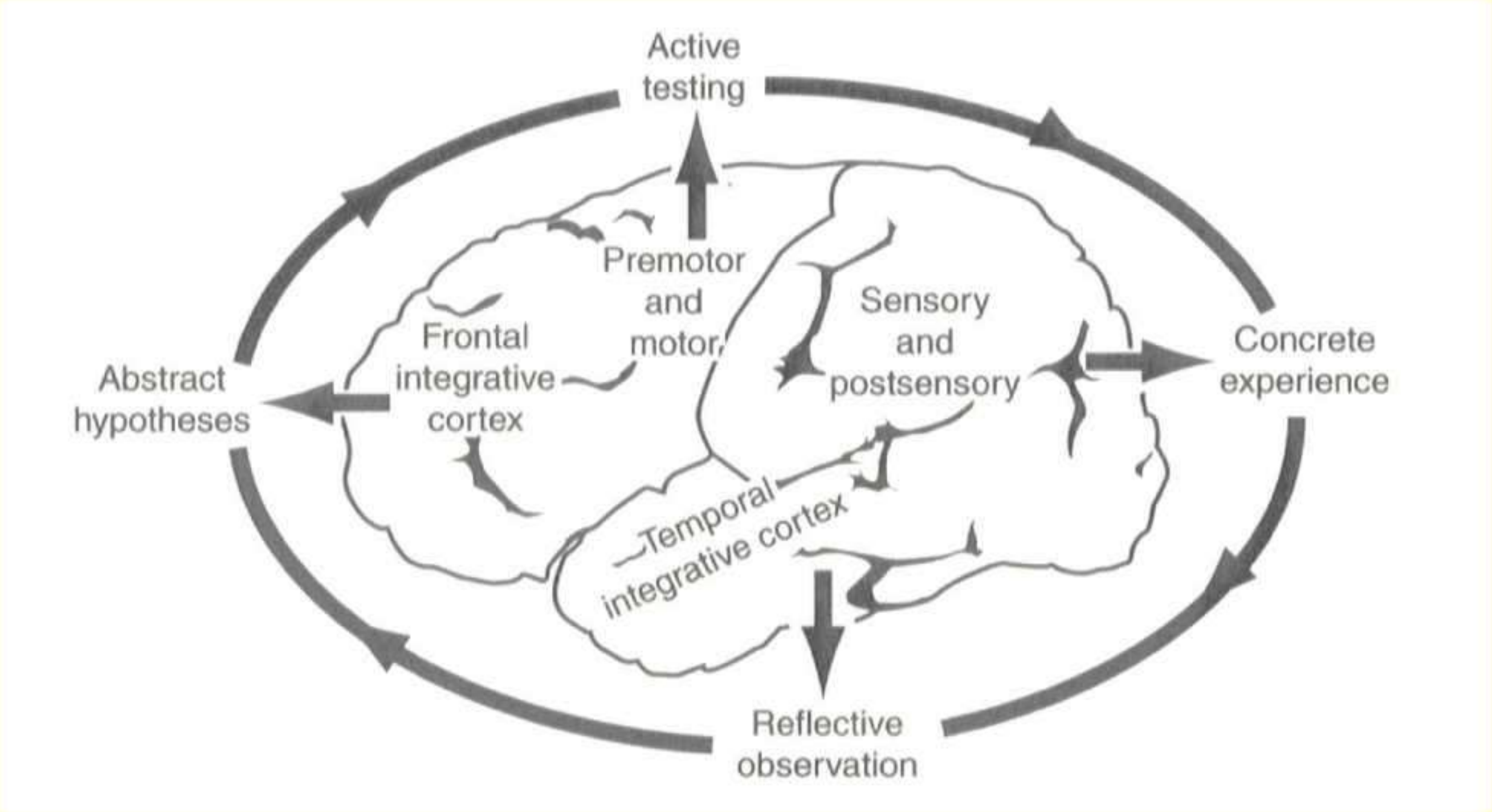
David A. Kolb, Ph.D.

Professor of Organizational Behavior

Case Western Reserve

Website: http://www.learningfromexperience.com

Zull's Model of Brain Function



Brain Functions for Learning Physics

Control

Sensory

Back Integrative Cortex

Where

(Relationships)

(Characteristics)

What

(Identification)

Language

Comprehension

Frontal Integrative Cortex

Making Plans

Evaluating

Problem Solving

Language

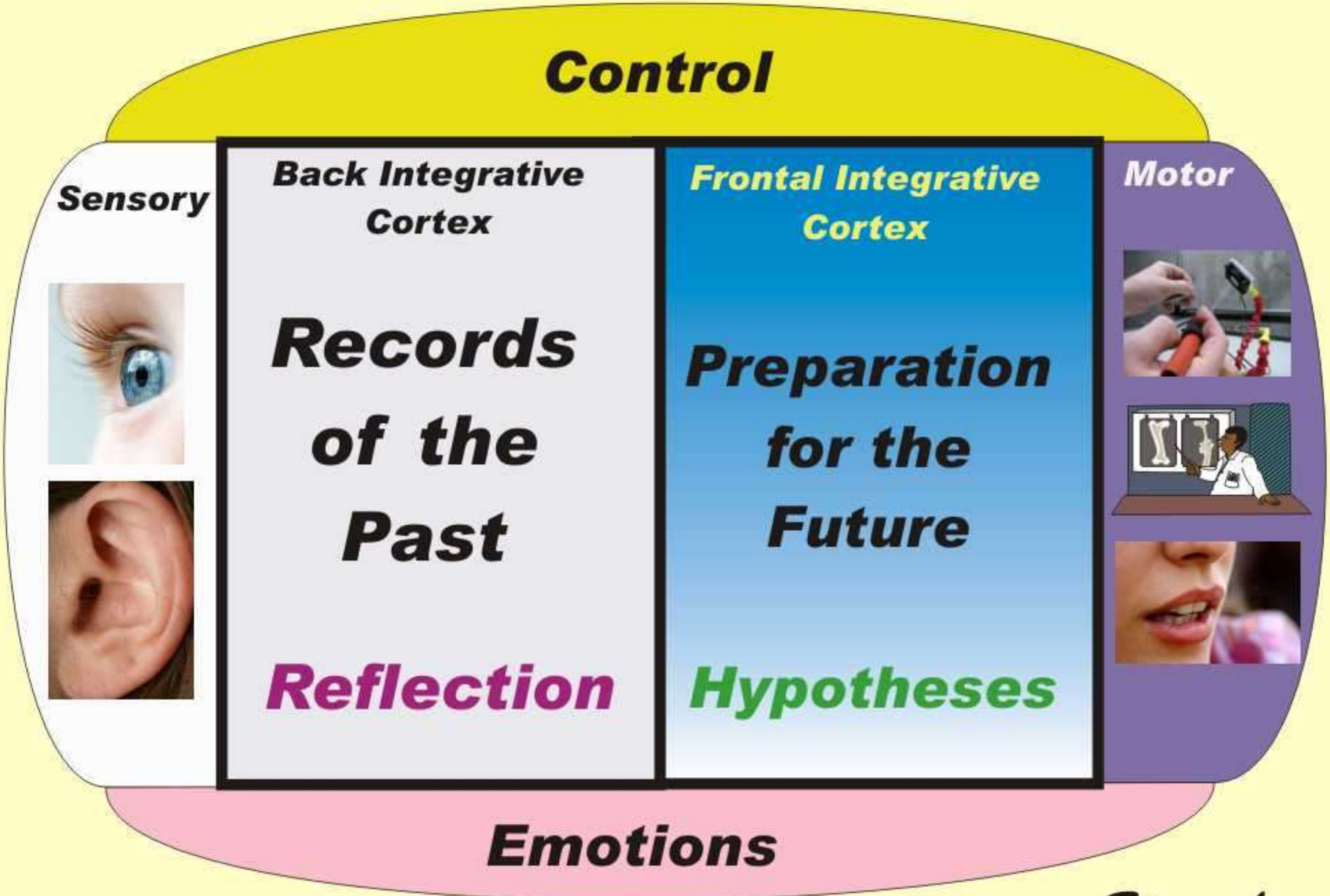
Assembly

Motor

Emotions

Sprawls

Brain Functions for Learning Physics



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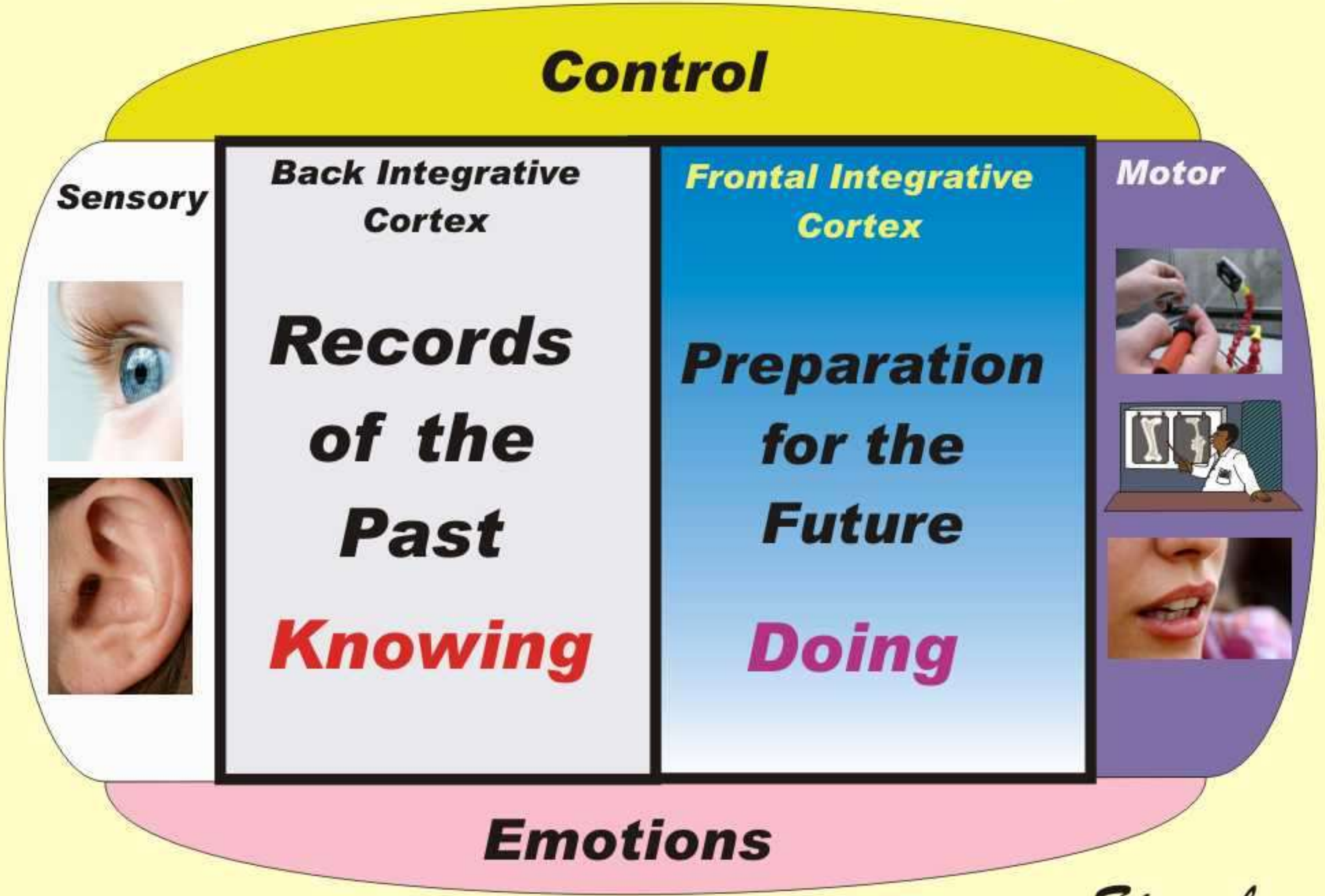
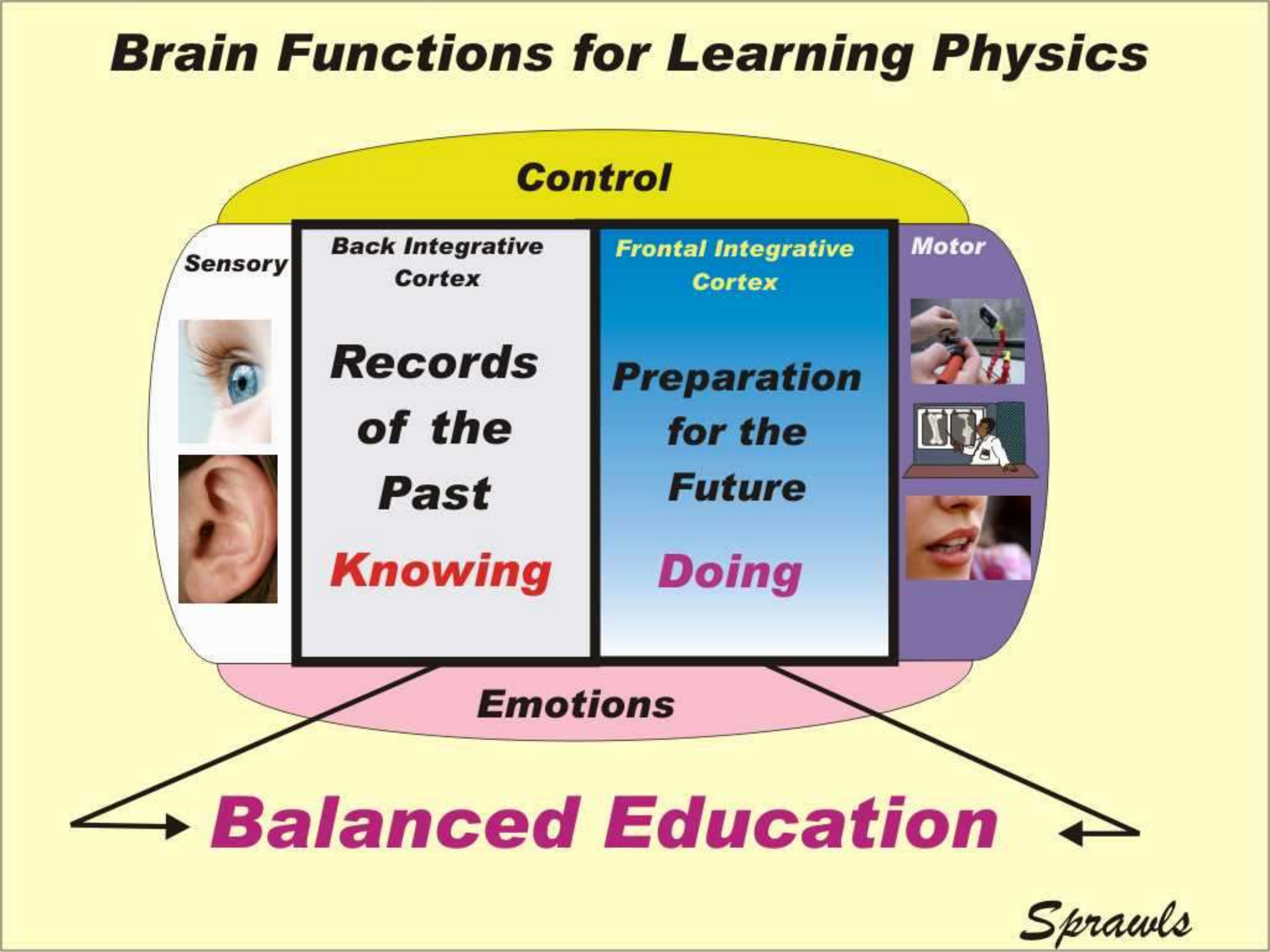
Brain Functions for Learning Physics



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
Balanced Education
Sprawls

Forming Knowledge Structures

Physical Universe

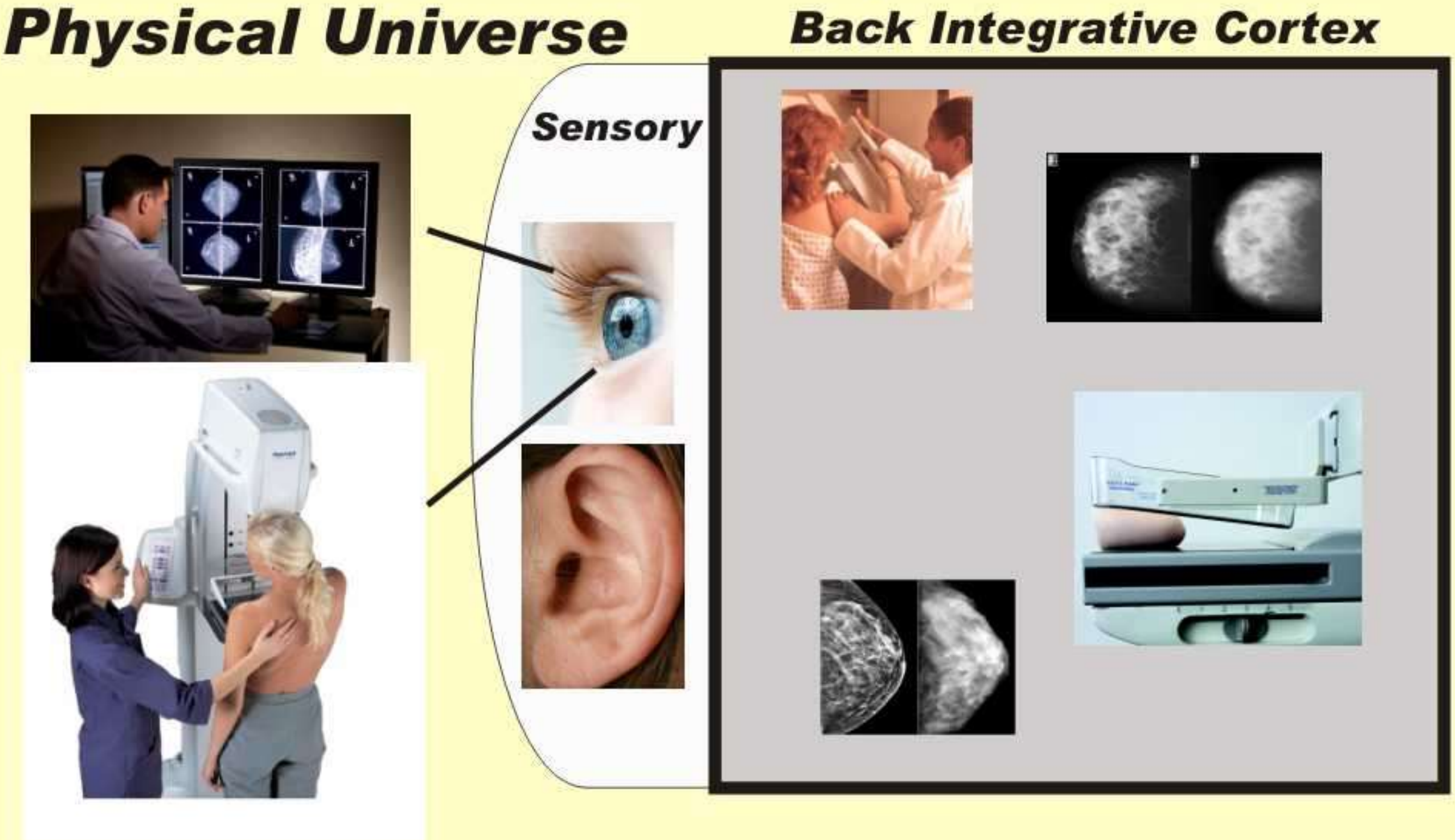
Back Integrative Cortex

Sensory

Visible Physical Objects

Sprawls

Forming Knowledge Structures



Visible Physical Objects

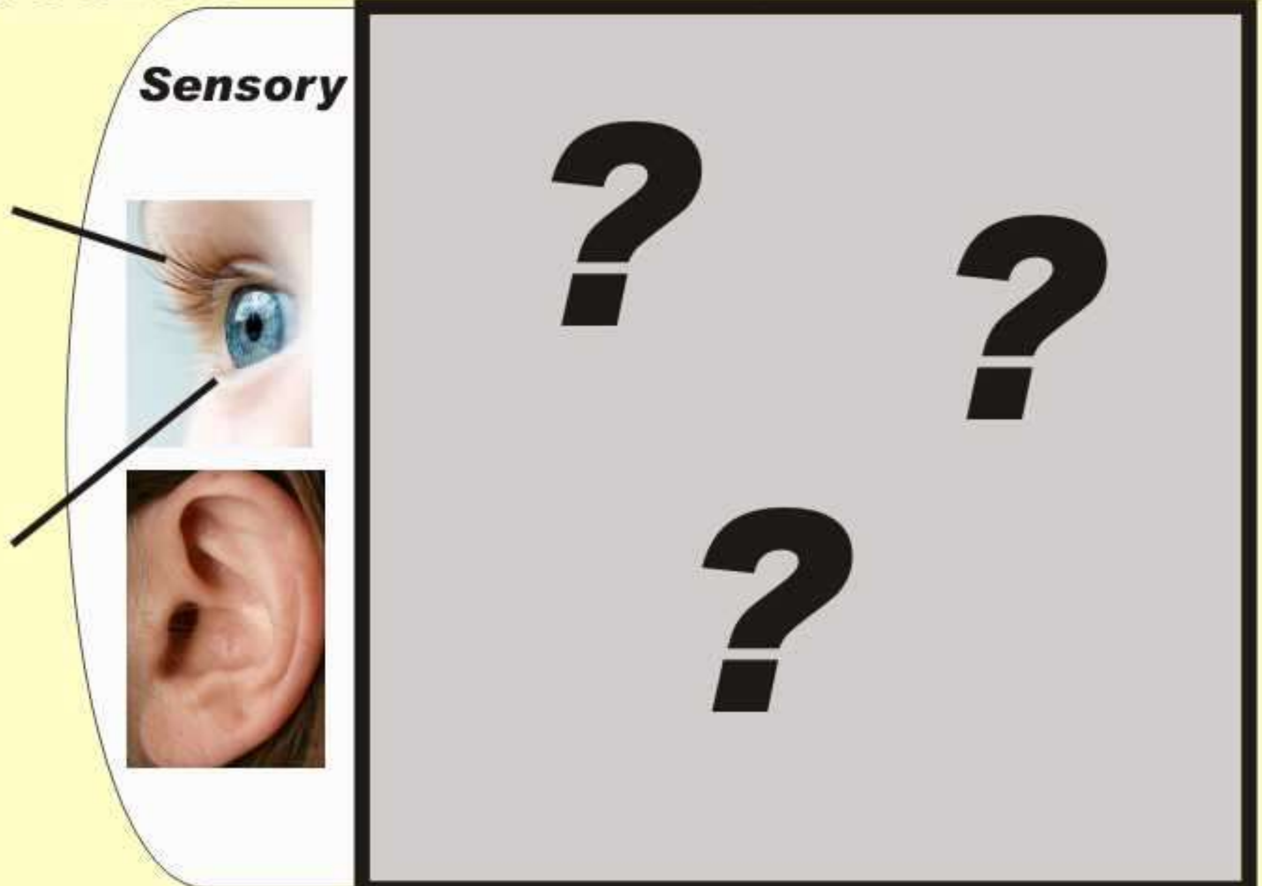
Sprawls

Forming Knowledge Structures

Physical Universe

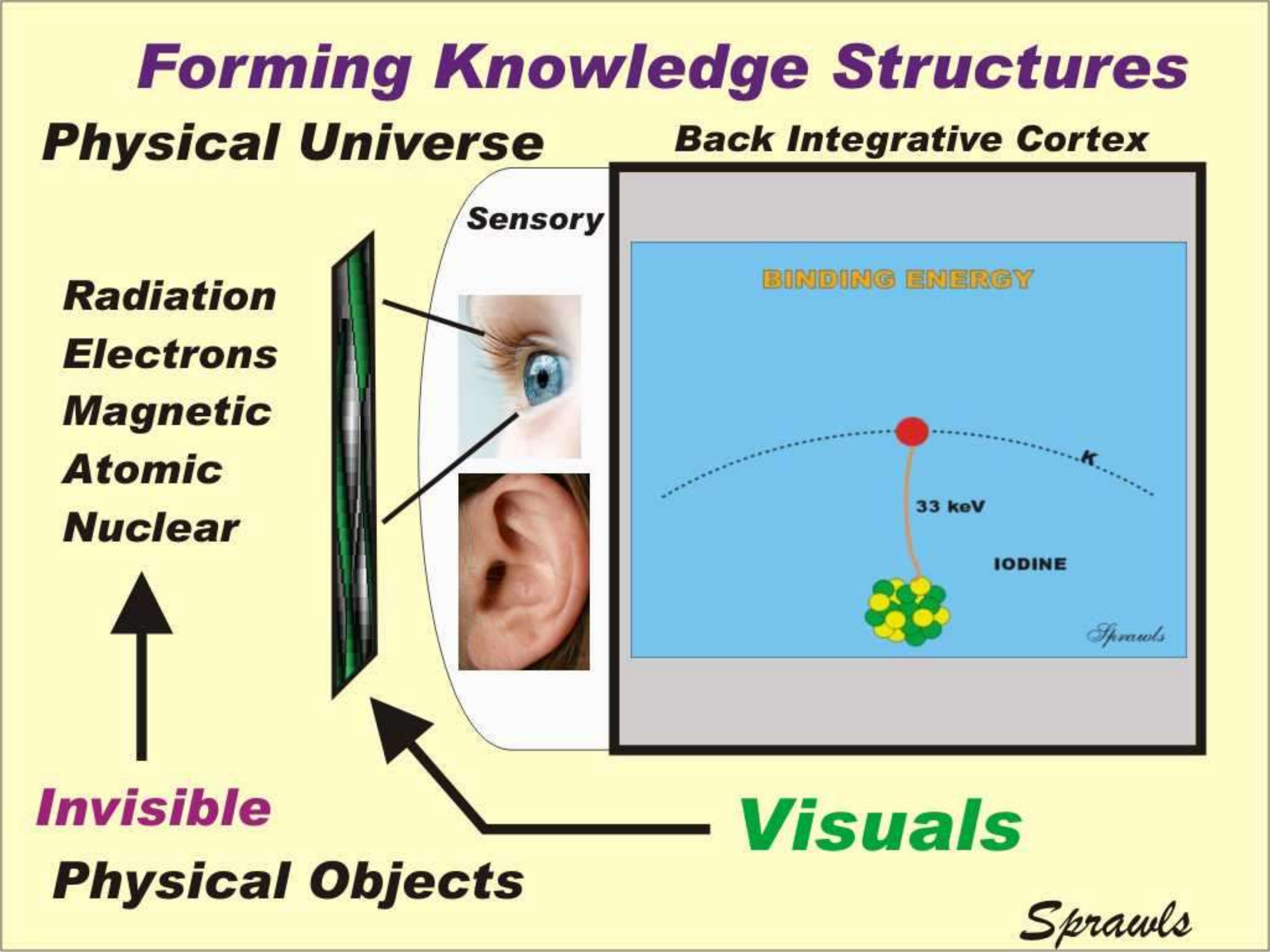
Back Integrative Cortex

Radiation
Electrons
Magnetic
Atomic
Nuclear



Invisible Physical Objects

Sprawls


Forming Knowledge Structures
Physical Universe
Back Integrative Cortex
Sensory
Radiation
Electrons
Magnetic
Atomic
Nuclear
BINDING ENERGY
K
33 keV
IODINE
Sprawls
Invisible
Visuals
Physical Objects
Sprawls

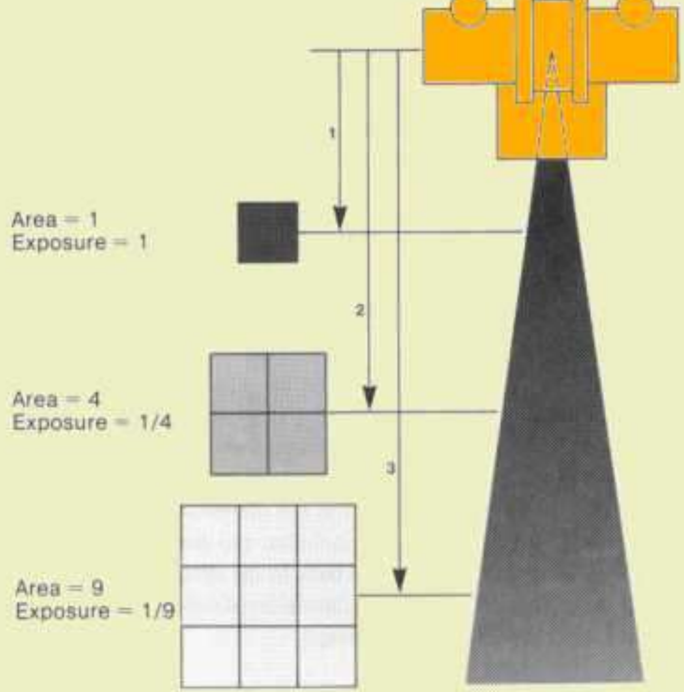
Forming Knowledge Structures

Physical Universe

Back Integrative Cortex

Inverse Square Effect

Sensory



Invisible

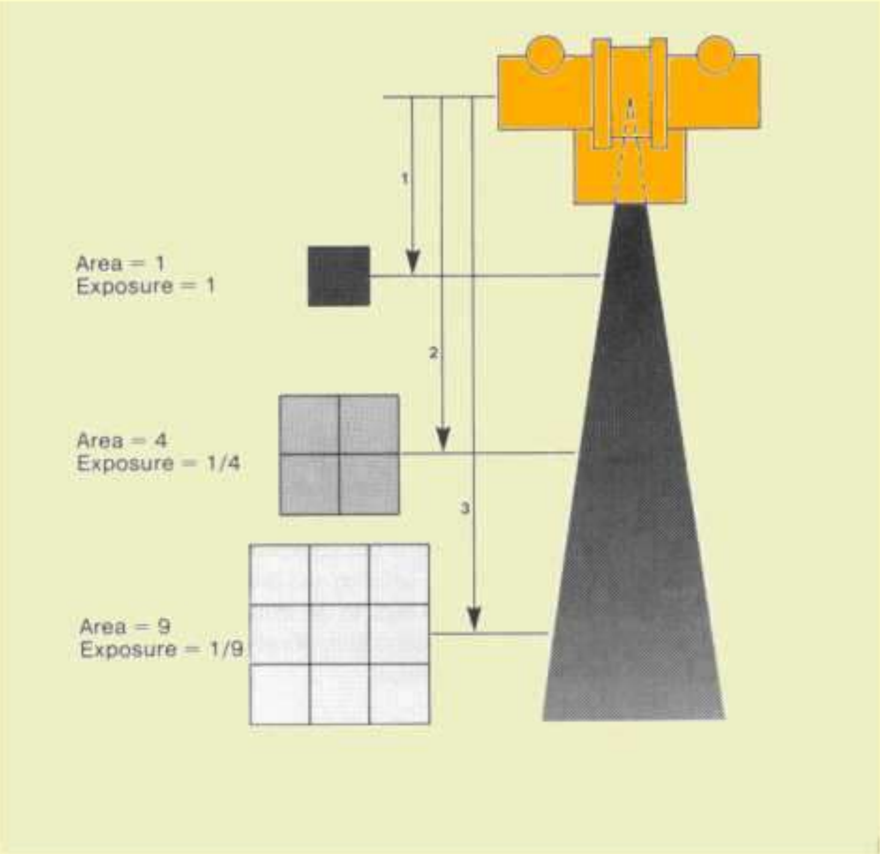
Concepts

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:

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

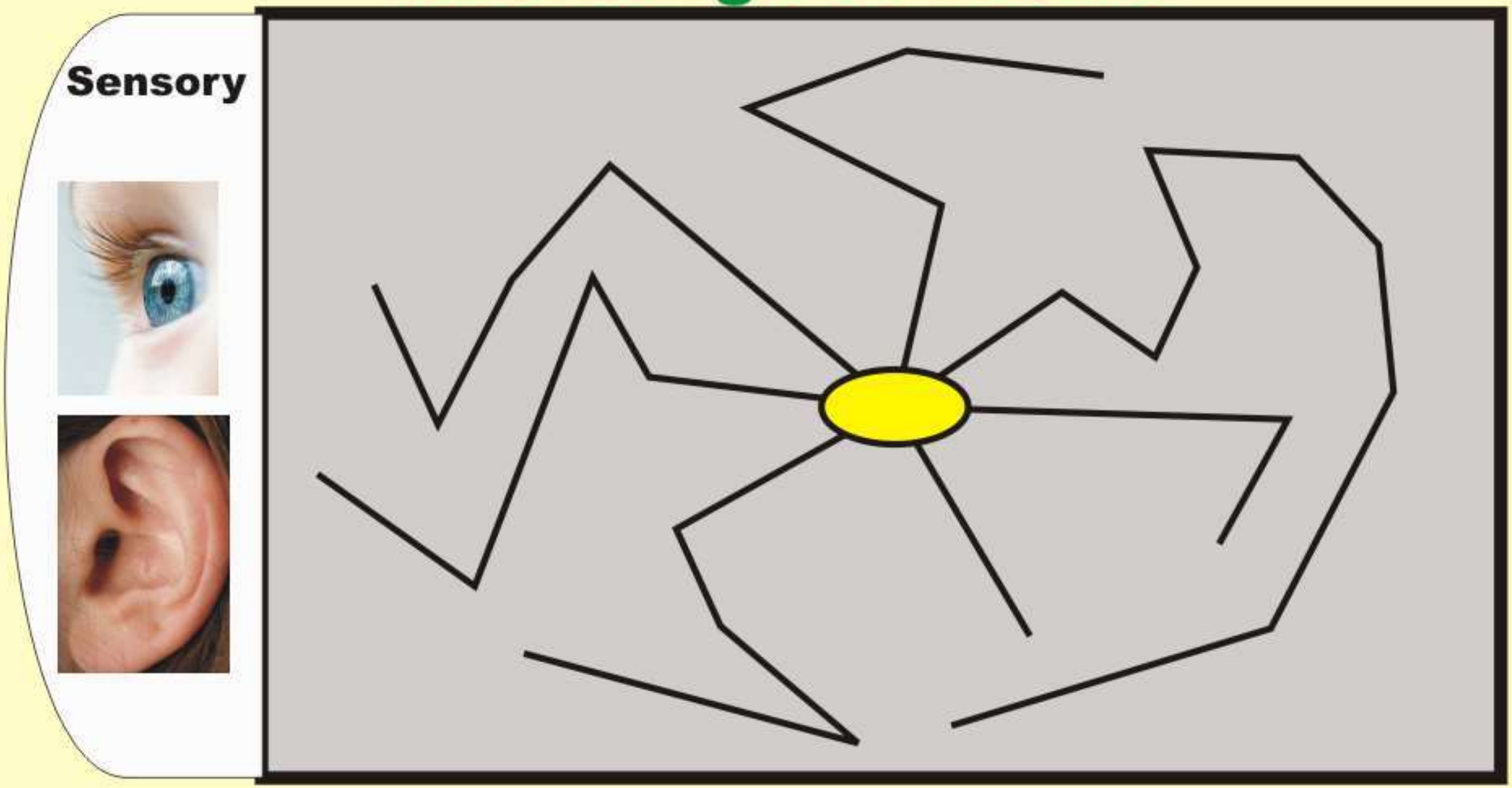
Visual

Verbal and Symbolic

Sprawls

Back Integrative Cortex

Integrating experience into existing knowledge structure



Meaning

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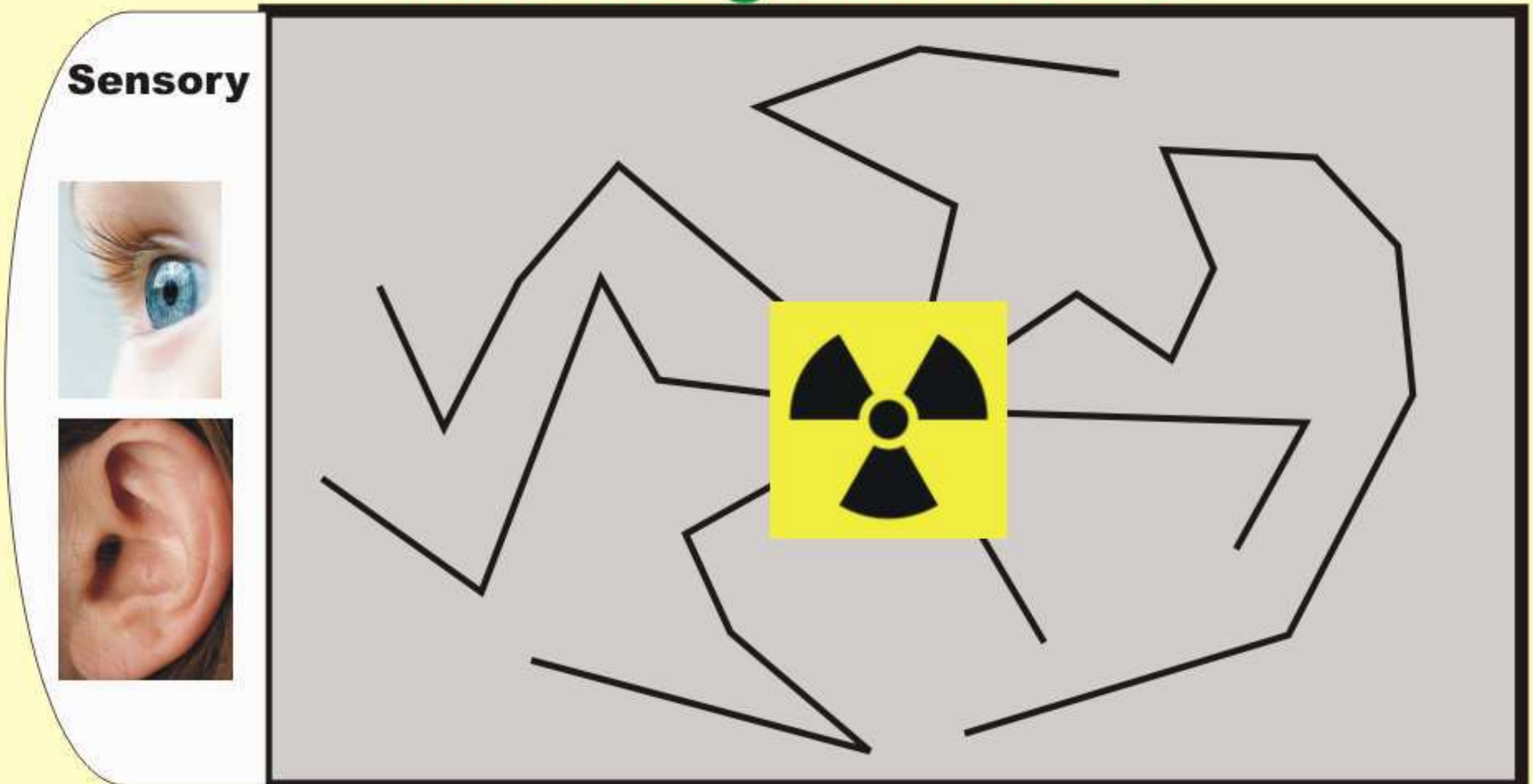
Back Integrative Cortex

Integrating experience into existing knowledge structure



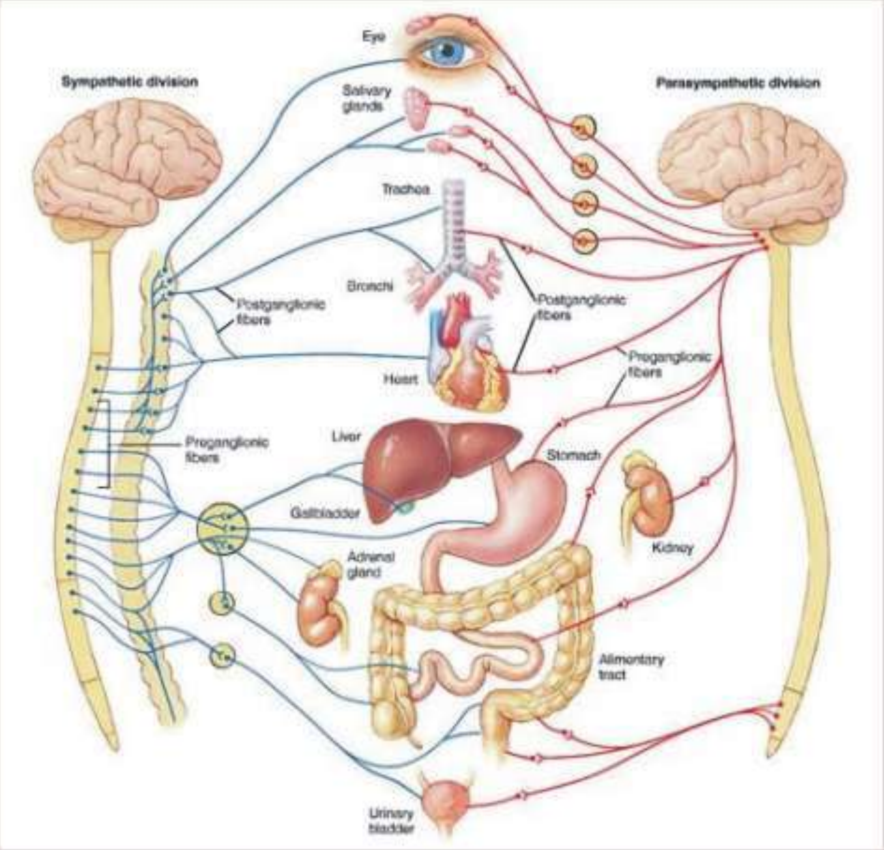
Meaning

Sprawls

Back Integrative Cortex

Integrating experience into existing knowledge structure

Sensory



Medical Knowledge

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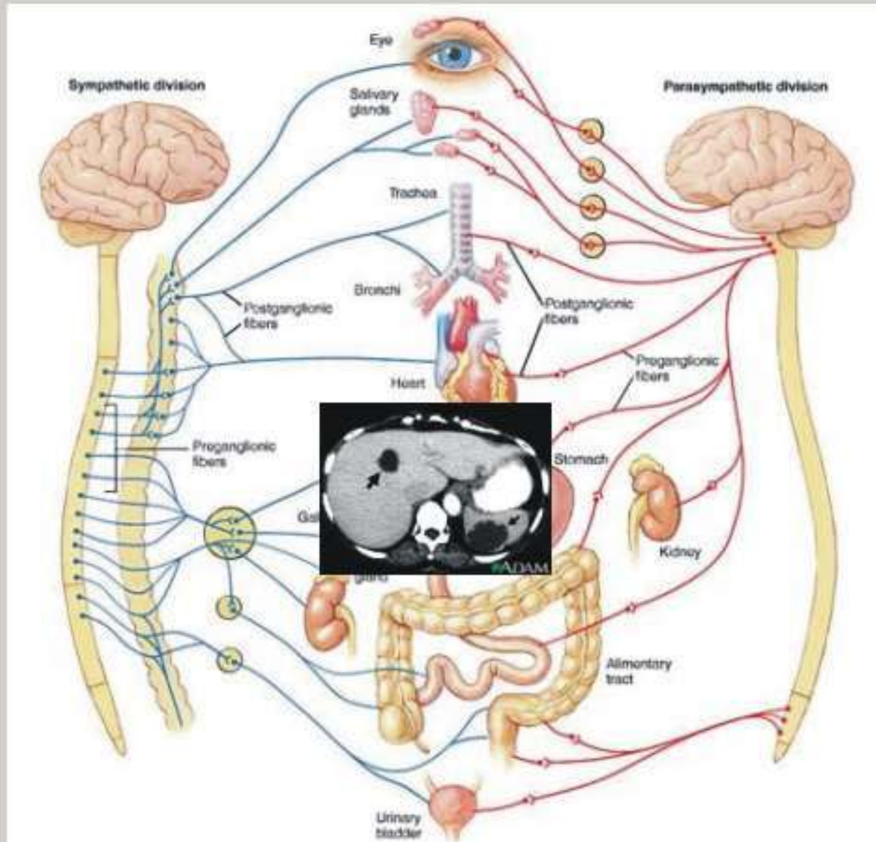
Back Integrative Cortex

Integrating experience into existing knowledge structure

Sensory

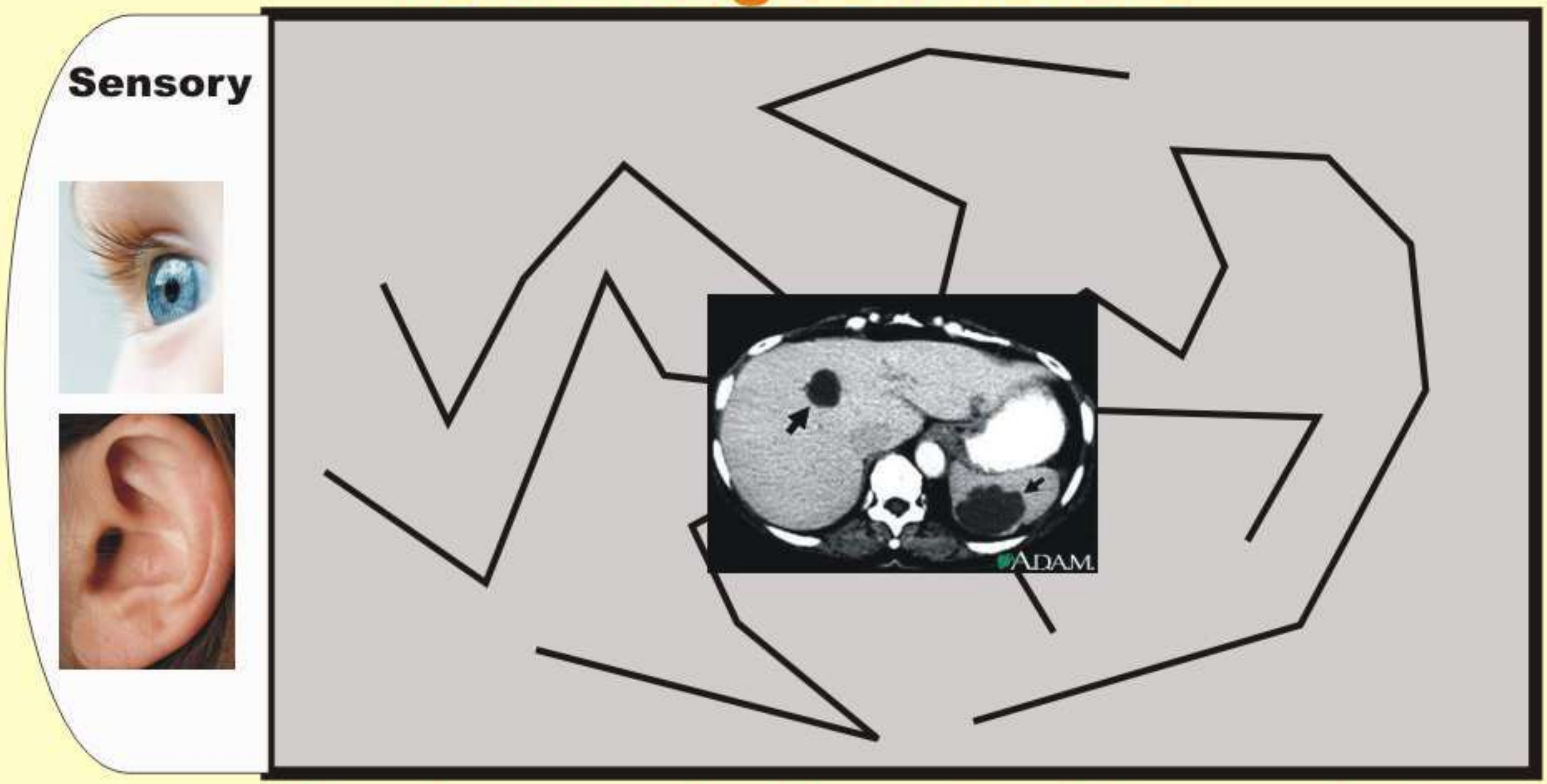


The image is the connection

Sprawls

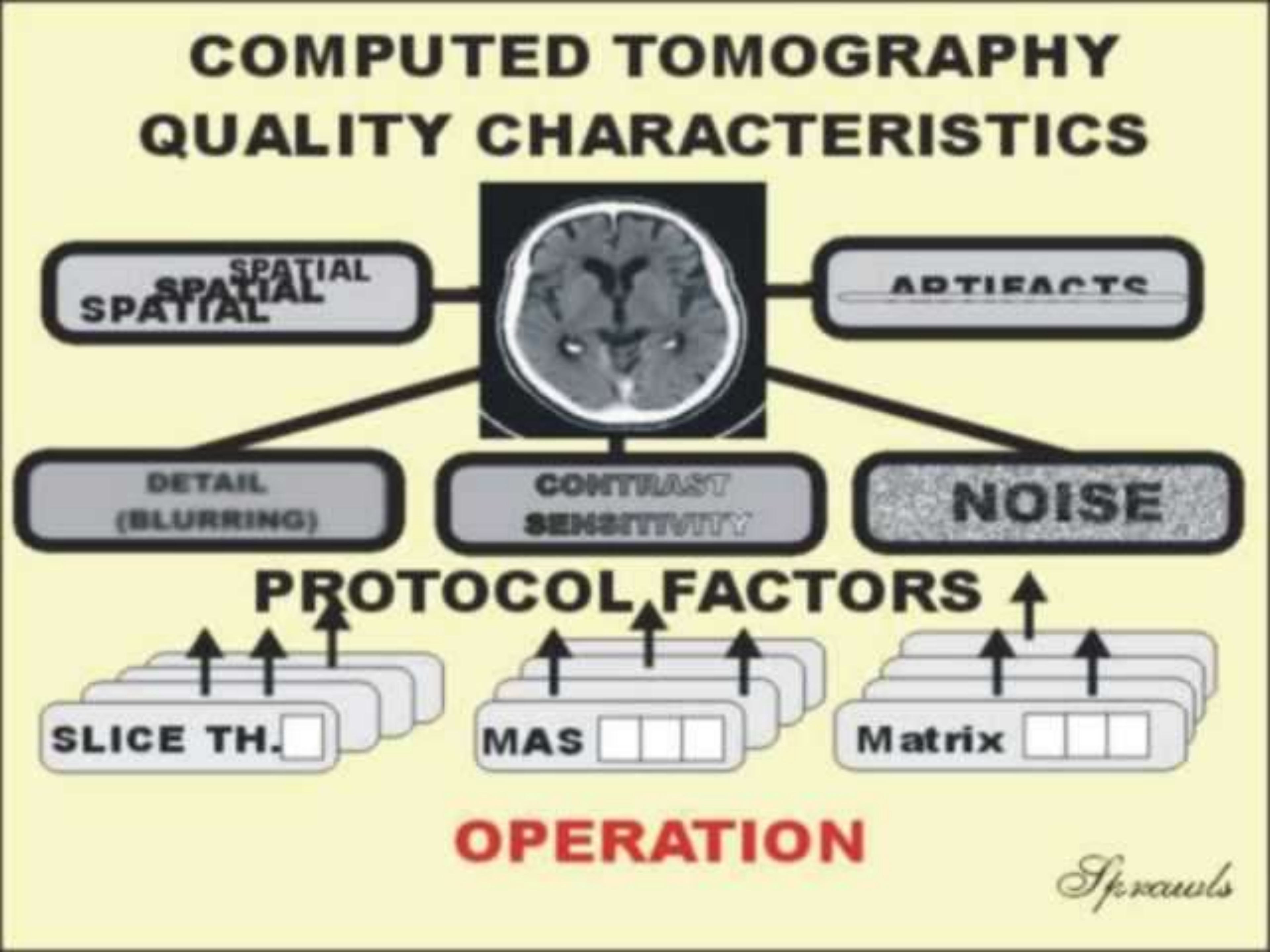
Back Integrative Cortex

Integrating experience into existing knowledge structure



The image is the starting point for learning physics

Sprawls

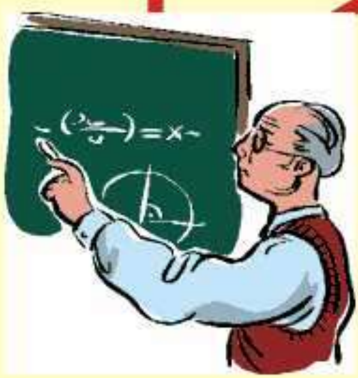


COMPUTED TOMOGRAPHY
QUALITY CHARACTERISTICS
SPATIAL
SPATIAL
SPATIAL
ARTIFACTS
DETAIL
(BLURRING)
CONTRAST
SENSITIVITY
NOISE
PROTOCOL FACTORS
SLICE TH.
MAS
Matrix
OPERATION
Sprawls

Forming Knowledge Structures

Physical Universe

Inverse Square Effect



Back Integrative Cortex

Sensory

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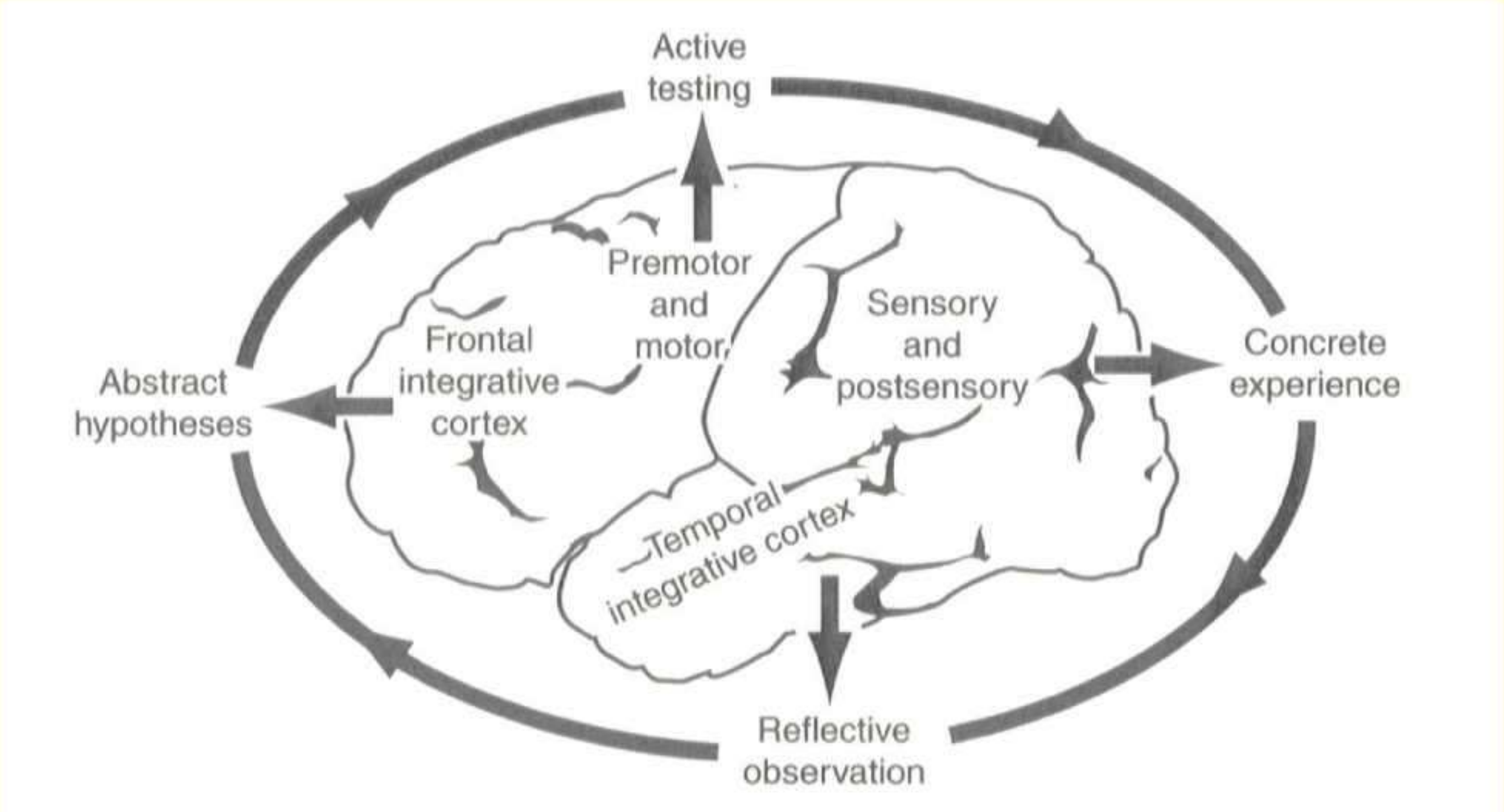
Verbal and Symbolic

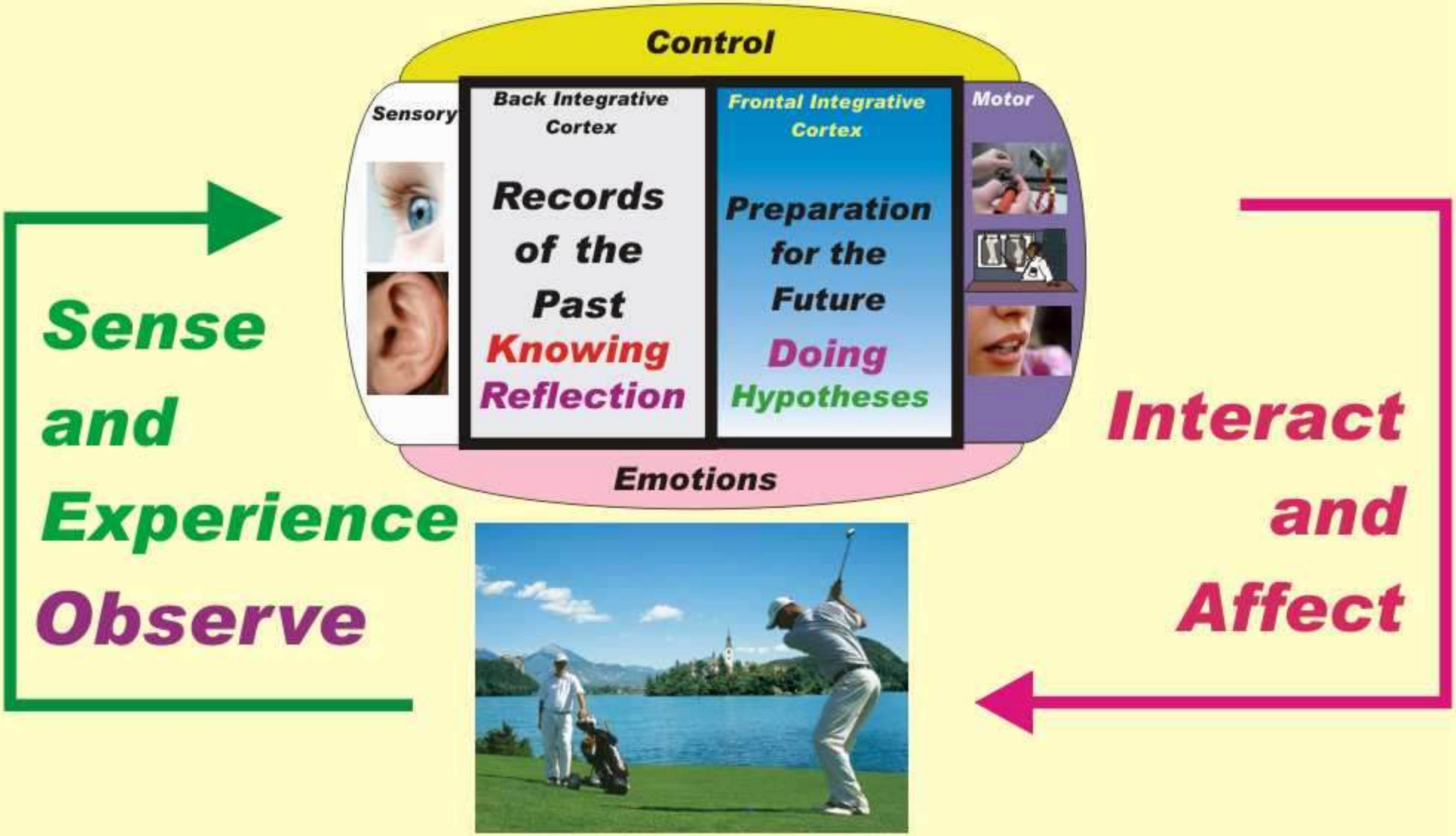
Sprawls

Zull's Model of Brain Function



Brain Functions for Learning Physics

Active Experimentation and Testing

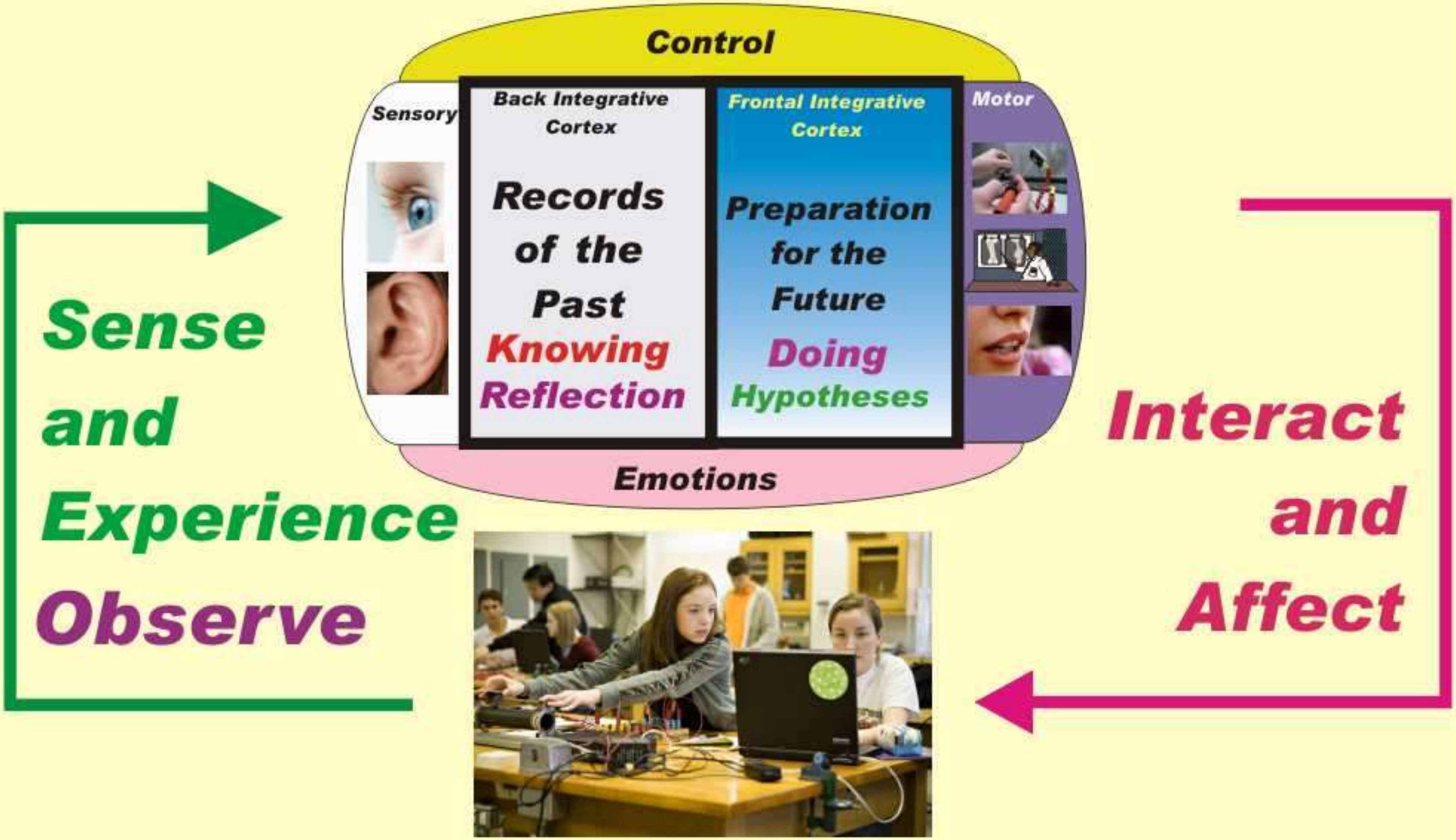


Physical Universe

Sprawls

Brain Functions for Learning Physics

Active Experimentation and Testing

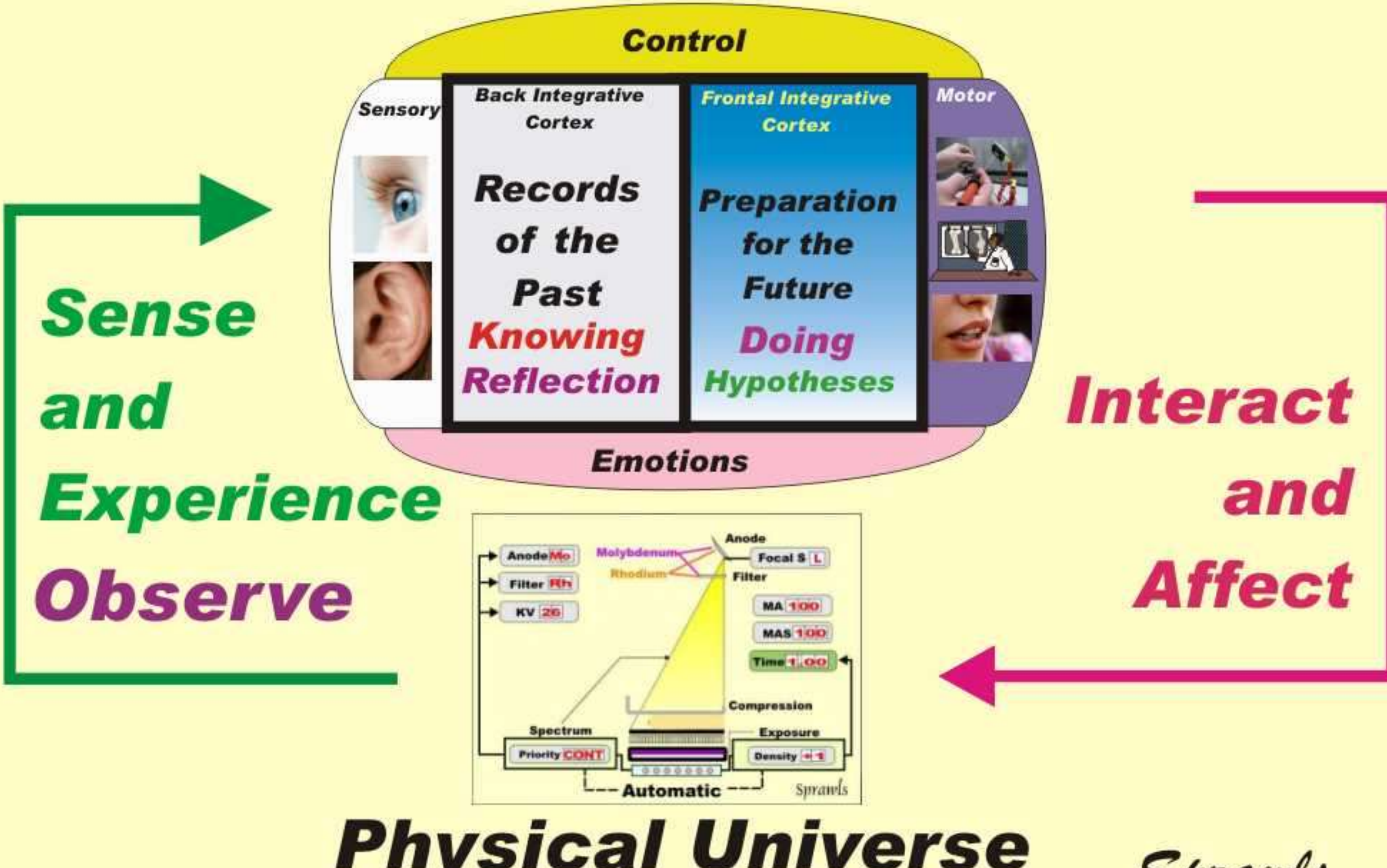


Physical Universe

Sprawls

Brain Functions for Learning Physics

Active Experimentation and Testing

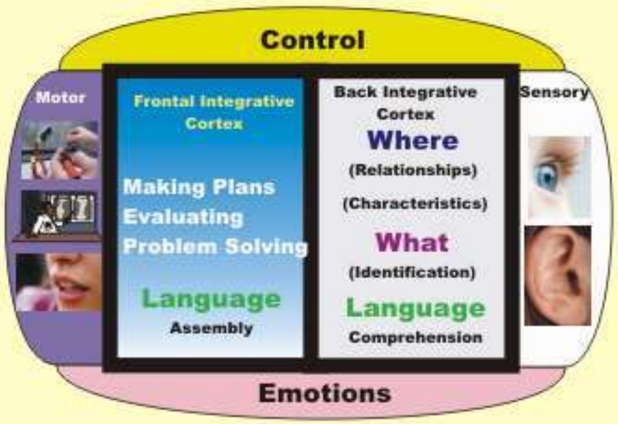


Sprawls

Brain Functions for Learning Physics

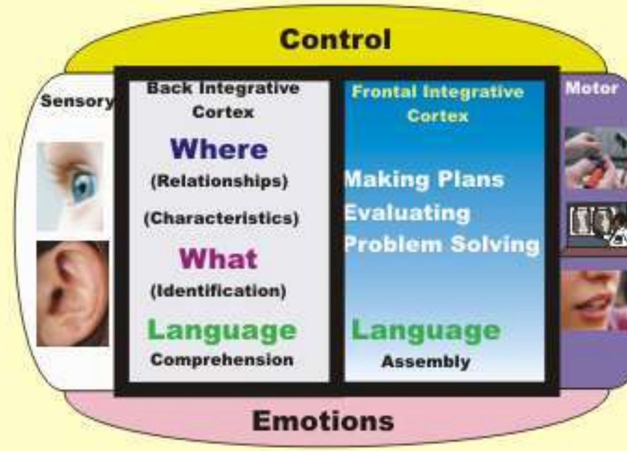
Two brains are better than one!

Collaborative Learning



Ben

?



Jerry

Problem Solving

Sprawls

Brain Functions for Learning Physics

Two brains are better than one!

Collaborative Learning

Problem Solving

Sprawls

Brain Functions for Learning Physics

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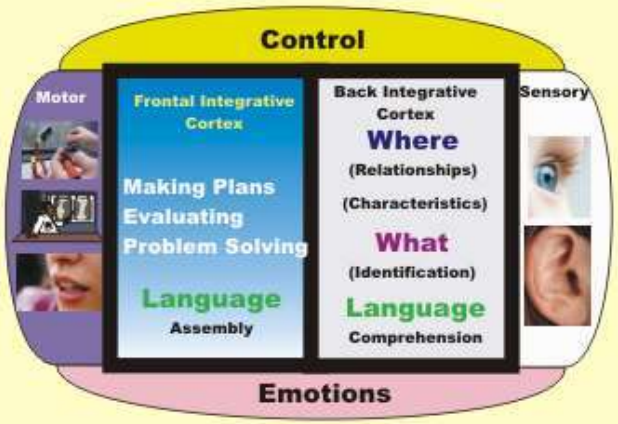
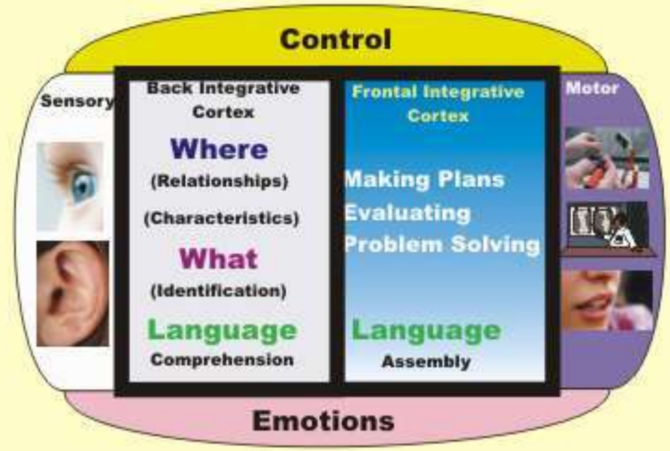
Collaborative Learning





Views
Perspectives
Experiences

Views
Perspectives
Experiences

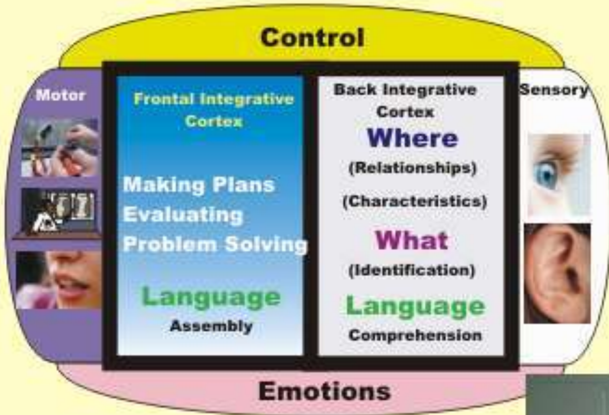
Problem Solved!

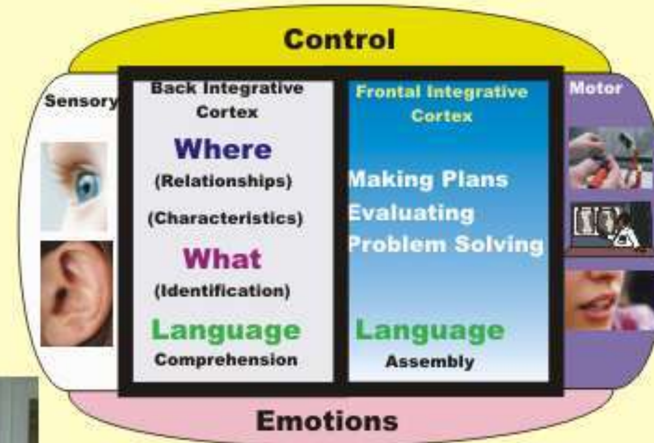
Sprawls

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

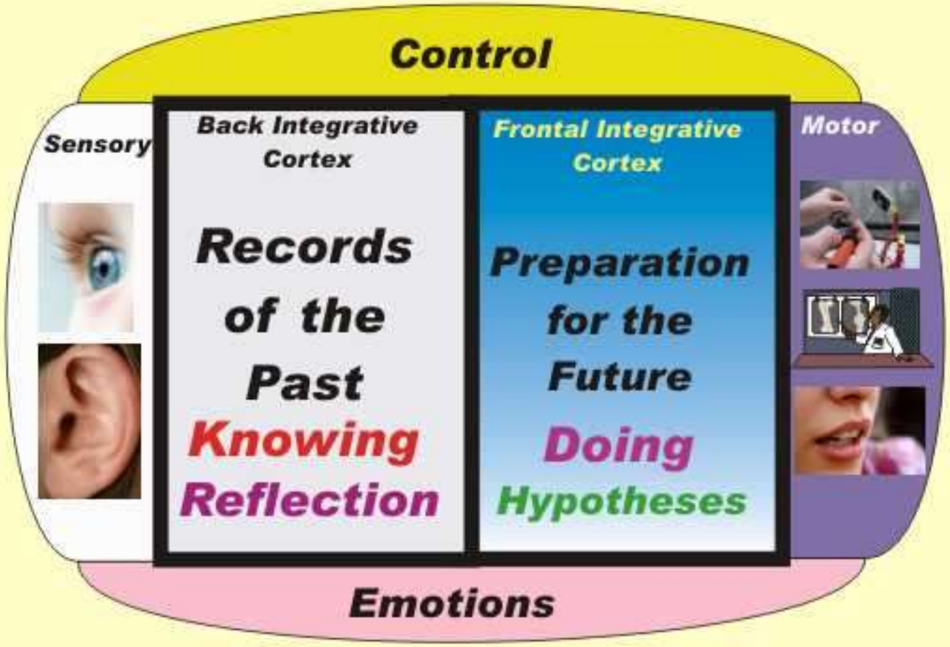
Two brains are better than one!

Collaborative Learning

Problem Solving
Analysis and Evaluation
Developing Plans

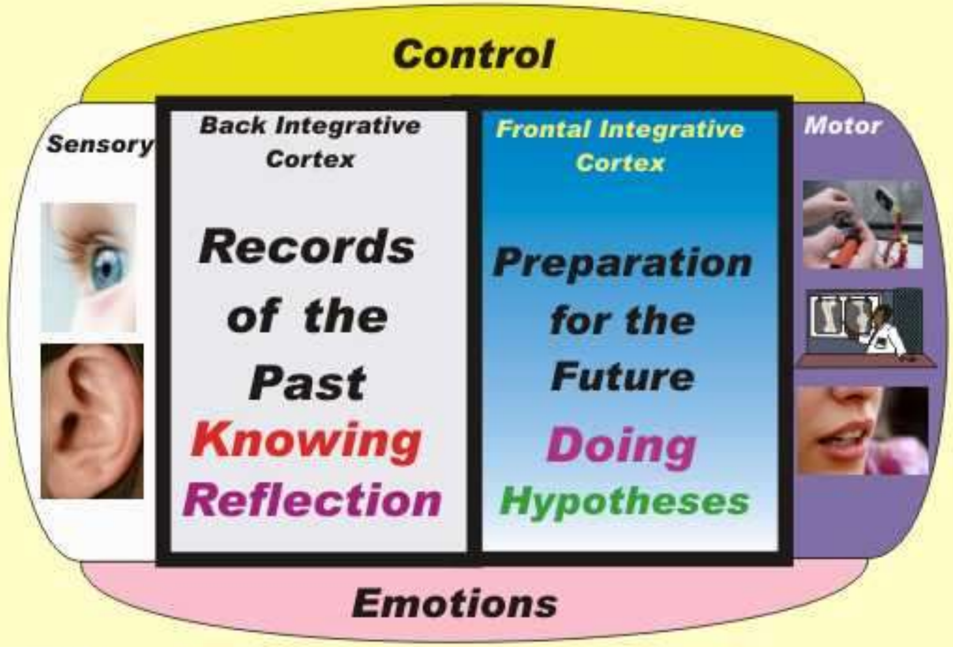
Sprawls

The Learning Environment



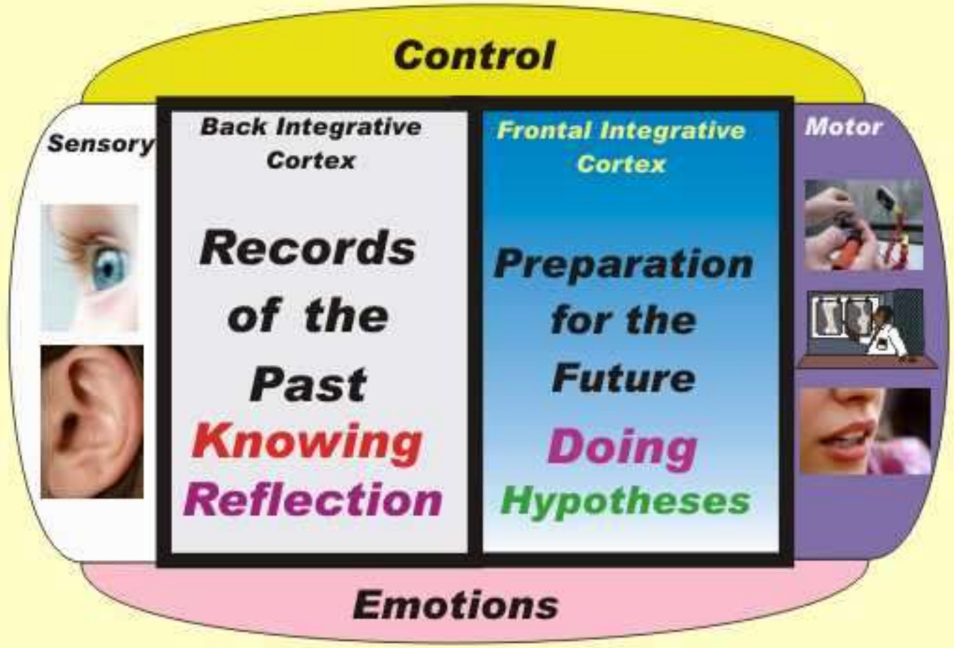
Sprawls

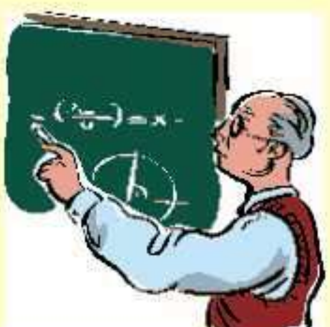
Rich Learning Environments



Sprawls

Challenging Learning Environments





Sprawls

Effective Learning

Rich Learning Environment

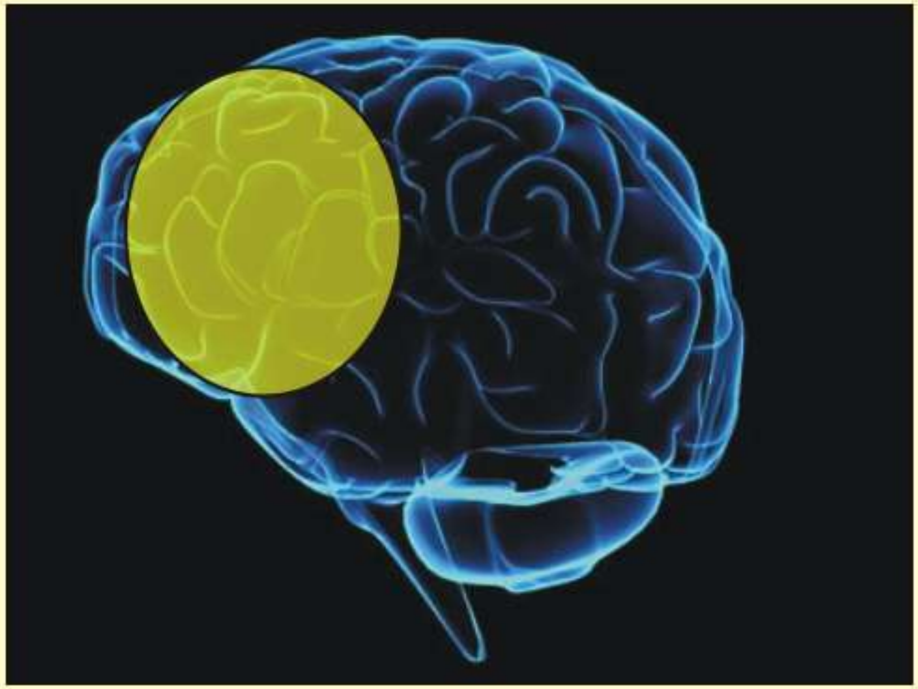
New and Different

Integrate into Existing Knowledge

——— Reflection ———>

Sprawls

Effective Learning

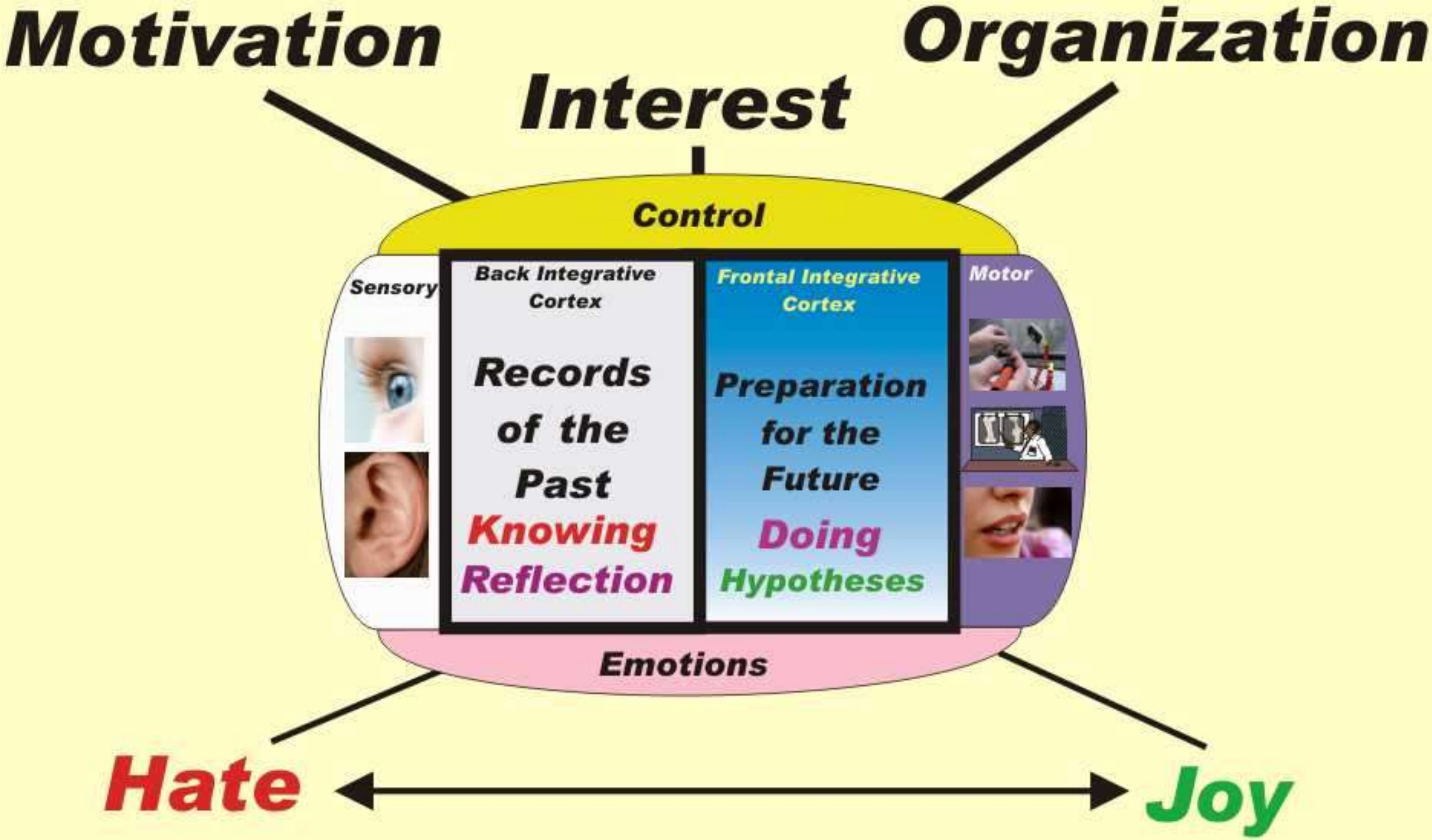


Interact **Review** **Reflect**

Developing useful knowledge for the future

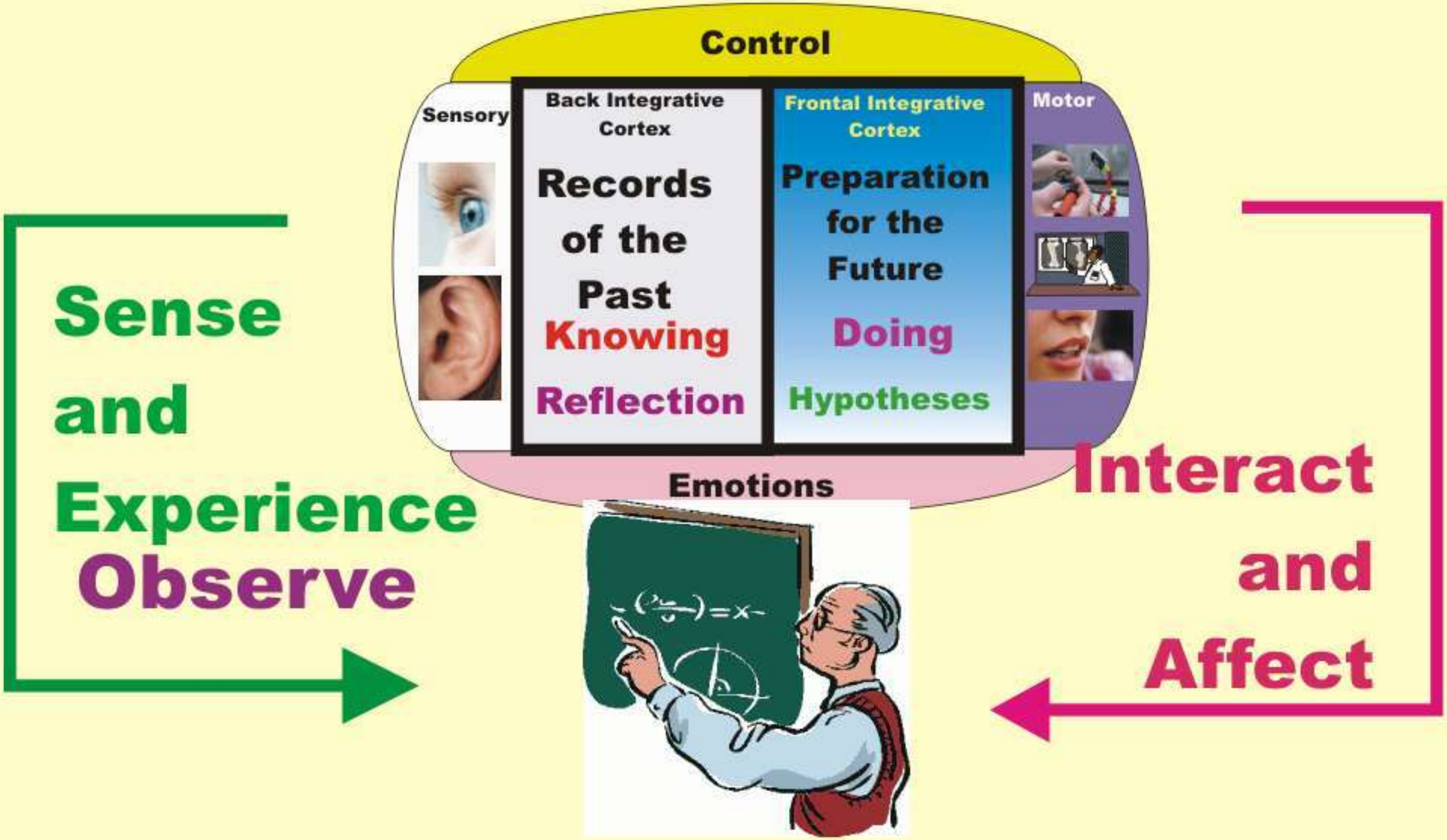
Sprawls

Brain Functions for Learning Physics



Sprawls

Brain Functions for Learning About
Learning Physics



Our Teaching

Sprawls

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

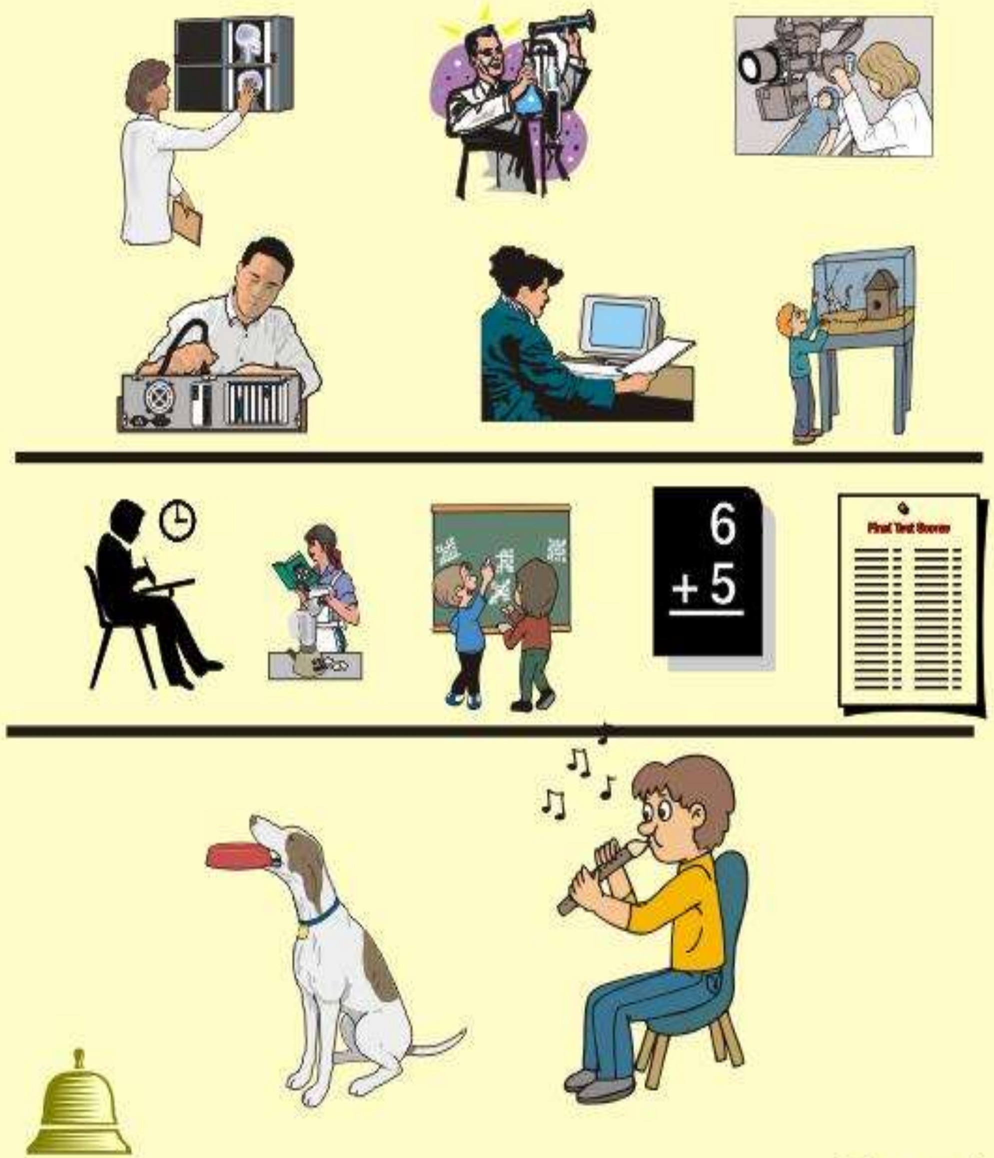
Gagné was also well-known for his sophisticated stimulus-response theory of eight kinds of learning which differ in the quality and quantity of stimulus-response bonds involved. From the simplest to the most complex, these are:

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

Sprawls

Gagne's Hierarchy of Learning

- PROBLEM SOLVING
- RULE LEARNING
- CONCEPT LEARNING
- DISCRIMINATION LEARNING
- VERBAL ASSOCIATION
- CHAINING
- STIMULUS RESPONSE
- SIGNAL LEARNING



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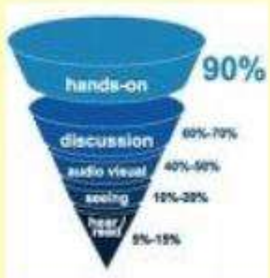
Edgar Dale (1900-1985)

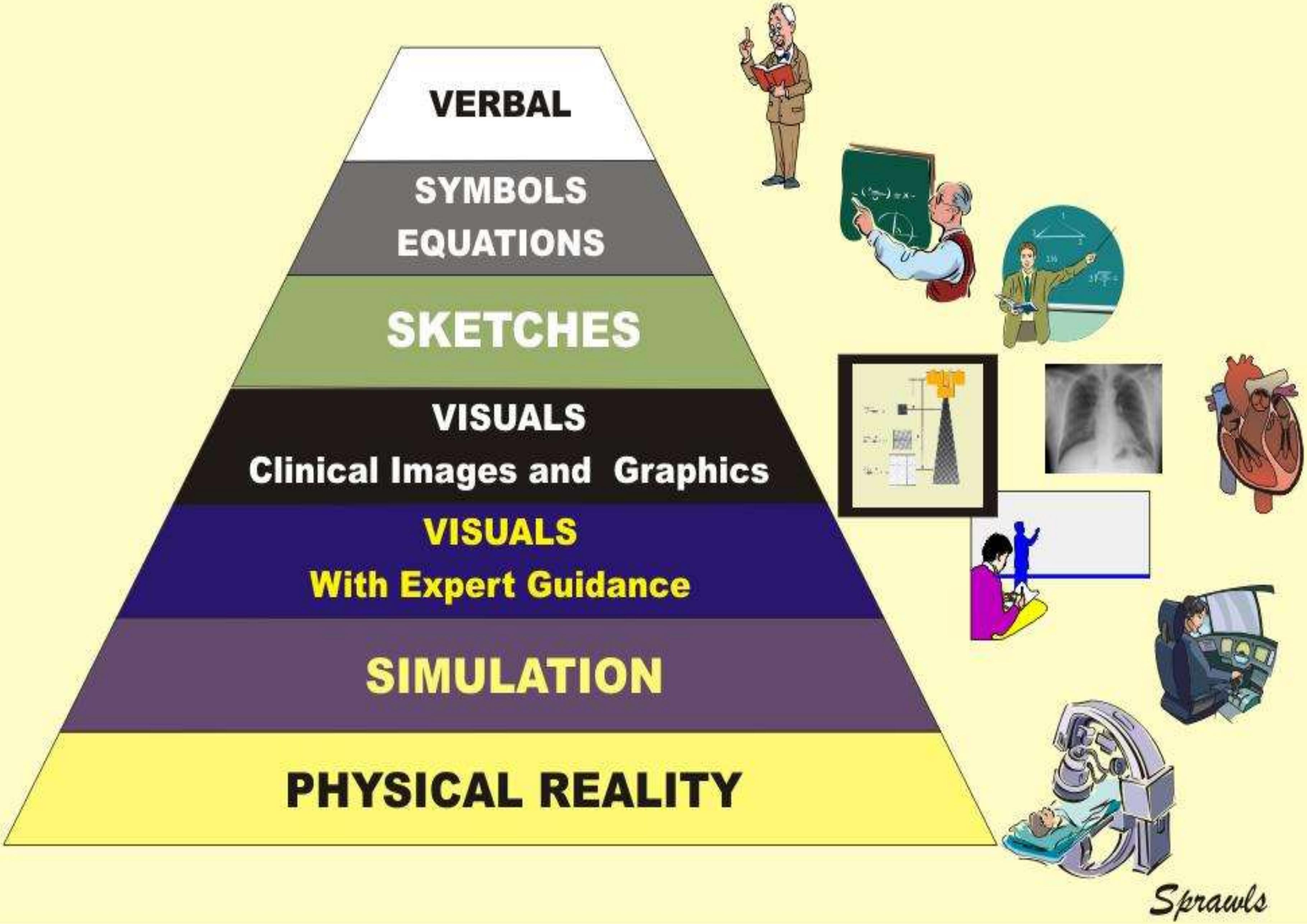
Educationalist who developed the famous

Cone of Experience theory

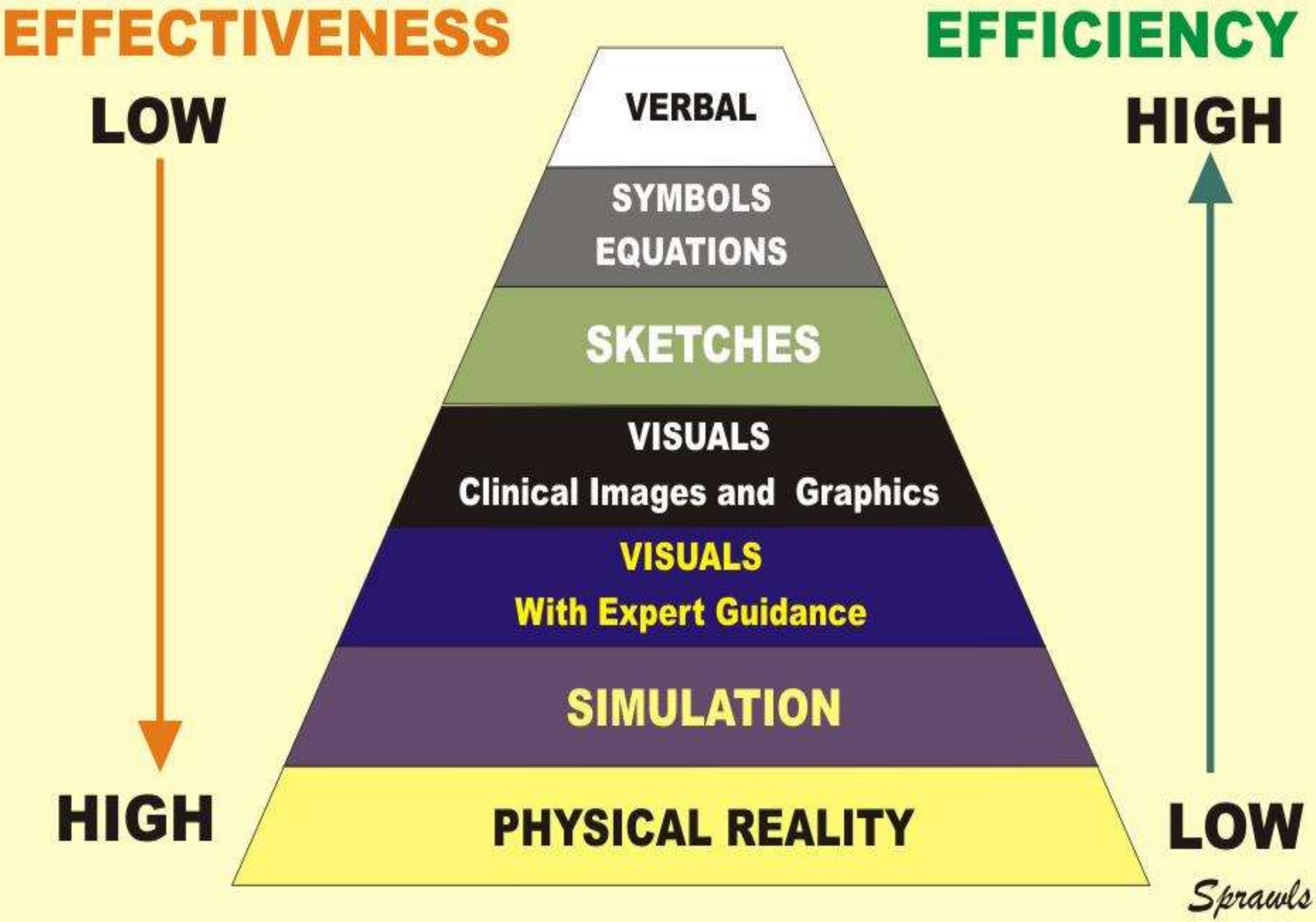


Sprawls

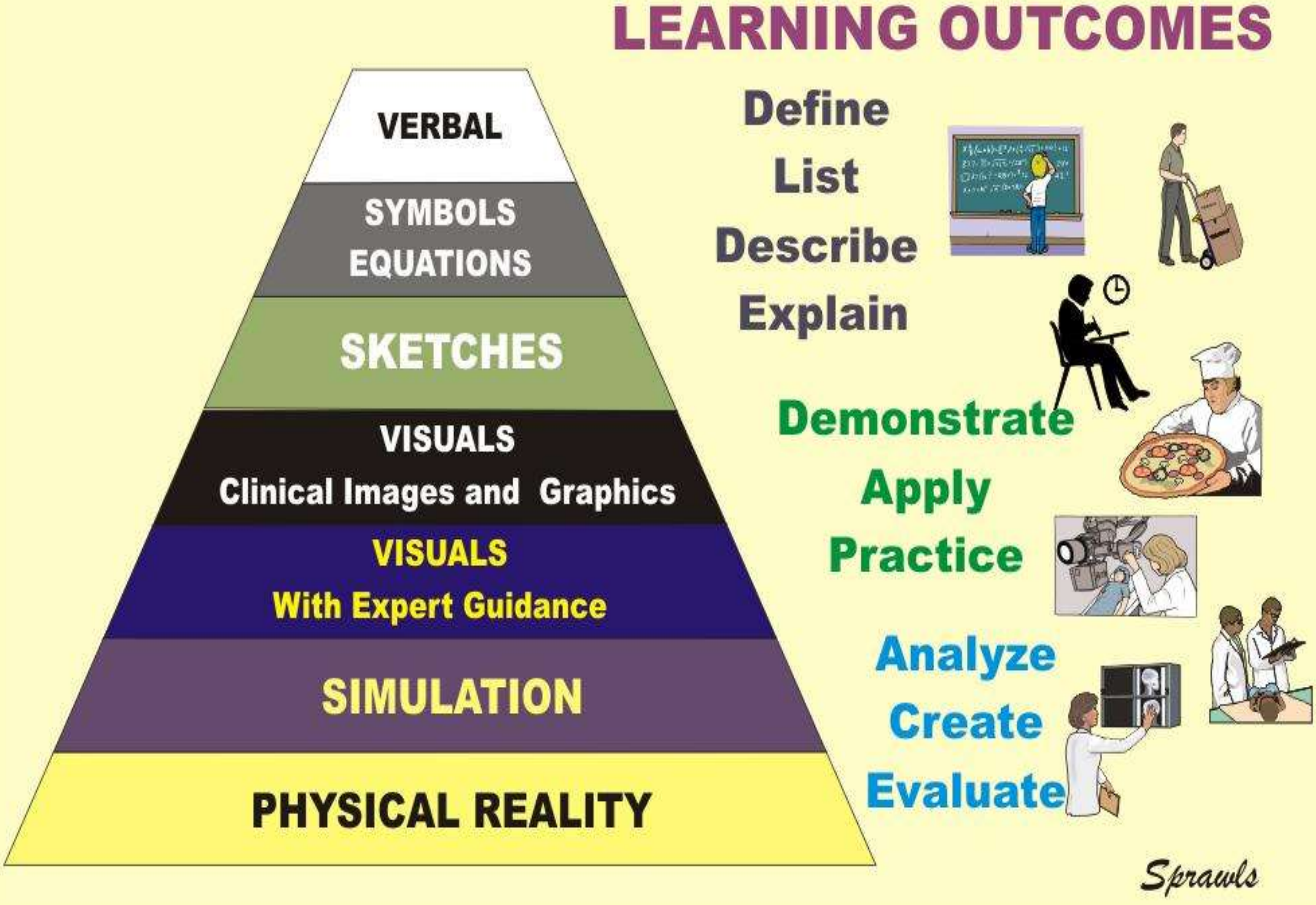
Cone of Experience for Medical Imaging Education

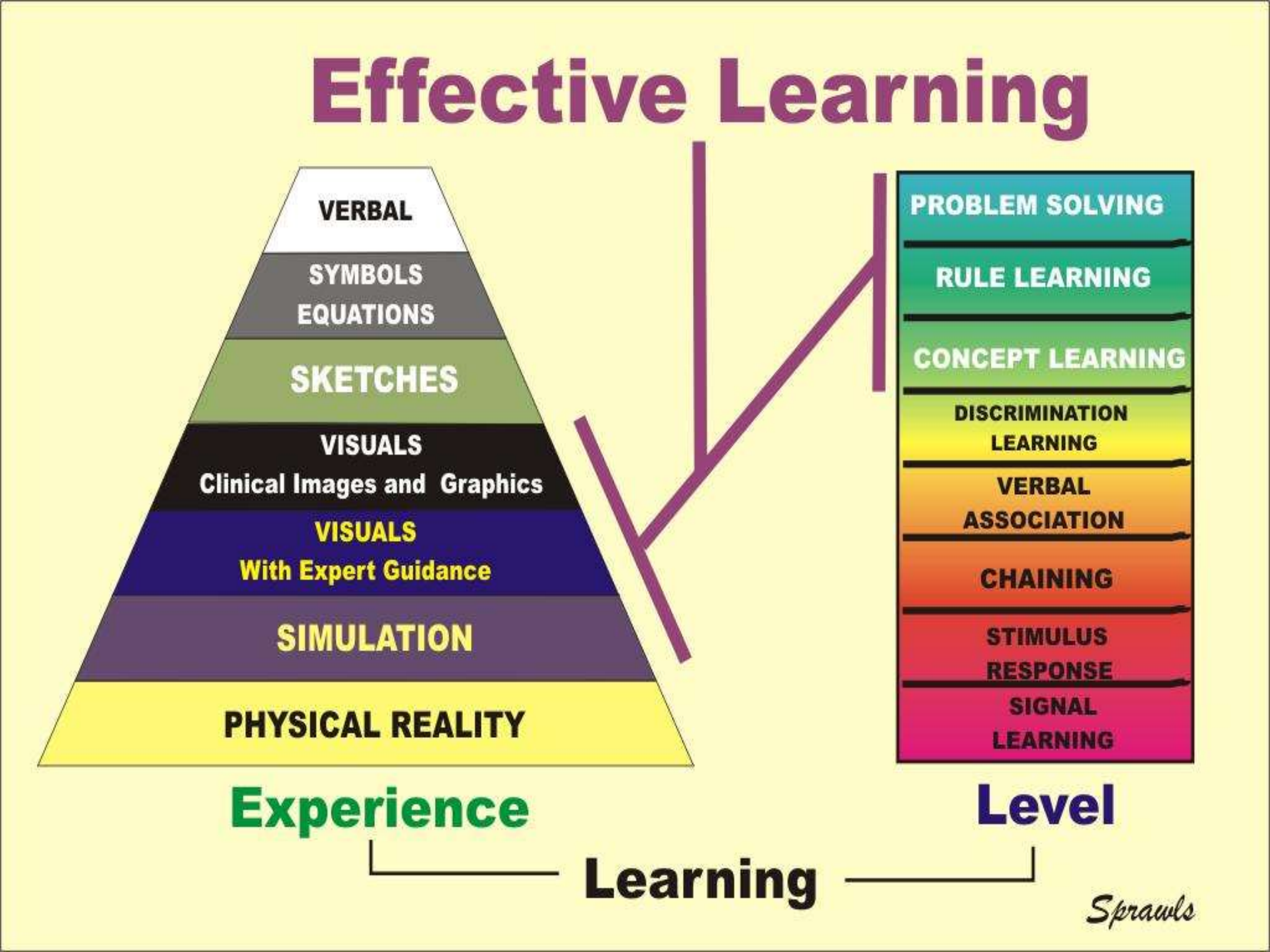


Cone of Experience for Medical Imaging Education



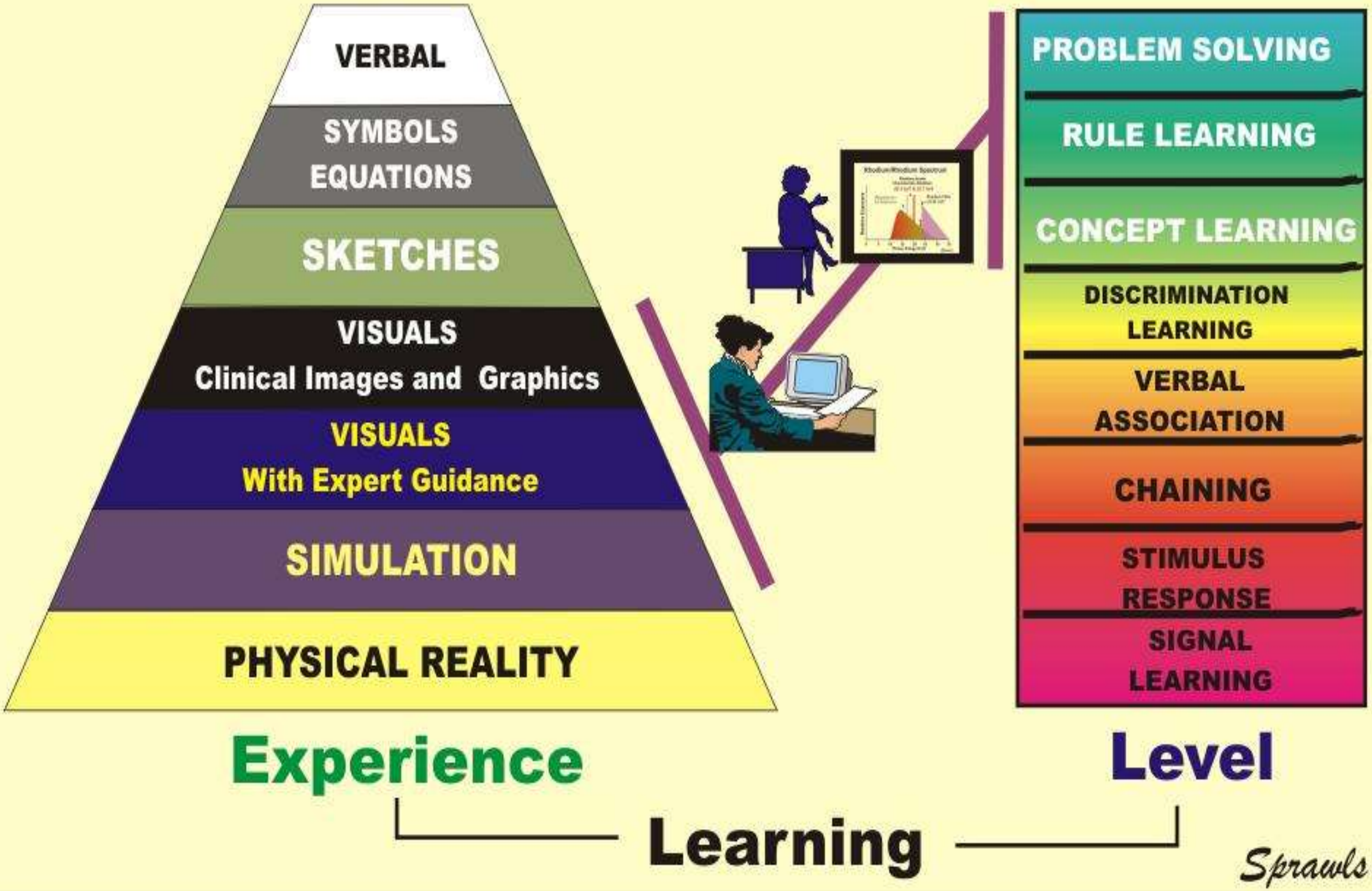
Cone of Experience for Medical Imaging Education




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

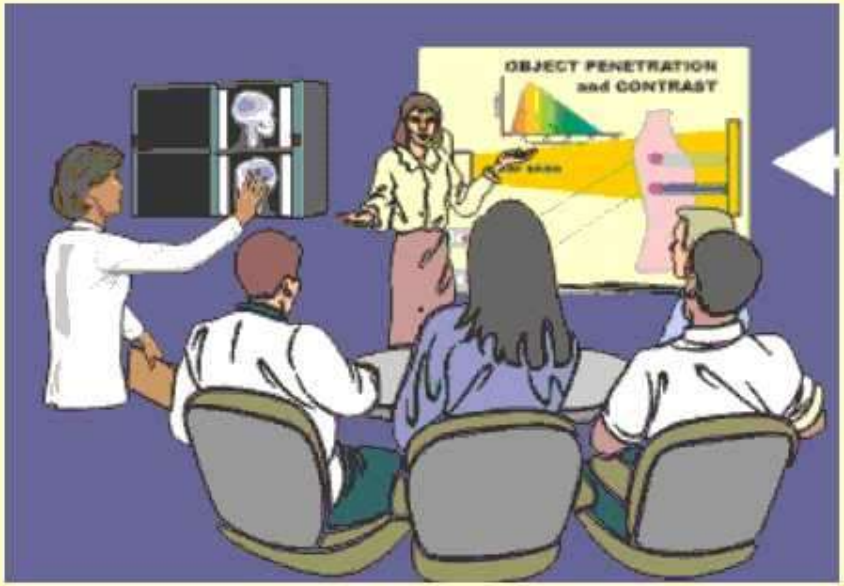
Visuals **Images** **Online Modules**

Resources and References

Sprawls

Rich Classroom and Conference Learning Activities

Learning Facilitator "Teacher"



Visuals

Representations of Reality

Organize and Guide the Learning Activity

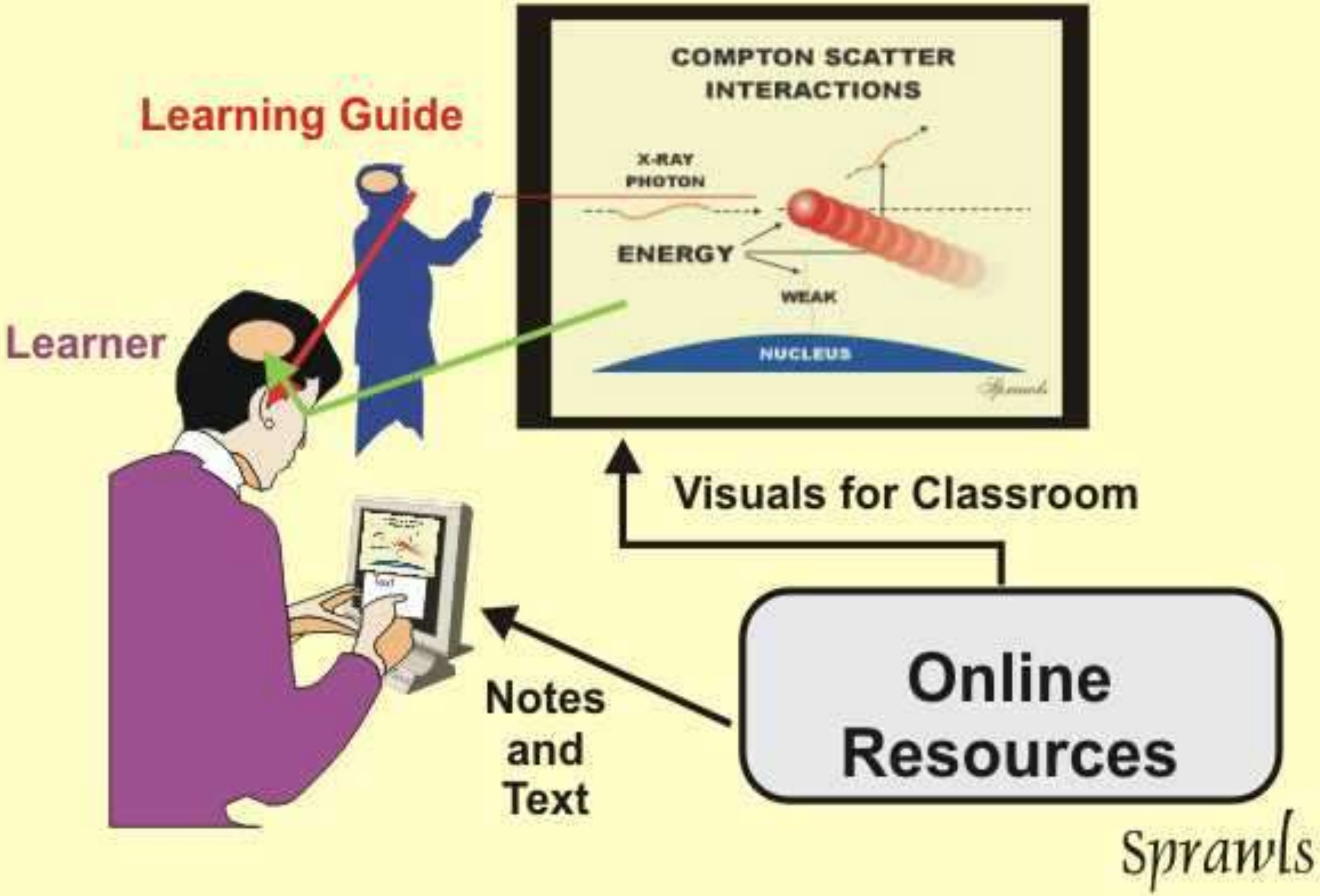
Share Experience and Knowledge

Explain and Interpret What is Viewed

Motivate and Engage Learners

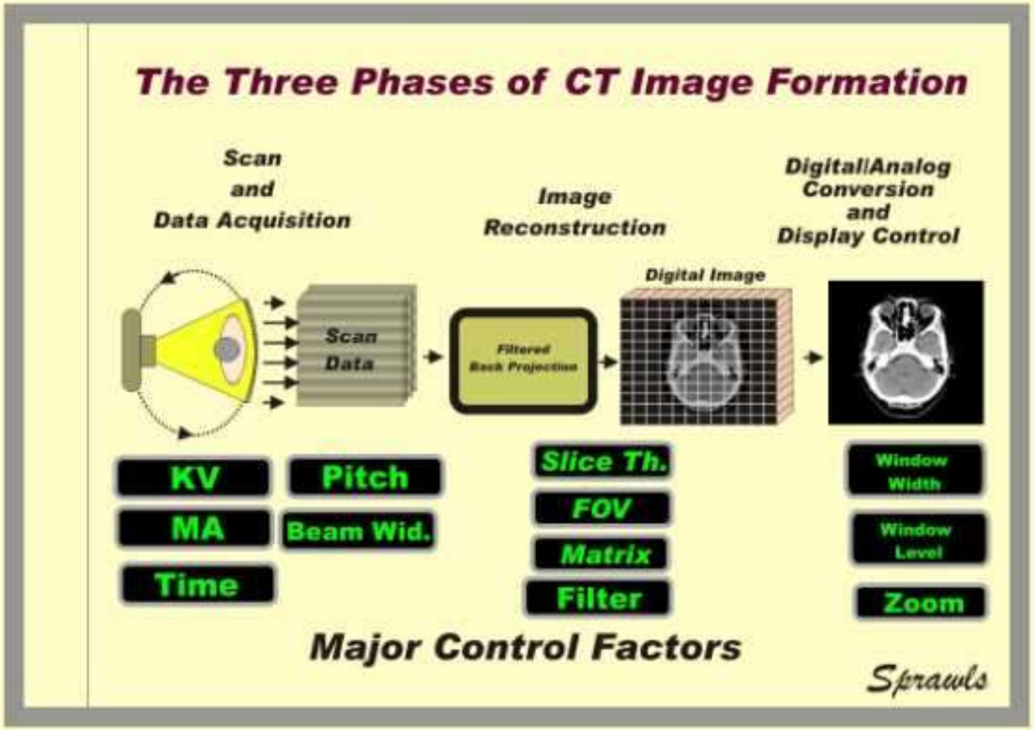
Sprawls

Technology Enhanced Learning



Visuals
for
Learning and Teaching

The Imaging Process



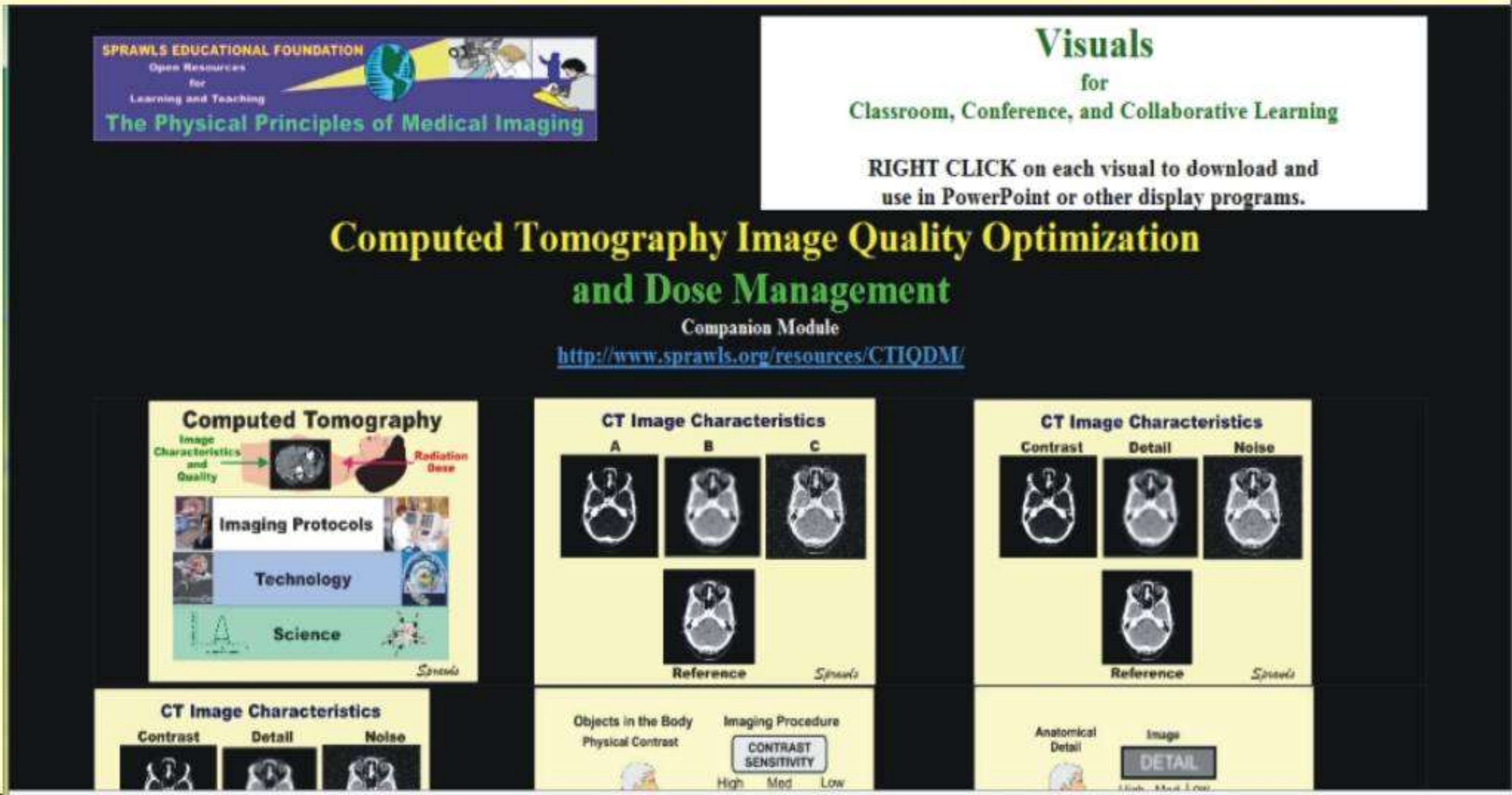
Clinical Images

Sprawls

Visuals

to be used by

Physicists in Classroom and Conference Discussions

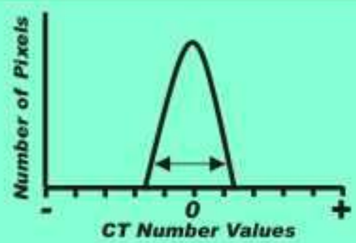


Computed Tomography

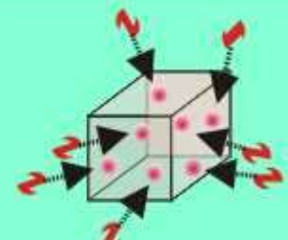
Image Characteristics and Quality →  ← **Radiation Dose**

Imaging Protocols

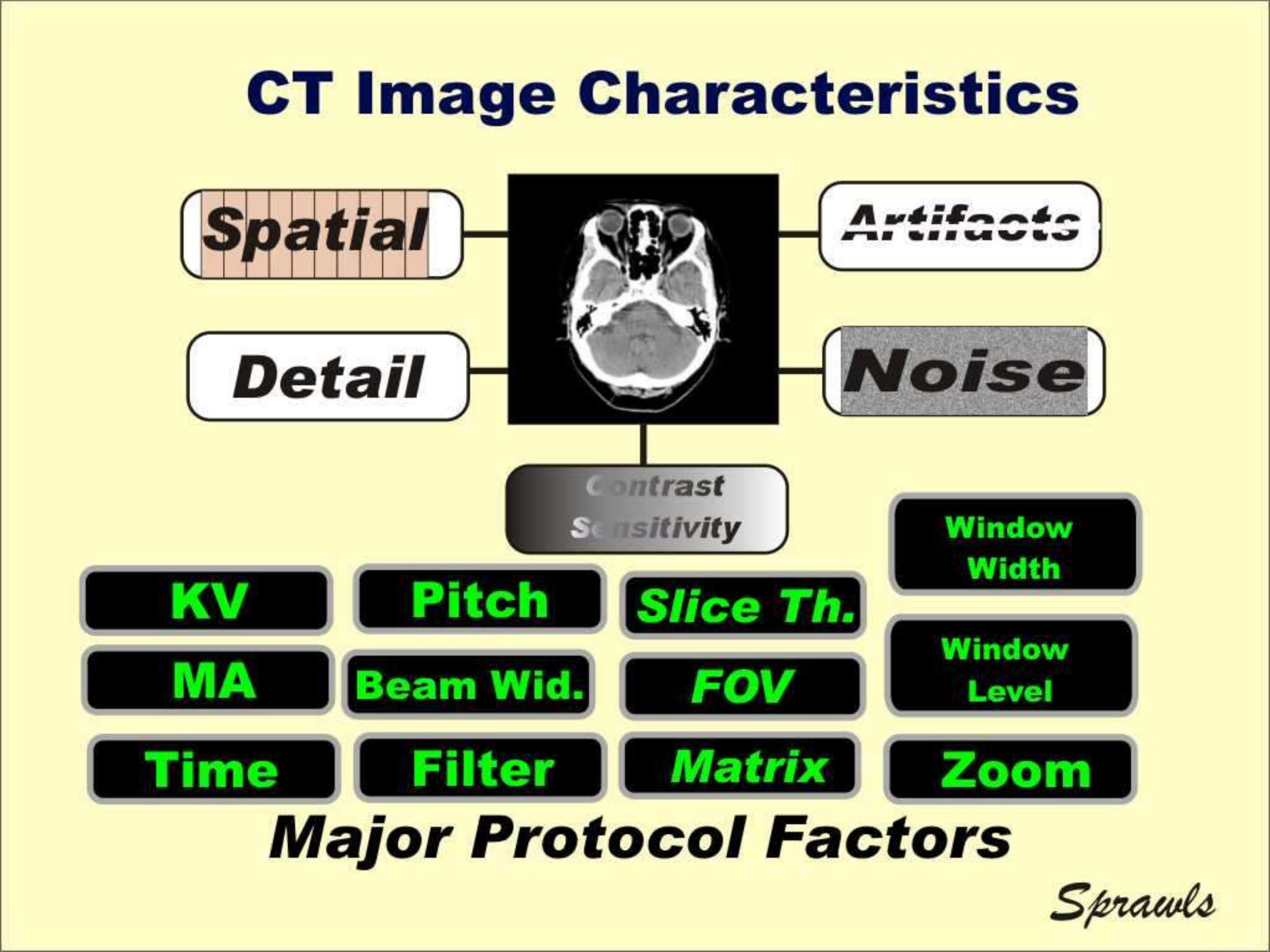
Technology



Science



Sprawls



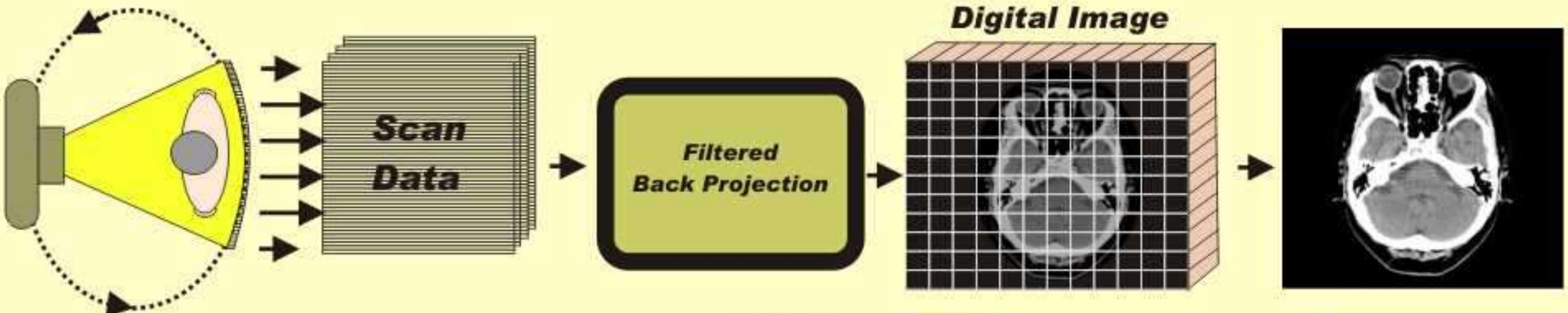
CT Image Characteristics
Spatial
Detail
Artifacts
Noise
Contrast
Sensitivity
Window
Width
KV
Pitch
Slice Th.
Window
Level
MA
Beam Wid.
FOV
Time
Filter
Matrix
Zoom
Major Protocol Factors
Sprawls

The Three Phases of CT Image Formation

Scan and Data Acquisition

Image Reconstruction

Digital/Analog Conversion and Display Control



KV

Pitch

MA

Beam Wid.

Time

Slice Th.

FOV

Matrix

Filter

Window Width

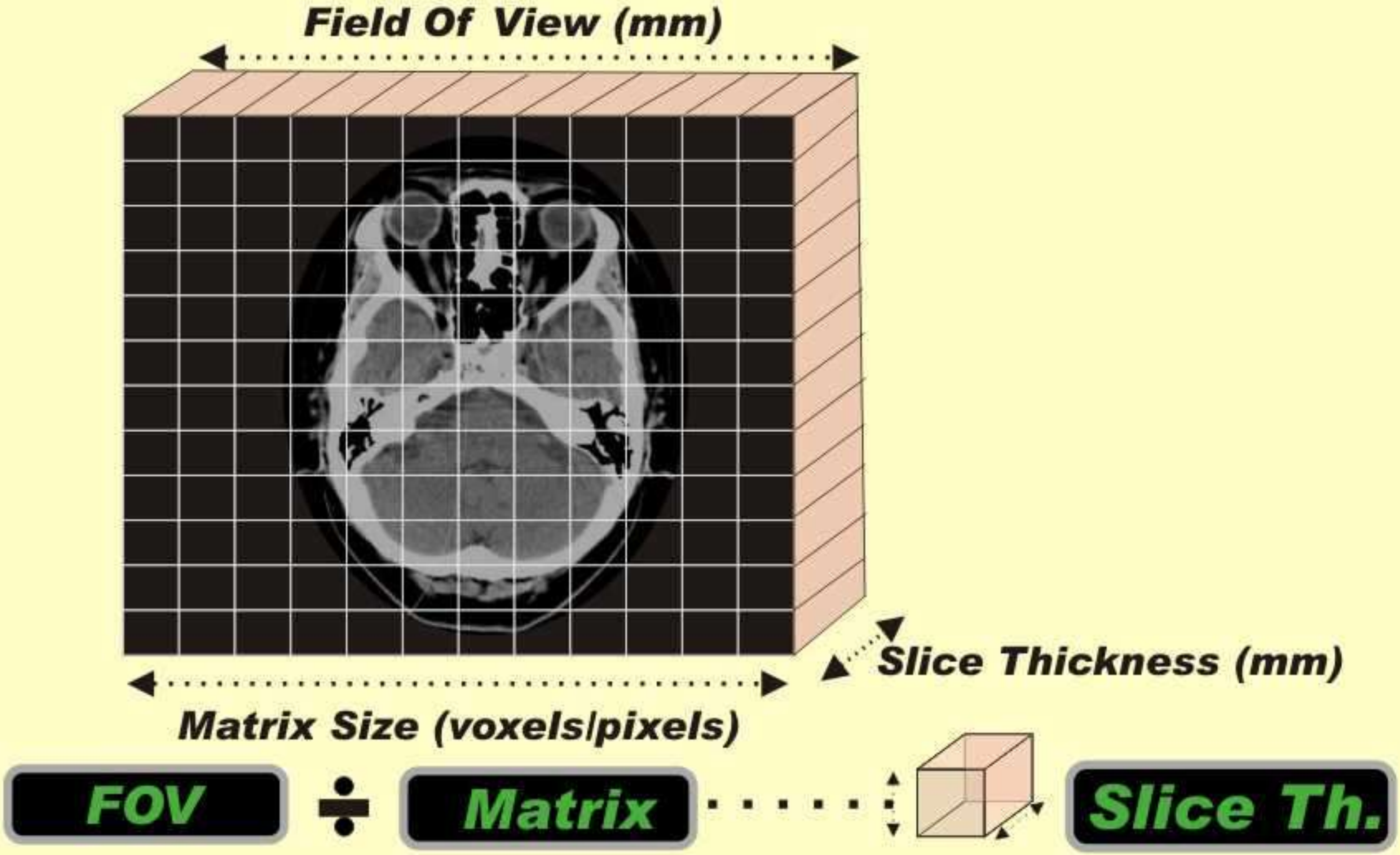
Window Level

Zoom

Major Protocol Factors

Sprawls

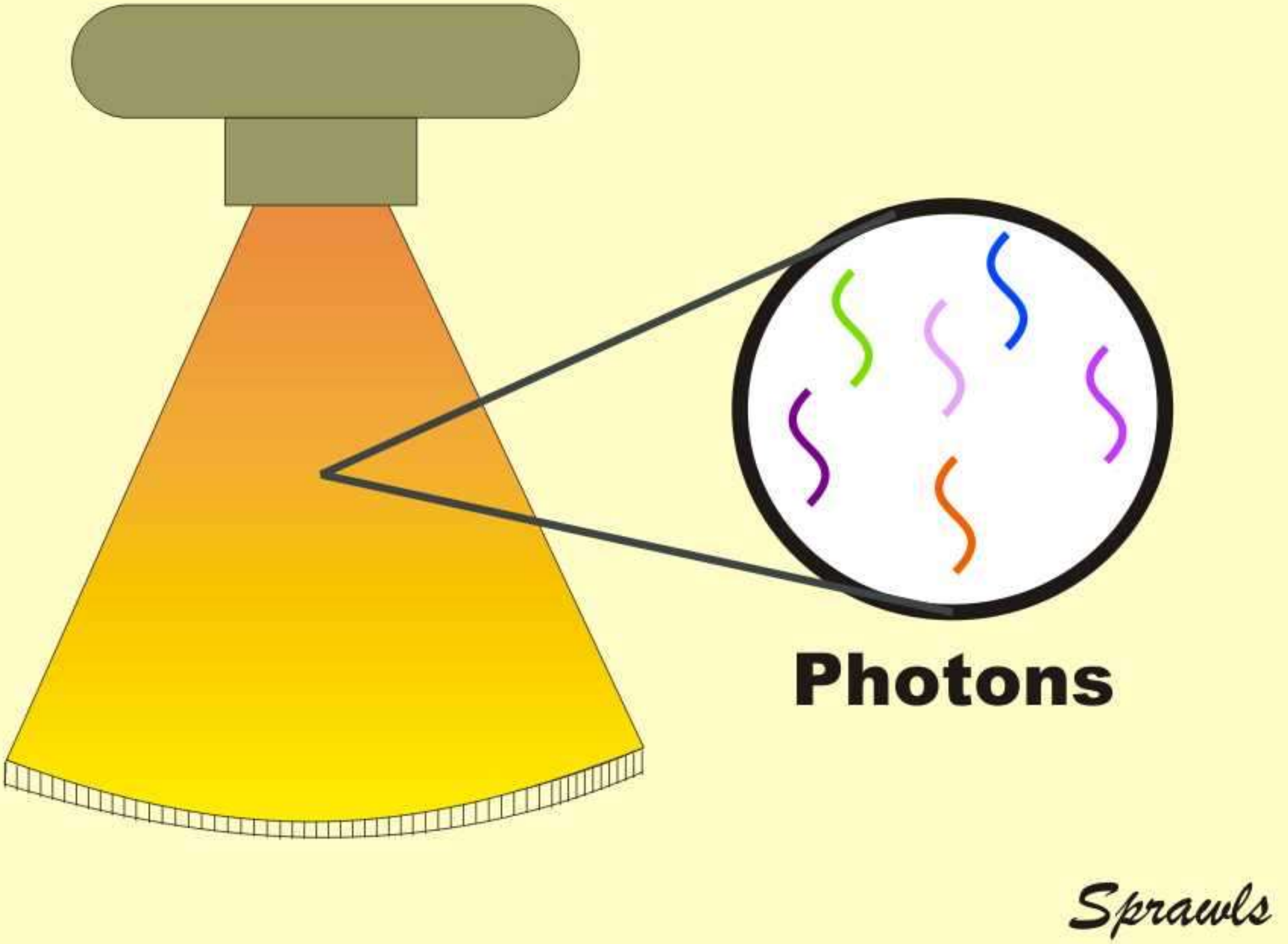
CT Slice Divided into Matrix of Voxels



Voxel Size Controlled By

Sprawls

The Quantum Structure of the X-ray Beam



X-ray Photons Interact With Tissue in A Voxel

Radiation Dose

determined by

Concentration

of

Absorbed Energy

per voxel

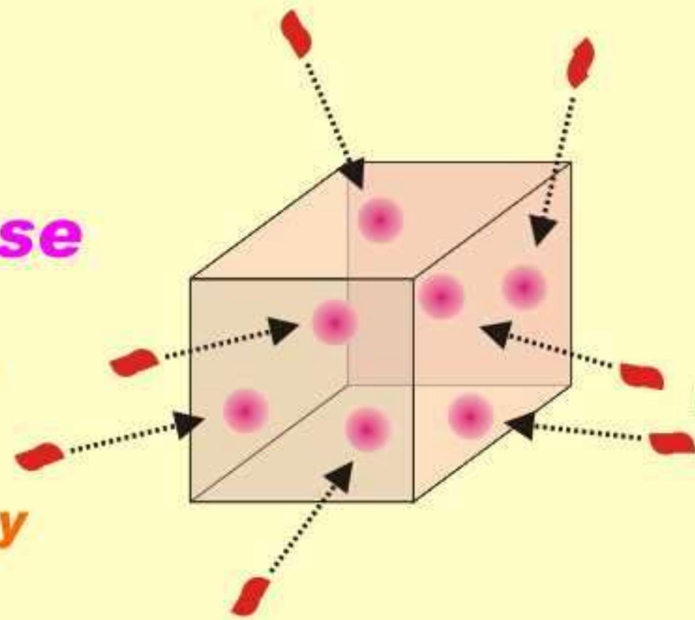


Image Noise

determined by

Number of Photons

per voxel

Dose is increased

by

increasing number

of photons.

Noise is reduced

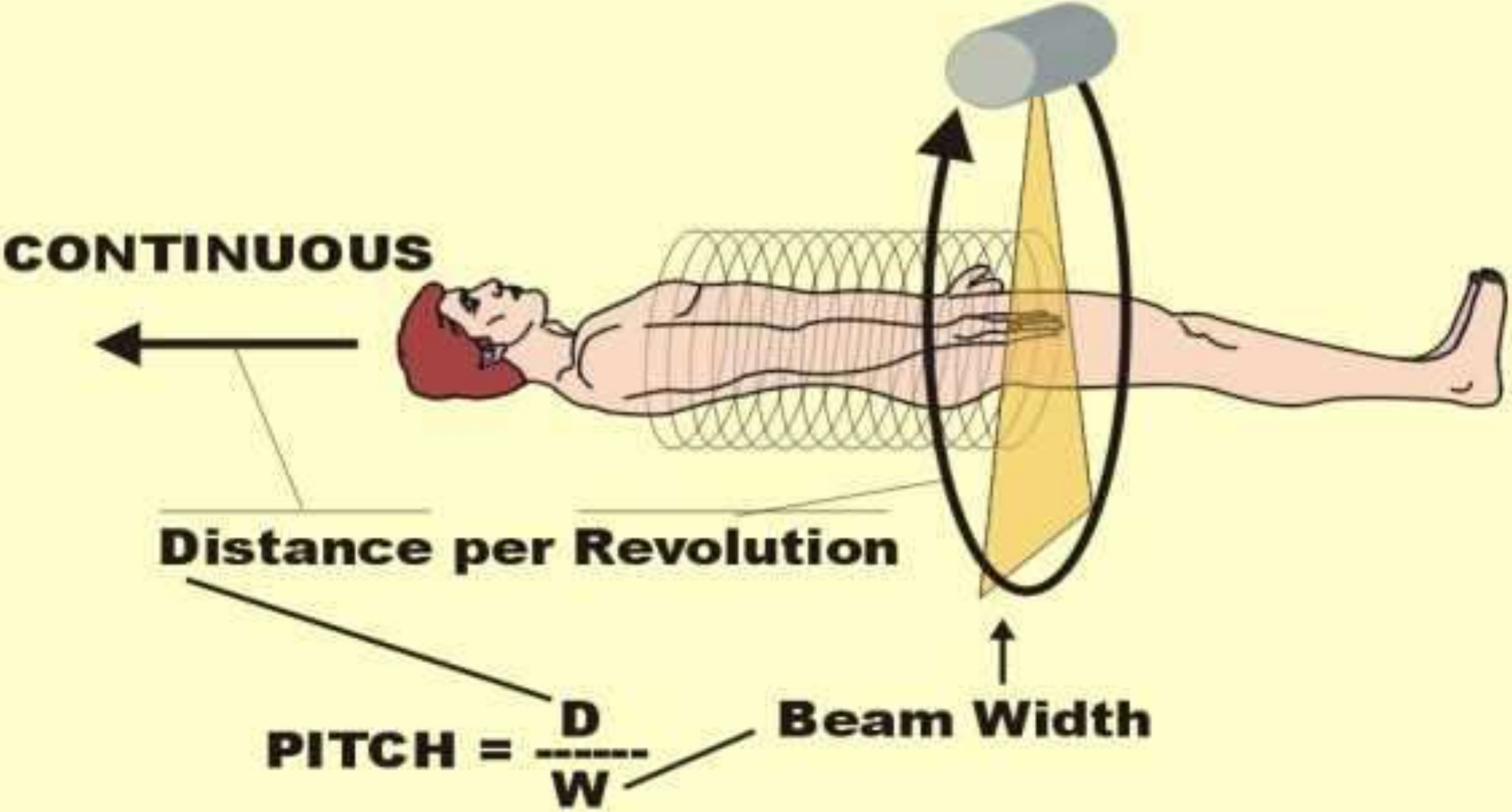
by

increasing number

of photons.

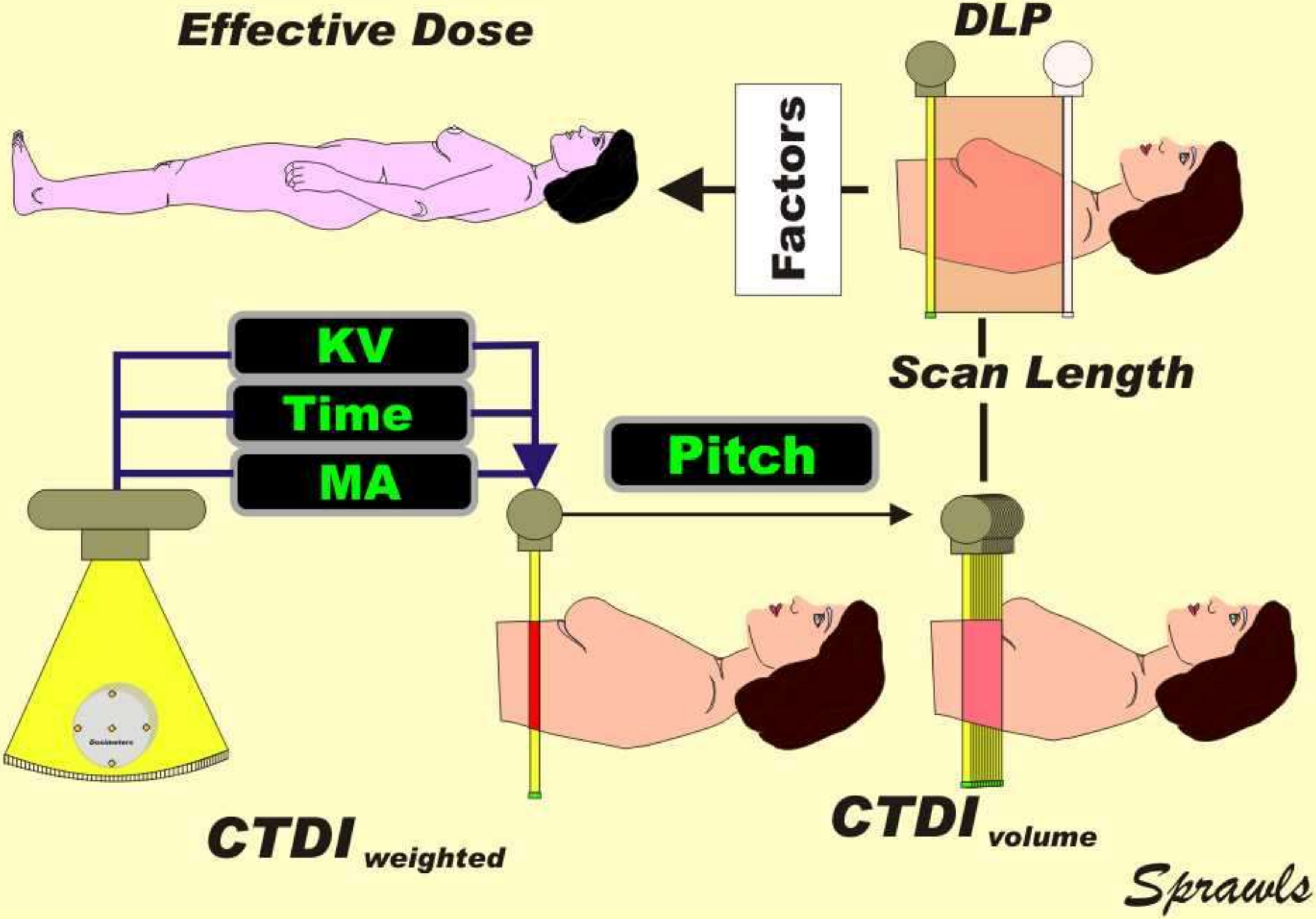
Sprawls

SPIRAL SCAN



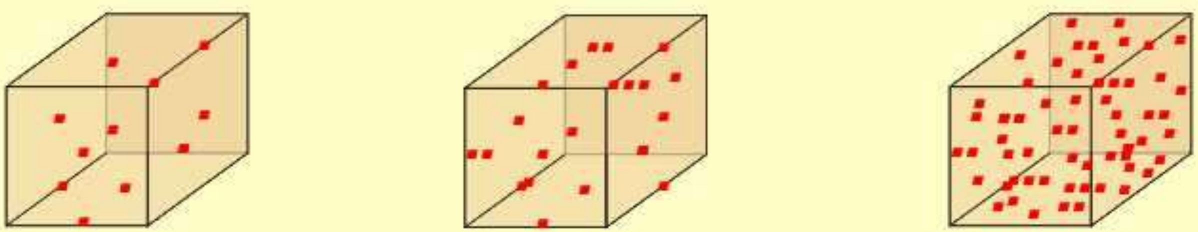
Sprawls

CT Dose Quantities



Decreasing Noise

Requires Increased Photons Absorbed Per Voxel



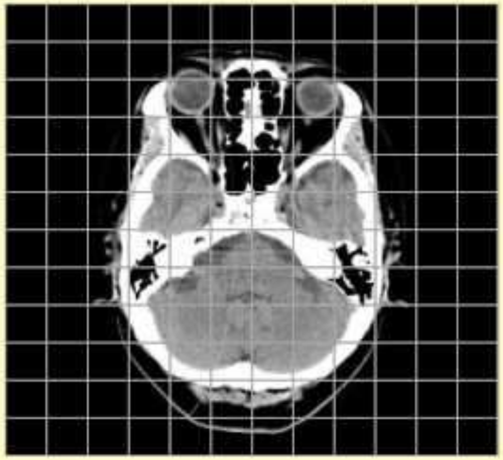
Produces Increasing Dose

Sprawls

Effect of Matrix Size on Image Noise

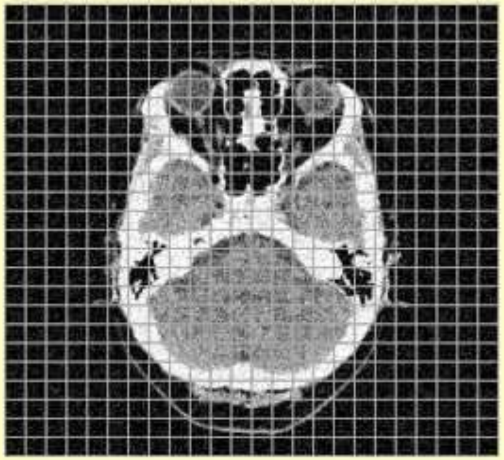
Small **Matrix** Large

Large Voxels



Low Noise

Small Voxels

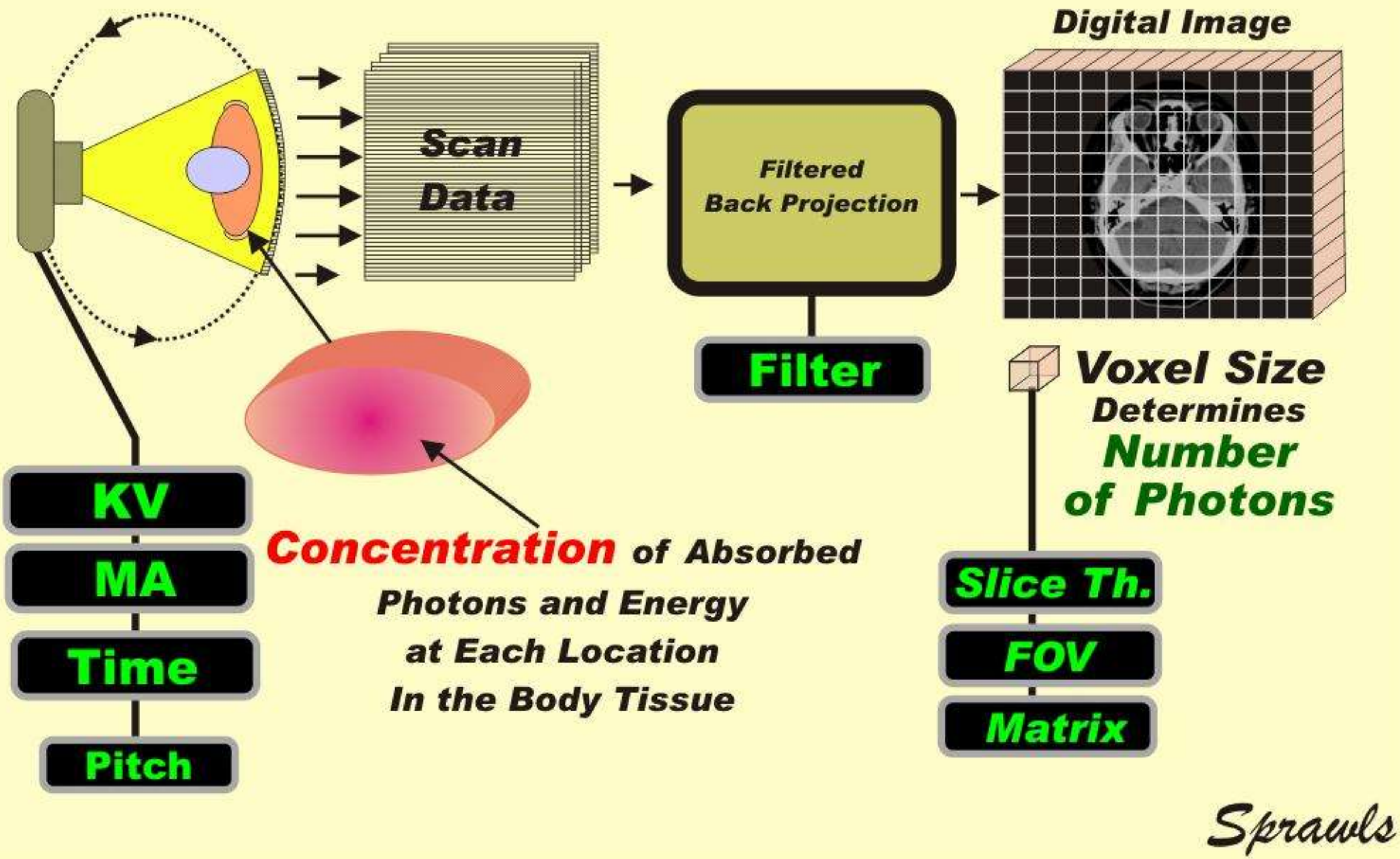


High Noise

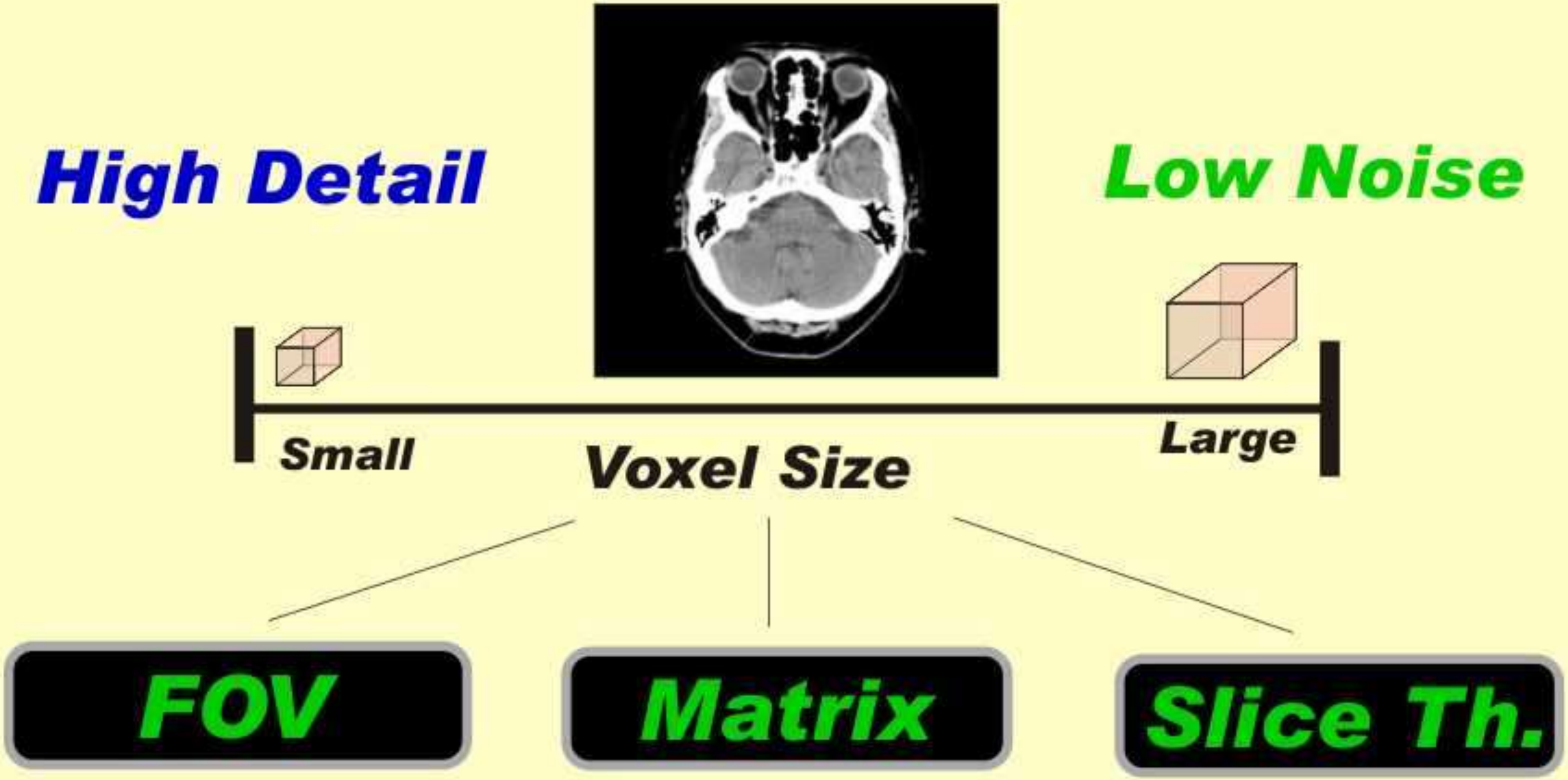
The same radiation dose for both images.

Sprawls

Factors That Determine Image Noise



Two Major Image Quality Goals

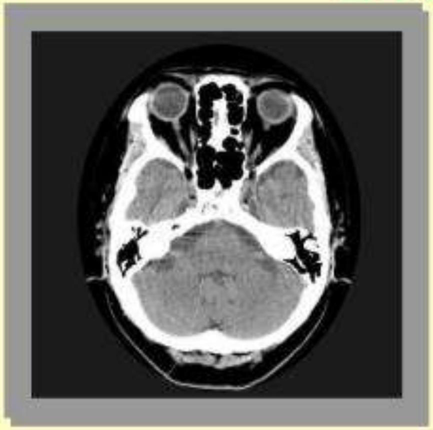


Protocol Factors

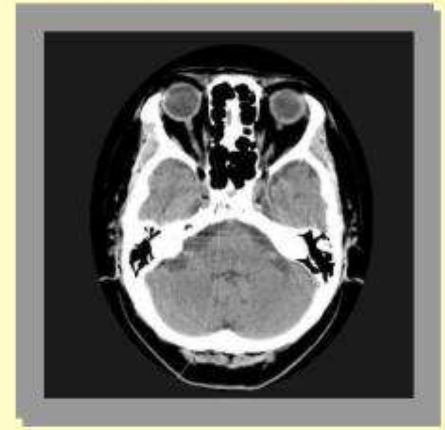
Sprawls

Relationship of Radiation Dose to Image Detail

Lower Dose



Higher Dose



When detail is increased by

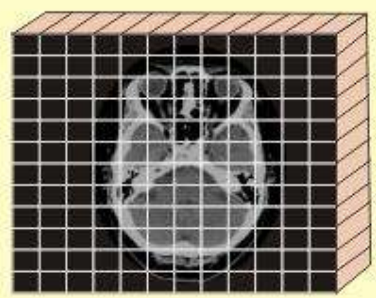
Decreasing Slice Th.

Increasing Matrix

Decreasing FOV

Noise Increases

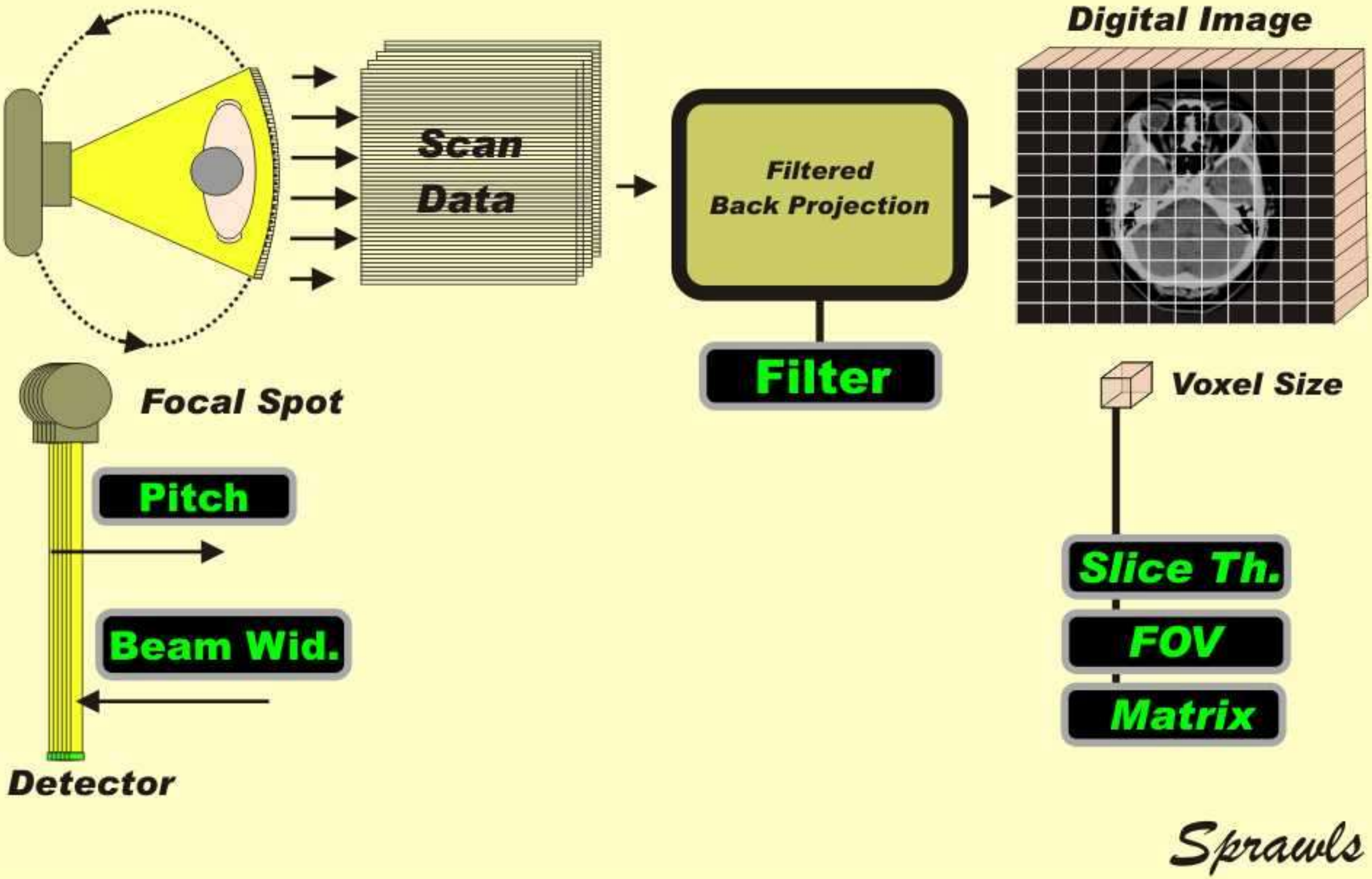
Because of decreased voxel size



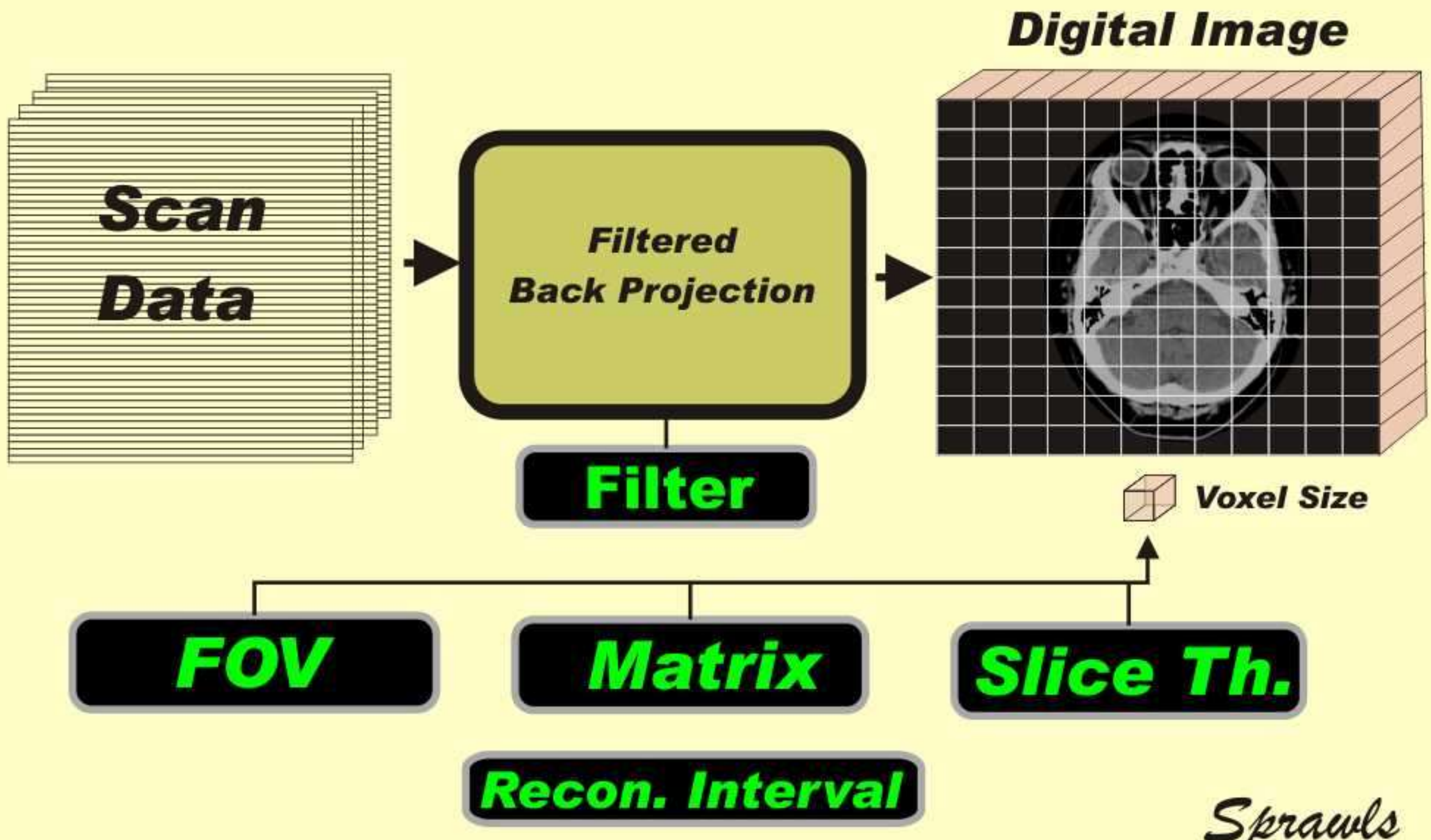
Dose must be increased to reduce noise.

Sprawls

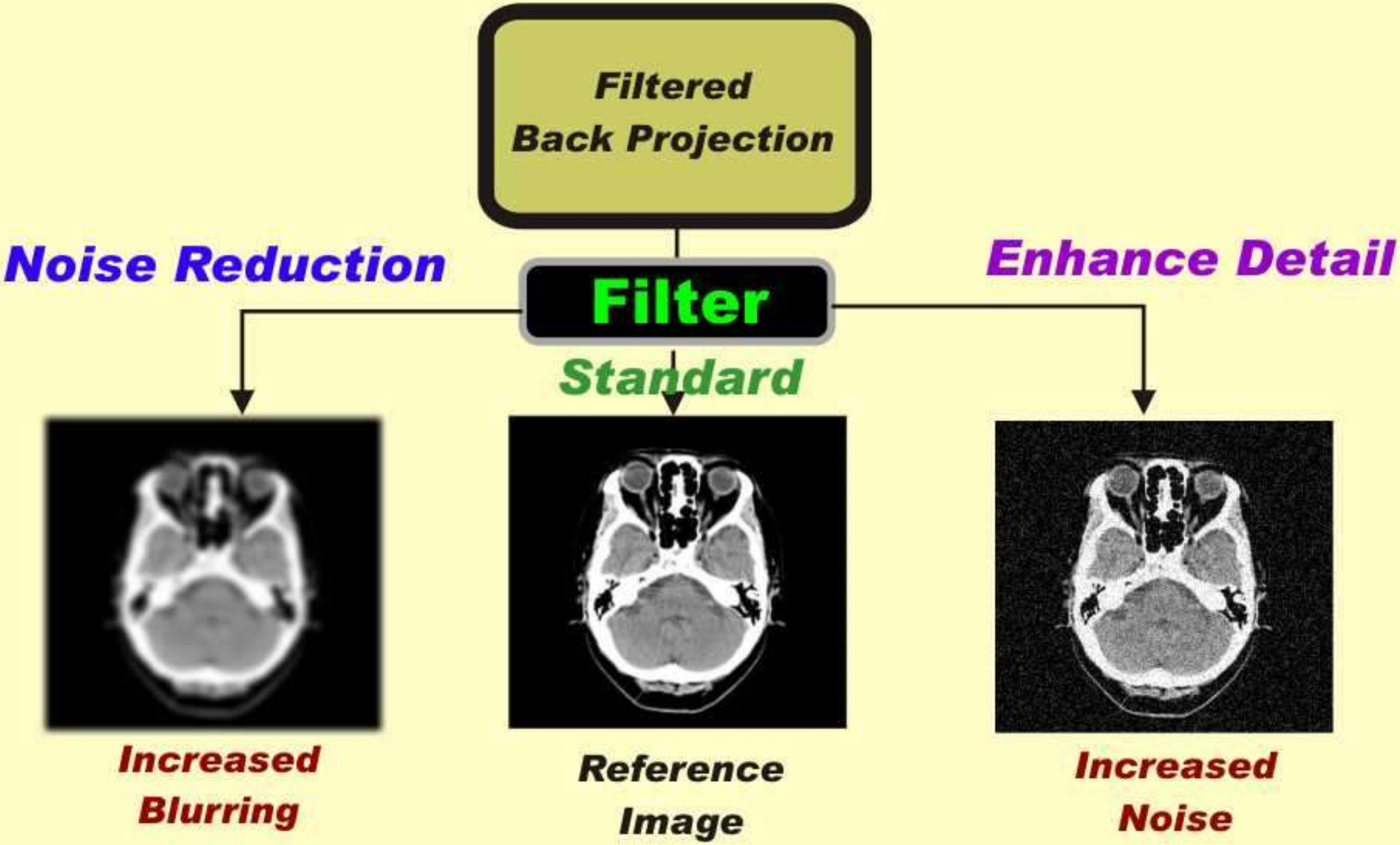
Factors That Determine Image Detail
(Sources of Blurring)



CT Image Reconstruction



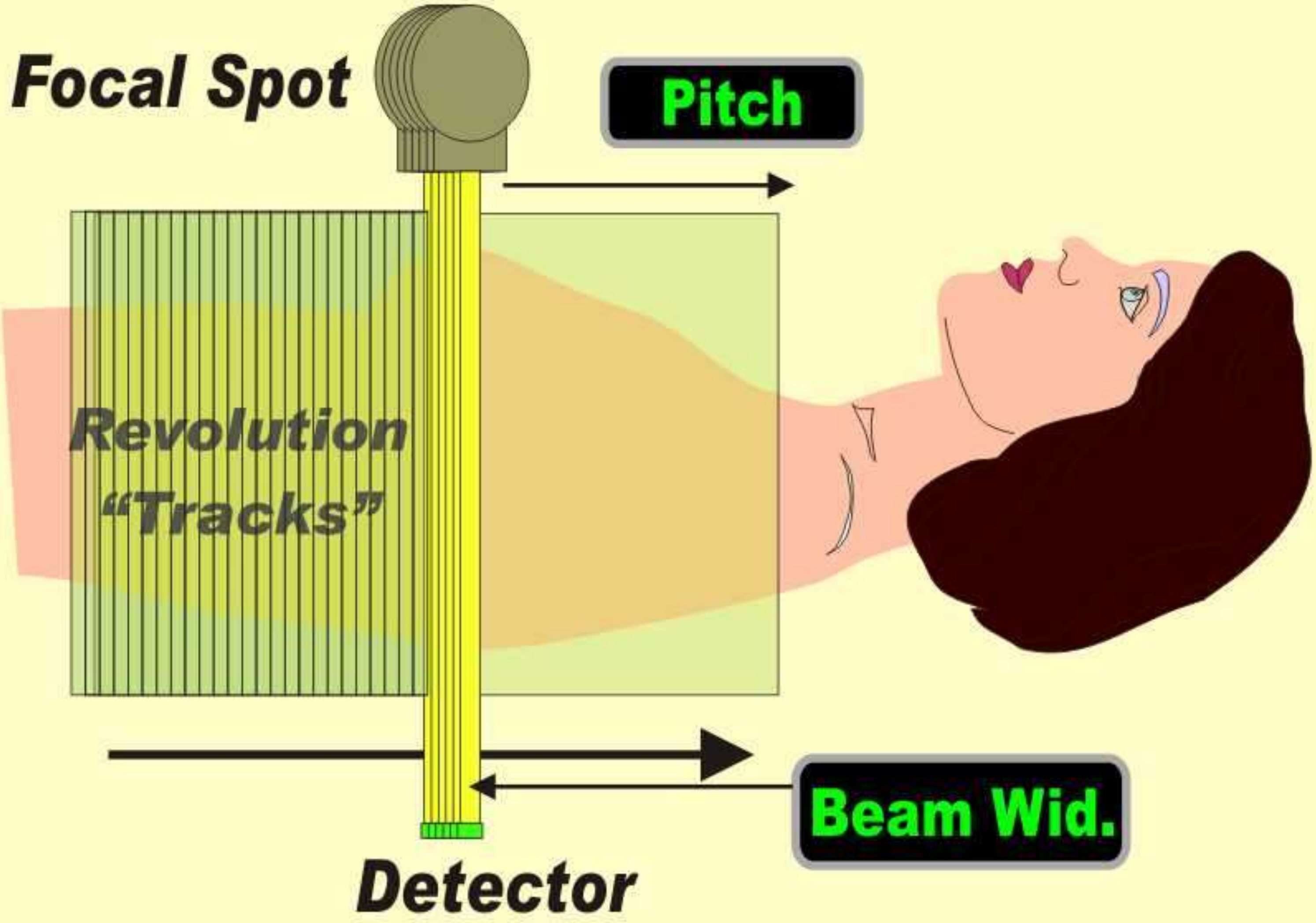
Reconstruction Filter Kernels



(Effects exaggerated for illustration here)

Sprawls

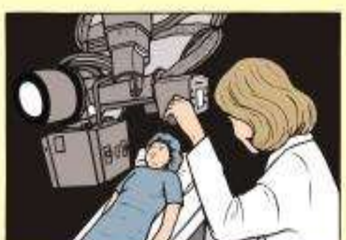
Scan Data Set

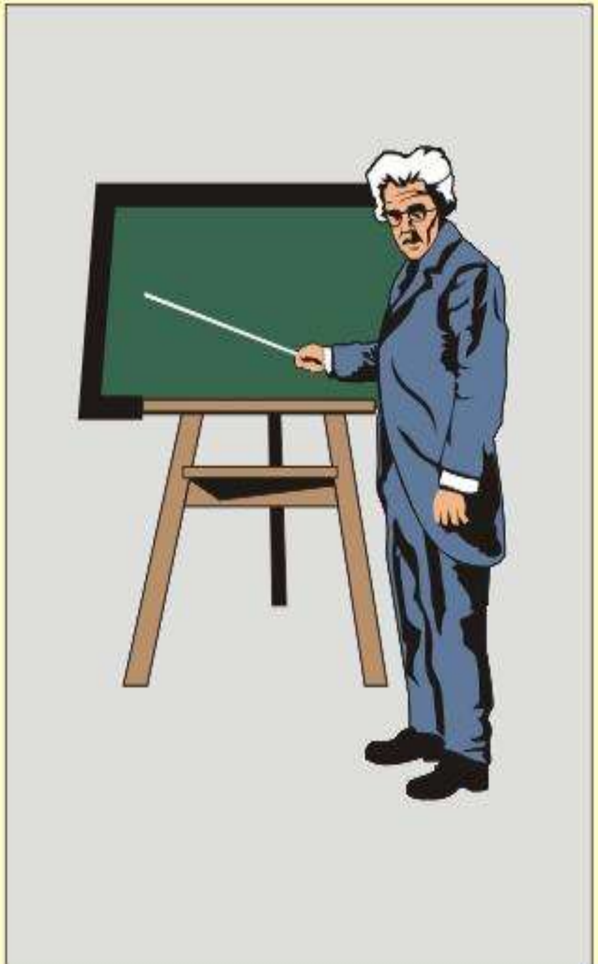


Sprawls

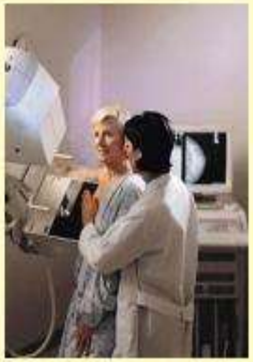
WINDOW
or
BARRIER

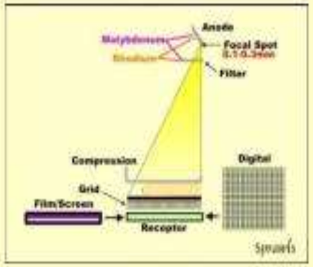
THE LEARNERS





PHYSICAL UNIVERSE

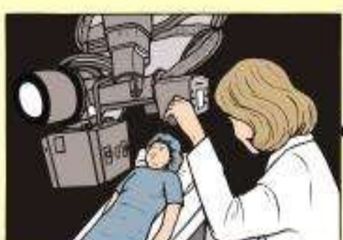




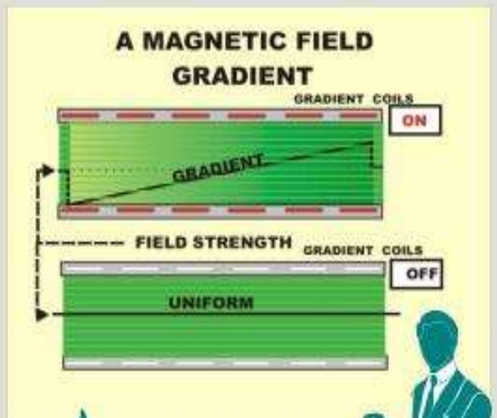
Sprawls

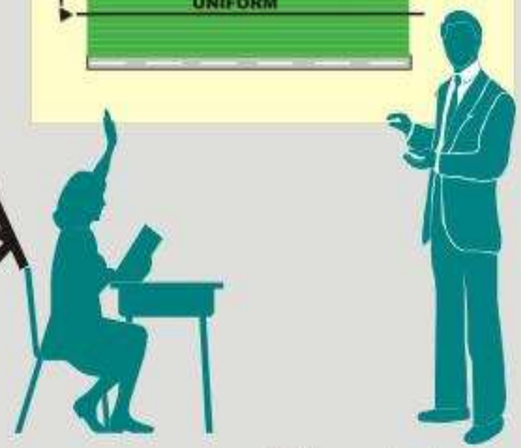
WINDOW
or
BARRIER

THE LEARNERS



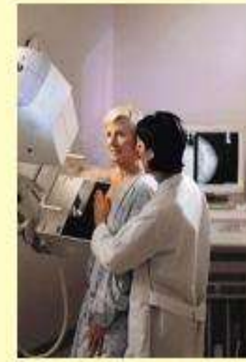
Visuals

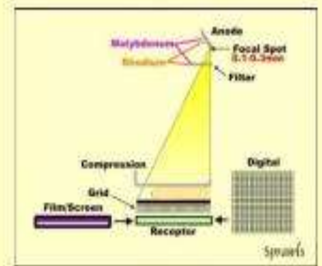


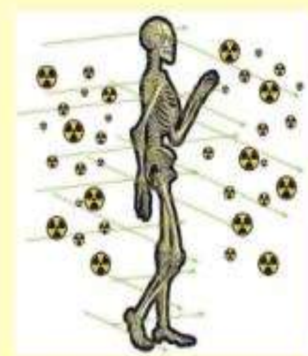


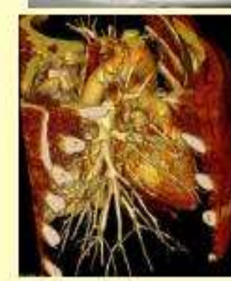
Physicists

PHYSICAL UNIVERSE





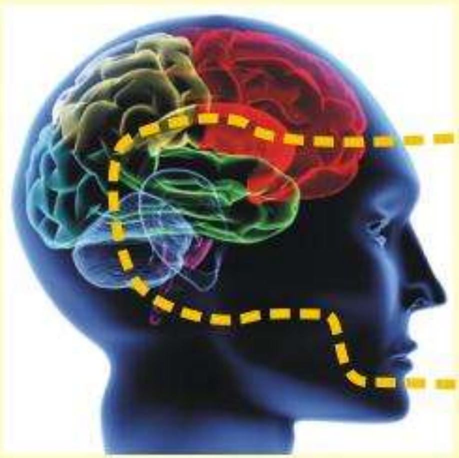




Sprawls

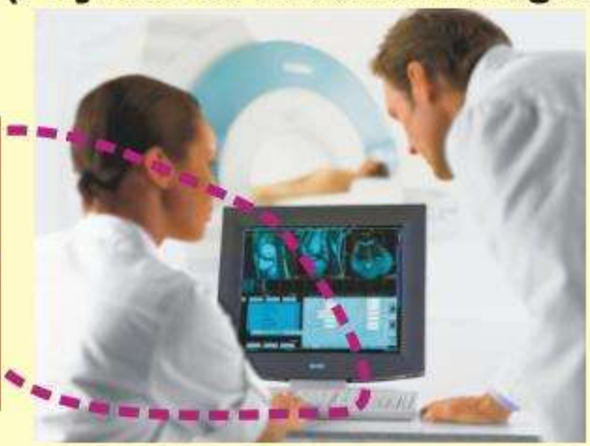
The Elements of
A Highly Effective Educational Session

The Brain



The Physical Universe

(Physics of Medical Imaging)



Perform

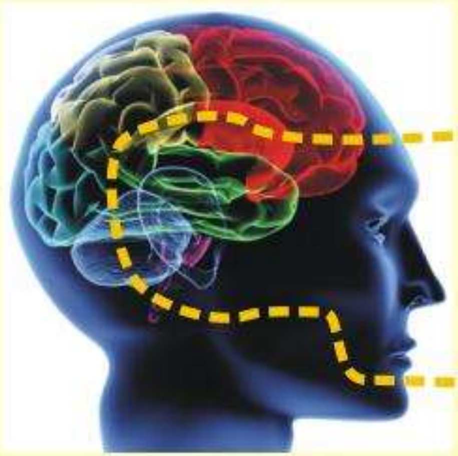
Evaluation

Observation, Tests, and Exams

Sprawls

The Elements of A Highly Effective Educational Session

The Brain



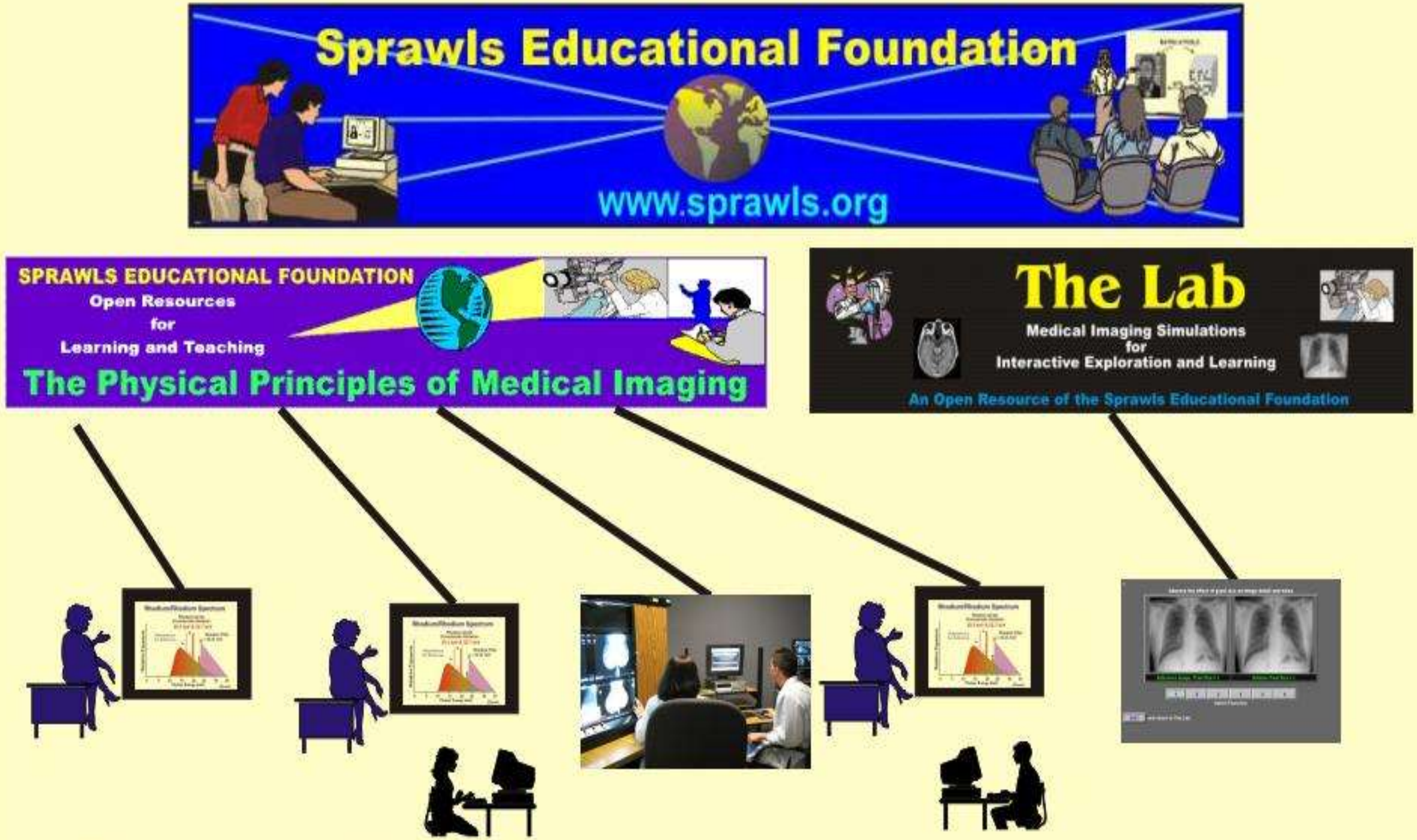
Follow Up

- **R**eview
- **R**efresh
- **R**eflect
- **R**ecall
- **R**emember
- **R**e-inforce

The Physical Universe
(Physics of Medical Imaging)

Web-based Resources
(www.sprawls.org/ipad)

Sprawls



In Partnership with Other Medical Physics Teachers

to be More Effective and Efficient in Providing

Medical Imaging Education

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.

Sprawls

Effective Medical Imaging Physics Learning
...In The Clinic

The Real World Motivating Interactive Collaborative

The Physicist Provides:
Learning Modules & Collaboration

Sprawls

Modules for Self Study and Collaborative Learning in the Clinic

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

Computed Tomography Image Quality Optimization and Dose Management

Perry Sprawls, Ph.D.

To step through module, CLICK HERE.
To go to a specific topic click on it below.

Introduction and Overview	Image Quality Characteristics	Contrast Sensitivity
Visibility of Detail	Visual Noise	Spatial (Geometric) Characteristics
Artifacts	Identifying Characteristics	Characteristics Identified
Image Quality and Dose	CT Image Formation Process	The Scanning Motions
Views and Rays	Multiple Row Detectors	Helical and Spiral Scanning
Image Reconstruction and Voxels	CT Numbers	Hounsfield Unit Scale
Optimizing CT Procedures	Absorbed Dose	Dose Distribution Within Patient
CT Dose Index (CTDI)	Weighted CTDI	Volume CTDI
Dose for Multiple Slices	Dose Length Product (DLP)	Effective Dose
Summary of CT Dose Quantities	Factors That Determine Dose	Factors Affecting Image Detail

Mammography Physics and Technology

for effective clinical imaging

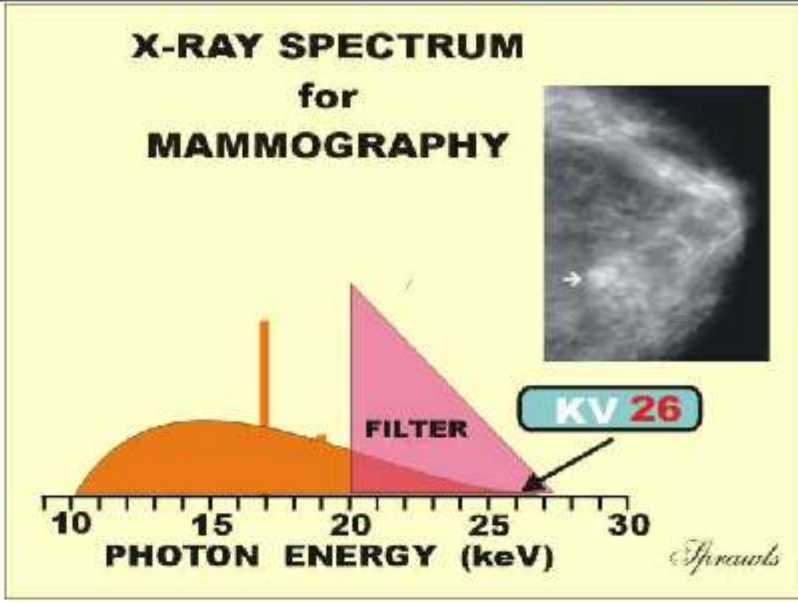
Perry Sprawls, Ph.D.

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


planar



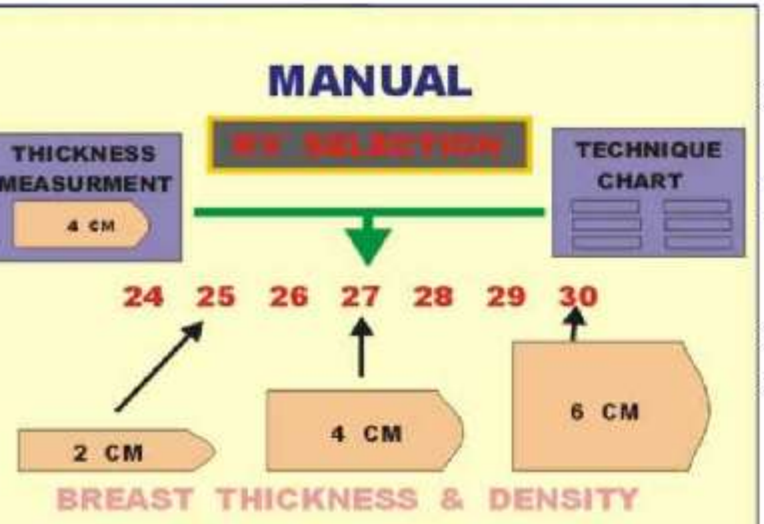
e x-ray beam spectrum is one of the most critical factors that must be justed to optimize a procedure with respect to contrast sensitivity and dose.

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)

creasing 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.

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

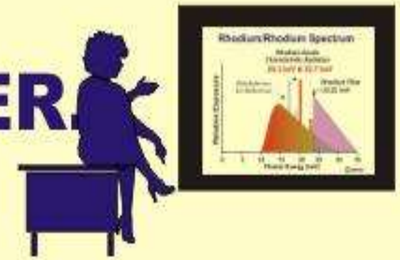


Mammography systems have indicators that display the thickness of the compressed breast. This along with a general assessment of breast density is used to manually select an optimum KV either from experience or an established technique chart.

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.

The Values We Hold

The PHYSICIST is the TEACHER.



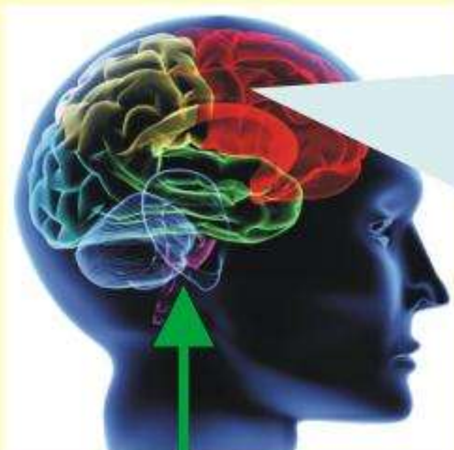
TECHNOLOGY is the TOOL that can be used for effective and efficient teaching.

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

Sprawls

The Elements of A Highly Effective Educational Session

The Brain



The Physical Universe

(Physics of Medical Imaging)

Developing a knowledge structure.

Needs Analysis

Learning Objectives

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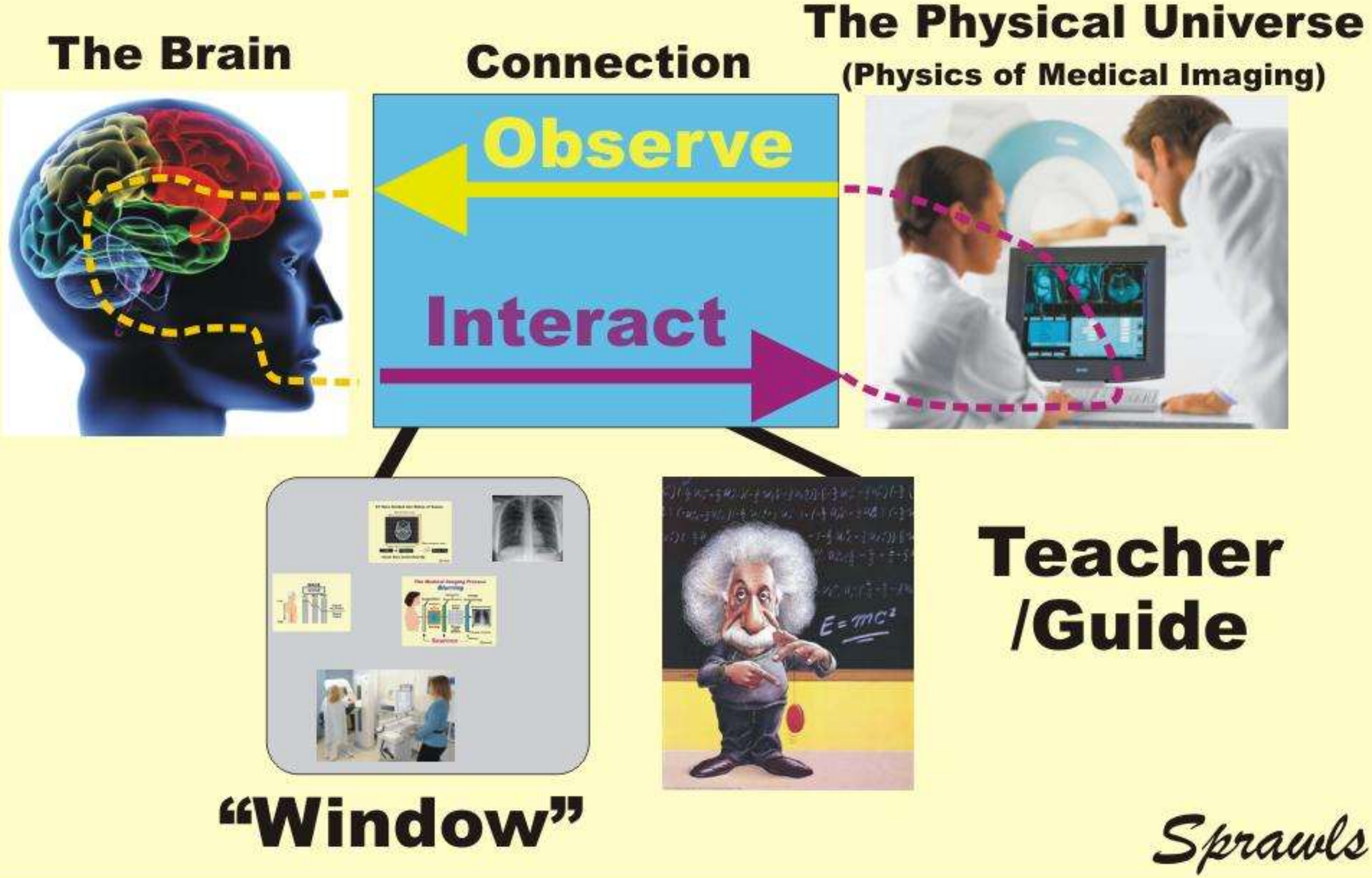

The Elements of
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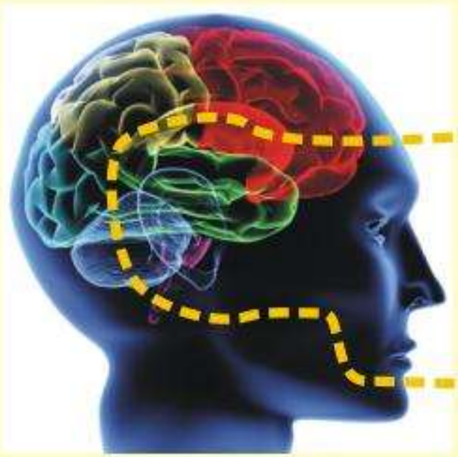
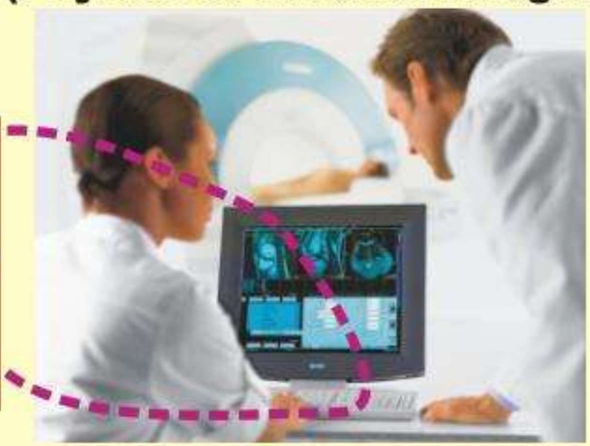
The Brain



Perform

The Physical Universe

(Physics of Medical Imaging)



Evaluation

Observation, Tests, and Exams

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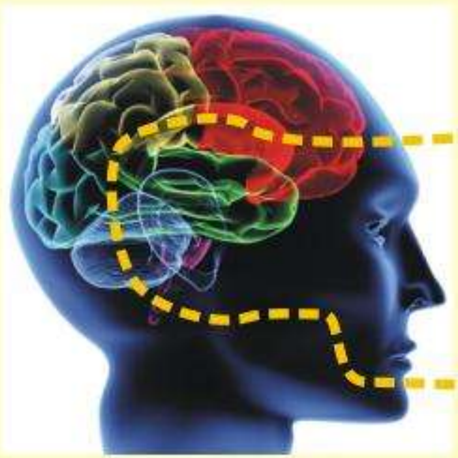
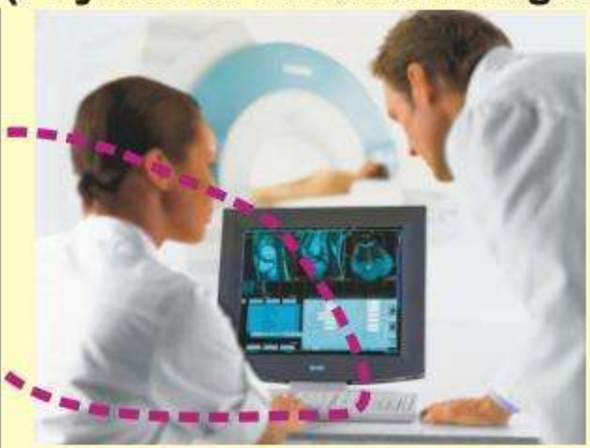
The Brain



Follow Up

Review
Refresh
Reflect
Recall
Remember
Re-inforce

The Physical Universe
(Physics of Medical Imaging)



Web-based Resources
(www.sprawls.org/ipad)

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The Elements of
A Highly Effective Educational Session

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and

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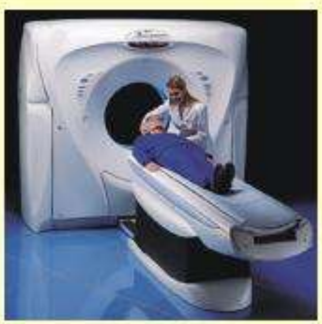

Handouts and Resources

at

http://www.sprawls.org/ipad