Clinically Focused Physics Education





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Website

http://www.sprawls.org/clinphys

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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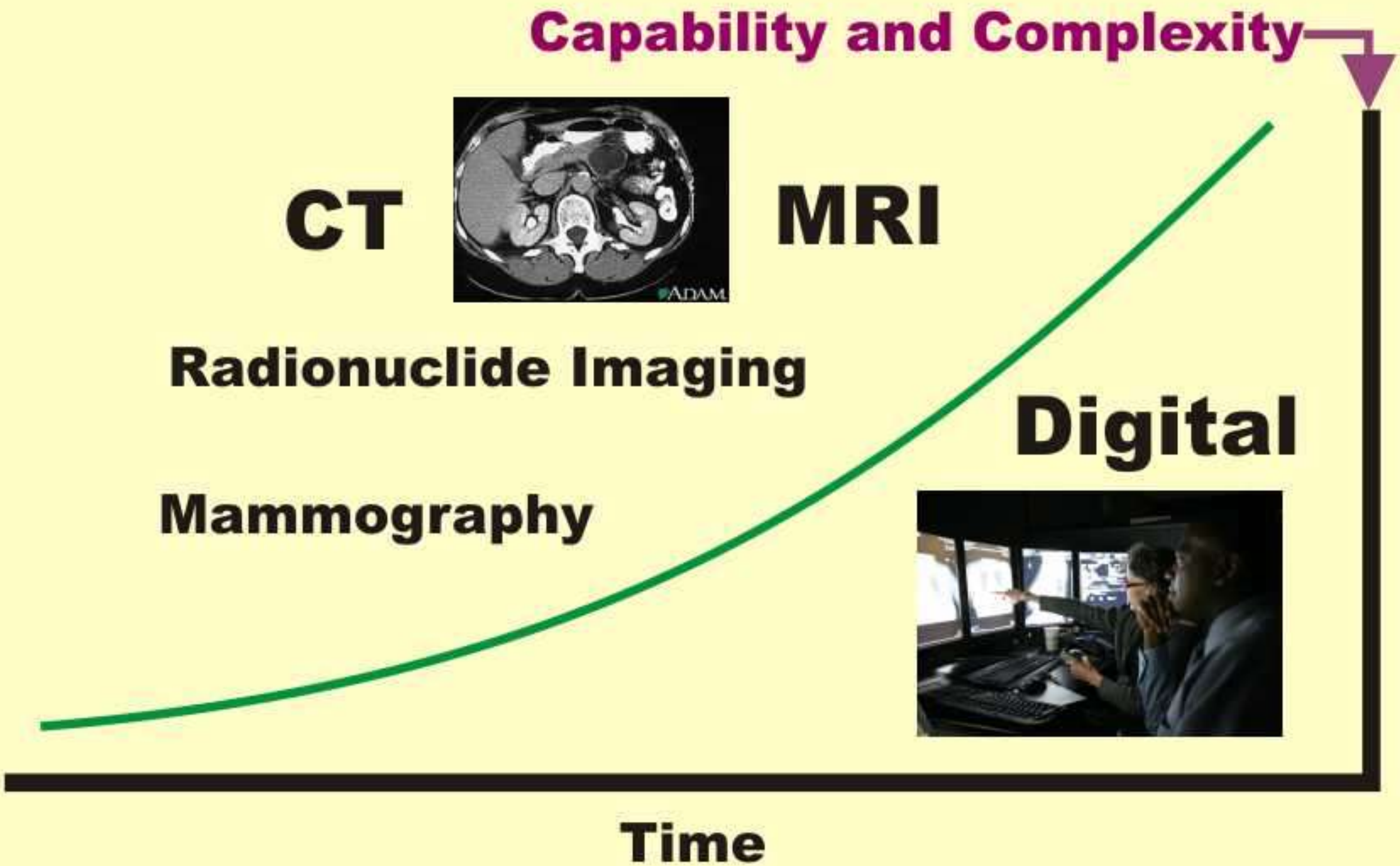
Continuing Growth in the Need for Physics Knowledge



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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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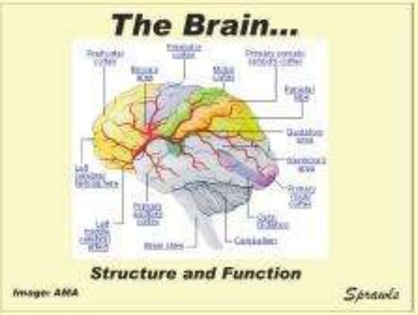
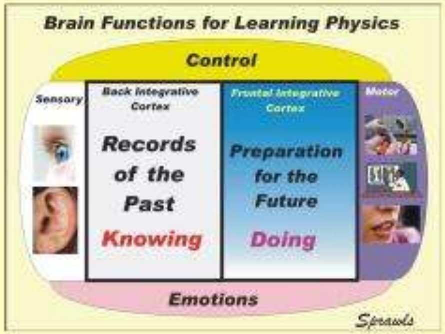
The Mental Process of Learning Physics





Perry Sprawls, Ph.D.

Emory University

and

Sprawls Educational Foundation

http://www.sprawls.org

LEARNING is...

Building a knowledge structure in the mind

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Learning Physics is by..

Encounter and Experience

Physical Universe

Brain

Images: BYU and Howstuff works

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Learning is....

Building knowledge structures in the brain

Image: UCDavis

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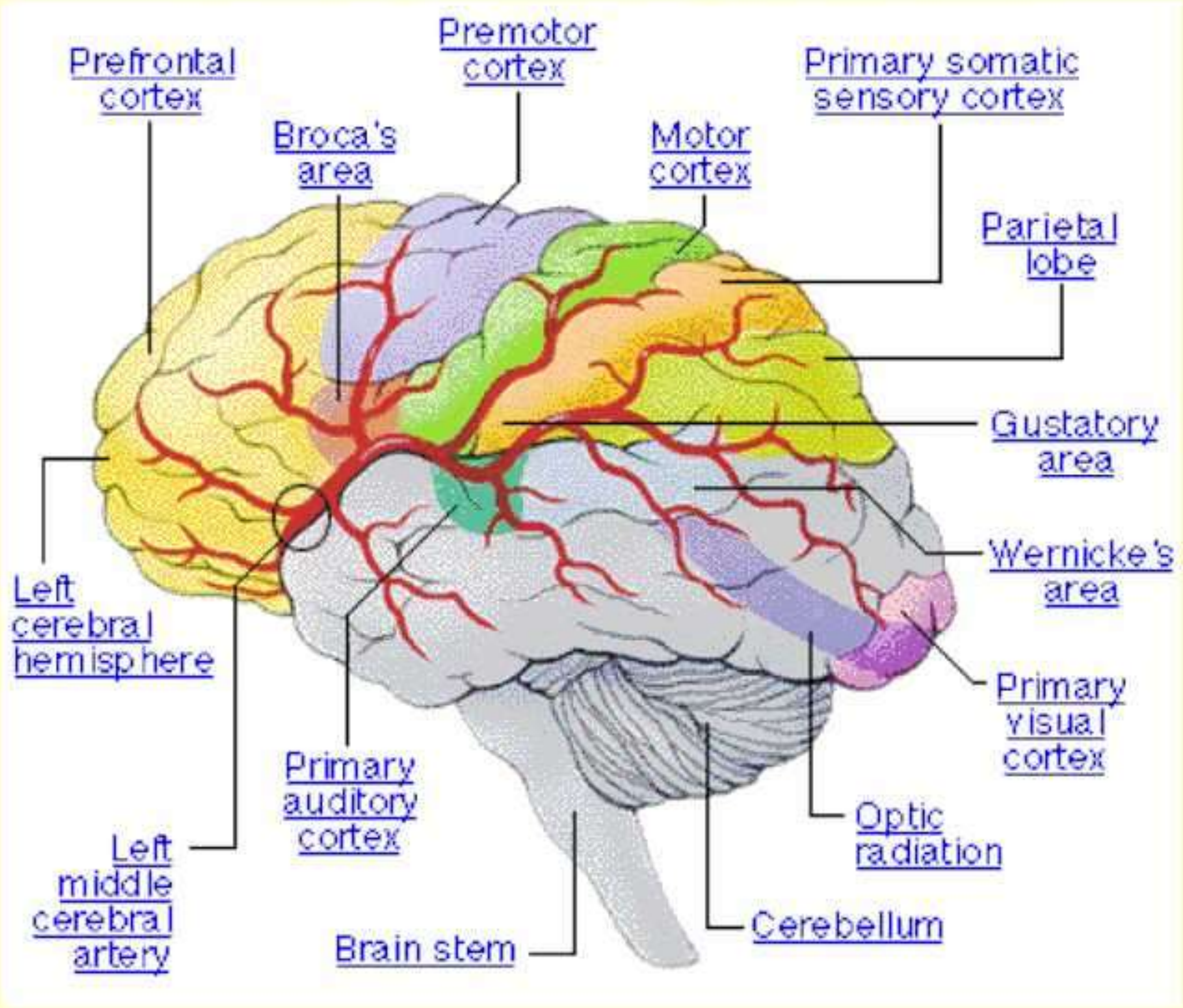
The Brain...



Structure and Function

Image: AMA

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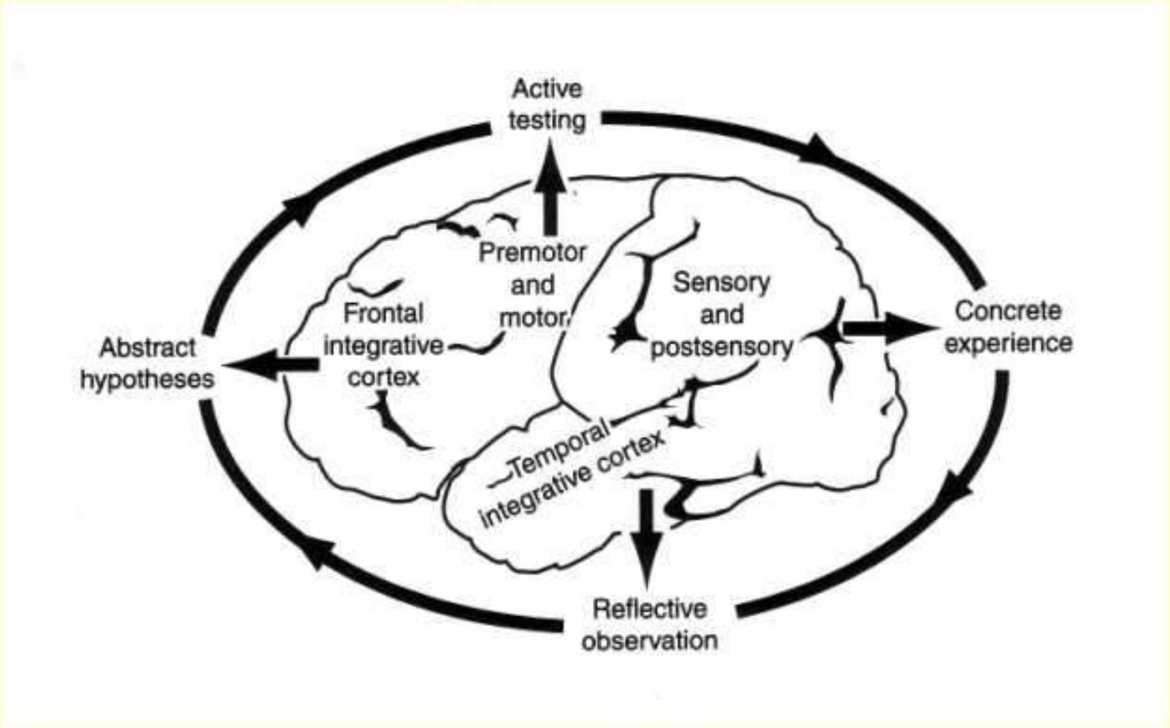
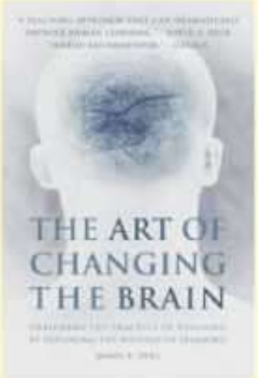
Zull's Model of Brain Function

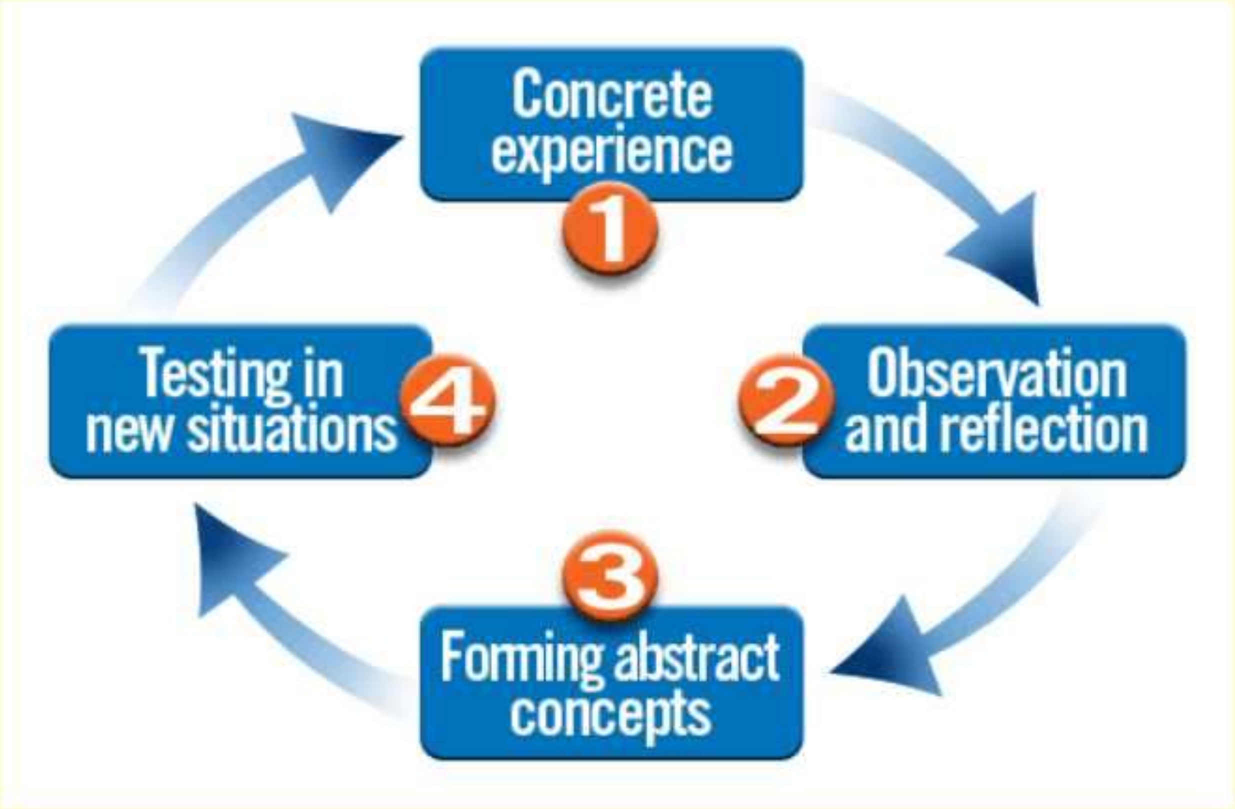


James Zull, Ph.D.
Professor of Biology
Professor of Biochemistry
Director of University Center for Innovation in Teaching and Education
Case Western Reserve

Reference:



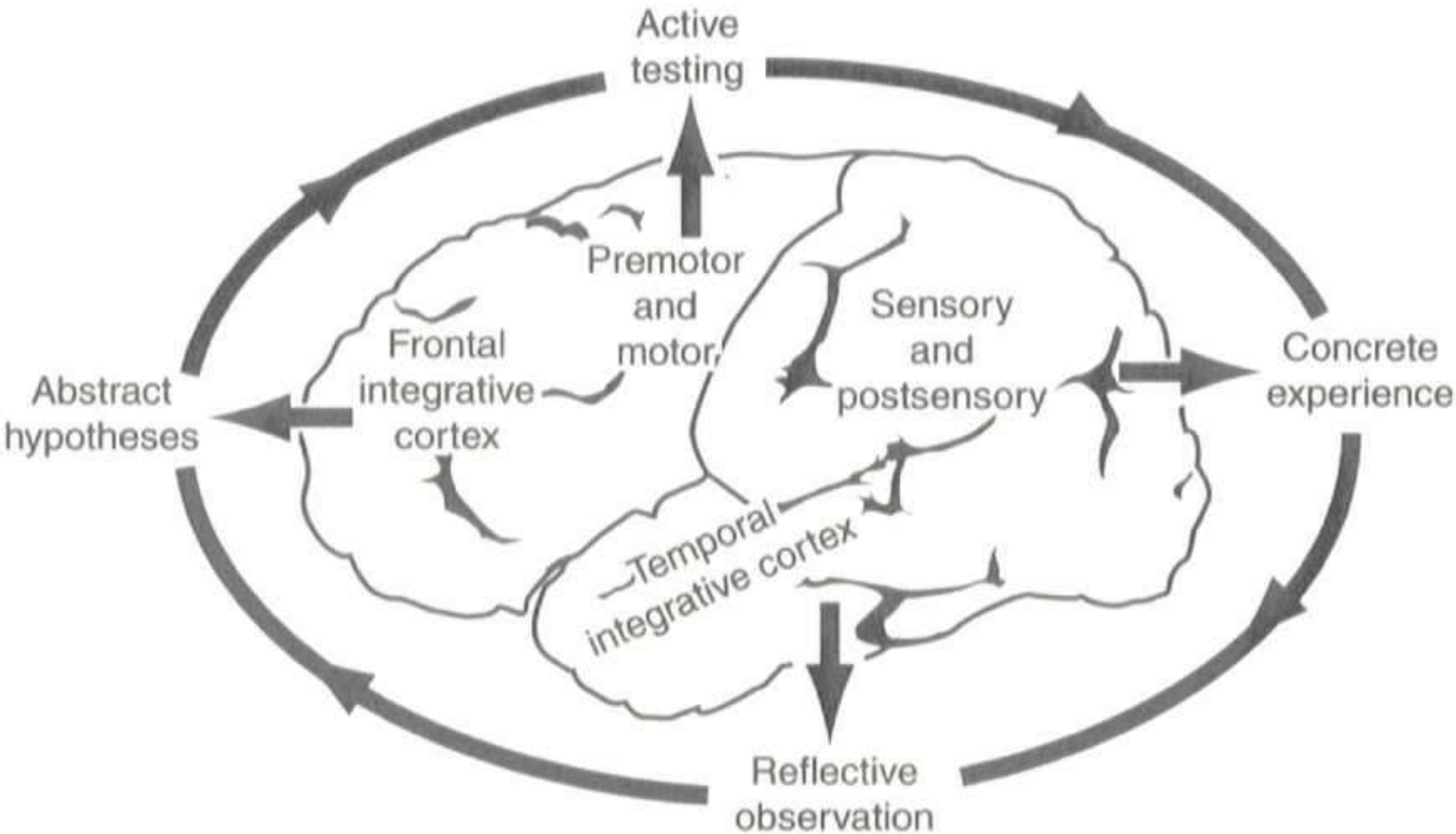
Kolb's Experiential Learning Model

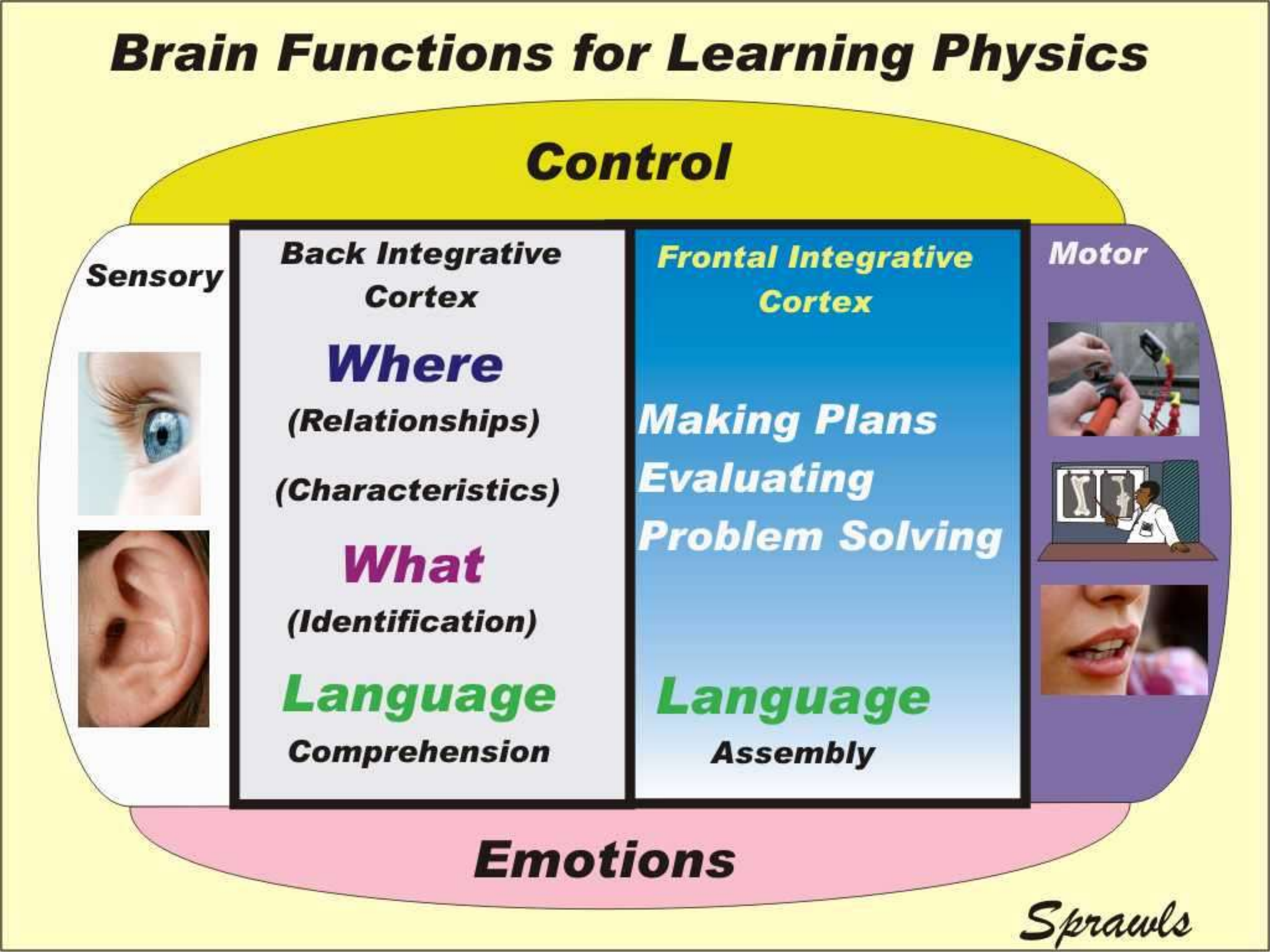


David A. Kolb, Ph.D.
Professor of Organizational Behavior
Case Western Reserve

Website: http://www.learningfromexperience.com

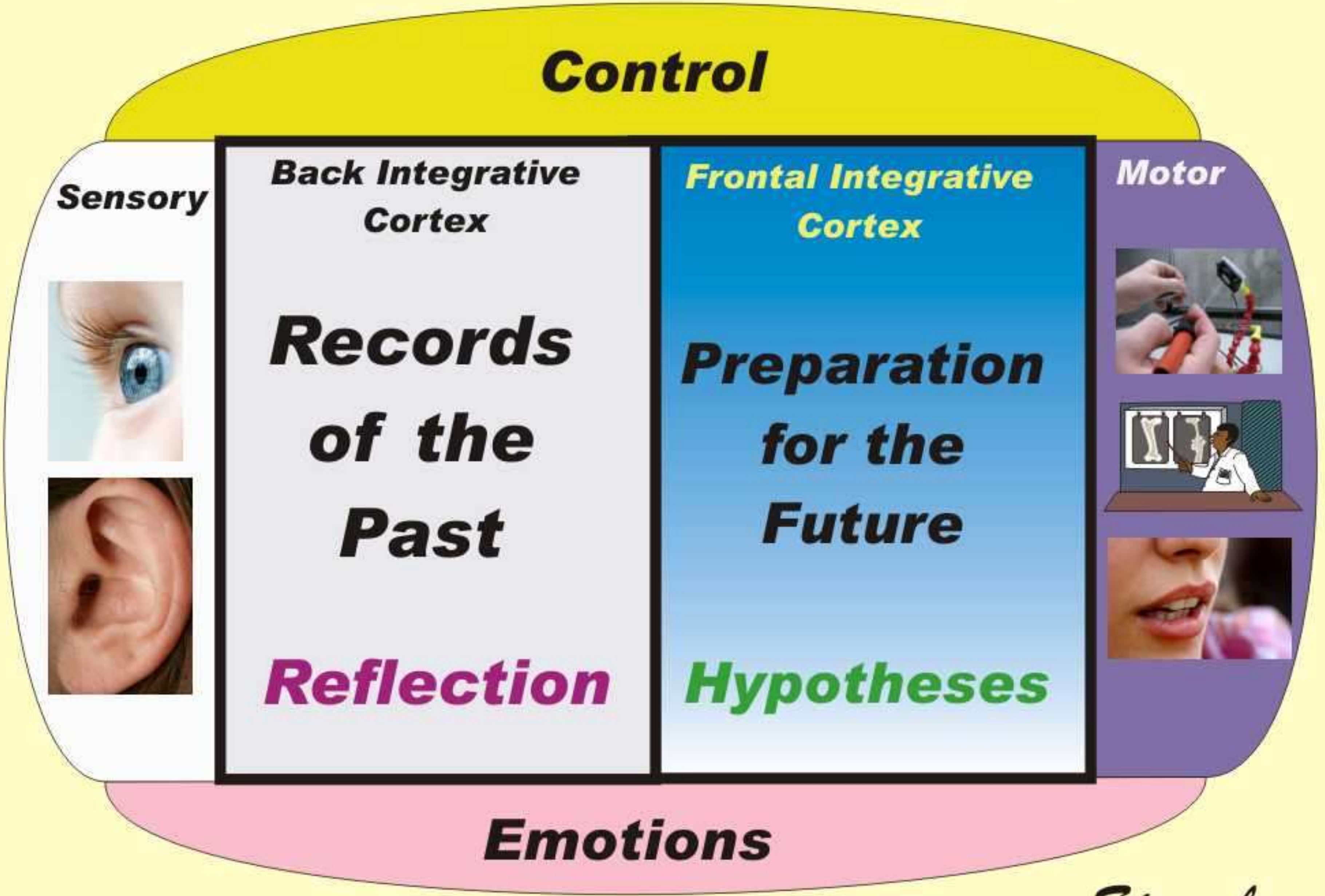
Zull's Model of Brain Function





Brain Functions for Learning Physics
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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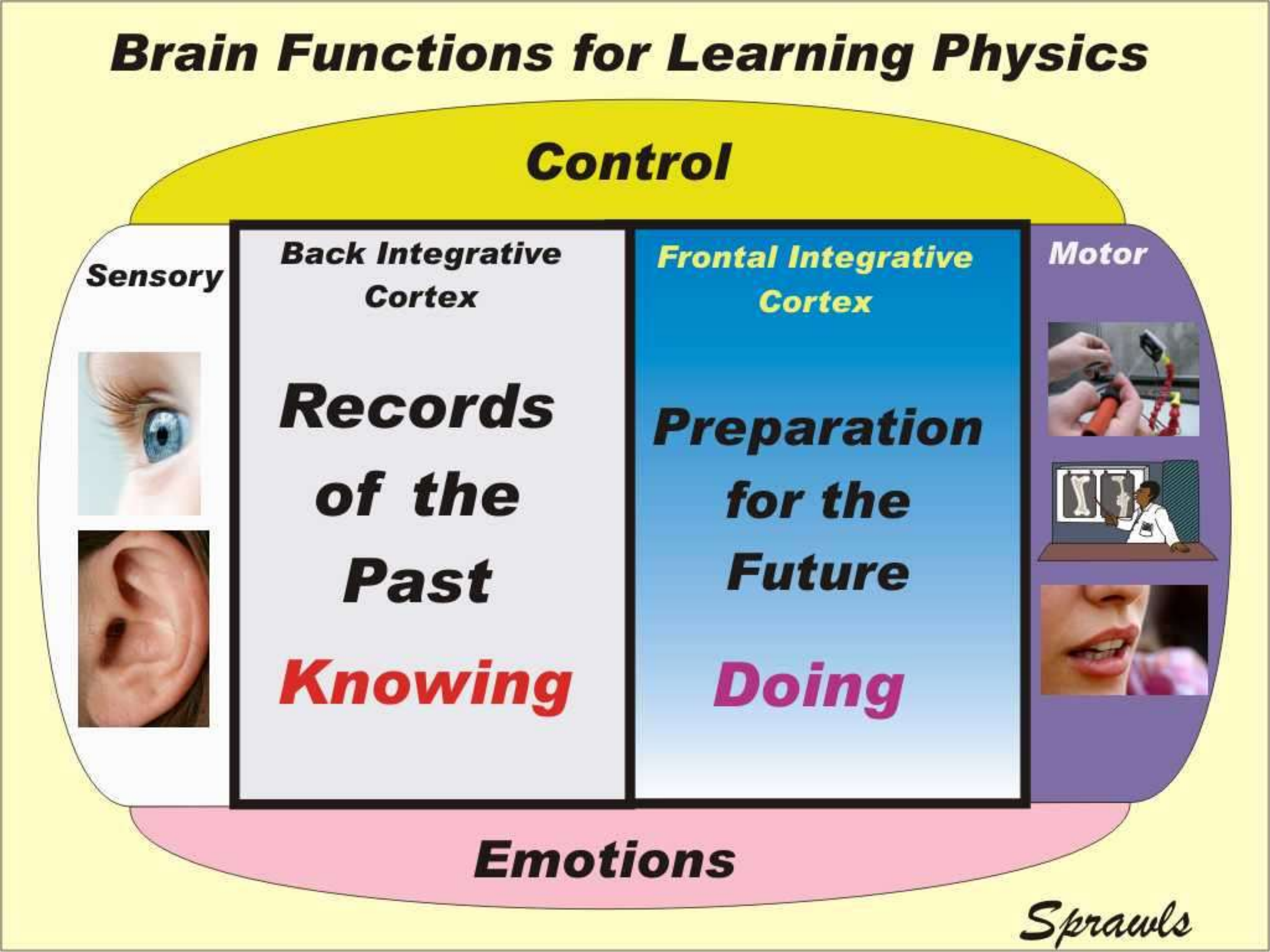
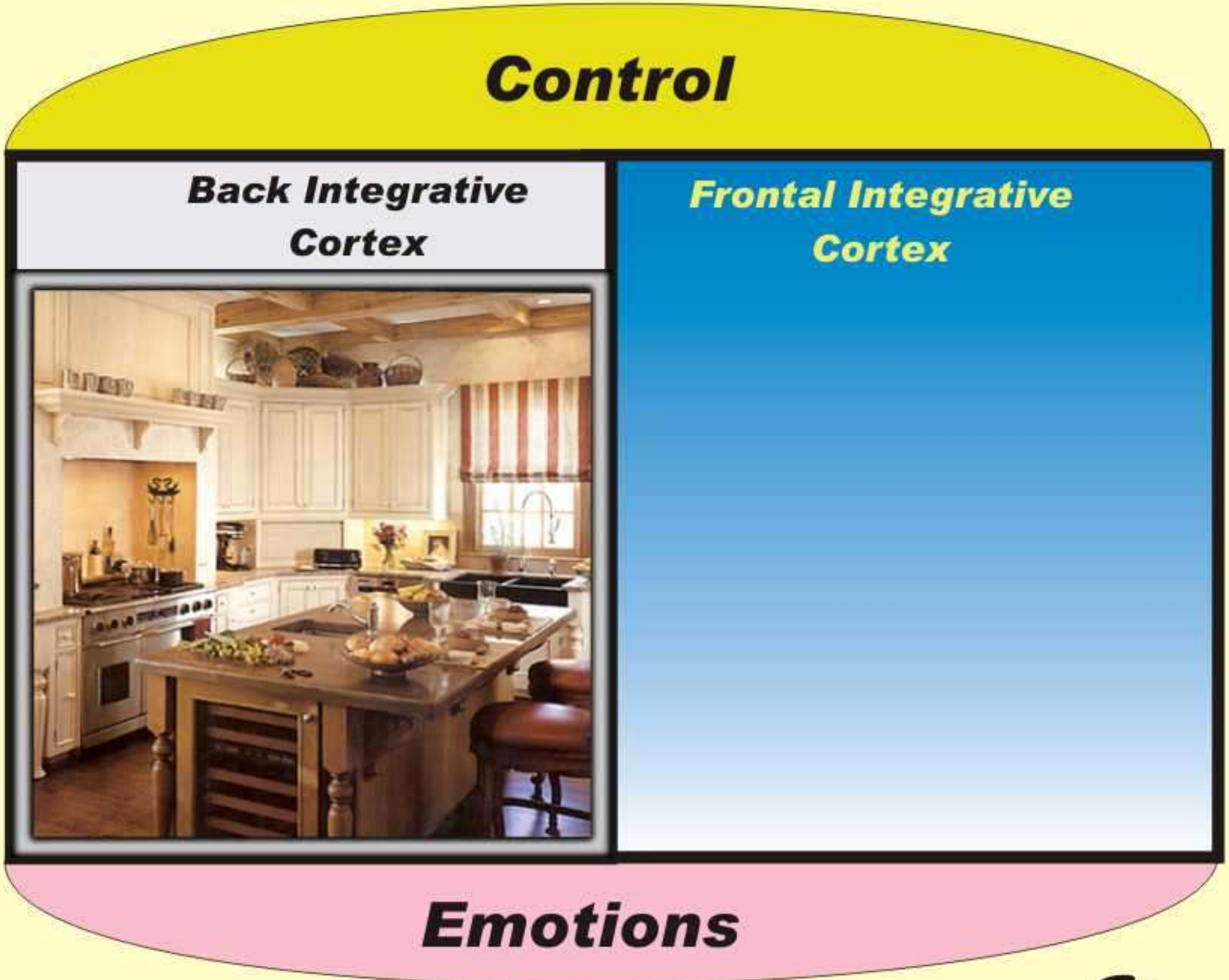

Brain Functions for Learning Physics
Control
Sensory
Back Integrative Cortex
Records of the Past
Knowing
Frontal Integrative Cortex
Preparation for the Future
Doing
Motor
Emotions
Sprawls

Let's Think about lunch.

Brain Functions for Preparing Lunch



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Brain Functions for Preparing Lunch

Control

Back Integrative Cortex

Frontal Integrative Cortex

Emotions

Sprawls

Brain Functions for Preparing Lunch

Control

Back Integrative Cortex

Frontal Integrative Cortex

Emotions

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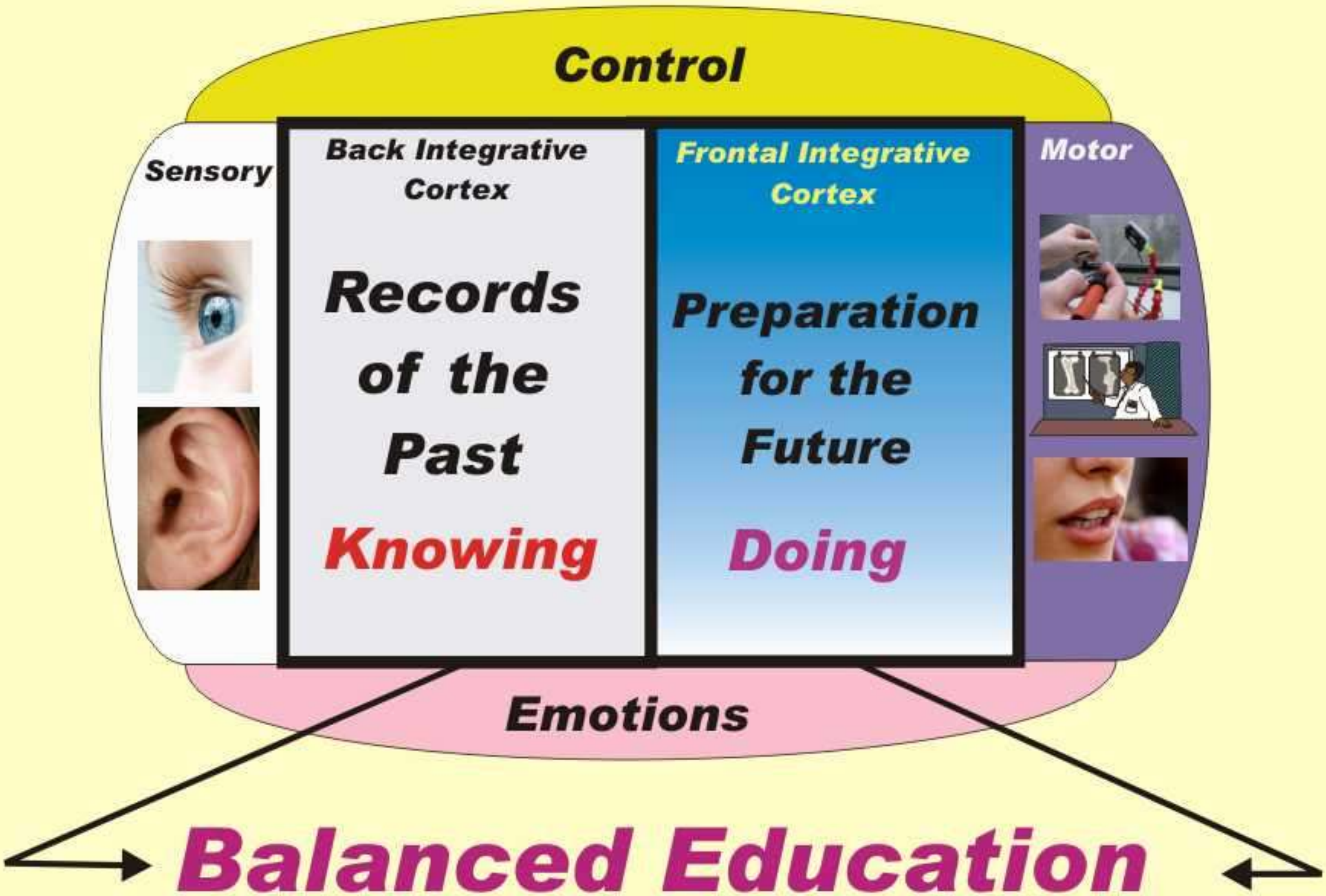
Brain Functions for Learning Physics



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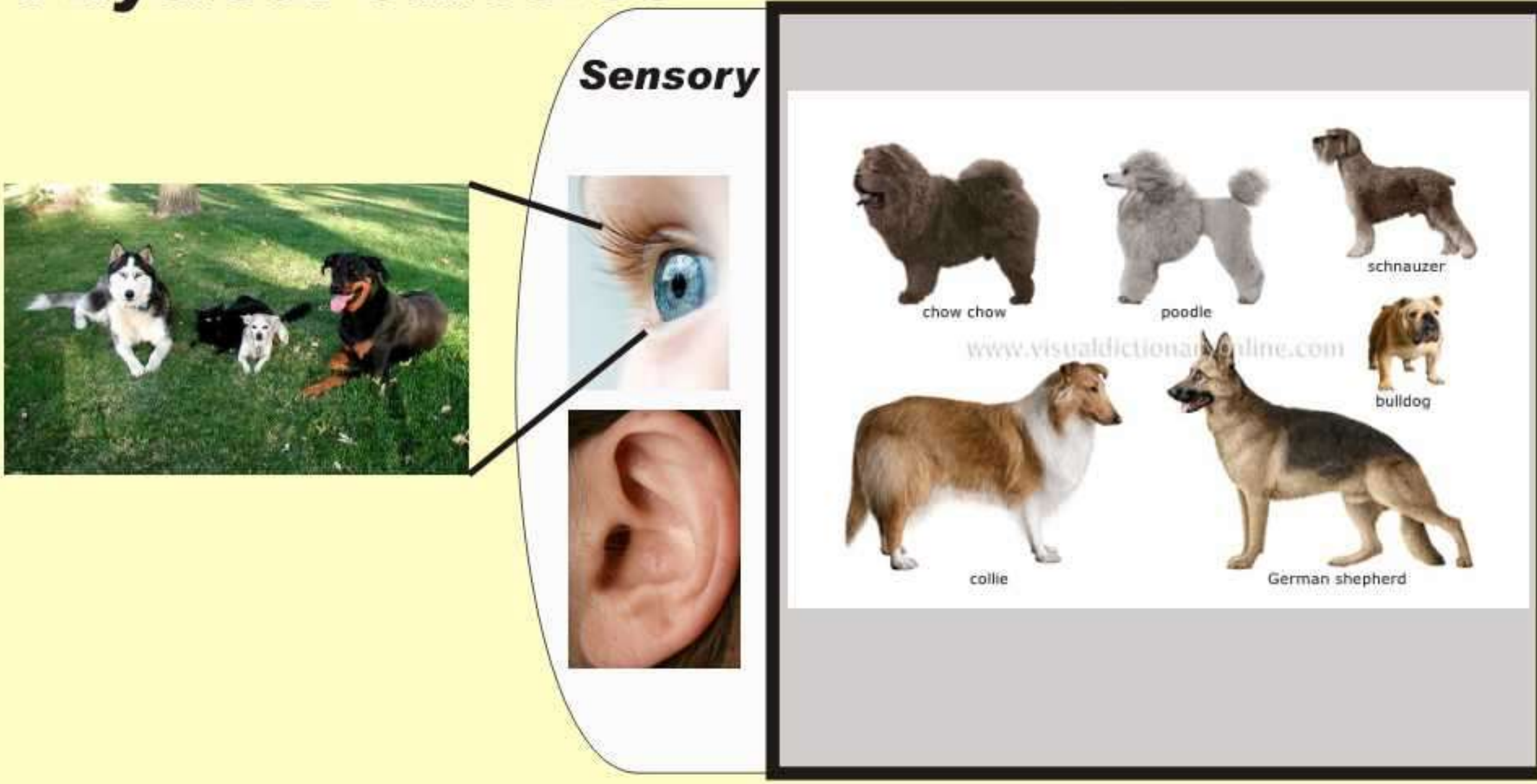
Forming Knowledge Structures

Physical Universe | **Back Integrative Cortex**



Visible Physical Objects

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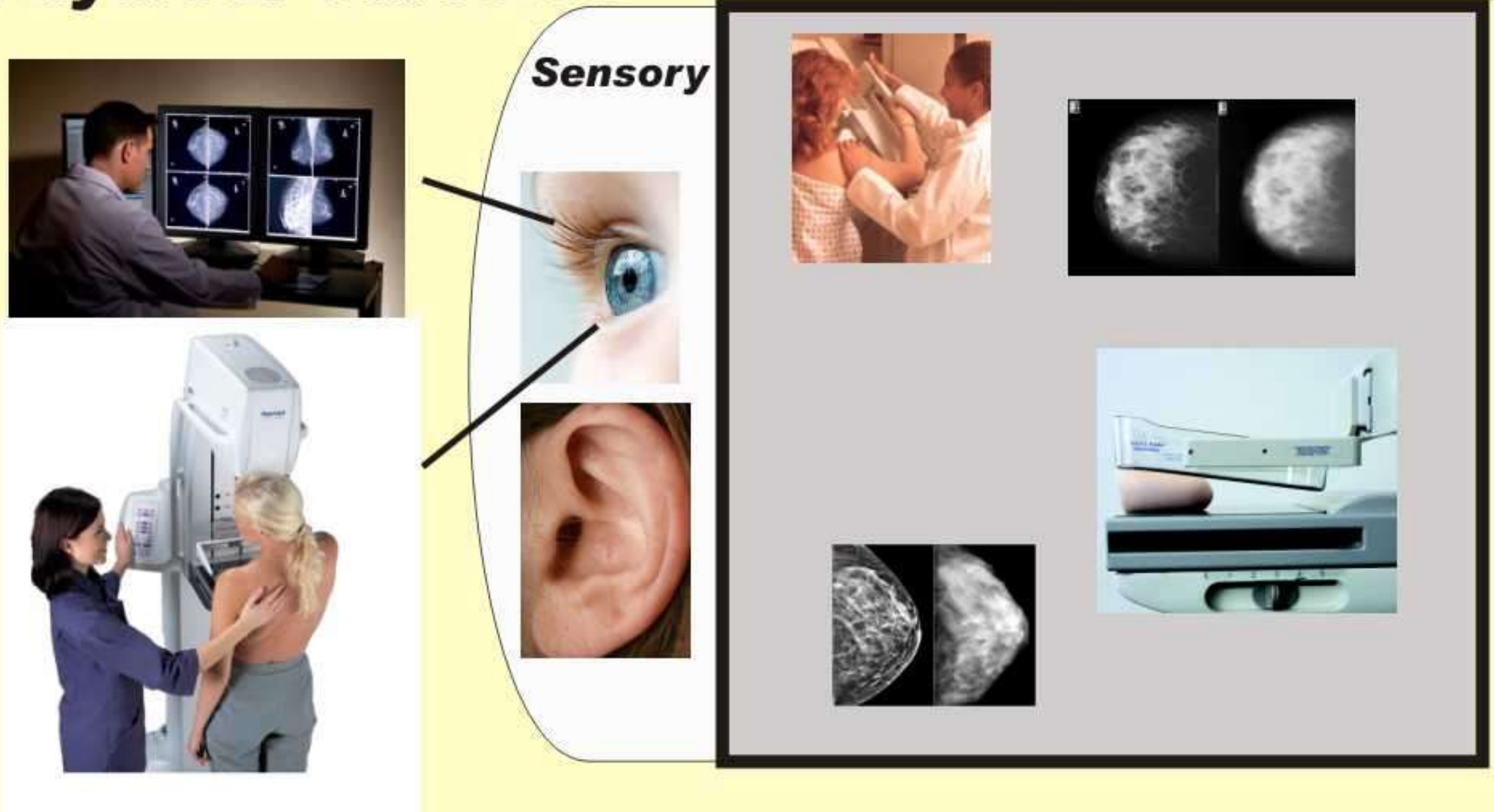
Forming Knowledge Structures

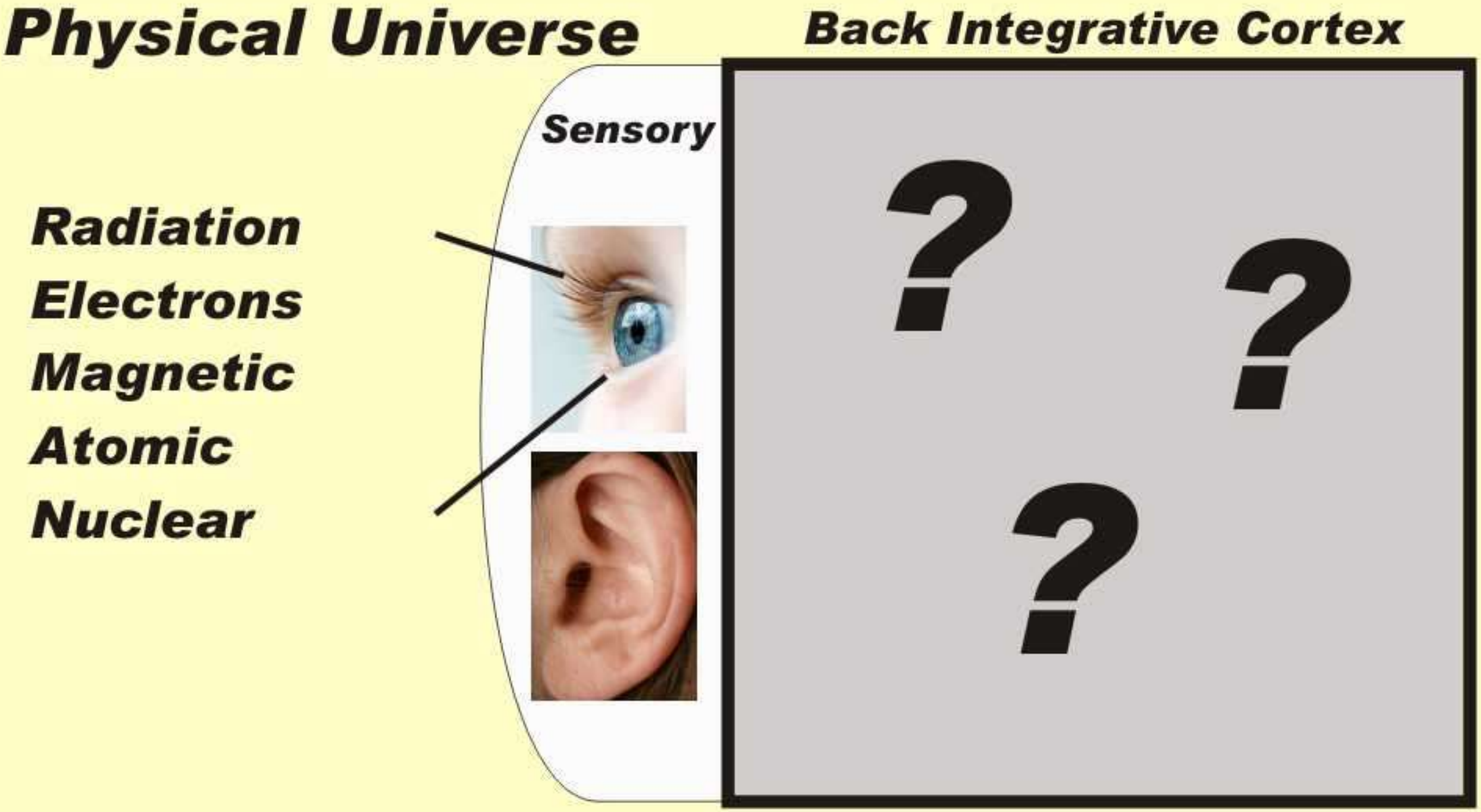
Physical Universe **Back Integrative Cortex**



Visible Physical Objects

Sprawls

Forming Knowledge Structures



Invisible Physical Objects

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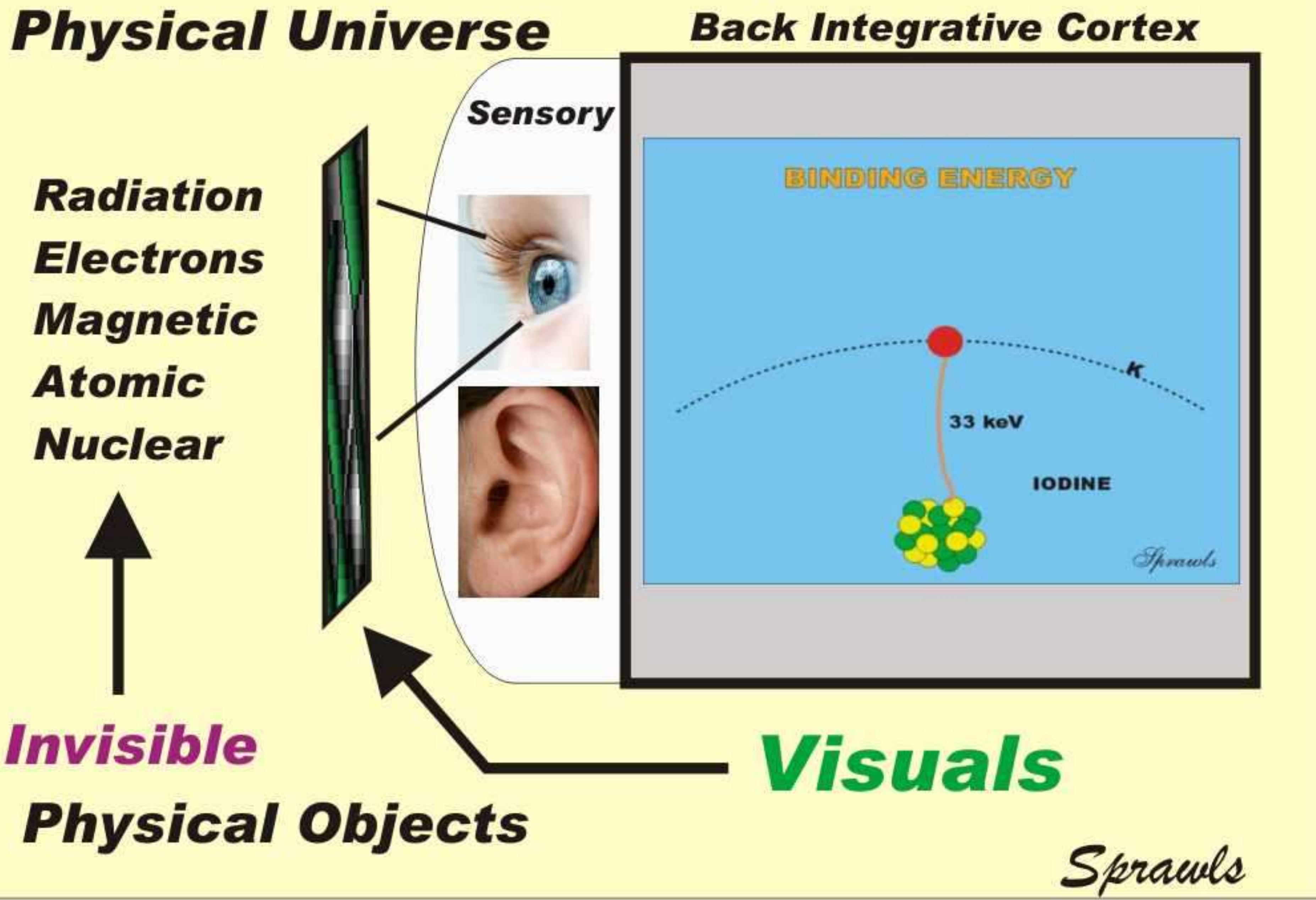
Forming Knowledge Structures



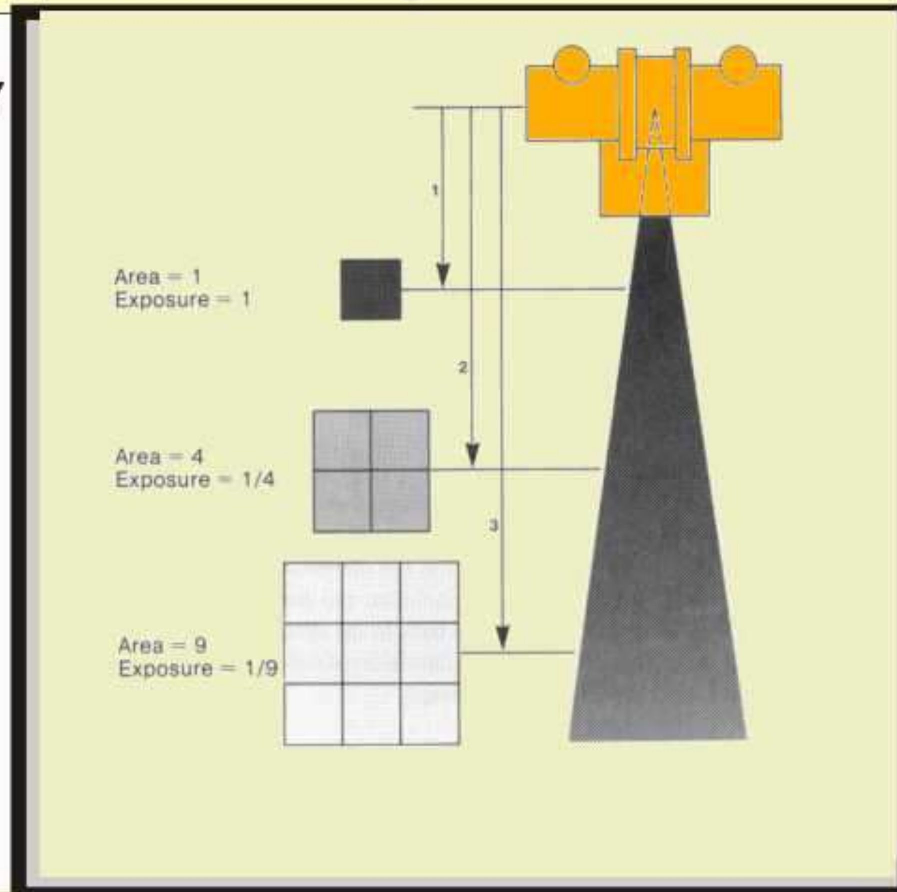
Forming Knowledge Structures

Physical Universe

Inverse Square Effect

Back Integrative Cortex

Sensory



Invisible

Concepts

Ideas

Visuals

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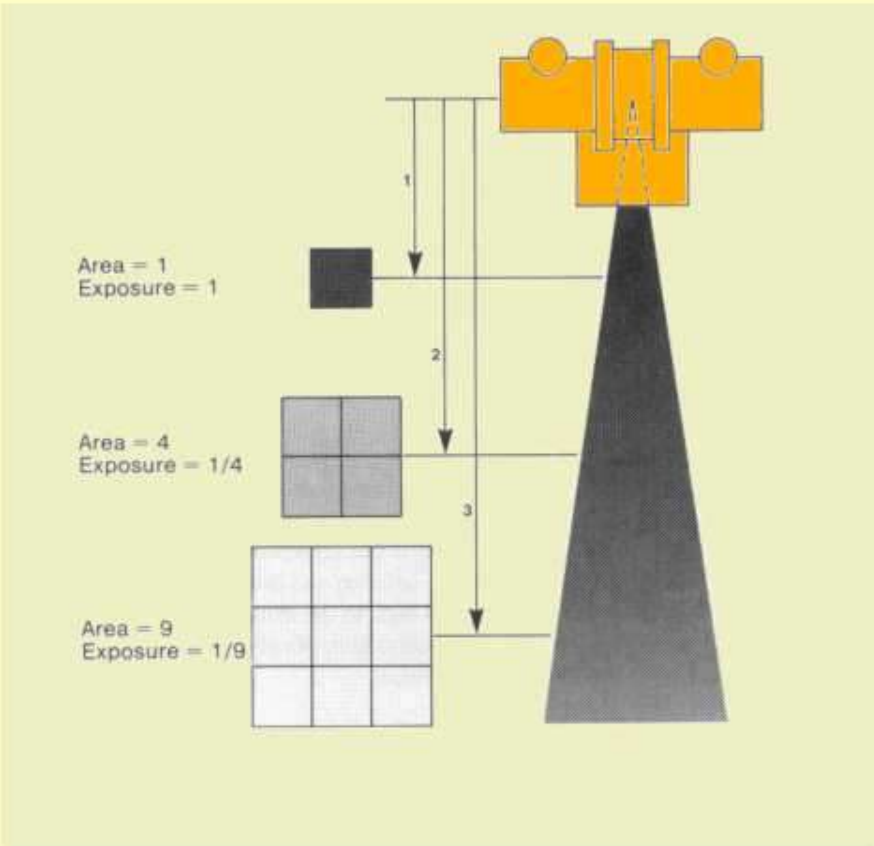
Forming Knowledge Structures



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

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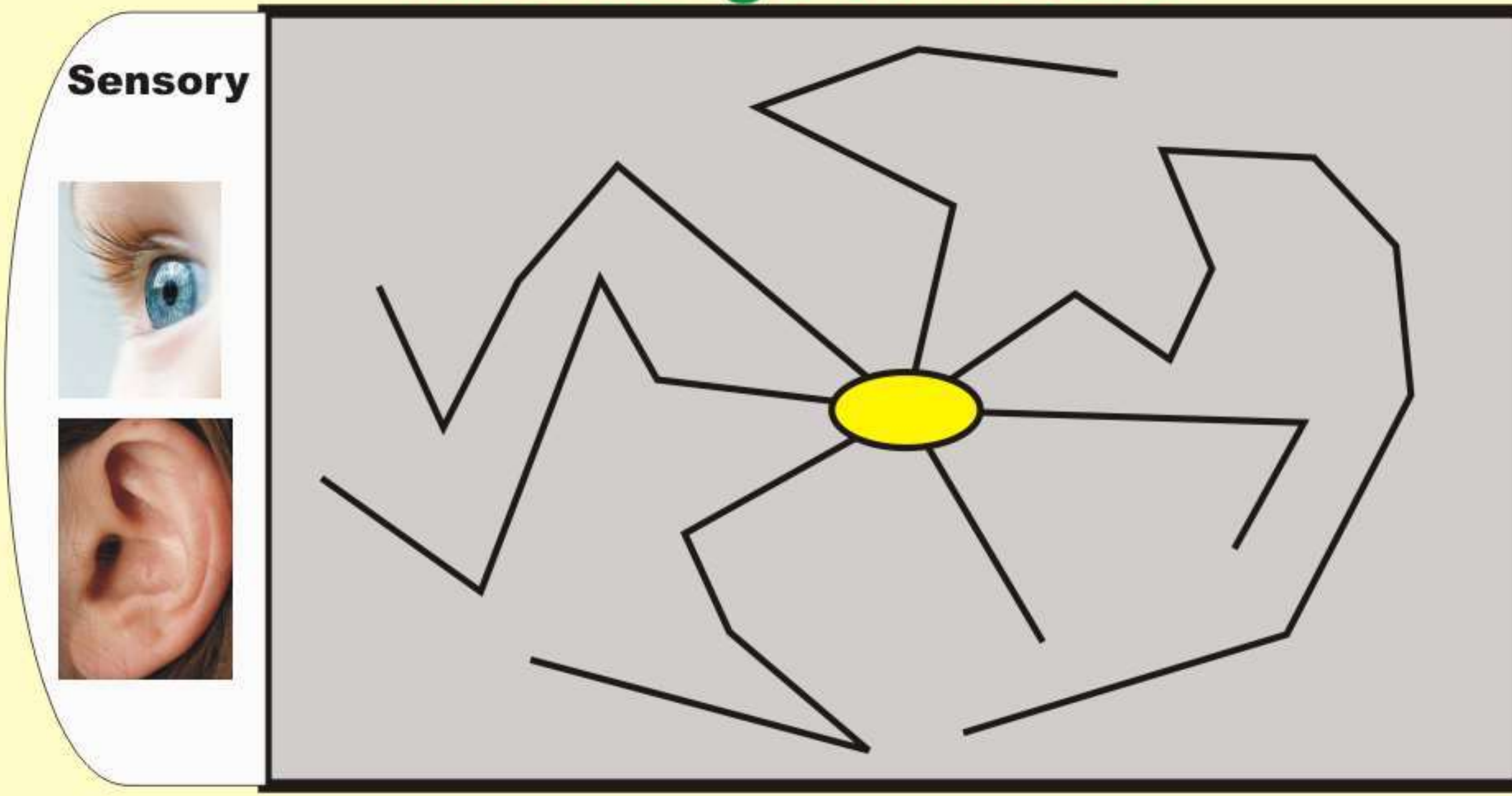
Back Integrative Cortex

Integrating experience into existing knowledge structure



Meaning

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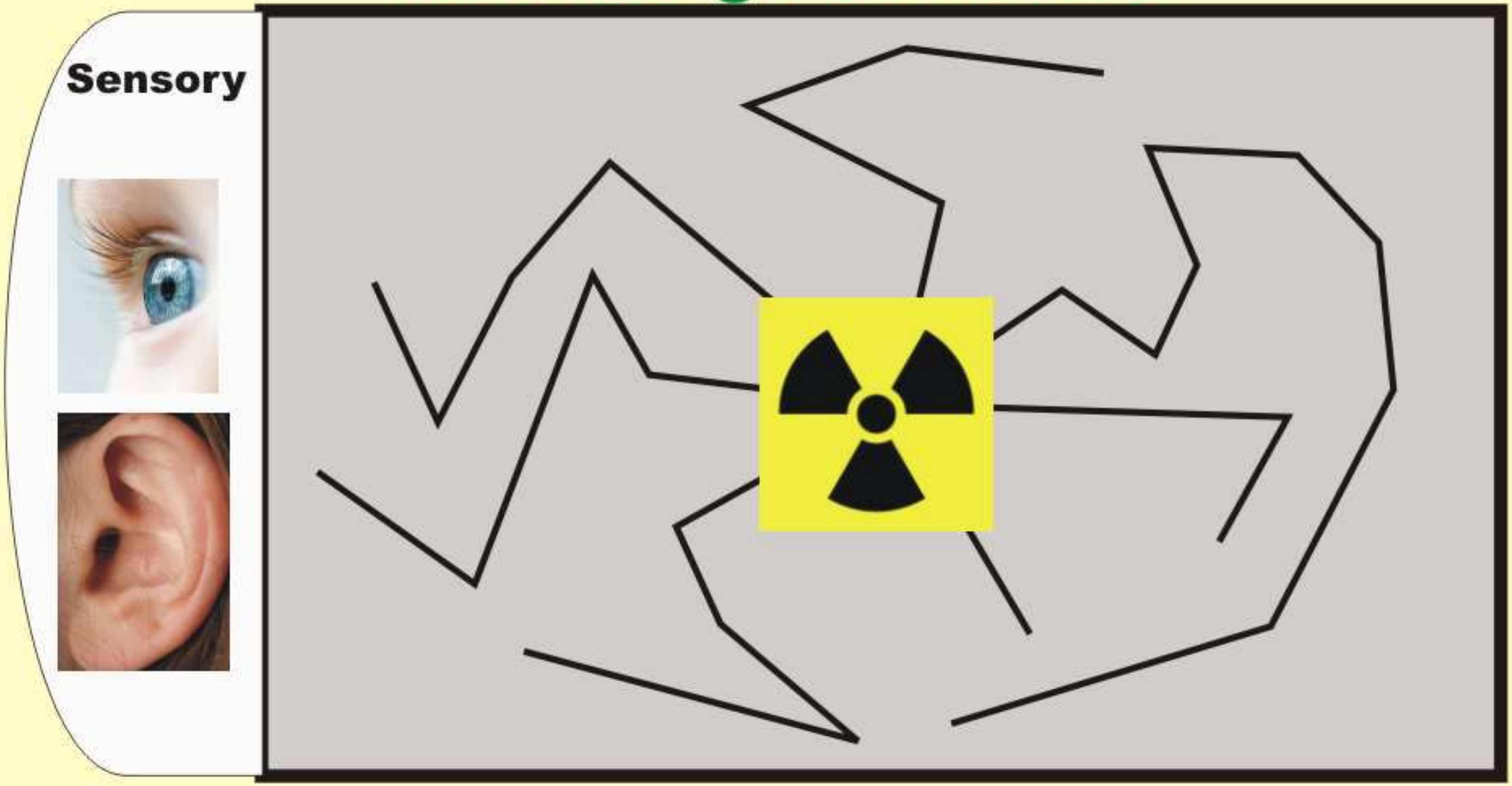
Back Integrative Cortex

Integrating experience into existing knowledge structure



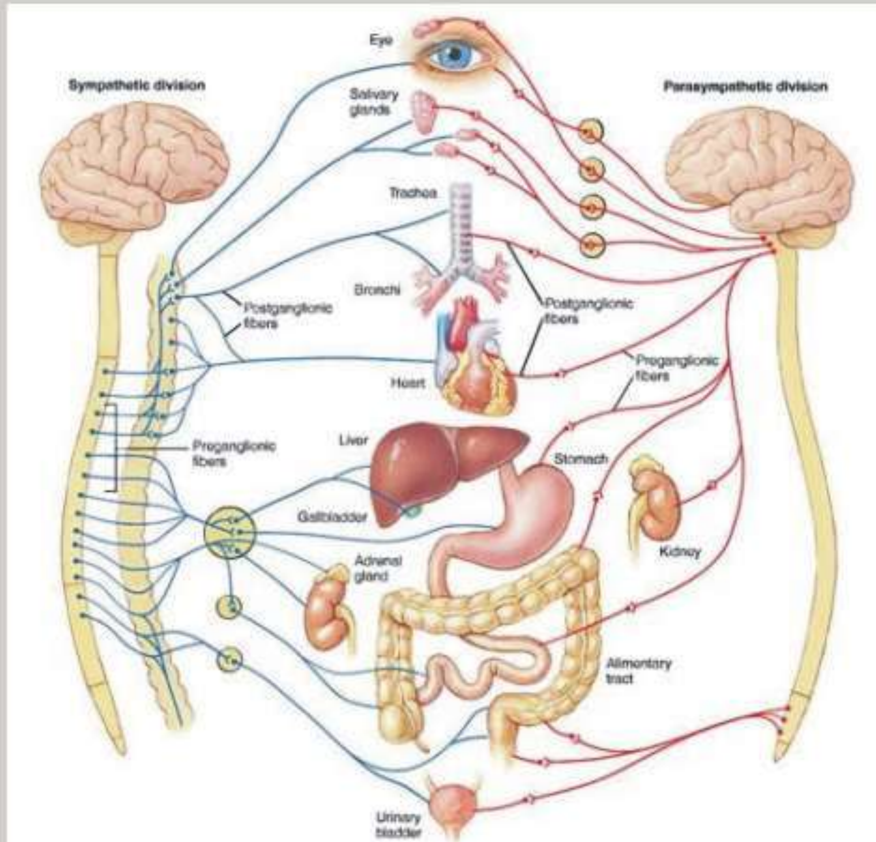
Meaning

Sprawls

Back Integrative Cortex

Integrating experience into existing knowledge structure

Sensory



Medical Knowledge

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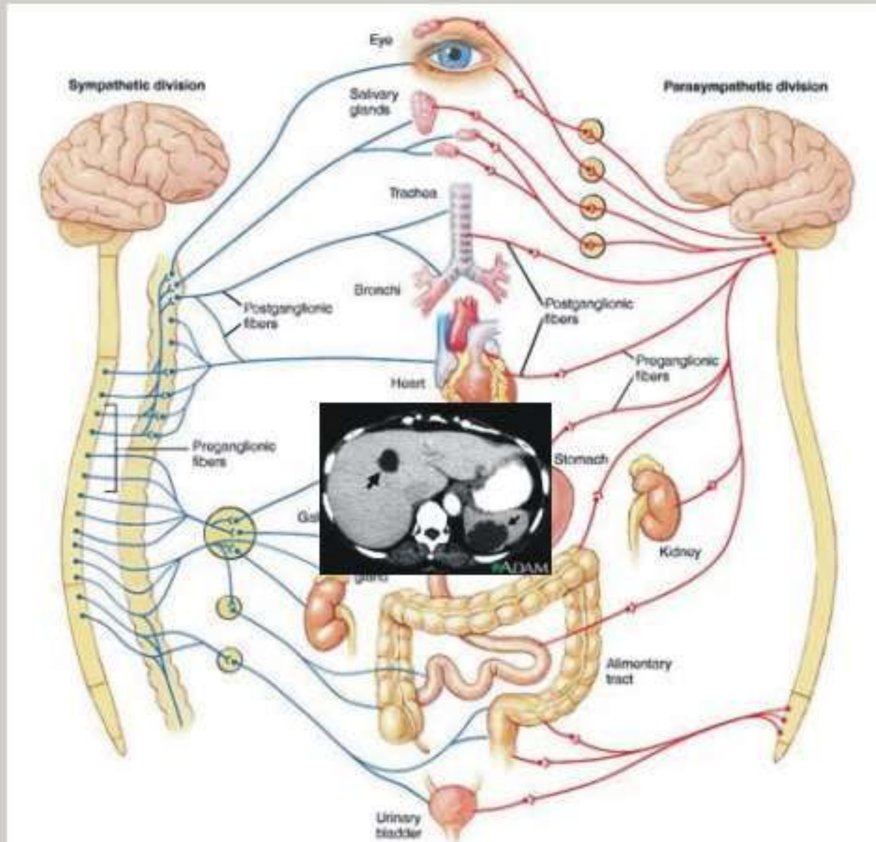
Back Integrative Cortex

Integrating experience into existing knowledge structure

Sensory



The image is the connection

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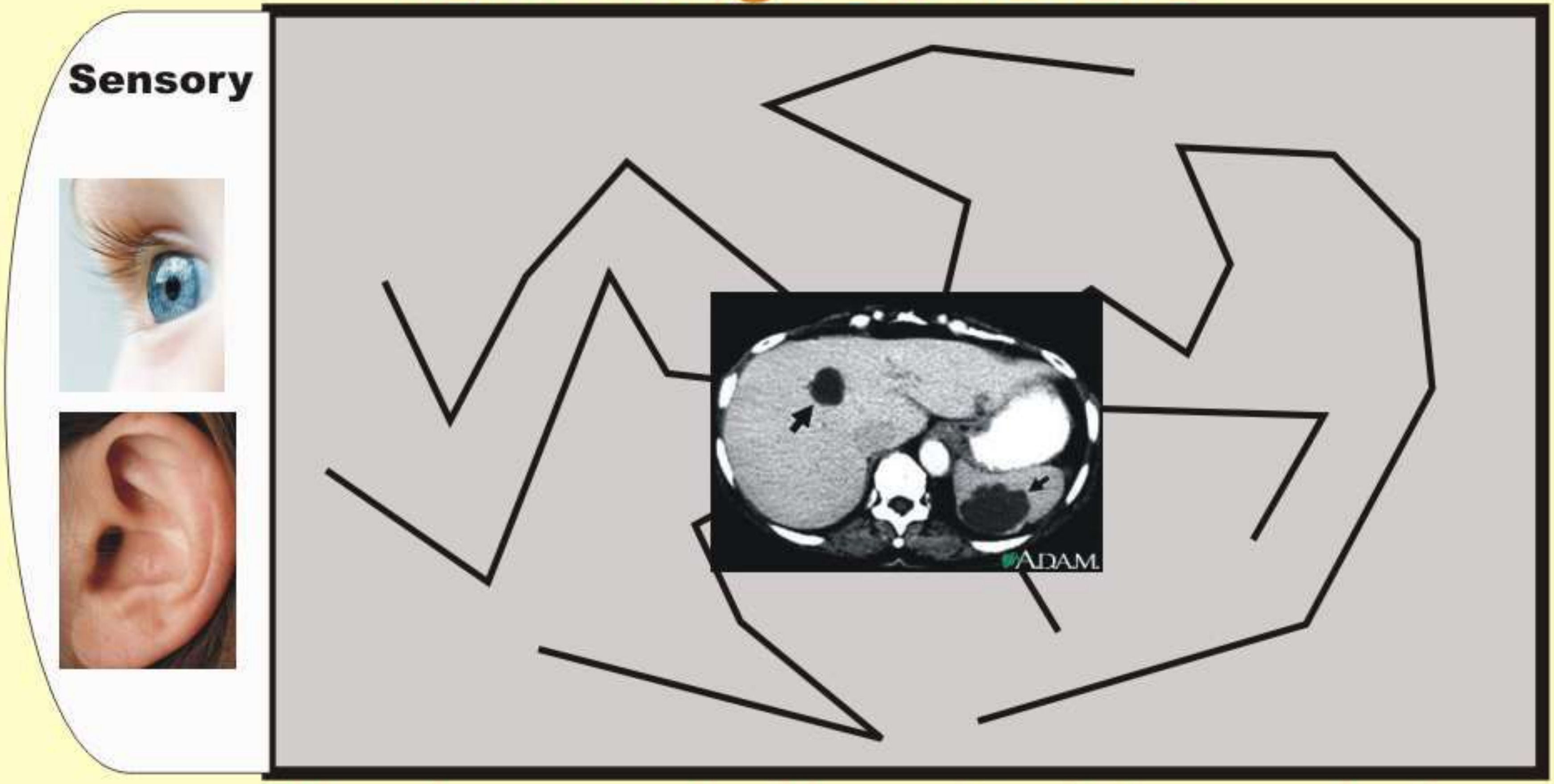
Back Integrative Cortex

Integrating experience into existing knowledge structure



The image is the starting point for learning physics

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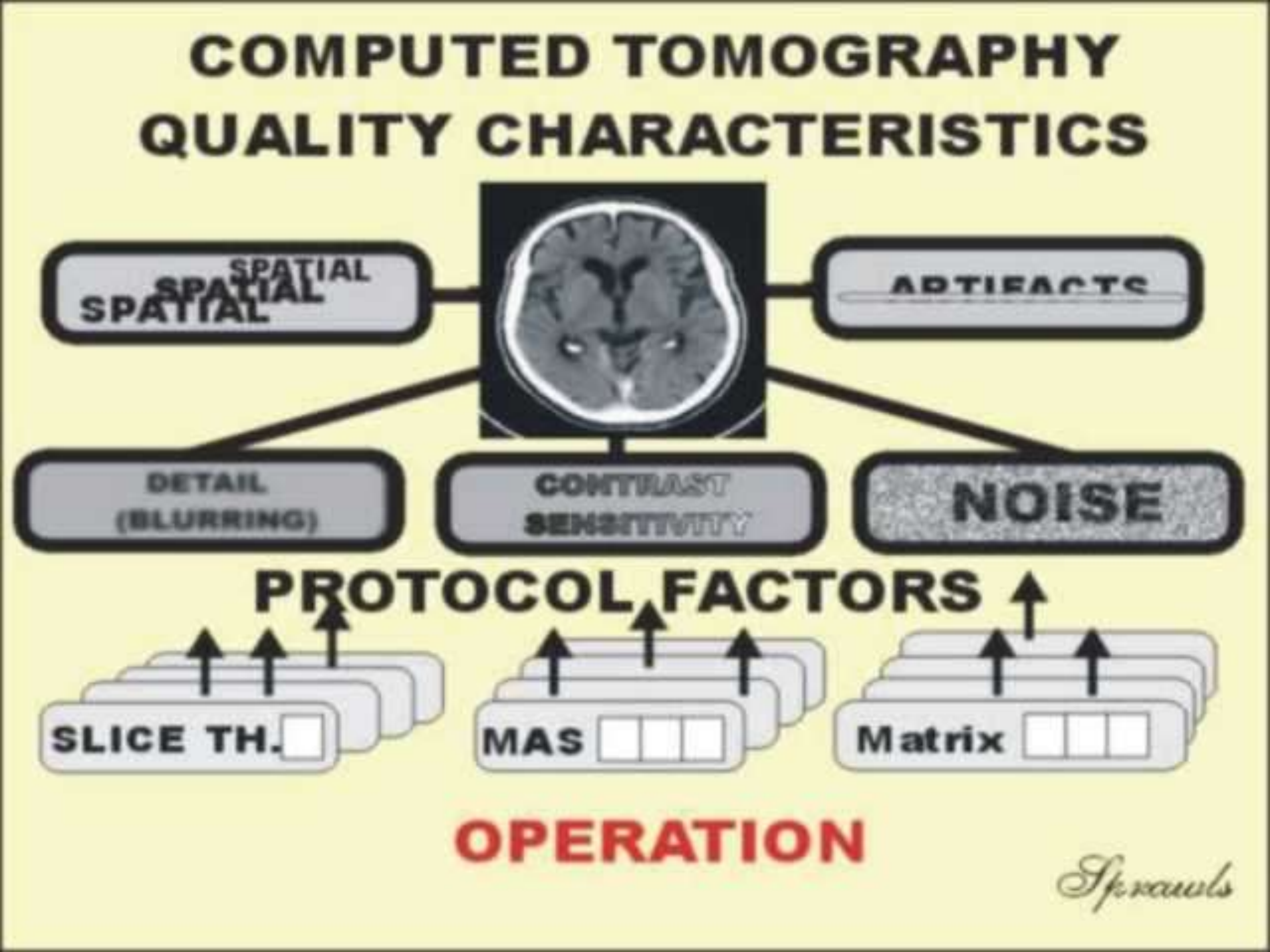
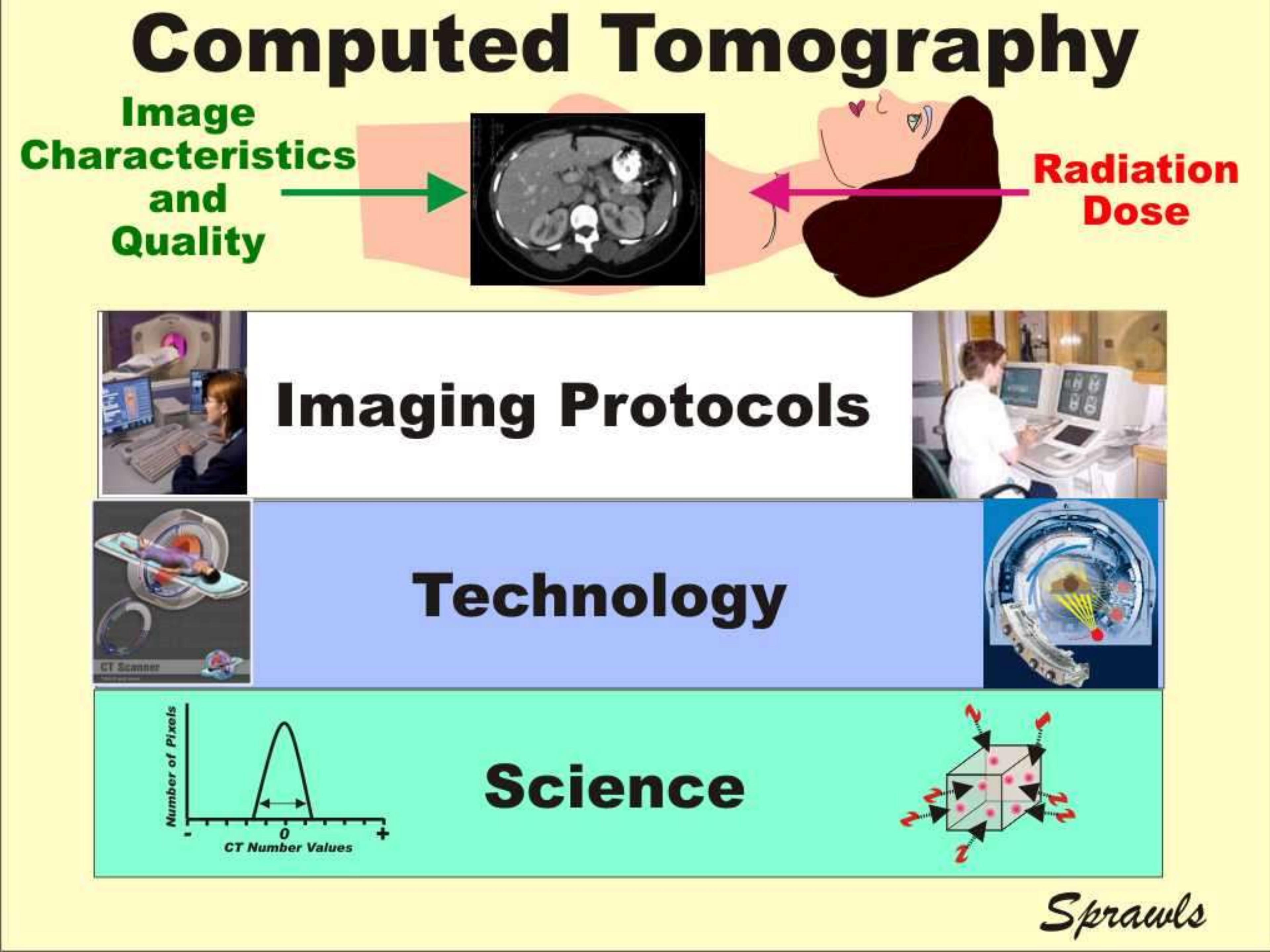
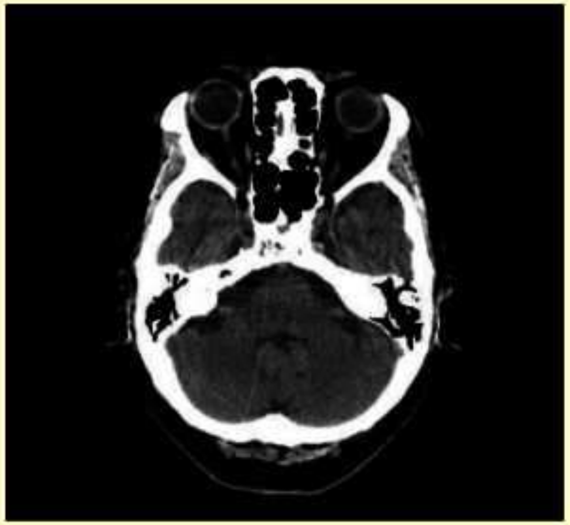

COMPUTED TOMOGRAPHY
QUALITY CHARACTERISTICS
SPATIAL
SPATIAL
SPATIAL
ARTIFACTS
DETAIL
(BLURRING)
CONTRAST
SENSITIVITY
NOISE
PROTOCOL FACTORS
SLICE TH.
MAS
Matrix
OPERATION
Sprawls

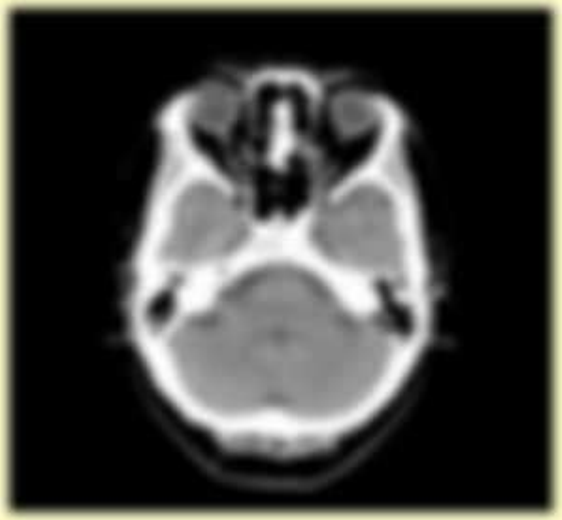

Computed Tomography
Image Characteristics and Quality
Radiation Dose
Imaging Protocols
Technology
CT Scanner
Science
Number of Pixels
CT Number Values
-
0
+
Sprawls

CT Image Characteristics

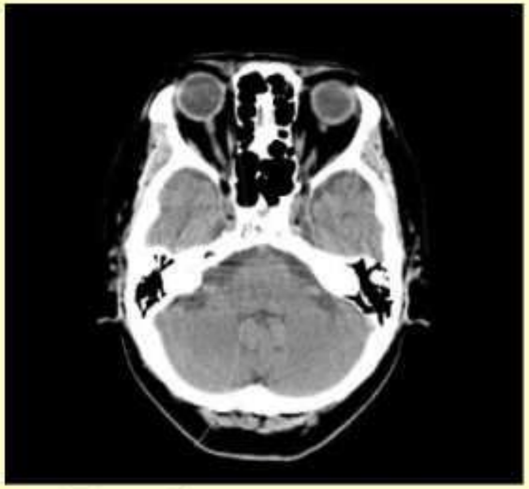
A



B



C



Reference

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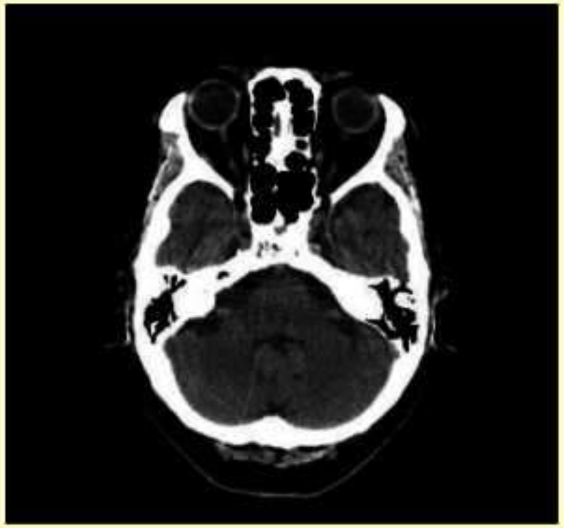
CT Image Characteristics

Contrast



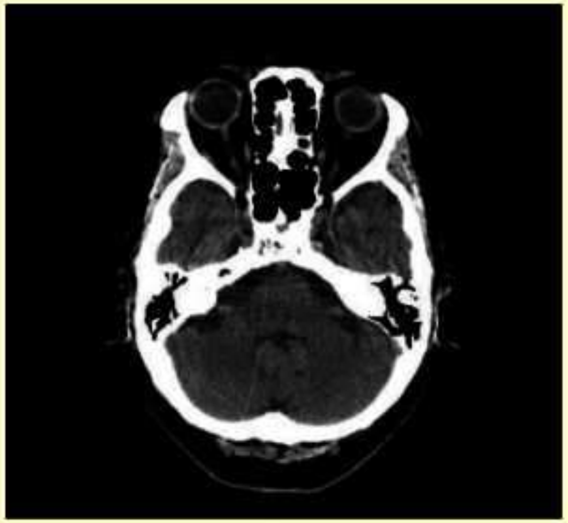
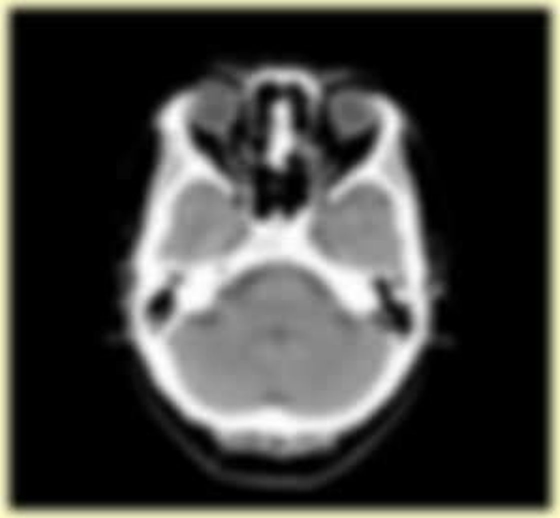
Detail

Noise

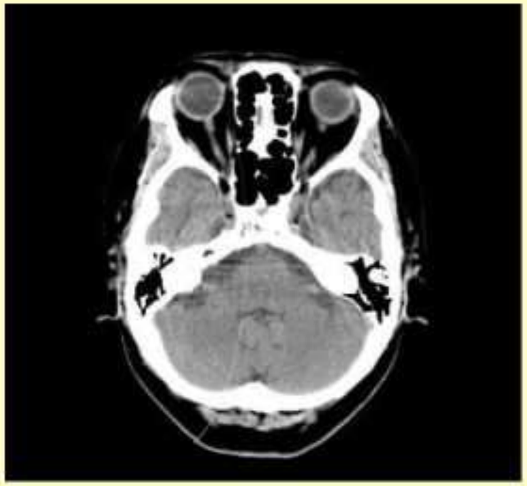
Reference

Sprawls

CT Image Characteristics

Contrast	Detail	Noise
		
Same	Low	Low

Reference



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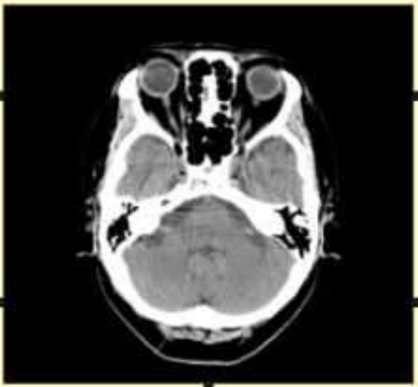
CT Image Characteristics



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

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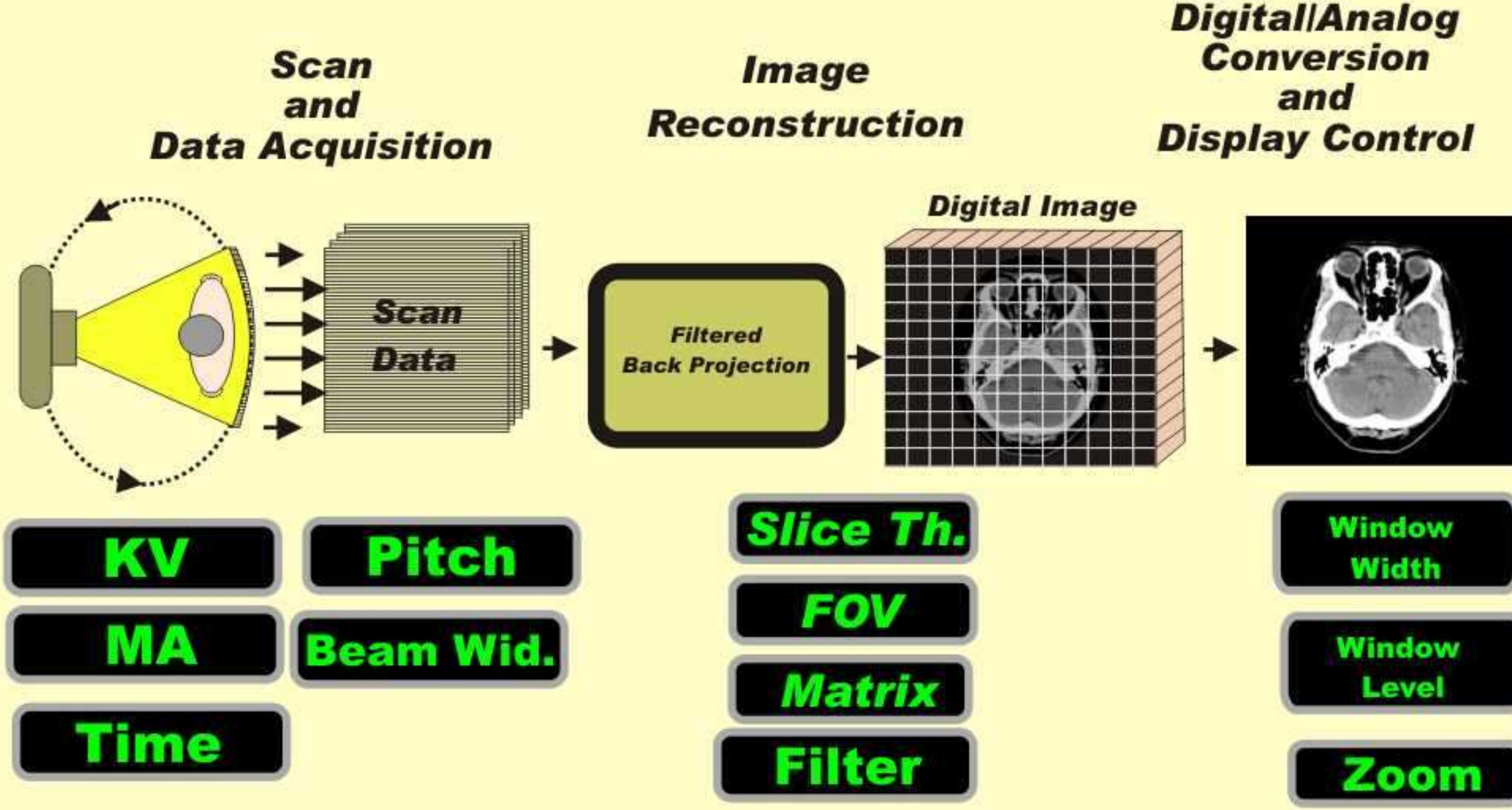
The Three Phases of CT Image Formation



Major Protocol Factors

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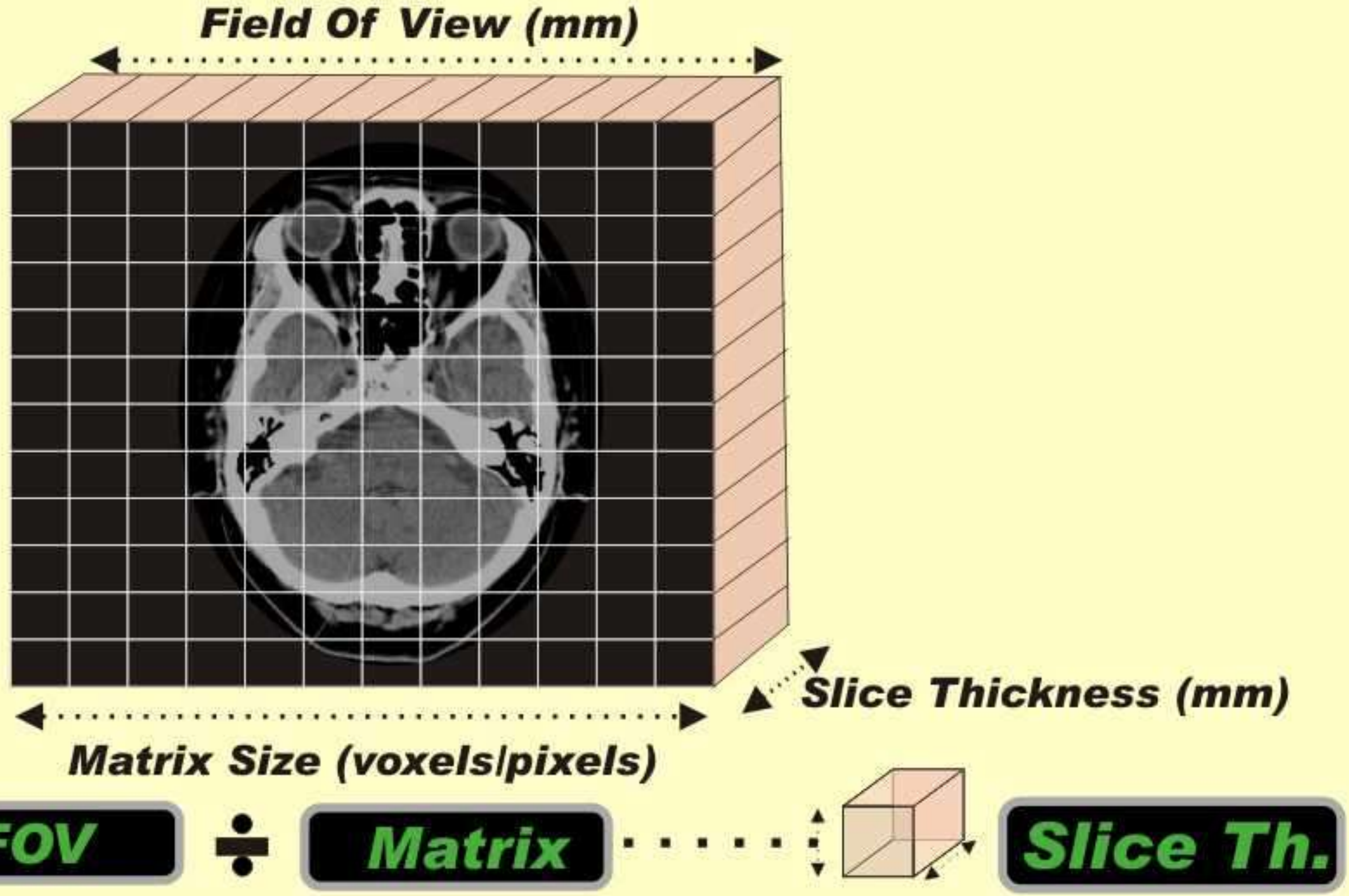
CT Slice Divided into Matrix of Voxels



Voxel Size Controlled By

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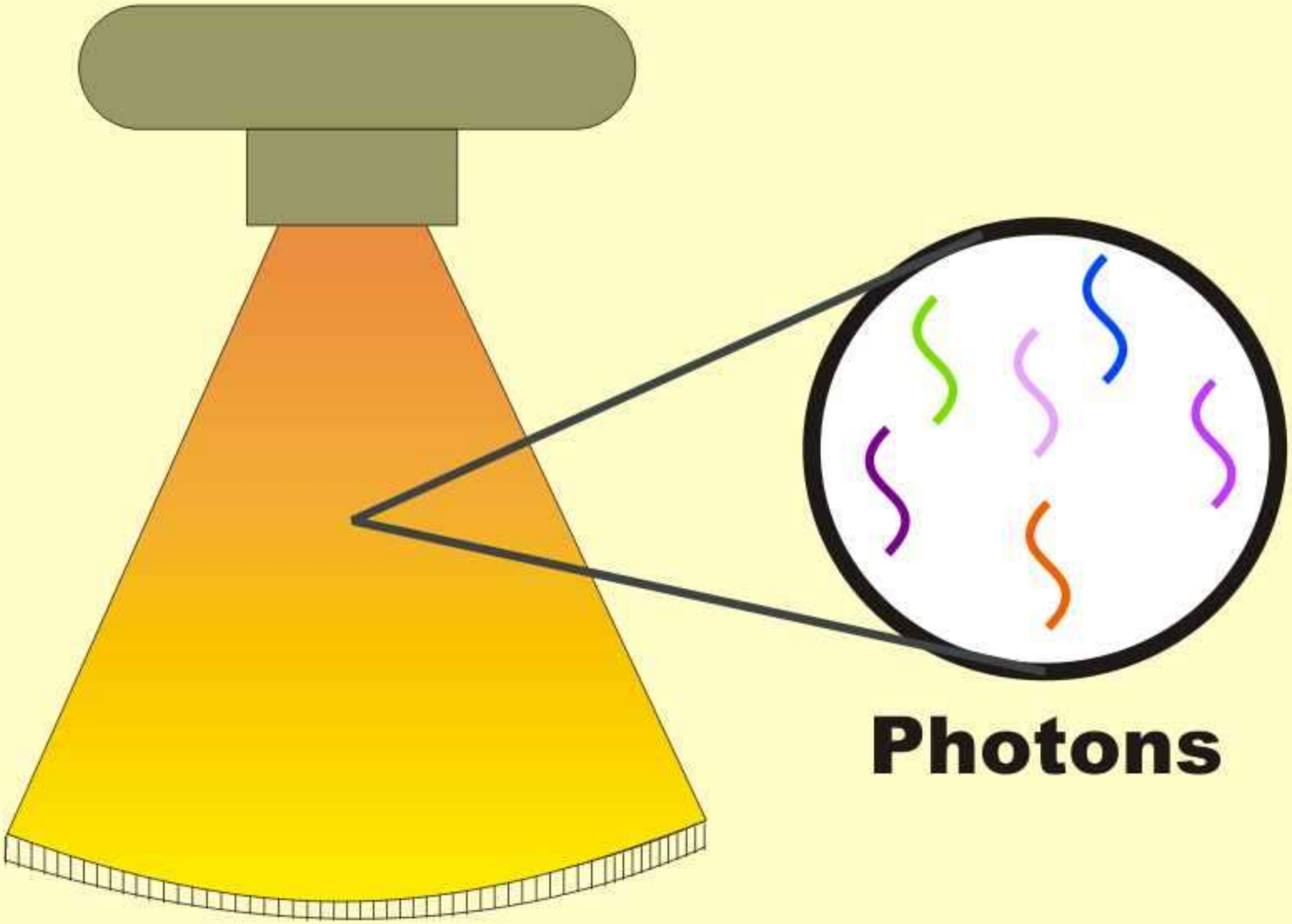
The Quantum Structure of the X-ray Beam



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X-ray Photons Interact With Tissue in A Voxel

Radiation Dose

determined by

Concentration

of

Absorbed Energy

per voxel

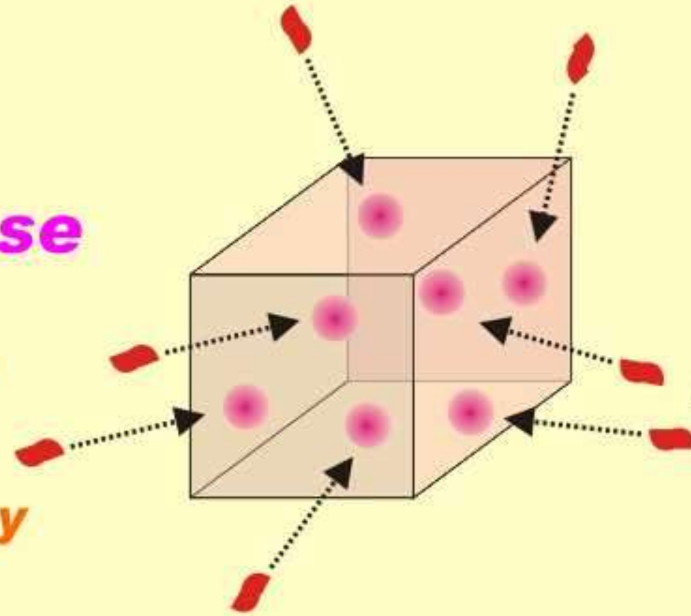

Image Noise

determined by

Number of Photons

per voxel

Dose is increased

by

increasing number

of photons.

Noise is reduced

by

increasing number

of photons.

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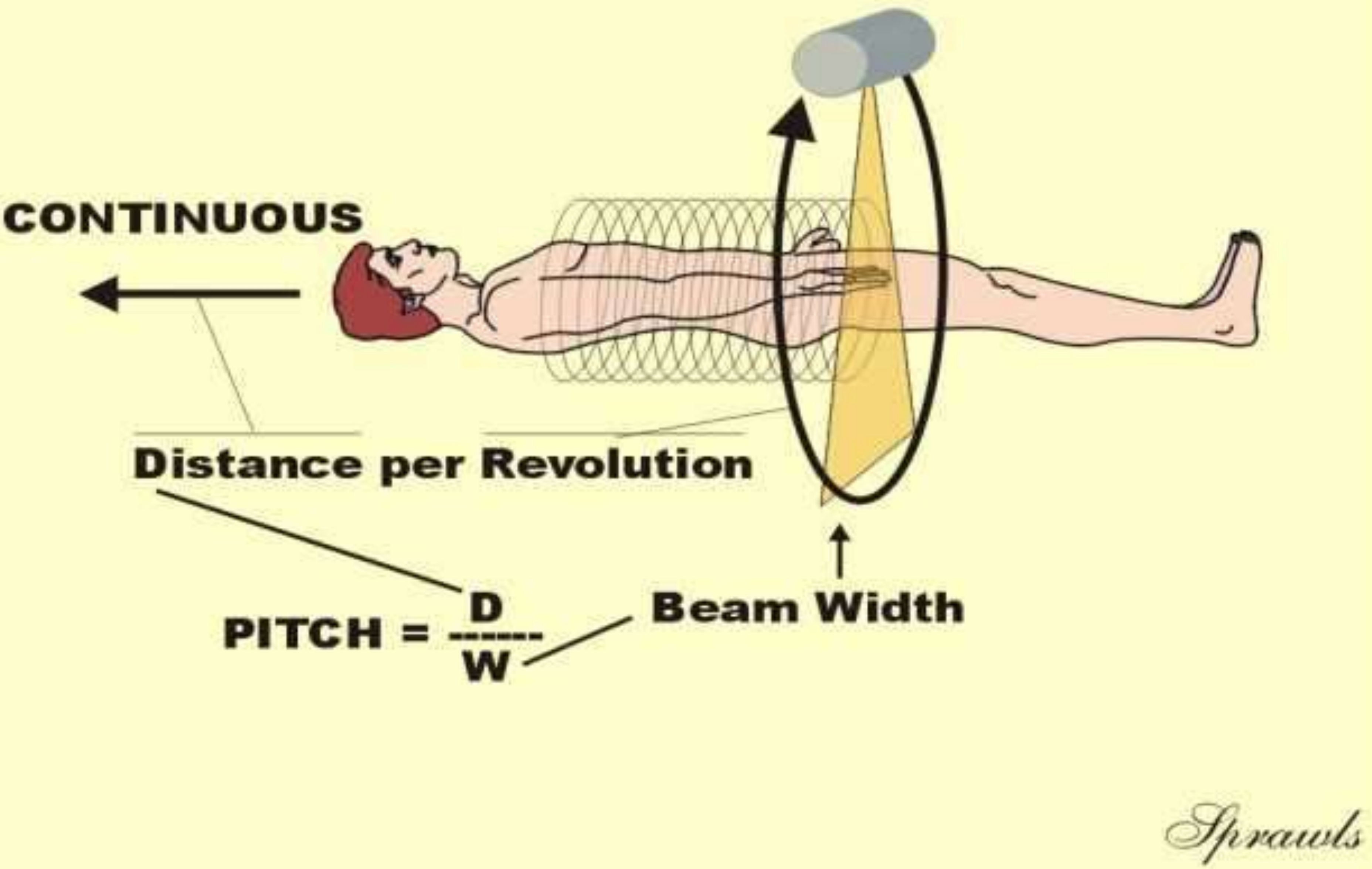
SPIRAL SCAN



CONTINUOUS
Distance per Revolution
Beam Width
PITCH = D / W
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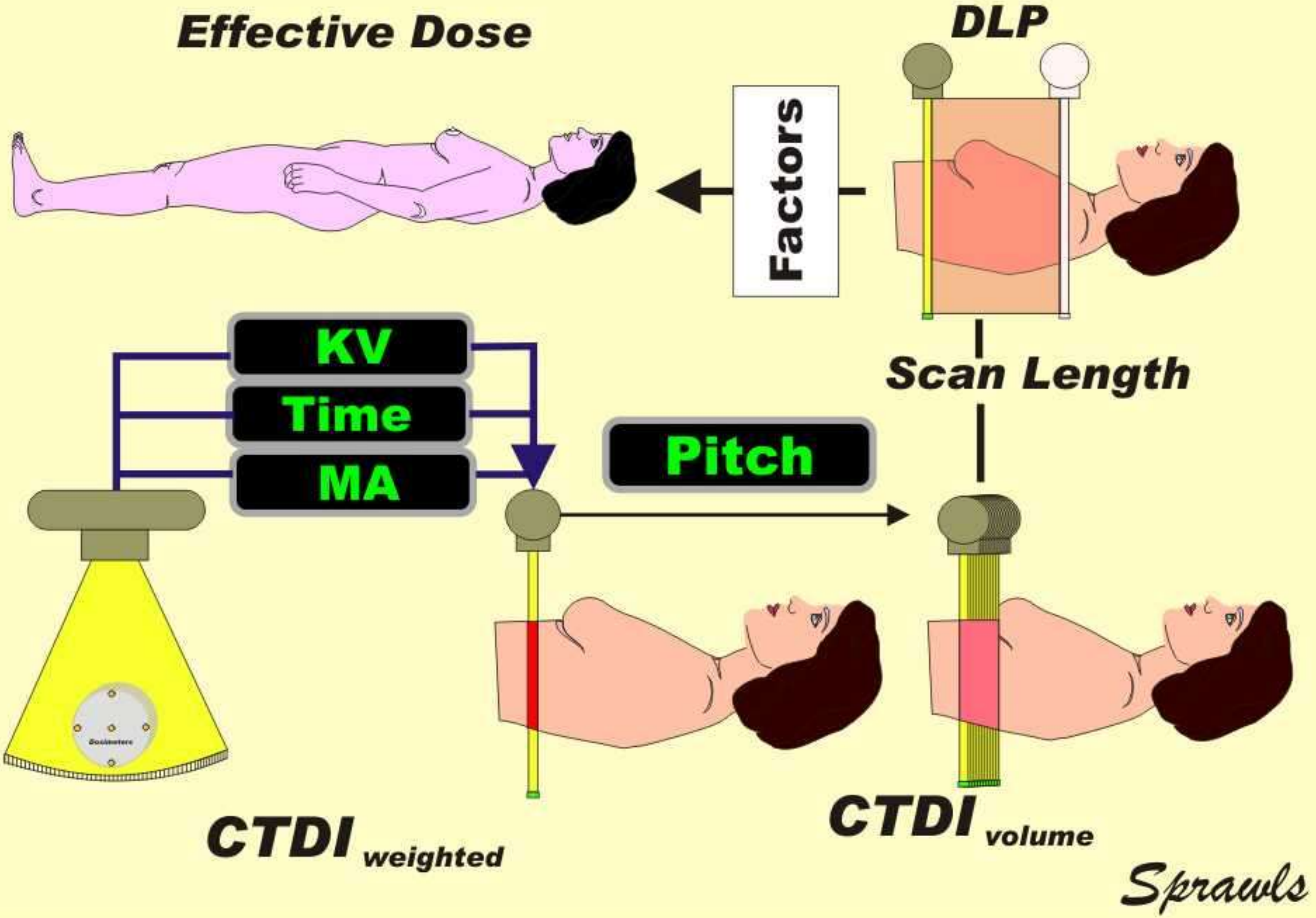
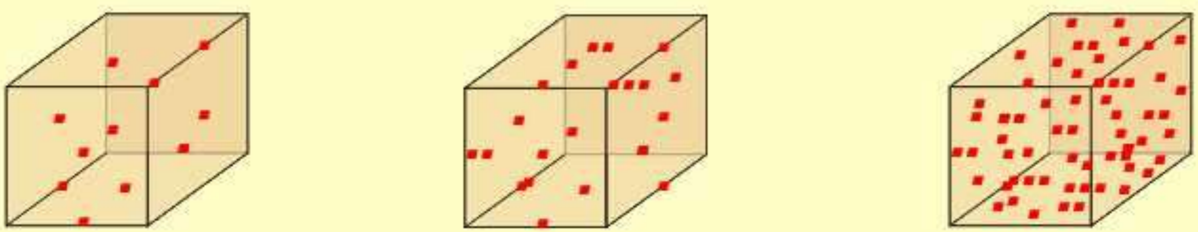
CT Dose Quantities



Decreasing Noise

Requires Increased Photons Absorbed Per Voxel



Produces Increasing Dose

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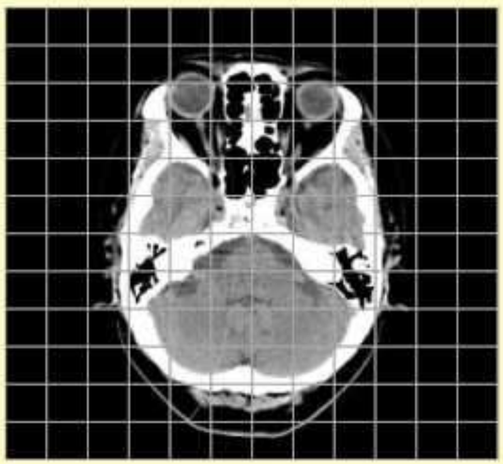
Effect of Matrix Size on Image Noise

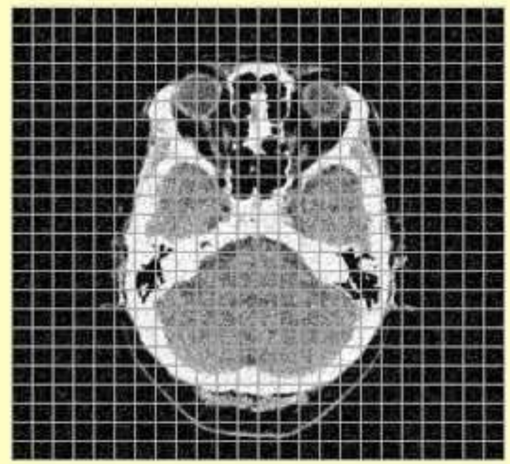
Small **Matrix** **Large**

Large Voxels



Low Noise

Small Voxels



High Noise

The same radiation dose for both images.

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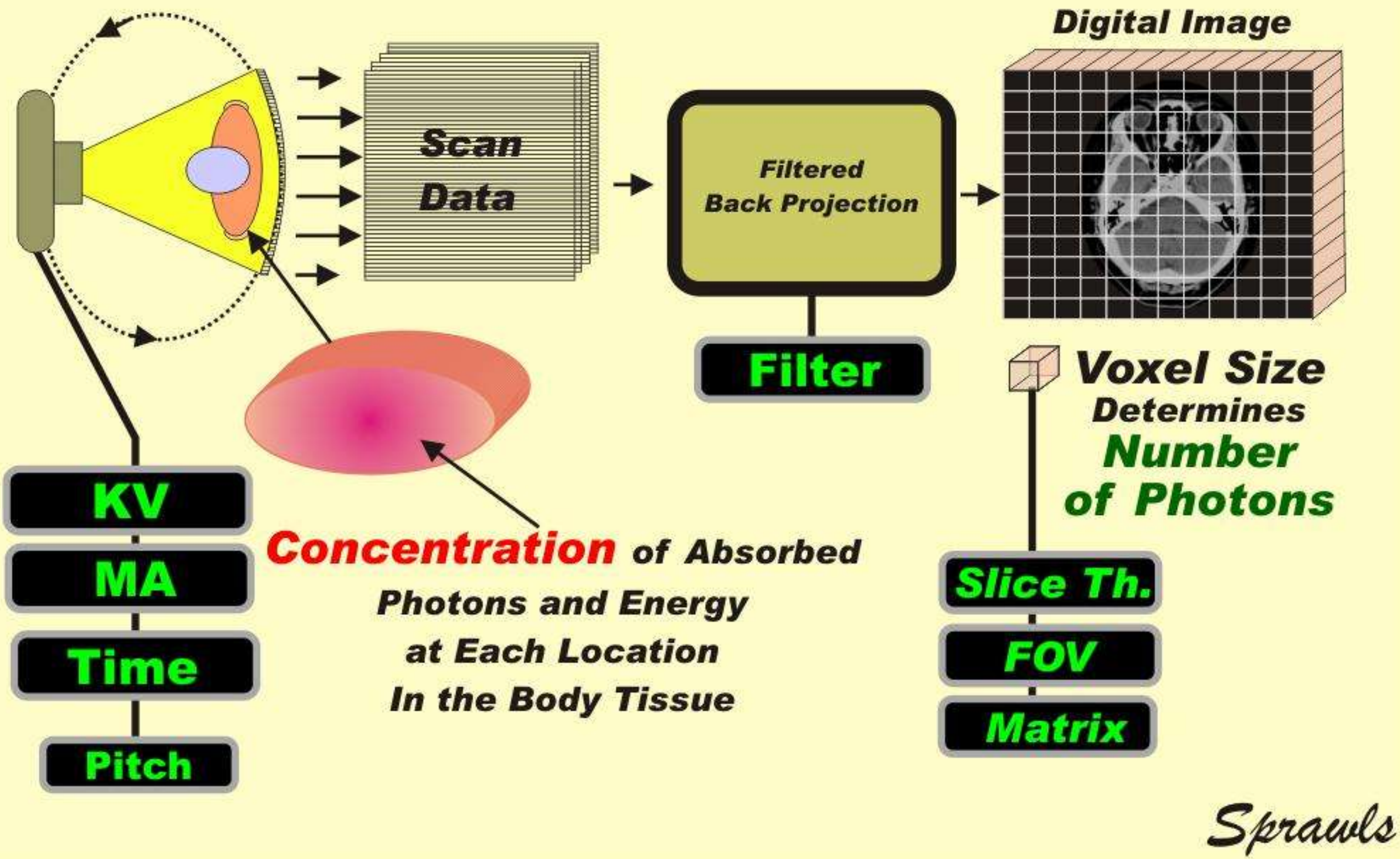
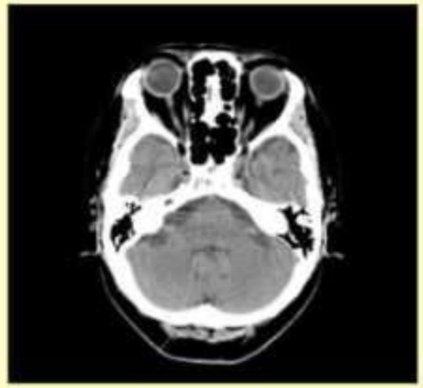
Factors That Determine Image Noise



Two Major Image Quality Goals

High Detail



Low Noise

Small — **Voxel Size** — Large

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

Protocol Factors

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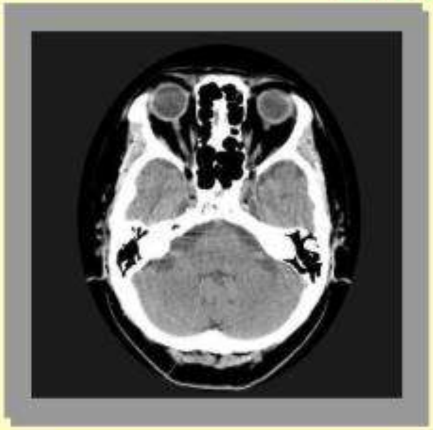
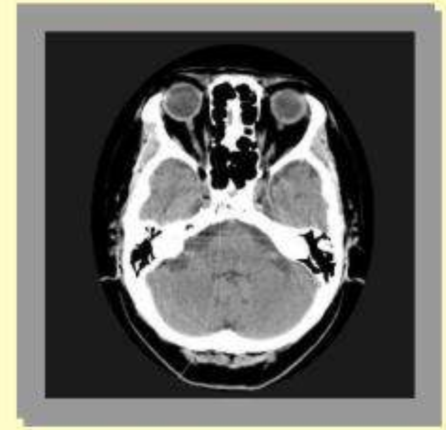
Relationship of Radiation Dose to Image Detail

Lower Dose



Higher Dose

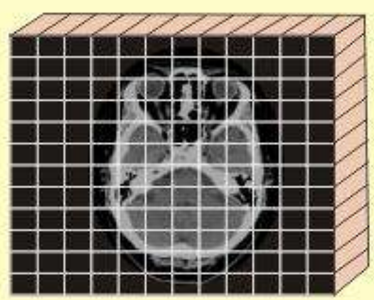


When detail is increased by

- **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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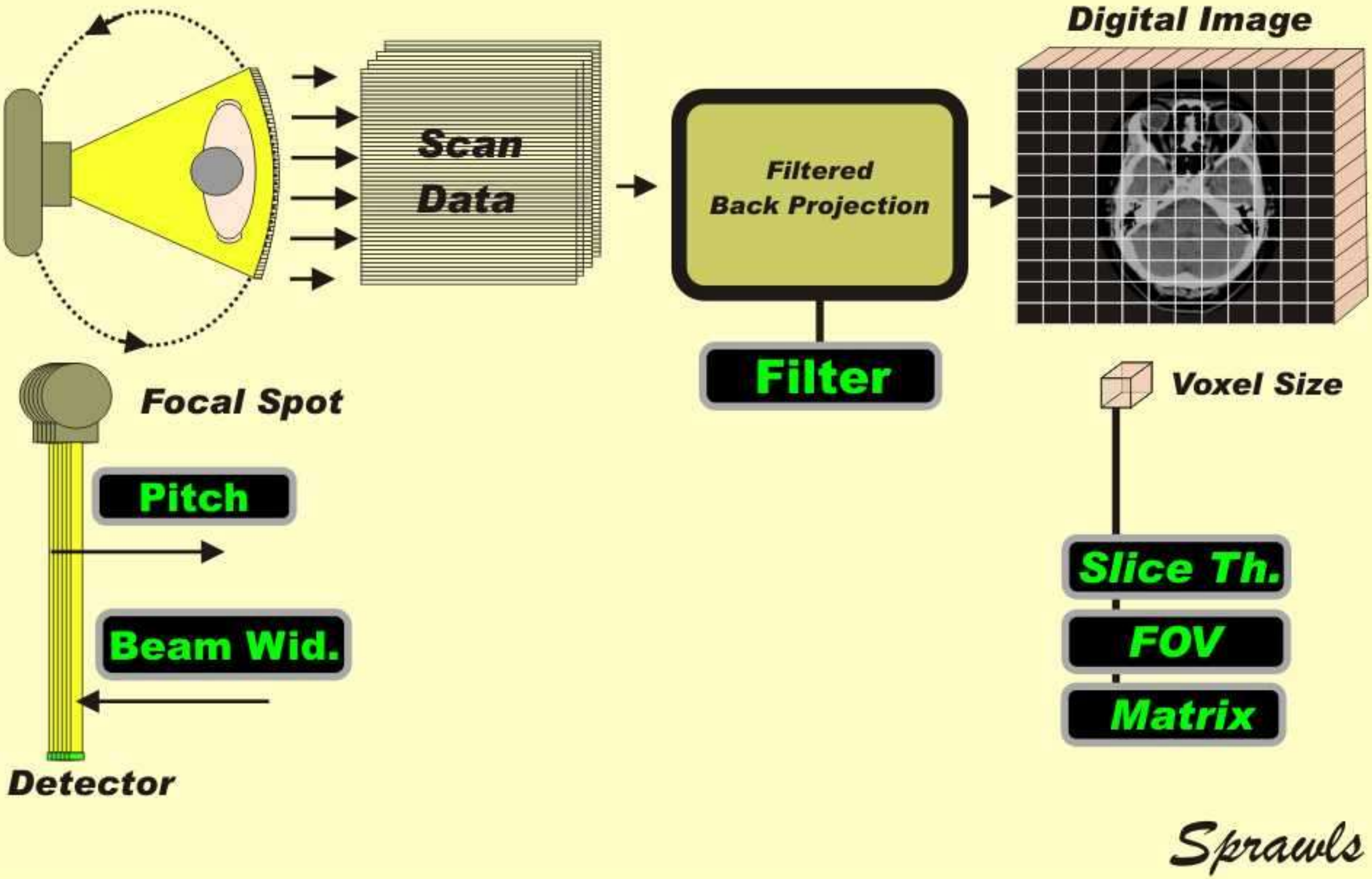
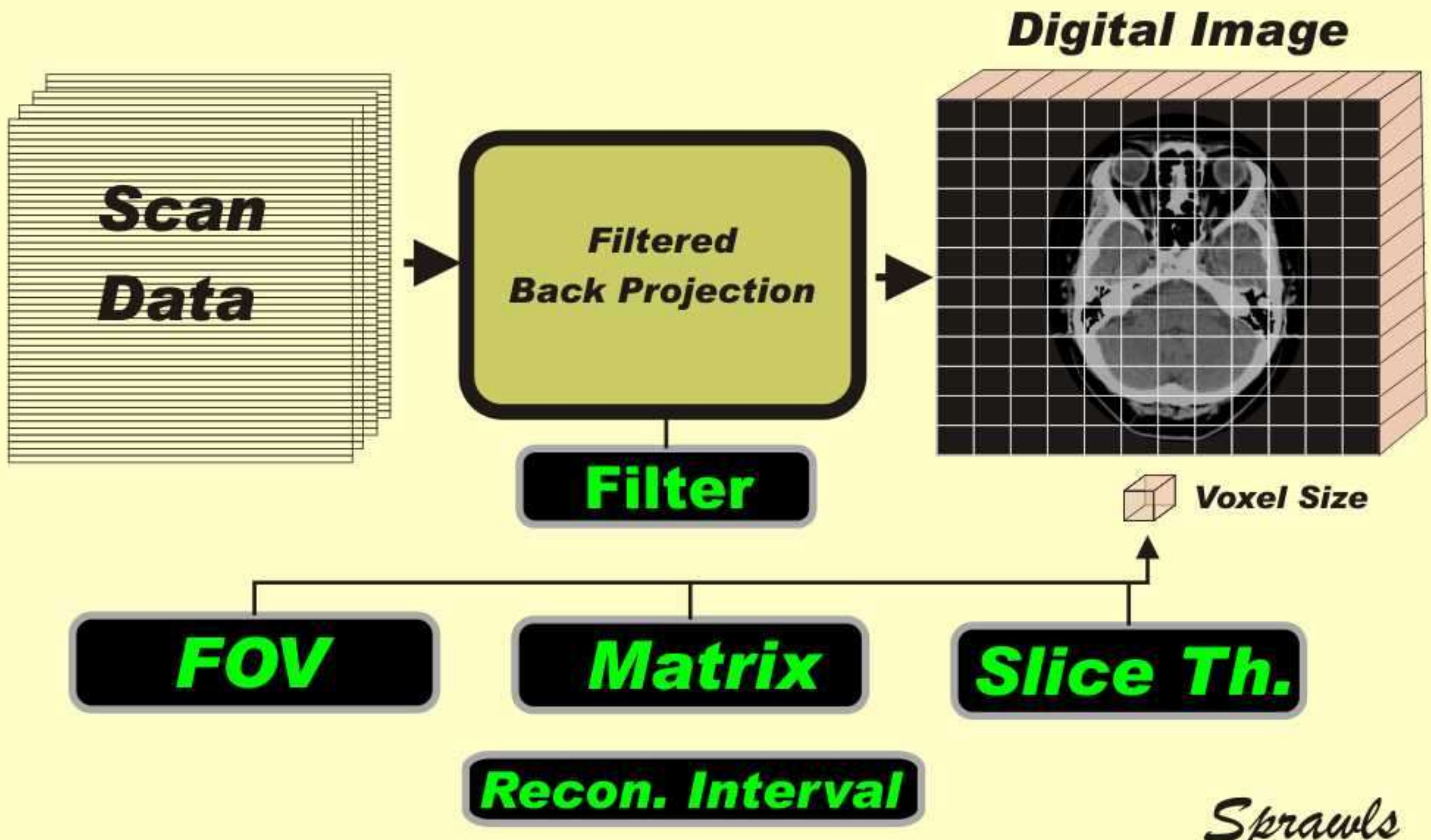
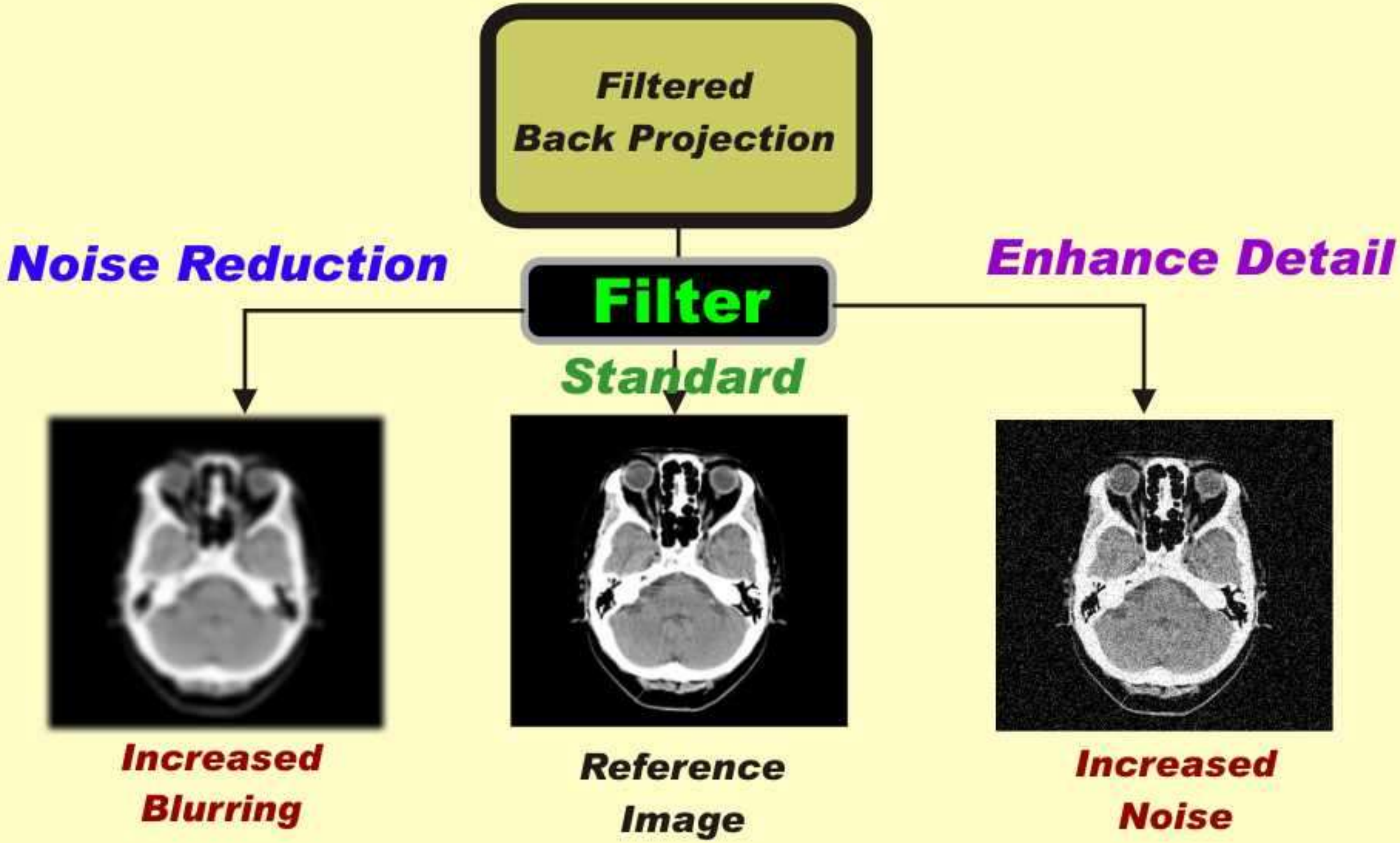
Factors That Determine Image Detail (Sources of Blurring)



CT Image Reconstruction



Reconstruction Filter Kernels



(Effects exaggerated for illustration here)

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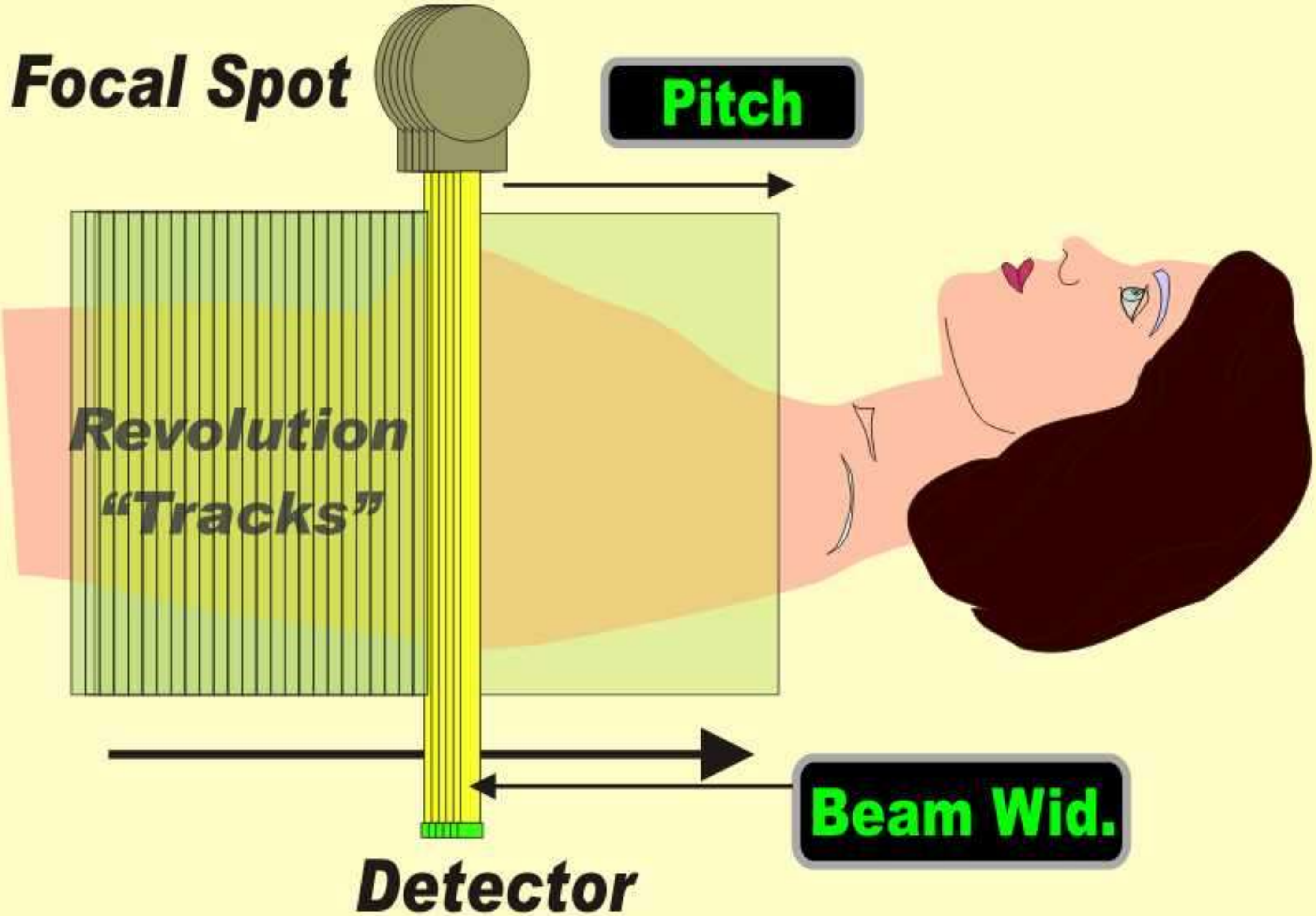
Scan Data Set



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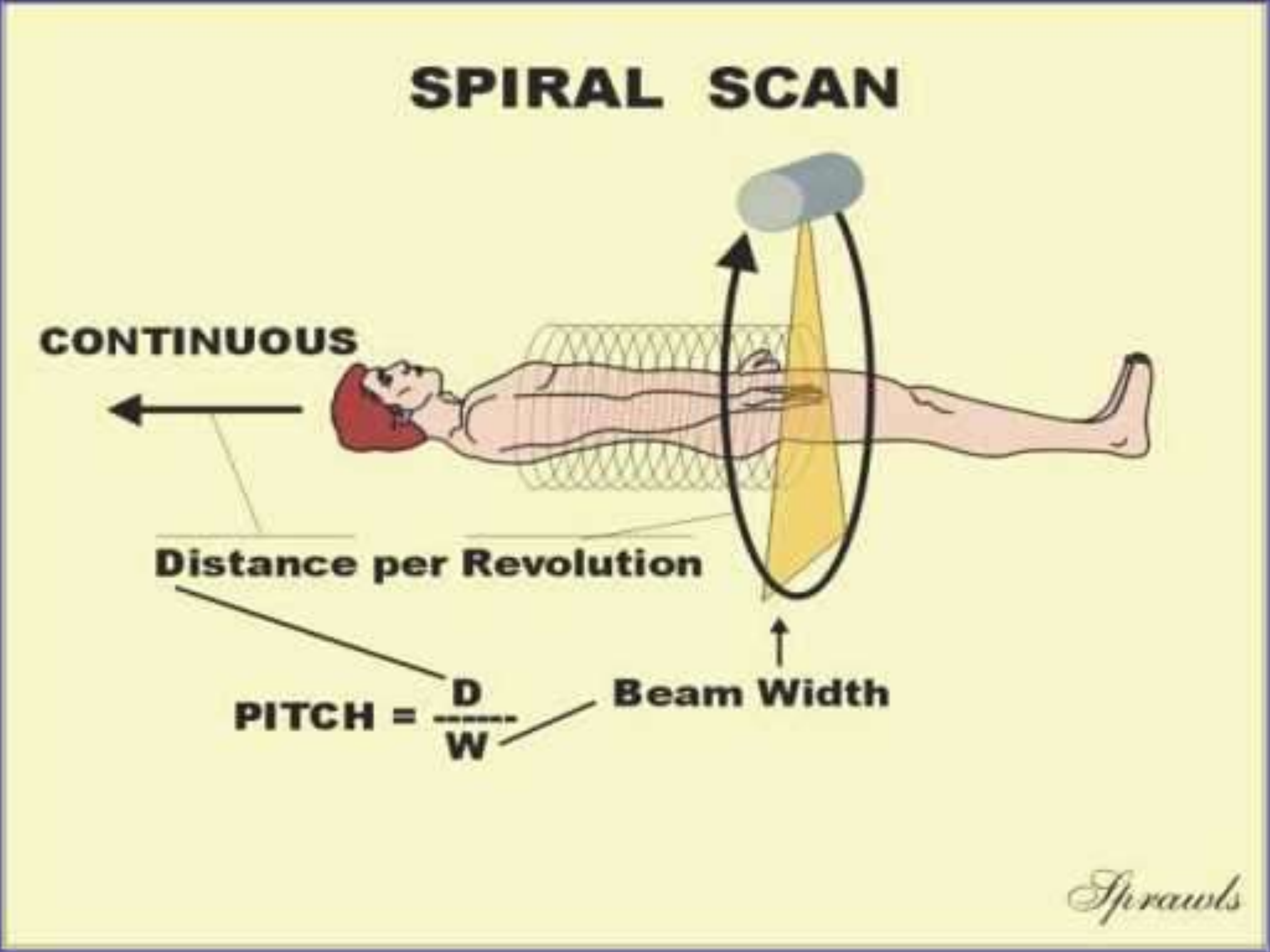
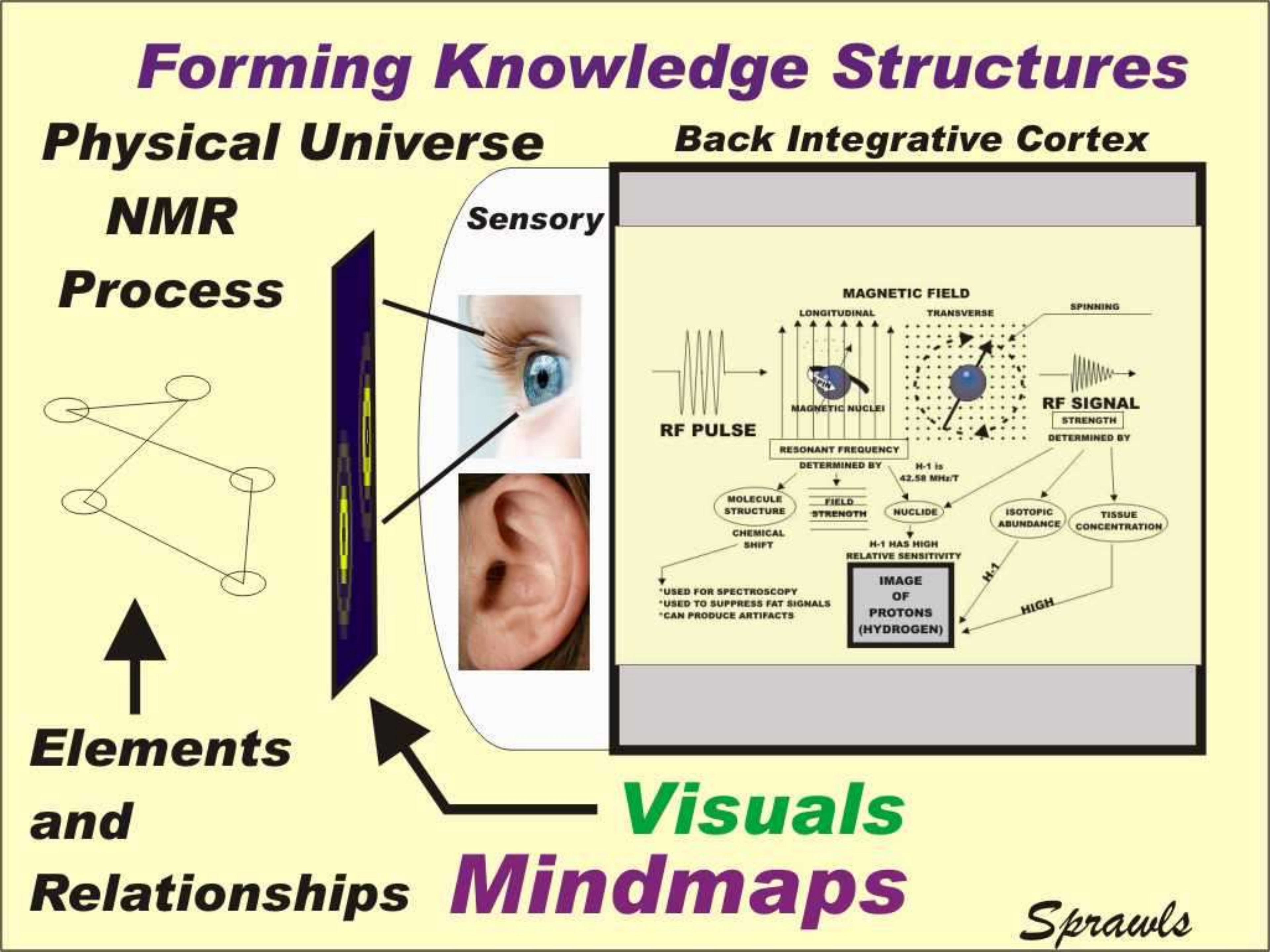
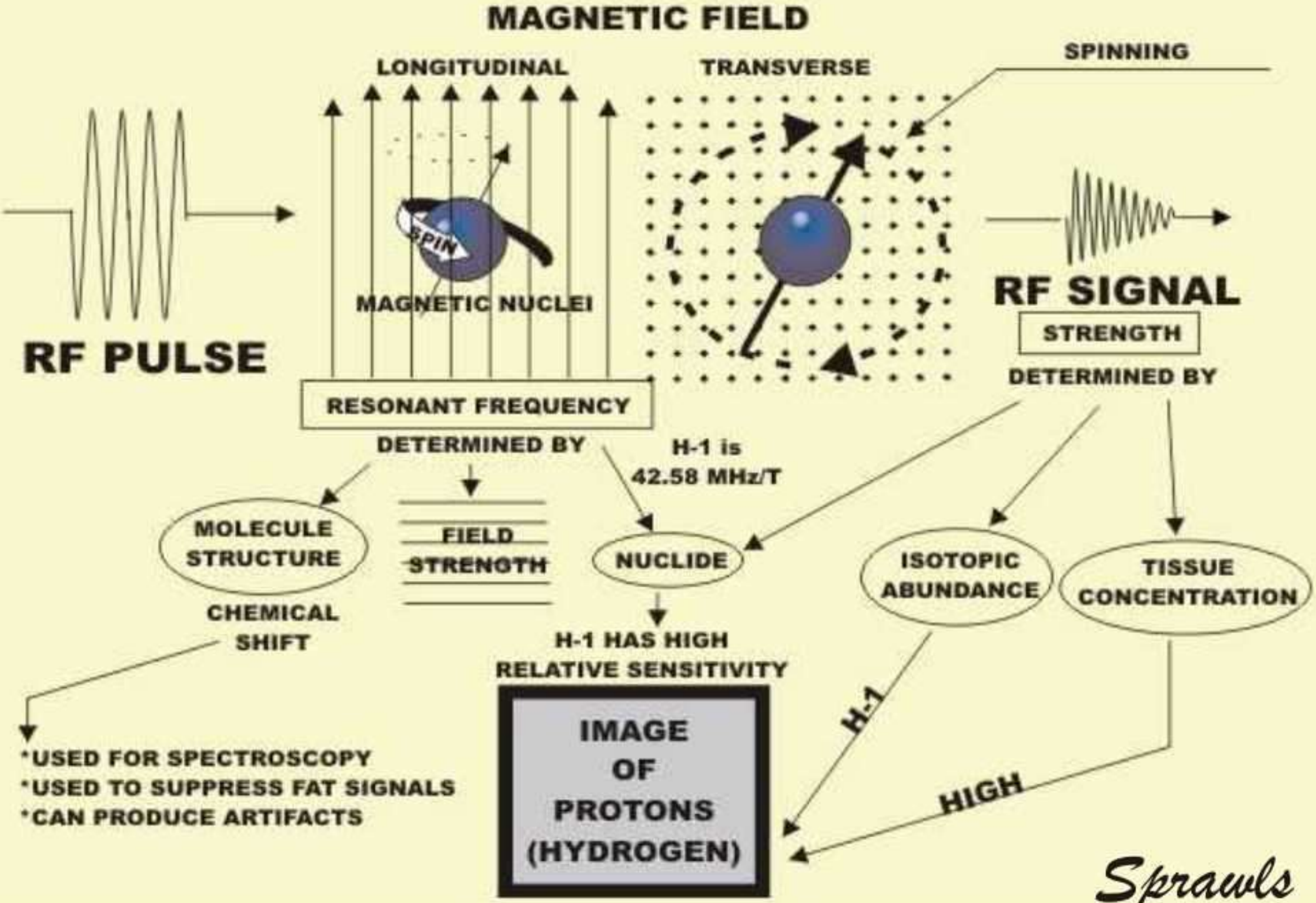
11 Spiral (helical) scanning moves the body continuously through the beam.





Forming Knowledge Structures
Physical Universe
NMR
Process
Back Integrative Cortex
Sensory
MAGNETIC FIELD
LONGITUDINAL
TRANSVERSE
SPINNING
SPIN
MAGNETIC NUCLEI
RF PULSE
RF SIGNAL
STRENGTH
DETERMINED BY
RESONANT FREQUENCY
DETERMINED BY
H-1 is
42.58 MHz/T
MOLECULE
STRUCTURE
FIELD
STRENGTH
NUCLIDE
ISOTOPIC
ABUNDANCE
TISSUE
CONCENTRATION
CHEMICAL
SHIFT
H-1 HAS HIGH
RELATIVE SENSITIVITY
*USED FOR SPECTROSCOPY
*USED TO SUPPRESS FAT SIGNALS
*CAN PRODUCE ARTIFACTS
IMAGE
OF
PROTONS
(HYDROGEN)
H-1
HIGH
Elements
and
Relationships
Visuals
Mindmaps
Sprawls

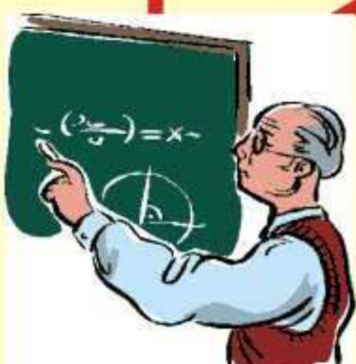
Mind Map of the NMR Process



Forming Knowledge Structures

Physical Universe

Inverse Square Effect



Back Integrative Cortex

Sensory

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:

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

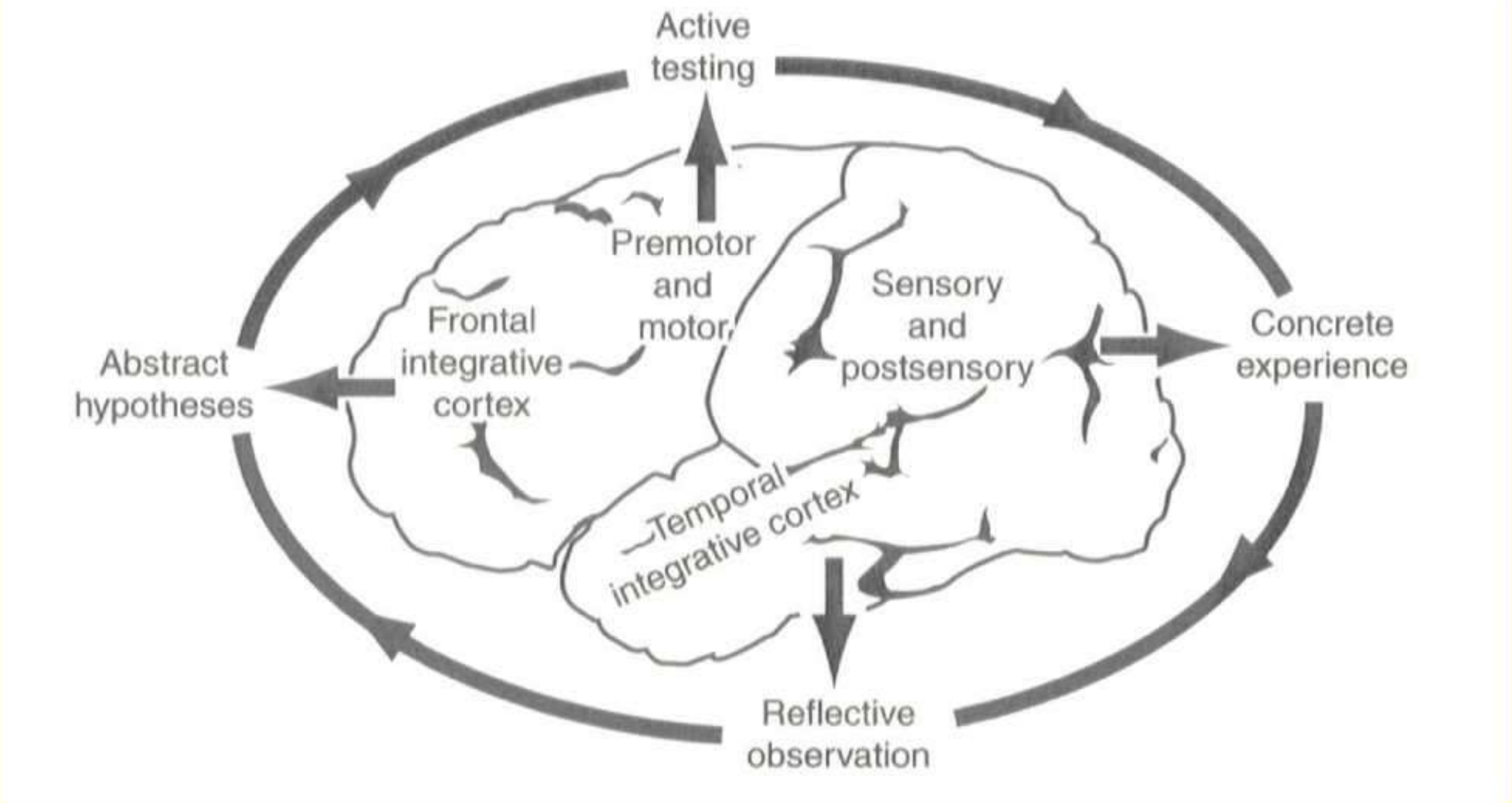
As P and pi remain constant, the luminous intensity is proportional to the inverse square of distance:

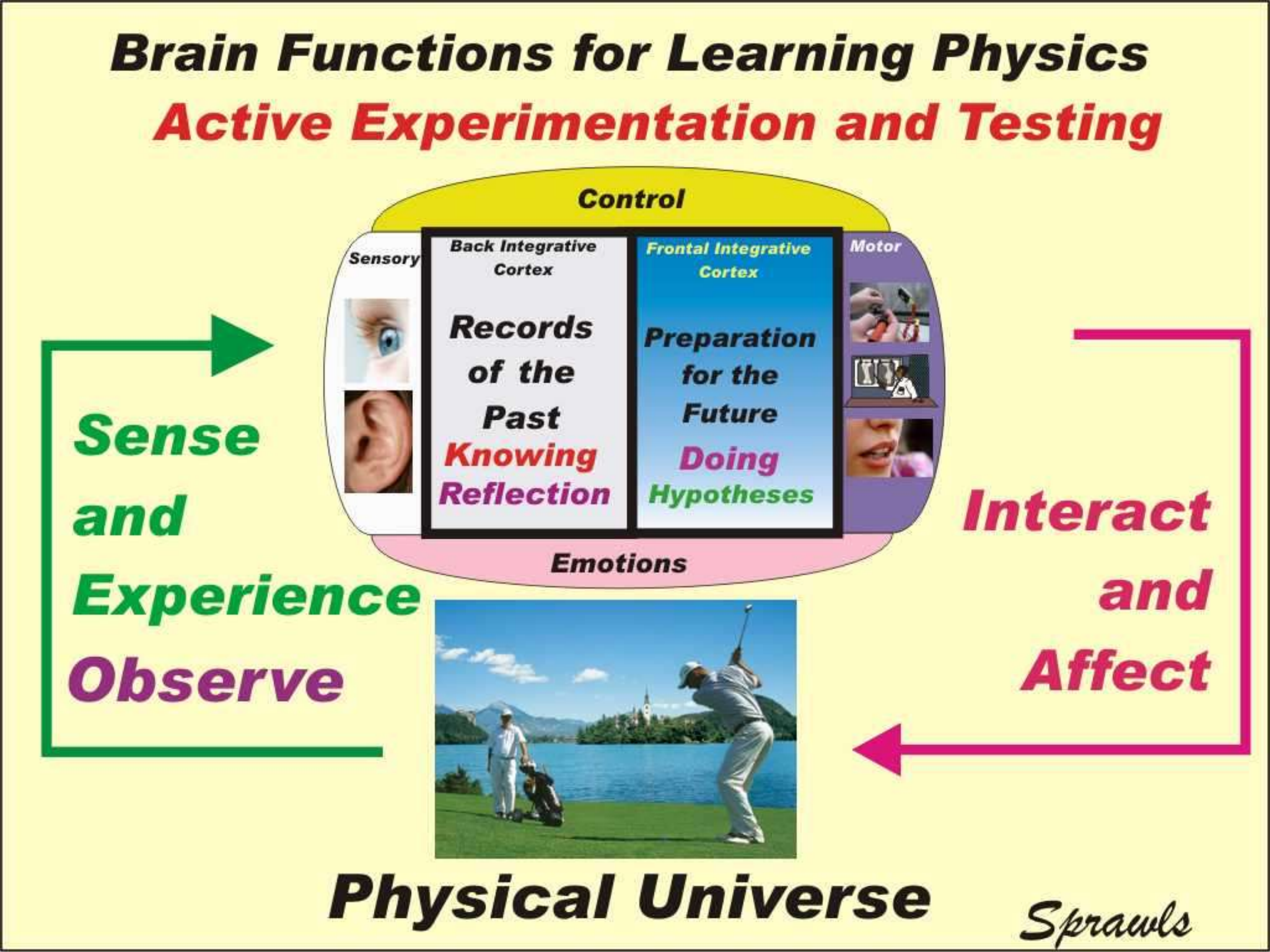
$$I \sim 1 / r^2$$

Verbal and Symbolic

Sprawls

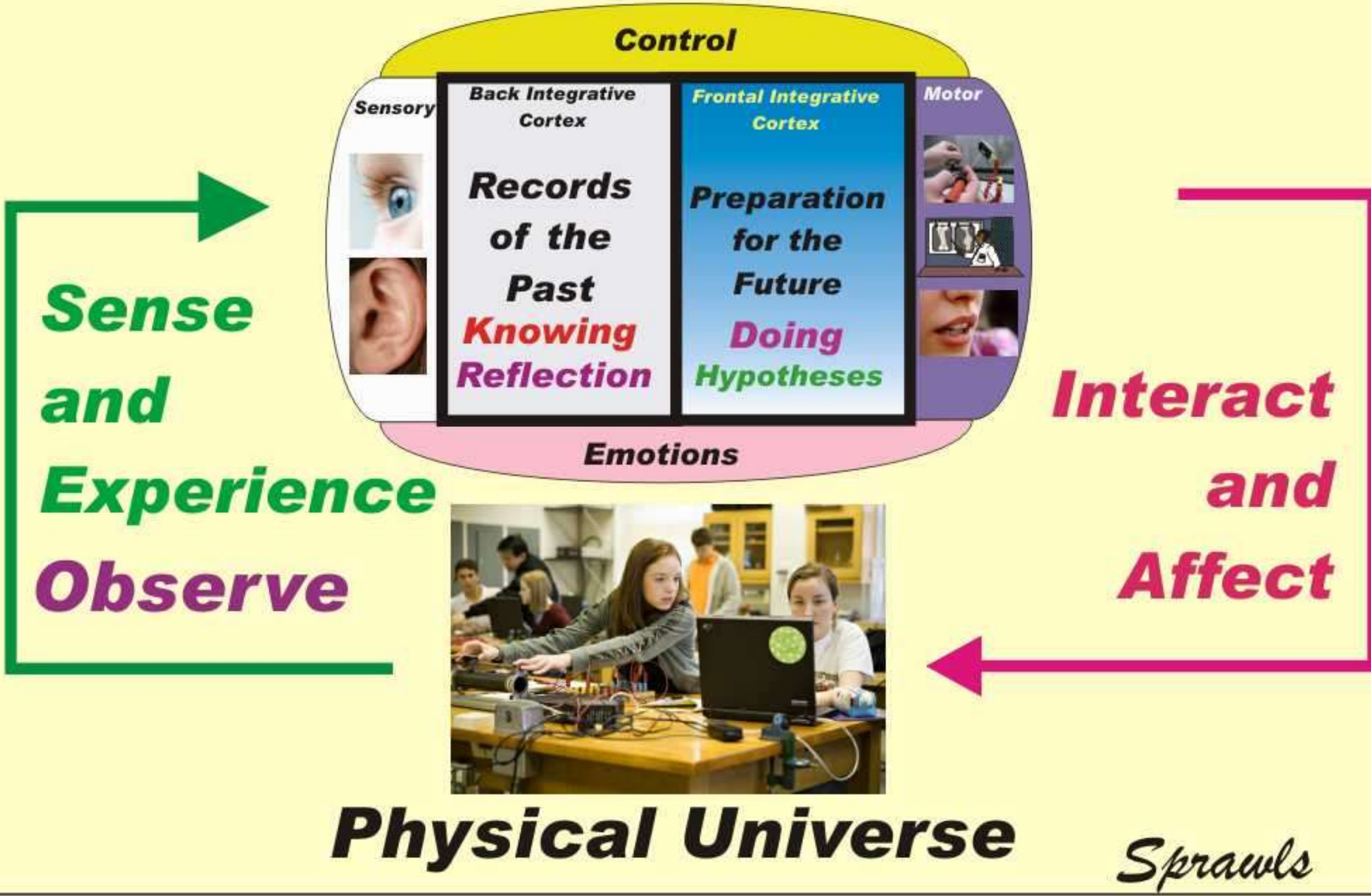
Zull's Model of Brain Function




Brain Functions for Learning Physics
Active Experimentation and Testing
Control
Sensory
Back Integrative Cortex
Records of the Past
Knowing
Reflection
Frontal Integrative Cortex
Preparation for the Future
Doing
Hypotheses
Motor
Emotions
Sense and Experience
Observe
Interact and Affect
Physical Universe
Sprawls

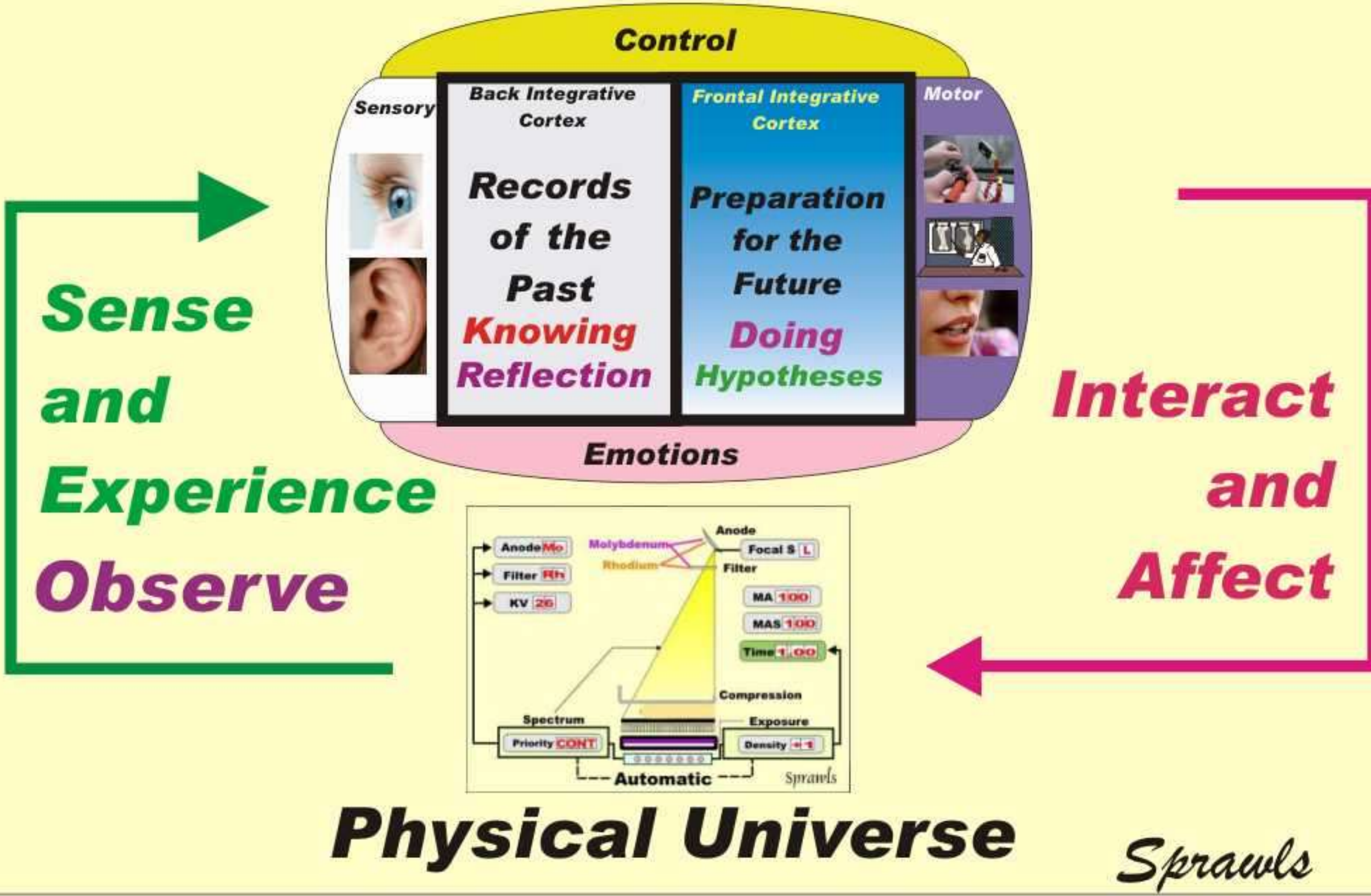
Brain Functions for Learning Physics

Active Experimentation and Testing



Brain Functions for Learning Physics

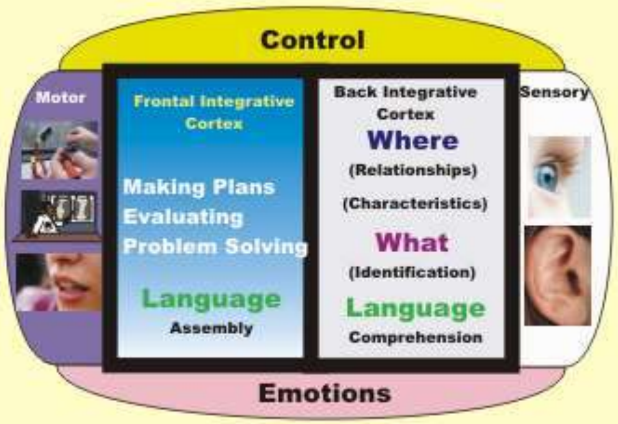
Active Experimentation and Testing



Brain Functions for Learning Physics

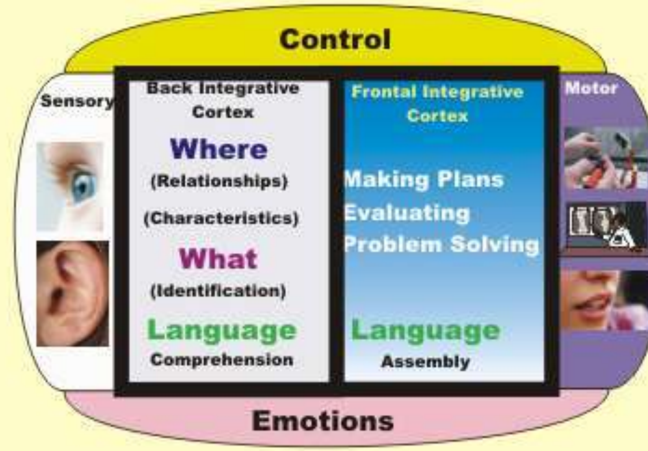
Two brains are better than one!

Collaborative Learning



Ben

?



Jerry

Problem Solving

Sprawls

Brain Functions for Learning Physics

Two brains are better than one!

Collaborative Learning

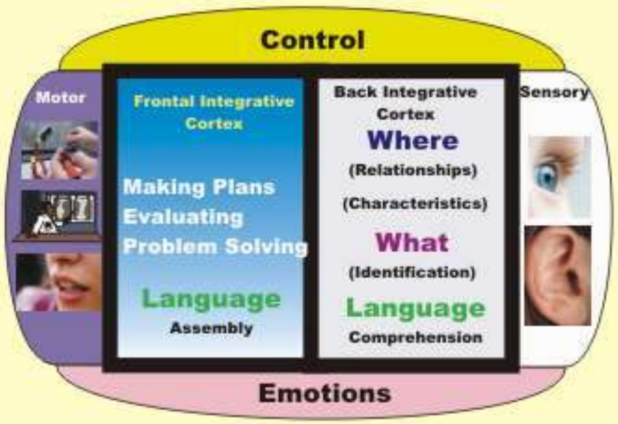
Problem Solving

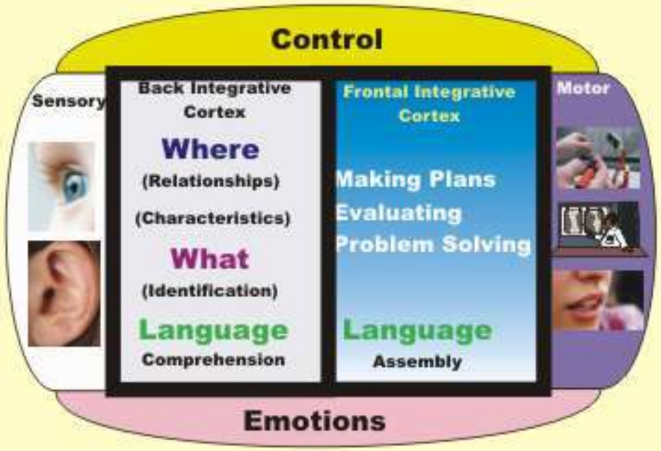
Sprawls

Brain Functions for Learning Physics

Two brains are better than one!

Collaborative Learning





Views
Perspectives
Experiences

Views
Perspectives
Experiences

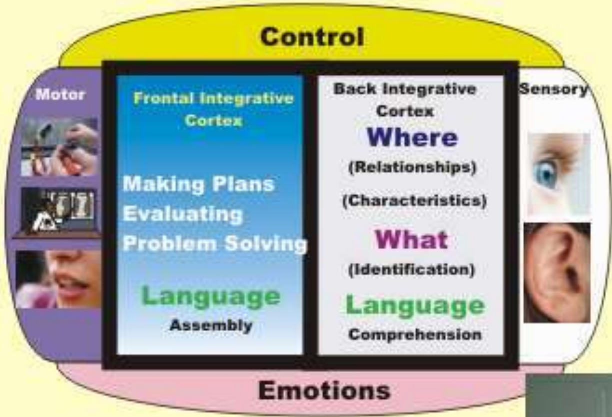
Problem Solved!

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

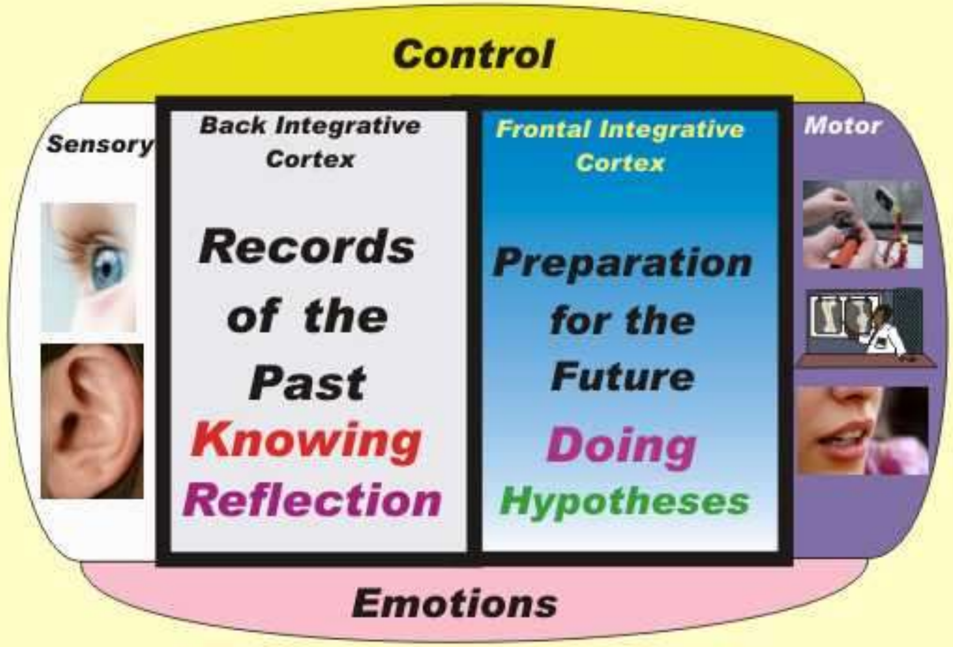
Two brains are better than one!

Collaborative Learning

Problem Solving
Analysis and Evaluation
Developing Plans

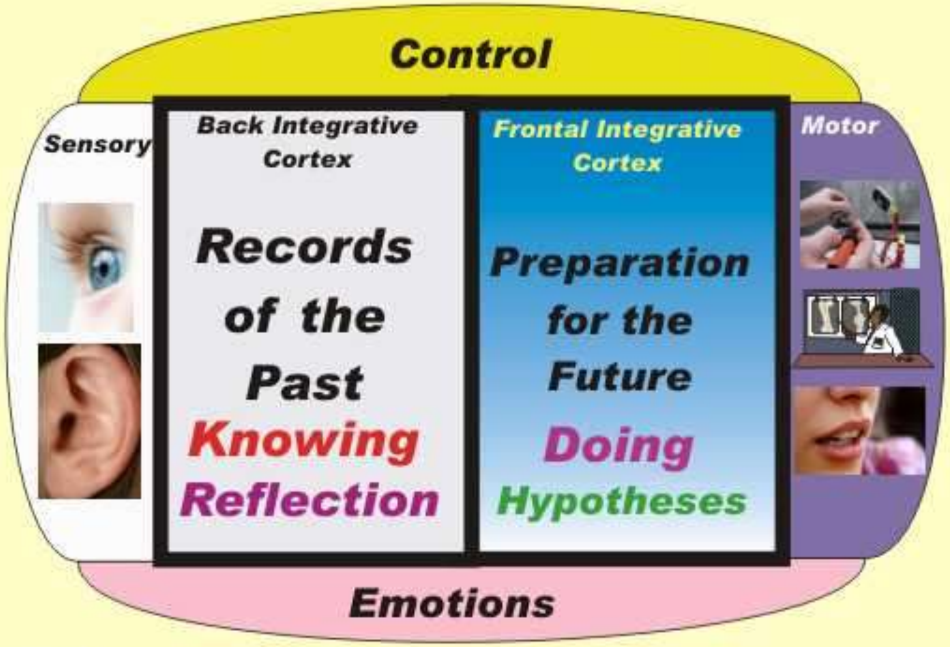
Sprawls

The Learning Environment



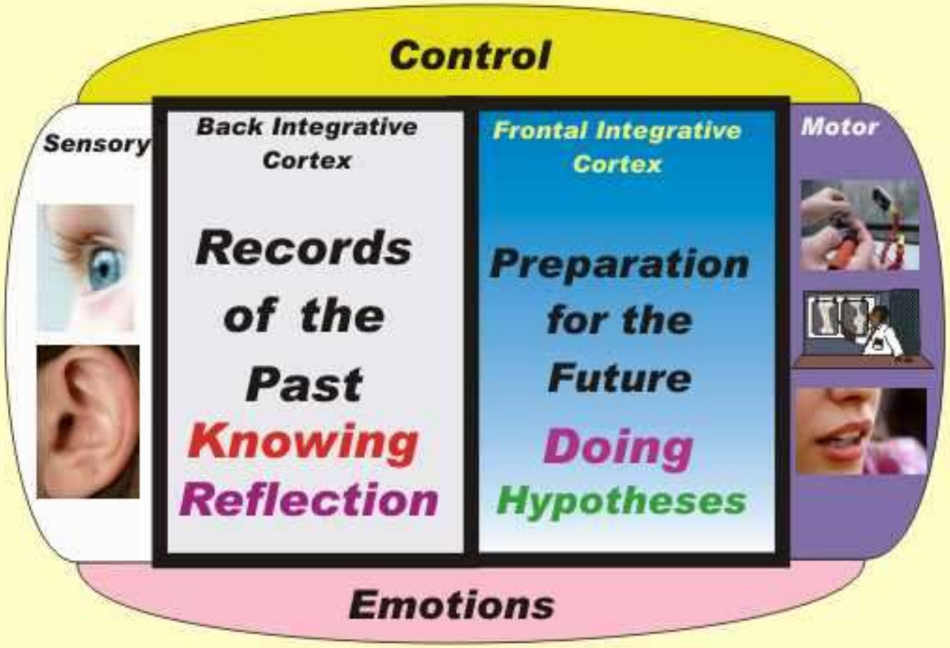
Sprawls

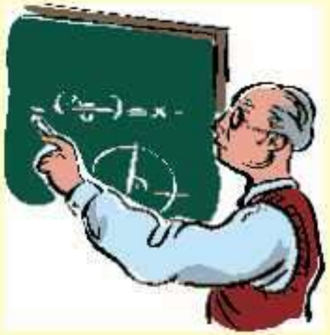
Rich Learning Environments



Sprawls

Challenging Learning Environments





Sprawls

Effective Learning

Rich Learning Environment

New and Different

Integrate into Existing Knowledge

——— Reflection ———>

Sprawls

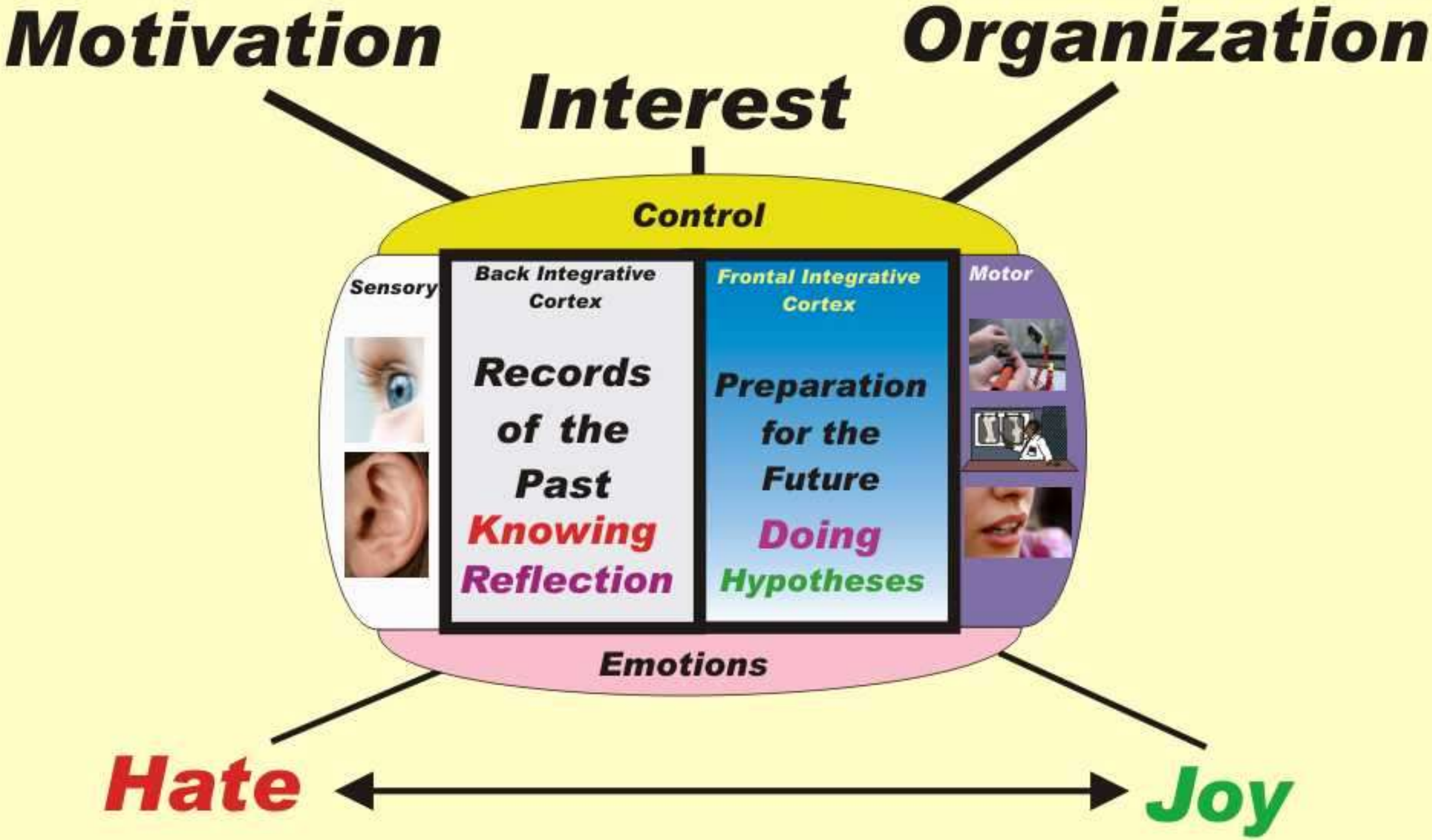
Effective Learning

Interact Review Reflect

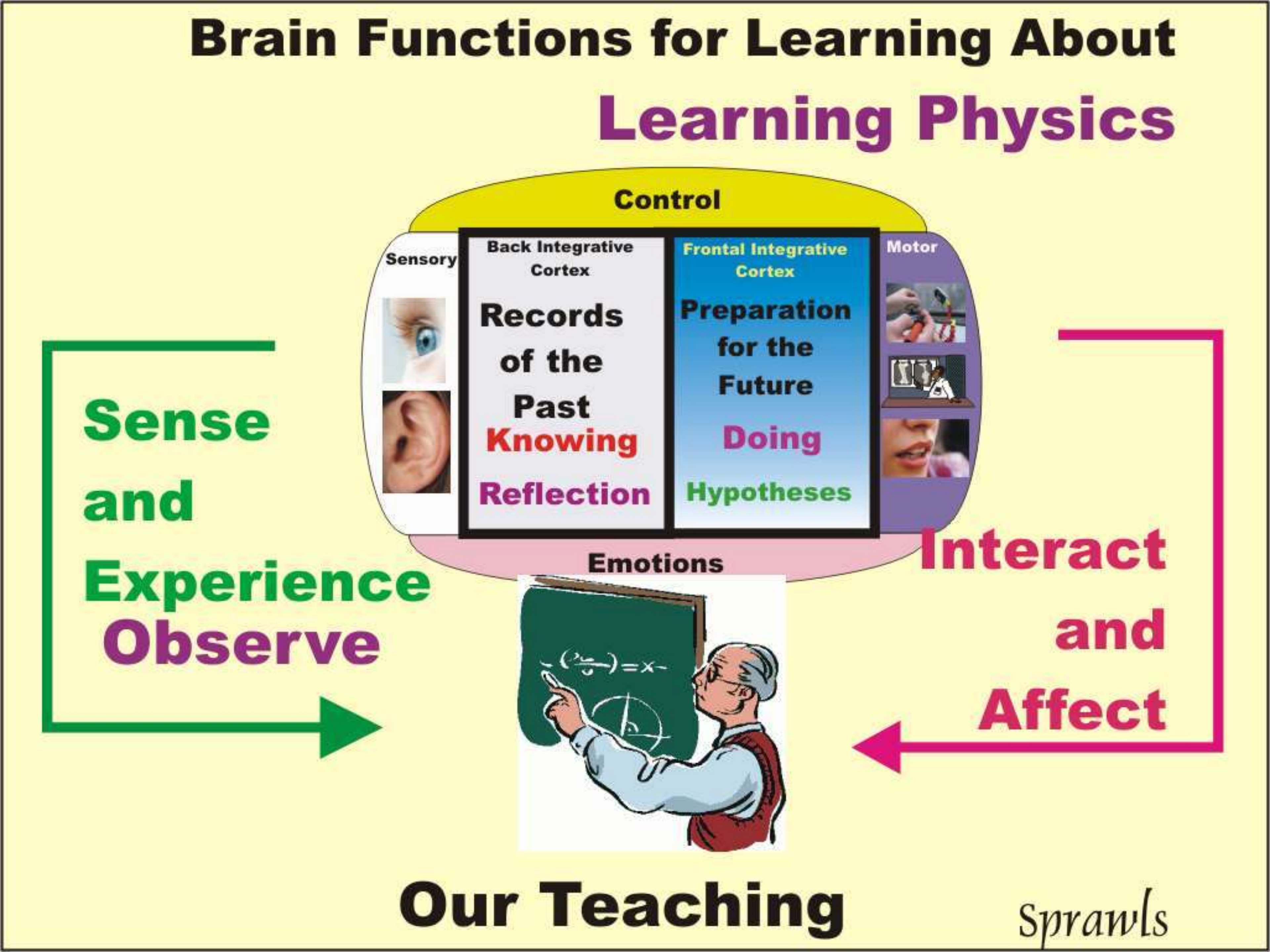
Developing useful knowledge for the future

Sprawls

Brain Functions for Learning Physics



Sprawls


Brain Functions for Learning About
Learning Physics
Control
Sensory
Back Integrative Cortex
Records of the Past
Knowing
Reflection
Frontal Integrative Cortex
Preparation for the Future
Doing
Hypotheses
Motor
Emotions
Sense and Experience
Observe
Interact and Affect
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

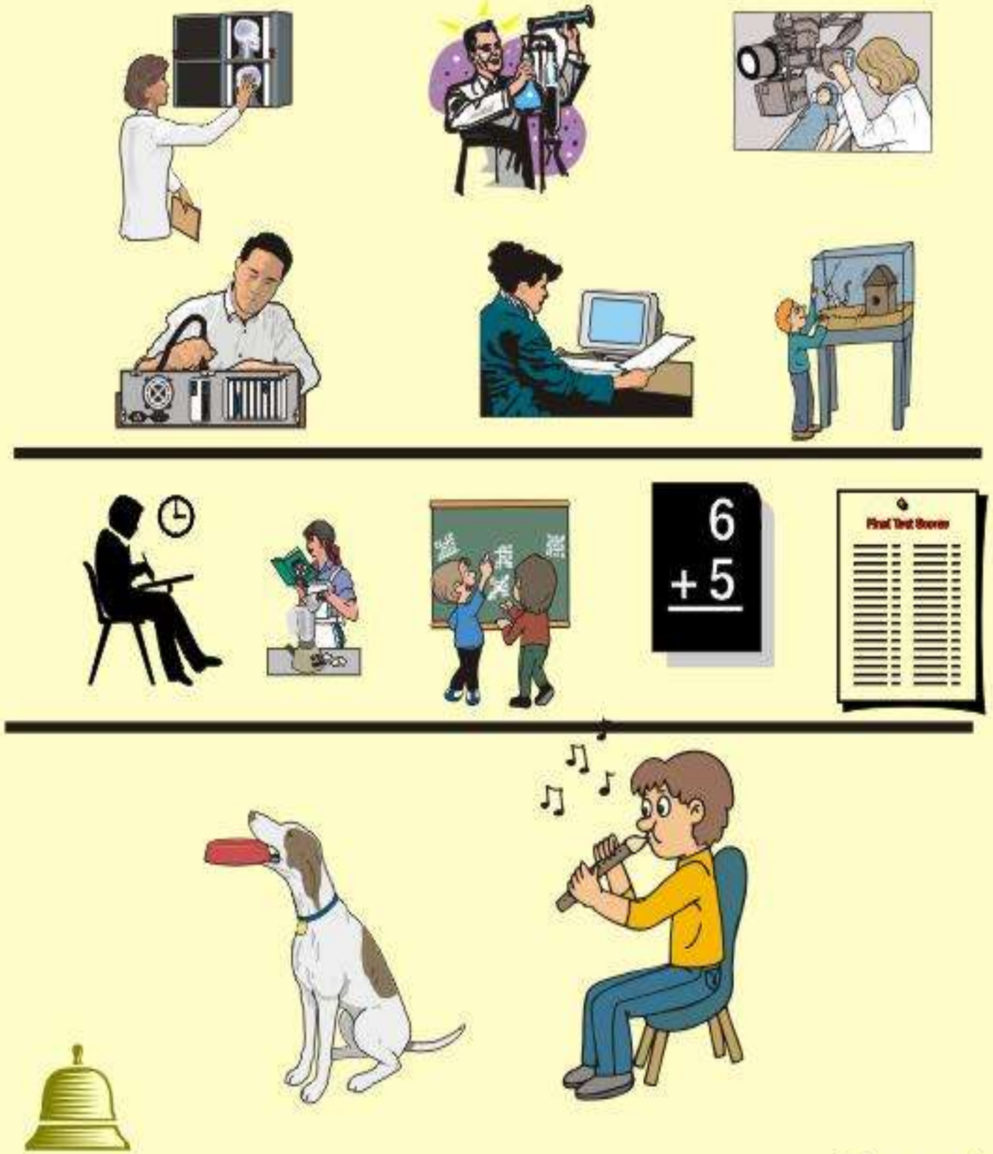
Gagné was also well-known for his sophisticated stimulus-response theory of eight kinds of learning which differ in the quality and quantity of stimulus-response bonds involved. From the simplest to the most complex, these are:

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

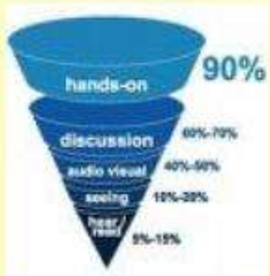


Sprawls

Edgar Dale (1900-1985)

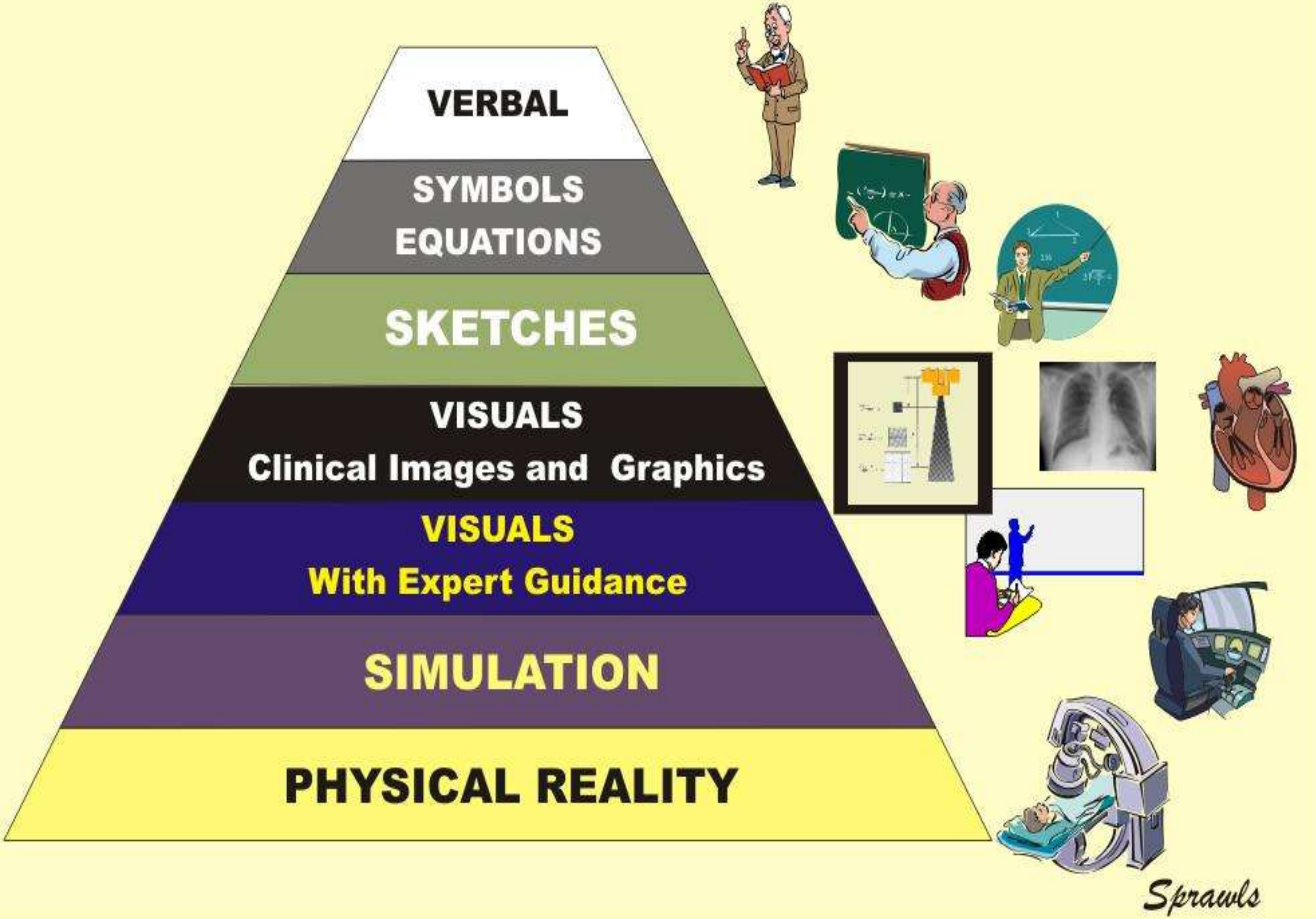
Educationalist who developed the famous

Cone of Experience theory

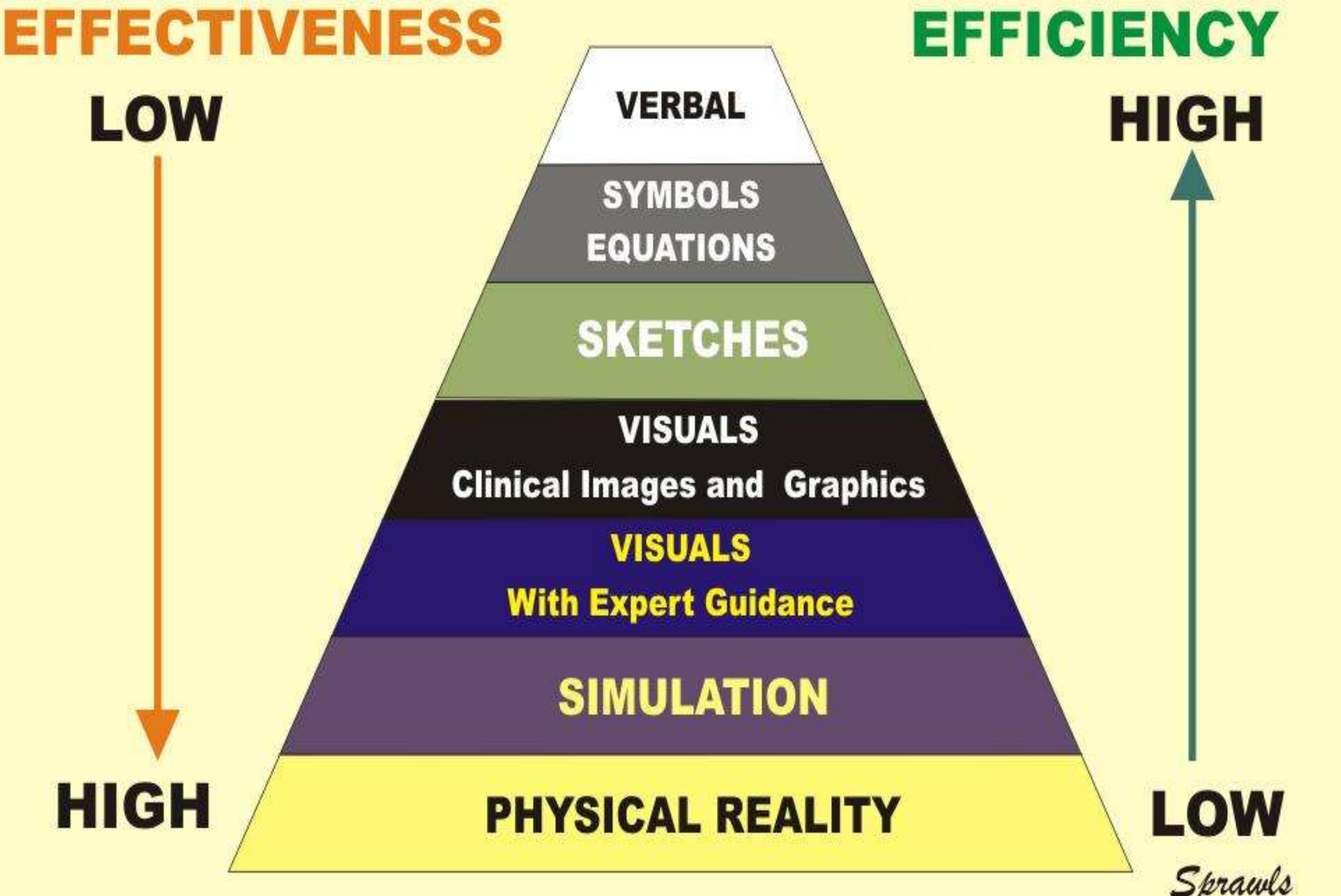


Sprawls

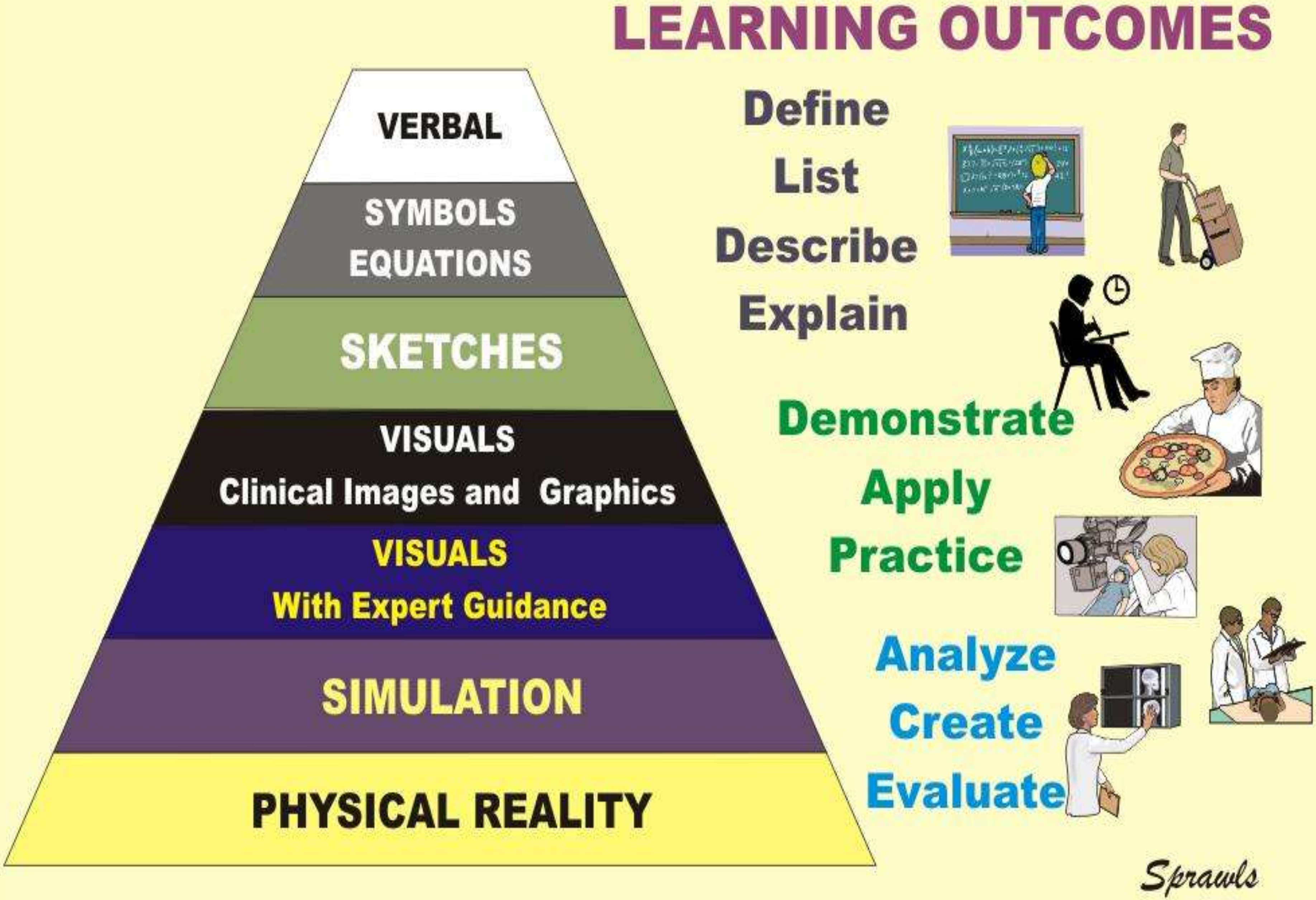
Cone of Experience for Medical Imaging Education

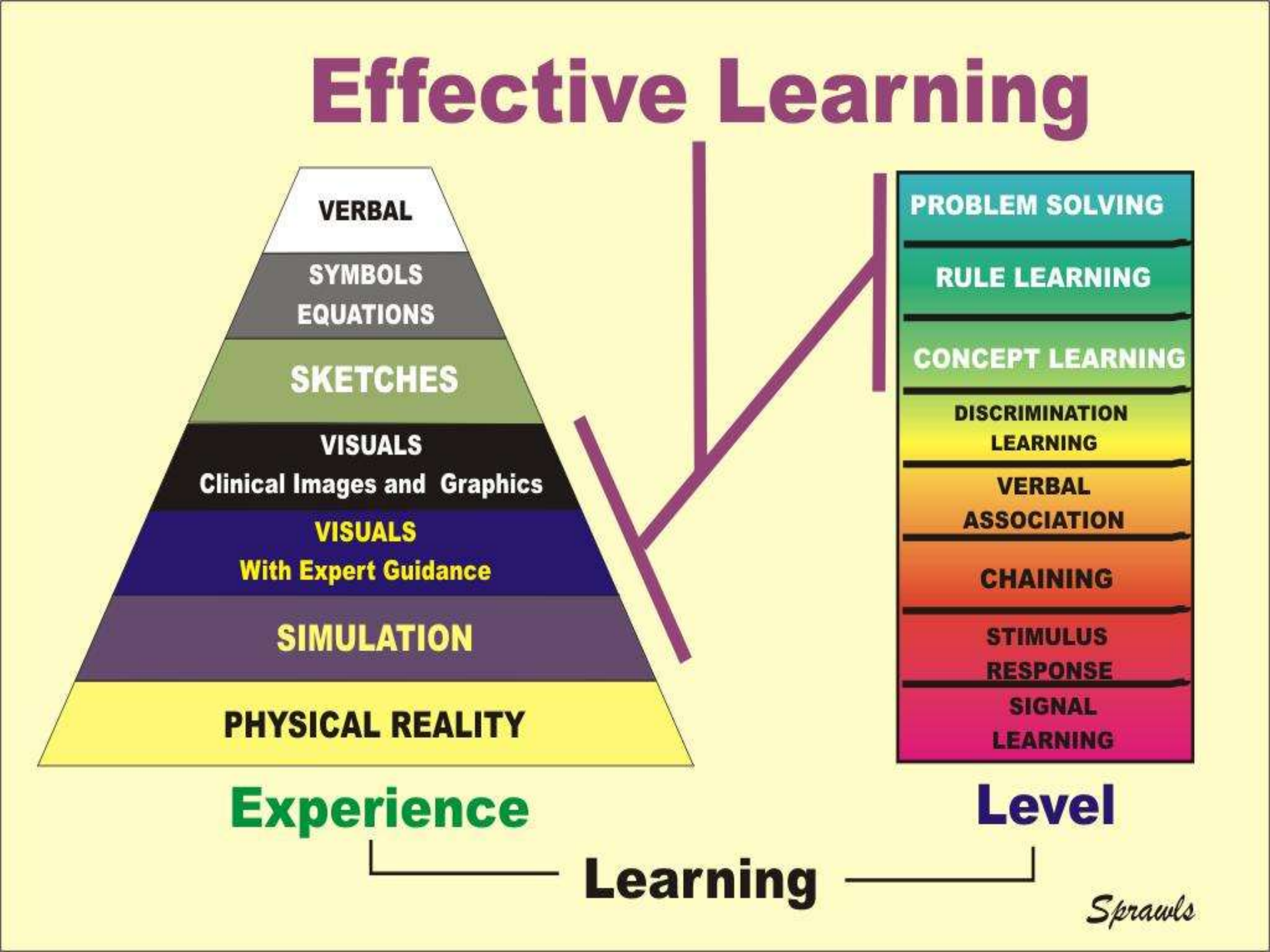


Cone of Experience for Medical Imaging Education



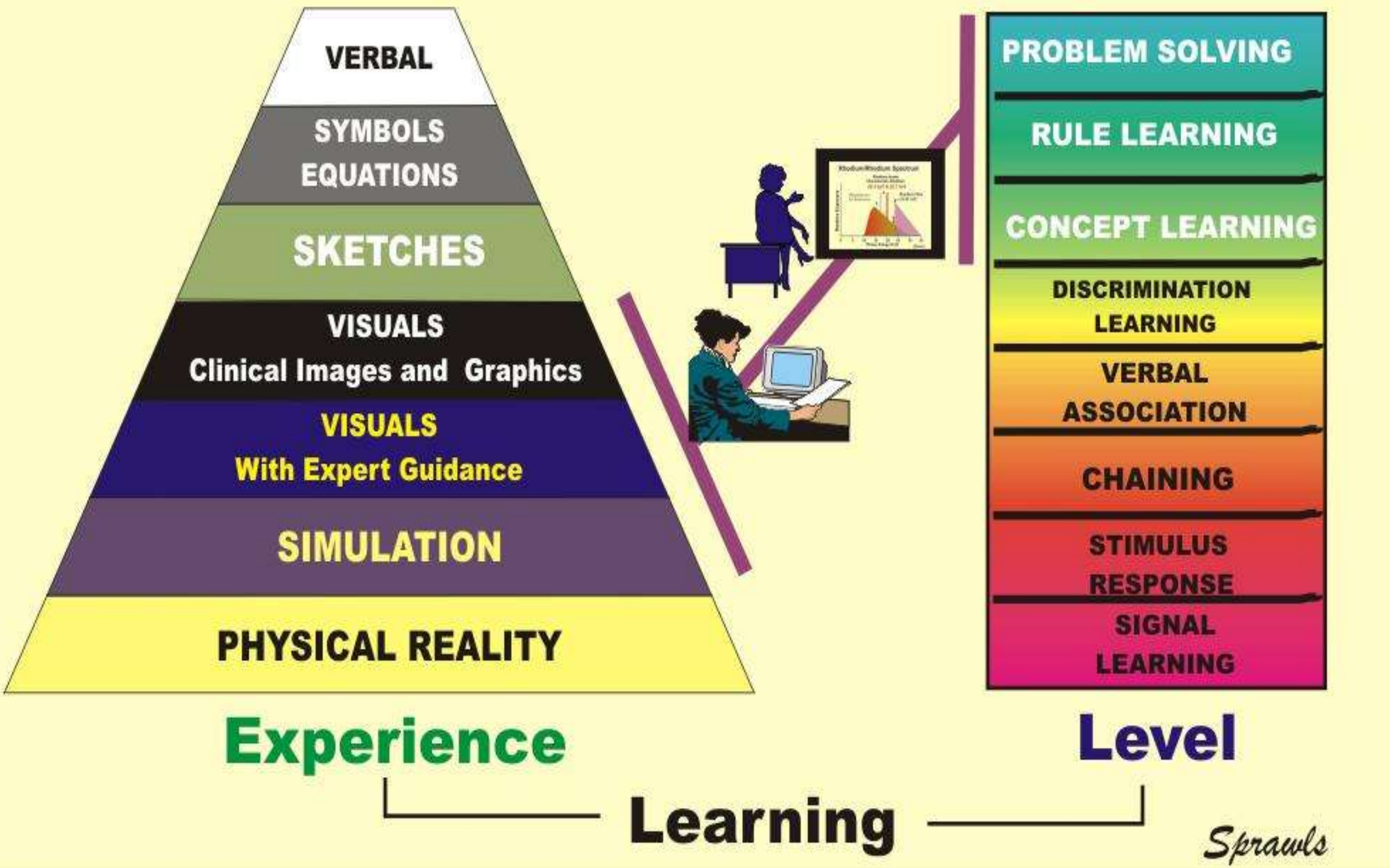
Cone of Experience for Medical Imaging Education





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

Physics Education

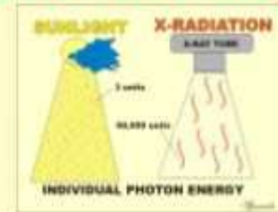
General Basics

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

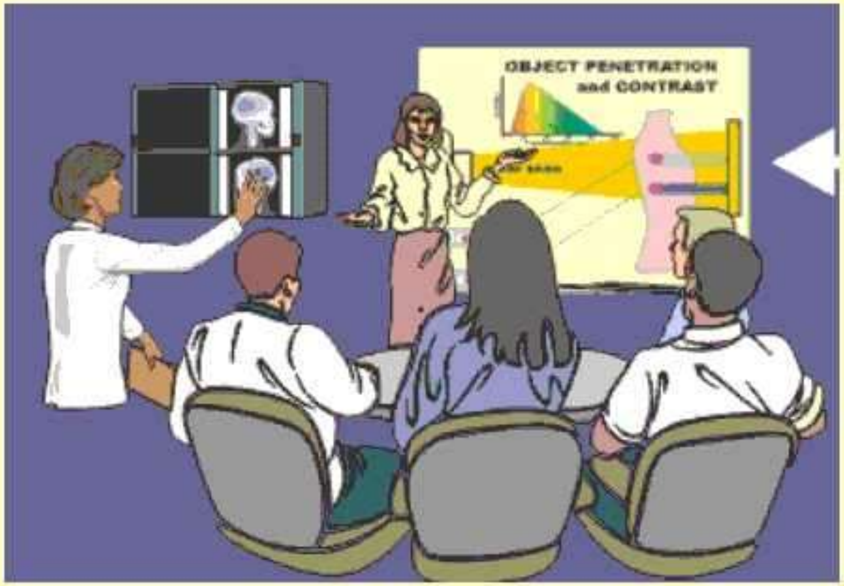
Radiation Safety

Biological Effects
Personnel Protection
Patient Dose Management

Sprawls

Rich Classroom and Conference Learning Activities

Learning Facilitator "Teacher"

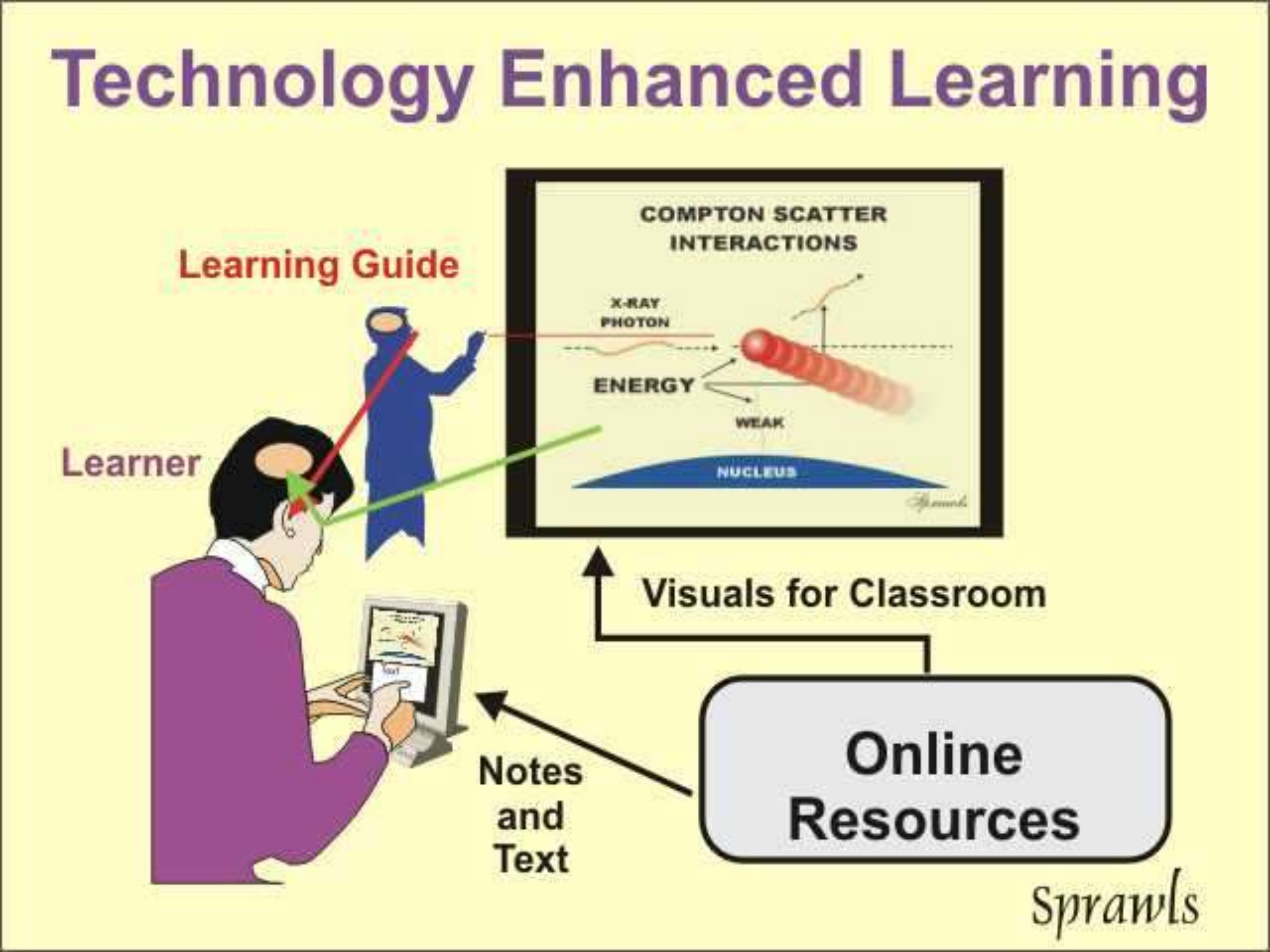


Visuals

Representations of Reality

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

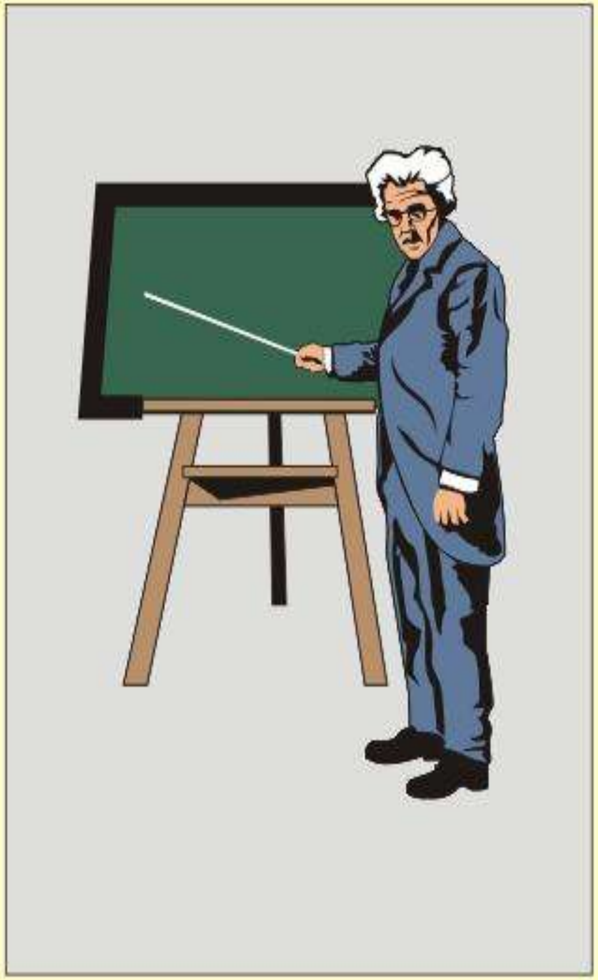
Sprawls



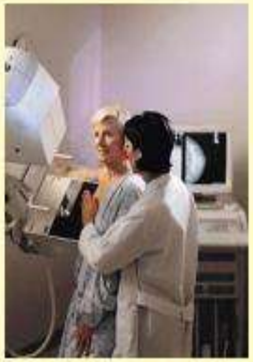
Technology Enhanced Learning
COMPTON SCATTER INTERACTIONS
Learning Guide
X-RAY PHOTON
ENERGY
WEAK
Learner
NUCLEUS
Visuals for Classroom
Notes and Text
Online Resources
Sprawls

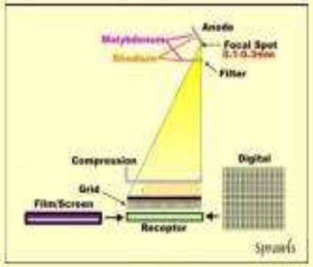
WINDOW or BARRIER

THE LEARNERS

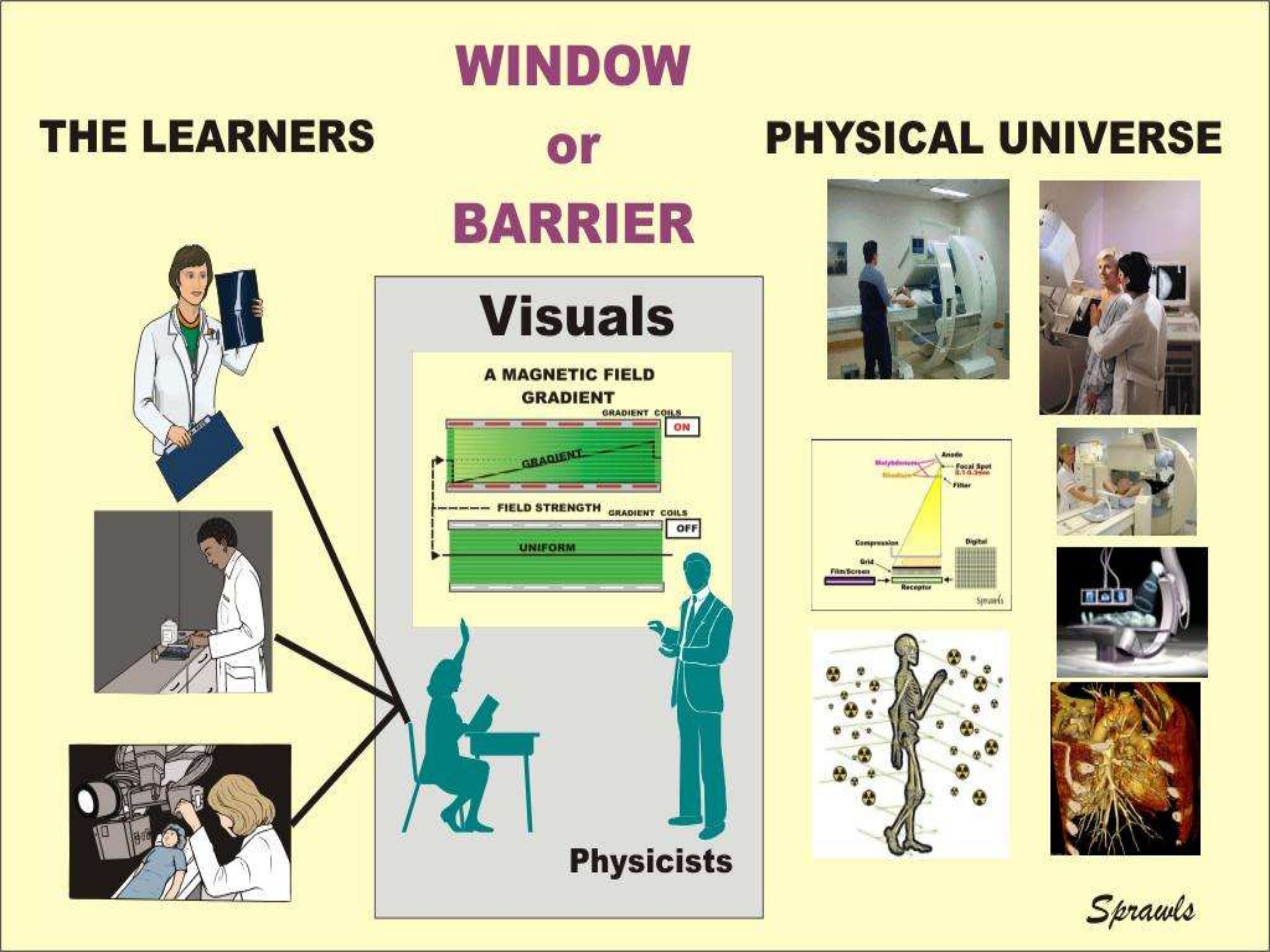


PHYSICAL UNIVERSE



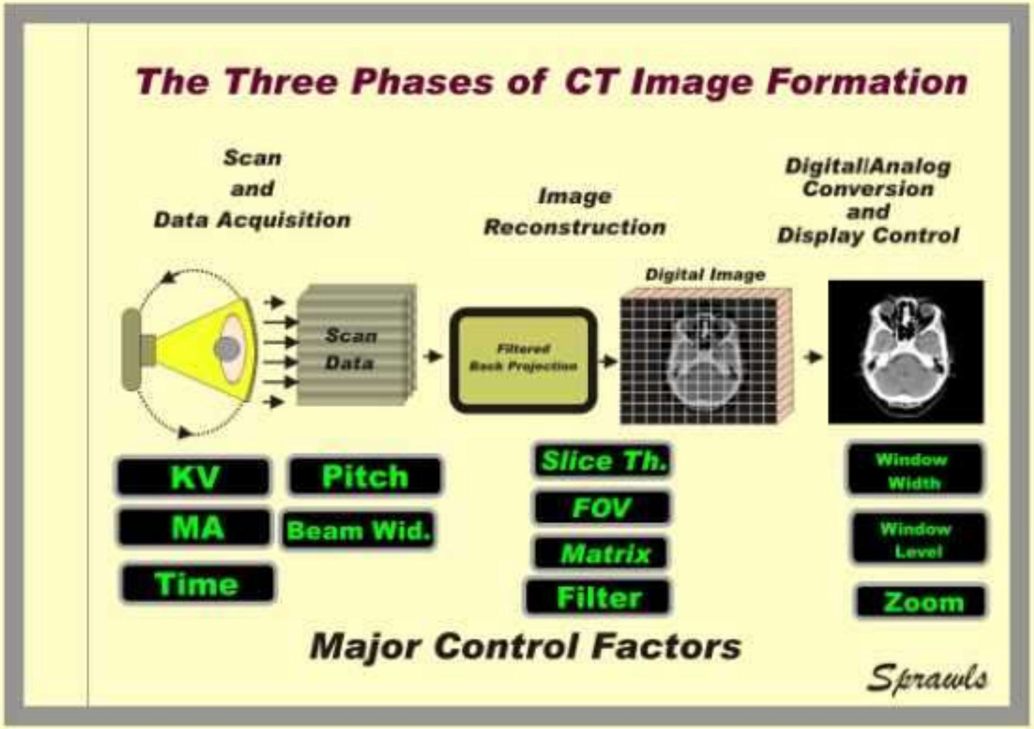


Sprawls


WINDOW
or
BARRIER
THE LEARNERS
PHYSICAL UNIVERSE
Visuals
A MAGNETIC FIELD
GRADIENT
GRADIENT COILS
ON
GRADIENT
FIELD STRENGTH
GRADIENT COILS
OFF
UNIFORM
Anode
Filter
Compression
Digital
Grid
Film/Screen
Receptor
Physicists
Sprawls

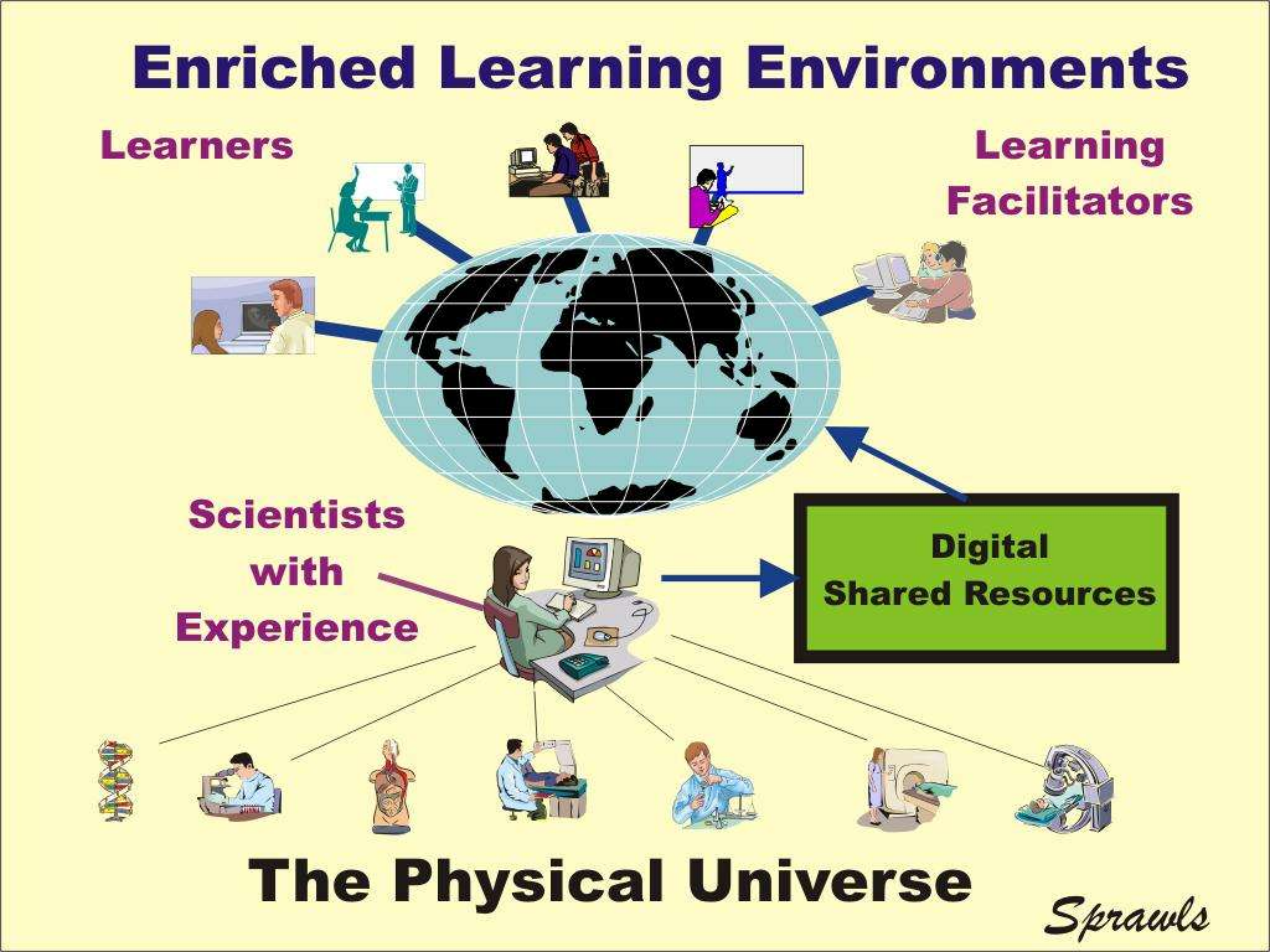
Visuals
for
Learning and Teaching

The Imaging Process

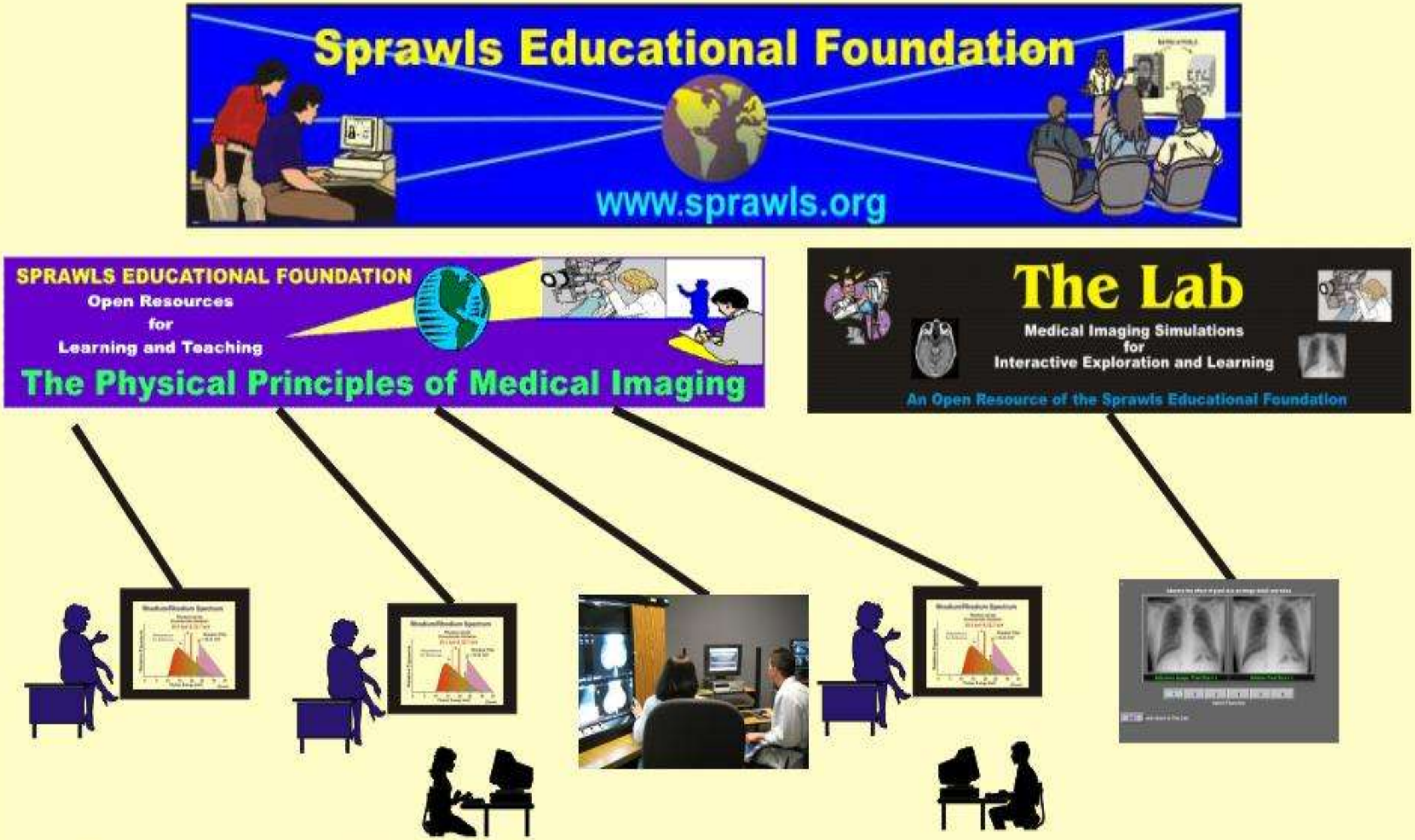


Clinical Images

Sprawls



Enriched Learning Environments
Learners
Learning
Facilitators
Scientists
with
Experience
Digital
Shared Resources
The Physical Universe
Sprawls



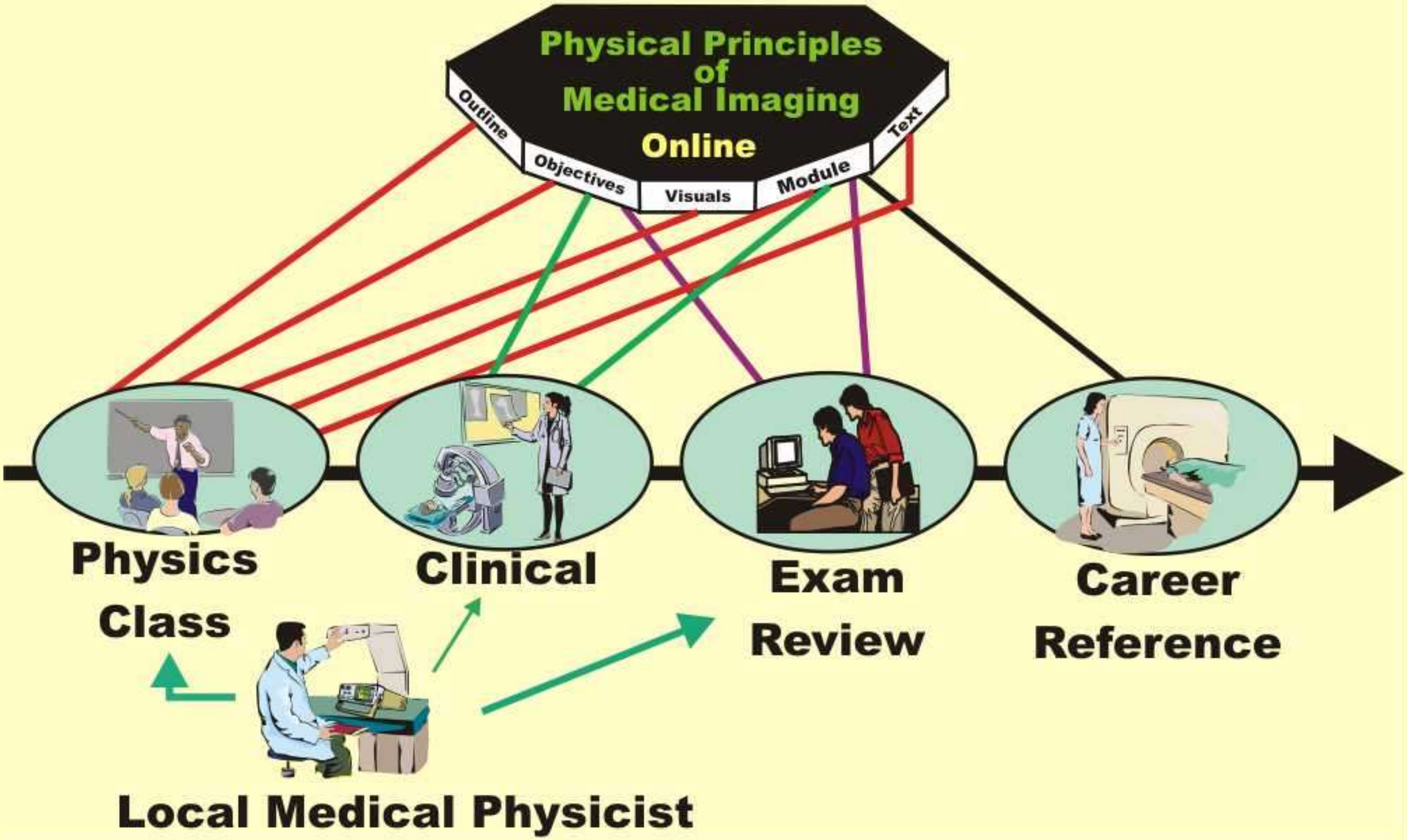
In Partnership with Other Medical Physics Teachers

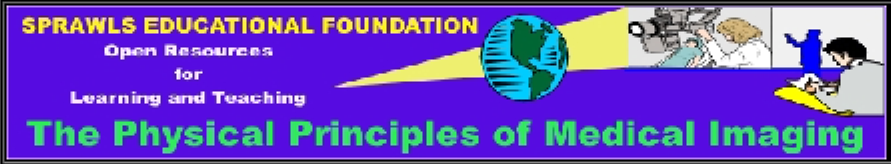
to be More Effective and Efficient in Providing

Medical Imaging Education

Medical Physics Education

Integrated Learning





Mammography Physics and Technology

for effective clinical imaging

Perry Sprawls, Ph.D.

To step through module, CLICK HERE.

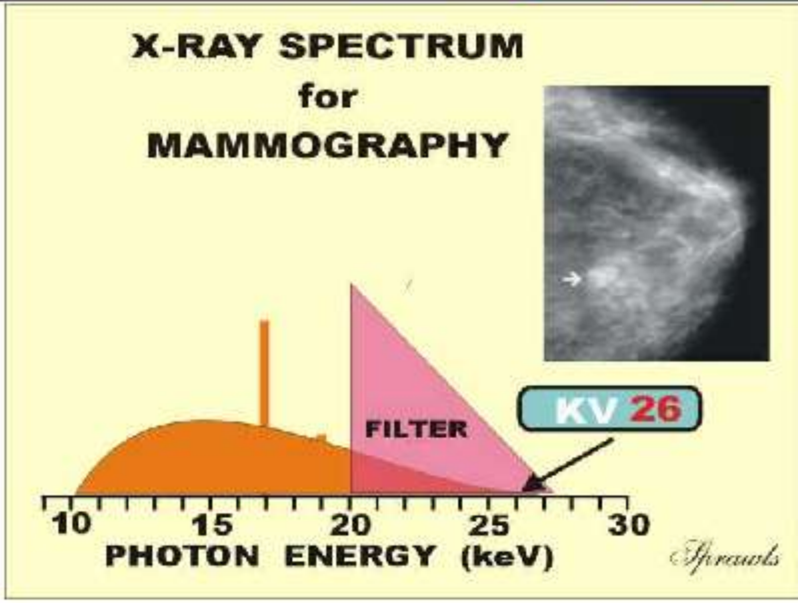
To go to a specific topic click on it below

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.

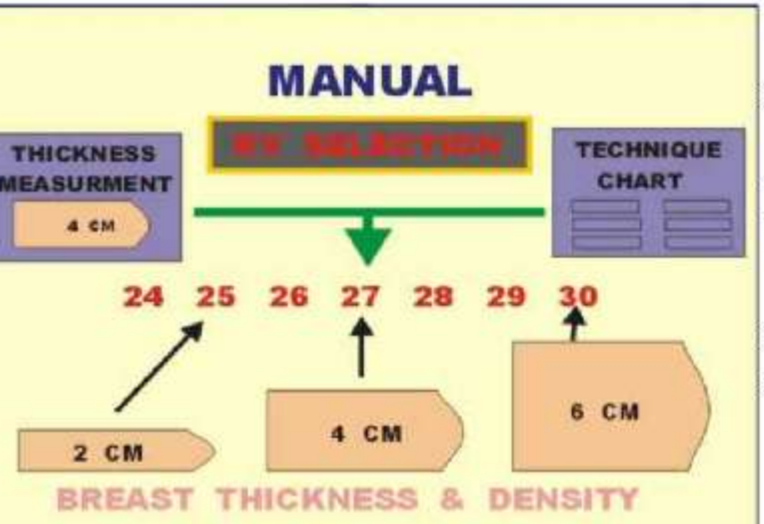
e can think of it as a three-step procedure:

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.

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.

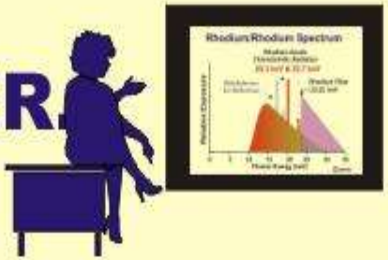


Mammography systems have indicators that display the thickness of the compressed breast. This along with a general assessment of breast density is used to manually select an optimum KV either from experience or an established technique chart.

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

Clinically Focused Physics Education





Website

http://www.sprawls.org/clinphys