Effective

Medical Physics Educational Activities

Models and Methods

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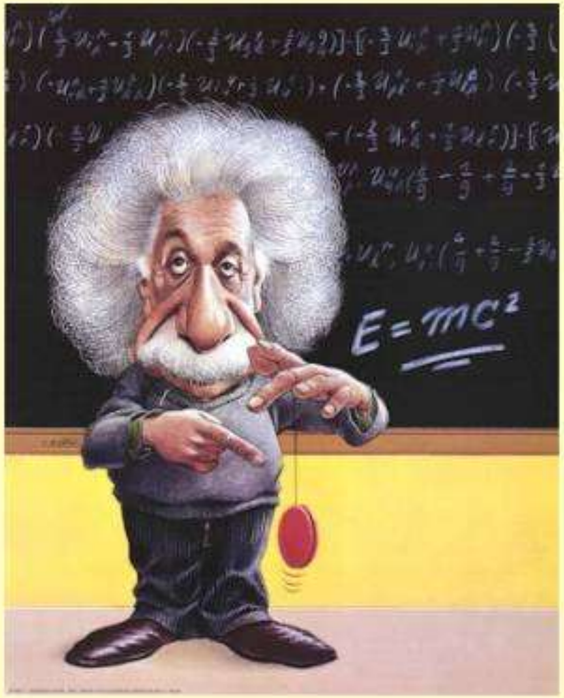
Sprawls Educational Foundation
www.sprawls.org

View this presentation at
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

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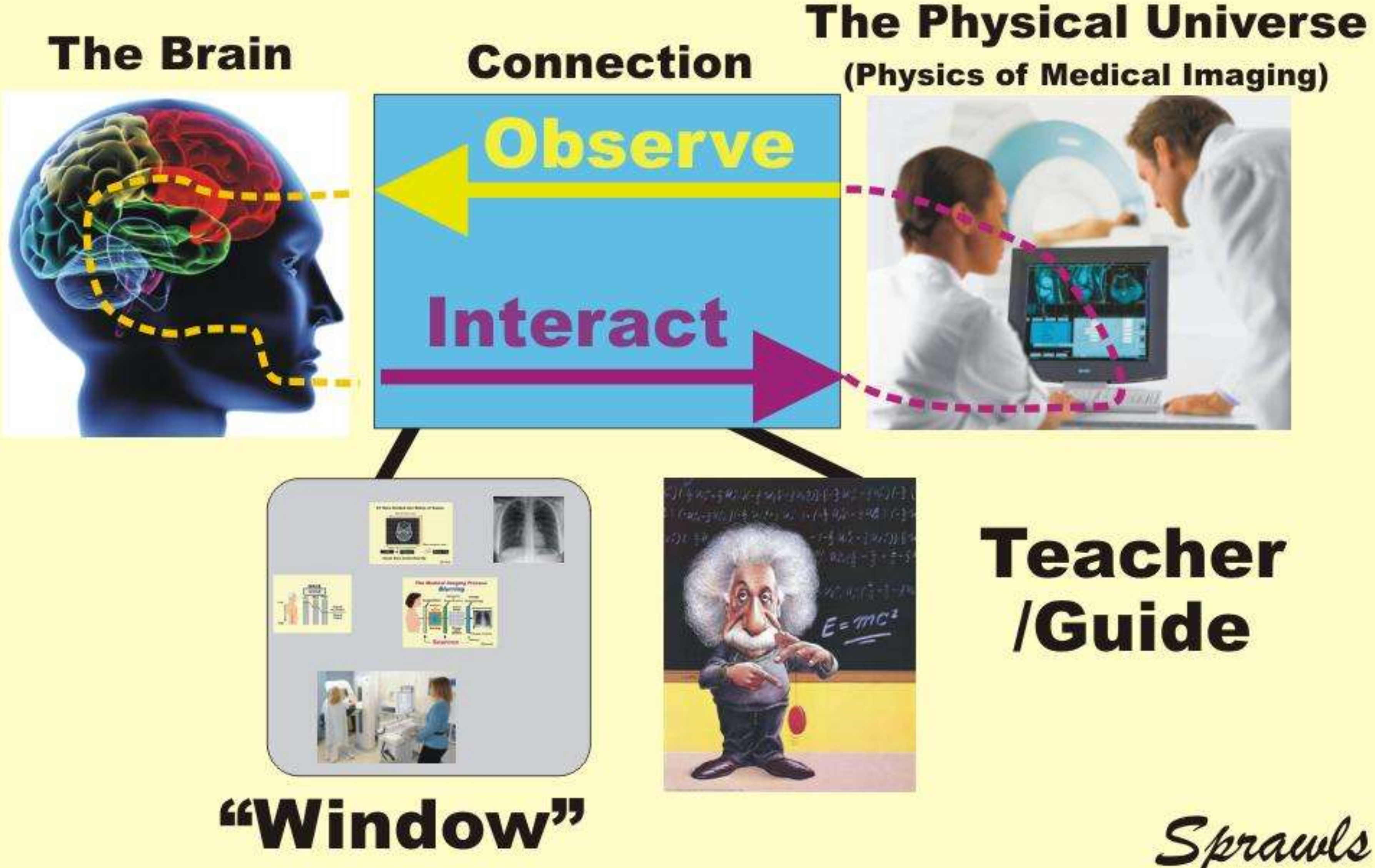
The Elements of A Highly Effective Educational Session



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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January 23, 1896

The Spectrum of Learning Activities

For

Medical Physics

Effectiveness

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The Spectrum of Learning Activities

For

Medical Physics

Verbal ⟷ **Visual**

Effectiveness

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The Spectrum of Learning Activities

For

Medical Physics

Passive ⟷ Interactive

Verbal ⟷ Visual

Effectiveness

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The Spectrum of Learning Activities

For

Medical Physics

Easy ⟷ Effort

Passive ⟷ Interactive

Verbal ⟷ Visual

Effectiveness

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The Spectrum of Learning Activities

For

Medical Physics

$	⟷	$$$$
Easy	⟷	Effort
Passive	⟷	Interactive
Verbal	⟷	Visual

Effectiveness

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The Spectrum of Learning Activities

For

Medical Physics

Tradition ⟷ Ionnivation

$ ⟷ $$$$

Easy ⟷ Effort

Passive ⟷ Interactive

Verbal ⟷ Visual

Effectiveness

Sprawls

The Spectrum of Learning Activities

For

Medical Physics

Tradition ⟷ **Ionnivation**

$** ⟷ **$$$$

Easy ⟷ **Effort**

Passive ⟷ **Interactive**

Verbal ⟷ **Visual**

Effectiveness

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The Spectrum of Learning Activities

For

Medical Physics

Where do you fit in?

Effectiveness

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The Spectrum of Learning Activities

For

Medical Physics










Effectiveness

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Large Classroom
Effective or Efficient ?

Large Classroom
Effective or Efficient ?

Effective Medical Physics Education
is like a
Giant Puzzle

What do you bring to the table?

What do I bring to the table?

~~A Lecture~~

~~To Talk To You~~

~~Tell You What I Know~~

Share Experience
and
Some Resources

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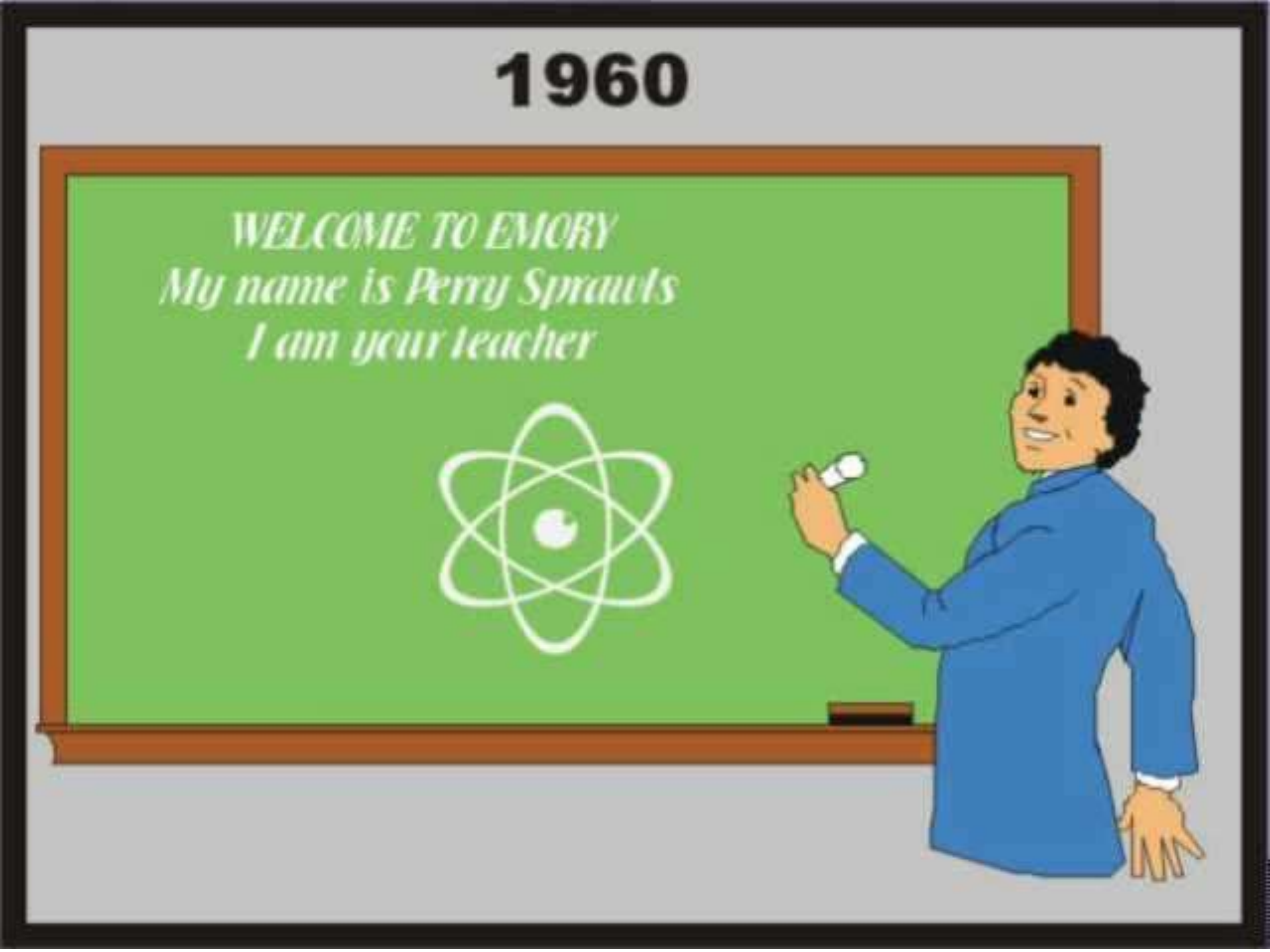
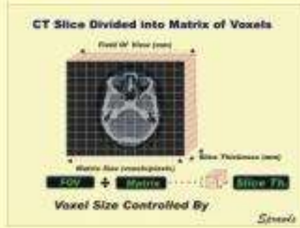

1960
WELCOME TO EMORY
My name is Perry Sprawls
I am your teacher

The Traditional Classroom

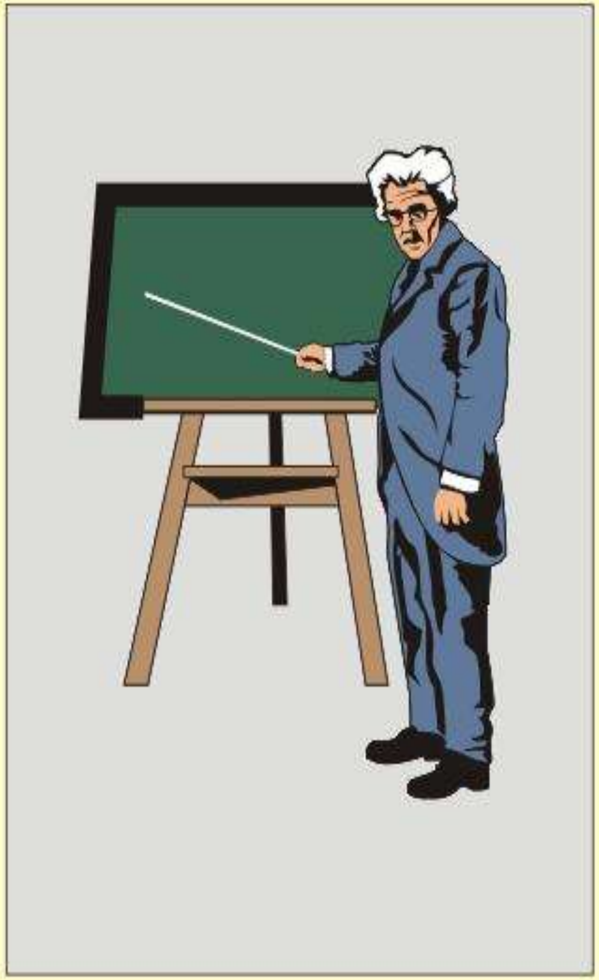
" A Box for Enclosing Students..."



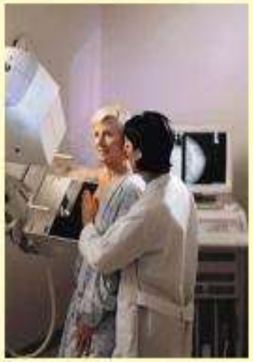
And hiding them from the world about which they should learning.

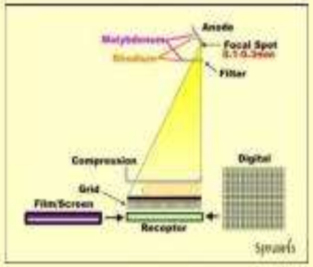
WINDOW
or
BARRIER

THE LEARNERS



PHYSICAL UNIVERSE



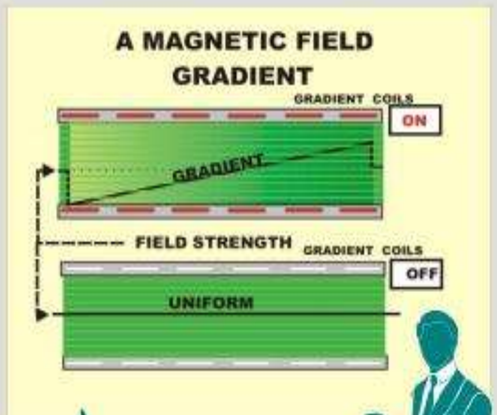


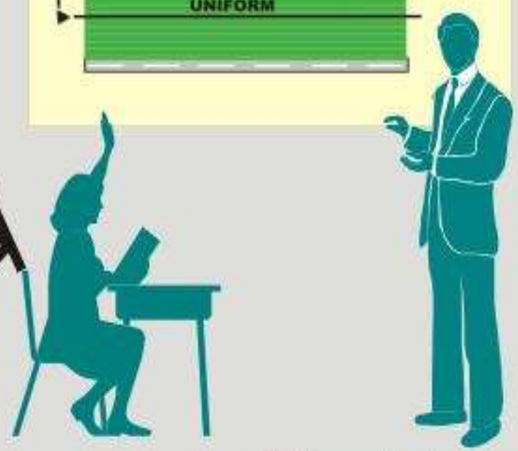
Sprawls

WINDOW
or
BARRIER

THE LEARNERS

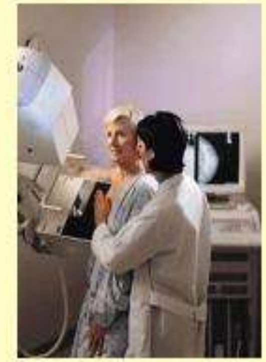
Visuals

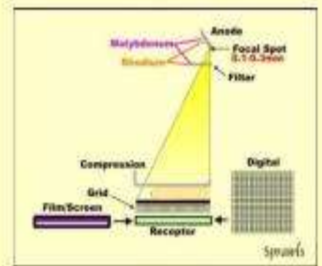


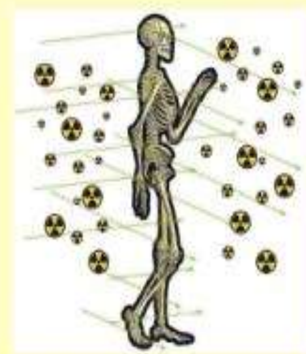


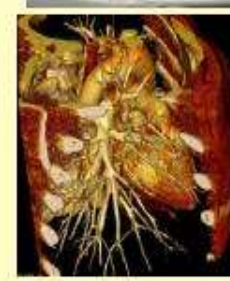
Physicists

PHYSICAL UNIVERSE









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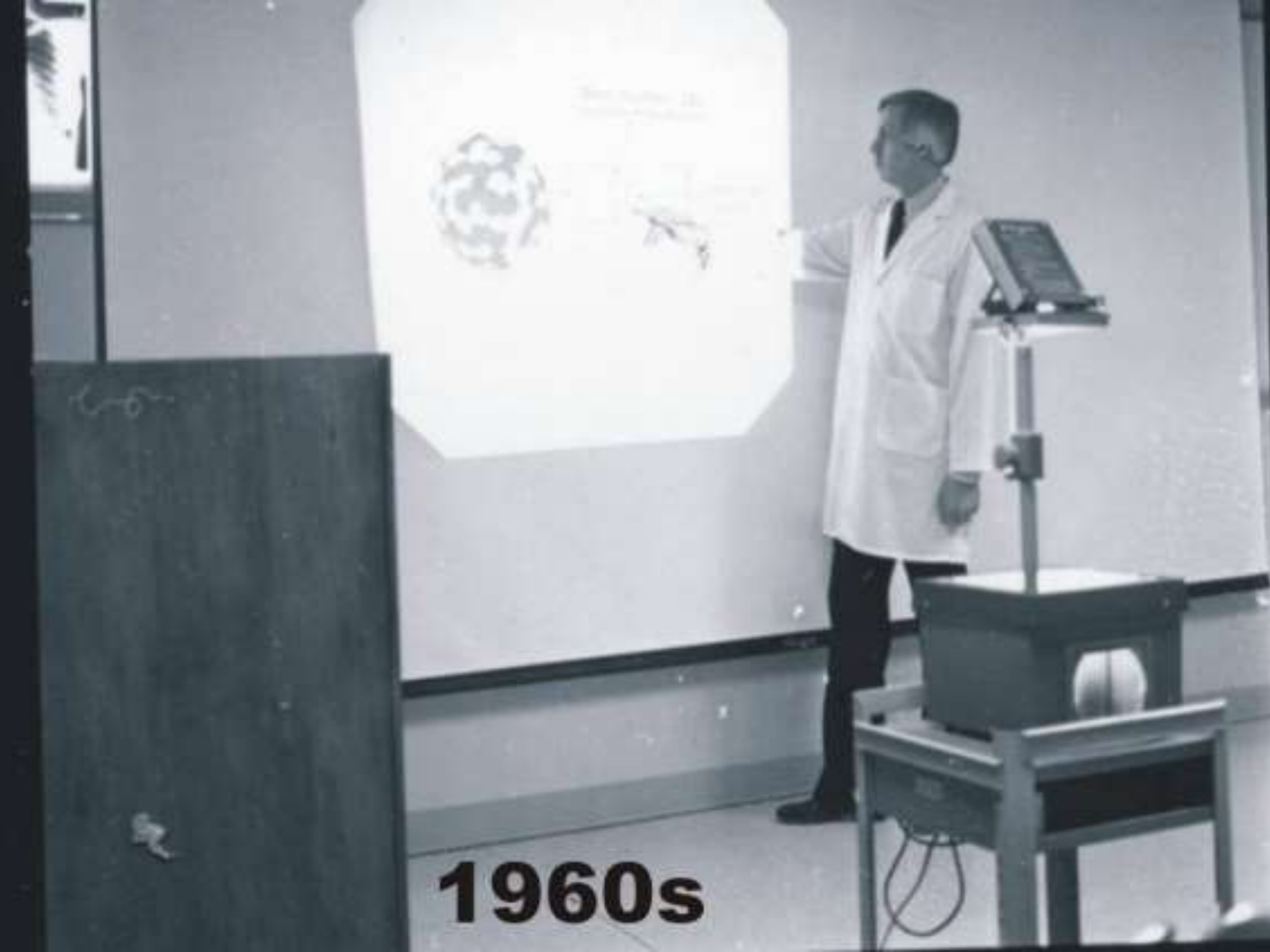
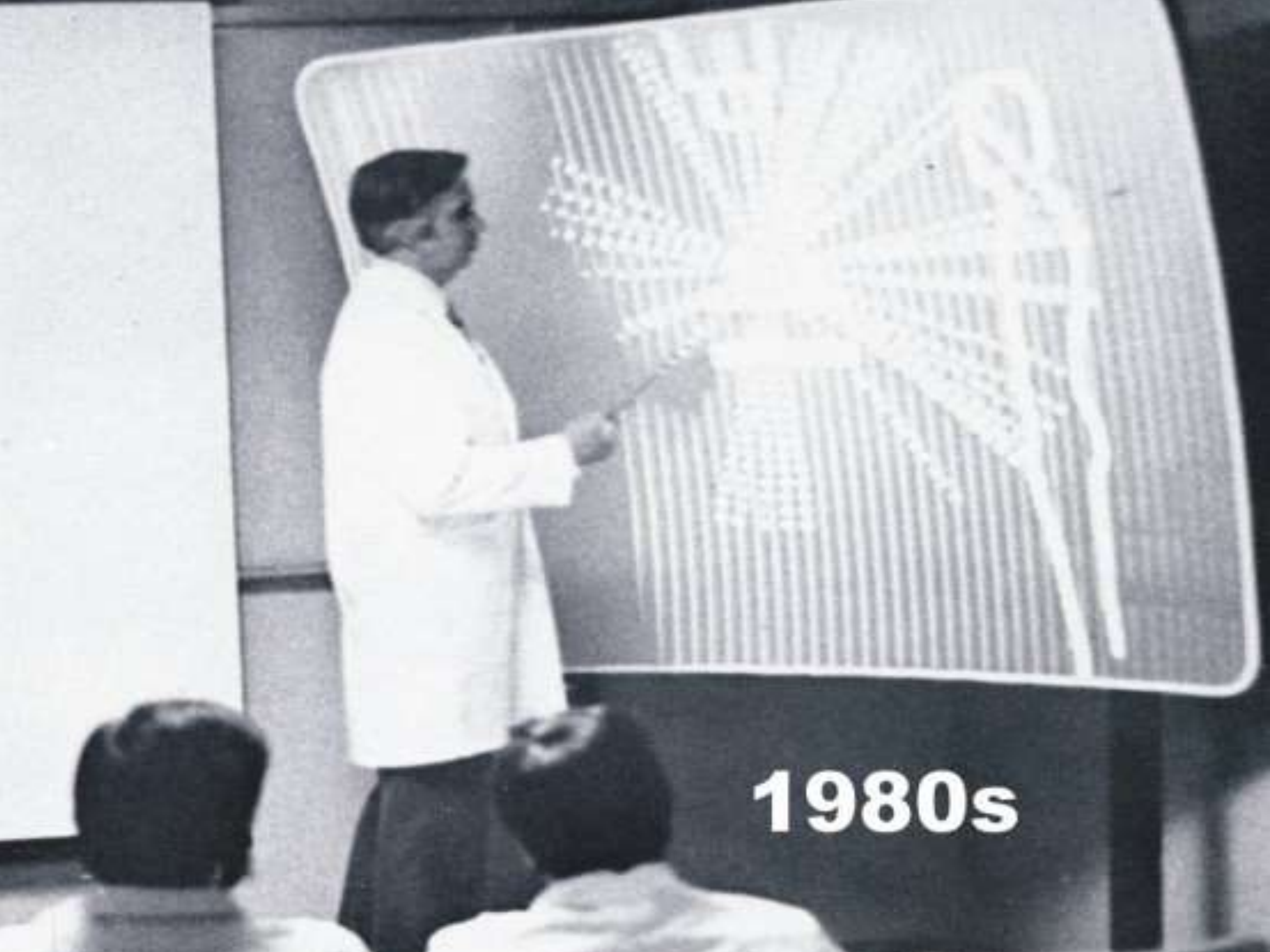

1960s


1980s

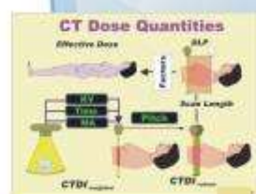
The Sprawls Resources

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

Emory

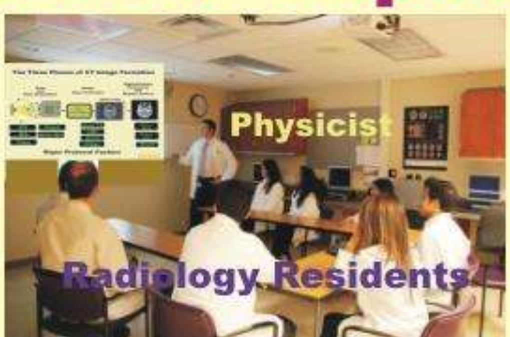
www.sprawls.org/resources

Open Access
Educational Resources



Visuals **Books** **Modules**

Global Impact



Enhancing Radiology Education
in Every Country of the World

The Collaborative Teaching Model

Sprawls Online Resources

Modules **Books** **Visuals**

Enhance the performance of physics faculty

Residents & Radiologists

Local Universities

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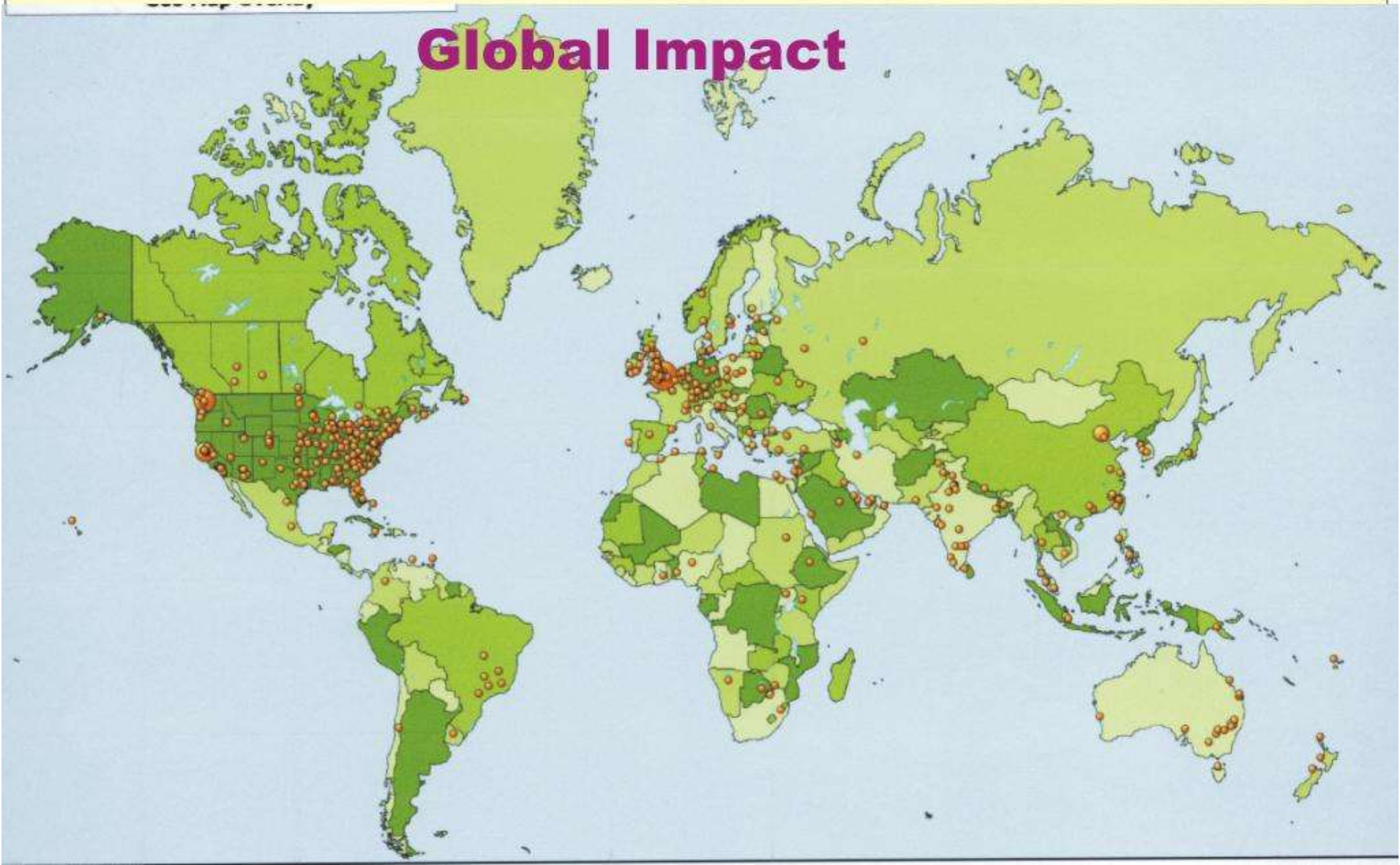
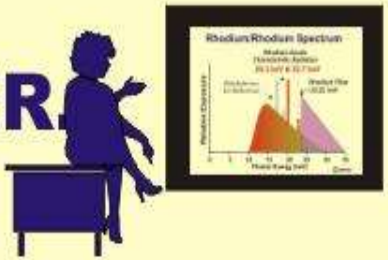
The Sprawls Resources

Users, April 2013



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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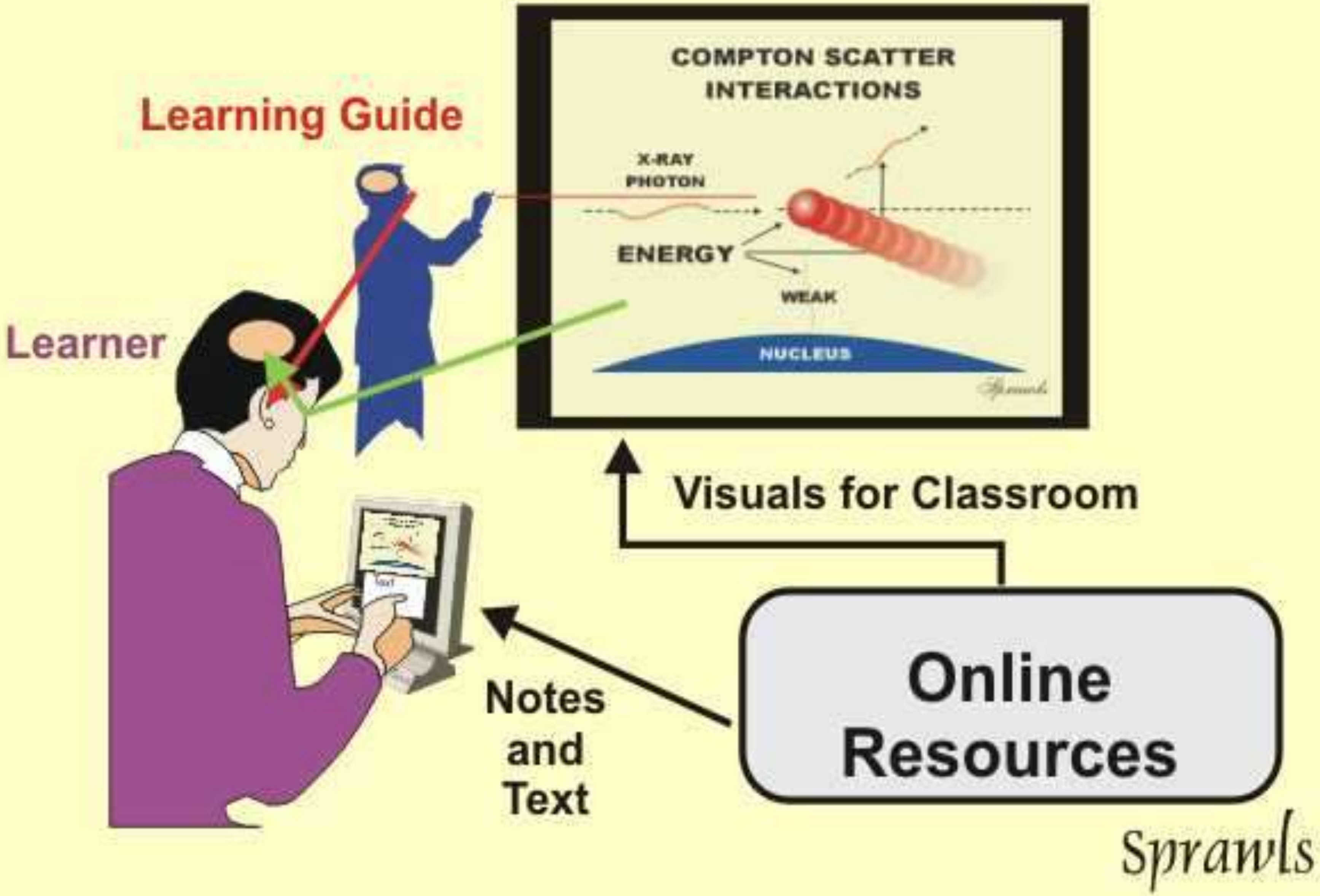
Technology Enhanced Learning



The Barrier

Physics Education

Clinical Imaging

Efficiency

Location, Resources, Human Effort, Cost

Limited Experience

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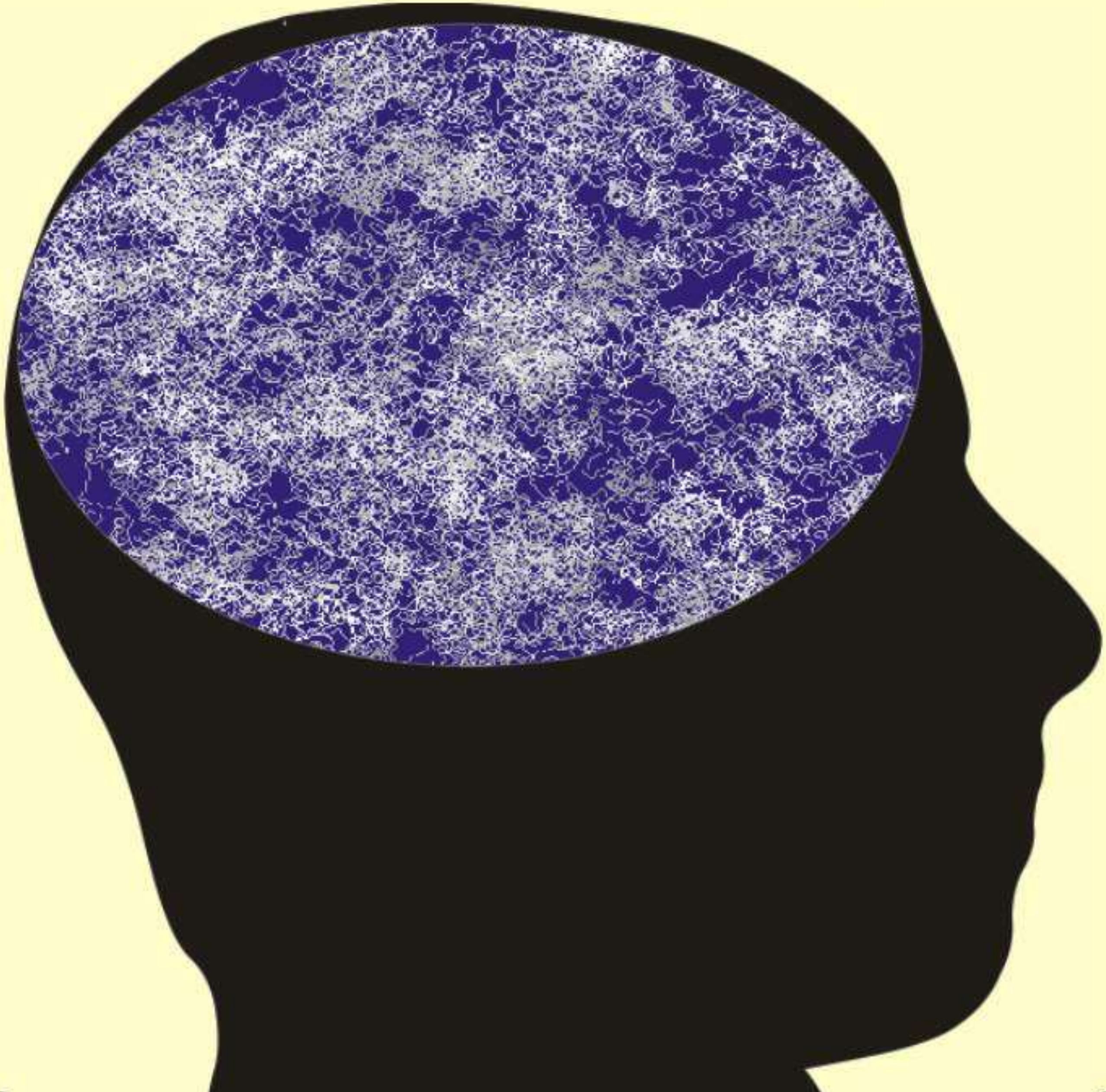
Your Mind



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Your Mind

Network of A Lifetime of Experiences

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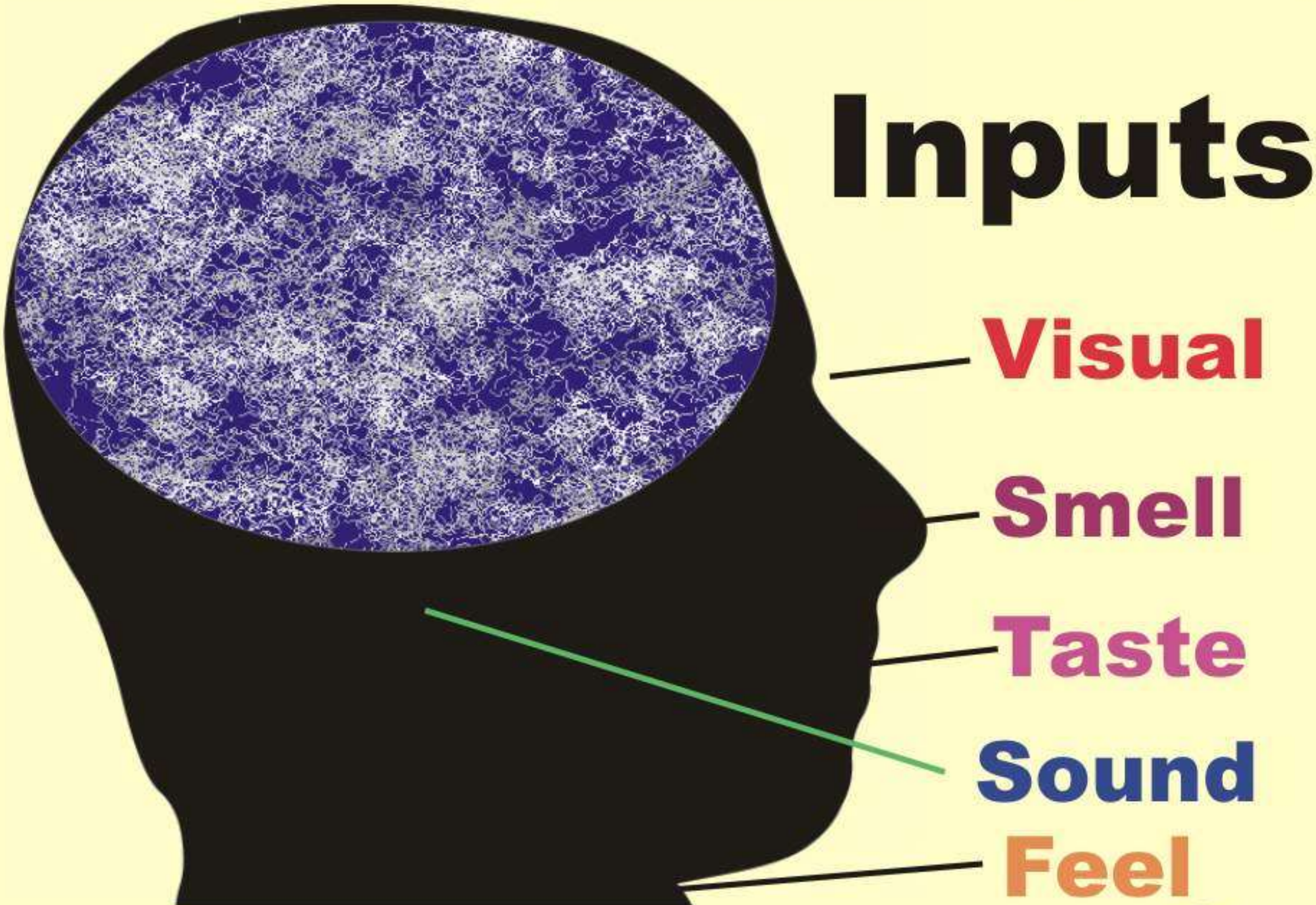
Network of Sensory Experiences



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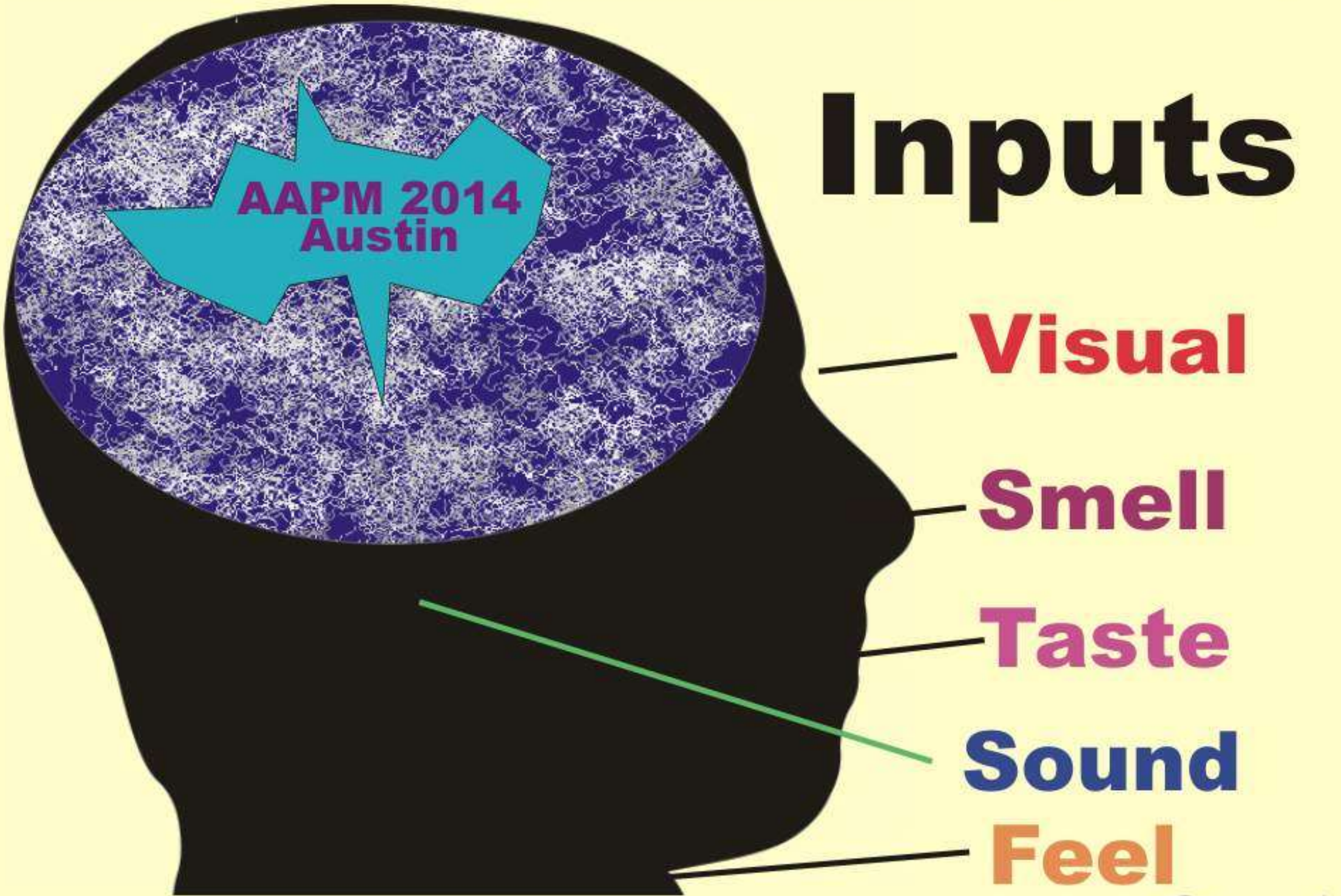
Network of Sensory Experiences



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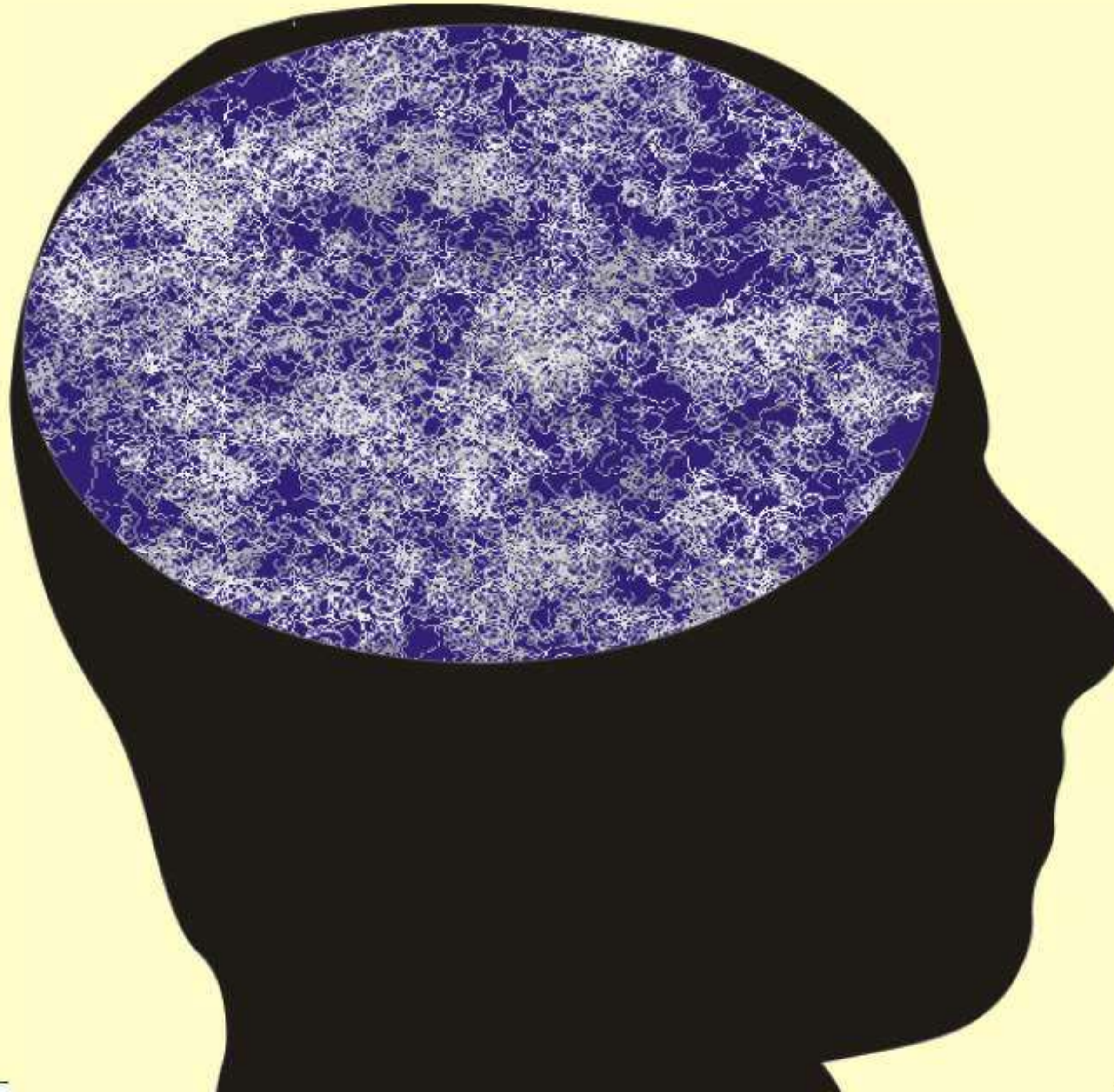
Exploring Your Mind

What Can You See?



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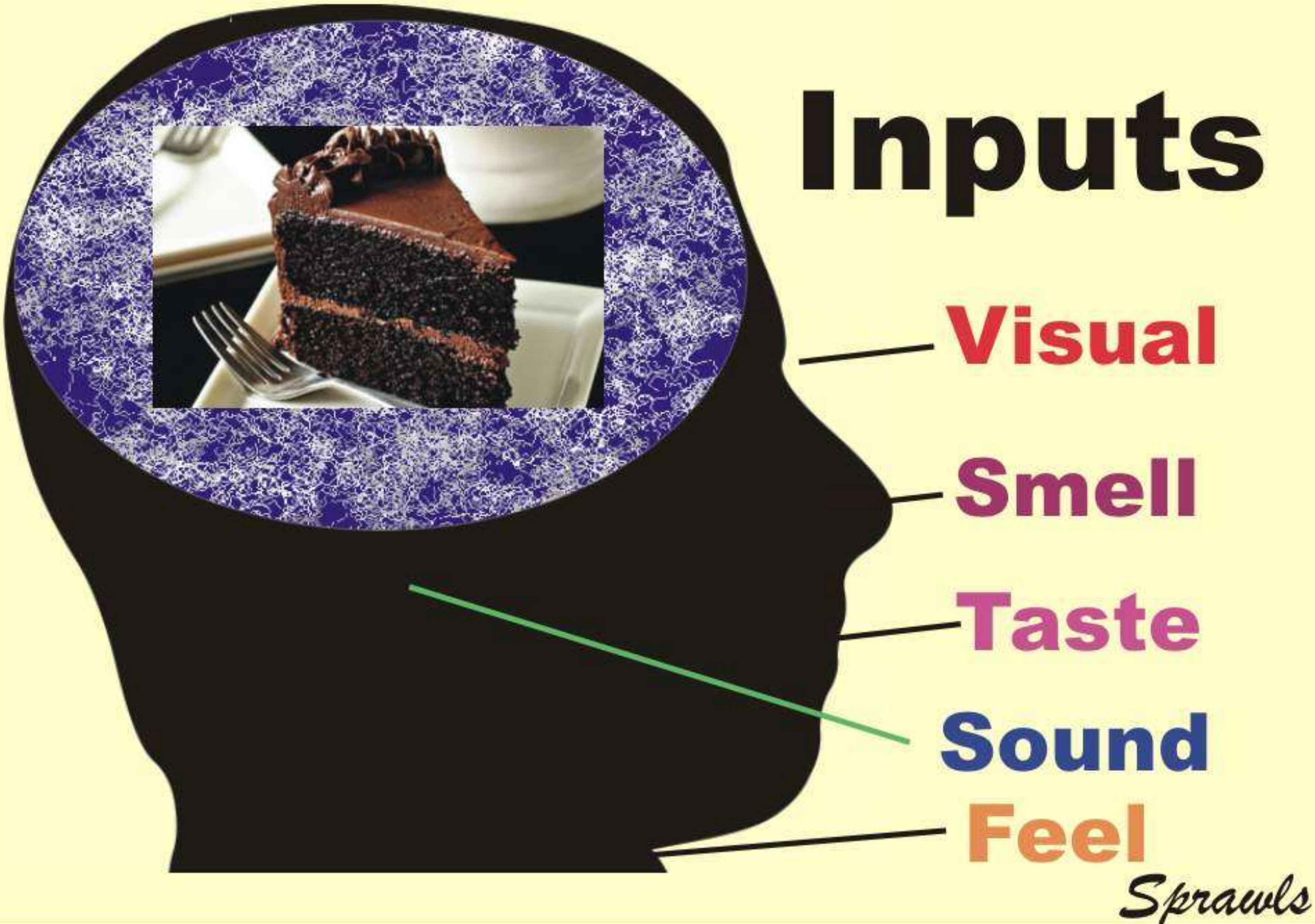
Network of Sensory Experiences



Chocolate Cake

Ingredients

Baking spray, for spraying custard cups

1 stick butter

2 ounces bittersweet chocolate

2 ounces semisweet chocolate

1 1/4 cups powdered sugar

2 whole eggs

3 egg yolks

1 teaspoon vanilla

1/2 cup all-purpose flour

Vanilla ice cream, for serving

Directions

Preheat the oven to 425 degrees F. Spray four custard cups with baking spray and place on a baking sheet.

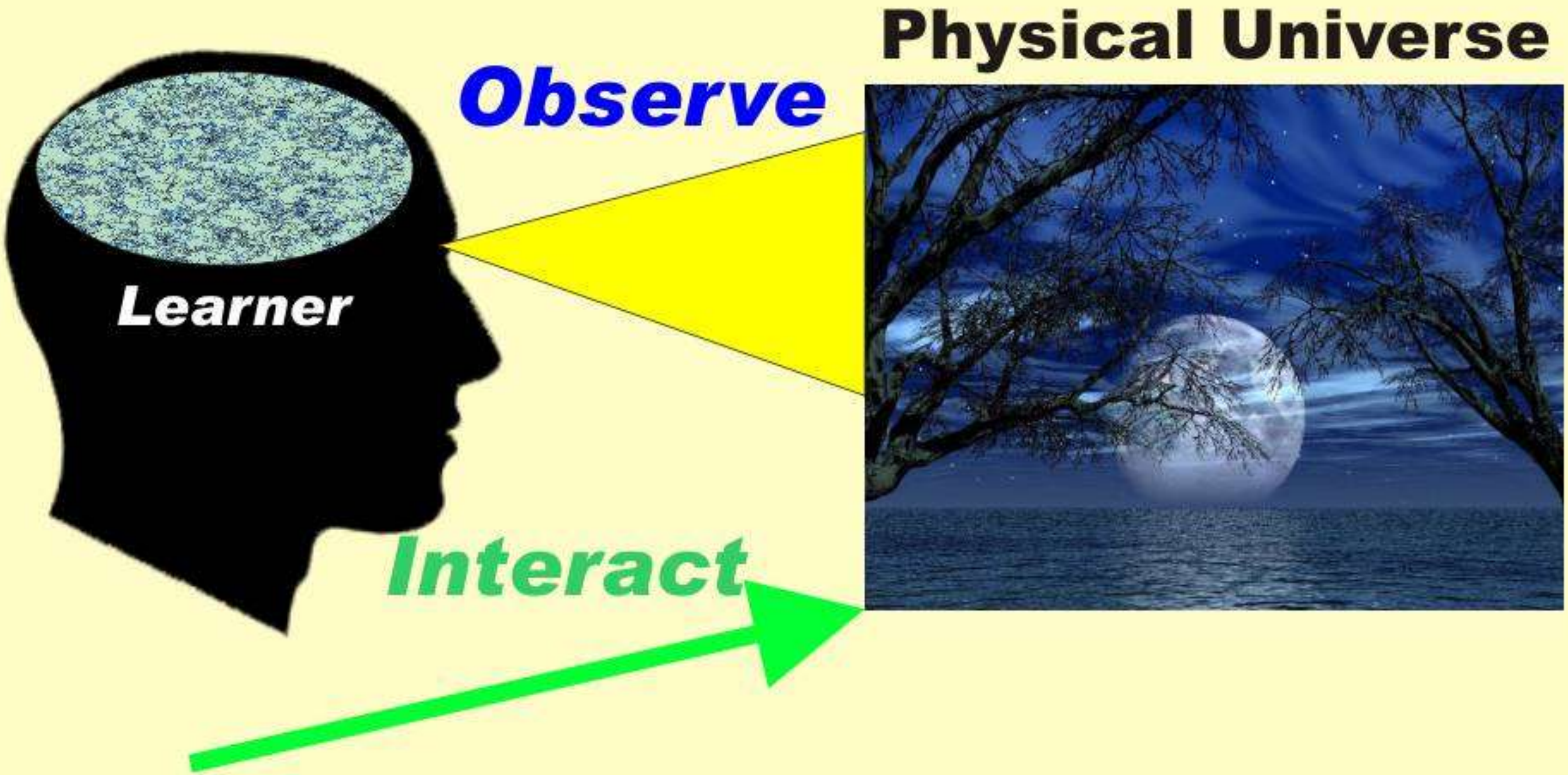
Microwave the butter, bittersweet chocolate and semisweet chocolate in a large bowl on high until the butter is melted, about 1 minute. Whisk until the chocolate is also melted. Stir in the sugar until well blended. Whisk in the eggs and egg yolks, then add the vanilla. Stir in the flour. Divide the mixture among the custard cups.

Bake until the sides are firm and the centers are soft, about 13 minutes. Let stand 1 minute. Invert on individual plates while warm and serve with vanilla ice cream.

CATEGORIES: Chocolate, Dessert, Cake | View All

Learning is a Natural Human Process

We Learn by Experience



Sprawls

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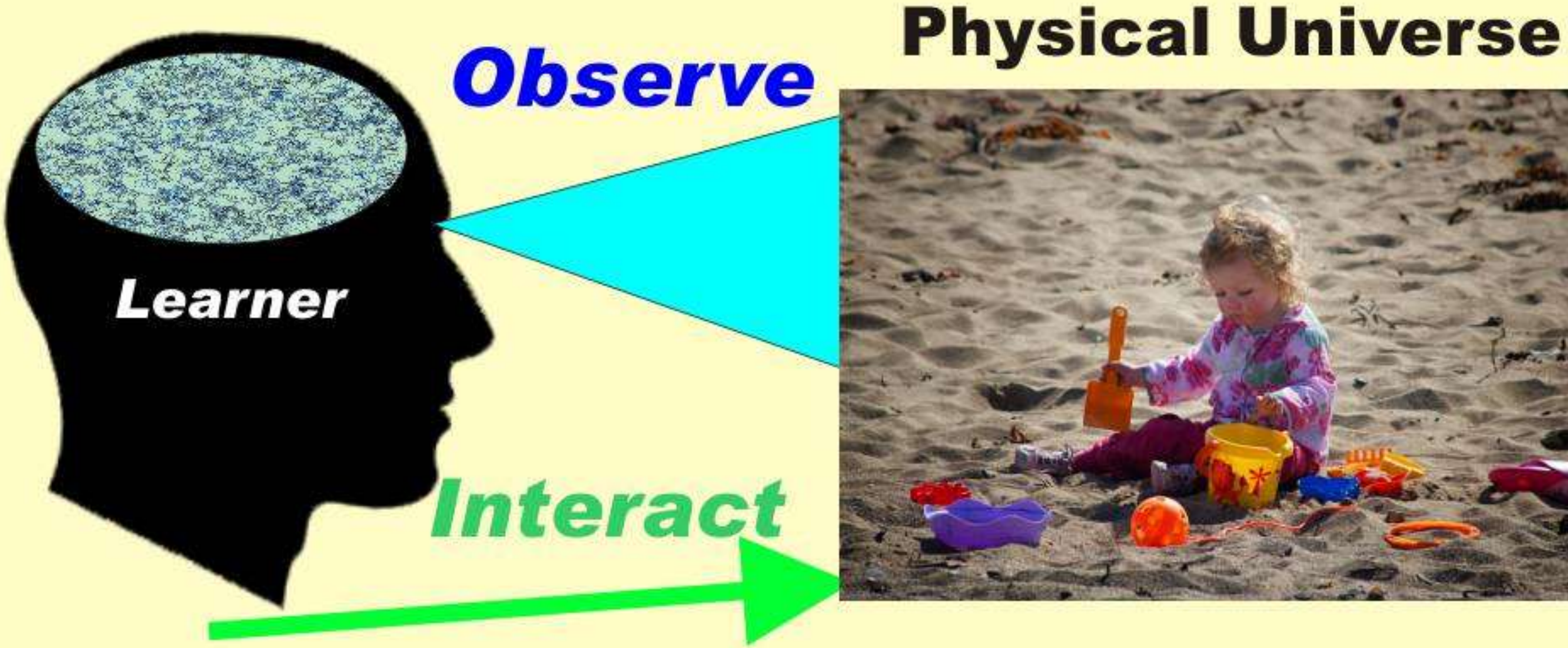

Our Early Physics Learning Activities

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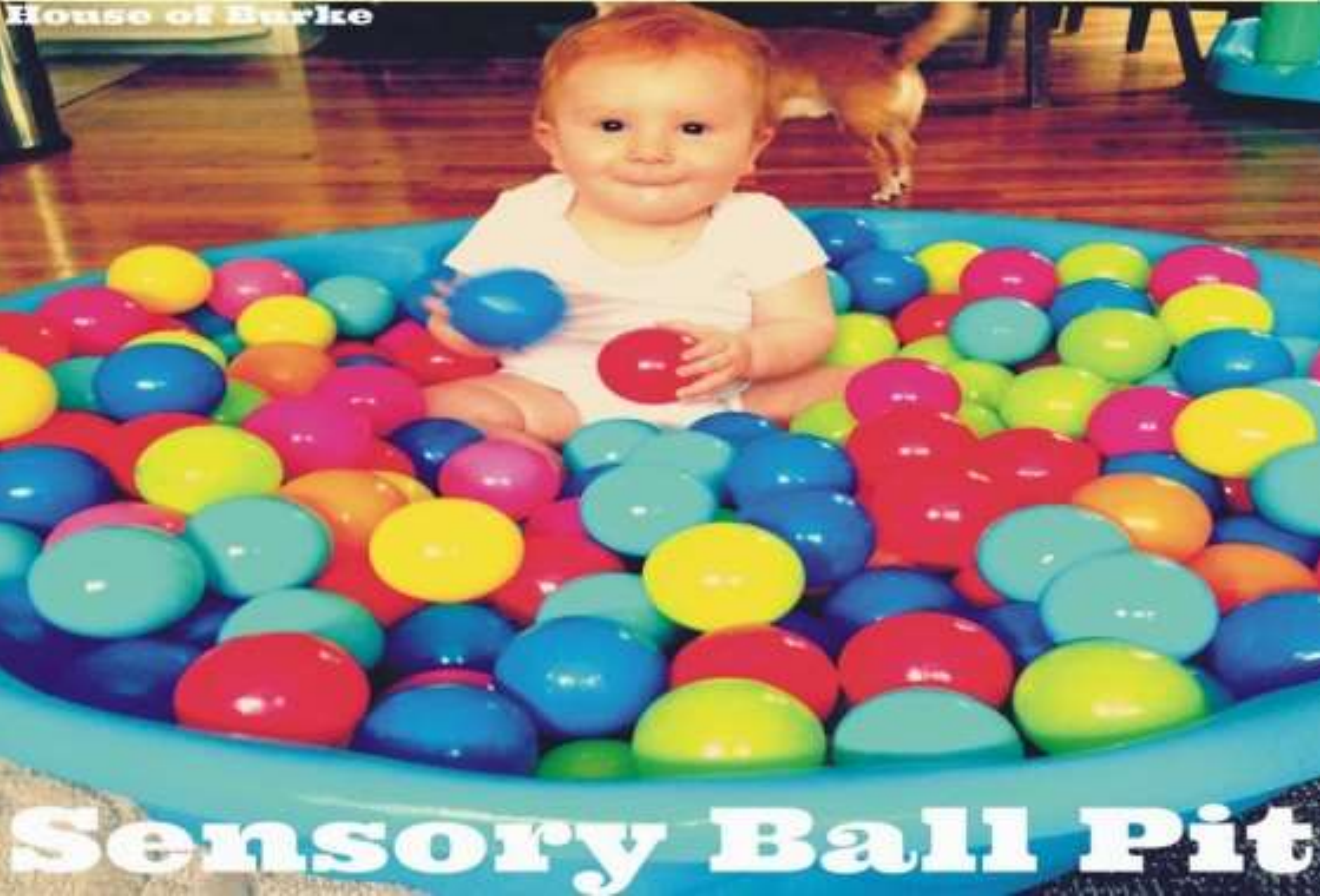
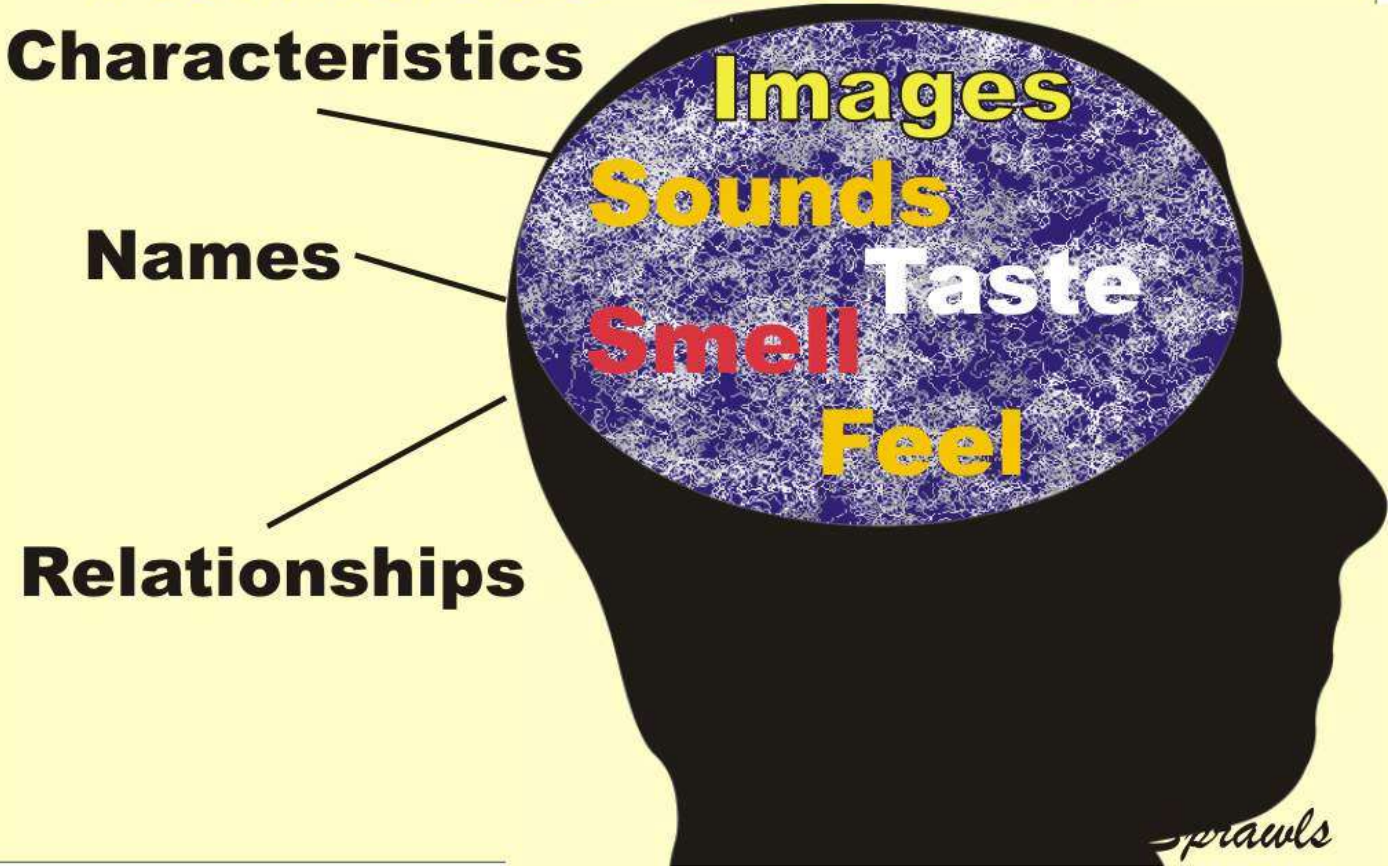
One of Our First Physics Lessons

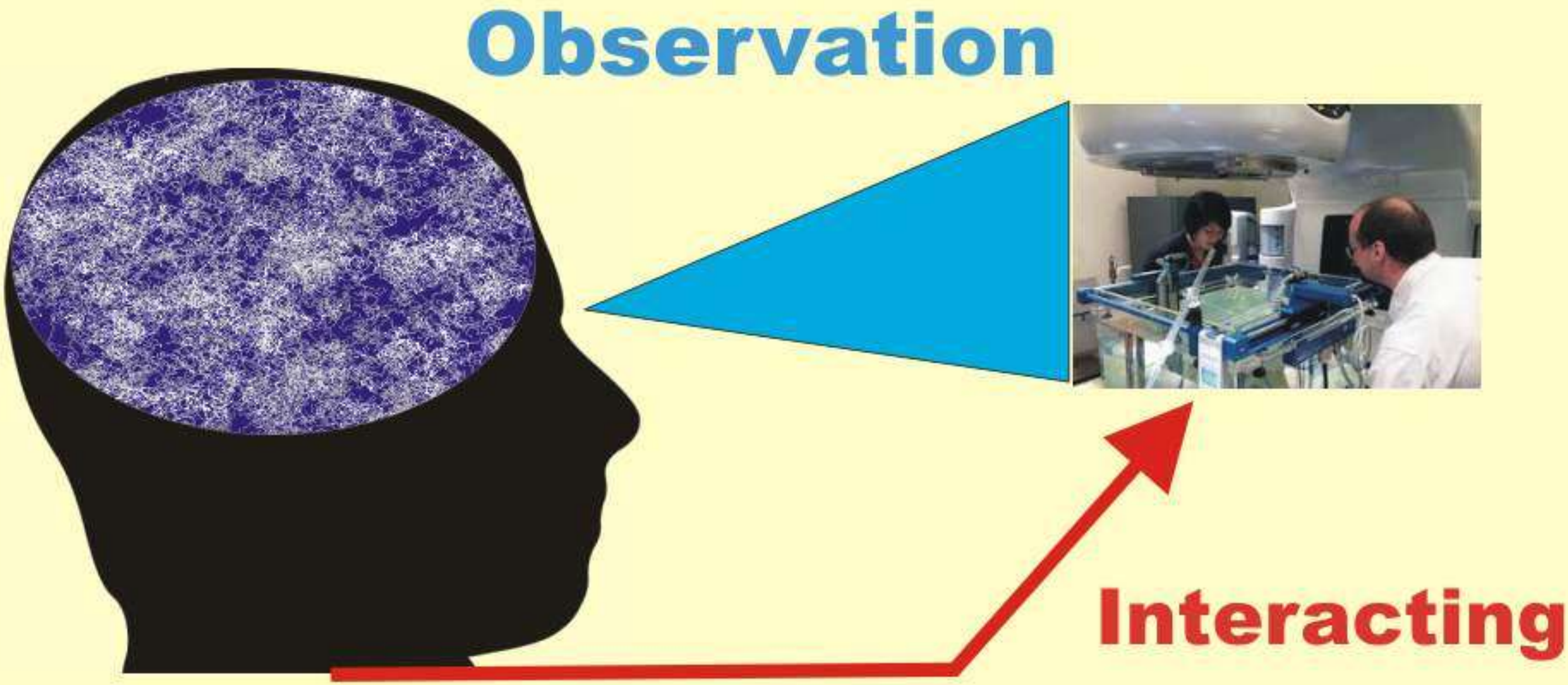


Knowledge Structure Formation

Atributes Elements



Learning By Direct



A Natural Human Function

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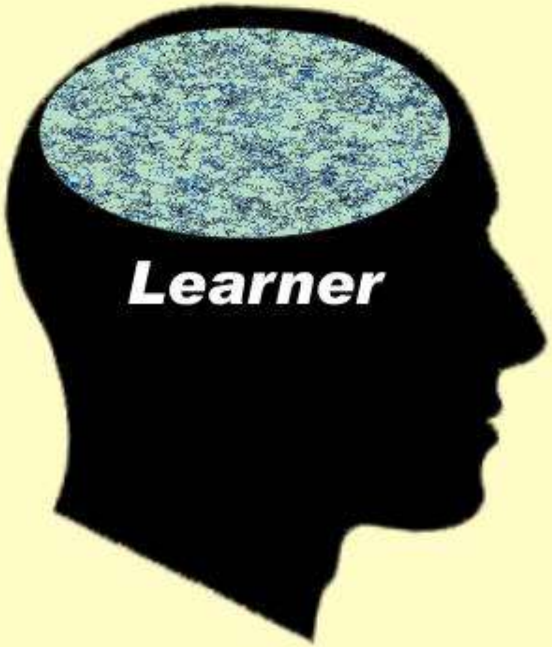
Teaching

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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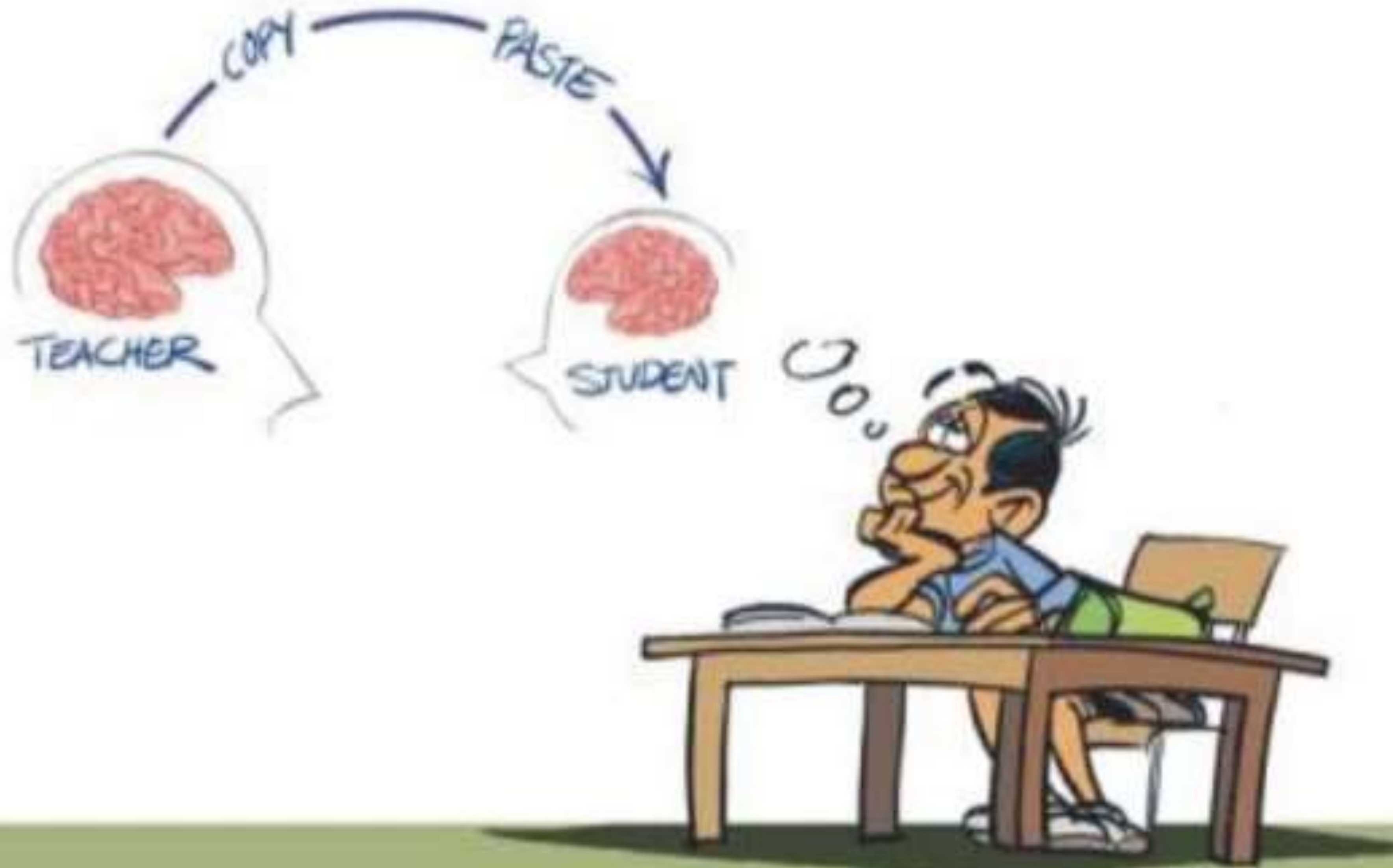
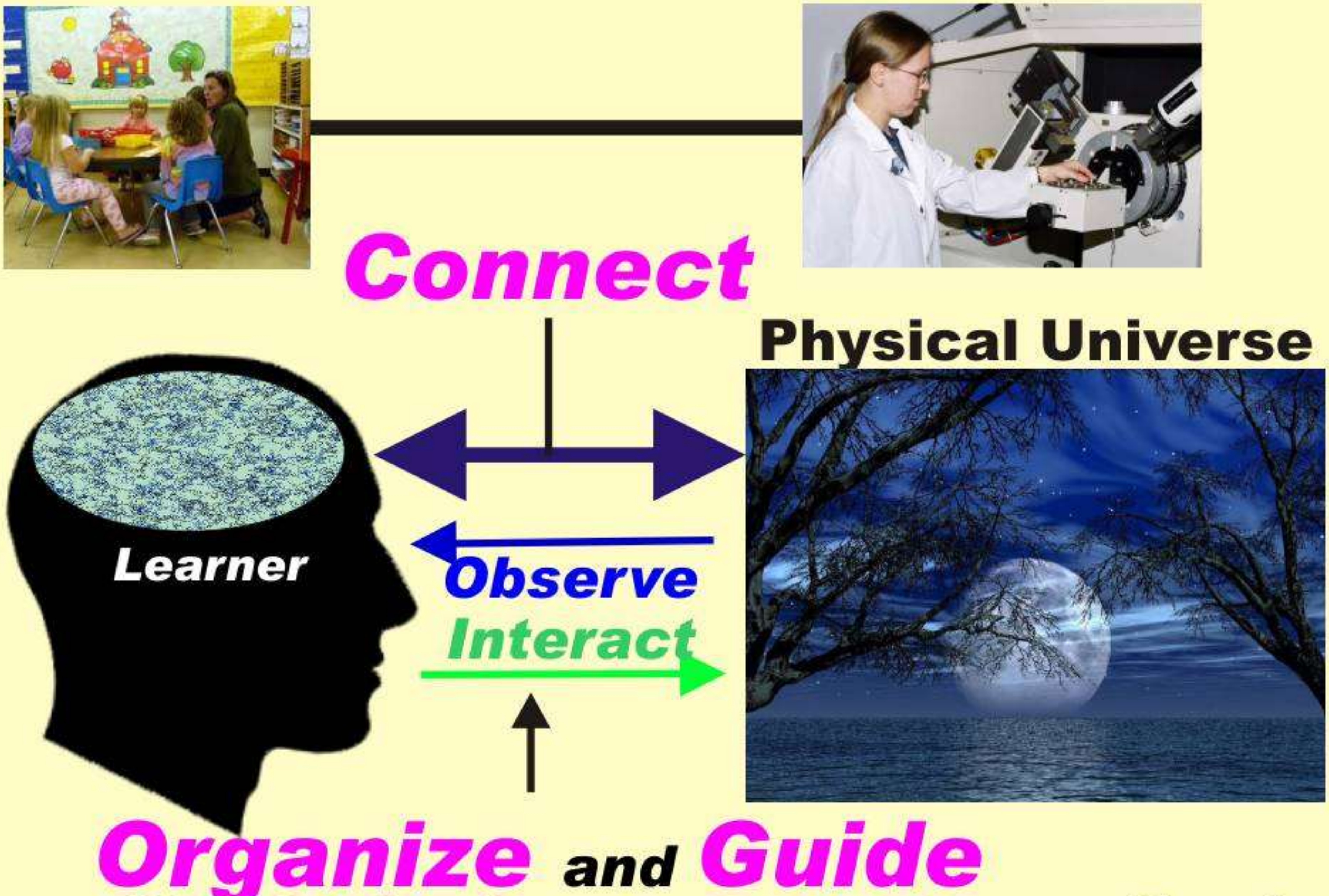
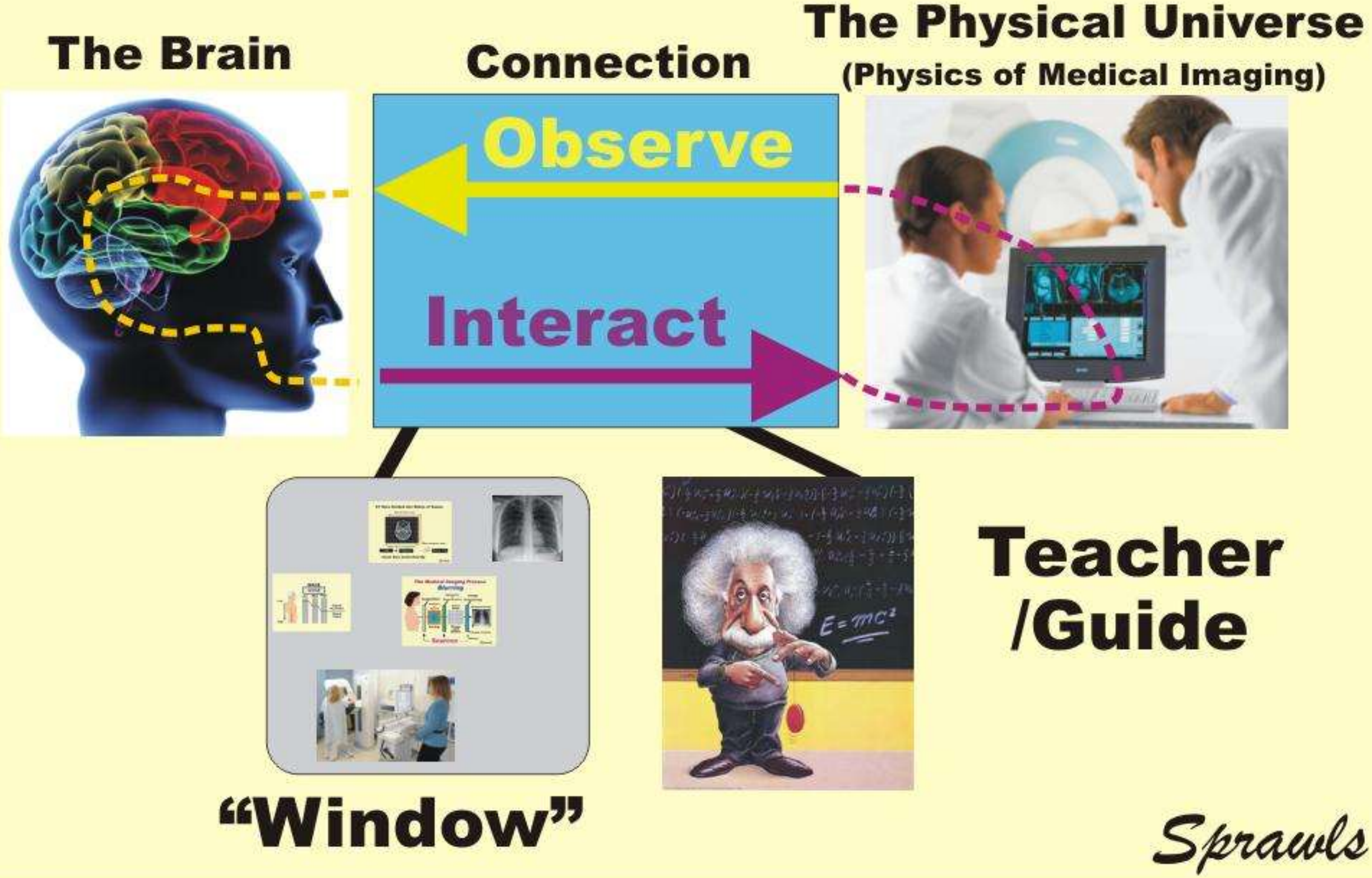
Teaching Physics Is Not



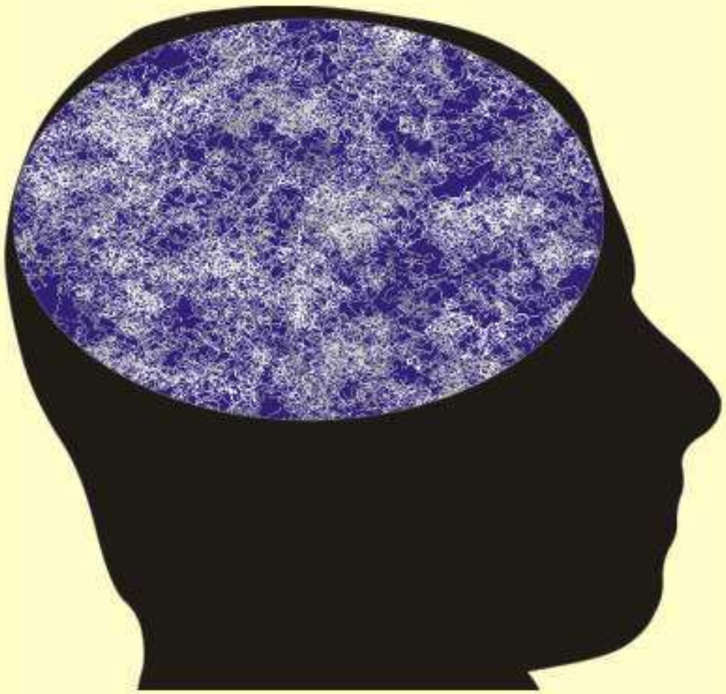
The Role of Formal Education

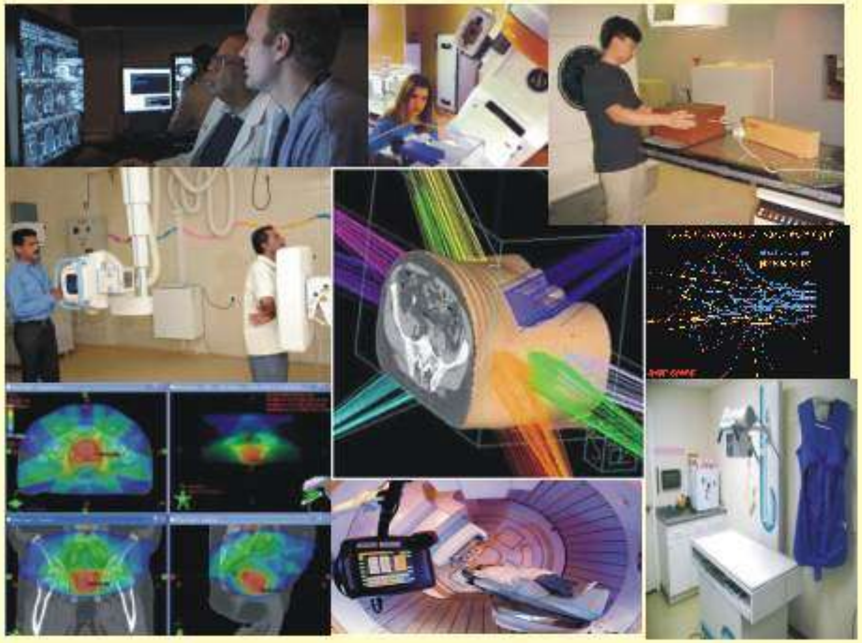


The Elements of A Highly Effective Educational Session



What do they need?





"Know" or to "Do"

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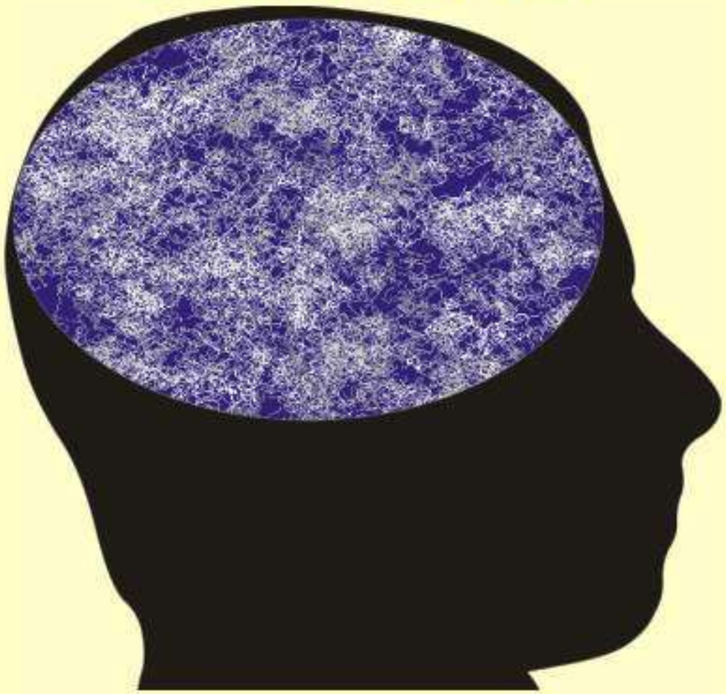
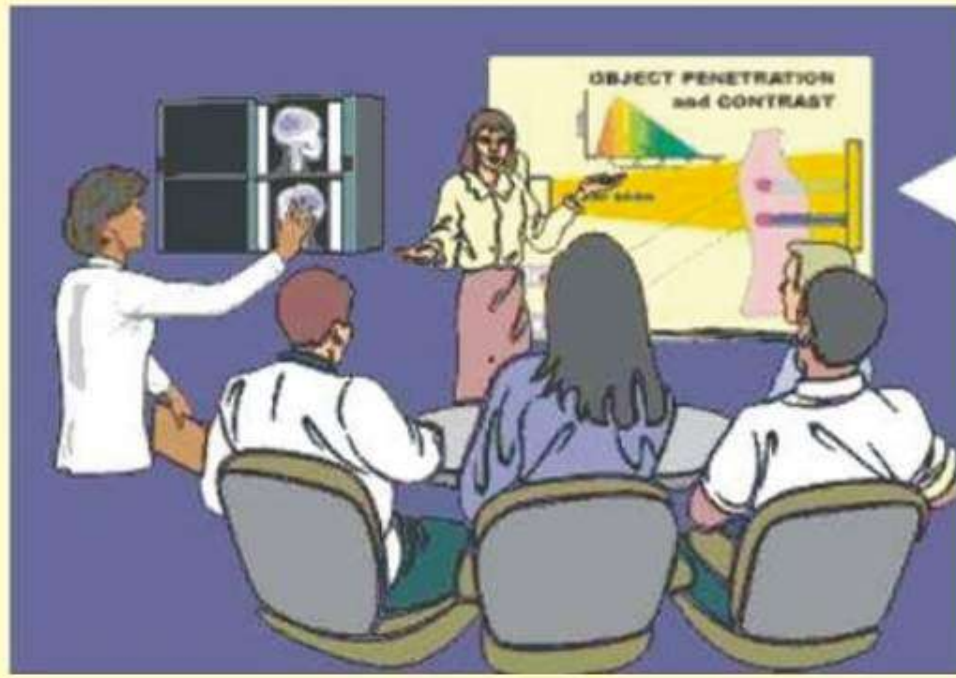
What do you need?

You As An Educator





Provide a highly-effective learning experience

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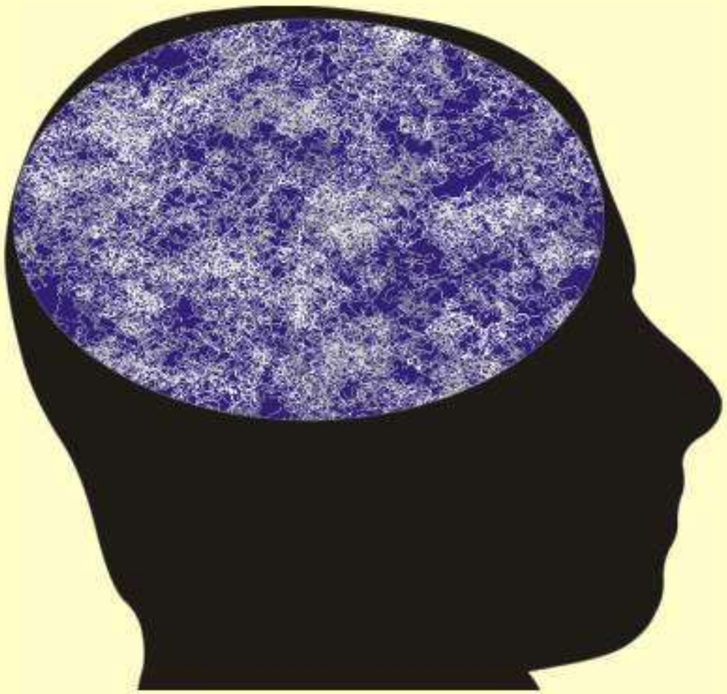
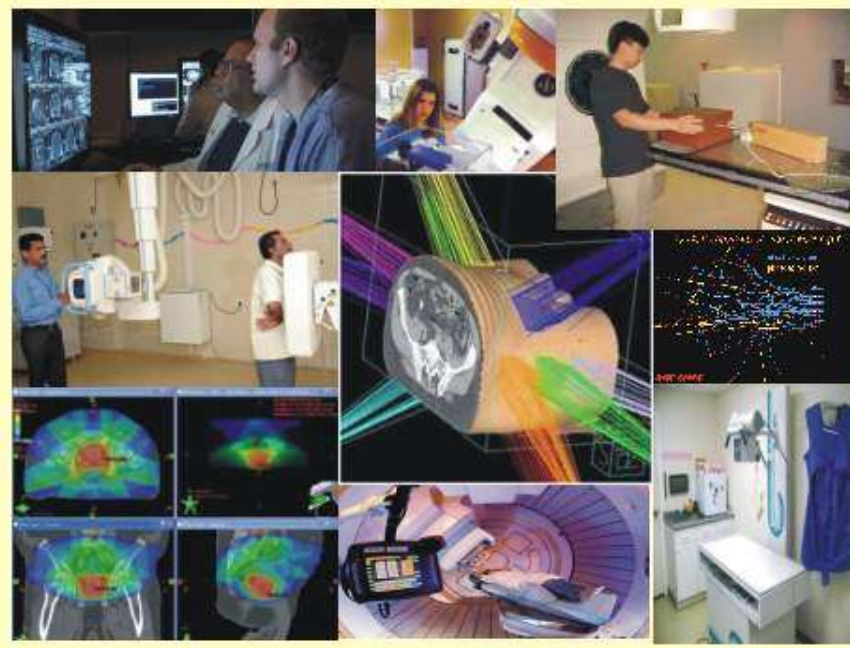
Here is our challenge!

Learner



Medical Physics Universe



How are you going to do it?

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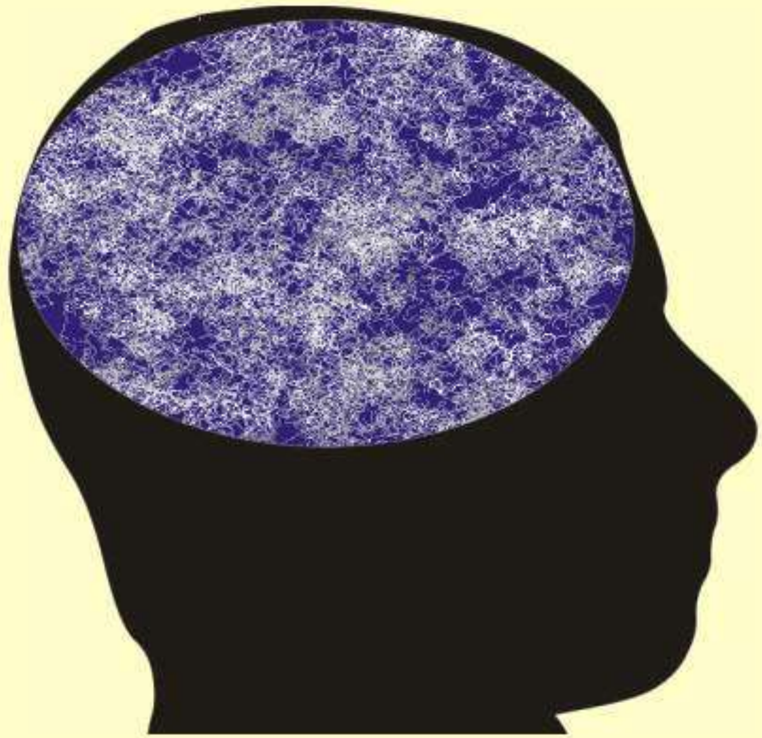
Learning Medical Physics

is



Building a Knowledge Structure in the Mind

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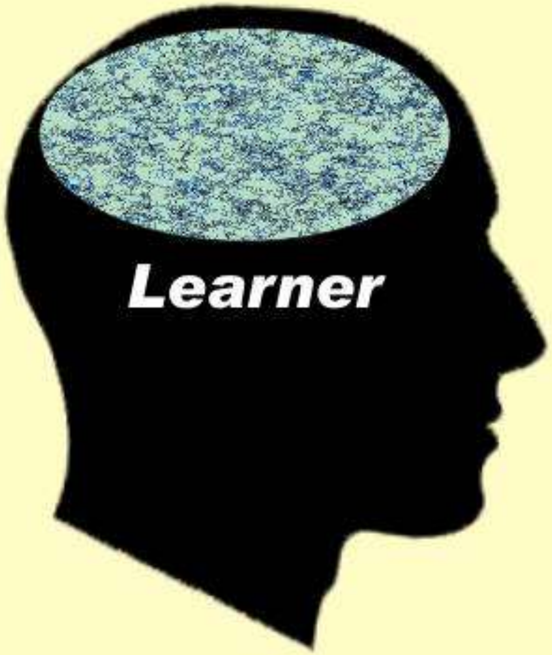
Learning Physics
is
Building a Knowledge Structure
in the Brain



Physical Universe

A mental representation of physical reality

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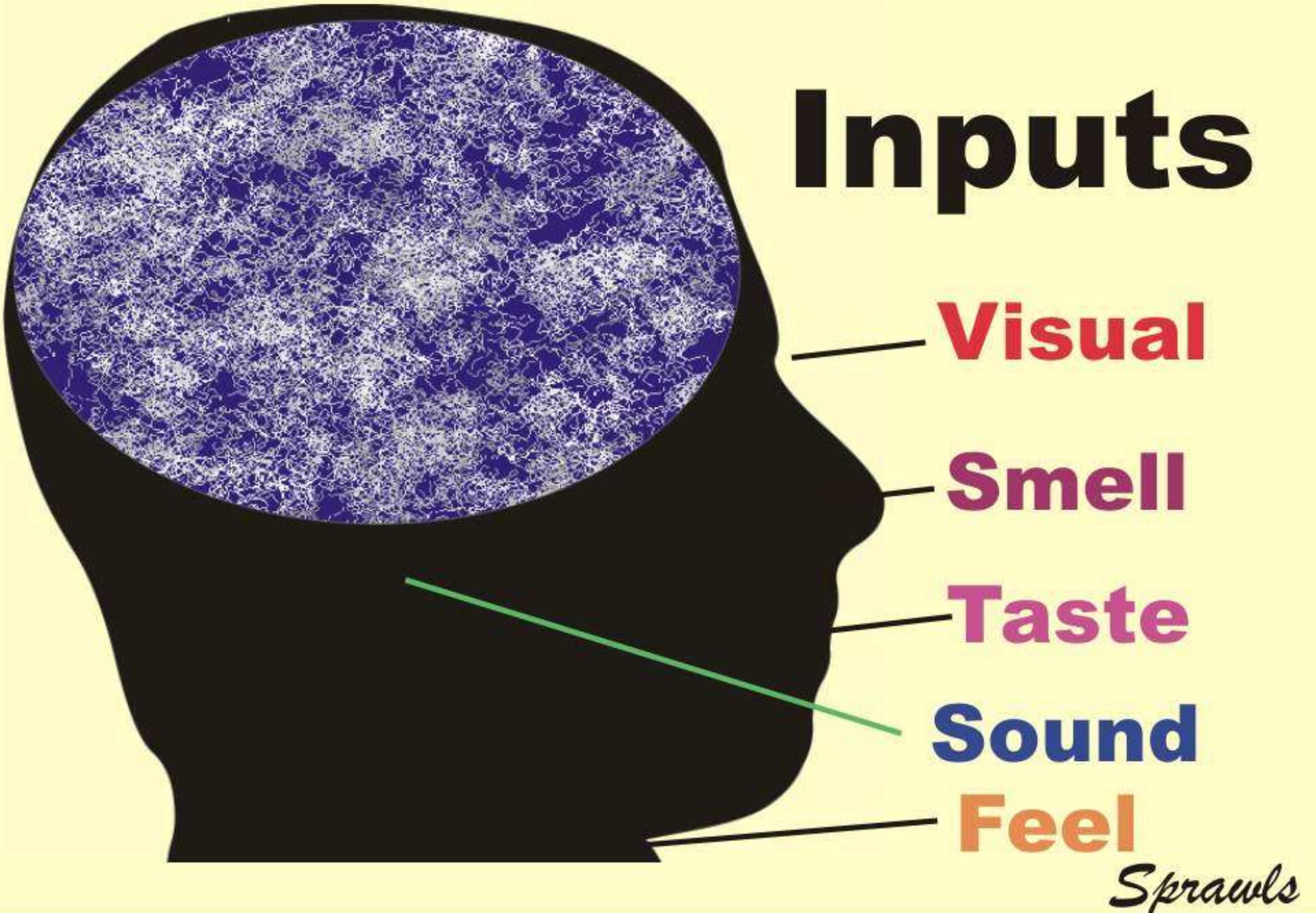
Knowledge Structure of Medical Physics

Network of Sensory Experiences

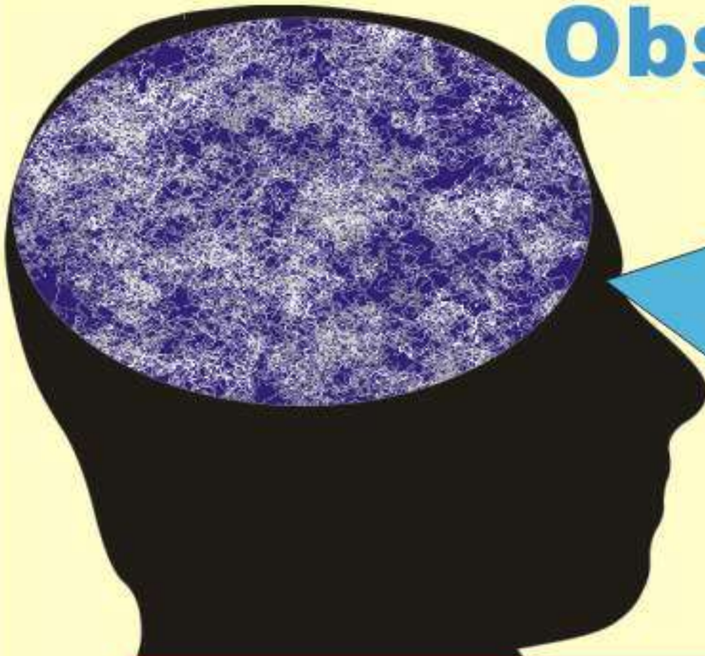


Learning Medical Physics

Requires

Observation

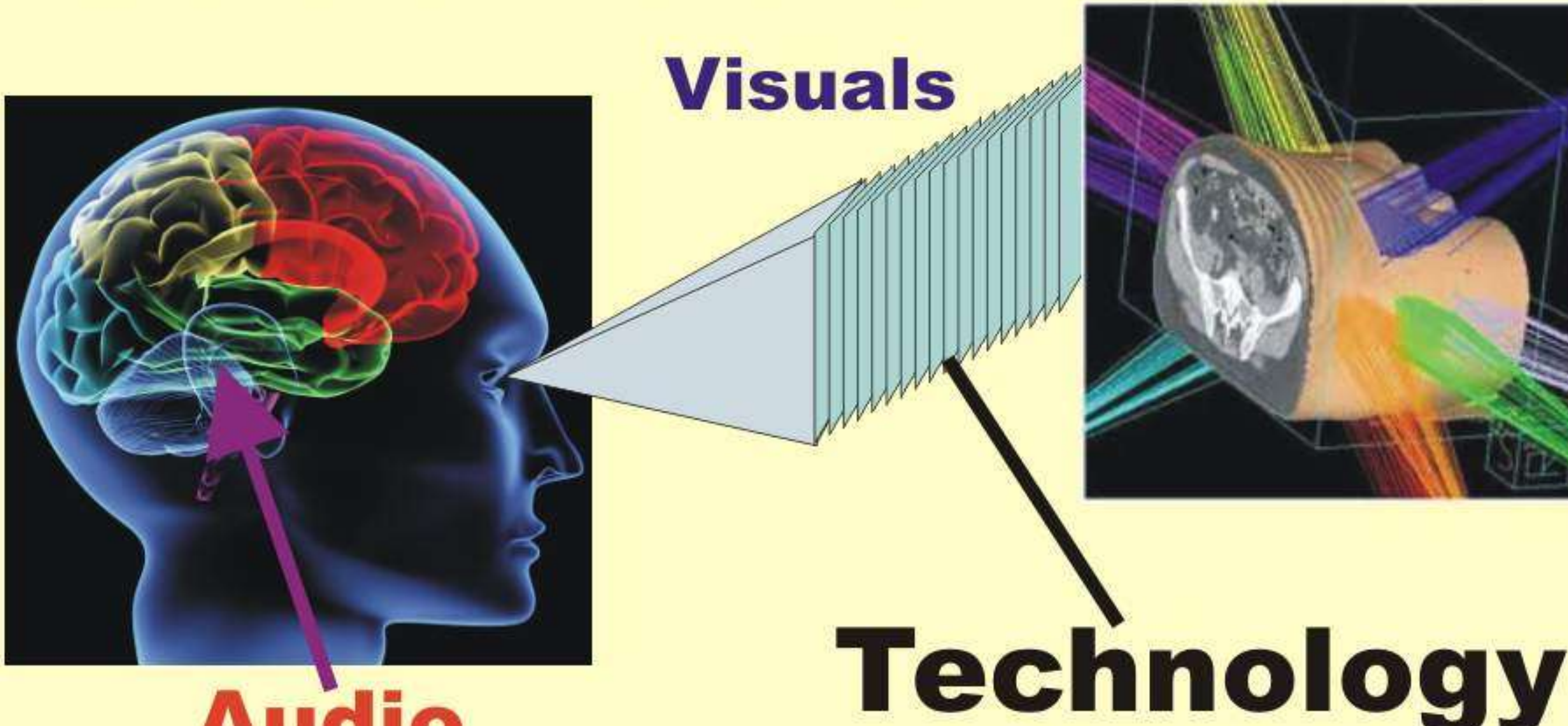
Medical Physics Universe



Interacting With

Sprawls

The Most EFFECTIVE way to Build Physics Knowledge Structures



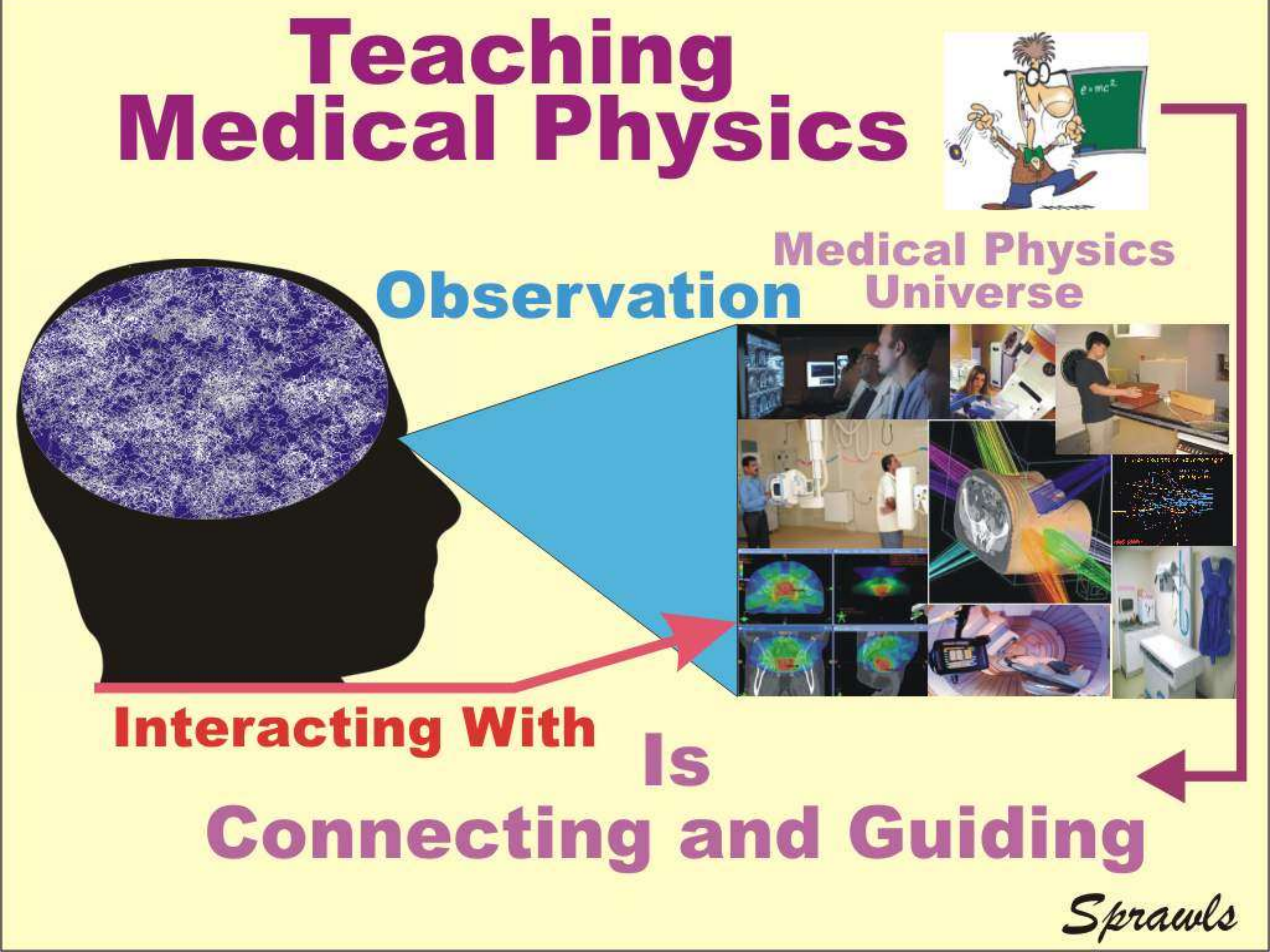
Audio

Human

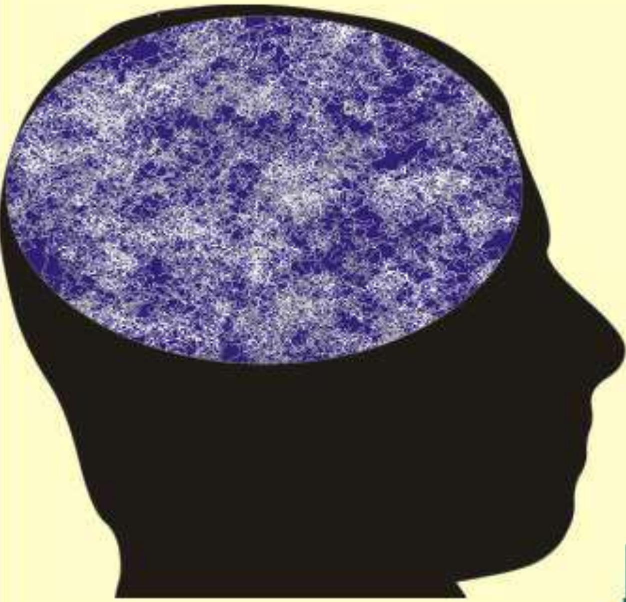
(Teacher)

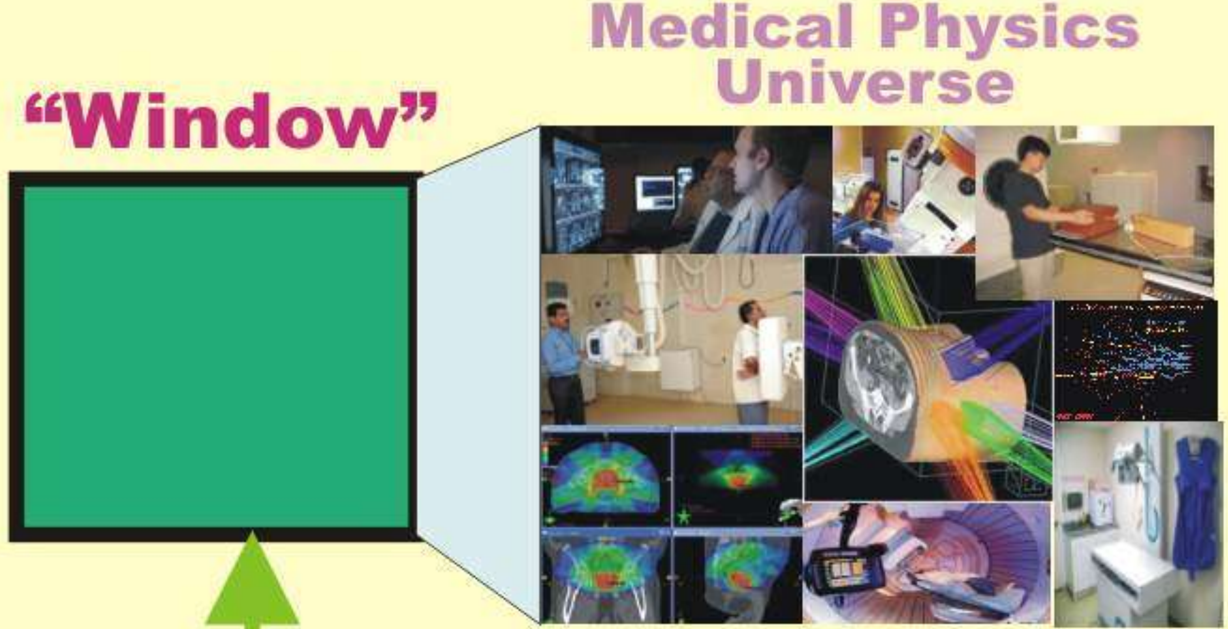
Guiding The Process

Sprawls


Teaching
Medical Physics
e=mc²
Medical Physics
Universe
Observation
Interacting With
Is
Connecting and Guiding
Sprawls

Teaching Medical Physics





Provide Window

Guide the Learning Process

Teacher must

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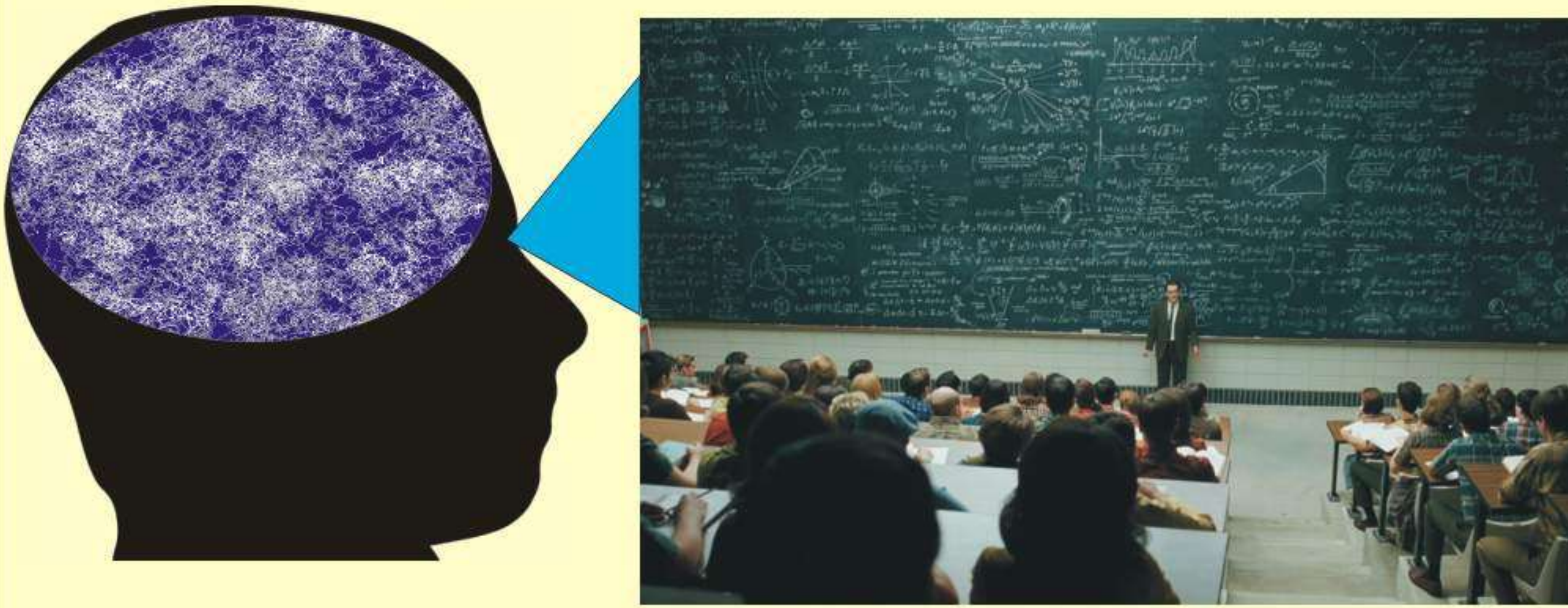
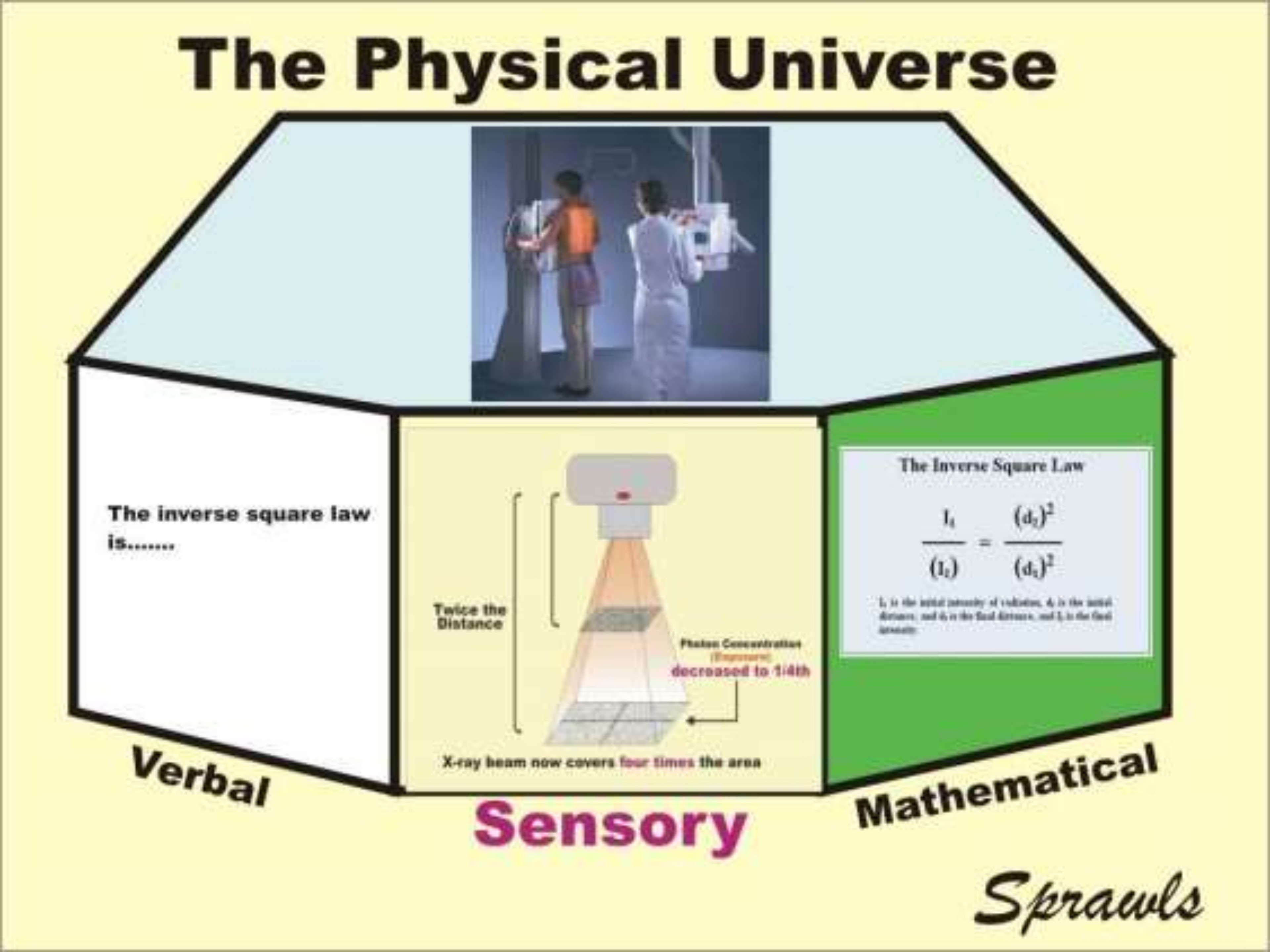
A Traditional "Window" to the Physical Universe

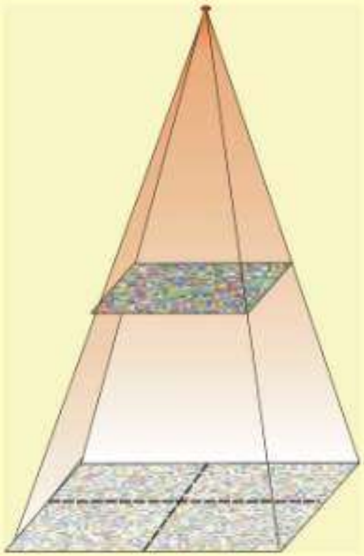


Sprawls


The Physical Universe
The inverse square law is.......
Twice the Distance
Photon Concentration
decreased to 1/4th
X-ray beam now covers four times the area
The Inverse Square Law
Verbal
Sensory
Mathematical
Sprawls

Medical Physics Knowledge Structures

Sensory



Linguistic

The inverse-square law states that the exposure decreases inversely to the square of the distance from the source.

Quantative

$$E_2 = E_1/(d_2/d_1)^2$$

Sprawls

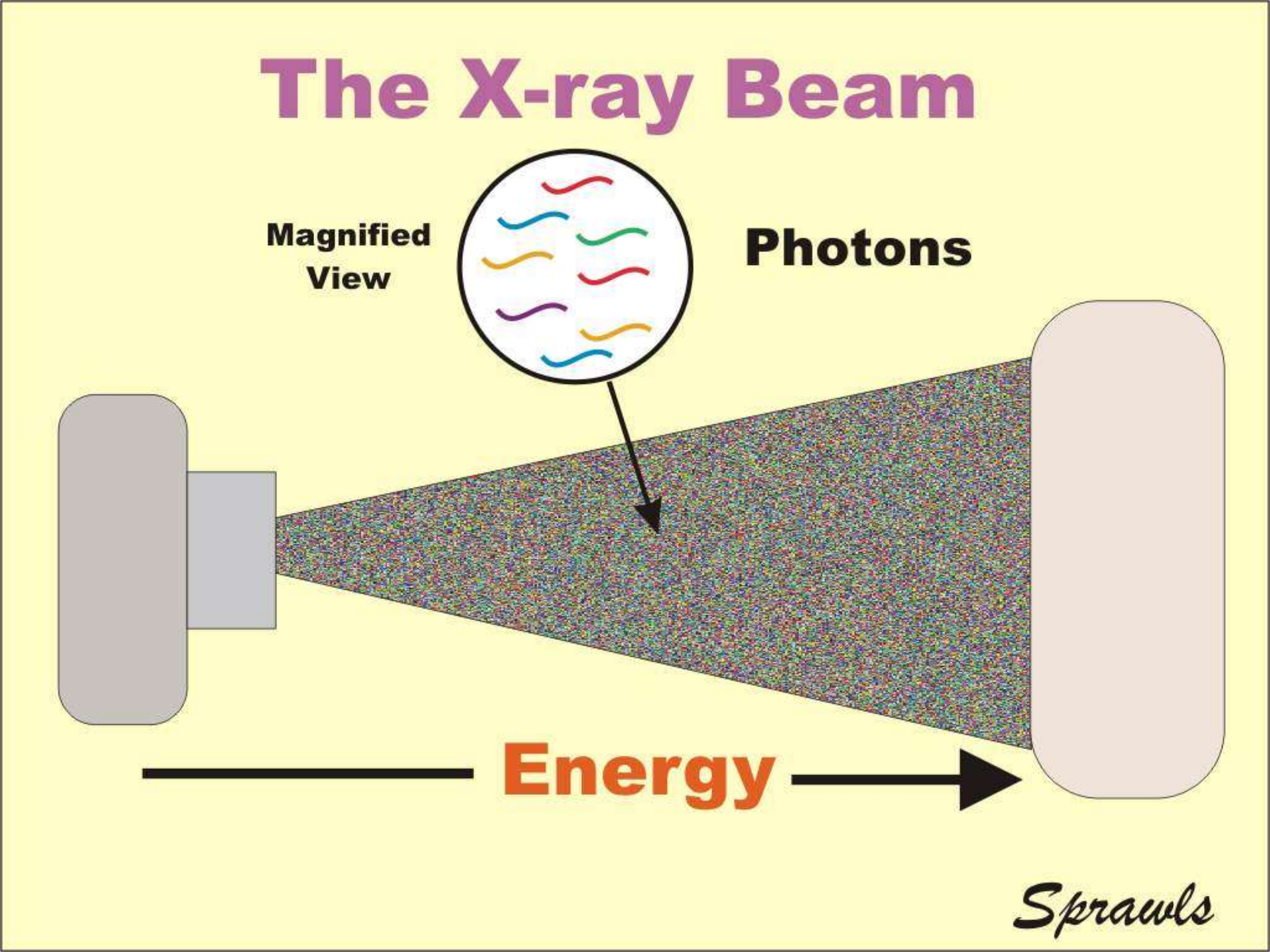
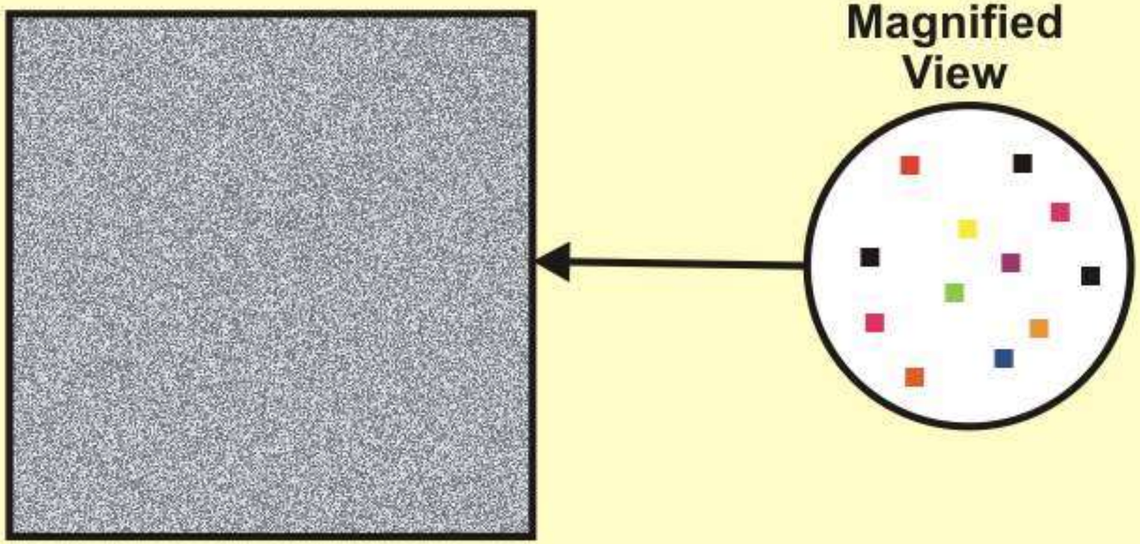
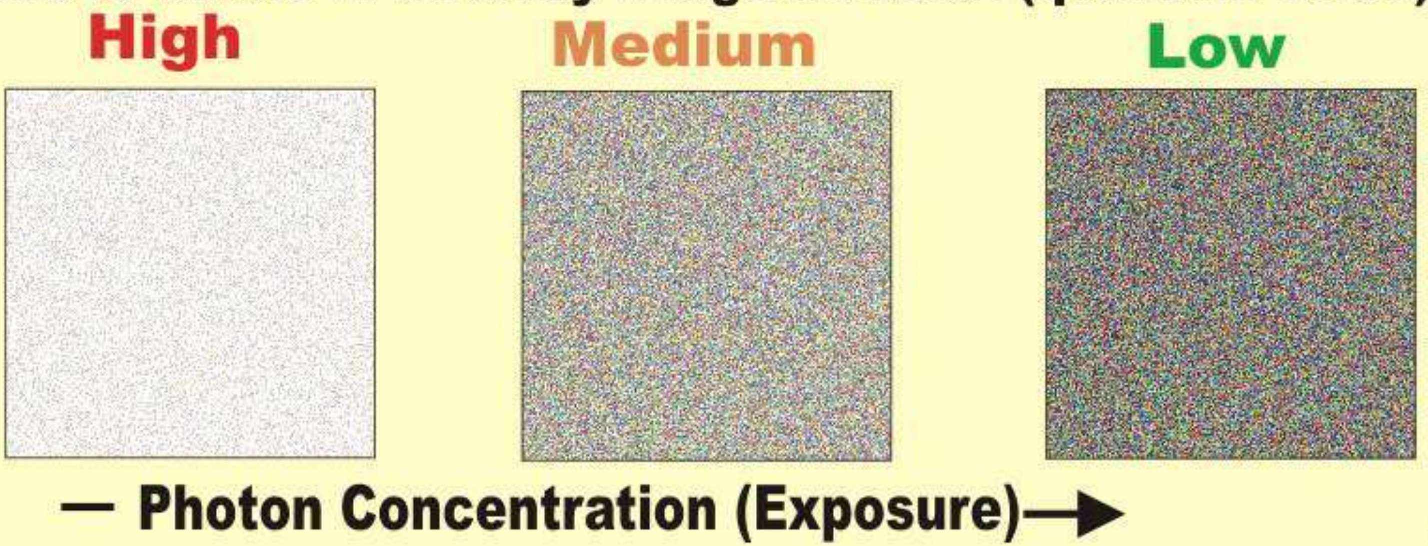

The X-ray Beam
Magnified View
Photons
Energy
Sprawls

Image Of An X-ray Beam

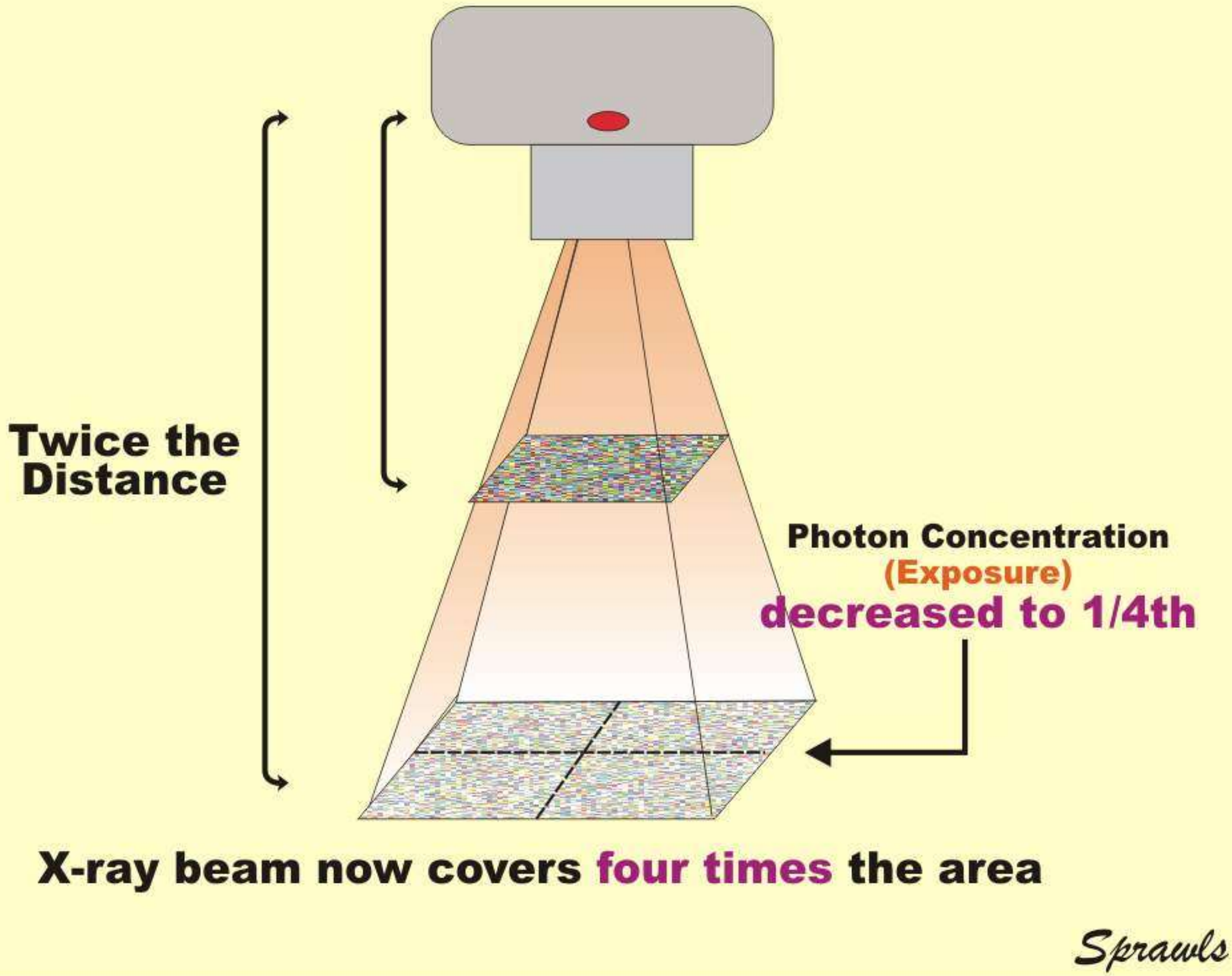
A Random Distribution of Photons



This is visible in an x-ray image as noise (quantum noise).

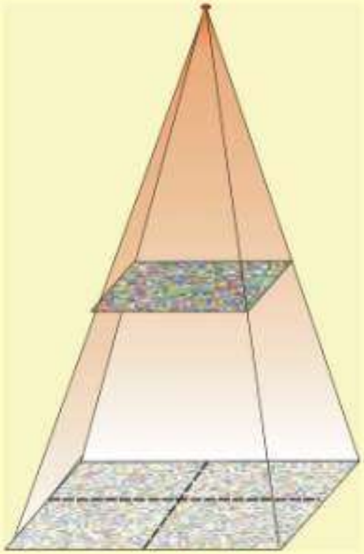


Sprawls


Twice the Distance
Photon Concentration
(Exposure)
decreased to 1/4th
X-ray beam now covers four times the area
Sprawls

Medical Physics Knowledge Structures

Sensory



Linguistic

The inverse-square law states that the exposure decreases inversely to the square of the distance from the source.

Quantative

$$E_2 = E_1/(d_2/d_1)^2$$

Sprawls

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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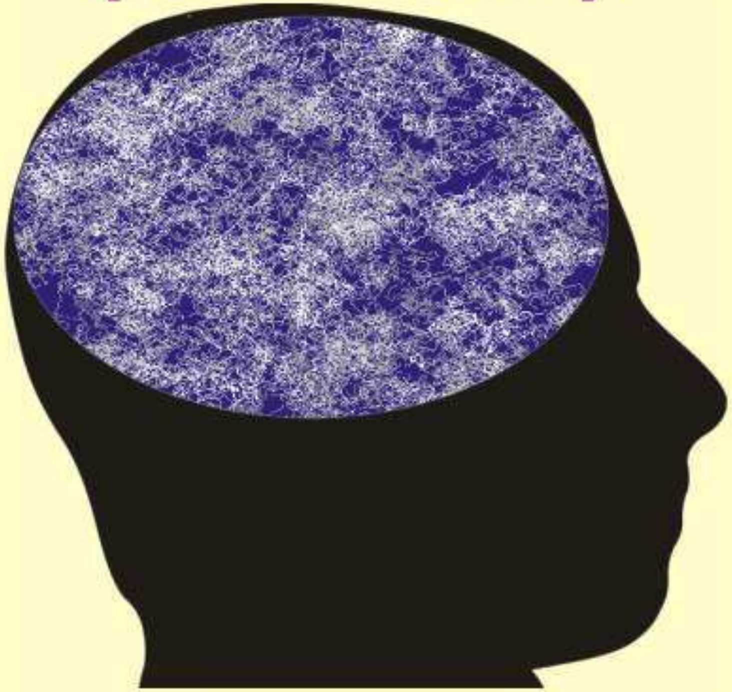
What do they need?

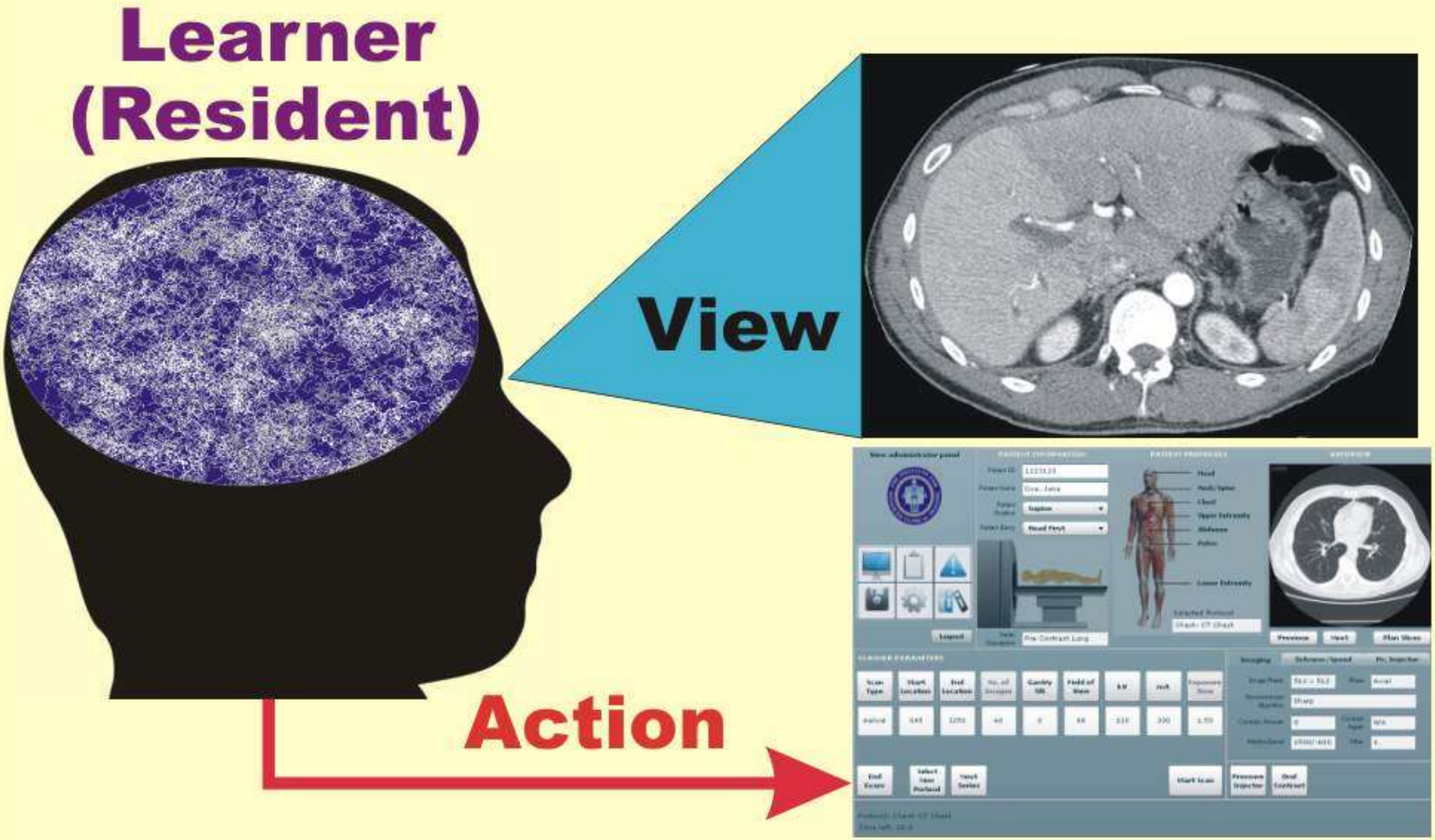
Learner (Resident)



Optimize CT image quality and manage dose.

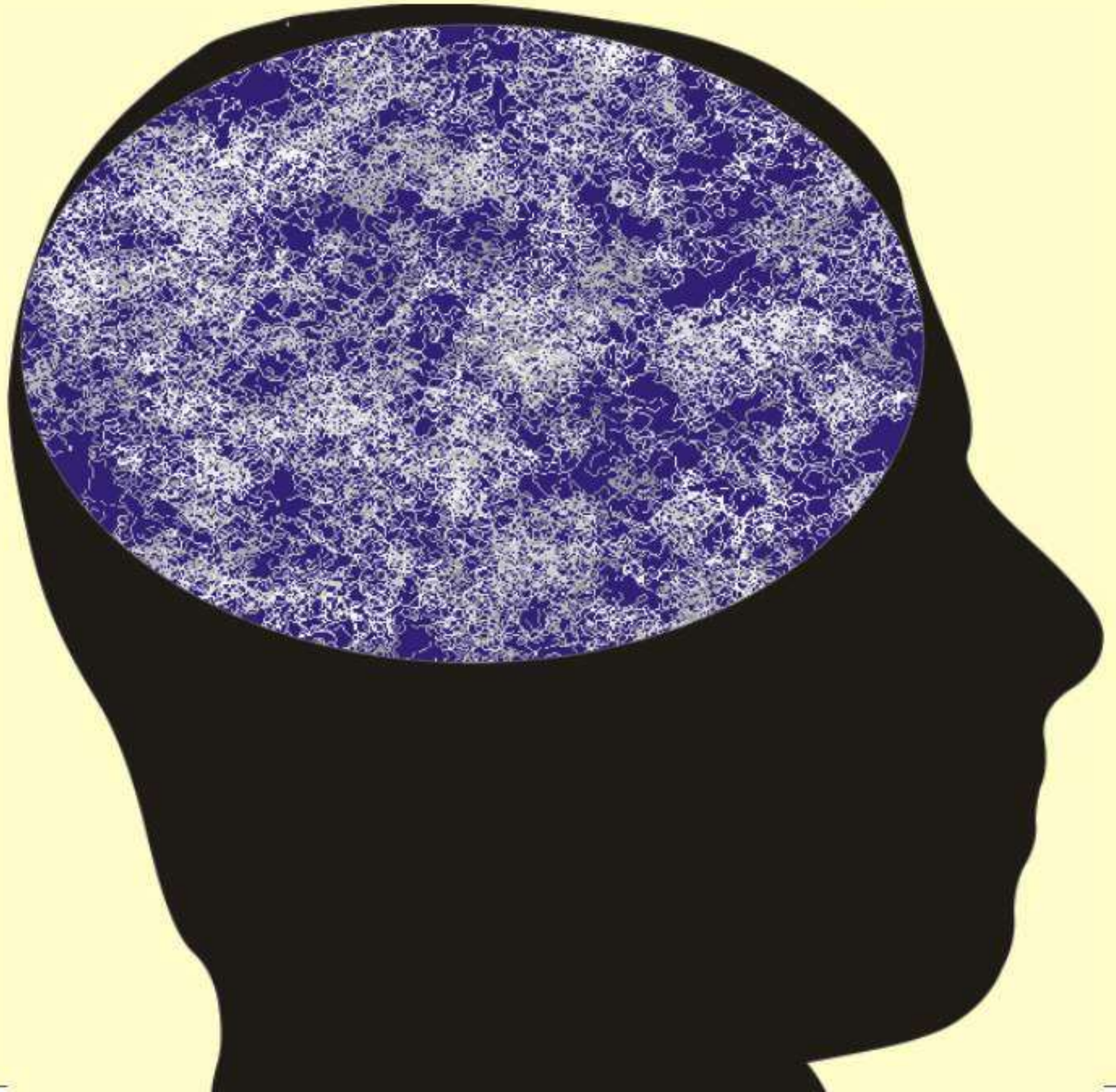
Sprawls

What do they need to DO?



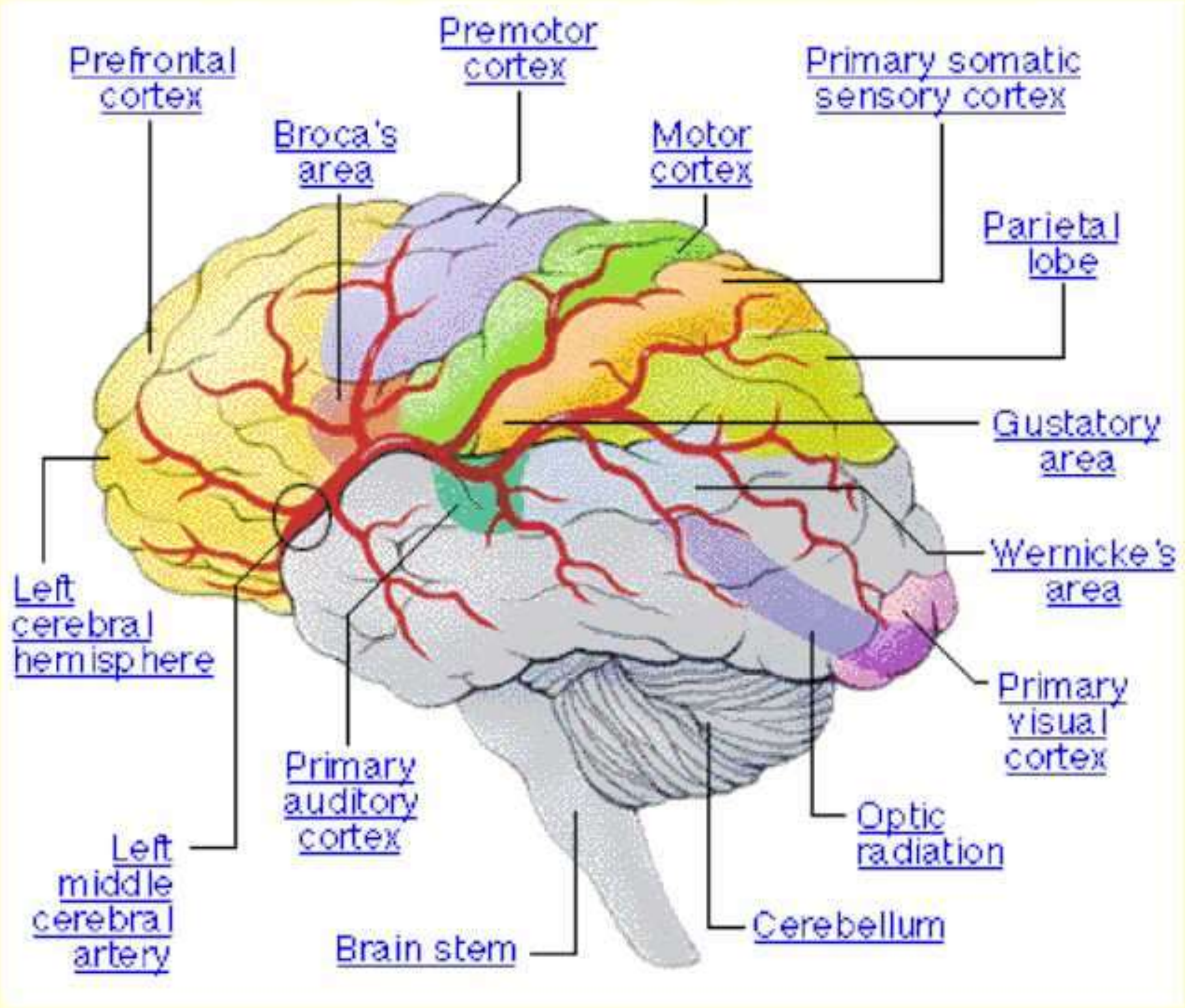
Sprawls

Your Mind



Sprawls

The Brain...



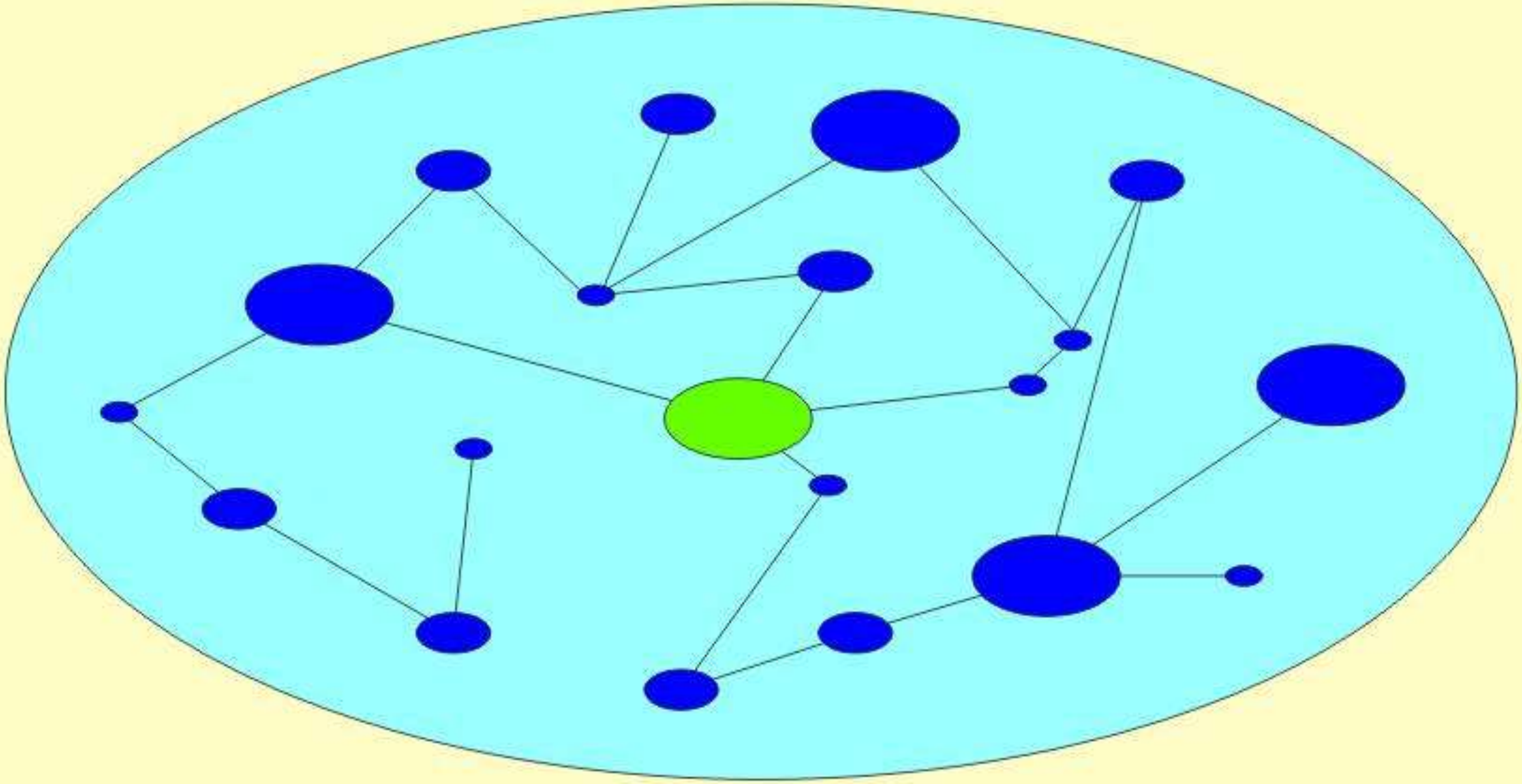
Structure and Function

Image: AMA

Sprawls

Knowledge Structures in the Brain

A Complex Network



Concepts

Images

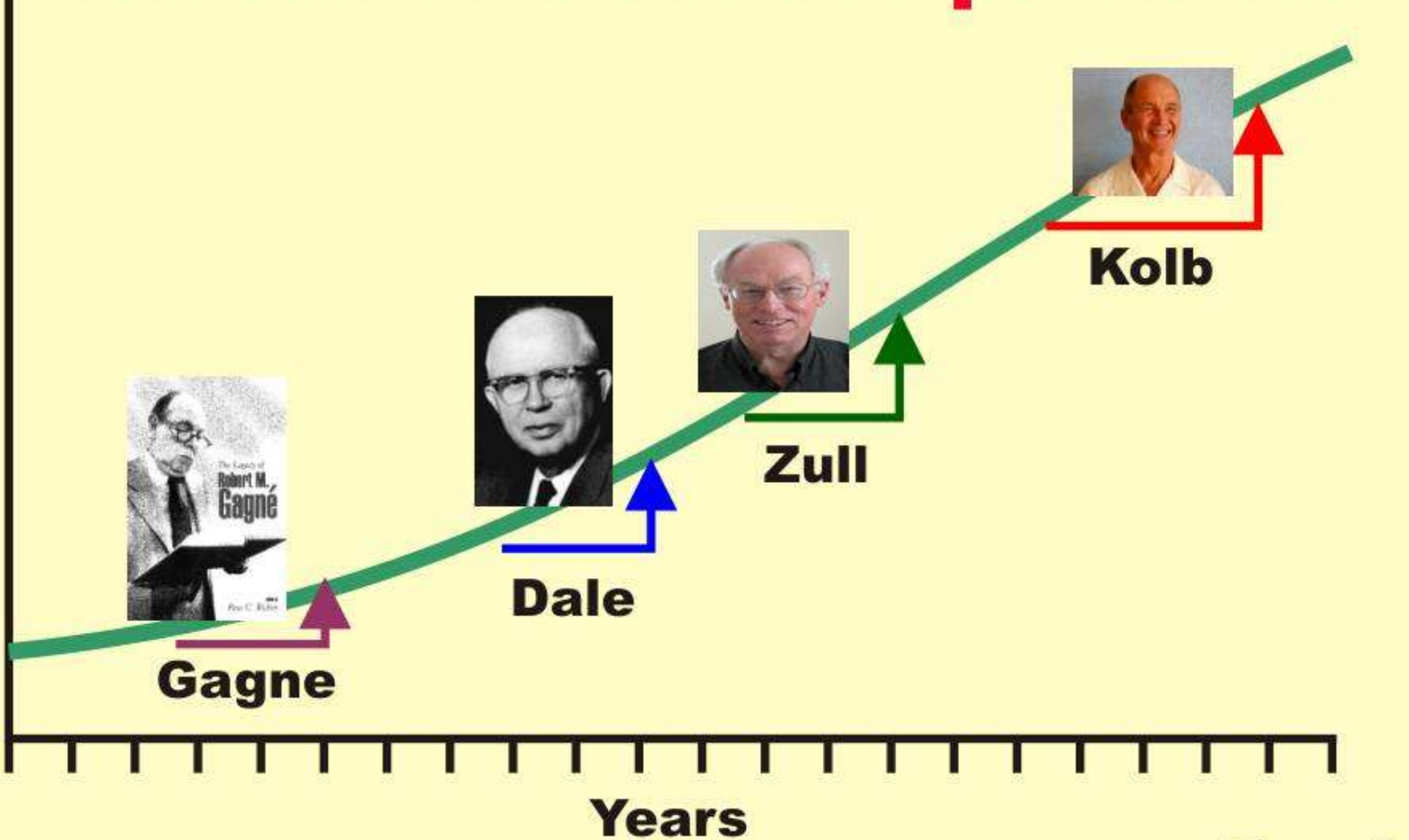
Language

Facts

Sprawls

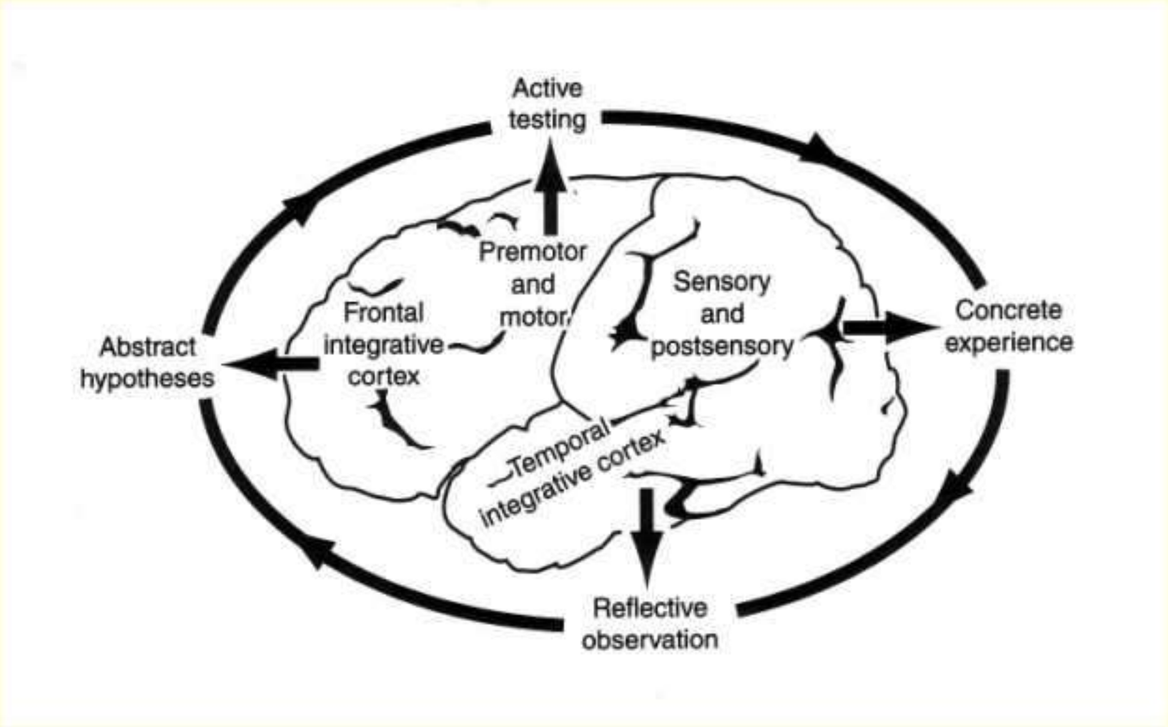
Knowledge of the Learning & Teaching Process

We learn from the pioneers



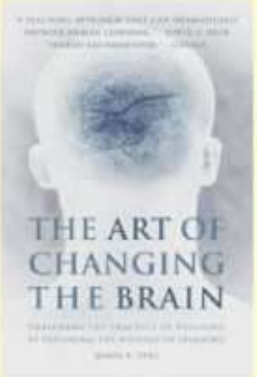
Sprawls

Zull's Model of Brain Function

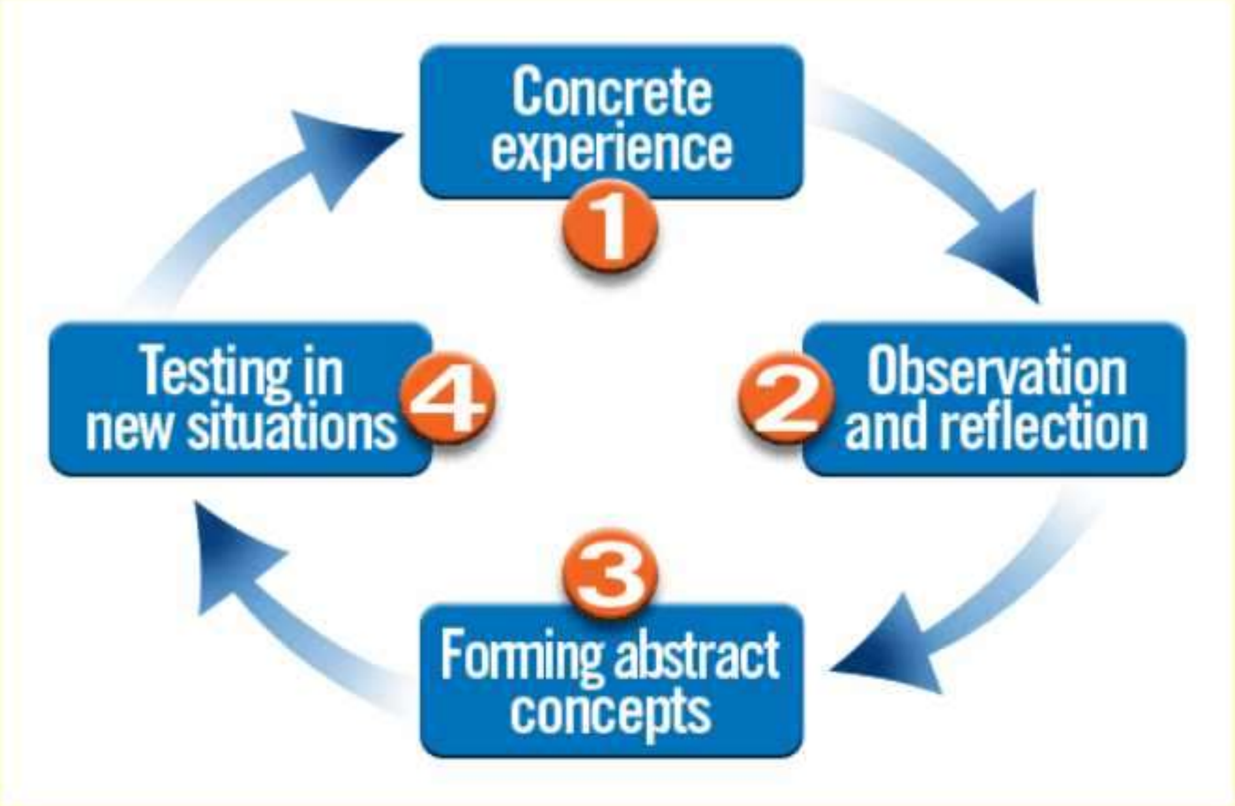


James Zull, Ph.D.
Professor of Biology
Professor of Biochemistry
Director of University Center for Innovation in Teaching and Education
Case Western Reserve

Reference:



Kolb's Experiential Learning Model



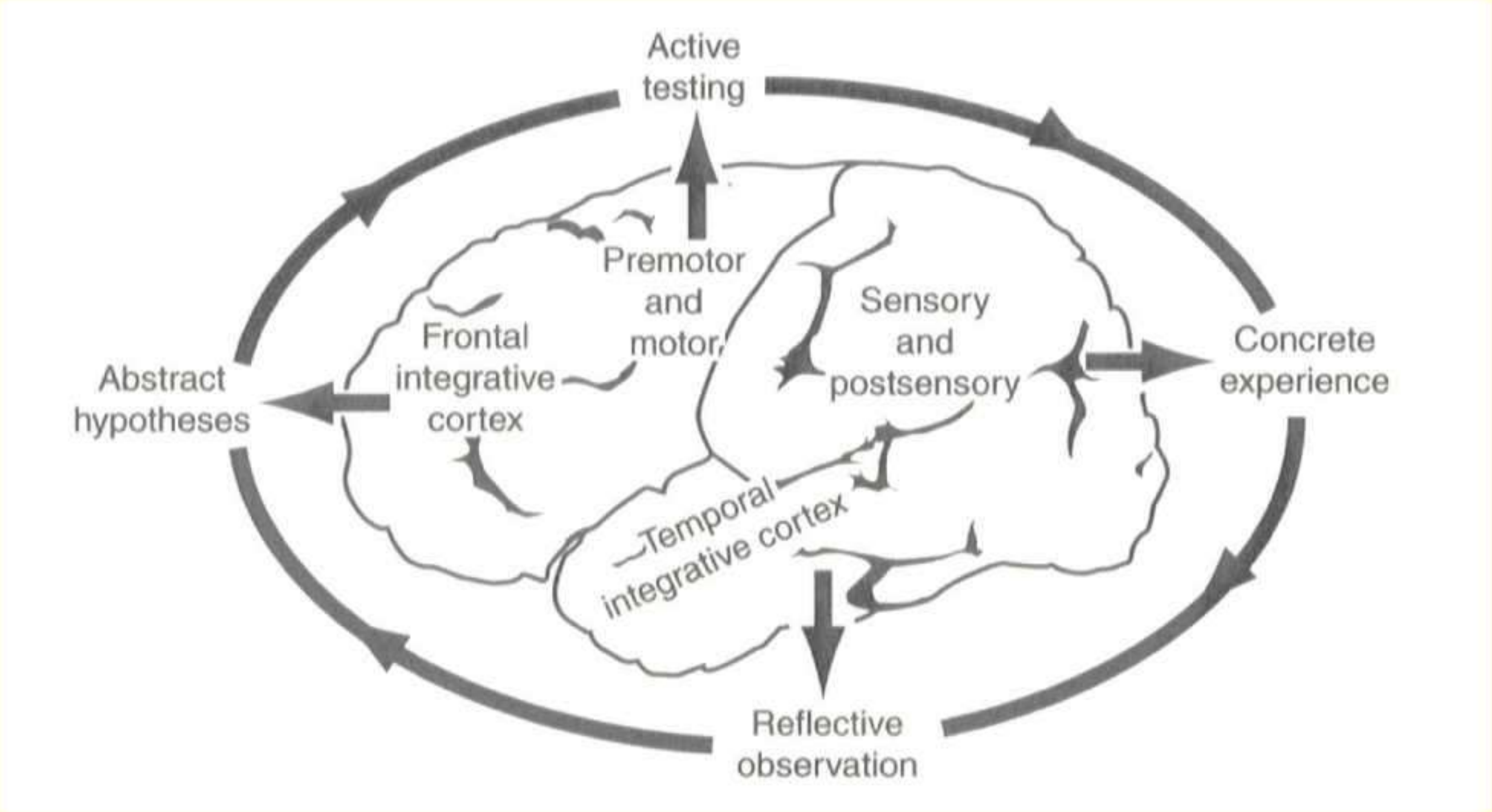
David A. Kolb, Ph.D.

Professor of Organizational Behavior

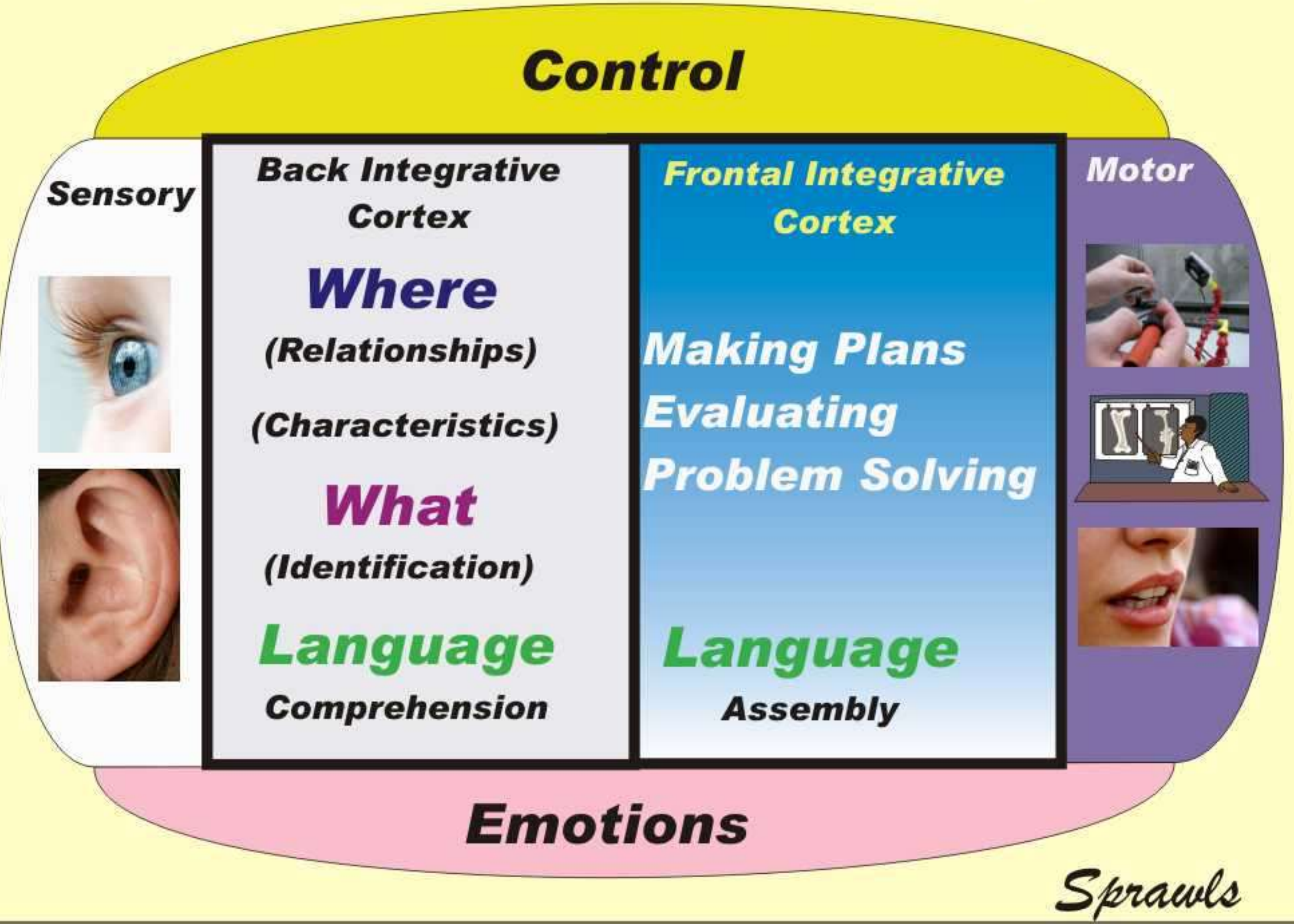
Case Western Reserve

Website: http://www.learningfromexperience.com

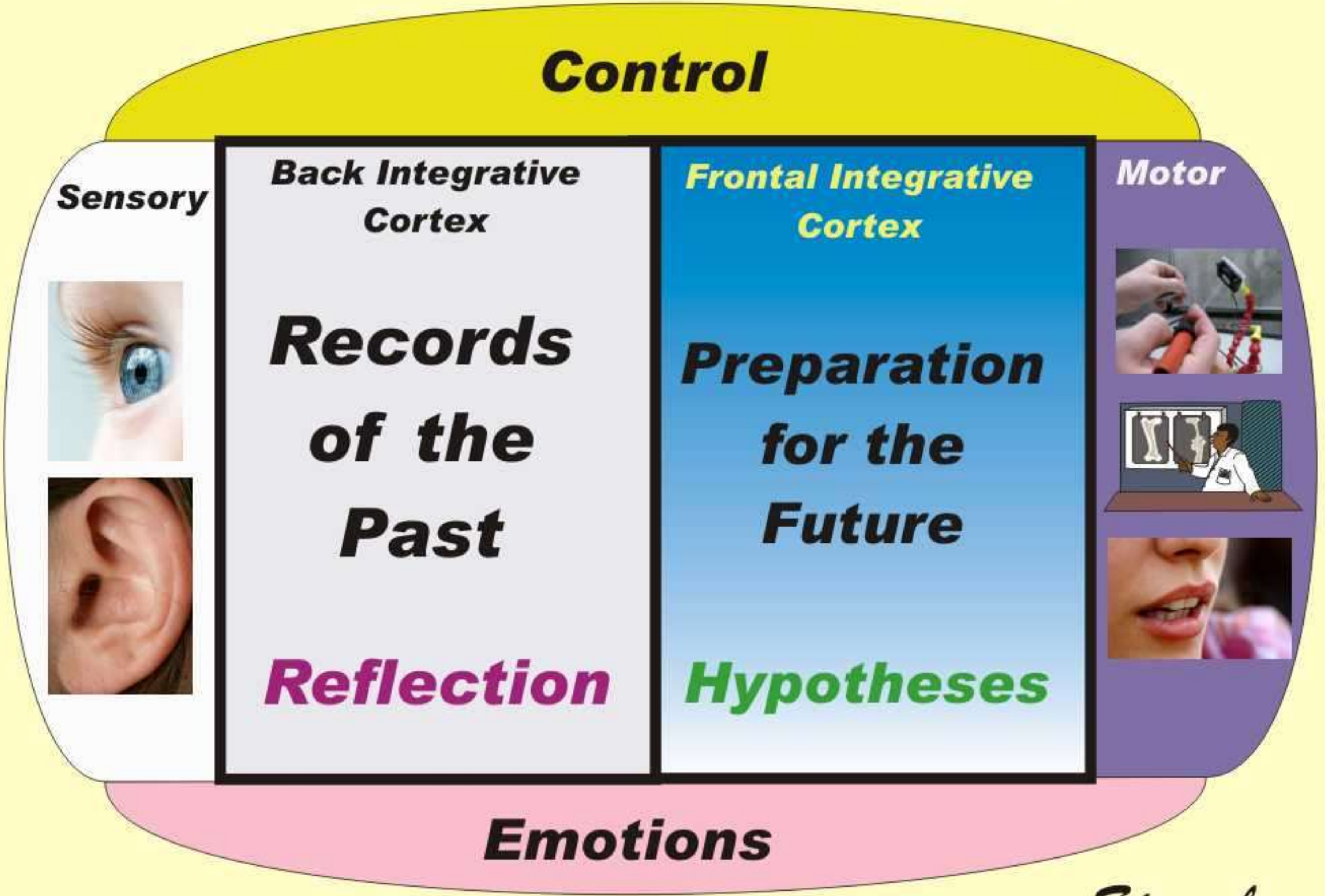
Zull's Model of Brain Function



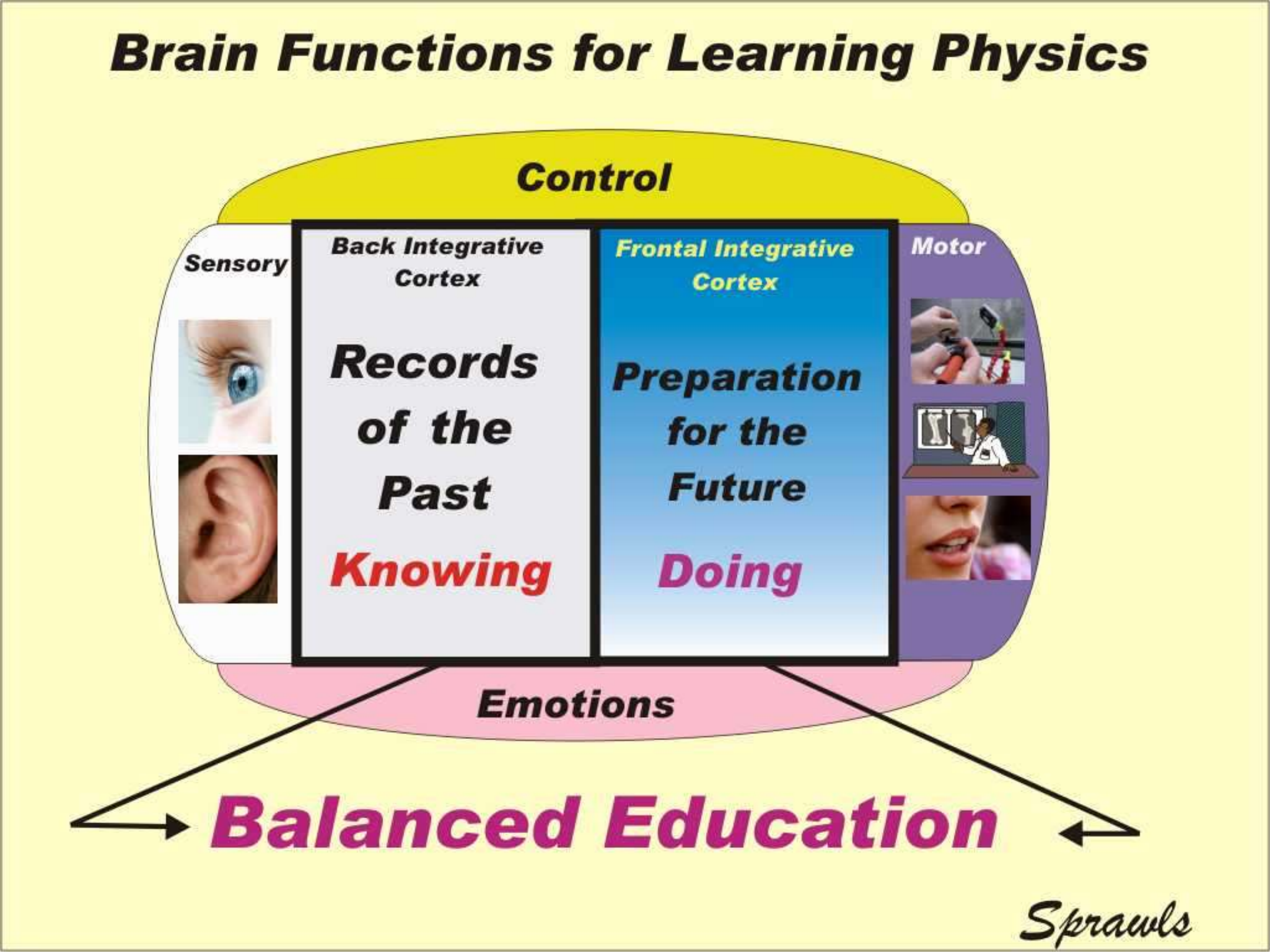
Brain Functions for Learning Physics



Brain Functions for Learning Physics



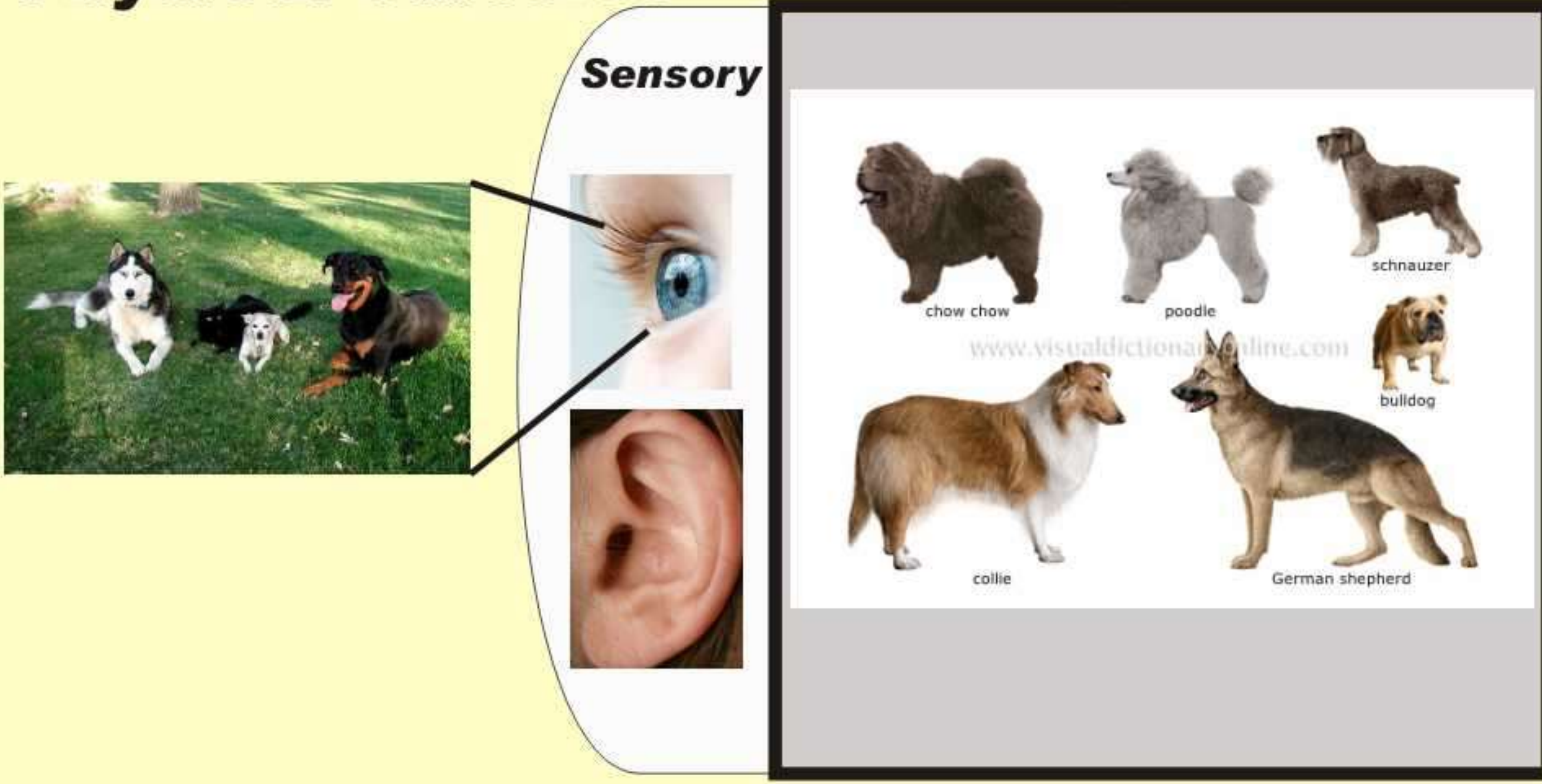
Sprawls


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

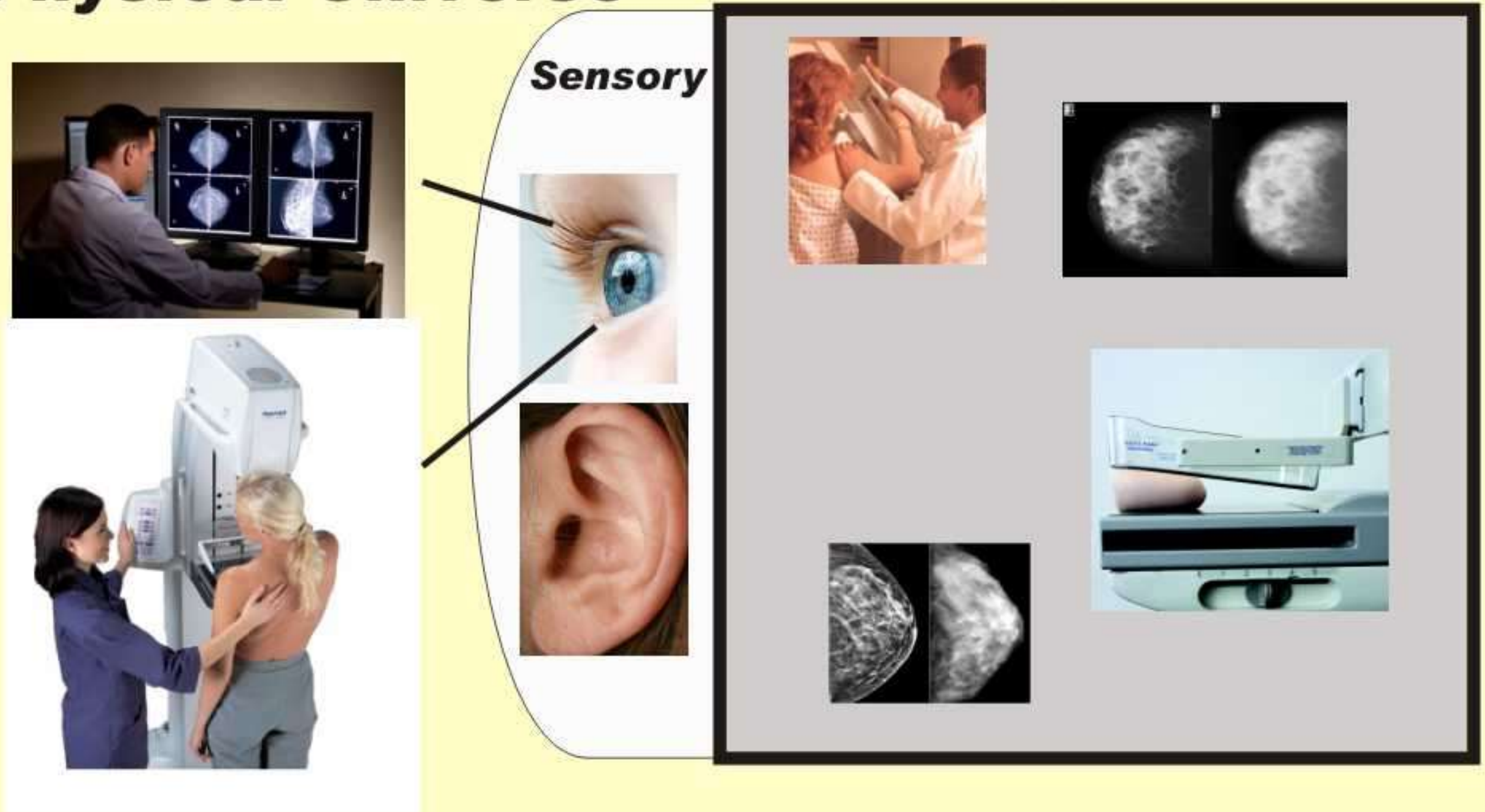


Visible Physical Objects

Sprawls

Forming Knowledge Structures

Physical Universe **Back Integrative Cortex**



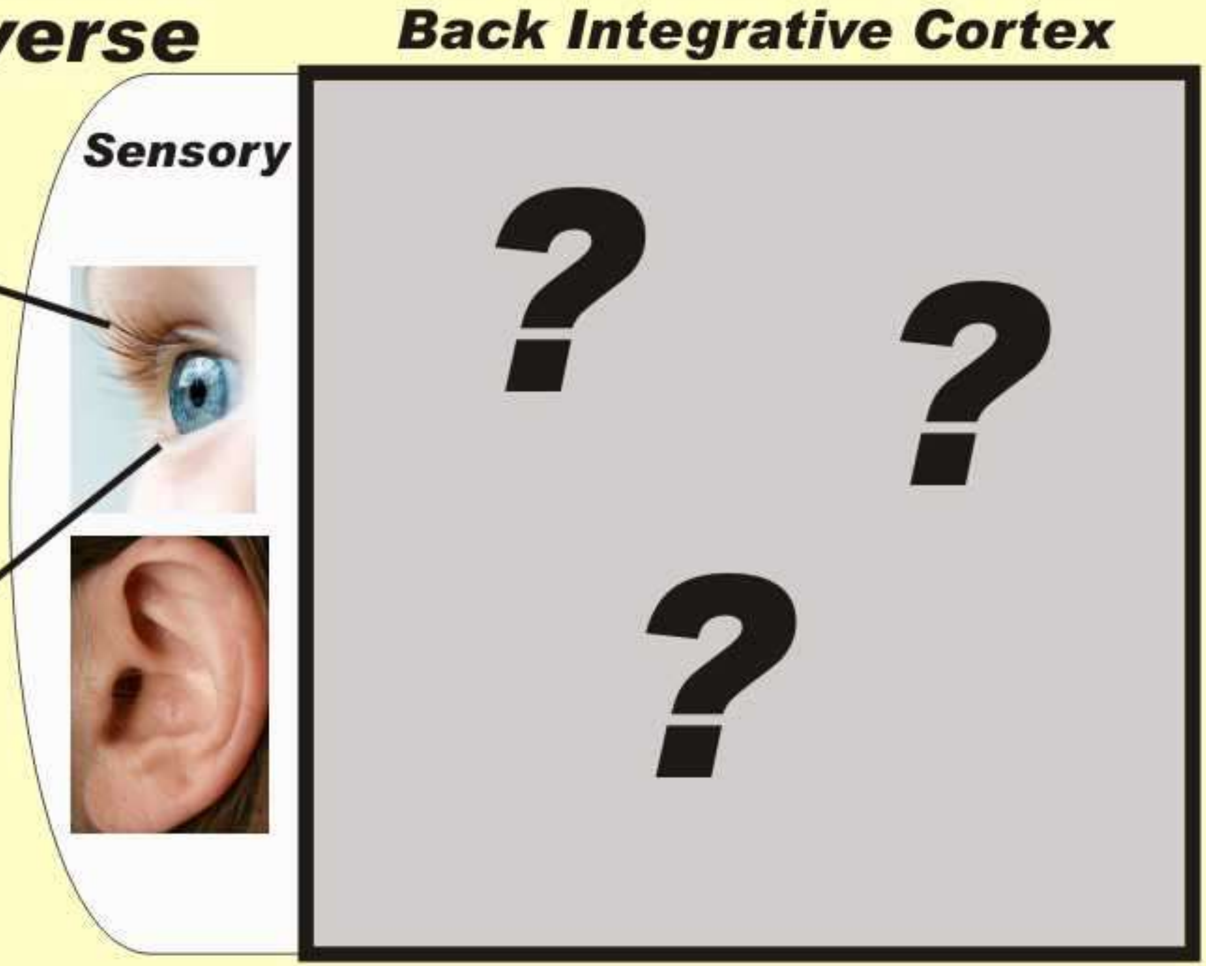
Visible Physical Objects

Sprawls

Forming Knowledge Structures

Physical Universe

Radiation
Electrons
Magnetic
Atomic
Nuclear



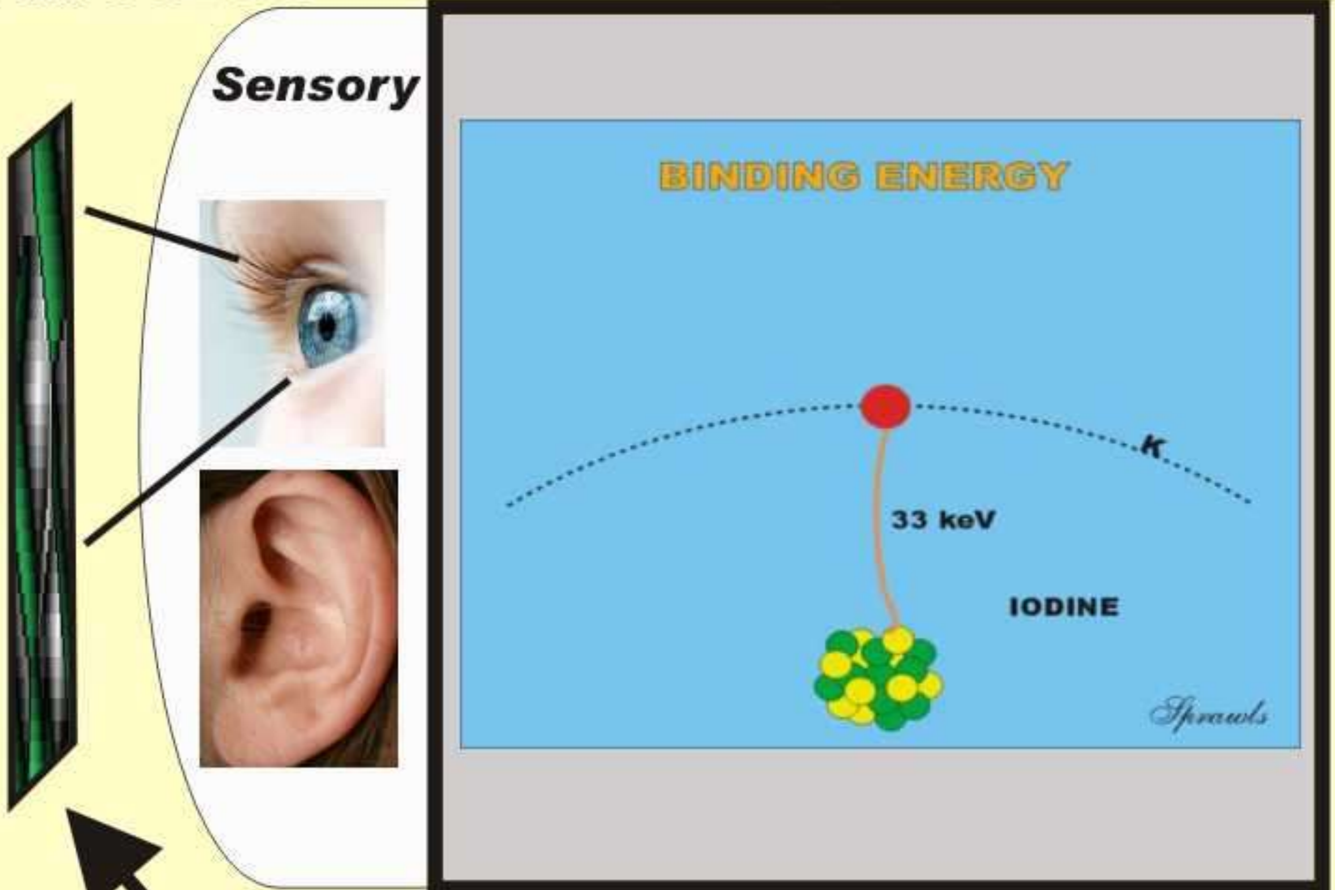
Invisible Physical Objects

Sprawls

Forming Knowledge Structures

Physical Universe

Back Integrative Cortex



Radiation
Electrons
Magnetic
Atomic
Nuclear

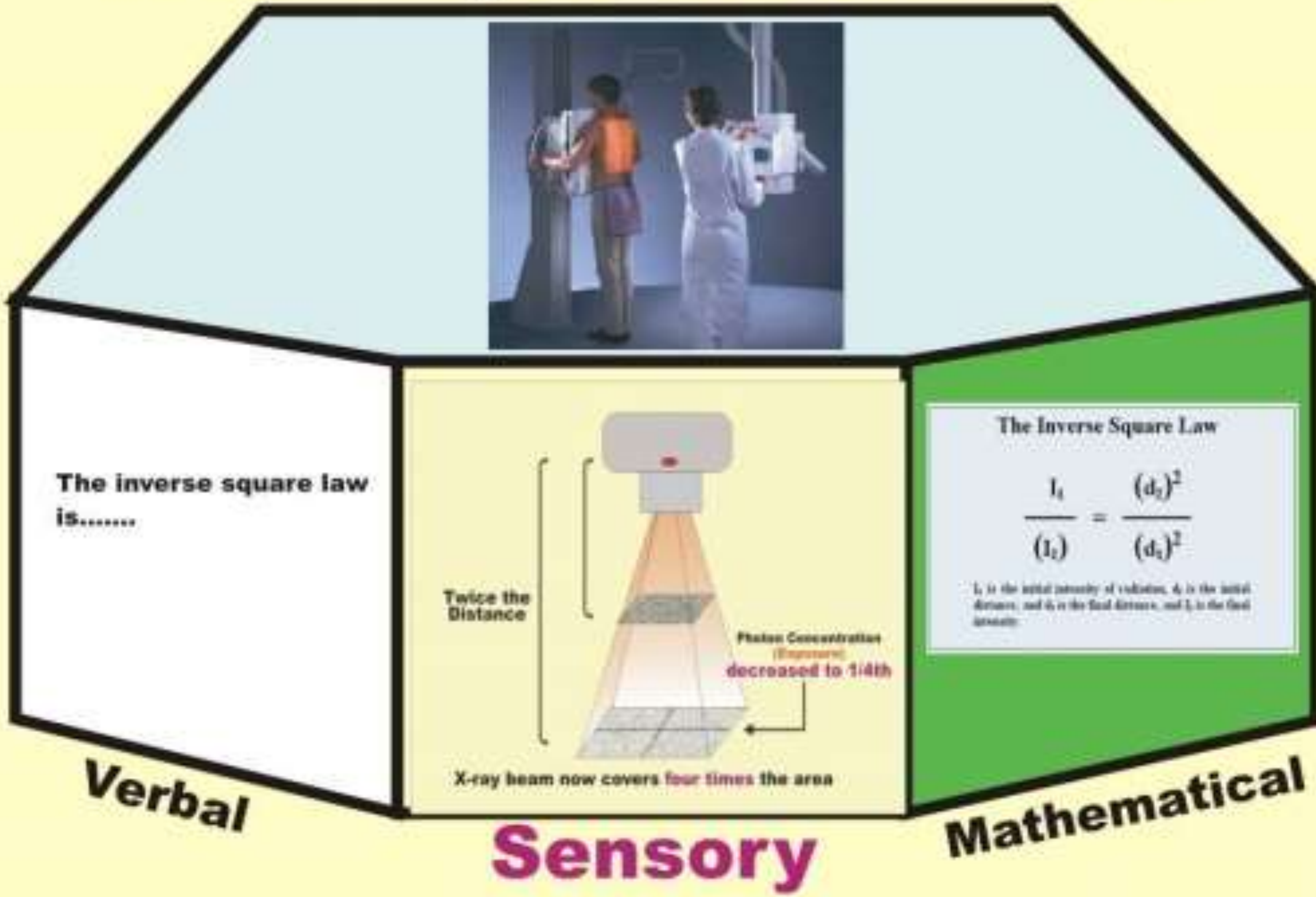
Invisible

Visuals

Physical Objects

Sprawls

The Physical Universe



Sprawls

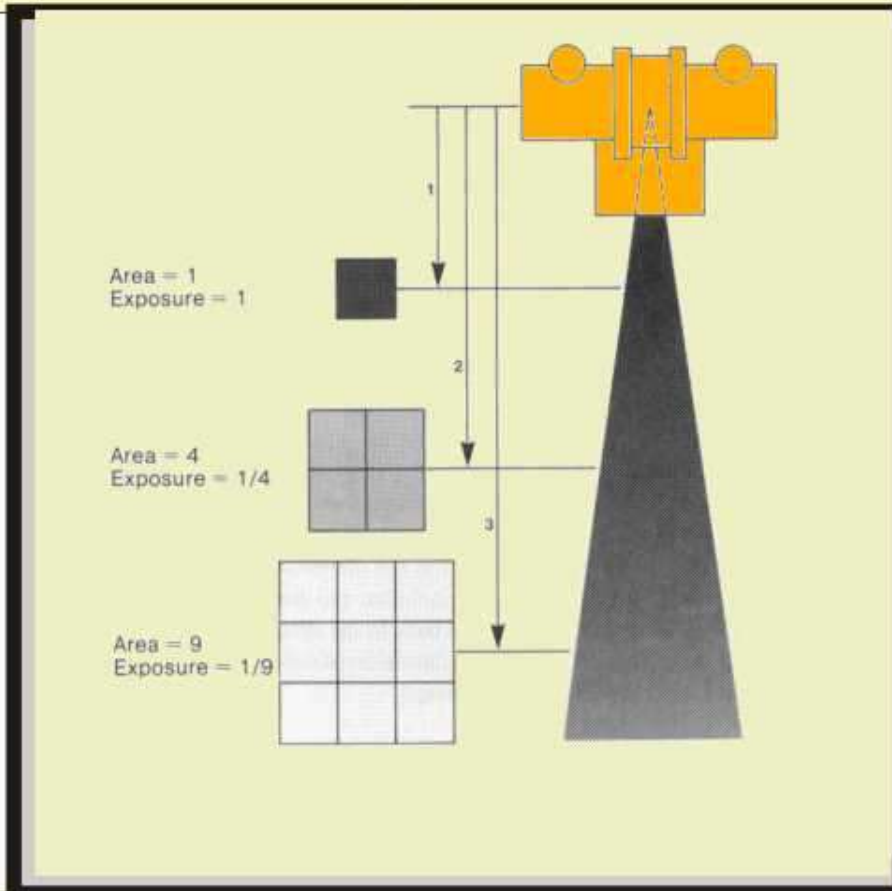
Forming Knowledge Structures

Physical Universe

Back Integrative Cortex

Inverse Square Effect

Sensory



Invisible

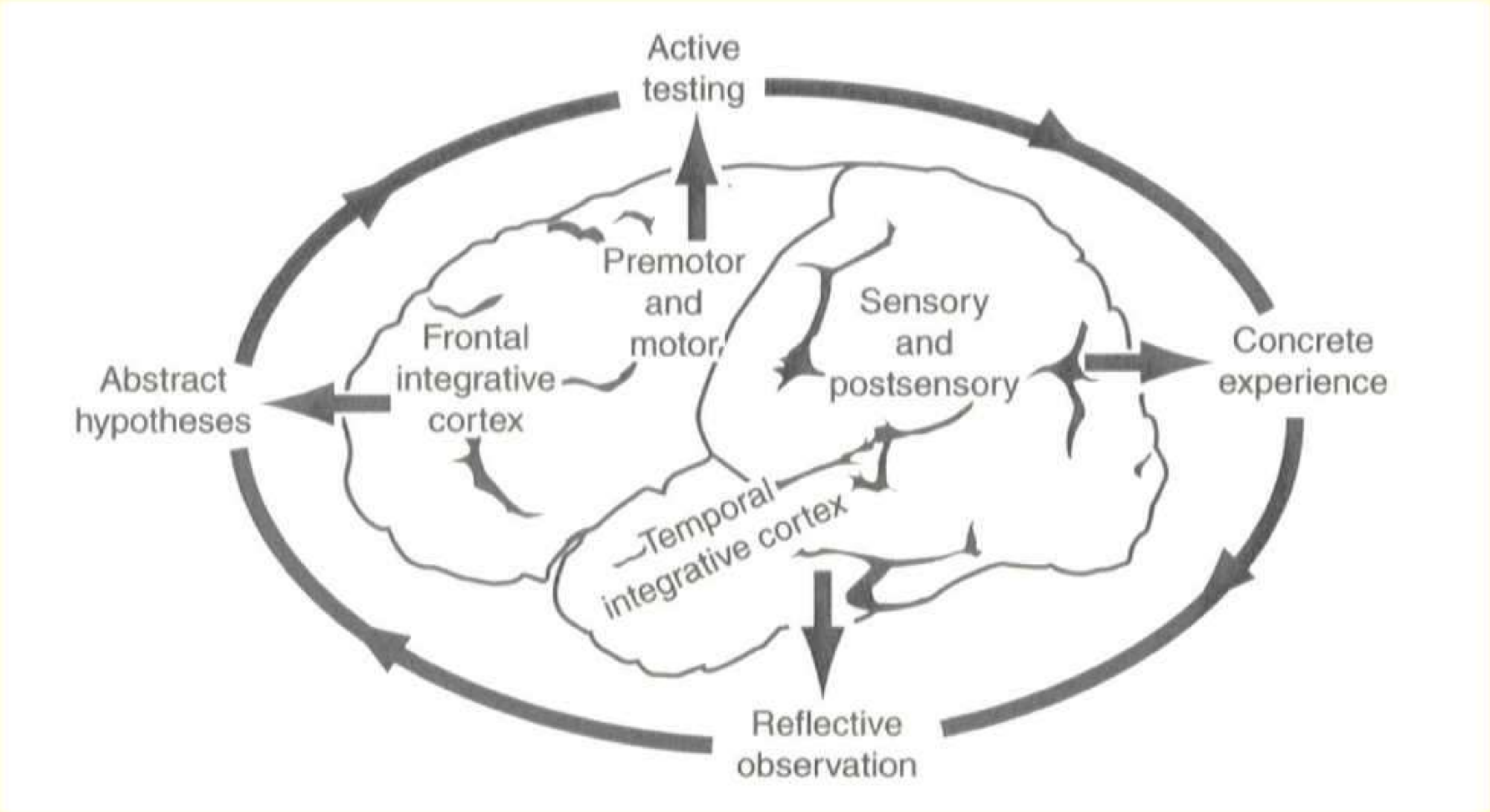
Concepts

Ideas

Visuals

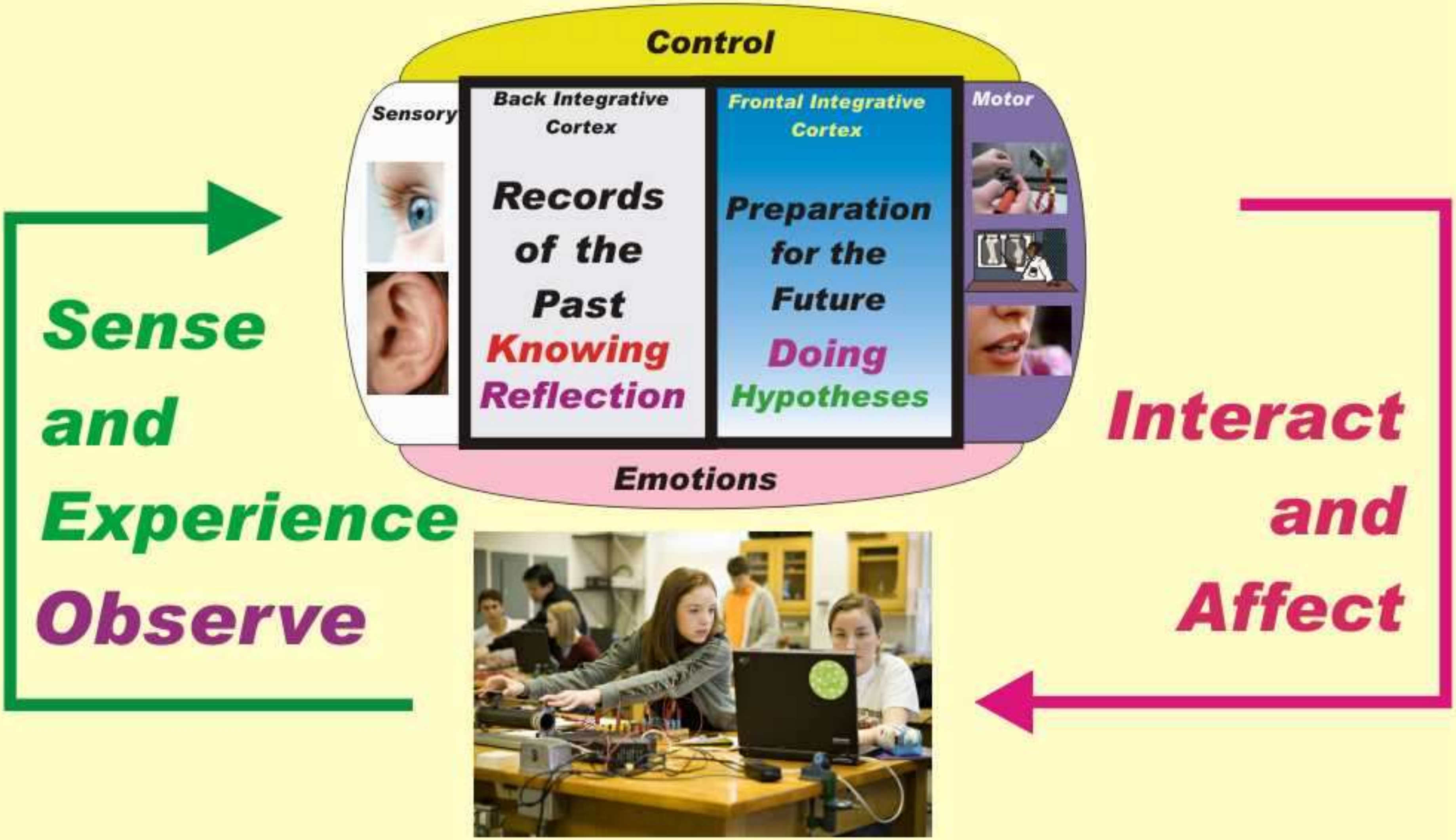
Sprawls

Zull's Model of Brain Function



Brain Functions for Learning Physics

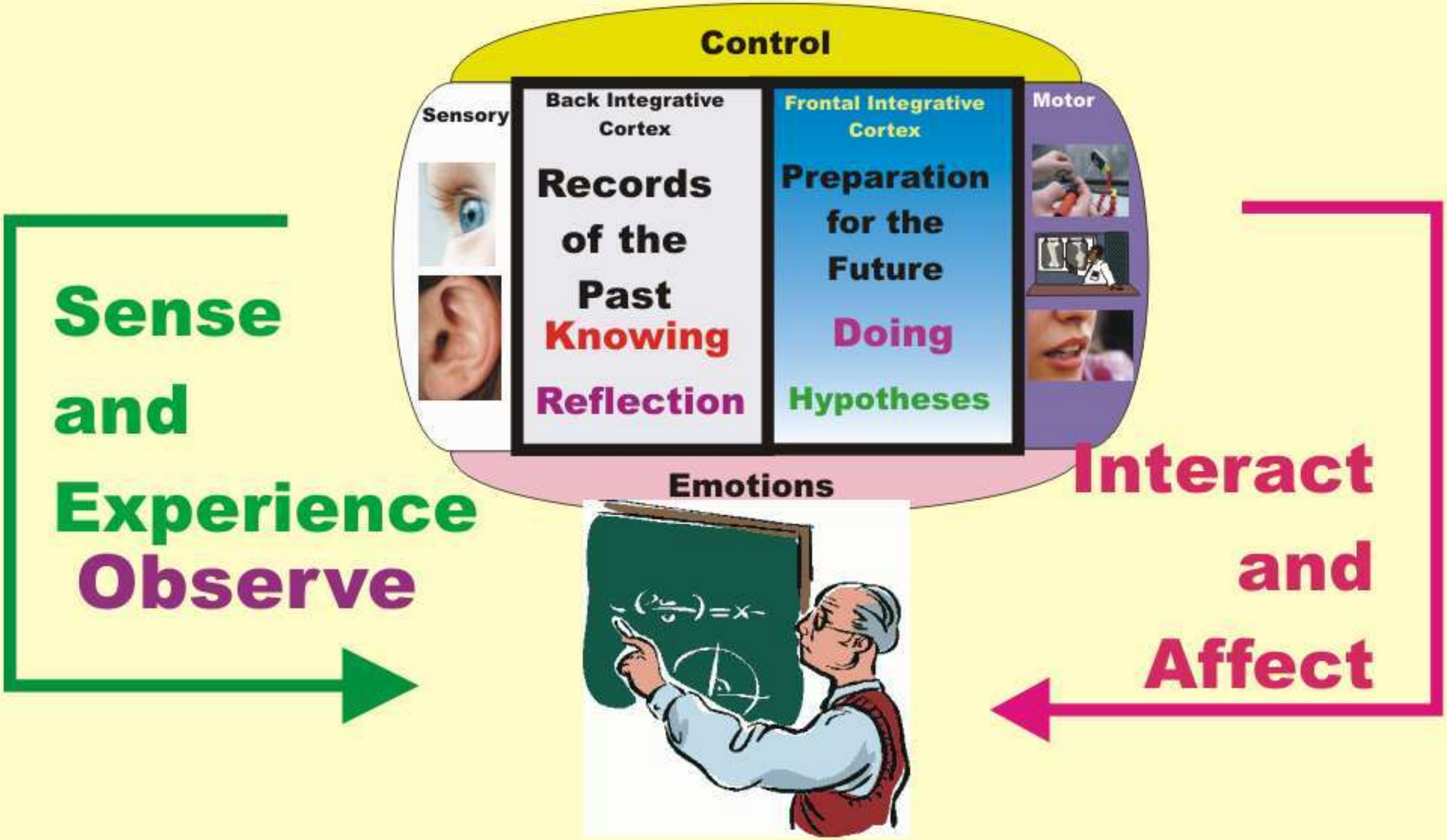
Active Experimentation and Testing



Physical Universe

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

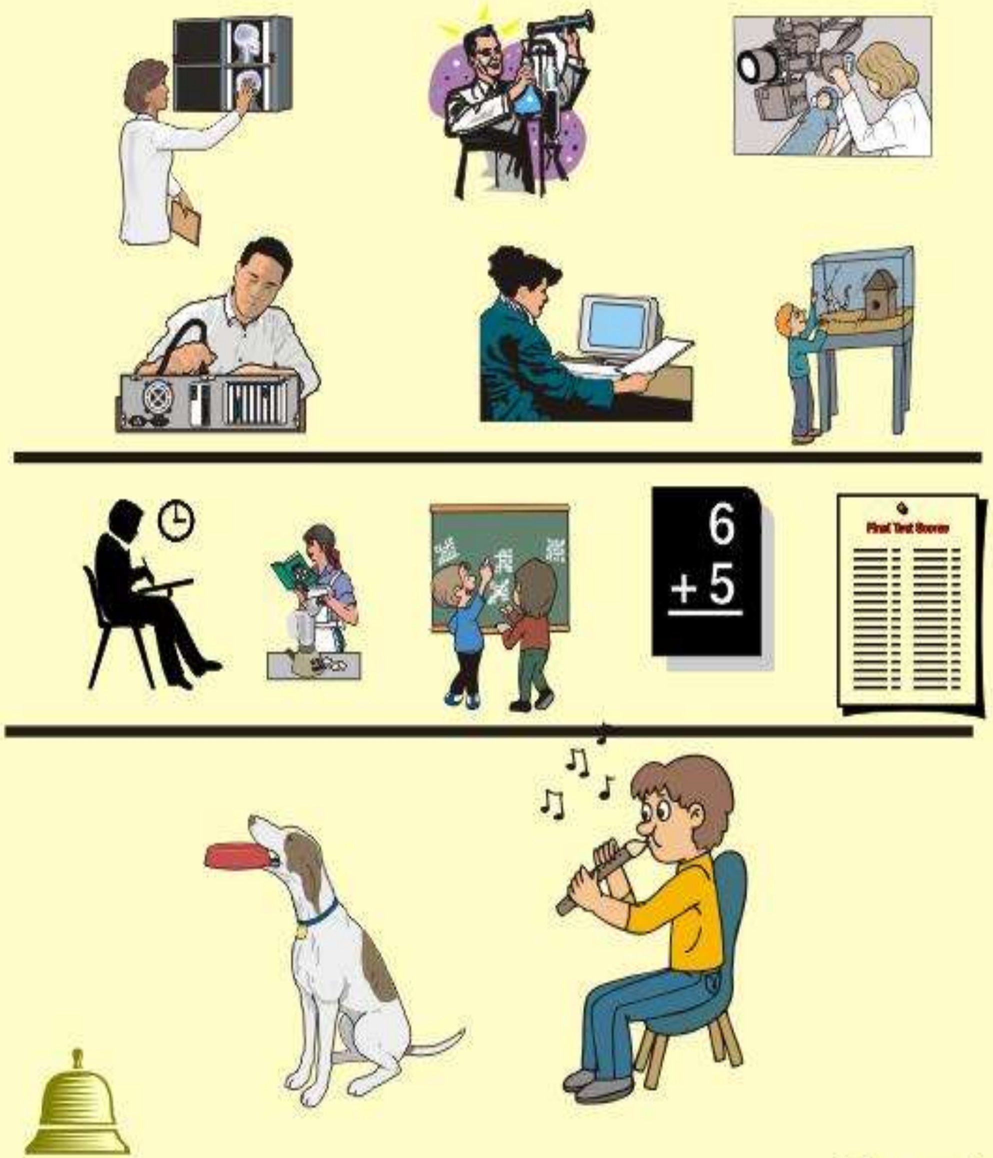
Gagné was also well-known for his sophisticated stimulus-response theory of eight kinds of learning which differ in the quality and quantity of stimulus-response bonds involved. From the simplest to the most complex, these are:

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

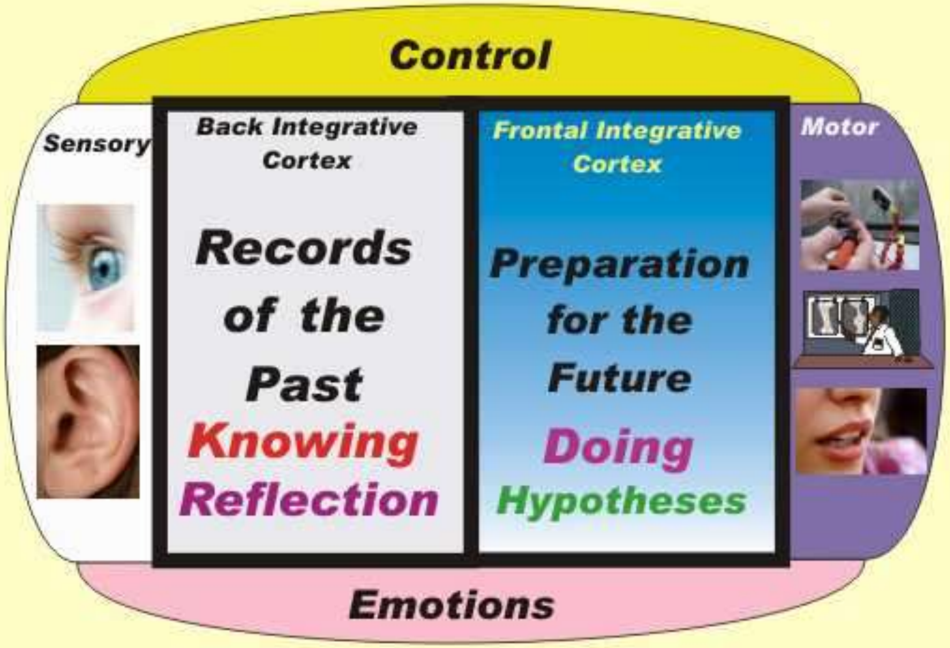
Gagne's Hierarchy of Learning

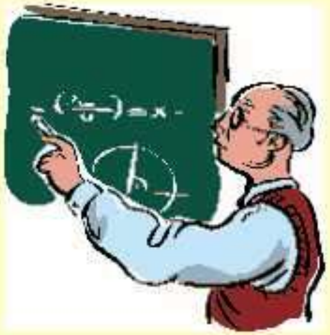
- PROBLEM SOLVING
- RULE LEARNING
- CONCEPT LEARNING
- DISCRIMINATION LEARNING
- VERBAL ASSOCIATION
- CHAINING
- STIMULUS RESPONSE
- SIGNAL LEARNING



Sprawls

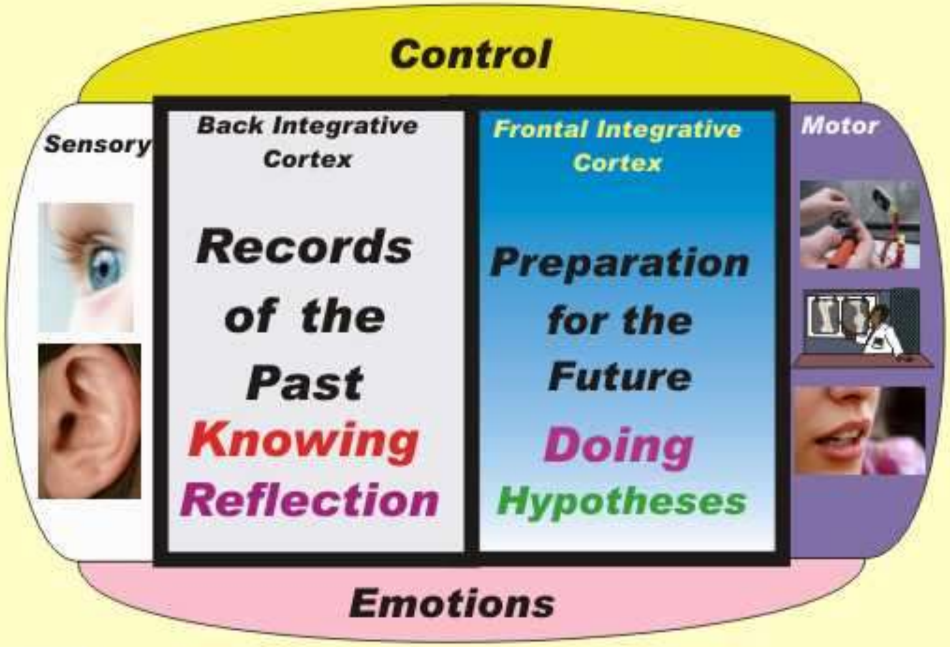
Challenging Learning Environments





Sprawls

Rich Learning Environments

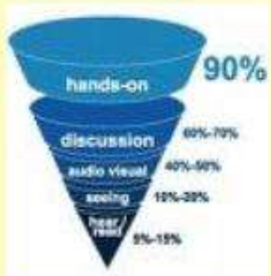


Sprawls

Edgar Dale (1900-1985)

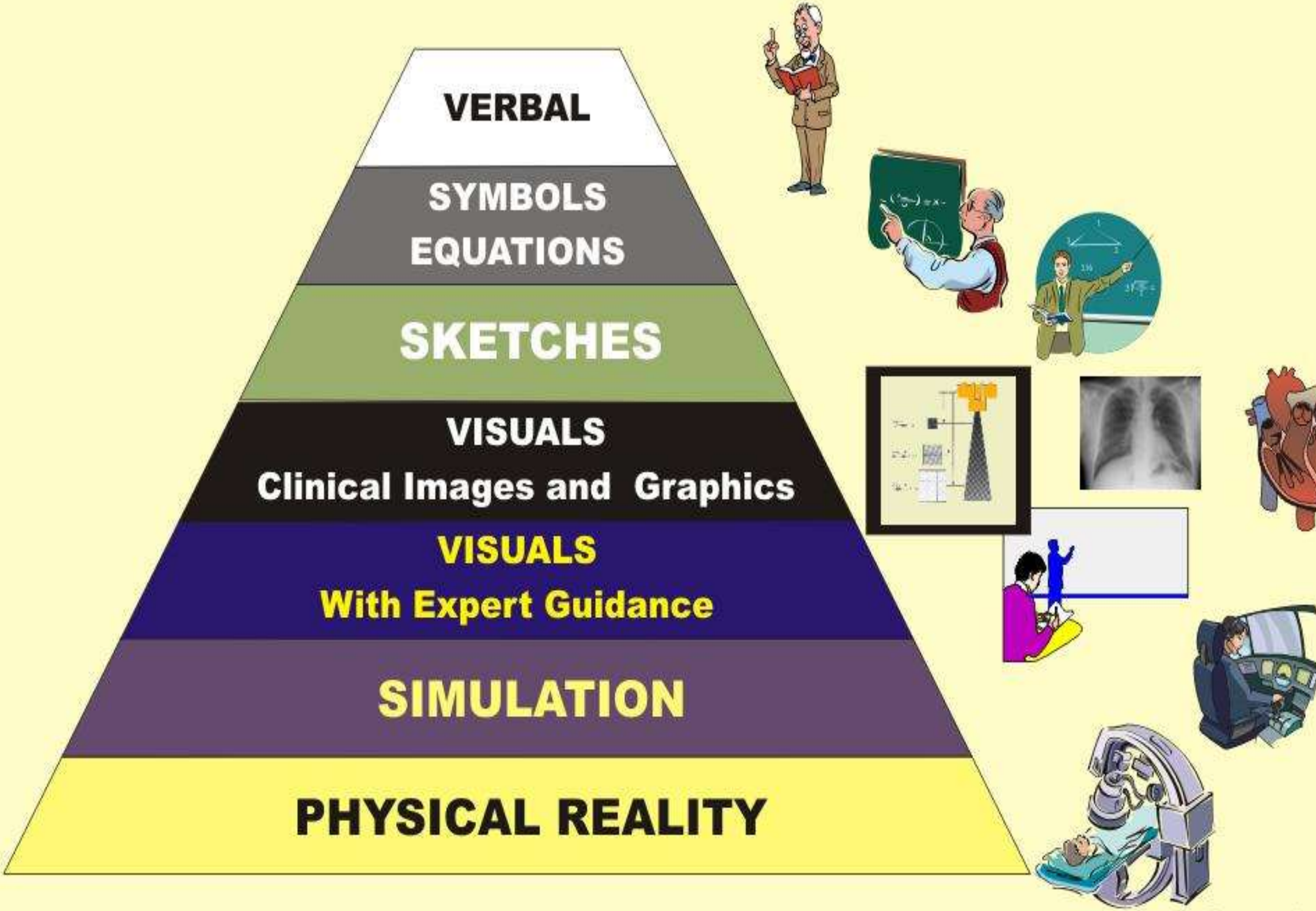
Educationalist who developed the famous

Cone of Experience theory



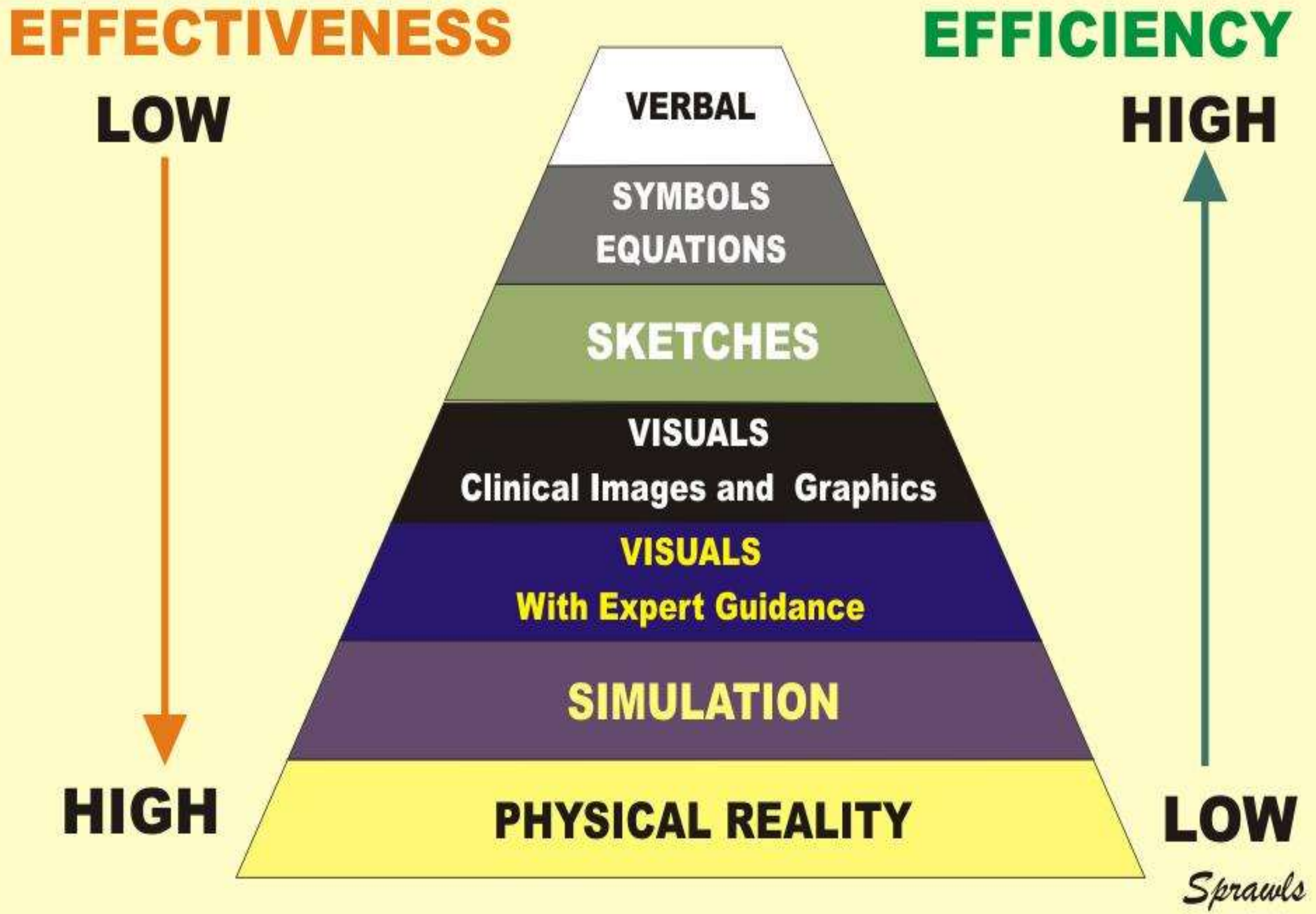
Sprawls

Cone of Experience for Medical Imaging Education

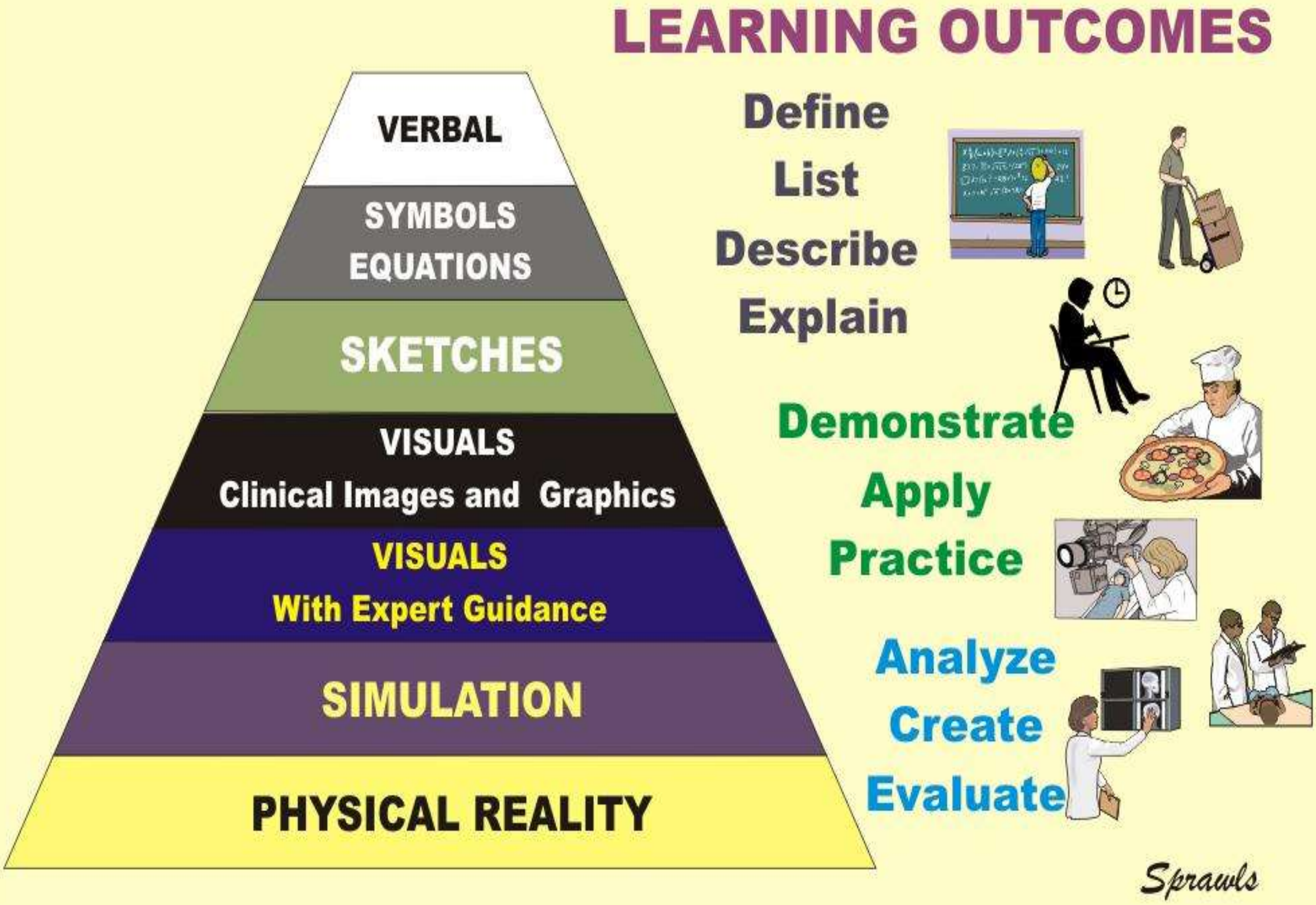


Sprawls

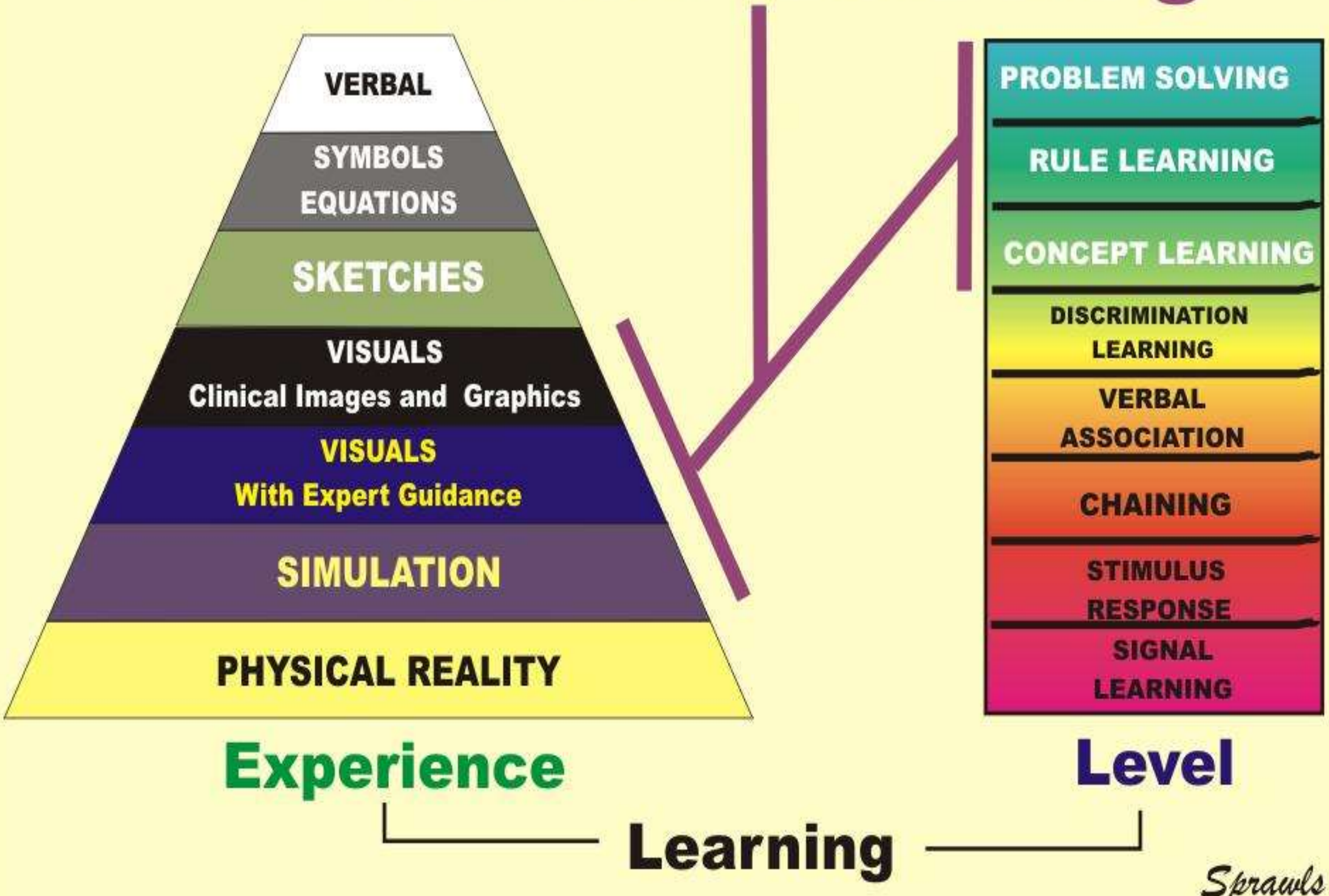
Cone of Experience for Medical Imaging Education



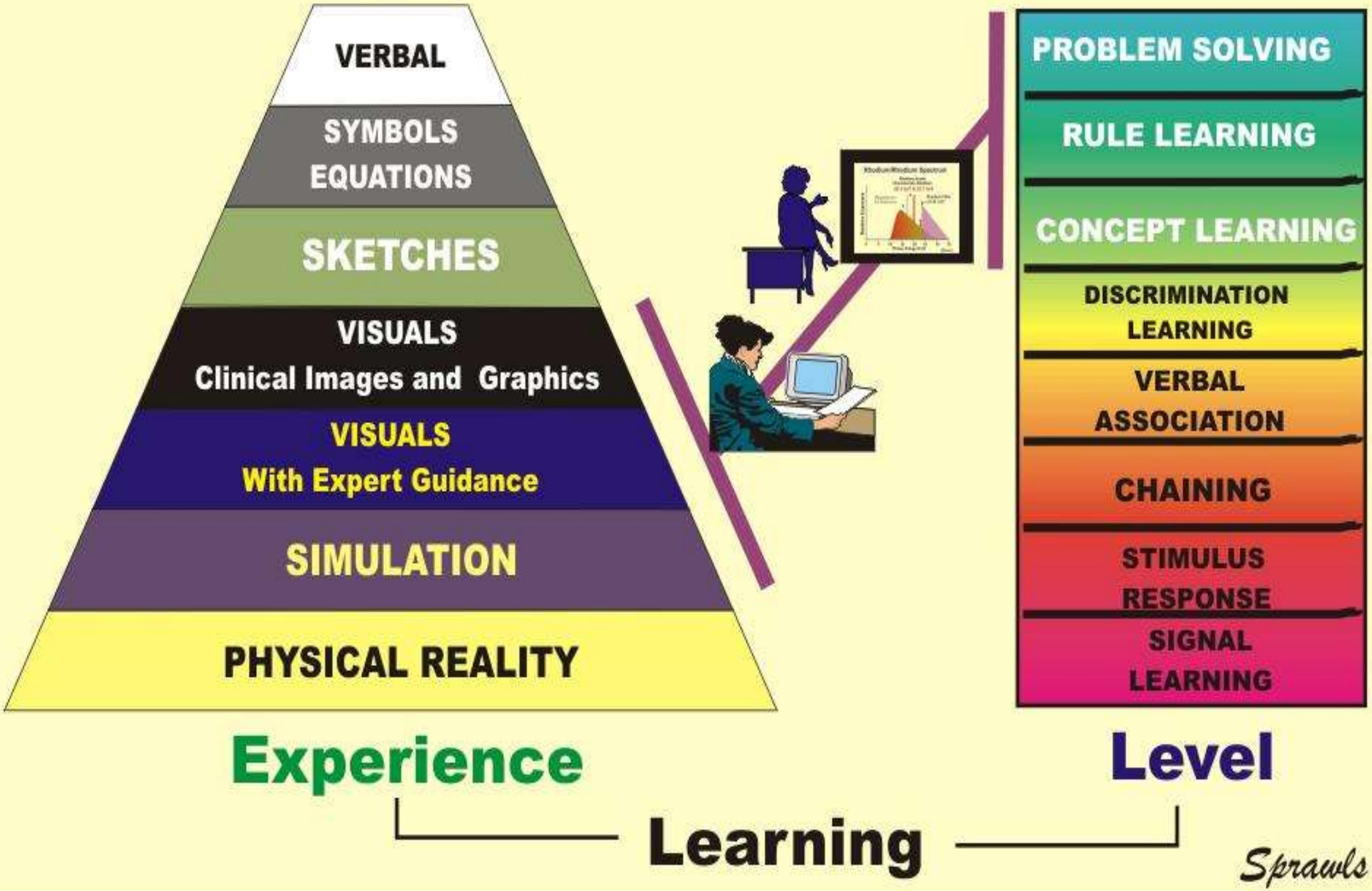
Cone of Experience for Medical Imaging Education



Effective Learning



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

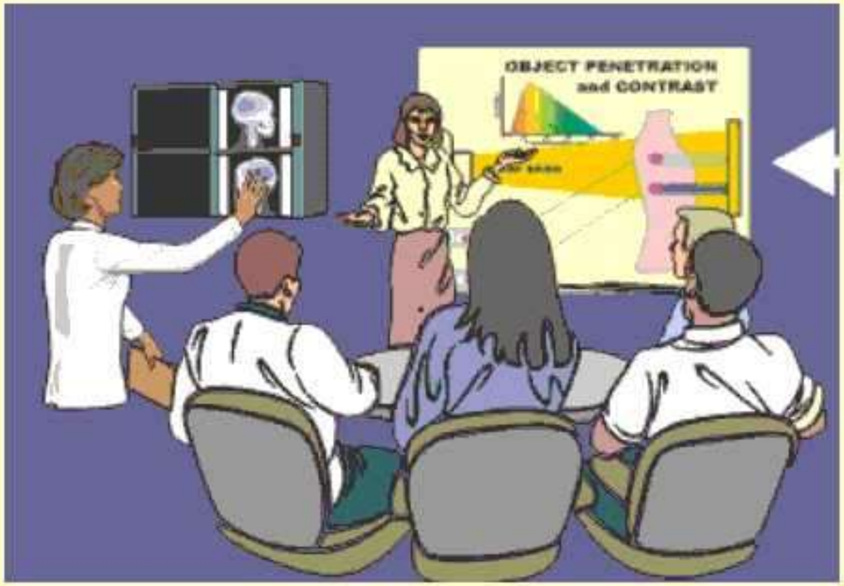
Visuals Images Online Modules

Resources and References

Sprawls

Rich Classroom and Conference Learning Activities

Learning Facilitator "Teacher"



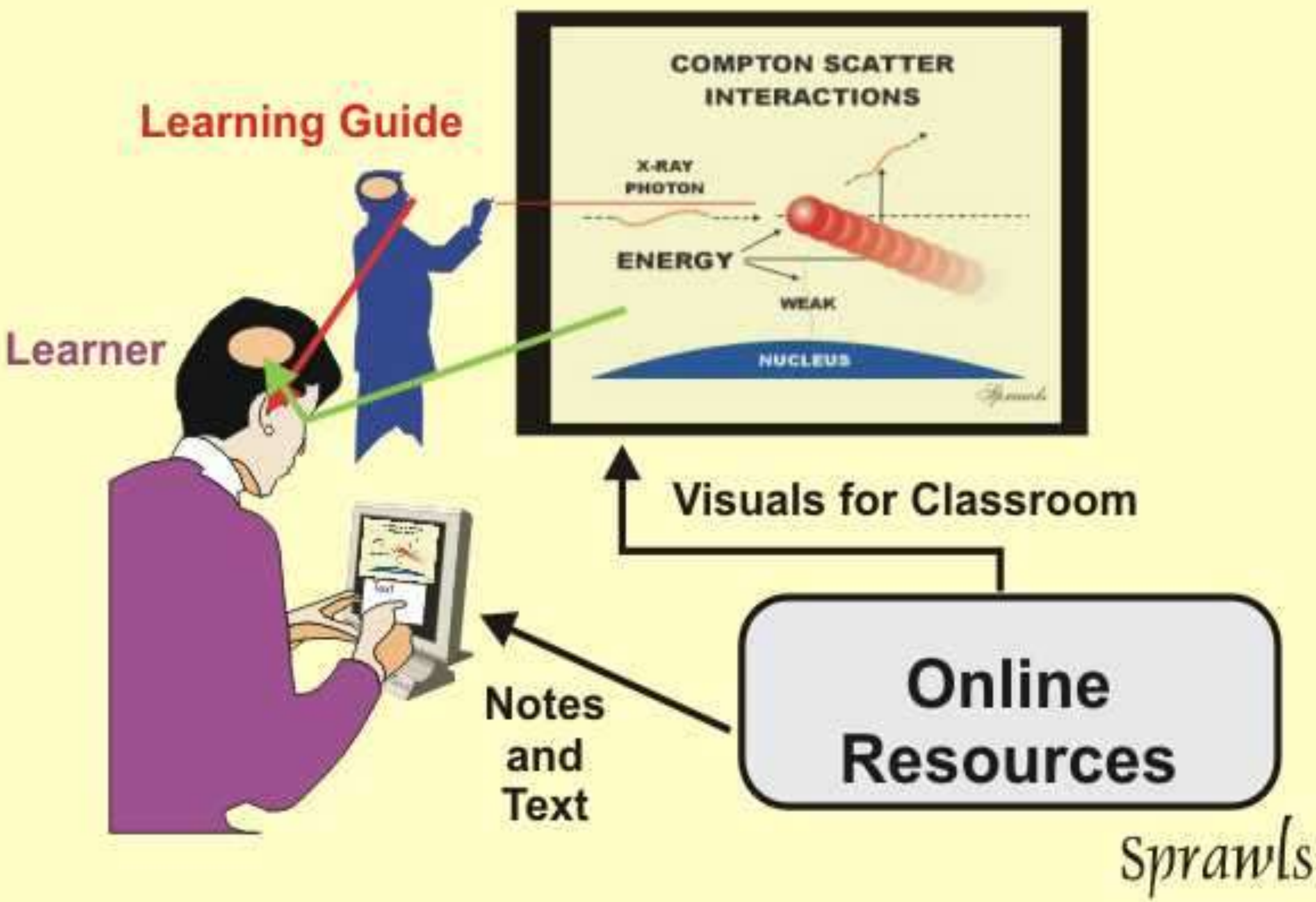
Visuals

Representations of Reality

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

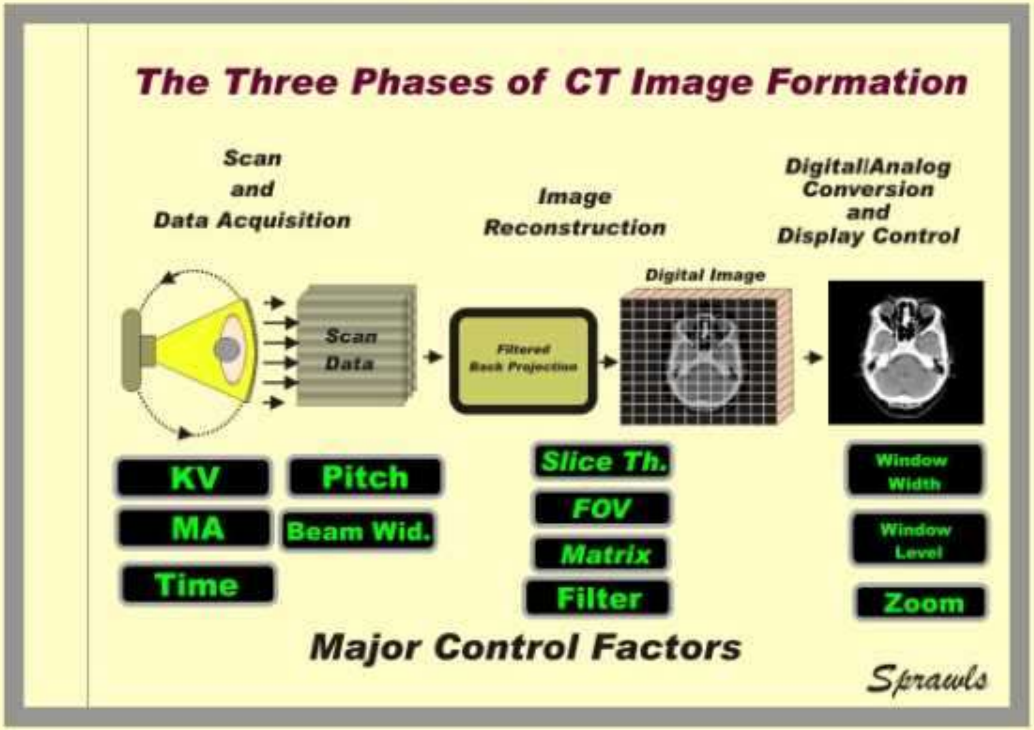
Sprawls

Technology Enhanced Learning

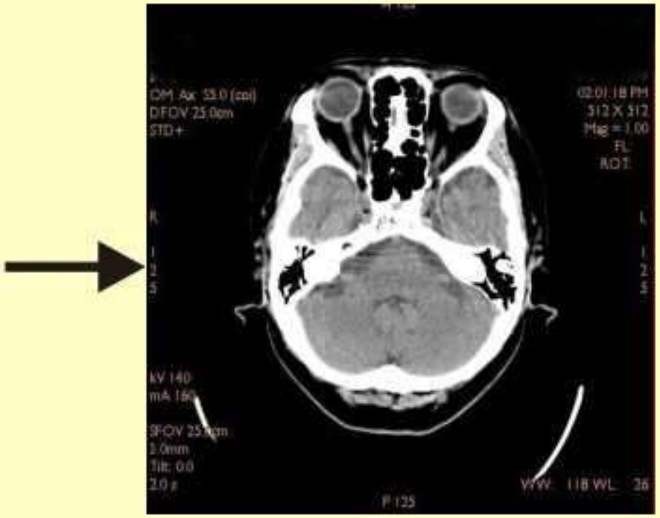


Visuals for Learning and Teaching

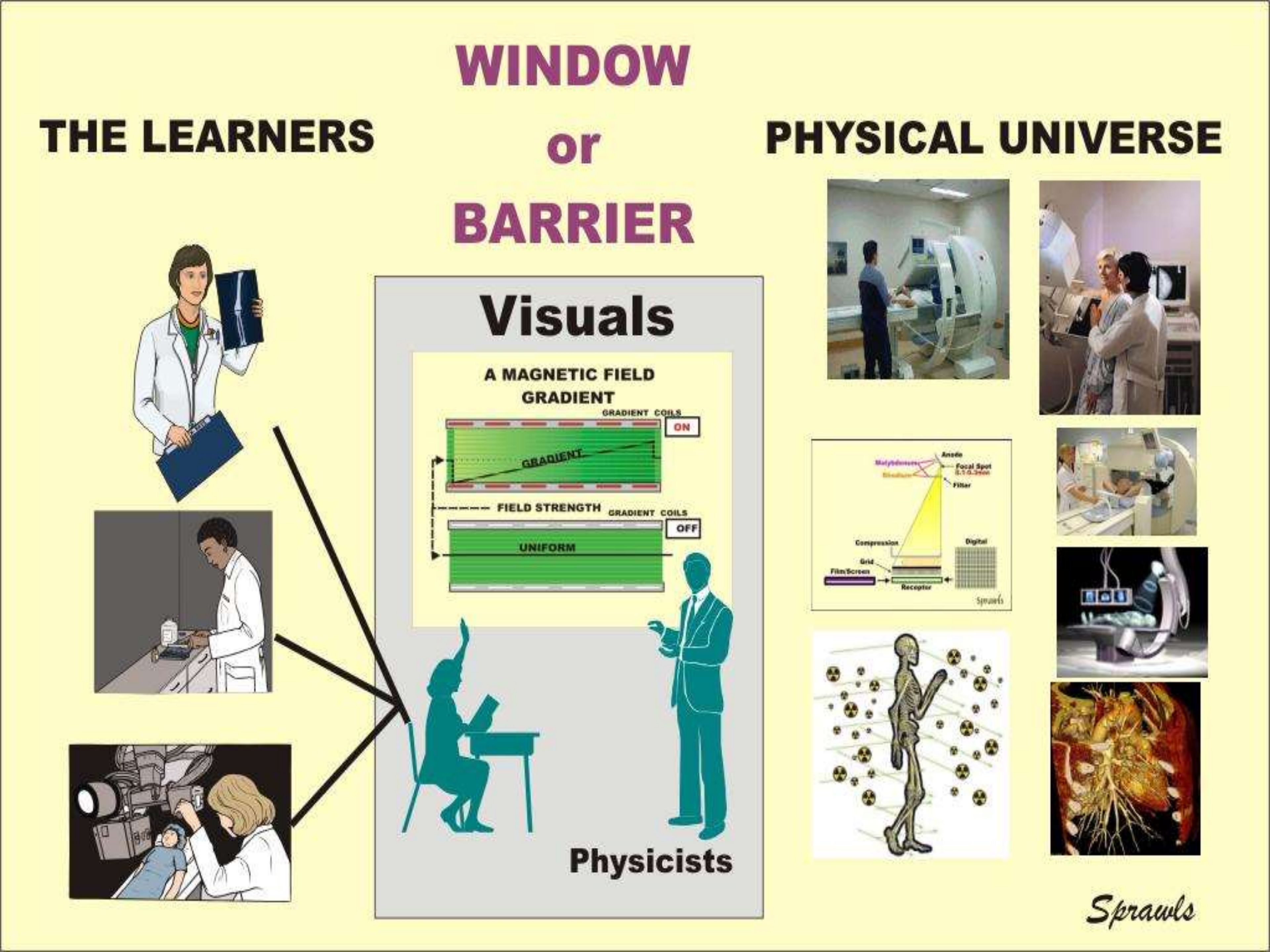
The Imaging Process



Clinical Images



Sprawls


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

Technology Tools

Developing Digital Images

"Paint"

"Draw"

Bitmaps

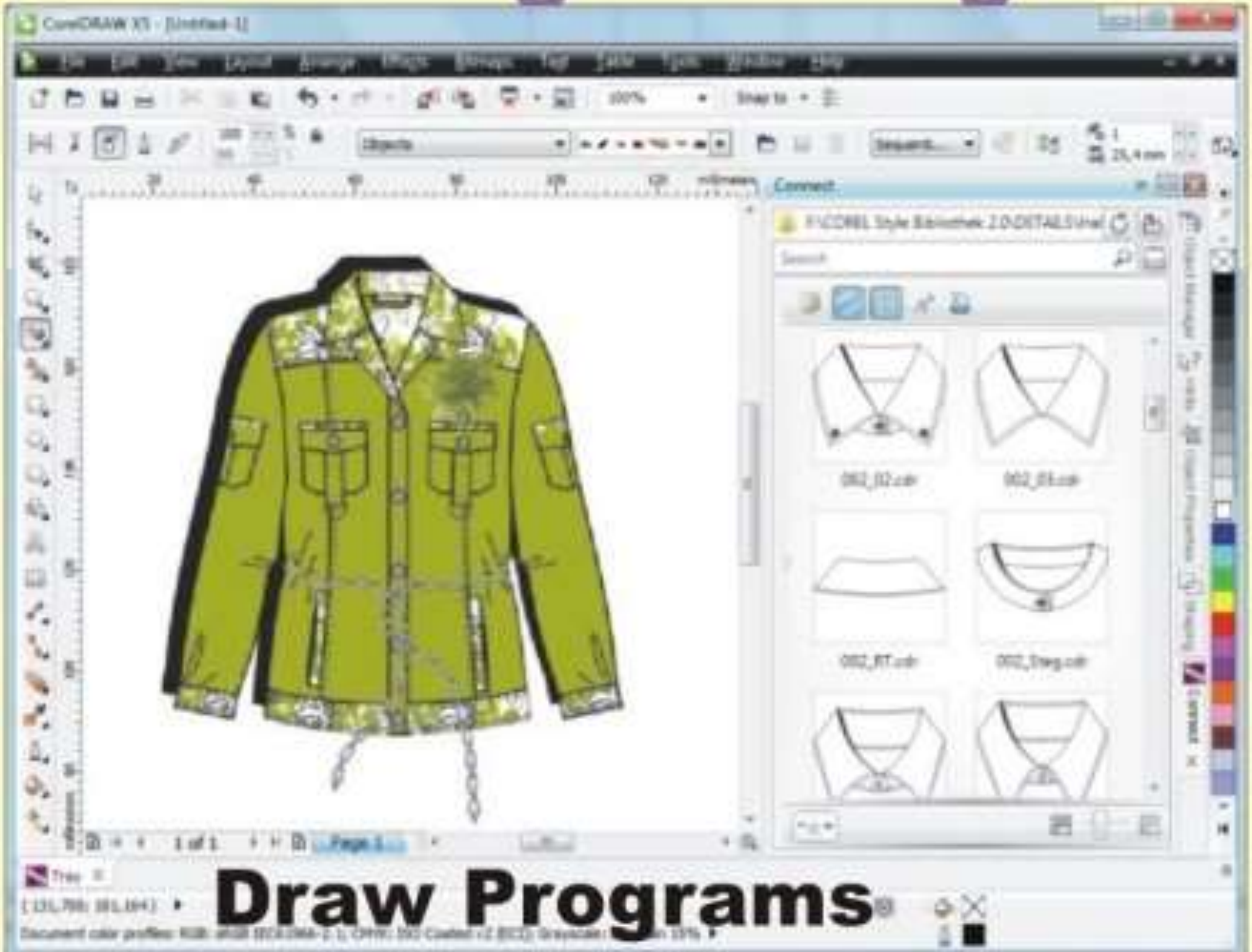
This illustration is a raster file, made up of pixels.

Vectors

This illustration is a vector file. The paths have been highlighted for comparison.

Technology Tools

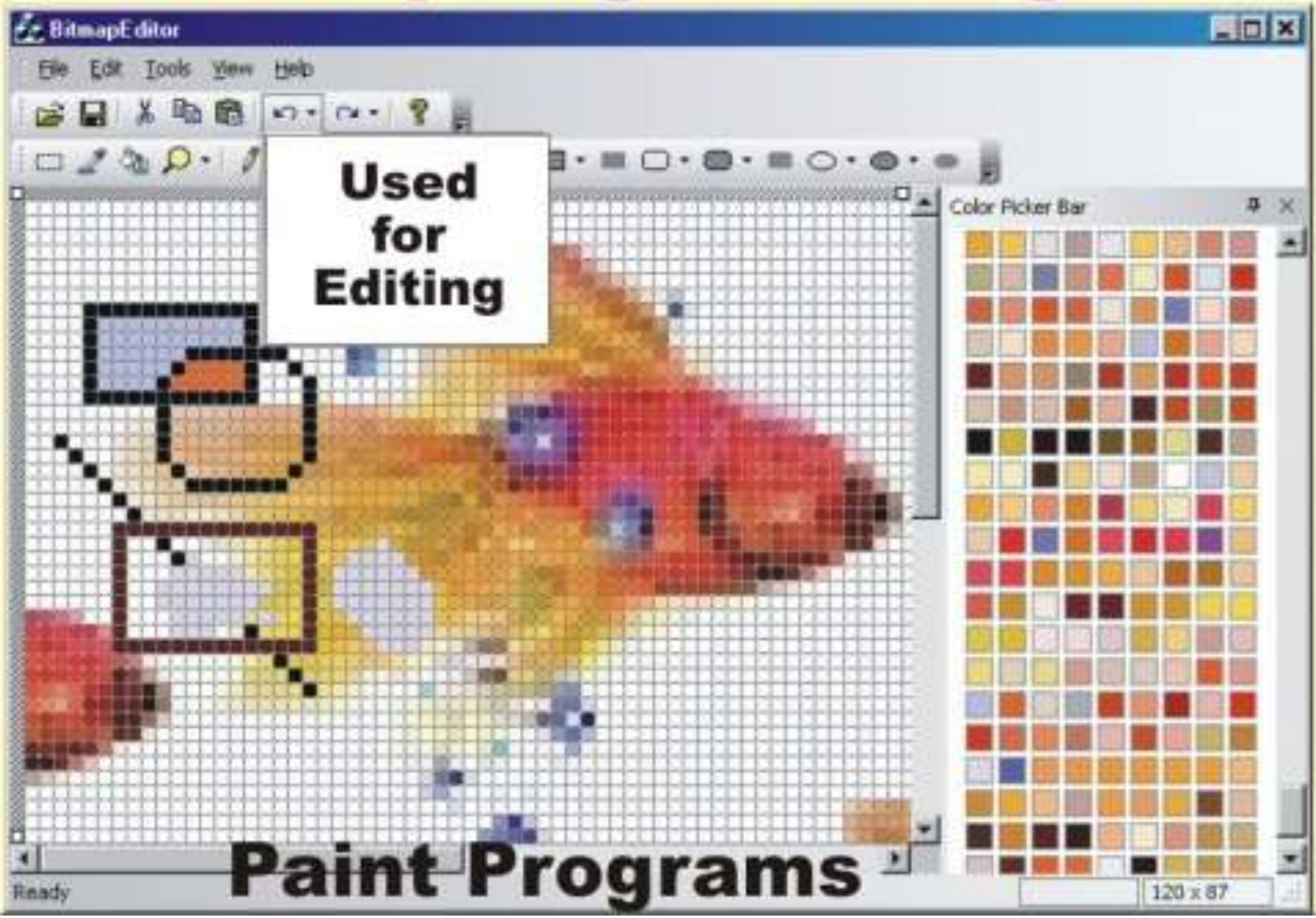
Vector Digital Images



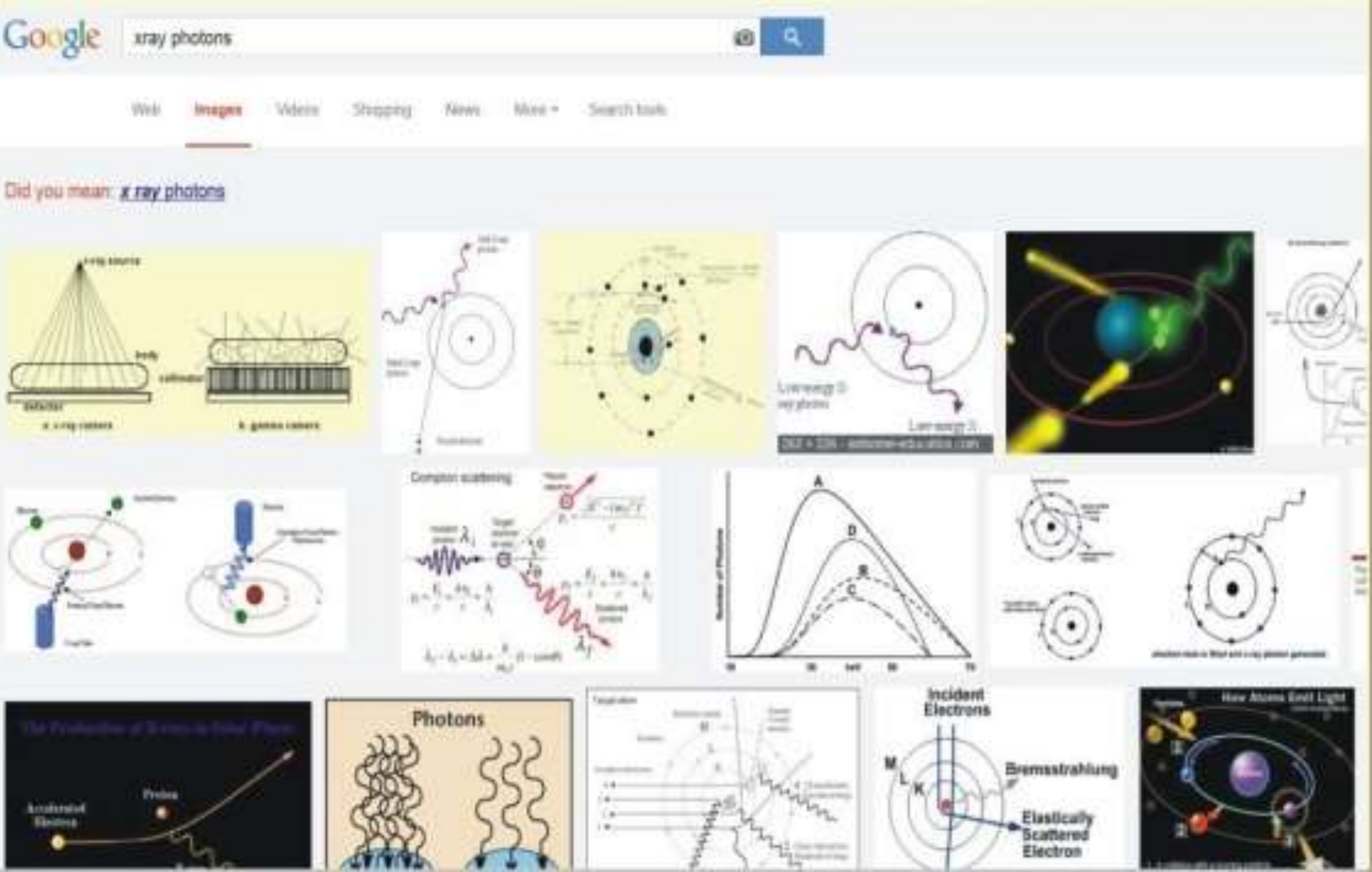
Draw Programs

Technology Tools

Bitmap Digital Images



Google Images



Google Images

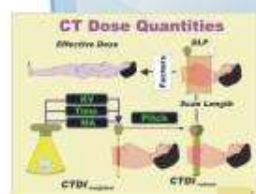
The Sprawls Resources

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

Emory

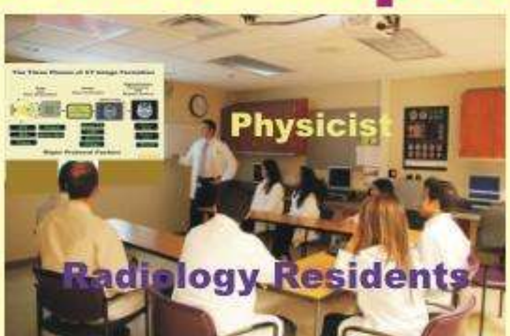
www.sprawls.org/resources

Open Access
Educational Resources



Visuals **Books** **Modules**

Global Impact



Enhancing Radiology Education
in Every Country of the World

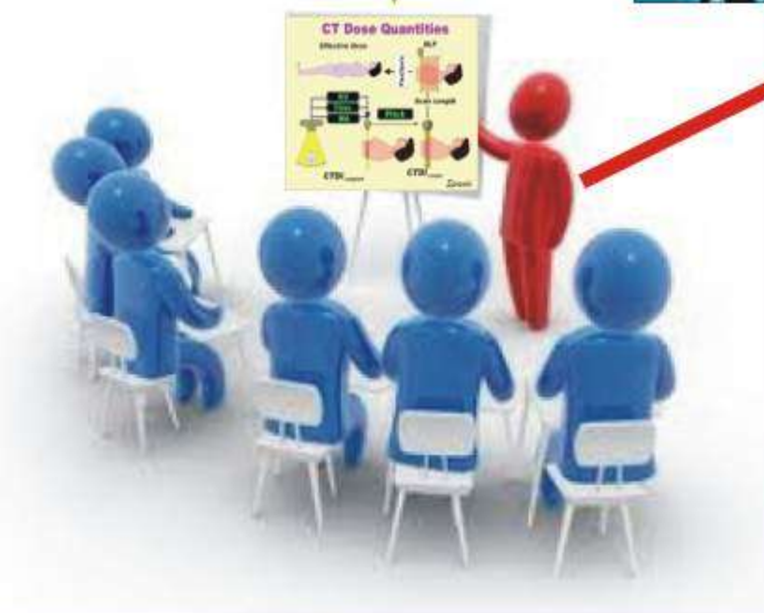
Collaborative Teaching is Sharing the Work

Resource Physicist

Create visuals and related resources

Share with the World

Medical Physics Universe



Local Physicist

Organizes
Guides
Shares Experience
Motivates
Role Model

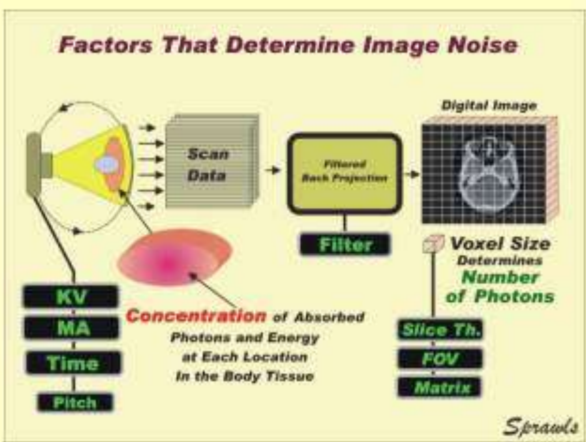
Sprawls

Collaborative Teaching is Sharing Experience, Perspectives, and Opportunities

Physicist

Radiologist

Clinical Applications



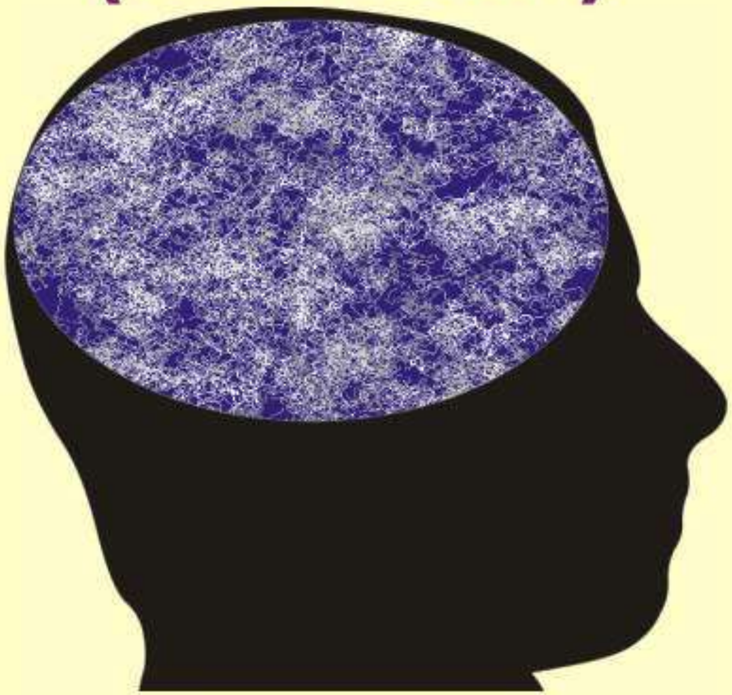
Principles and Concepts

Radiology Residents

Sprawls

What do they need?

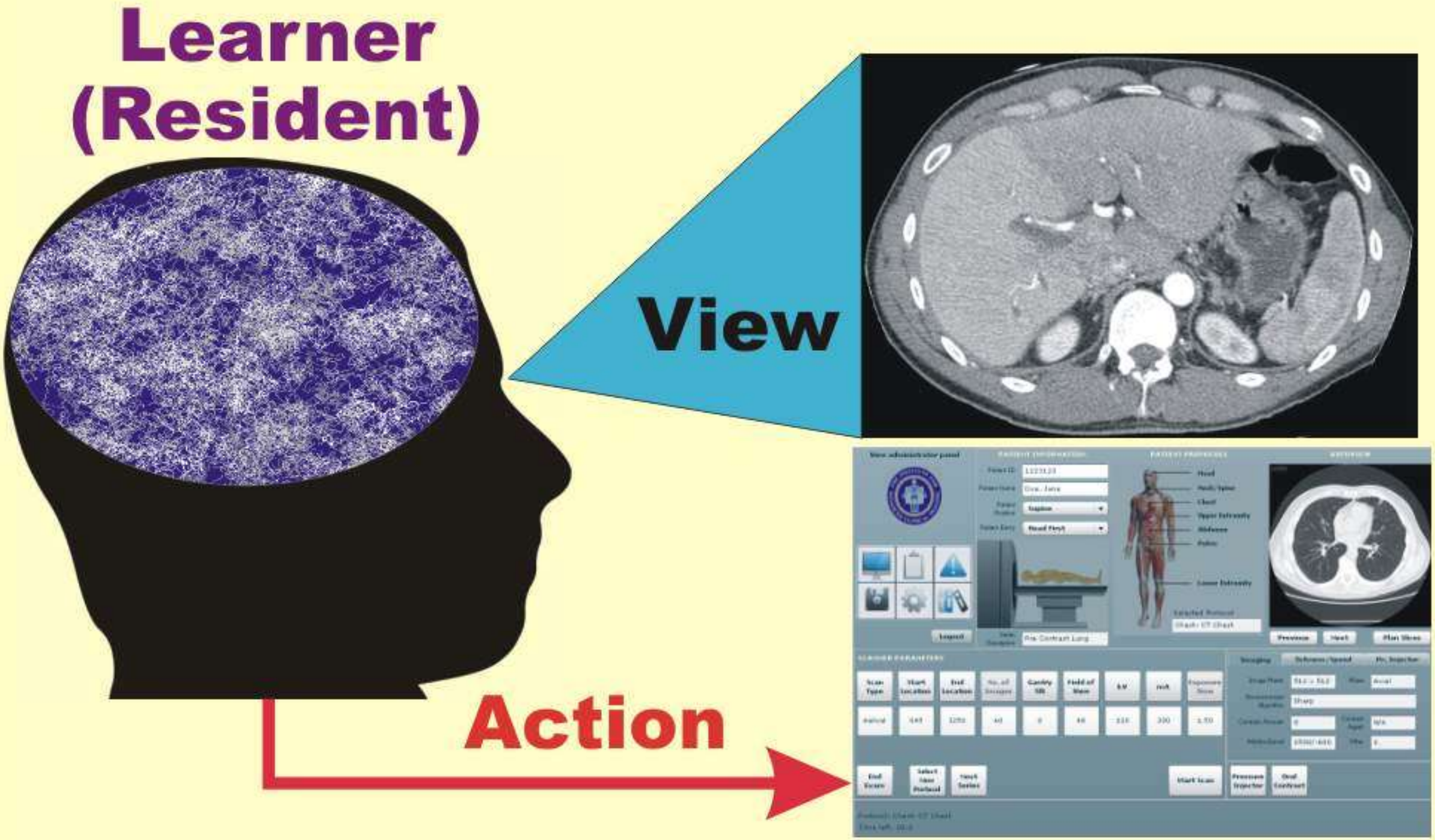
Learner (Resident)



Optimize CT image quality and manage dose.

Sprawls

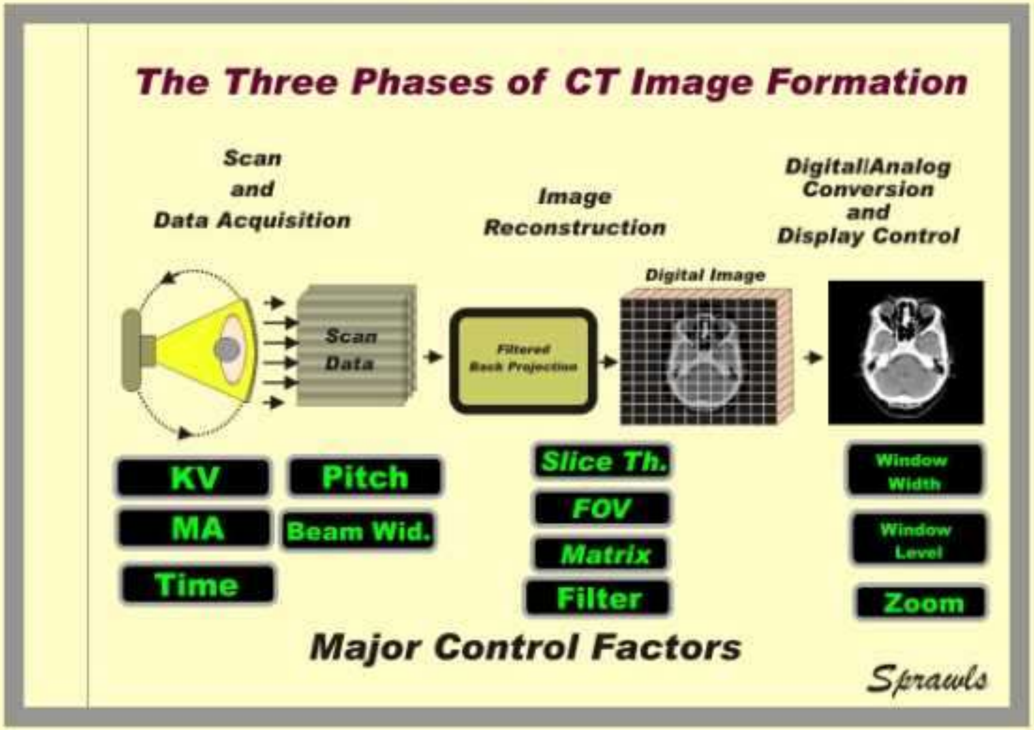
What do they need to DO?



Sprawls

Visuals for Learning and Teaching

The Imaging Process



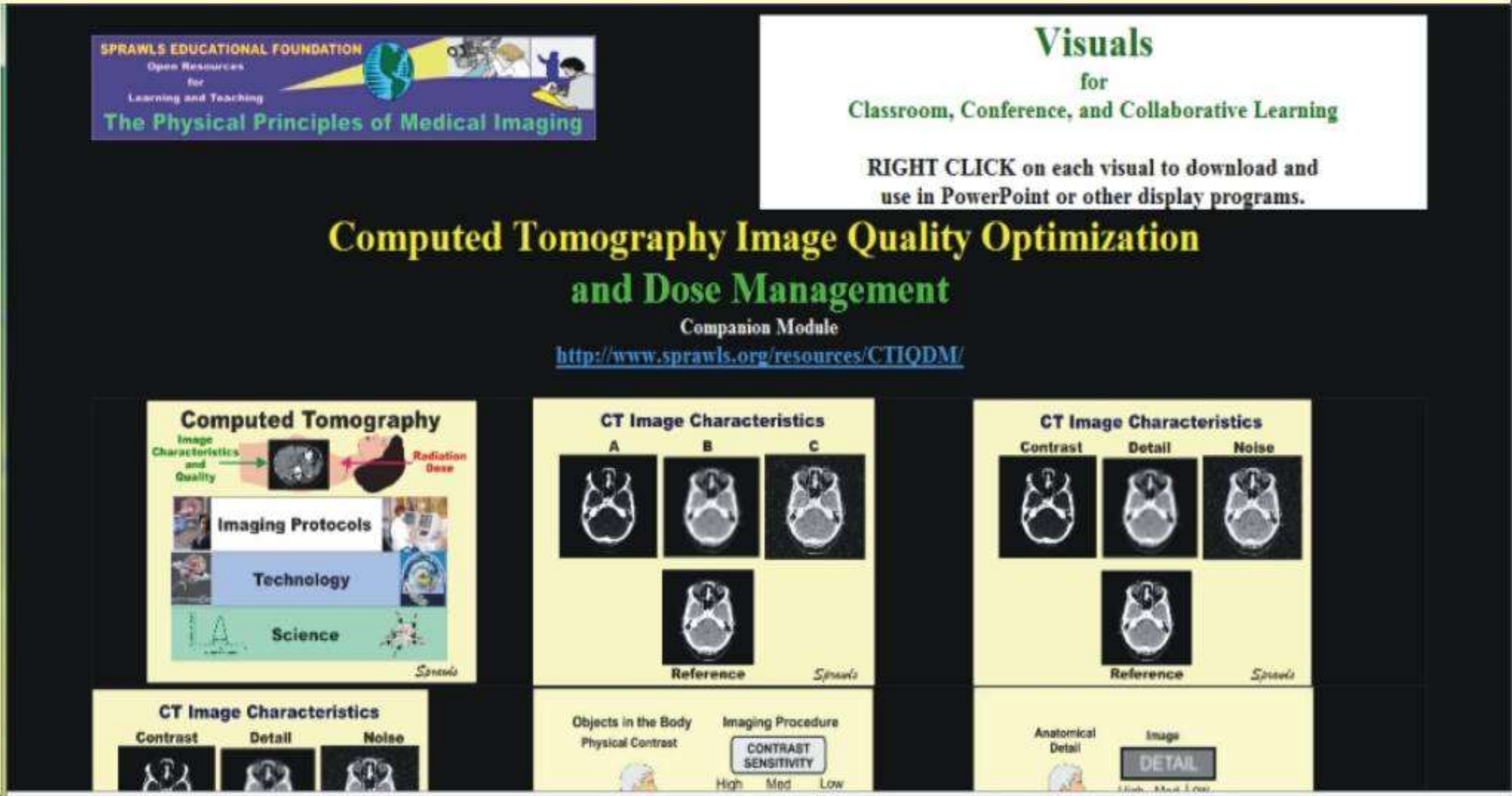
Clinical Images

Sprawls

Visuals

to be used by

Physicists in Classroom and Conference Discussions



Modules for Self Study and Collaborative Learning in the Clinic

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

Effective Medical Imaging Physics Learning
...In The Clinic

The Real World Motivating Interactive Collaborative

The Physicist Provides:
Learning Modules & Collaboration

Sprawls

Mammography Physics and Technology

for effective clinical imaging

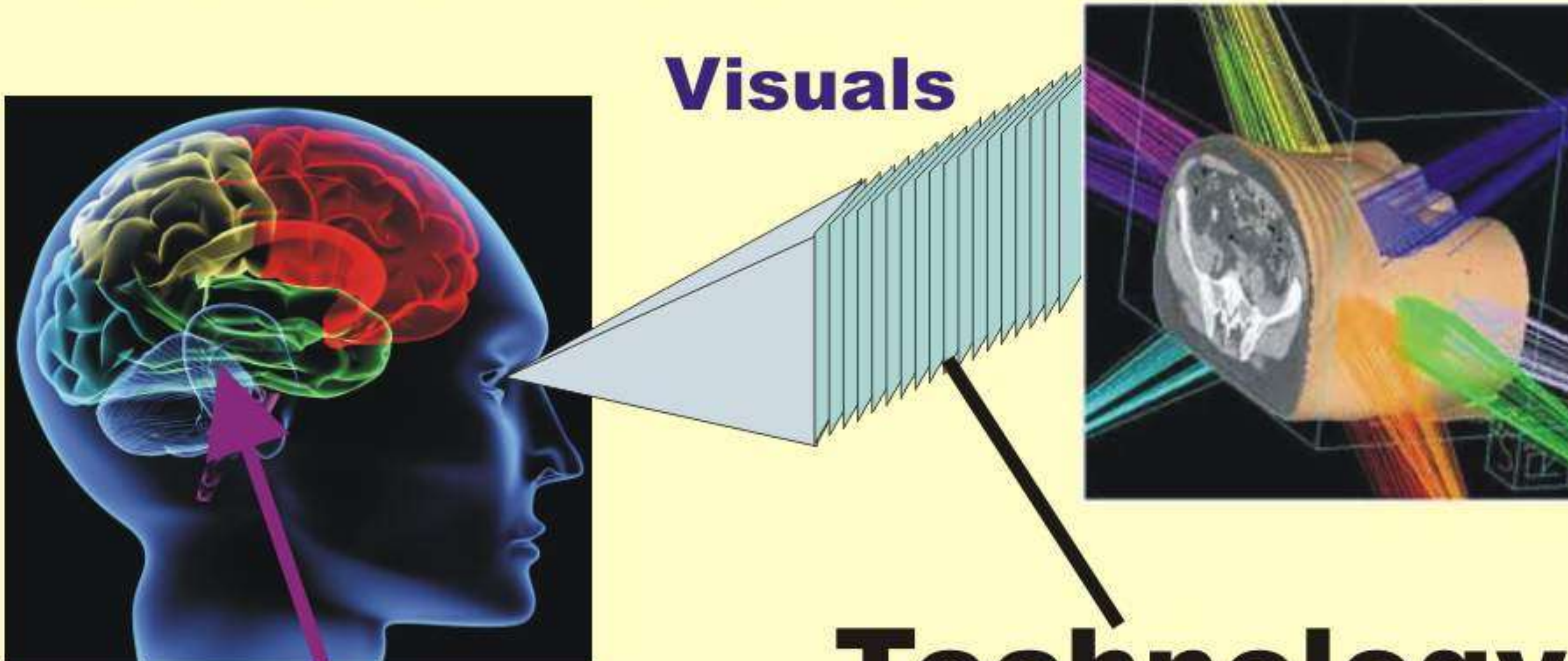
Perry Sprawls, Ph.D.

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

The Most **EFFECTIVE** way to
Build Physics Knowledge Structures



Technology

Audio

Human

(Teacher)

Guiding The Process

Sprawls

Visuals

to be used by

Physicists in Classroom and Conference Discussions

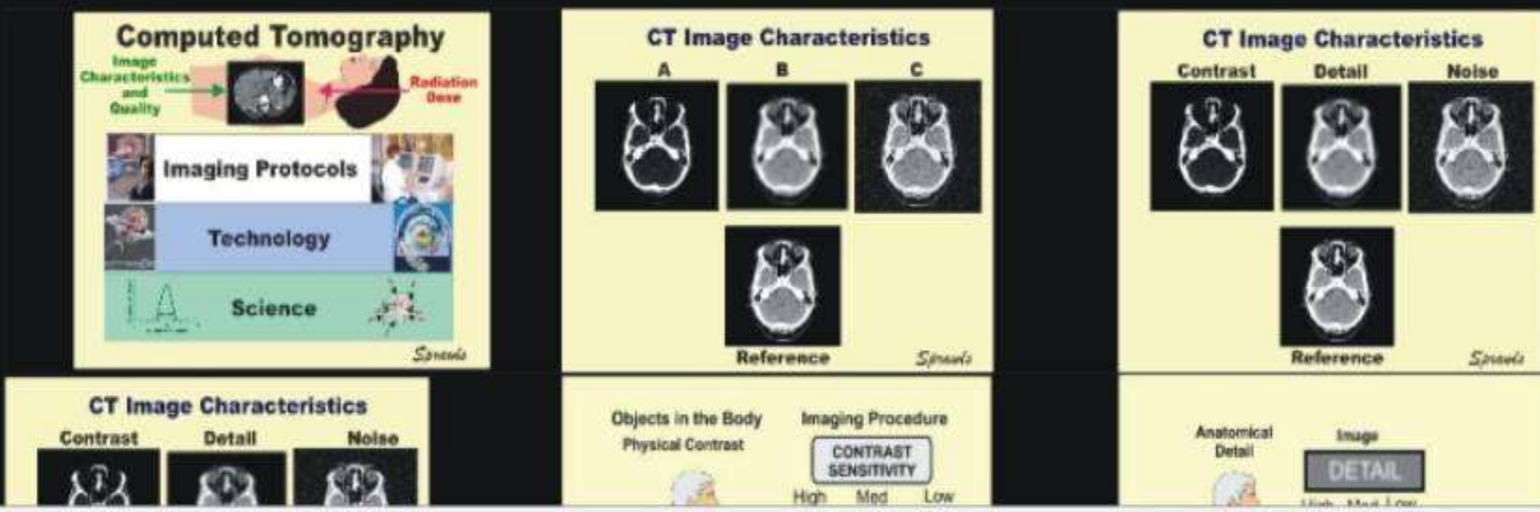
SPRAWLS EDUCATIONAL FOUNDATION
Open Resources for Learning and Teaching
The Physical Principles of Medical Imaging

Visuals
for
Classroom, Conference, and Collaborative Learning

RIGHT CLICK on each visual to download and use in PowerPoint or other display programs.

Computed Tomography Image Quality Optimization and Dose Management

Companion Module
http://www.sprawls.org/resources/CTIQDM/



CT Image Characteristics

Spatial

Detail

Artifacts

Noise

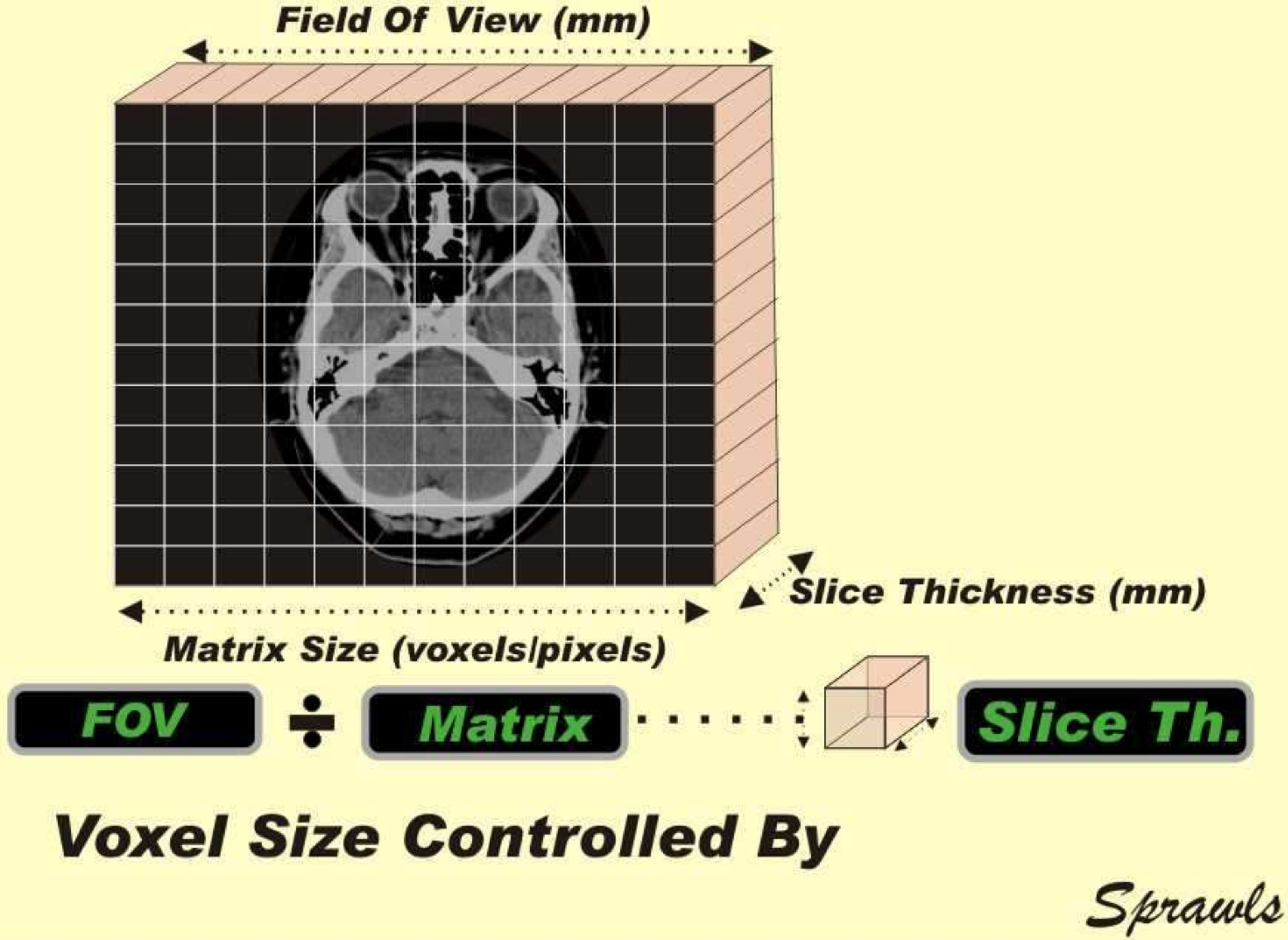
Contrast Sensitivity

KV	Pitch	*Slice Th.*	Window Width
MA	Beam Wid.	*FOV*	Window Level
Time	Filter	*Matrix*	Zoom

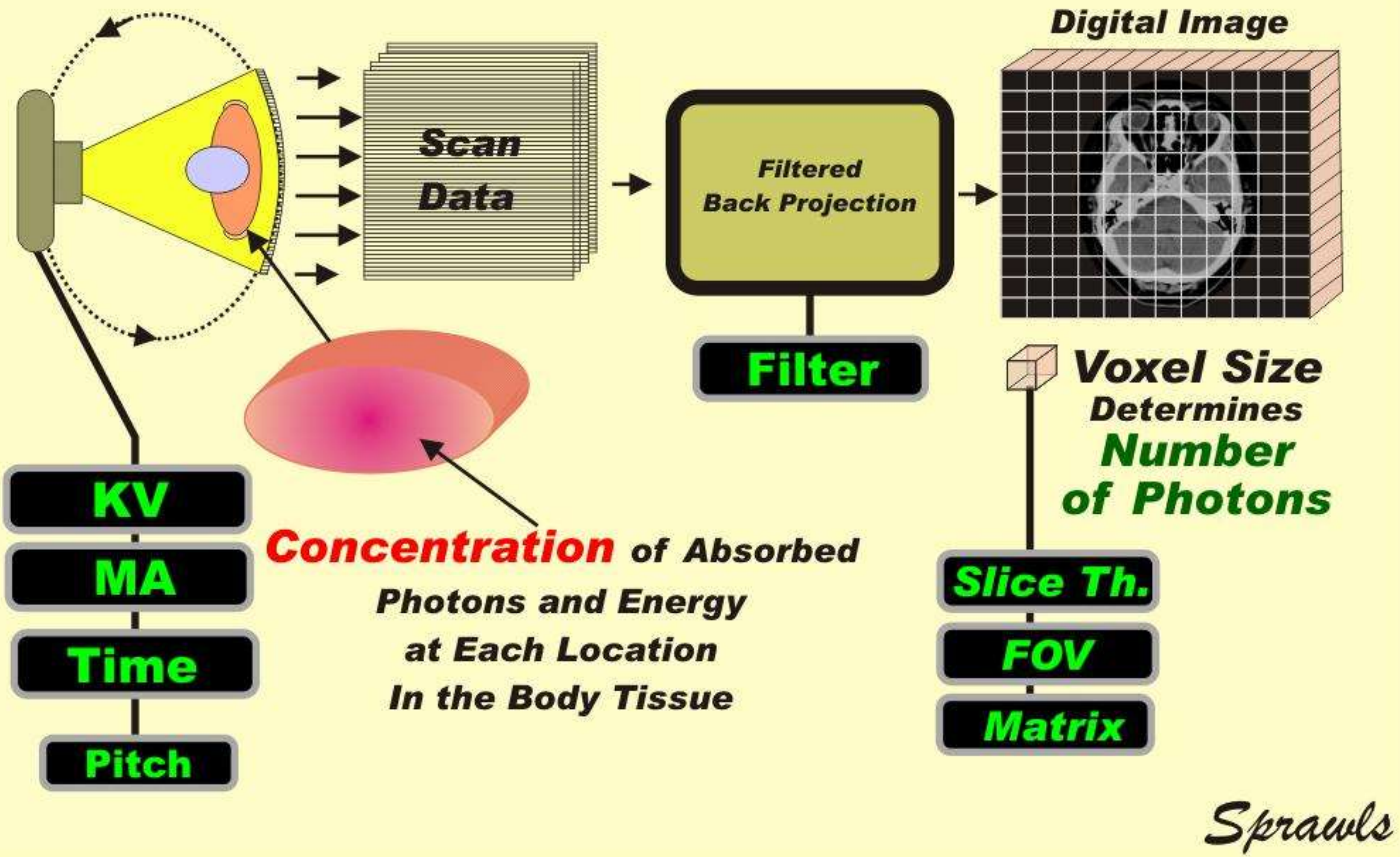
Major Protocol Factors

Sprawls

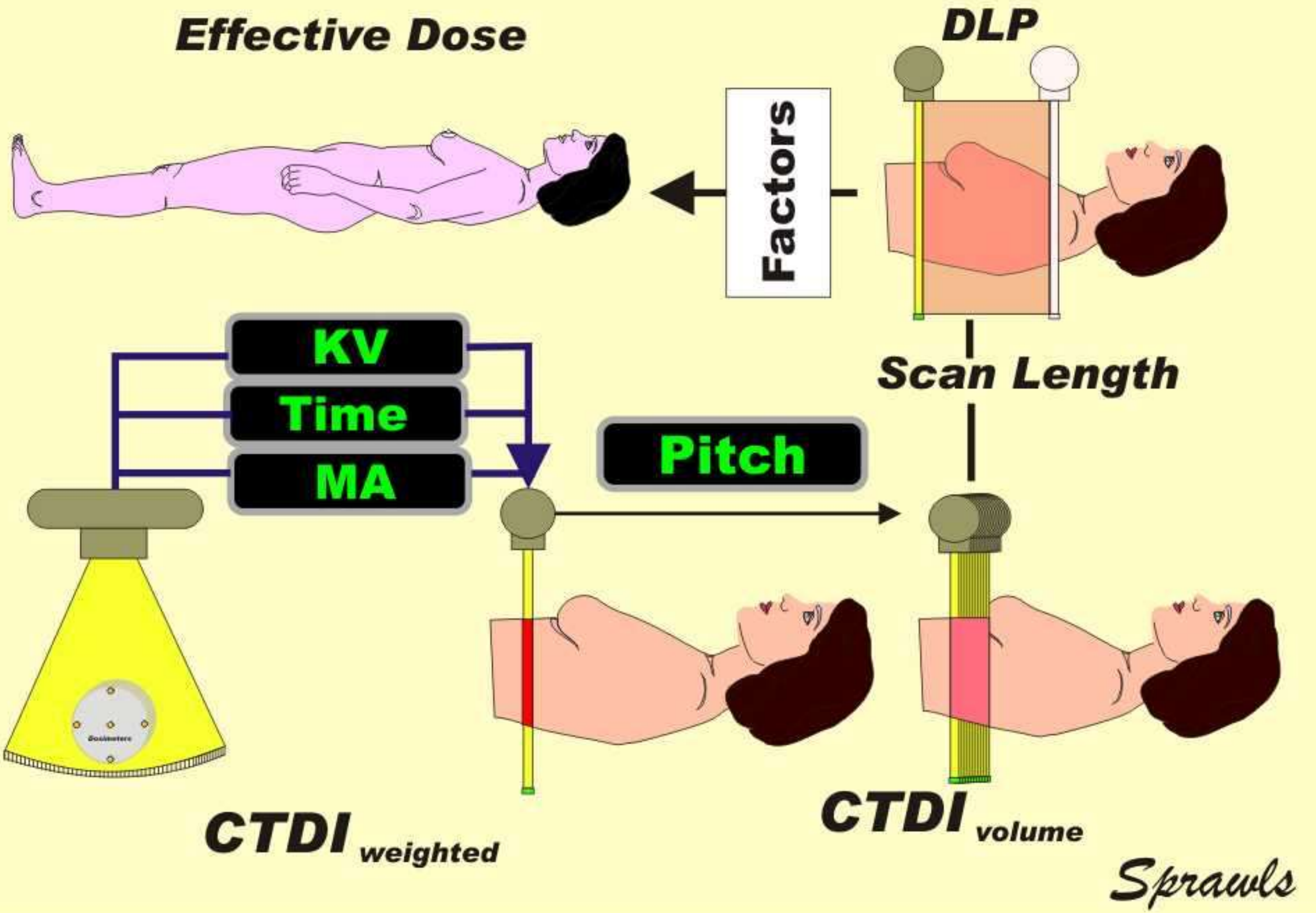
CT Slice Divided into Matrix of Voxels



Factors That Determine Image Noise

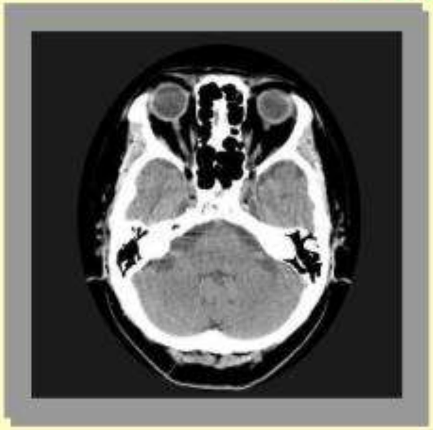


CT Dose Quantities

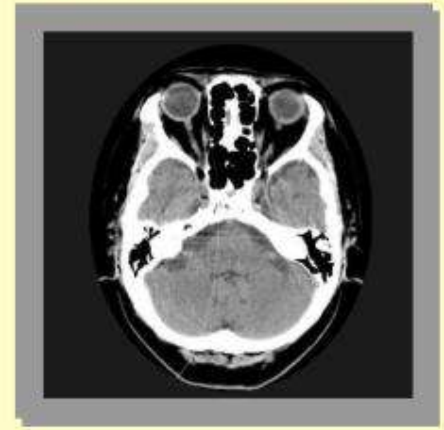


Relationship of Radiation Dose to Image Detail

Lower Dose



Higher Dose



When detail is increased by

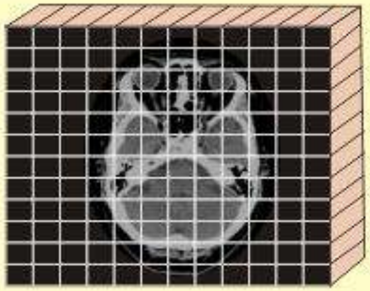
Decreasing **Slice Th.**

Increasing **Matrix**

Decreasing **FOV**

Noise Increases

Because of decreased voxel size



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

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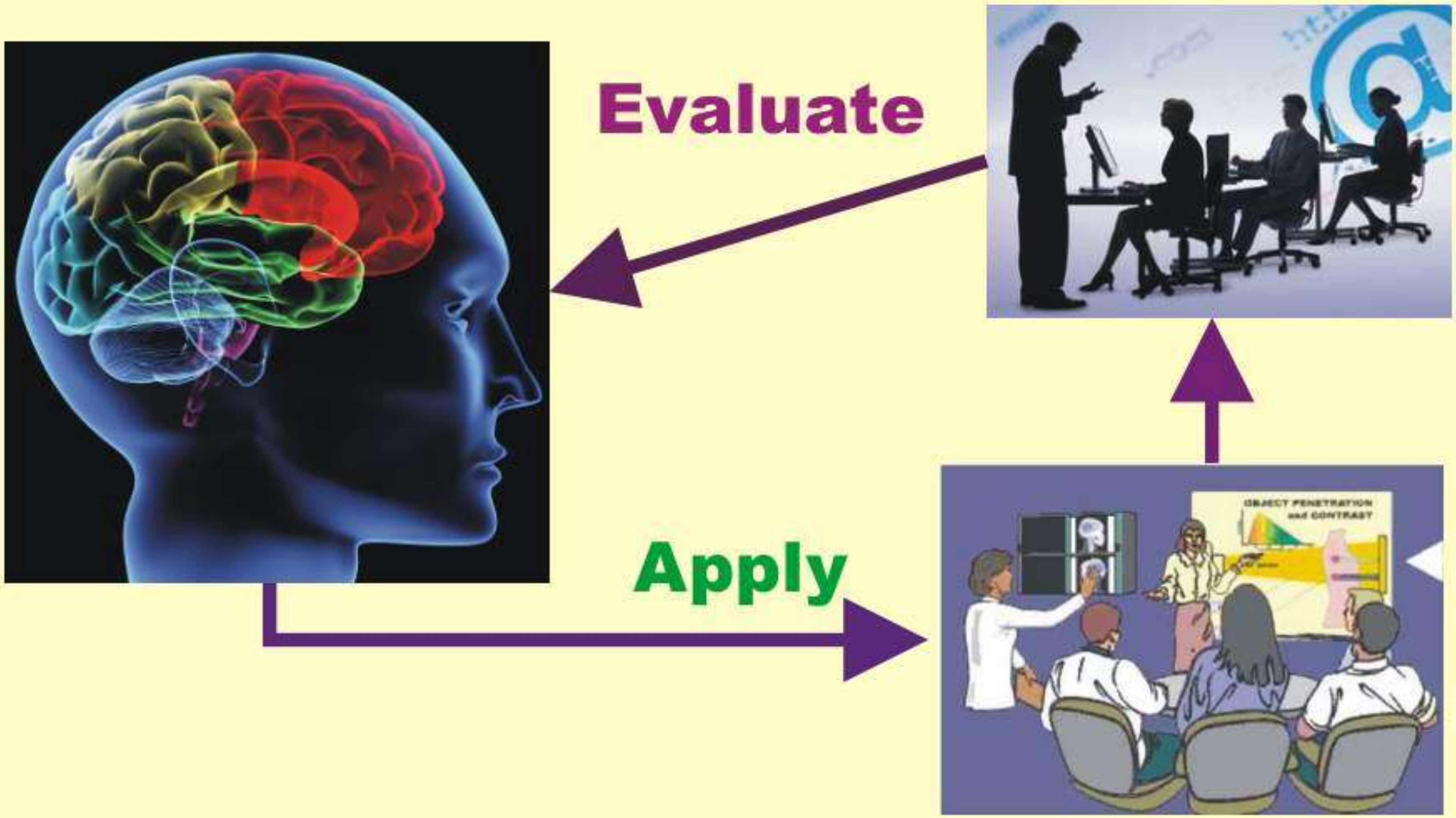
Conclusion

Using Knowledge For

More Effective & Efficient Learning Activities



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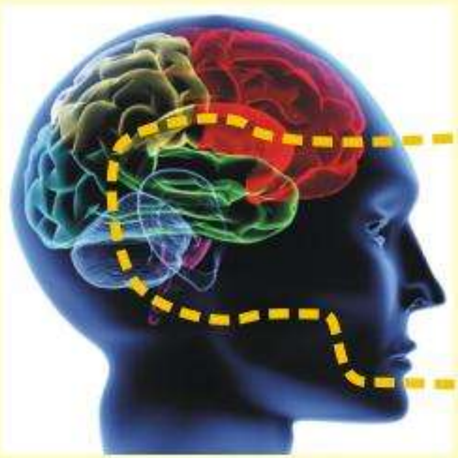
The Elements of
A Highly Effective Educational Session

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)

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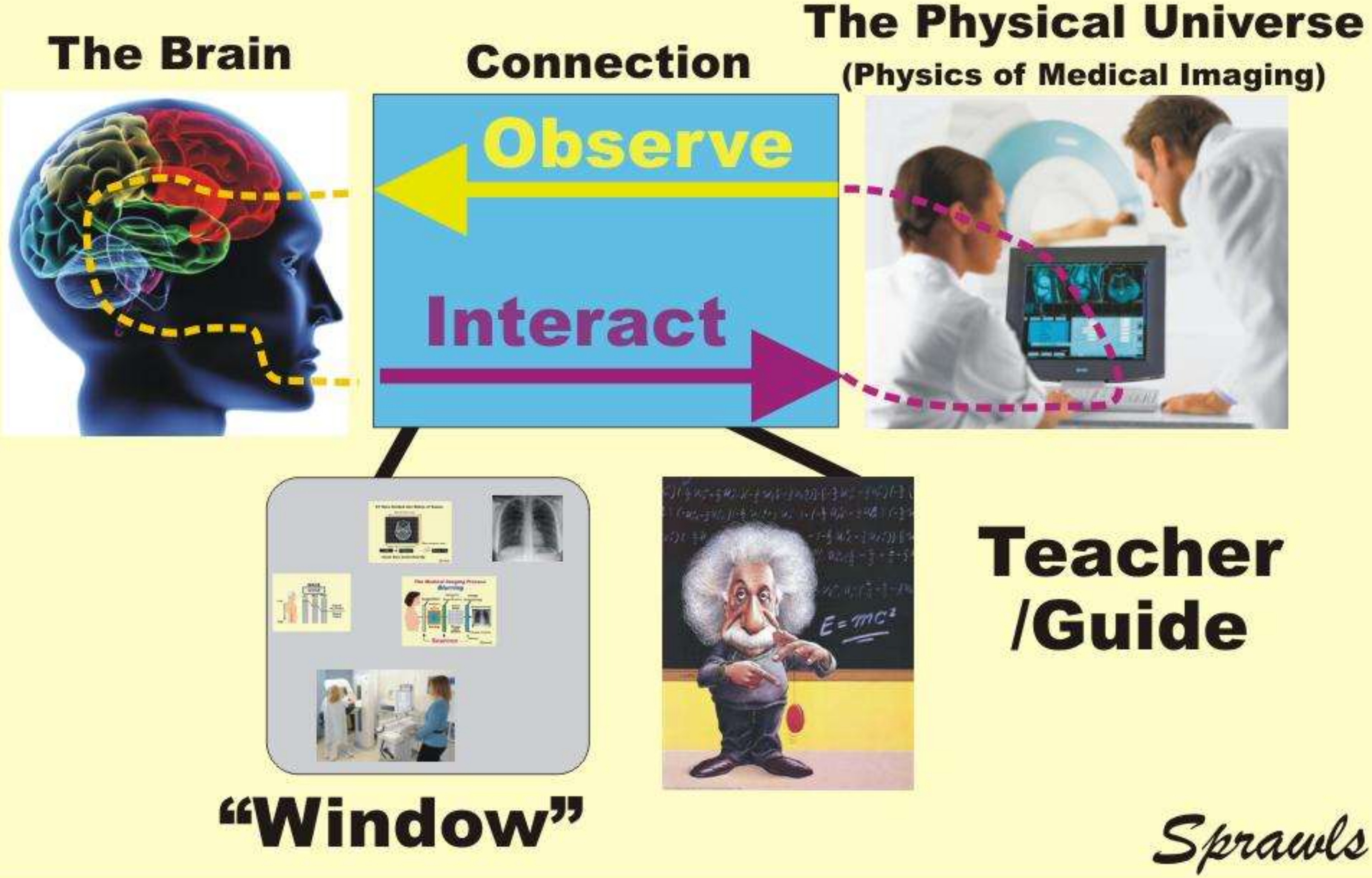
The Elements of
A Highly Effective Educational Session



What is my contribution to effective medical physics education?

I do windows.

Sprawls

Enriching Medical Physics Education by Visualizing the Invisible

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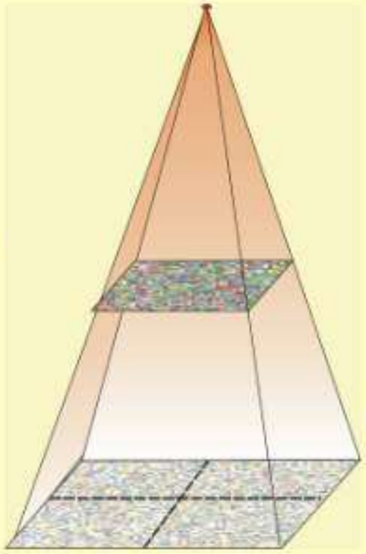
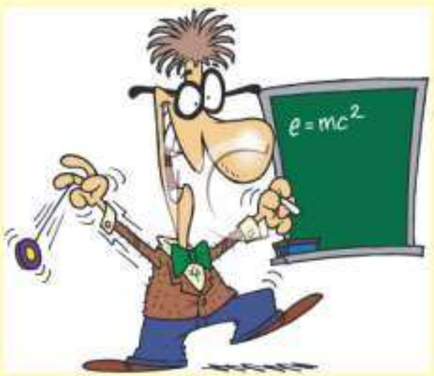


View this presentation at
www.sprawls.org/ipad

A Collaborative Model of Medical Physics Education Including Online Resources



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Effective

Medical Physics Educational Activities

Models and Methods

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