

Play and Science Running Together



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Good Thinking

Good thinking is a matter of making connections, and knowing what *kinds* of connections to make.

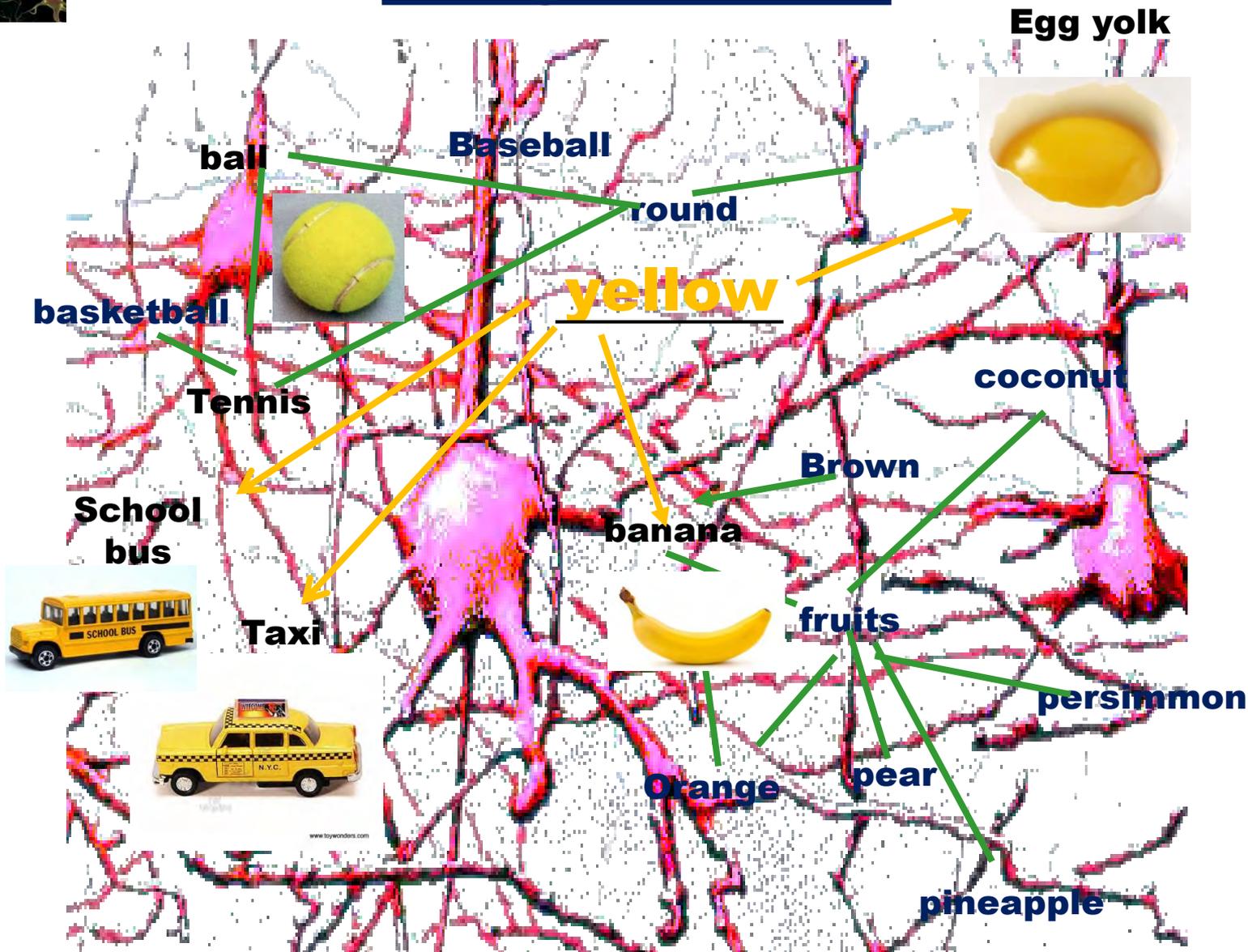
---*David Perkins*



Experience → builds a representative network



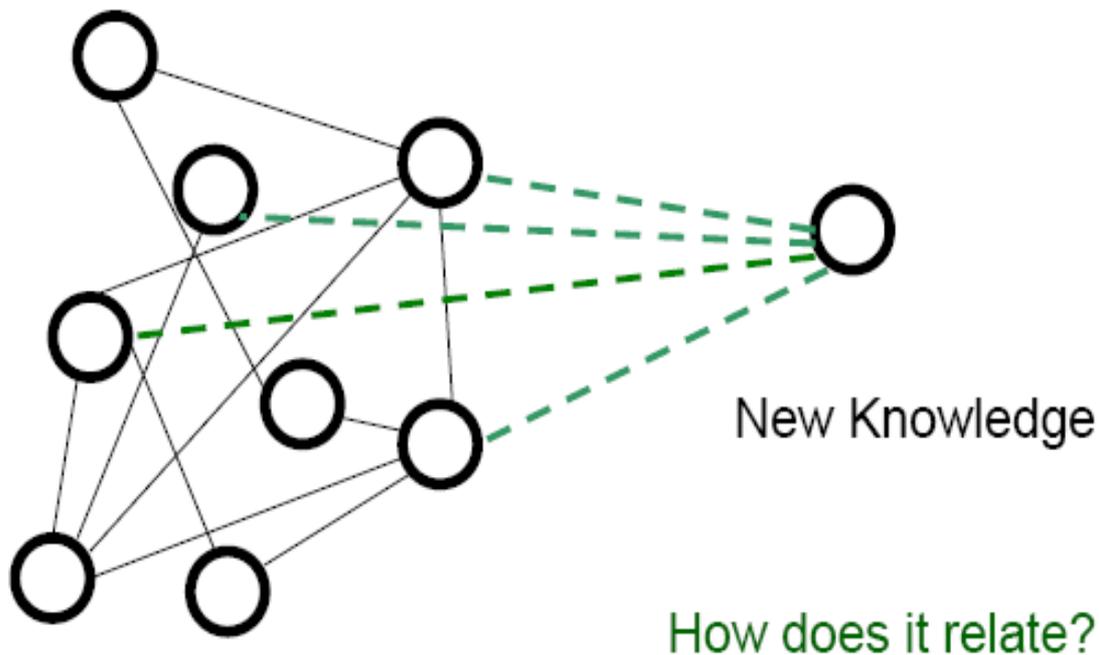
Making Connections





Distributed Networks: Making Connections

Schema





Distributed Networks: Economy and Efficiency

The distribution system in the brain

1. **“Re-purposes”** the **same cell** for participation on countless related brain circuits.
2. It helps in protecting the brain from catastrophic memory loss by distributing many of *the composing elements* of our memories **throughout the brain.**

Thus, we can lose some aspect of a memory, but not lose the entire memory; or even lose some *types* of memory while retaining other types.



Memory Test

- **Knitting**
 - **Thread**
 - **Knife**
 - **Syringe**
 - **Silver**
 - **Pin**
 - **Sewing**
- Sharp**
 - Point**
 - Thimble**
 - Haystack**
 - Shiny**
 - Injection**
 - Embroidery**





Memory Test

Embroidery

Knitting

Needle



Memory Test

- Knitting
 - Thread
 - Knife
 - Syringe
 - Silver
 - Pin
 - Sewing
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 - Haystack
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 - Injection
 - Embroidery

The human brain naturally organizes *related information* into a Gestalt, not in random lists or individual parts.

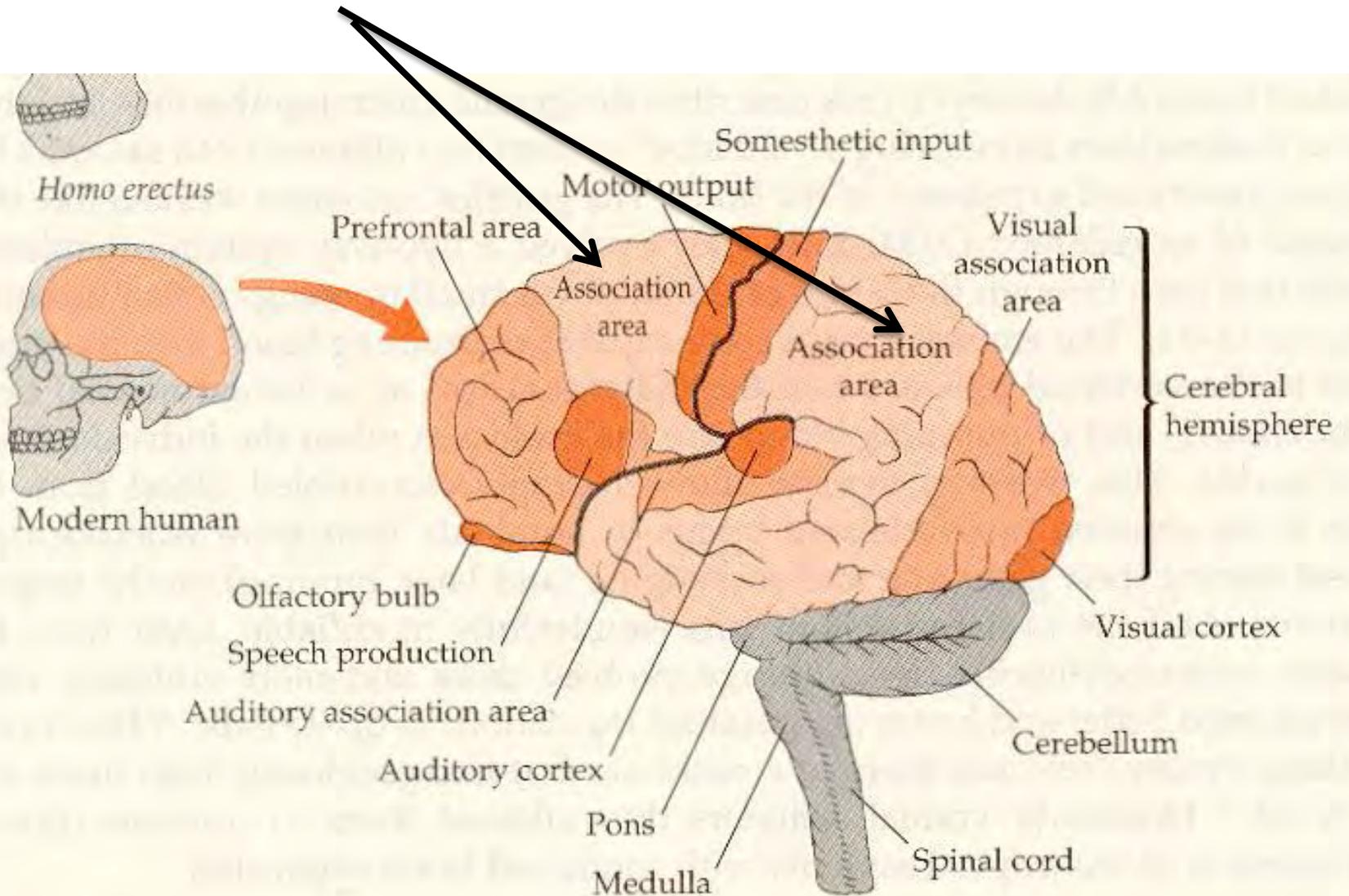


Making Connections

Most of what one knows is **domain-specific** (patterns, concepts, or connected categories) and **task-specific** and organized into structures known as **schemas.**”

-- (Pellegrino, et al.)

The **Association Cortices** Make up **37%** of the Human Cerebral Cortex





Maintaining and Strengthening Memory

Bridge

10%

Past content

Build

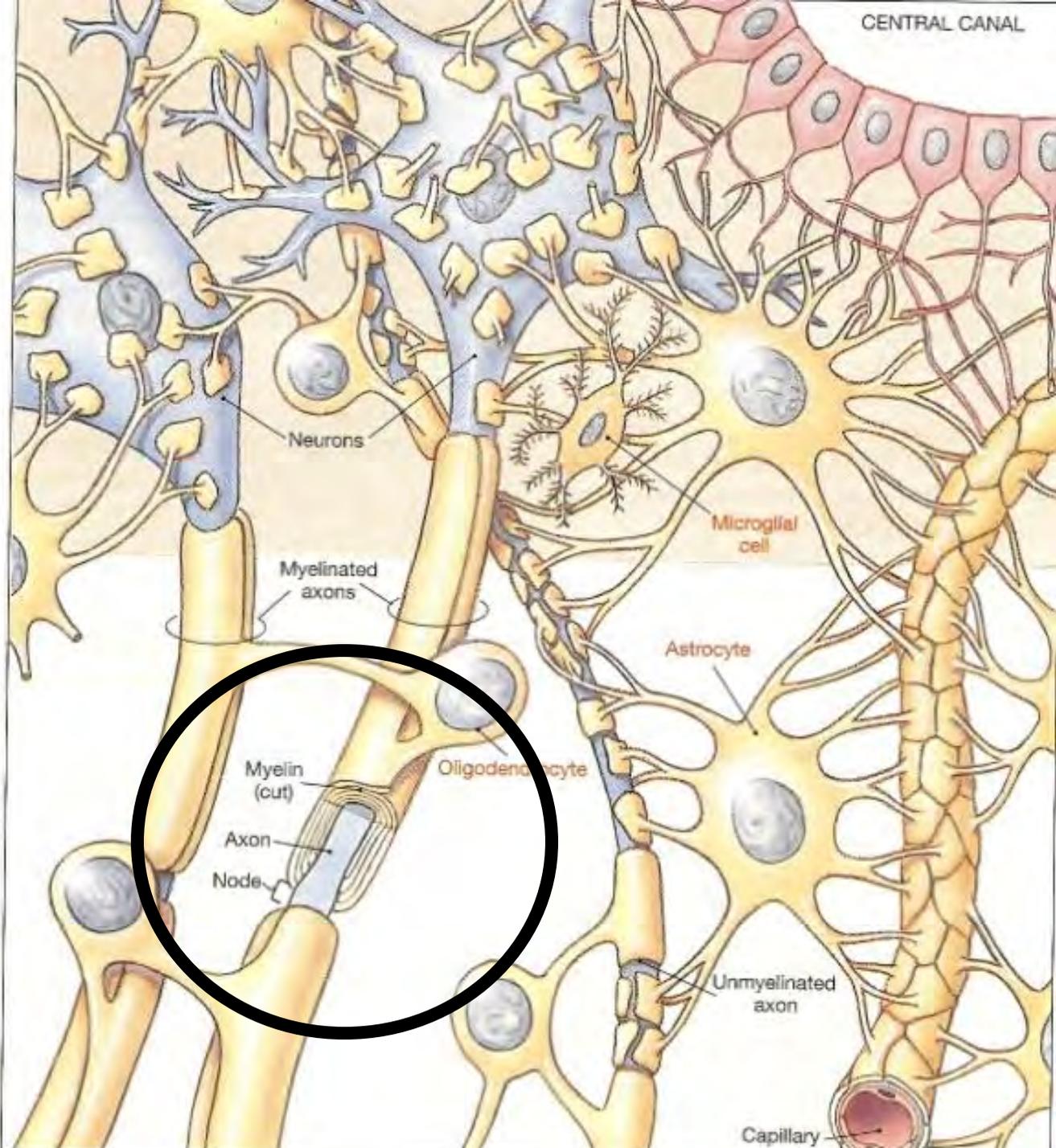
80%

New information

Extend

10%

Preview



CENTRAL CANAL

Neurons

Microglial cell

Myelinated axons

Astrocyte



Oligodendrocyte

Myelin (cut)
Axon
Node

Unmyelinated axon

Capillary

Look at the chart and say the colour not the word

YELLOW BLUE ORANGE

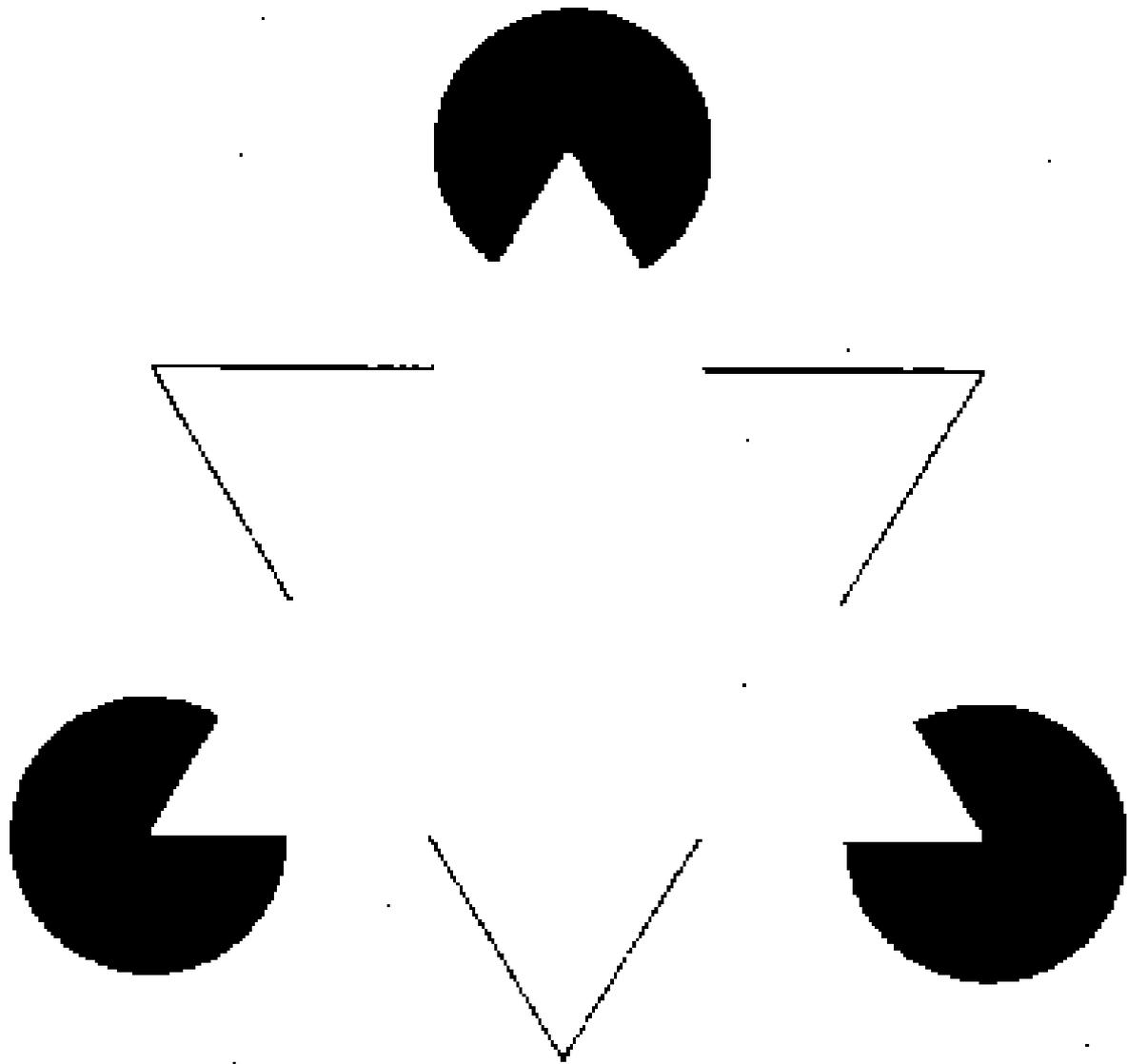
BLACK RED GREEN

PURPLE YELLOW RED

ORANGE GREEN BLACK

BLUE RED PURPLE

GREEN BLUE ORANGE





Brain-considerate Learning: PERC³S

There are five BC elements that the human brain seeks while processing incoming stimuli for personal “meaning,” which makes the information “memorable” and worth remembering.

(1) Patterns (derivatives of experience)

(2) Emotions

(3) Relevance

(4) Context, Content, and Cognitively-appropriate

(5) Sense-making → **Problem-solving**



Patterns, emotions, relevance, context, content and sense-making are critical factors in driving (1) attention, (2) motivation, (3) learning, (4) memory formation, and (5) recall. Collectively, these 5 factors are the primary criteria for transfer into long-term memory storage.



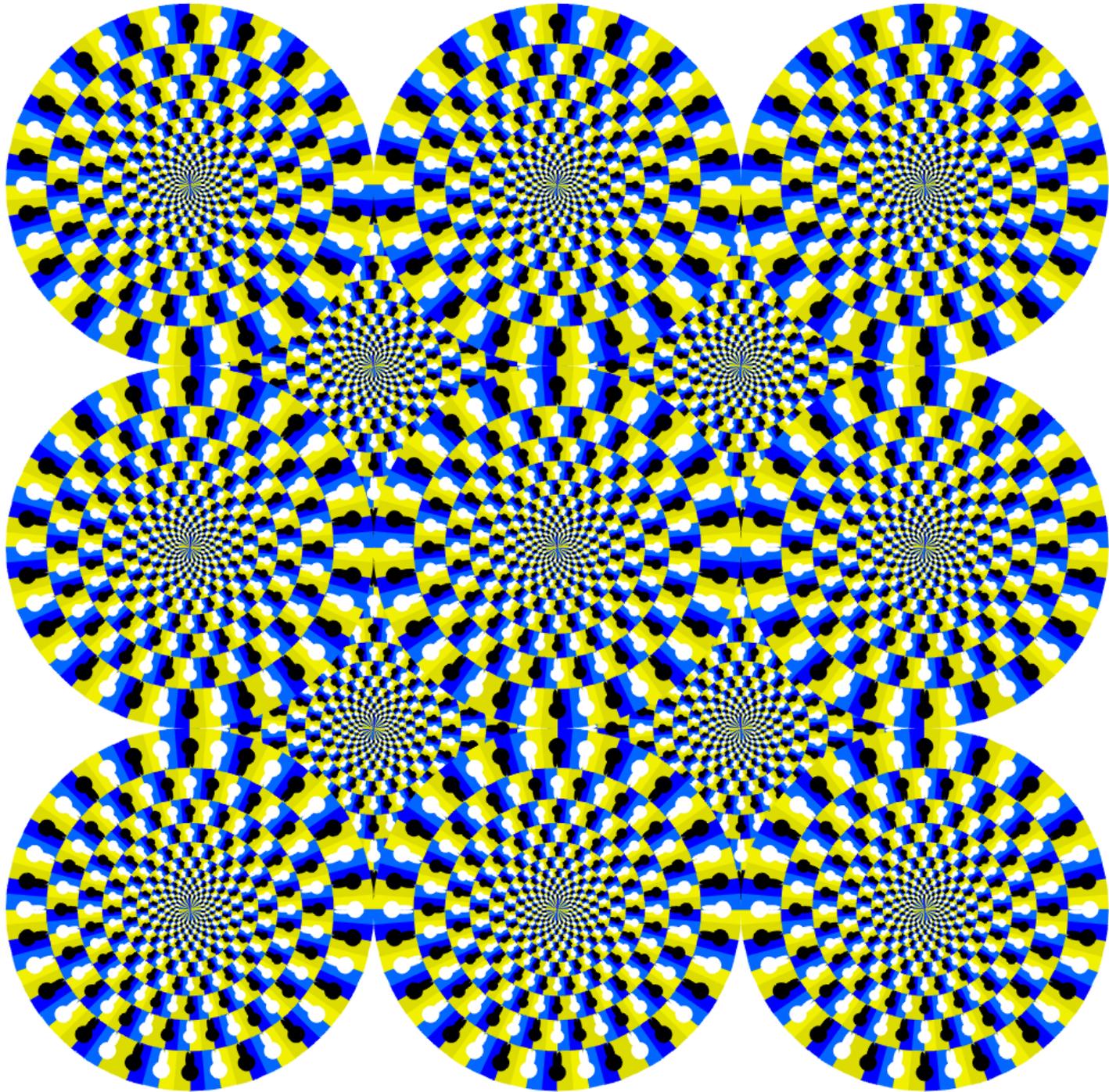
Patterns → Quick Answers

Mary's mother had only four children: April, May, June and ...?

The **pattern-seeking** human brain always searches for **patterns** → you responsively answer “**July**” which is the next month in a deeply ingrained sequential pattern, but does not answer the question correctly. The correct answer is **Mary - Mary's mother** is where the question actually begins.









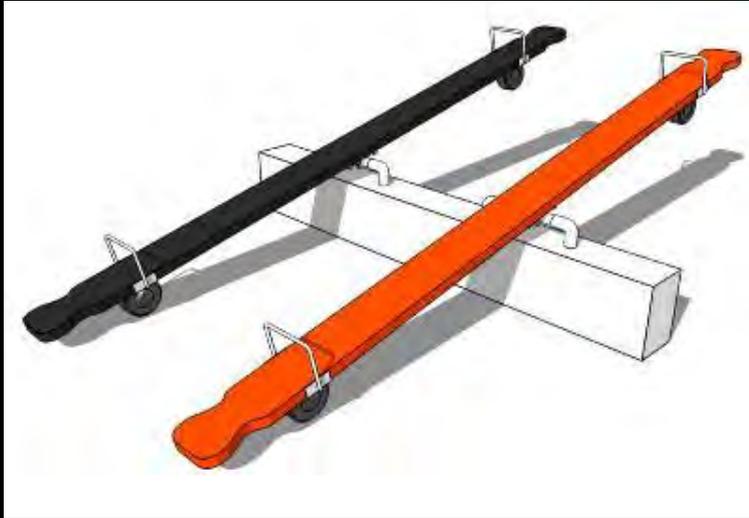
...dos not fit past familiar patterns.



Jean Piaget: How is Learning Maximized?

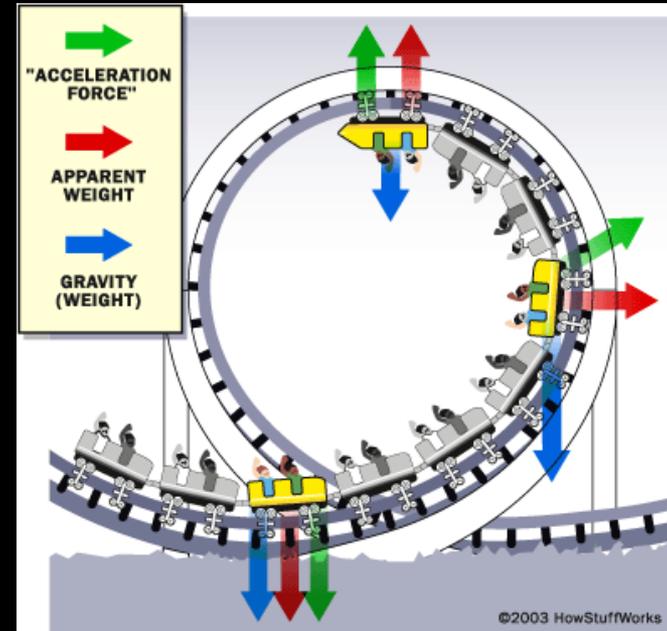
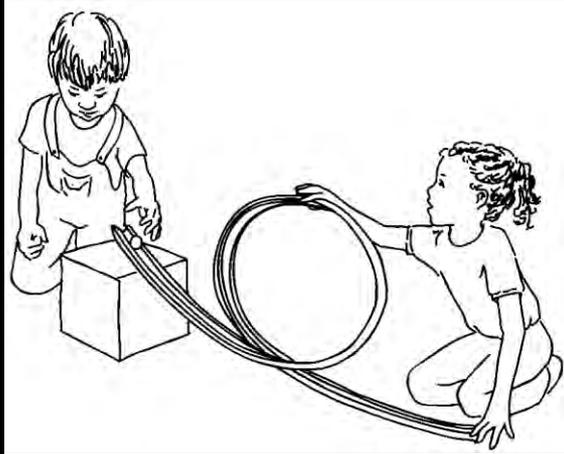
Learning should be **active** and
discovery-based - *“Play is the
serious business of childhood.”*

Play and Science Running Together









We were never “born to read.”

We were born to

Invent,

Innovate,

Improvise,

and

Improve



EINSTEIN NEVER USED FLASH CARDS



HOW OUR CHILDREN REALLY LEARN—
AND WHY THEY NEED TO PLAY MORE
AND MEMORIZE LESS

KATHY HIRSH-PASEK, PH.D., AND
ROBERTA MICHNICK GOLINKOFF, PH.D.,
WITH DIANE EYER, PH.D.

**“Playing
and
imagination
are what
makes
infants and
children
smarter.”**

**Auditory learners =
13%**

What does a modern scientist look like when he is working?



Relevant questions, imagination, predictions, inferences, patterns, hunches, experimenting (trial/error) skepticism, thinking, memory, curiosity, minimize errors, sense-making, a quest for knowledge →

Scientific and Engineering Practices



Research is a **formalized curiosity**. It is
poking and prying with a purpose.

-- Zora Neale Hurston

Today's STEM Initiatives are Not NEW

- Human beings were (and still are) **engaged in STEM experiences *before*** we called them STEM (problem-solving, meeting today's...)
- Our human advances have nearly always been dependent on an **improved understanding** of the world around us by investigating (“know”).

When was it invented?

Drug stores	
Contraceptives	
Inoculations	
Brain surgery	
Catheters (gastro-urinary disorders)	
Surgical equipment (scalpels, drills, forceps)	
False teeth	
Prosthetics	
Anesthetics	
Map-making	
Odometer	
Wind-powered cars	
Compass	
Underwater diving suit	
Lightning rod	
Parachute	
Magnifying glasses	
Pregnancy tests	
Tanks	
Spectacles	
Central heating	
Glass windows	
Lock and key	
Book-printing	
Postal Systems	

When was it invented?

Drug stores	9th Cent. AD
Contraceptives	Pre-Columbian Native Americans
Inoculations	10th cent. AD Chinese
Brain surgery)	15th cent. BC
Catheters (gastro-urinary disorders)	3rd cent BC
Surgical equipment (scalpels, drills, forceps)	15th cent. BC
False teeth	700 BC
Prosthetics	1000 BC
Anesthetics	2000BC
Map-making	3000 BC
Odometer	300 AD
Wind-powered cars	554 AD (China)
Compass	13th cent. AD
Underwater diving suit	1425 AD
Parachute	15th cent. AD (China)
Lightning rod	212 BC (Egypt)
Magnifying glasses	9th cent. BC
Pregnancy tests	700 BC (Egypt)
Tanks	1279 AD (China)
Spectacles	14th cent. AD
Central heating	200 BC (China)
Glass windows	60 BC (Rome)
Book-printing	700 AD (China)
Postal Systems	2000 BC



Over the centuries, STEM evolved into different applications and ventured into new territory driven by two forces: human need and human curiosity.



Creative Engineering game called

“What’s the solution?”

(in unison)

Not Optimizing design solutions





...out of spoons for your soup?



Thereifixedit.com

What's the solution?



...need to feed the baby and do the laundry sometimes ?



Thereifixedit.com

What's the solution?



...your windshield wiper motor burns out sometimes?



Thereifixedit.com 

What's the solution?



...your showerhead is broken?



What's the solution?



... your car didn't come equipped with a cup-holder?



What's the solution?



...your apartment doesn't come with an air conditioner? ?



What's the solution?



Has your car stereo been stolen?



Thereifixedit.com 

What's the solution?



...does the intense glare from the sun make the ATM screen completely unreadable for your “Honey”?



Thereifixedit.com

What's the solution?



Learning and Play

- ...an inventiveness side to **hands-on playing, tinkering, building, drawing, and investigating** where we slightly modify what is **real** and create a **new twist** on the known realities → basis of **new inventions** ranging from **product improvements** to totally **new products** or “gadgets”, processes, and **new ways of thinking.**
- Solving problems grounded in today’s reality → lays the foundation for **solving *similar* problems** that might emerge in the future. Without the **early foundation/experience**, solving new predictable/unpredictable challenges → difficult at best/impossible at worst.



"Open Architecture"

Author Joseph Epstein said, "We are what we **read.**"
Neuroscientists would modify that statement to say that "We are what we ***experience.***"

The human brain is the only organ that depends on **experience** to **determine its development** (how, where, when and if it develops and when it stops.)



Play and Piagetian Theory of Conservation

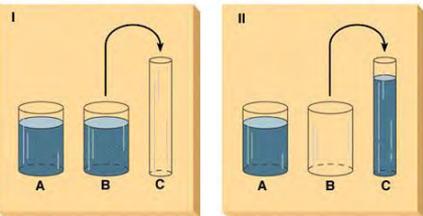
Piaget: **the pre-operational stage** → children perform in characteristic ways on *conservation* tests. Piaget: *conserving* = to *preserve an mental internal representation* (ages 5 - 7).

The Conservation of Liquid Quantity:

1. Shown two short **beakers** each with a wide **radius** → filled with 100 ml **water** → child watches → child is asked “...more or the same?” (the 2 beakers have = amounts of water) → the child agrees
2. Shown a **tall narrow beaker** with small radius → water is poured from one of the short-wide beakers into the tall narrow beaker → child asked, “Which contains more, or do they contain the same amount?” **children ↓ 6** → “the tall beaker has more” (swayed by perceptual cue of height)

Piaget, Human Development, 7e. Copyright © 1998, McGraw-Hill Companies, Inc. All Rights Reserved.

Piaget's Conservation Task





The Conservation of Mass:



Was Piaget correct? Yes, but only for children with ↓ **experience** playing with water.

- Children in Thailand and Brazil who **live along rivers** → correct answers well before age 6.
- Piaget's **Conservation of Mass** experiments? Children in Central/South America, Mexico and Africa who grow up in **pottery-making cultures** → correct answers considerably earlier in their development





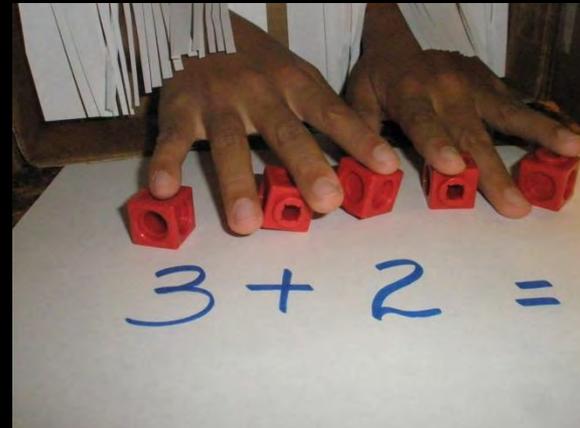
Play in Mathematics

Too often students learn how to **recite** the (ordinal) numbers

- without learning an appreciation for **matching** the **symbol** with the **quantity** it represents
- without learning how to **manipulate quantities** in the “mind’s eye” and...

1. know **what** the quantify represents in the end
2. understand **how** we consistently arrive at **that** specific number (not a random operation)

1	
2	
3	
4	
5	





Mathematics & Science

Teach simple → complex math/science concepts: **bouncing a ball**

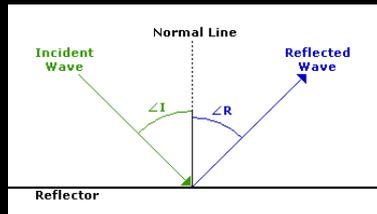
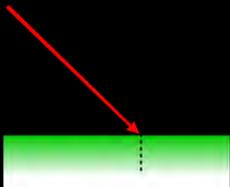


Ordinal numbers - counting: The sensory “cues”

- auditory (ball, impact noise, and voices)
- visual cues (motion & color)
- social (watch others for cues)
- kinesthetic cue (touch counting -muscle memory)

Geometry: Bouncing the ball to one another

- Angles
- Estimating angles (bounce in between)
- Fractions (bounce in between = $\frac{1}{2}$ way; bounce 2 times must “find” $\frac{1}{3}$ of the way in between)



Science:

- Force, motion, velocity
- “Laws of reflection and refraction” (conform to the same laws as “light” reflection - angle of incidence = angle of reflection)

Play and Water

“Oil and water don’t mix.”

Daniel Kahneman, the first **non-economist** to win a **Nobel Prize in economics** received his award for “**theory-induced blindness**” – the loyalty to a belief about some aspect of how the world works that is **so strong** that it **prevents** you from seeing how the world *really works*.



Making a Lava Lamp

Materials:

- Oil
- Water
- Colored dye
- Alka-Seltzer
- Flashlight

Procedure:

Pour 1 part water 4 parts oil into a container. Let the mixture settle. Pour 2-3 drops of colored dye into the container. Add $\frac{1}{2}$ tablet of Alka-Seltzer.

NGSS + CCSS = more of a solution than a mixture

Failure to Connect: “A Hole in the *Concept*” - Instructions

1. Read the excerpt on the next slide at normal speed.
2. Do not skim or give up halfway (read through to the end.)
3. Once you've finished, ask yourself how do you **feel** about reading the paragraph.



“Hole in the Concept”

A newspaper is better than a magazine. A seashore is better place than the street. At first it is better to run than to walk. You may have to try several times. It takes some skill, but it is easy to learn. Even young children can enjoy it. Once successful, complications are minimal. Birds seldom get too close. Rain, however soaks in very fast. Too many people doing the same thing can also cause problems. One needs lots of room. If there are no complications, it can be very peaceful. A rock will serve as an anchor. If things break loose from it, however, you will not get a second chance.



Making Connections

Was this paragraph **comprehensible** or
is it **meaningless** to you?

Note what happens in your mind when a
title is added.

- **Re-read** the excerpt (knowing the *title*,
now with no change to the contents)



Flying a Kite

(the missing piece to the comprehension puzzle)

A newspaper is better than a magazine. A seashore is better place than the street. At first it is better to run than to walk. You may have to try several times. It takes some skill, but it is easy to learn. Even young children can enjoy it. Once successful, complications are minimal. Birds seldom get too close. Rain, however soaks in very fast. Too many people doing the same thing can also cause problems. One needs lots of room. If there are no complications, it can be very peaceful. A rock will serve as an anchor. If things break loose from it, however, you will not get a second chance.

On Being Certain: Believing You Are Right Even When You're Not
Robert A. Burton, M.D.