How Today's Students Learn: Building Brain-considerate Classrooms

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Using Research from Cognitive Science to Enhance Student Learning

- What do we know about the brain?
- How does the brain "work"? How does the brain learn? (connections)
- The Developing Brain: How can we support and enhance brain development (in adverse social and economic environments)?
- What are some "best practices" found in the teaching-learning equation? (STEM/ST^{2}REAM → interdisciplinarity - connections) K-12 *applications* and K-12 *implications*

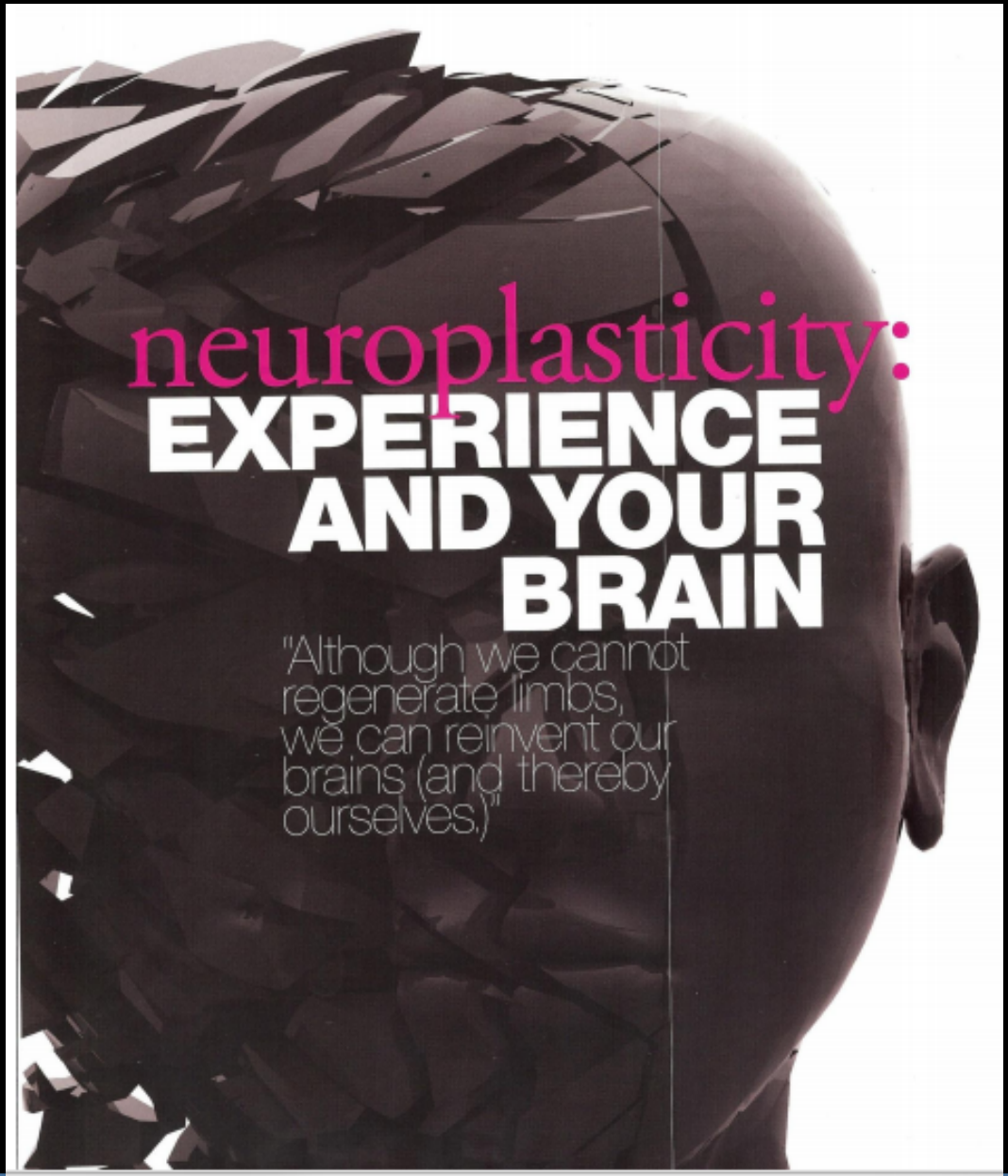
Quick writes and table talks

…a visual and conceptual tour…

The brain is without doubt our most fascinating organ. Parents, educators, and society as a whole have a tremendous power to shape the wrinkly universe inside each child's head, and, with it, the kind of person he or she will turn out to be. We owe it to our children to help them grow the best brains possible.

-- What is Going in There?
Lise Eliot

BrainWorld



neuroplasticity: EXPERIENCE AND YOUR BRAIN

"Although we cannot regenerate limbs, we can reinvent our brains (and thereby ourselves.)"

Neuroplasticity: experiences determine…

- which **brain cells** *communicate* with which other cells
- which **structures** *link together* and to what degree
- which cells release which ***neurotransmitters,*** when, and under what specific conditions they are released
- the precise calibration of ***structure-function*** **correlations** inside the brain.

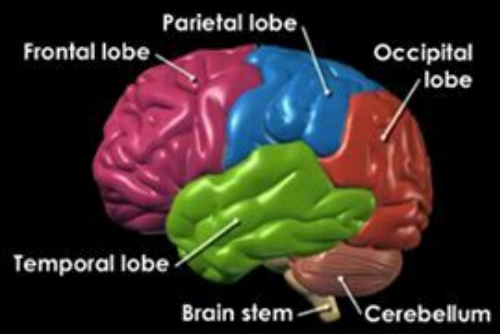
The Human Brain

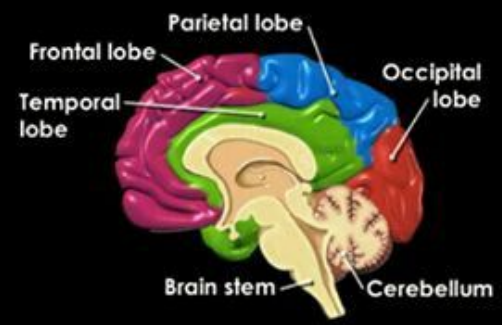
- **The most important take-home message from today concerning your students, regardless of age is that brains can change, brains do change, because all brains were *designed* to change. The long-term benefits of high quality education delivered by highly trained are well documented as changes in the brain** (Campbell,Pungello, Miller-Johnson, Burchinal, & Ramey, 2001; Ramey, 2006).
- **Intelligence and measurable IQ are variable and not fixed (interventions → IQ point gains of 30+ points)**
- **Everything we experience or do depends on the physics and the chemistry of the brain and spinal column (CNS).**

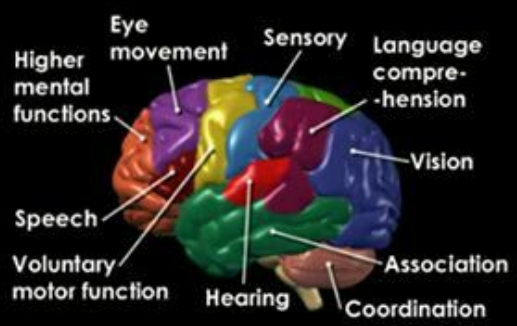
The Human Brain is Phenomenal

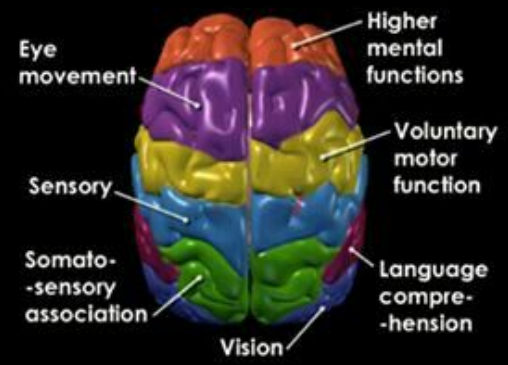
Your brain is the most phenomenal object in the universe and the most valuable piece of real estate on Earth (to you).

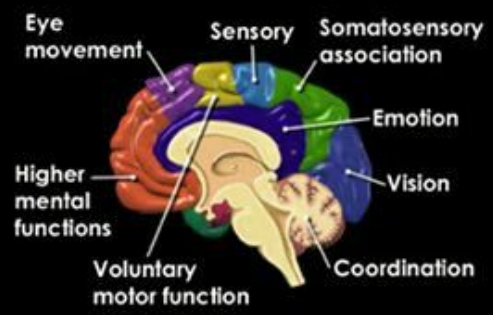
Hemispheres → Lobes → Circuits → Cells

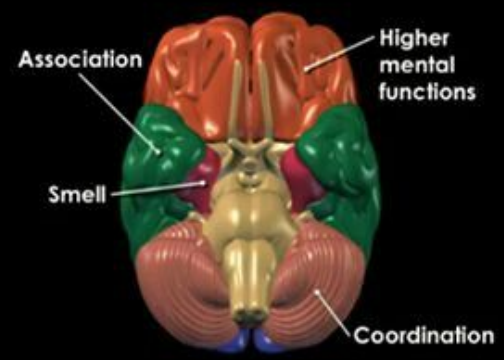




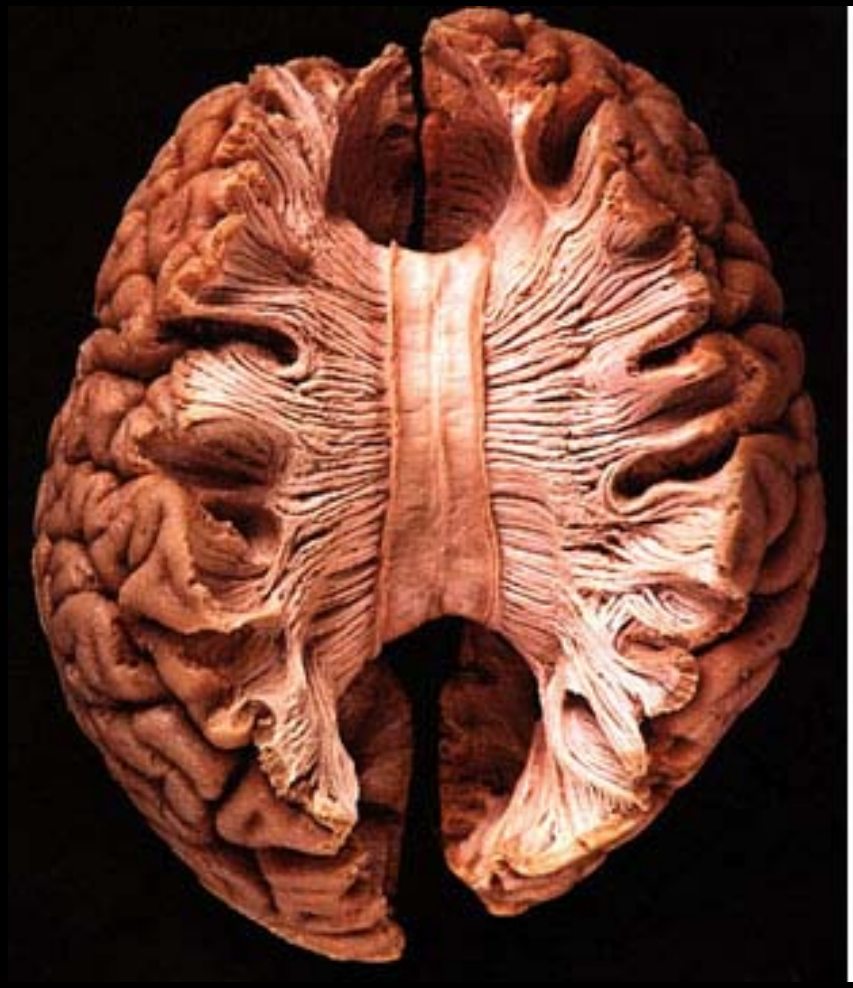


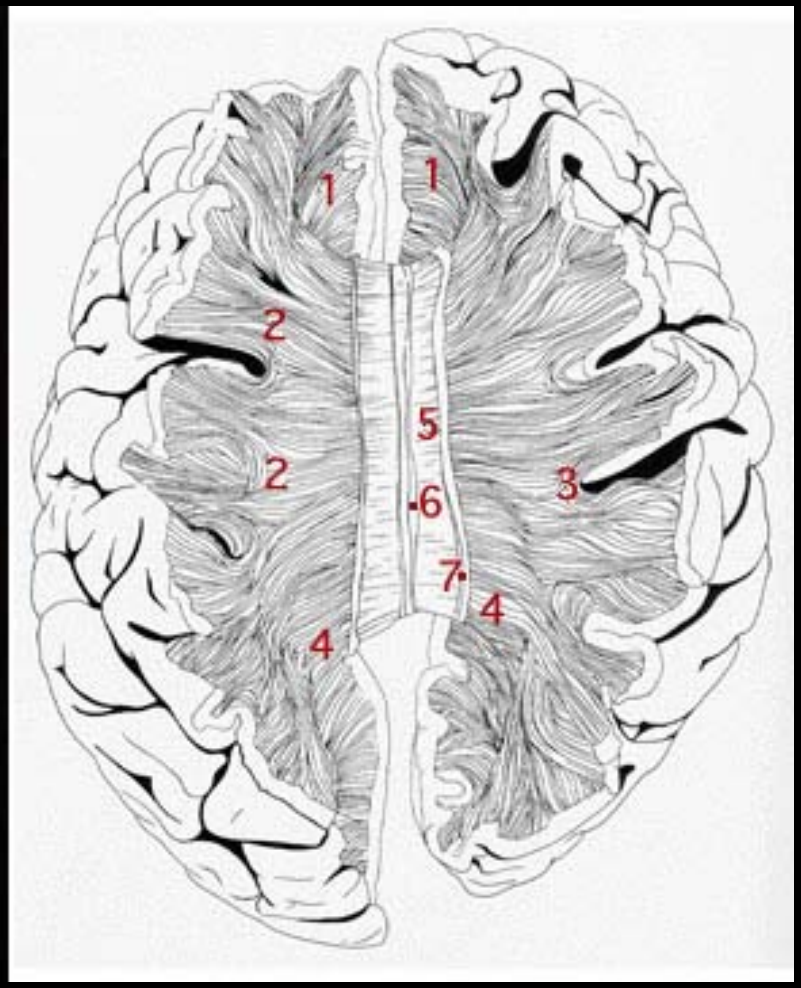






Are some people "left-brained," while others should be considered "right-brained"?





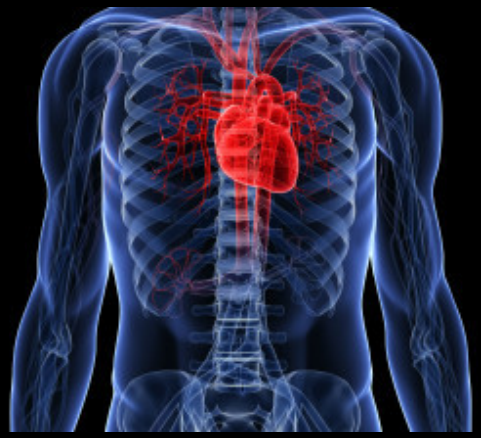
Hemisphericity

Corpus Callosum

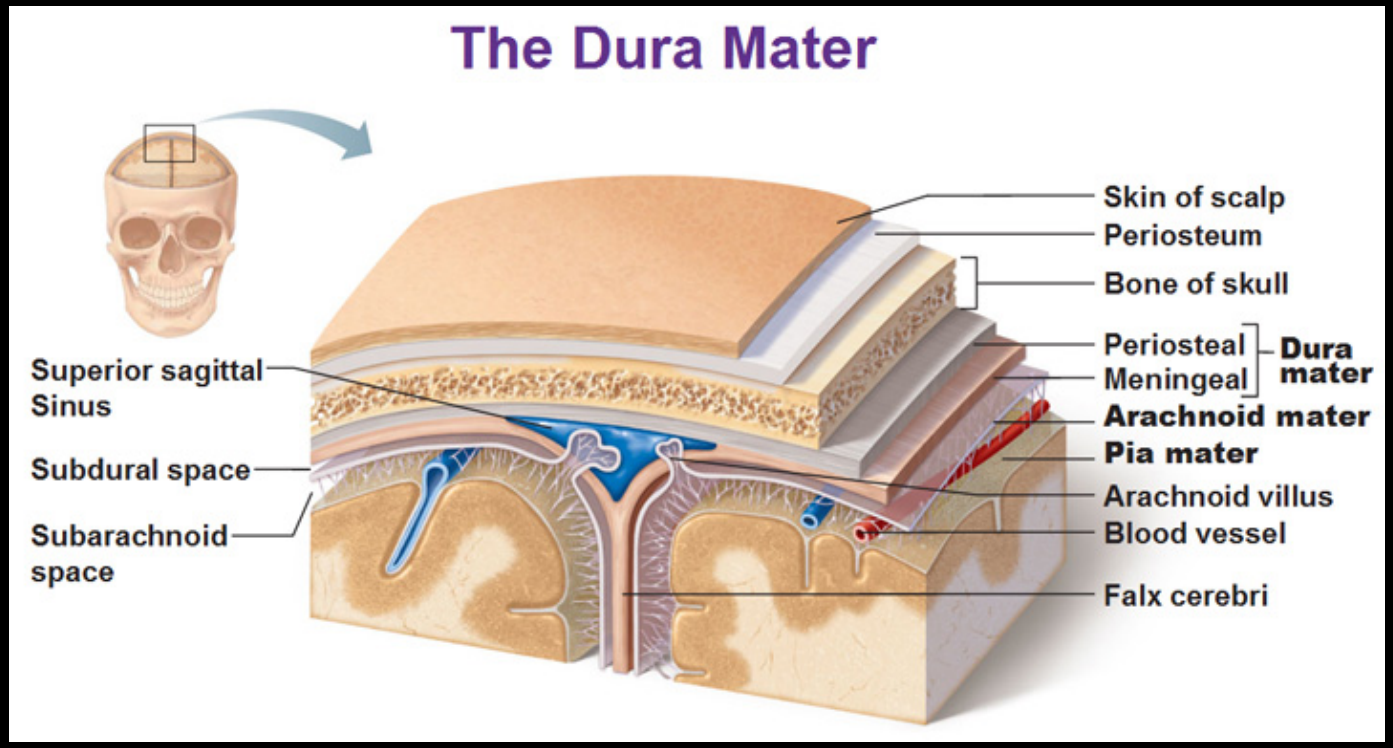
The Astonishing “Body-brain”

The human “body-brain” develops as one entity, not two separate systems emerging independent of one another.

The Best Protected Organ



The brain uses of a larger proportion of the human genome than any other organ. More genes are devoted to brain-building and brain functioning than any other organ. Over 50% of cardiac output → the brain



The Biological Brain by the Numbers

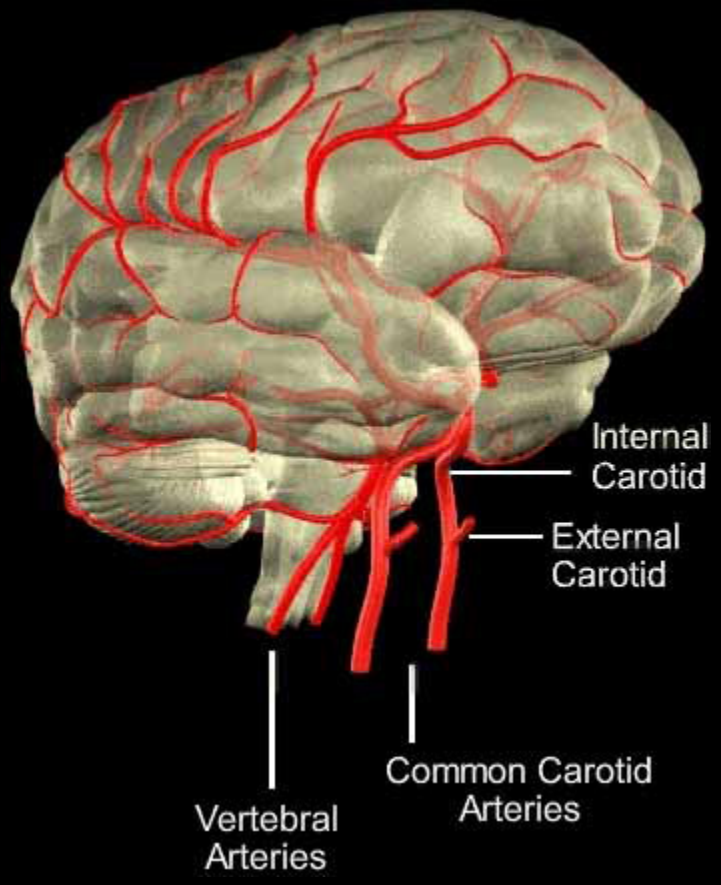
From 1 to 1,000 Trillion

What is important about the following numbers?

1	270
1.5	1,000
2	10,000
3	40,000
4	250, 000
18	100 billion
19	200 billion
52	900 Billion
100	1 trillion
150	1,000 trillion (quadrillion)

The Biological Brain by the Numbers

1 = Body-brain

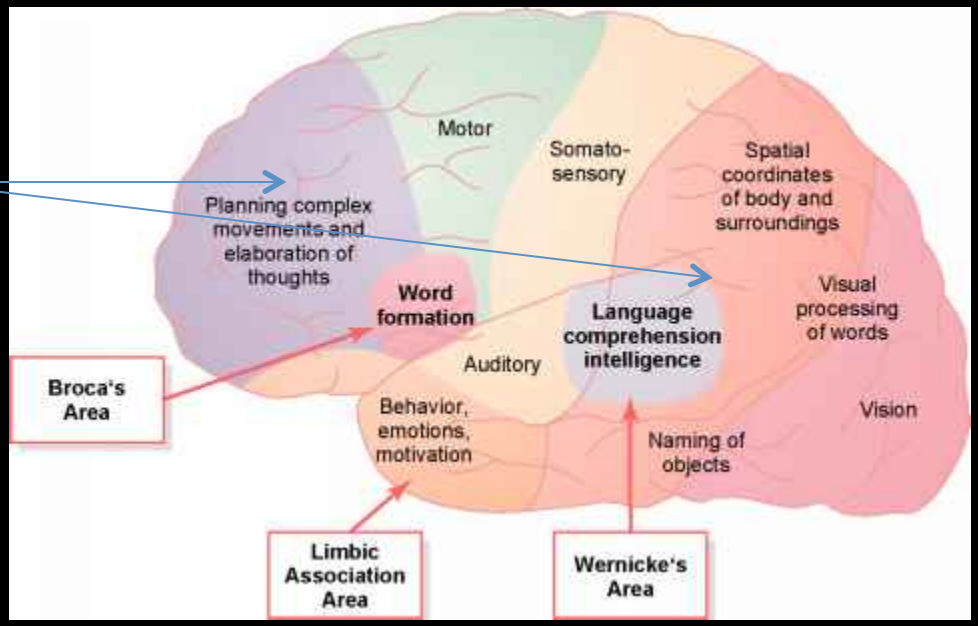


1.5 = Pints of blood that flow through the brain each minute

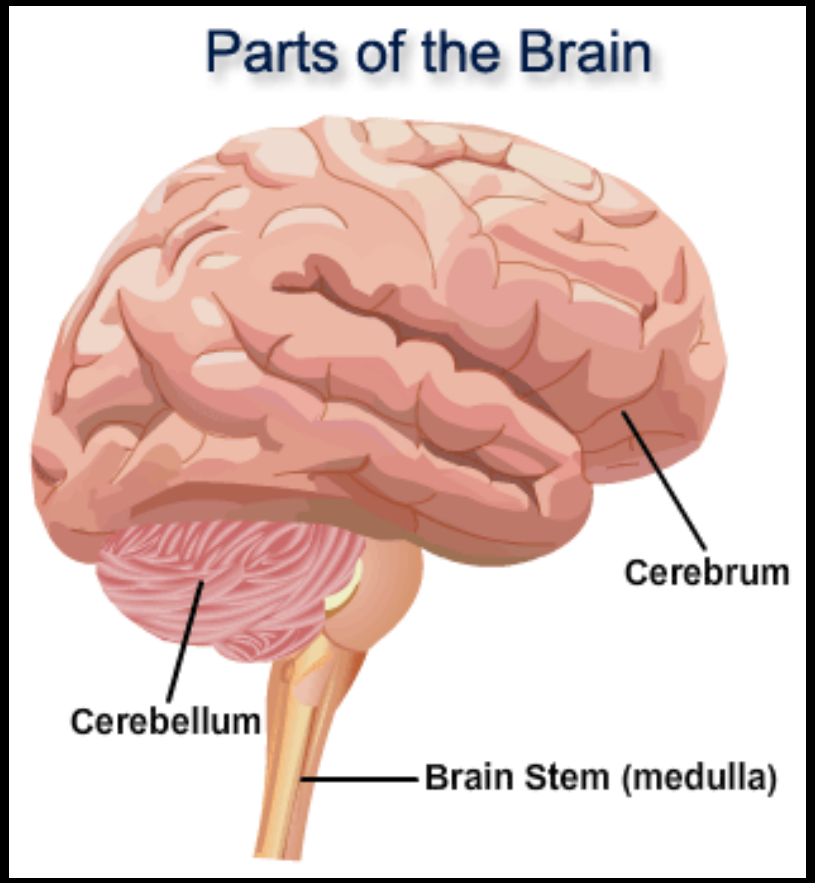
The Biological Brain by the Numbers

2 = Number of hemispheres
(*L* and *R*)

2 = Number of primary association areas of the cerebral cortex

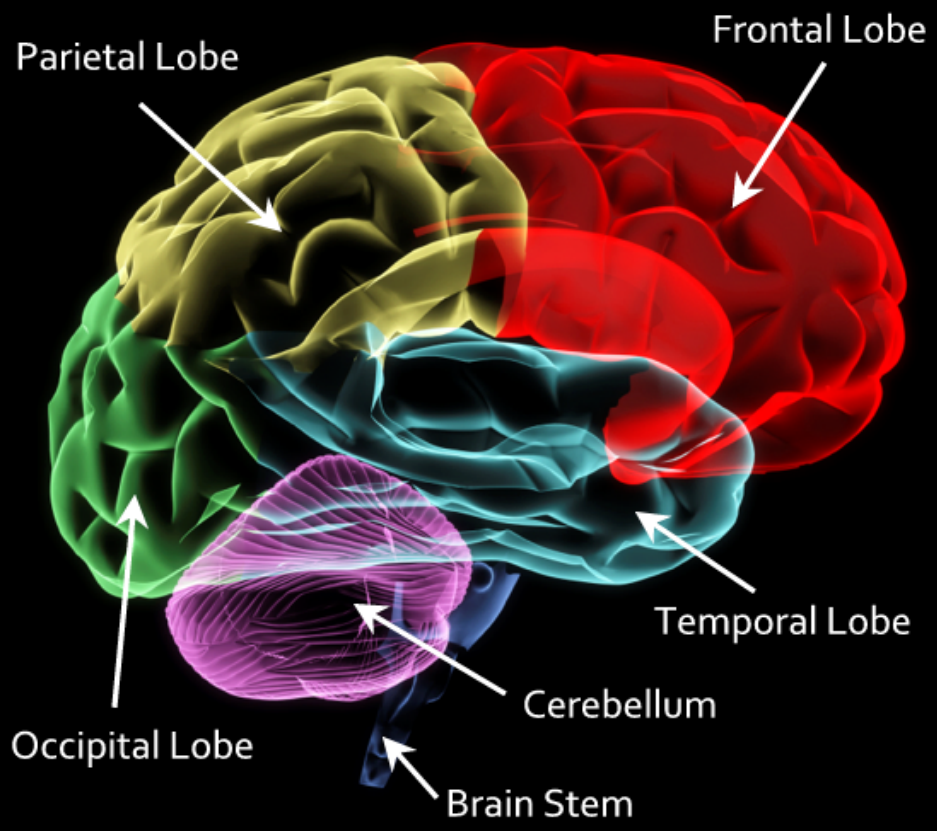


The Biological Brain by the Numbers



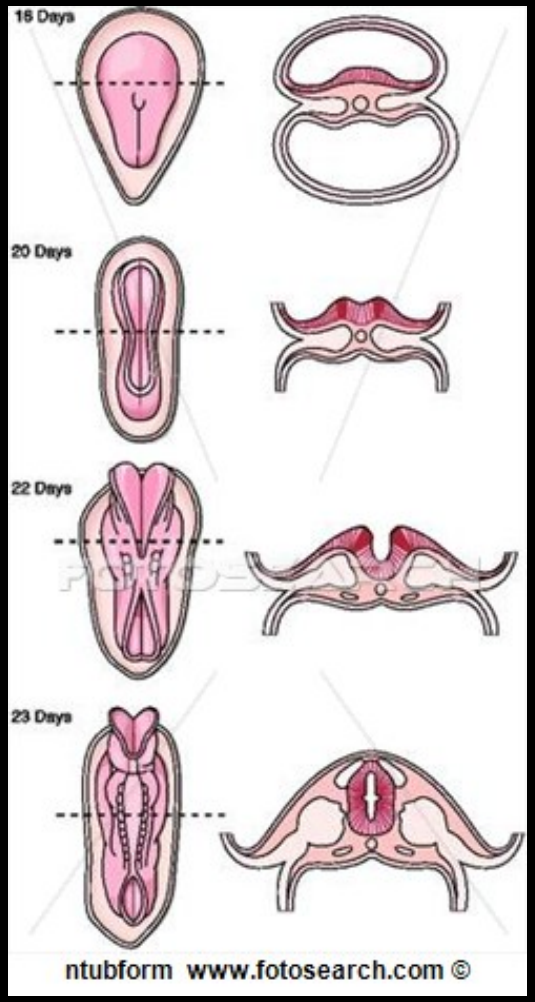
3 = Number of major brain areas (brain stem, cerebellum, cerebrum)

The Biological Brain by the Numbers



4 = Number of lobes in the brain (frontal, parietal, occipital, temporal)

The Biological Brain by the Numbers



18 = Number of days following fertilization that the earliest stages of brain development begin

The Biological Brain by the Numbers

Sense	Type of Sensory Input
1. Sight	Visible Light (eyes)
2. Hearing	Vibrations (air/ear)
3. Touch	Tactile contact (feeling/skin)
4. Taste	Oral contact with chemicals
5. Smell	Olfactory molecular experience (nose)

Contemporary science classrooms: 3 ½ - 4 (sight, sound, touch, and "wafting and whiffing" in chemistry (smell)

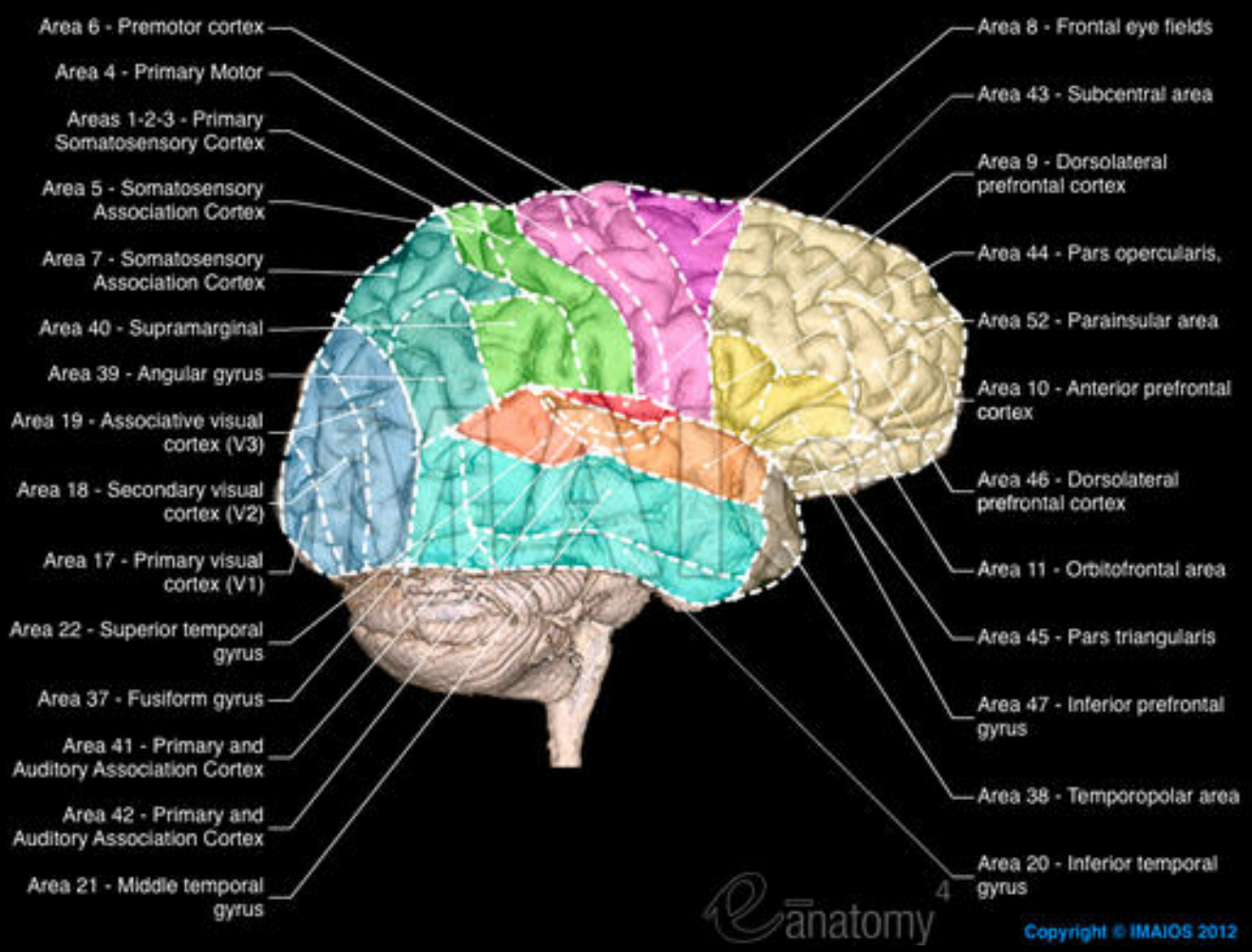
19 = Number of human senses

sweet, cinnamon-scented pumpkin pie

19 Human Senses (S. Kovalik)

Sense	***Type of Sensory Input***
6. Balance	Kinesthetic geotropic (coordination)
7. Vestibular	Repetitious movement (e.g. spinning)
8. Temperature	Molecular motion (heat)
9. Pain	Sensory reception (nocioception)
10. Eidetic imagery	Neuroelectrical image retention/production
11. Magnetic	Ferromagnetic orientation
12. Infrared	Long electromagnetic waves
13. Ultraviolet	Short " "
14. Ionic	Ionic charge (airborne)
15. Vomeronasal	Pheromonic sensing
16. Proximal	Physical closeness (of objects or people)
17. Electrical	Surface charges
18. Barometric	Pressure in the Atmosphere
19. Geogravimetric	Sensing differences in mass

The Biological Brain by the Numbers



52 = number of functional regions of the cerebral cortex originally defined and numbered by Korbinian Brodmann in the early 1900's.

The Biological Brain by the Numbers

The body-brain has a physique and a "chemique"

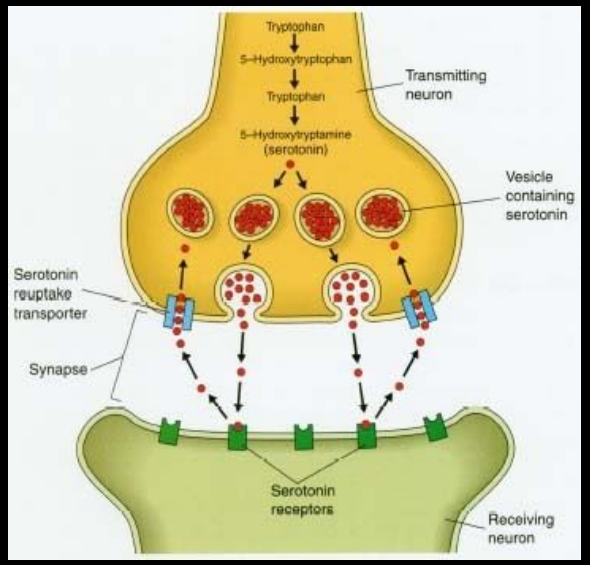
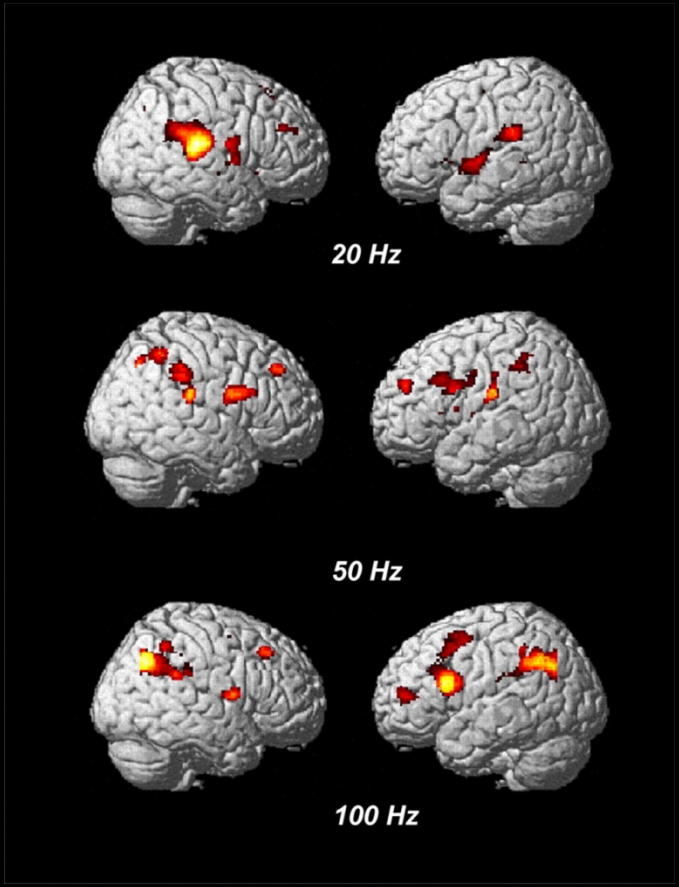


Table 11.1 Actions of Common Neurotransmitters

Neurotransmitter	Sites Where Released	Principal Actions
Acetylcholine	Brain Neuromuscular junctions Autonomic nervous system	Excitatory on skeletal muscles Excitatory or inhibitory on internal organs
Norepinephrine	Areas of brain and spinal cord Autonomic nervous system	Excitatory or inhibitory, depending on receptors Plays a role in emotions
Serotonin	Areas of brain Spinal cord	Usually inhibitory Involved in moods, sleep cycle, appetite
Dopamine	Areas of brain Parts of peripheral nervous system	Excitatory or inhibitory, depending on receptors Plays a role in emotions
Glutamate	Areas of brain Spinal cord	Usually excitatory Major excitatory neurotransmitter in brain
Endorphins	Many areas in brain Spinal cord	Usually inhibitory Natural opiates that inhibit pain
Gamma-aminobutyric acid	Areas of brain Spinal cord	Usually inhibitory Principal inhibitory neurotransmitter in brain
Somatostatin	Areas of brain Pancreas	Usually inhibitory Inhibits release of growth hormone

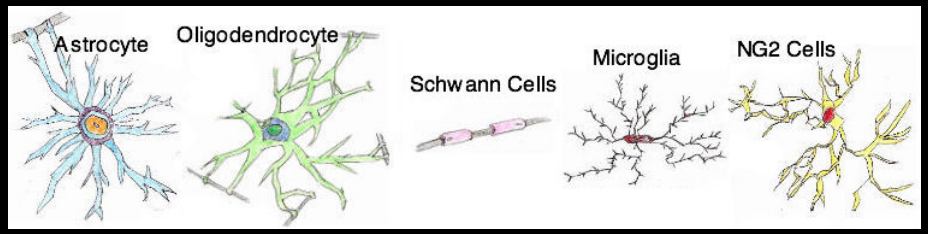
100+ = Neuroscientists have identified over 100 neurotransmitters in the human brain, but evidence suggests we have significantly more.

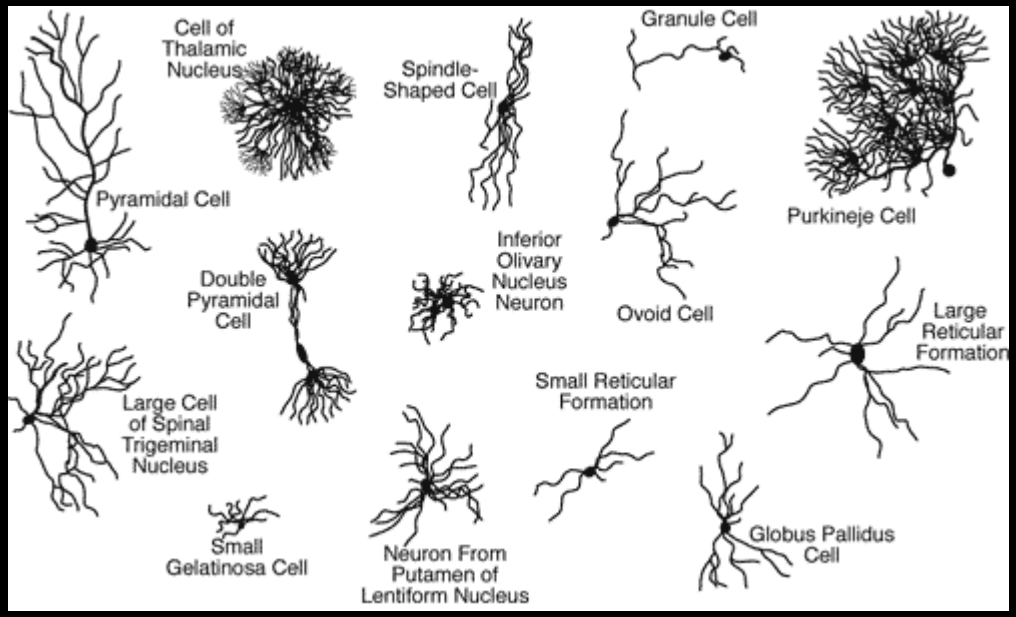
The Biological Brain by the Numbers

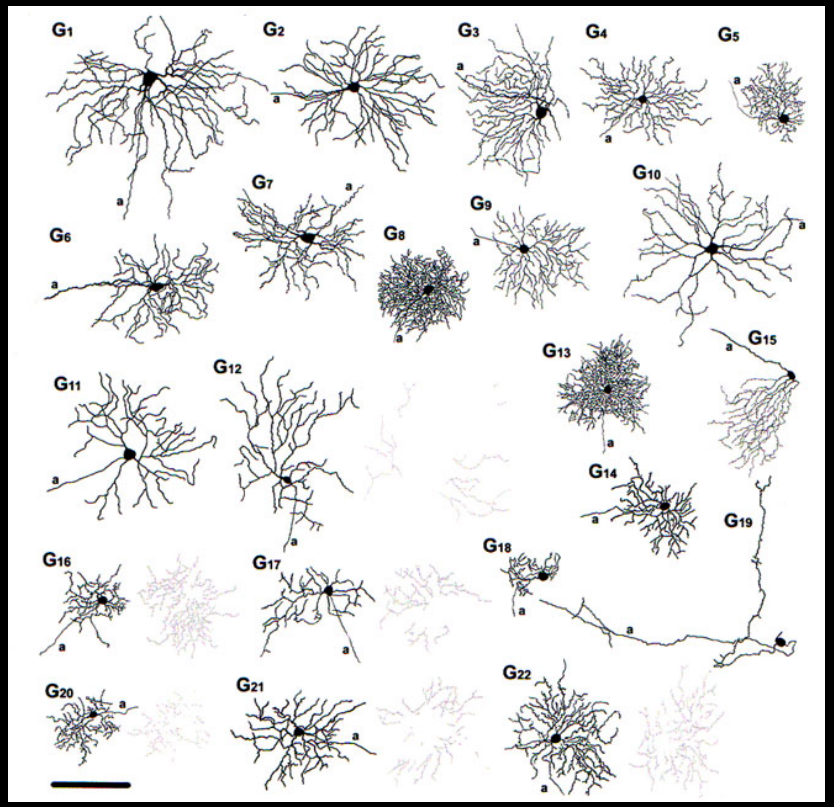


100+ = Number of different functional regions in the brain

The Biological Brain by the Numbers







22 different types of ganglion cells found in a mouse retina

150+ = Number of different types of brain cells

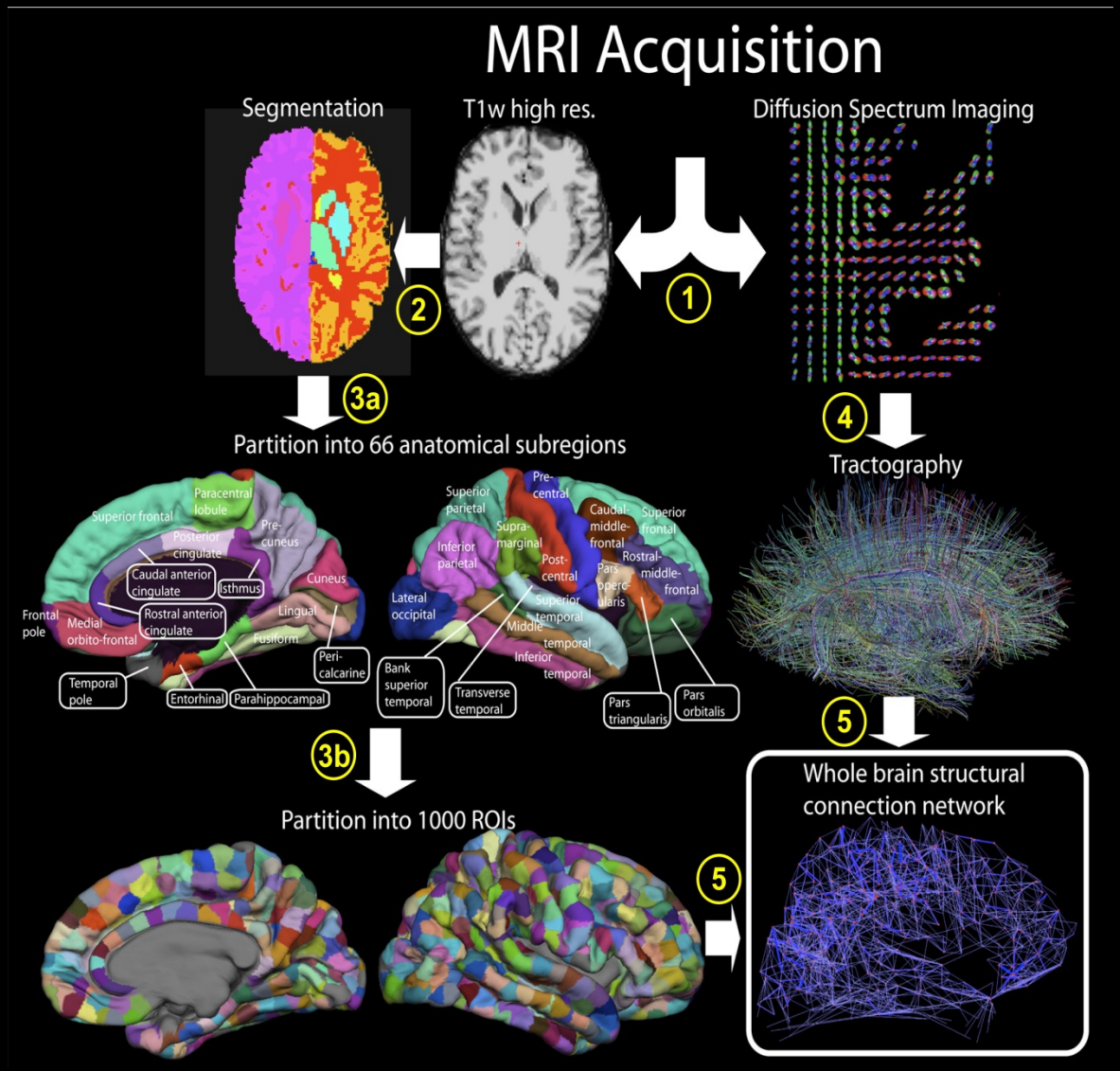
The Biological Brain by the Numbers

Electrical Signals in Neurons

- Like muscle fibers, neurons are **electrically excitable.** They communicate with one another using two types of electrical signals:
  - **Graded potentials** are used for short-distance communication only.
  - **Action potentials** allow communication over long distances within the body.

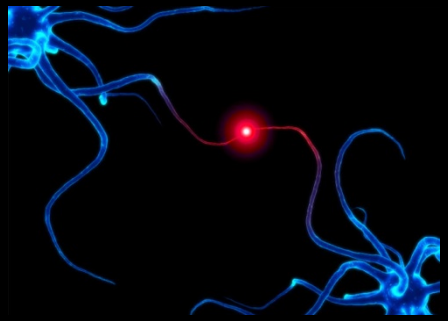
270 = m.p.h. at which neuronal signals travel

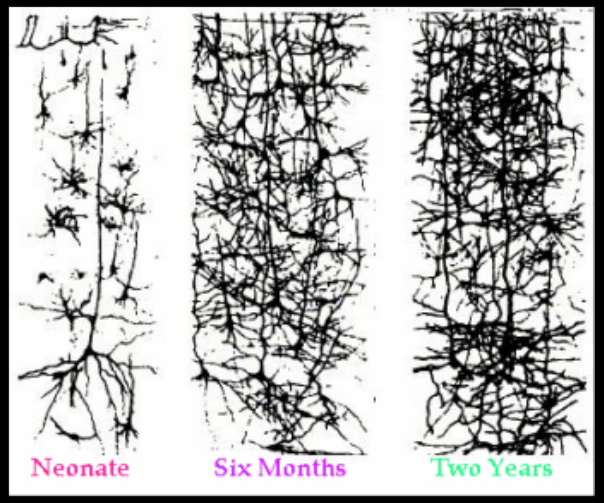
The Biological Brain by the Numbers

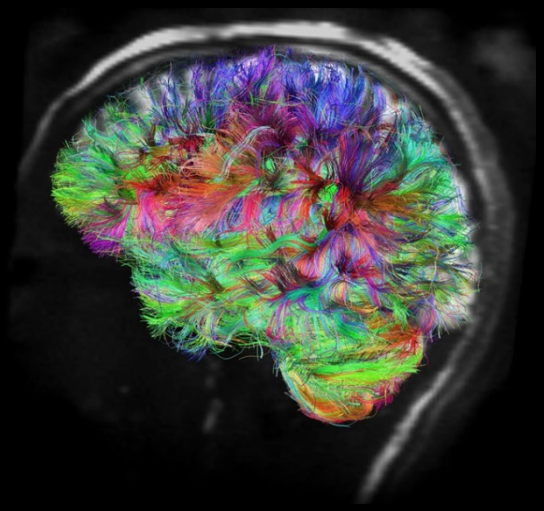


1,000 = Number of ROIs (regions of interest) housing the structural connection matrixes inside the brain (MRI)

The Biological Brain by the Numbers







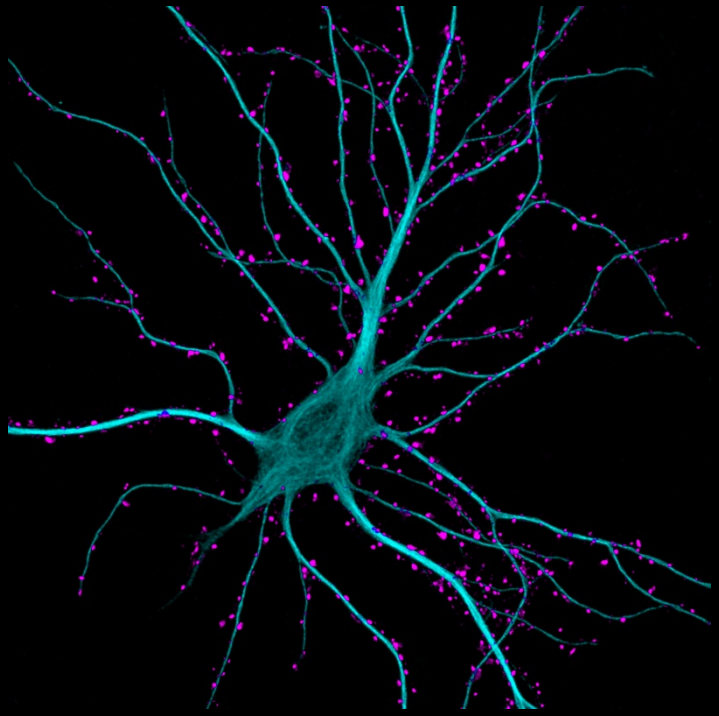
10,000 + = Number of connections made by each neuron

The Biological Brain by the Numbers

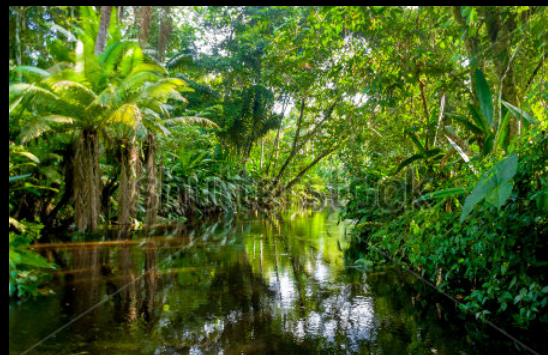
40,000 = Total miles of blood vessels and capillaries in the brain

The Biological Brain by the Numbers

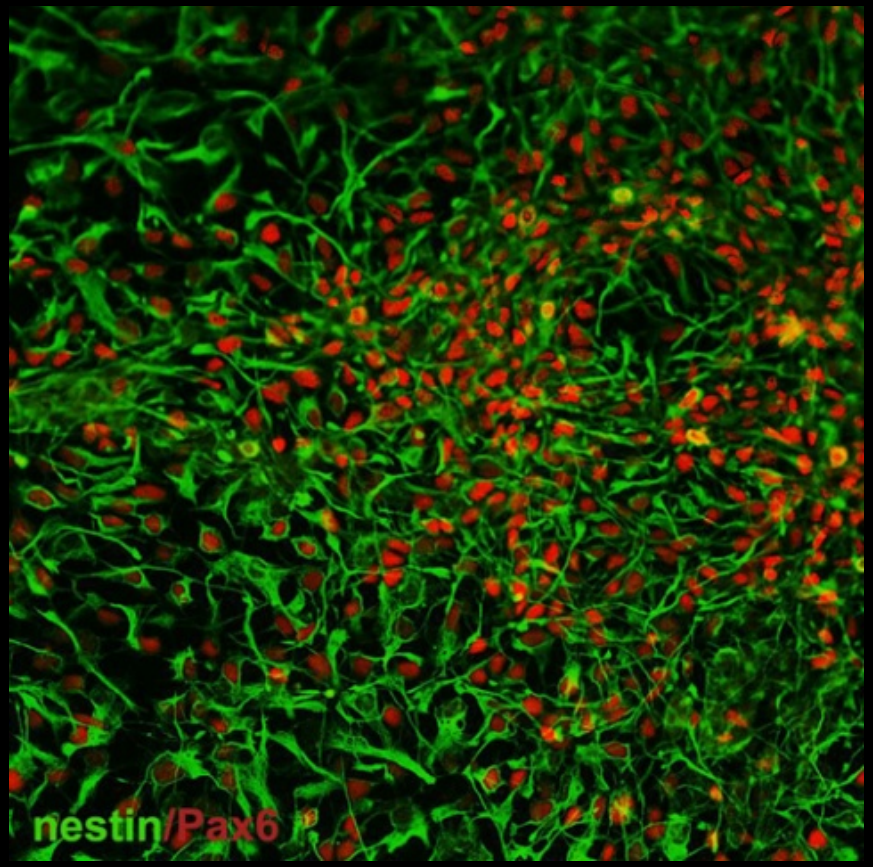
250,000 = Number of brain cells produced each minute during neurogenesis



100 billion = Number of neurons that we are born with (full-term)



The Biological Brain by the Numbers



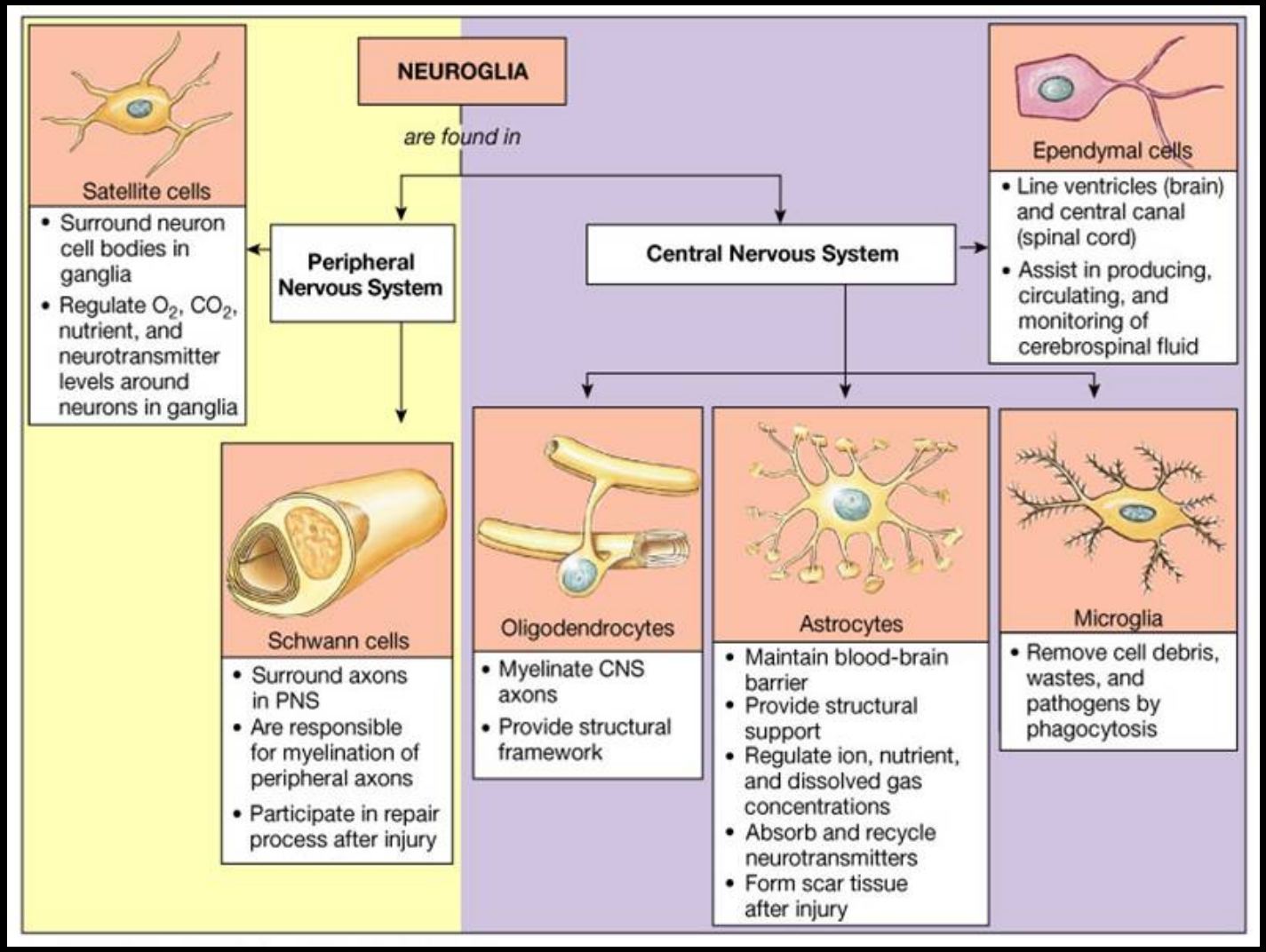
200 Billion = Number of neurons at the end of the 2nd trimester of pregnancy (neural proliferation → synaptic and neural pruning)

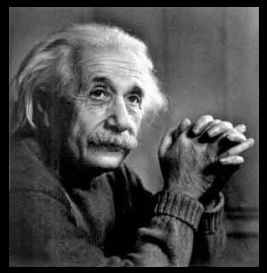
Neurons and Neural Connections

Peter Huttenlocher (University of Chicago) conducted a **synaptic census** of the brain. These connections are so small and plentiful that they had previously defied quantification.

Age	Numbers
End of 2nd Trimester	200 Billion **neurons**
At birth (full term)	100 Billion **neurons**
8 months old - **3 years**	1,000 Trillion **connections**
By age 10	500 Trillion **connections**
28-week old fetus	124 million **connections** (in a pinhead spec of brain tissue – 70K neurons)
Newborn	253 million **cons./spec**
8-month old infant	572 million **cons./spec**
By Age 12 (stabilizes)	354 million **cons./spec** **225%**

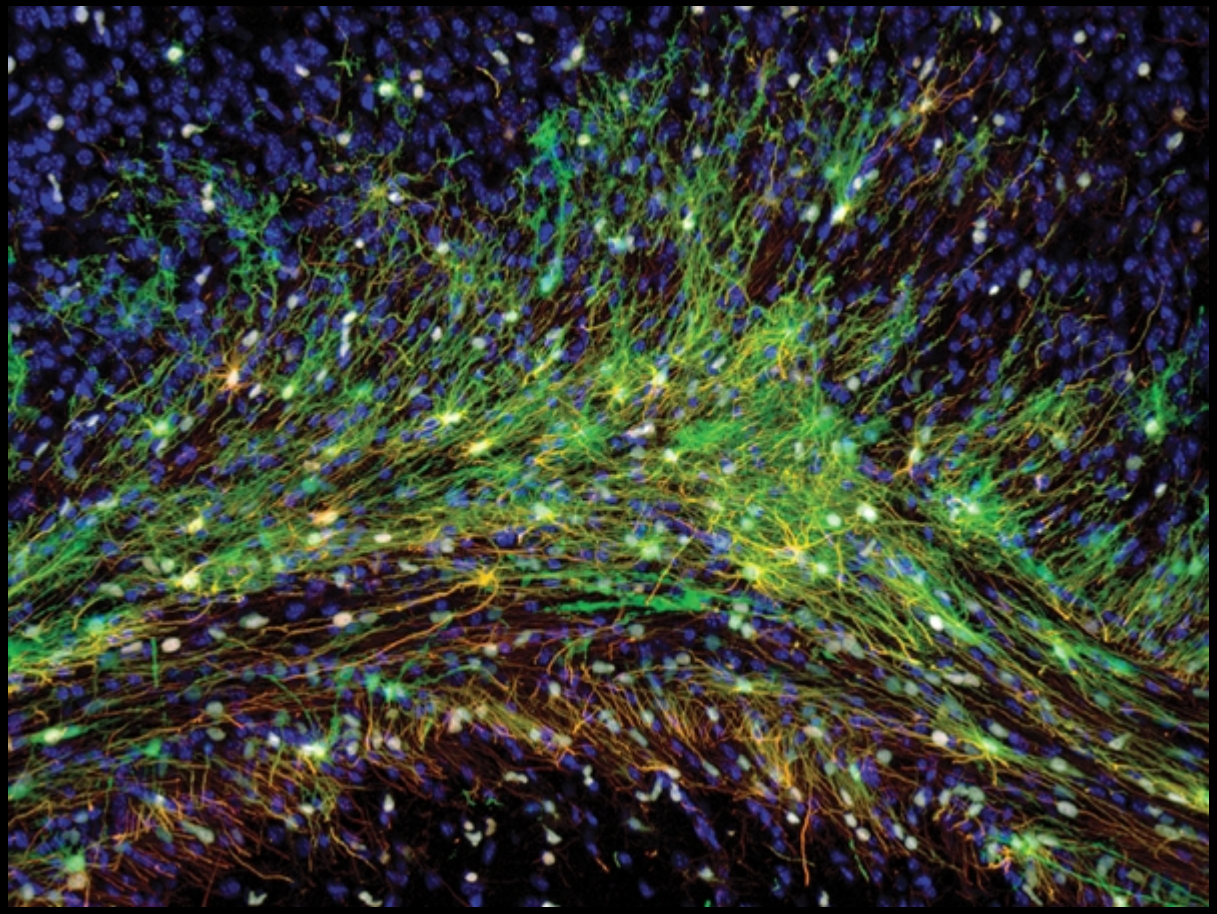
The Biological Brain by the Numbers





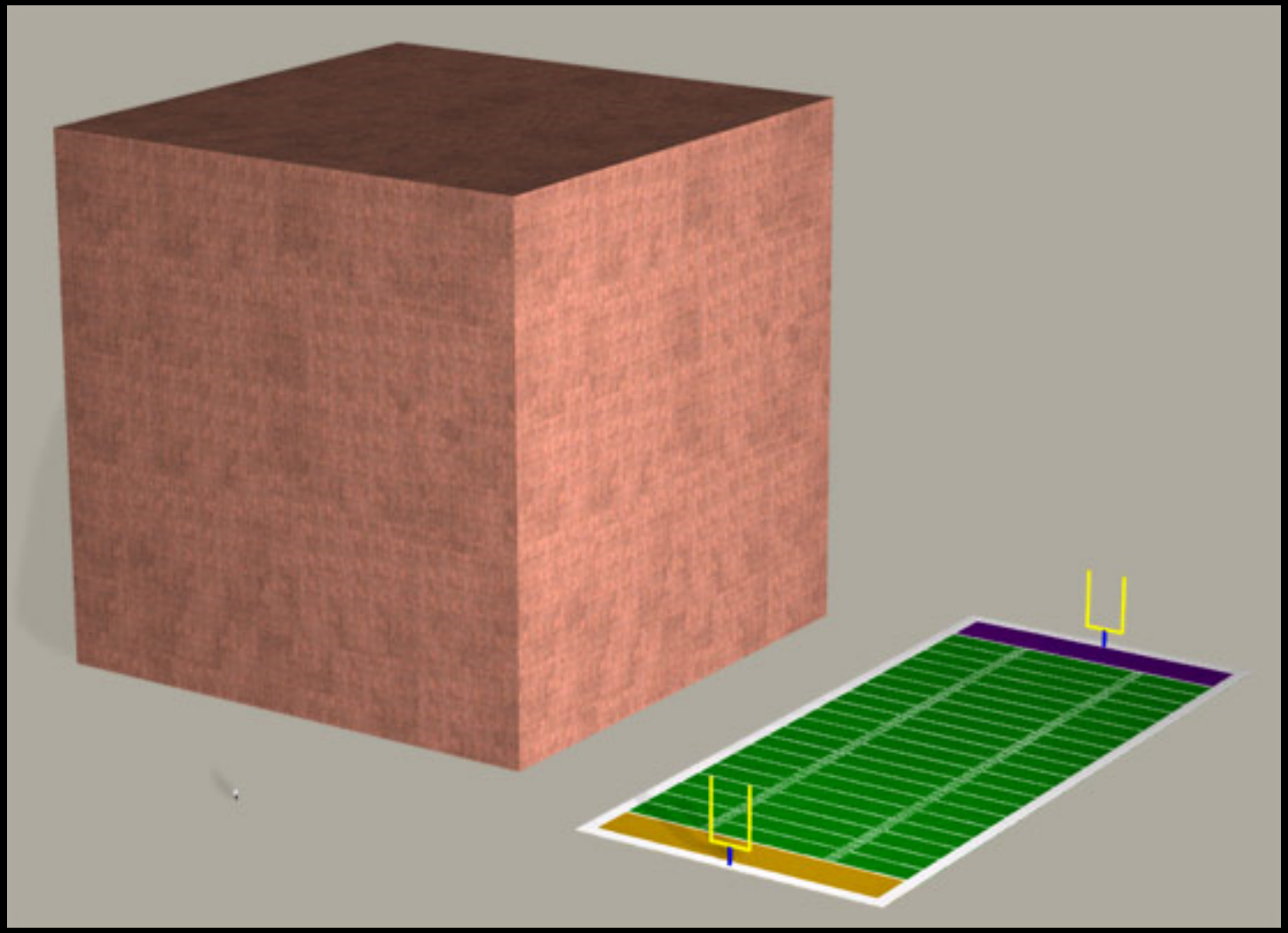
900 billion = Number of glial cells

The Biological Brain by the Numbers

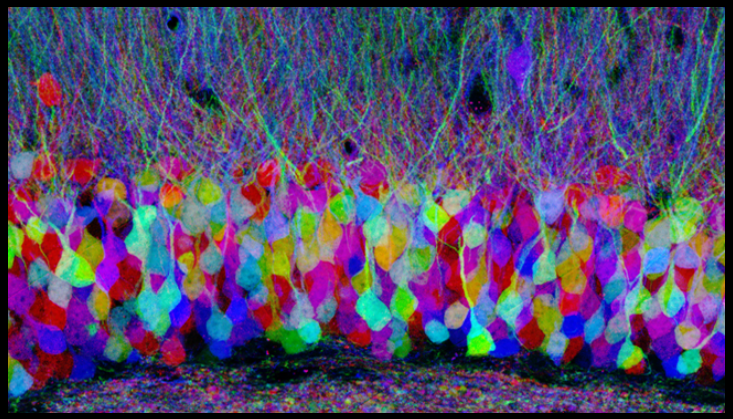


1 trillion = Number of total brain cells

One Trillion?: One Trillion Pennies

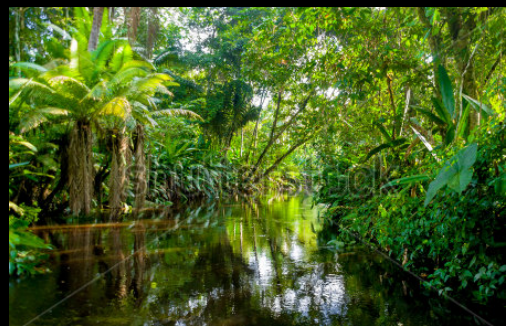


The Biological Brain by the Numbers



1,000 Trillion = Number of connections in the brain of an infant between the ages of 8 months and 3 years (synaptic proliferation)

(quadrillion)



“How does the human brain *learn?*”

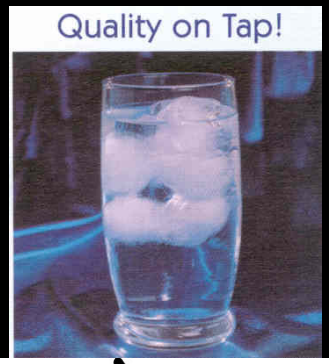
First question…

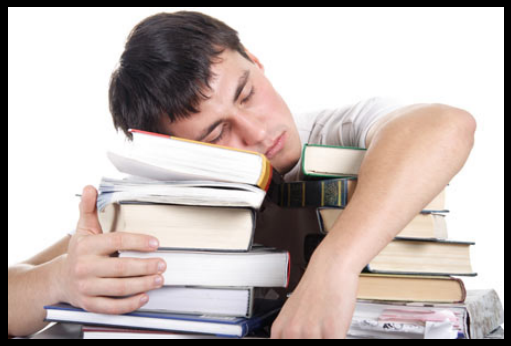
What do all brains need?

Regardless of Age, All Brains Need

3-3-3-3

Water (3 days)





Exercise

Sleep (3 days)

(stress mgt.)

Stimulating activities

Oxygen (3 mins.)

Nutrition (3 weeks)

Positive Attitude

(healthy brain)

Chi-Do™
HARMONY OF ENERGY

Neurophysiological Consequences of Laughter

- More blood →cerebral cortex and less to the limbic system (posterior hypothalamus "off" position).
- Cortical control over the large muscle groups is ↑ which ↑ body-kinesthetic performances.
- A slight ↑ in heart rate: a cardiovascular "positive."
- Increases one's ability to "focus" and pay attention.
- Enhances respiration: ↑ oxygenated blood to the brain.
- It fosters an improvement in problem-solving ability/ performance when mental-cognitive tests are preceded by laughter. (board games, laughter, etc.)

BC Attention-getting Teaching Strategies

- Humor
- Change
- Color
- Movement
- Discrepant events
- Patterns
- Emotions/social interactions
- A… suspenseful pause

Novelty
Prior knowledge activation
Music
Surprise
Personal relevance

Activate the intrinsic reward (dopamine-pleasure) system

No attention = No engagement = No Learning

…with liquid? ("critical competitor")

Unleashing the power of inquiry and metacognition

A distinction: Brain-derived answers vs. memorized answers

Brain-considerate Learning: “Walk and Read”

Dear Kenneth:
Your presentation on Monday was exceptional. I’ve heard teachers say it was one of the best professional development events they’ve attended. The teachers have been extremely receptive and have utilized some of your strategies. Please read the email below, which was sent from our 8th grade ELD teacher.

I wanted to share that I did the “Walk and Read” yesterday like Dr. Kenneth Wesson suggested. It went really well! When the students were *re-reading* really complex information, it was especially helpful. I told them *why* we were doing it and they were into it. Today’s conversation about the text greatly exceeded my expectations based on what they learned from their first reading of the same material.

I’m not totally sure how or why his strategy actually works yet, but it I’ll keep using it for sure! The kids liked it. (My calves aren’t so happy today from walking over 15,000 steps yesterday including 3 flights of stairs 10X and multiple trips around the quarter-mile track.)

I took some pictures and put them on my website too, here is the link:
https://wms-alamedausd-ca.schoolloop.com/reading?no_controls=t

Choice

Choice (student control)

- Hand-written or typed?

  Oral or written report?

  Five-pages with illustrations/clip art or 3 written pages

- Shifts students' attention from the *work* itself to "How will I *accomplish* the task?"

Fun-da-Mental Learning

The 4 E's of Cognition and (LT) Learning

1. **Emotions –** ↑**dopamine** (essential to activating the brain's reward circuitry – mesolimbic dopamine system)
2. **Enthusiasm – feedback → confidence to move forward**
3. **Experience – builds the brain circuitry that represent who we are, what we know and what we are capable of doing**
4. **Engagement – hands-on, minds-on, hearts-in learning experiences**

"This (educational) revolution arises from ongoing and compelling research on how children and adults learn (i.e., a science of learning). The old model of teaching as simply telling, and of learning as passive sit-and-get listening *will not* meet the needs of tomorrow's citizens."

Science for the Next Generation: Preparing for the New Standards
Thomas O'Brien, Professor of Science Education.
Binghamton University

Change the Narrative

Our best efforts in teaching requires a shift

from…

"What am *I* supposed to *teach*?"

to

"How do *my students learn*?"

Factors Influencing Stimulus → Response

In addition to desires, tendencies, appetites, instincts, inclinations…

Genetics	+Epigenetics and early nutrition
+Pre-natal care	+Age
+Early development (0-3)	+Emotions/emotional state
+Parenting	+Gender
+Physical history	+Perception/expectations
+Neuro-physiology	+Memory
+Prior learning (situated L')	+Diet
+Prior experiences	+Self-esteem
+Need state	+Disability
+Strengths	+Neural circuitry/plasticity*
+Formal Education	+Stress factors

Learning/Behavior

* **Neural plasticity:** The flexible nature of the brain to modify structures, alter its functioning and re-route neural circuitry as a response to new stimuli and ongoing learning experiences.

Making Connections

"Re-purpose" the same cells for participation on countless *related* brain circuits

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." ("script")

-- (Pellegrino, et al.)

Maintaining and Strengthening Memory

Bridge	Build	Extend
10%	80%	10%
Past content	New information	Preview

"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.)

Perceived "Attention Problem" in the Classroom

Slower-processing Brains

- **Auditory centers** process consonant sounds at **0.3 secs./per sound** (normal = **0.008)** → too slow to keep up with the fast pace of oral "languaging."
- These children fall behind → hear directions, but moments later ask, **"Can you say that again?"** although they have been **nodding affirmatively.**
- They have finished **processing of the *1st* sentence,** when you begin the ***3rd*** sentence, completely missing the 2nd sentence → teacher's instructions = disjointed information (a problem?) -- **underlying problem** lies within his/her **auditory and neural processing centers** (temporal lobe).

Threat and the Human Brain

Results of perceived threats in the environment

- Fight or flight? (*Freeze*-flight-fight-fright: ordered responses) – prepare for predators
- Freeze - Individuals are psychologically immobilized until the perceived threat/transgression has been resolved
- Can cause a complete loss of self-motivation
- Learning, memory and recall are among the first cognitive casualties
- Fright – lose control of our bladder and bowels – LT = bedwetting

Stress

- "Roller-coaster" stress (intermittent stress) is normal and healthy – it helps develop resiliency.
- Acute or chronic stress (frequent features of poverty) can leave a devastating imprint on the developing child - physically, psychologically, emotionally, as well as cognitive functioning.
  - Acute stress: brief, but severe stress resulting from exposure to trauma, abuse, violence. The human body is well adapted to deal with *short-term* stress or acute stress.

Stress

- Chronic stress: a high degree of continuous unmitigated stress. Regular exposure to chronic or acute stress shrinks neurons in the frontal lobes decreasing one's executive functions - planning, judgment, controlling impulsivity (Cook & Wellman, 2004).

- Chronic stress modifies the hippocampus, reducing a child's learning capacity (Vythilingam, 2002)

Executive Functions

- ***Executive functions*** **take place in the prefrontal cortex (a "global neuronal workspace" – S. Dehaene) and are what we use to manage our attention, emotions and our goal-directed behaviors.**
- **Heavily involved in executive functions are working memory and inhibition (attentional skills), they are among the last parts of the brain to mature.**
- **Working memory = holding information in your mind while mentally working with that information or updating it. (Examples would include mental math, long division, events, prioritizing the order in which tasks must be done for a project, remembering the sequence of events/characters in a short story/ novel, the lengthy process of decision- making).**

Executive Functions

- **Inhibitory control** = resisting inclinations to engage in behaviors different than the action, known to be most appropriate (controlling attention, emotions, and behavior - ignoring internal and external distractions or impulses). Competing goals.

- Children's emotional control relates to their **school readiness** and thereby their cognitive abilities.

- Lack of inhibition = ADHD/ADD. Deferred gratification (Walter Mischel's Marshmallow Test – Stanford). Estimating time.

Executive Functions

- ***Executive functions*** **call on an individual to reflect on what he/she already knows, to use that knowledge creatively (in different and new contexts), to use it to solve problems, and to use information and reason from multiple perspectives ("fluid intelligence").**

- ***Fluid intelligence*** **and** ***executive functions*** **work in tandem. Some individuals possess knowledge, but have difficulty acting effectively/intelligently in light of that accumulated knowledge. Successful behaviors should be guided by our accumulated knowledge and skills.**

Executive Functions

- Executive functions include (1) working memory, (2) inhibitory control, (3) focused concentration, (4) cognitive flexibility, and (5) reflection.
- They take time to develop (decades of practice and experience.)
- Executive functions are compromised under stress, when sleep deprived, for fearful.
- When we bring things back under control, we return to homeostasis.

Stress Responses

1. **Hyper-sensitive:** difficult to calm
2. **Hyper vigilant:** wide-eyed, looking around (predators?), muscle tension, defensive
3. **Shut down -** cannot think logically, processing/encoding difficulties, difficulties in learning and remembering (school)

Toxic Stress

Chronic stress or **"toxic stress"** can lead to the physical destruction of neurons in the **hippocampus** (an area in the brain associated with **learning and memory storage.)**

Cortisol, a hormone produced by the adrenal gland that activates important brain and body defenses to stress, is the most potent glucocorticoid produced by the adrenal glands.

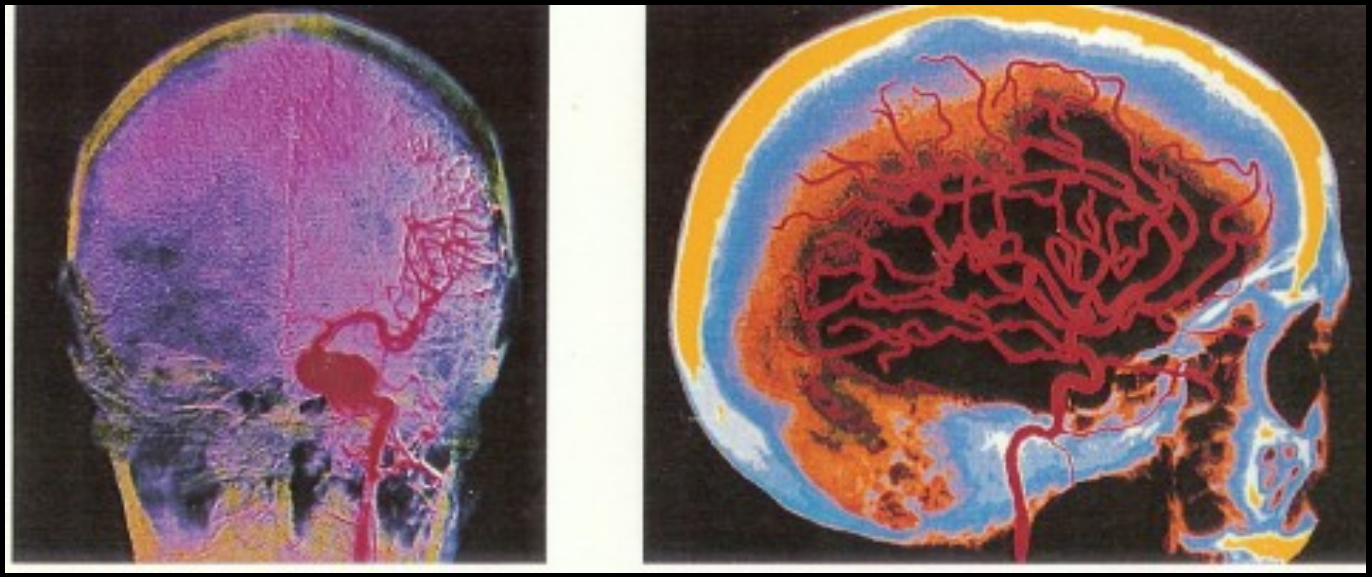
Even low levels of stress in a learning environment can lead to **prolonged learning difficulties** preventing schools from effectively carrying out their most important mission.

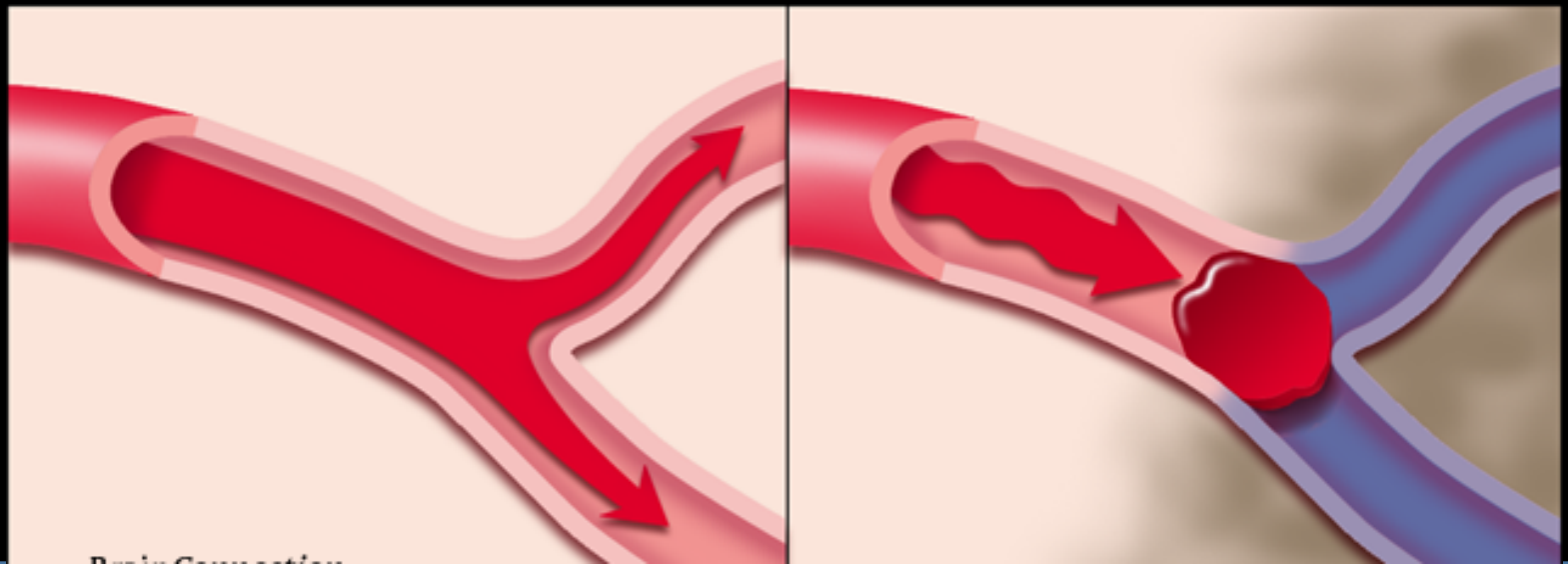
Daydreaming, Imagination and Creativity

- The hippocampus: laying down new memories
- Brain-imaging studies: heightened activations not only when recalling memories, but also when daydreaming.
- For approximately 30% of our waking hours, we tend to drift off and our brains turn on a "default network" composed of a connected web of brain regions that become activated when our mind shifts from "concentrate" to “wander/wonder"

Stress

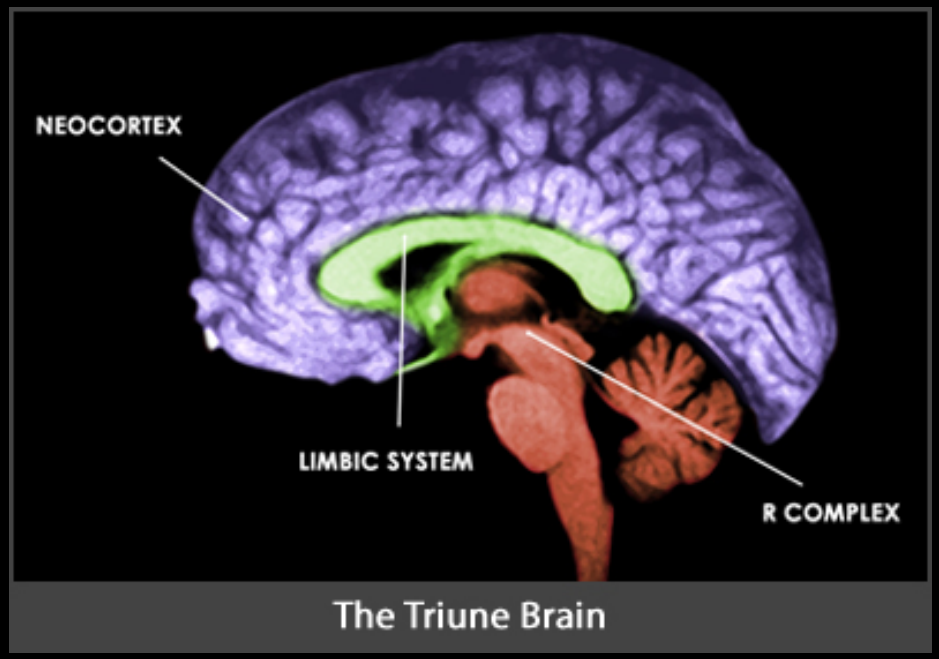
- The human imagination - one of the most powerful forces on earth.
- Everything that has ever been created by human hands began as an aspect of someone's imagination.
- The topic of your (30%) "wondering" and "mentally wandering" (what one imagines) depends largely on his/her personal state of stress.

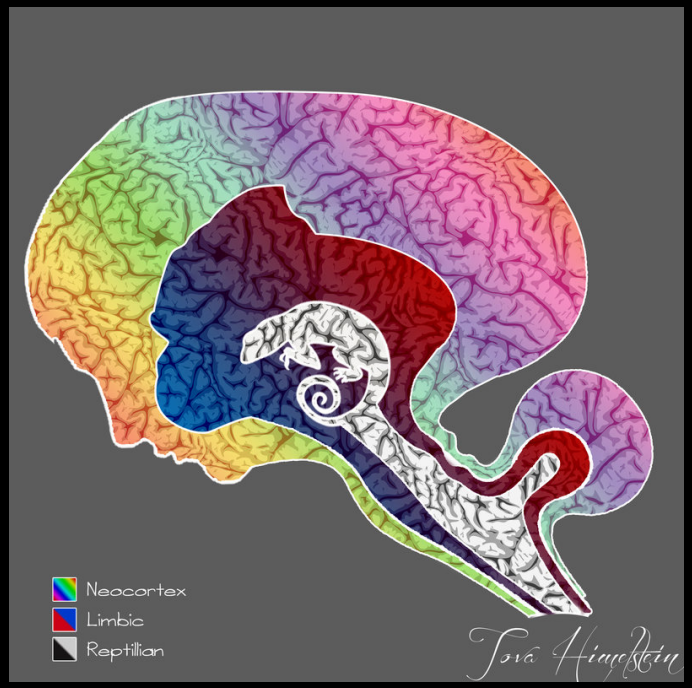




The "Triune Brain"

(Paul McLean)





Parts of the "triune brain" = the reptilian complex, the limbic system, and the neo-cortex

Positive Emotions → → → →

Growing Dendrites = Learning

Stress

- **No stress** → problem-solving (personal issues/ creative challenges) – ***adaptive***
- **Acute stress and chronic stress** = worry → search for and entertain solutions to **stress-producing circumstances** and those **persons** responsible (seek resolution → a return to homeostasis)
  - Obsessions and fixations on the stressor(s) → leaving no time for healthy productive thinking (the "good" in life
  - ***maladaptive*** ***and*** ***non-productive*** ***behaviors***

Poverty

Although it is important to be well-versed in *how to teach,* it is equally or more crucial that you are knowledgeable about *who you teach.*

Six Distinct Types of Poverty

Teaching with Poverty in Mind (E. Jensen, 2009)

1. **Absolute poverty:** scarcity of food, shelter and water.
2. **Generational poverty:** at least two consecutive generations born into poverty without the tools are opportunities to exit impoverished conditions.
3. **Relative poverty:** when income is below the regional standard of living averages.
4. **Rural poverty:** low populations in nonmetropolitan areas where employment opportunities are largely in the agricultural arena.

Six Distinct Types of Poverty

Teaching with Poverty in Mind (E. Jensen, 2009)

5. Situational poverty: the result of unemployment, environmental disaster or a temporary personal financial predicament.

6. Urban poverty: found in crowded, heavily populated, large inner-city areas where noise, violence, deteriorated government housing are dominant factors. Low-income neighborhoods are likely to have lower-quality, social, municipal and local services, as well as fewer green spaces and other safety hazards.

Poverty

According to the research of Kumanyika & Grier (2006) and others, poor children often

- did not attend preschool
- breathe contaminated air, drink impure water, and are exposed to lead in old peeling paint (associated with decreased IQ)
- have fewer books, toys, and other recreational or learning materials at home
- have less access to computers and the Internet (and use them and efficiently)
- add half as many words to their vocabularies annually, when compared to their more affluent peers – putting them on a slower trajectory for vocabulary development → influencing language development → academic language→ school success

Poverty

poor children…

- infrequently visit a library, a doctor or a dentist
- do not participate in healthy afterschool activities (athletics, dance, drama, music, etc.) because of financial limitations
- are lacking in academic content knowledge as well as general knowledge *capacity*
- have problems with attentional skills (focus, engagement, and disengagement when required)
- spend considerably more time watching TV
- have poor school attendance, lower grades and less chance of attending college
- live in and among turbulent personal relationships

Poverty

poor children…

- show high degrees of impulsivity, poor short-term memory
- are absent more frequently
- have impaired concentration
- are more likely to give up and become passive/ uninterested in school ("*learned helplessness*")
- experience reduced cognition, creativity, and LT memory
- demonstrate diminished social skills and social judgment
- show reduced motivation, determination and effort
- experience lower rates of high school completion (adolescence is a particularly vulnerable time to be exposed to chronic stress – Fishbein et al., 2006)

Poverty

The research of Blair (2008) Evans, Gonnella, Marcynyszyn, Gentile & Salpekar (2005) and others, **poor children**

- **are more likely to come from single-family homes**
- **have parents who are overstressed trying to meet the daily survival needs of their families (food, clothing, shelter, transportation, etc.), and find it difficult to focus on the wants/ needs of their children -- they are often less nurturing**
- **have caregivers or parents who are less emotionally responsive (attunement) and less dependable leaving the children feeling isolated and unloved**
- **have parents who are more prone to drug abuse and incarceration**

Poverty

The research of Blair (2008) Evans, Gonnella, Marcynyszyn, Gentile & Salpekar (2005) and others, **poor children**

- **are more likely to deal with evictions, utility discon-nections, overcrowding, lack a stove or refrigerator**
- **are less likely to have parents who are interested in their child's school activities, who will help with homework, who read to their children daily, take their children to informal science centers or who can coach them in learning new skills**
- **have teachers who give less positive reinforcement, assign less homework, perceive their classroom behaviors as "acting out," although the behaviors are more associated with chronic stress disorders**

Poverty

Language development and poverty:

- The quantity, quality, and context of parents' speech matter significantly, in early language development (Hoff, 2003).
- However, low-income caregivers speak in shorter and more grammatically simple sentences (Weizman & Snow, 2001).
- In their parent-child conversations, there is less back-and-forth in language exchanges, there are few questions asked and fewer explanations given, resulting in a more limited range of language capabilities, which affects academic language skills.

Stress and Poverty

- Poor children are subject to both acute *and* chronic stress, and experience significantly greater chronic stress than their more affluent peers (Almeida, Neupert, Banks, & Serido, 2005).
- When stress is chronic and unmediated, it results in a condition known as "allostatic load" - - "carryover" stress. When the body-brain is *no longer able to return* to a healthy state of homeostasis, it adapts to the negative condition causing the body-brain to become hyper-responsive or hypo-responsive (Szanton, Gill, & Allen, 2005).

Prolonged Stress and the Romanian Orphans

- Correlation between ↑ localized neural connections and ↑ glucose (energy) consumed **to maintain those regional connections.** A ↑ energy consumed in support of normal localized brain functions.

- Areas of **decreased glucose metabolism** found in the Romanian orphans included the…
  - Amygdala
  - Temporal lobe (emotions, memory)
  - Orbital frontal cortex
  - Orbital gyrus
  - Prefrontal infralimbic cortex
  - Lateral temporal cortex
  - Medial temporal cortex
  - Brainstem

Stress

Compared to a *healthy* neuron, stressed neurons in the frontal lobes generate a weaker signal and extend fewer connective branches (synapses) to other brain cells.

Negative Emotions → → → →

S.A.I.L.

The environmental preconditions that should be experienced by students <u>prior to</u> initiating formal instruction include...

S afety (physical and emotional)

A cceptance (no "put-downs")

I nclusion, interactions and involvement

(interpersonal/social aspect of memory formation)

After satisfying these prerequisite neurophysiological and hierarchical conditions, <u>students are biologically ready for</u>

L earning *(students feel their immediate environment is secure enough for them to take risks, explore and discover).*

Source: Kenneth Wesson (2011). *Education for the Real World; Six great ideas for parents and educators*. Brain World, Issue 2, Volume II Winter 2011.

Students who have chronic safety concerns also tend to *underperform* academically (Pratt, Tallis, & Eysenck, 1997)

S.A.I.L.

Parents/home provide the first "safety net"

Victims of trauma need

- **Validation (do not trivialize their experience).**
- **A safe place**
- **A support system**
- **An orientation towards the future ("When I grew up…" versus "If I grow up…)**

Poverty

Of the many interwoven and multifaceted factors impacting the lives of children in poverty, there is one that educators *can* control – – Cognitive lags.

Down Side of Emotional Learning

Continued stress in the learning environment causes the increased secretion of "cortisol" which constantly stimulates the bodies' alarm systems and learning becomes the first casualty.

Building

Supportive

Relationships

(PRE-school = Positive Relational Experiences)

President Obama and the Handshake →

Performance avoidance

(and "idea aversion")

My arm… (A's/B's

How can we become effective creative schools, if we penalize students for making errors?

Carol Dweck: Mind-set

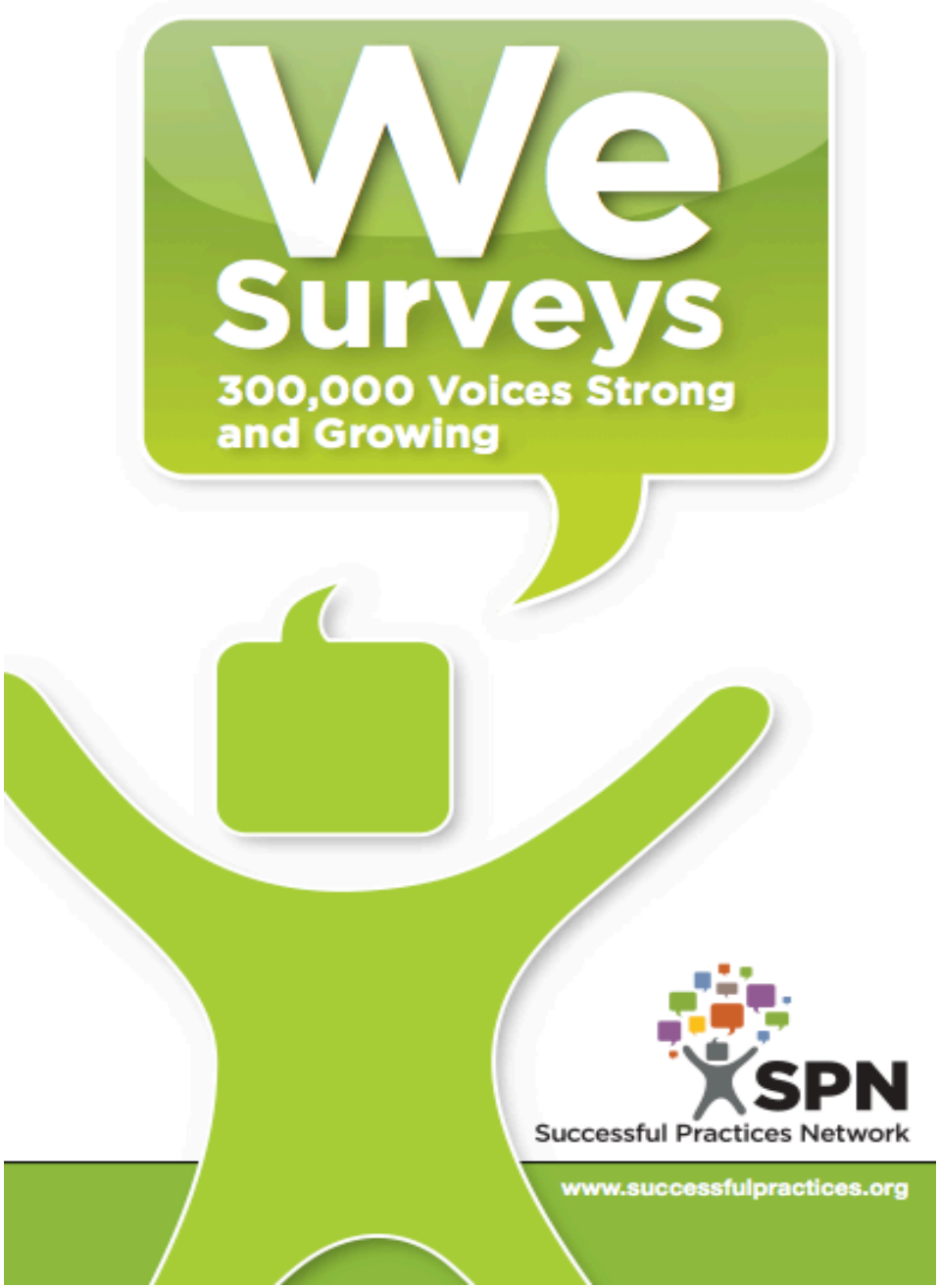
- **"Entity orientation" - "You are smart or not smart, and hard work can't change that status."** ("Math ability is primarily genetic.")

- **Carol Dweck (Stanford U.): Students who believed "I have the power to significantly change how intelligent I am and my academic performance," ("growth mind-set") received higher grades. Informing students that they were able to *make* themselves "smarter" by hard work led them to work harder → higher grades.**
- **This intervention had the greatest effect on students who *initially believed* in genetically-based intelligence ("fixed mind-set"). (Control group: taught how memory works, showed no such gains.)**

Emotional Intelligence in Education

Learning requires effort, and one of the best predictor's of students' effort and engagement in school is the relationships that they have with their teachers (Osterman, 2000.)

Students function more effectively when they feel respected and valued and function poorly when they feel disrespected or marginalized (National Research Council, 2004)



We **Lead**

We **Teach**

We **Learn**

We **Support**

The Gap That Goes Unnoticed

There is a wide gap (a disconnect) between what *we* ***think*** we deliver to our students on a regular basis and what ***they*** *believe* we are delivering to them.

We Learn Student Survey
(Grades 6-12)
217,596 student voices

We Teach Instructional Staff Survey
21,028 voices

Teacher – Student Comparisons

T – I make learning exciting for my students.	86%
S – My teachers make learning fun.	41%

Teacher – Student Comparisons

T – I am aware of my students' interests outside of school.	84%
S – My teachers know my interests outside of school.	28%

Teacher – Student Comparisons

T – Students can apply what I am teaching to their everyday lives.	92%
S – I can apply what I learn to my everyday life.	59%

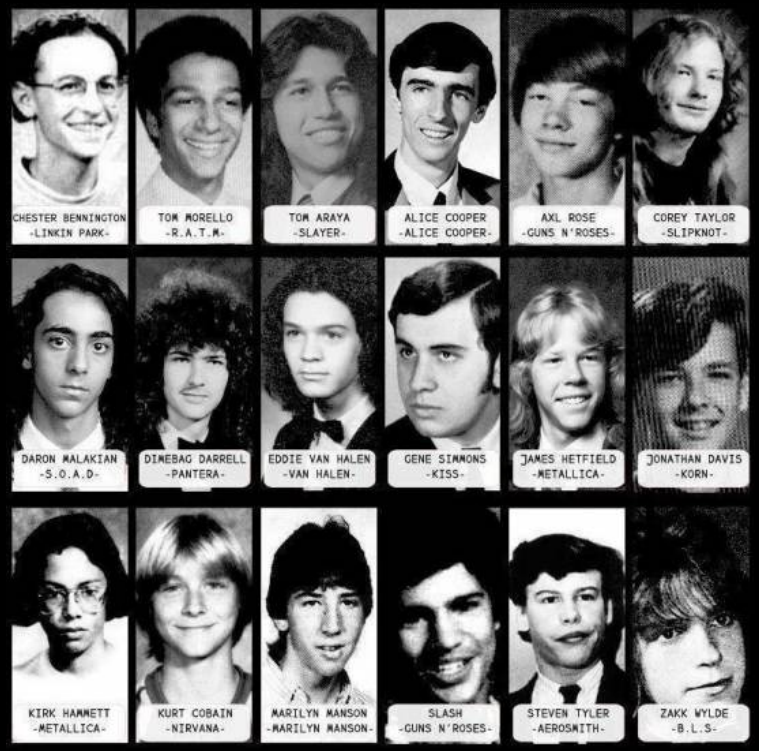
Emotions and Learning

#1 Getting to know your students on a personal level.

#2 Getting to know your students even better on a personal level.

Attend an out-of-school activity, event, performance, etc. with each student and his/her family

The Size of Your Smile



In a UC Berkeley study, high school yearbook photos of graduating seniors were carefully analyzed in a 30 year long longitudinal study **ranking those graduates' smiles by size.** They look for correlation between success in life, personal and emotional well-being, and the size of their smile in their yearbook photos. Researchers were **able to predict** how long their lives would be, how long their marriage would be, their scores on standardized tests of "well-being," and how inspiring they would be to others, **based exclusively on the <u>size</u> of their yearbook smile.**

Emotions and Learning

1. Students find that what they care about becomes the *easiest* to learn; they remember *best* what they understand.

2. Students don't care what *you know,* until they know that you care.

3. "Students learn as much *for* a teacher as they do *from* a teacher."

Linda Darling-Hammond
Stanford University

PERC^{3}S

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

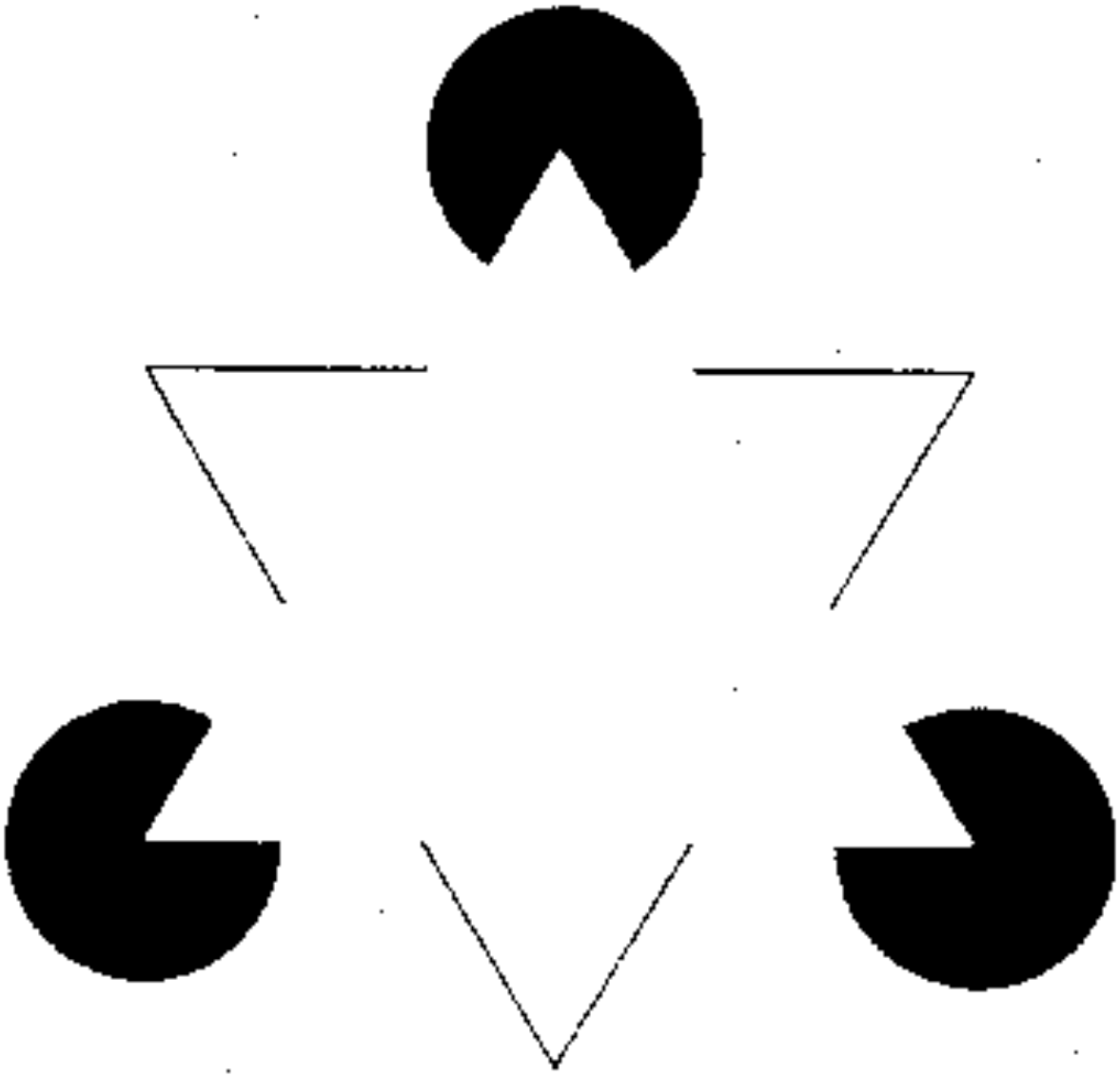
(5) Sense-making → Problem-solving

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.



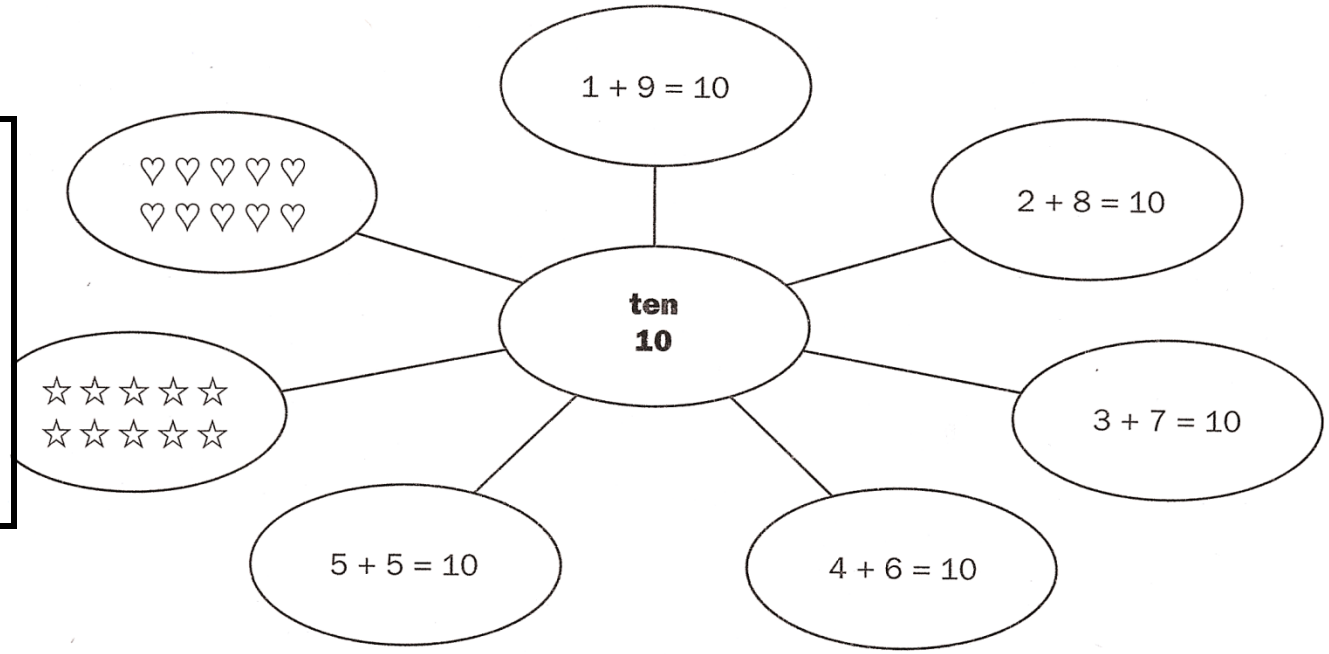
Patterns: Understanding/Remembering Medical Terms

All medical terms must *make sense.*

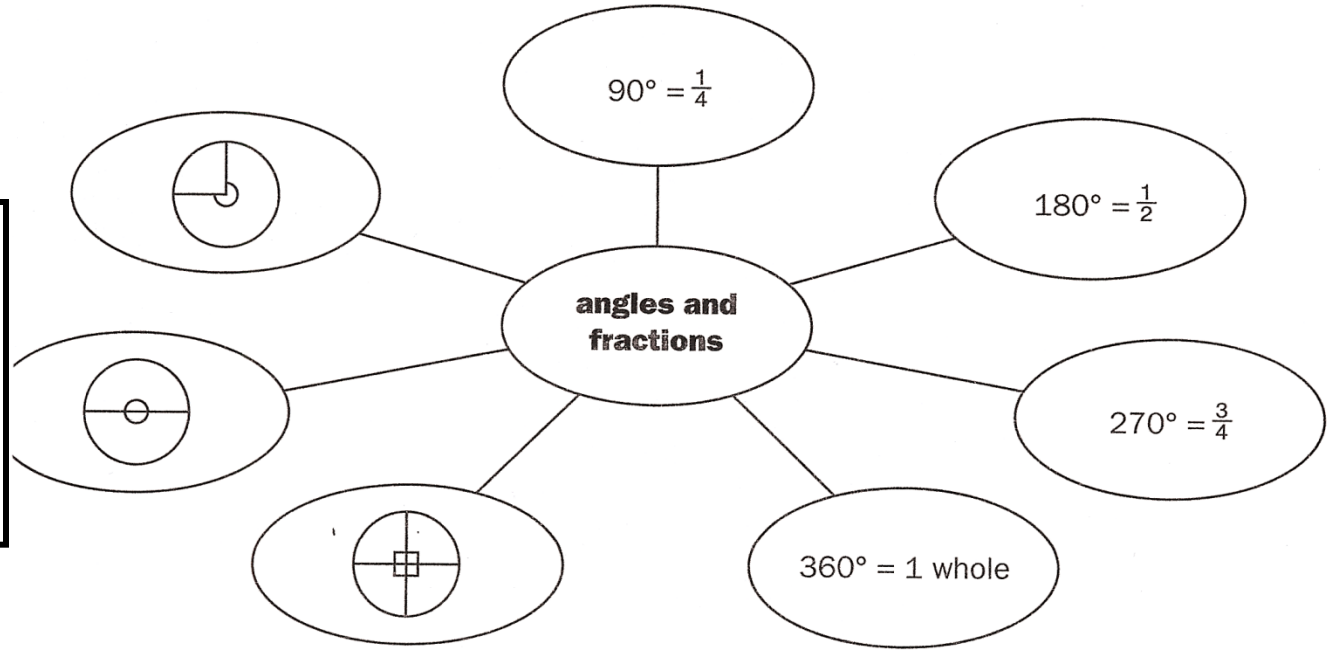
Sciencemaster.com

Verbs → **Nouns** ↓	**-algia** (pain)	**-centesis** (puncture)	**-ectomy** (removal)	**-tomy** (incision)	**-itis** (inflamation)	**-plasty** (surgical repair)	**-megaly** (enlargement)	**-sclerosis** (hardening)
Angio- (vessel)	--	angiocen-tesis		angiotomy	angitis	angioplasty	angiomegaly	angiosclerosis
Craino- (skull)	--	craniocen-tesis	(hemispher-rectomy)	craniotomy	--	cranioplasty	--	craniosclerosis
Cardio- (heart)	cardialgia	cardiocen-tesis	--	cardiotomy	carditis	cardioplasty	megalocardia	cardiosclerosis
Derma- (skin)	--	dermacen-tesis	--	(incision)	dermatitis	dermaplasty	--	sclerderma
Gastro- (stomach)	gastria	gastrocen-tesis	gastrectomy	--	gastritis	gastroplasty	gastromegaly	--
Neuro- (nerve)	neuralgia	--	--	--	neuritis	--	--	multiple sclerosis
Osteo- (bone)	ostealgia	osteocen-tesis	--	osteotomy	osteoarthritis	ostoplasty	osteomegaly	osteosclerosis

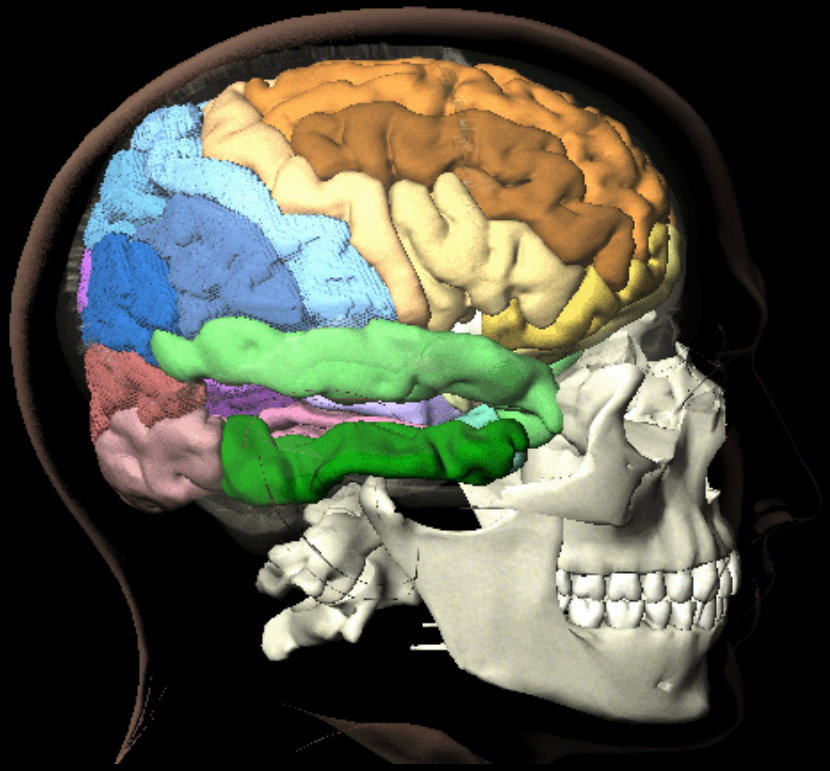
Ways To Make Ten



Parts, Wholes, Fractions, and angles



“How does the human brain *learn best?*”



…in this language learning experience…

- Which child has the greatest chance of learning?
- What is each child experiencing?
- What is each child likely to take away from his/her experience?

Emotions and Education

COVER STORY

EMOTIONS & EDUCATION

How Children Feel Affects How They Learn

By Kenneth Wesson

Children from troubled homes and rough neighborhoods were asked, "What do you want to be when you grow up?" Sadly, their answers consistently began with the phrase, "If I grow up..."

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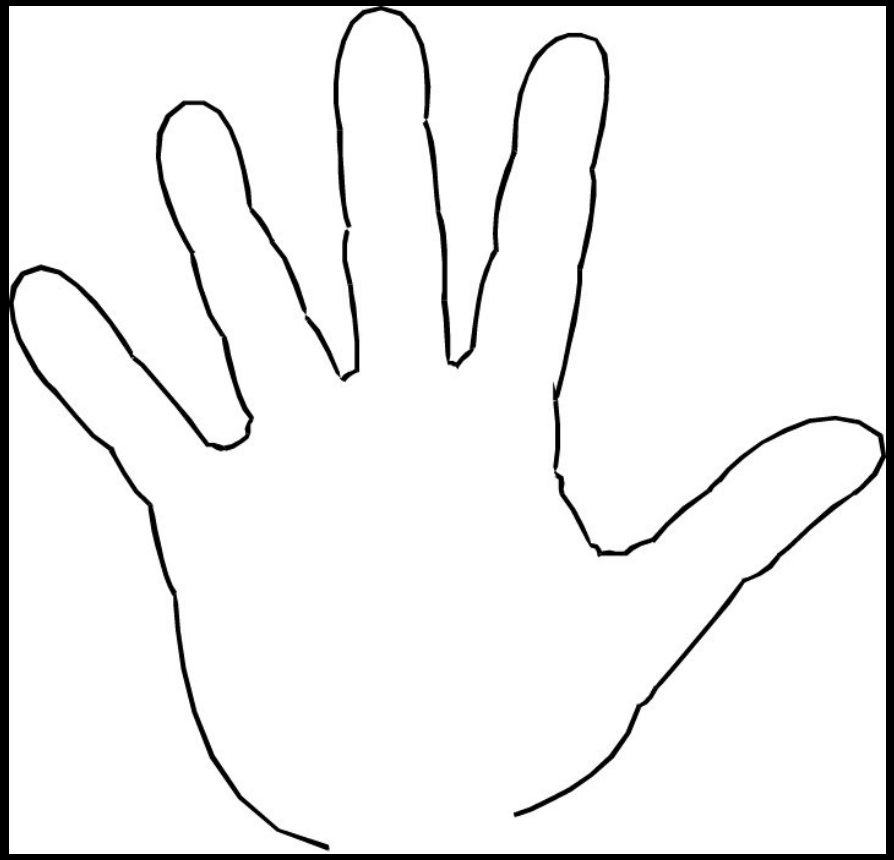
BrainWorld

Emotional Fulfillment:
A Helping Hand Fosters Growing Minds



Have each student write the name of a classmate who helped him/her along the path of learning a given concept in class

Source: Kenneth Wesson (2011). *Education for the Real World; Six great ideas for parents and educators*.
Brain World, Issue 2, Volume II Winter 2011.

The Helping Hand
“Create” the Classroom Culture

- "Find someone in the classroom who can help you with..."
- It directs students to non-judgmental/low-risk, developmentally-appropriate help
- It validates the helper
- “To teach is to learn *twice.*”
- Decreases bullying -- simultaneously builds relationships
- The Strive Research Group at Stanford University

Emotions

"An emerging theme is the question of how emotions interact with and influence other domains of cognition, in particular attention, memory, and reasoning."

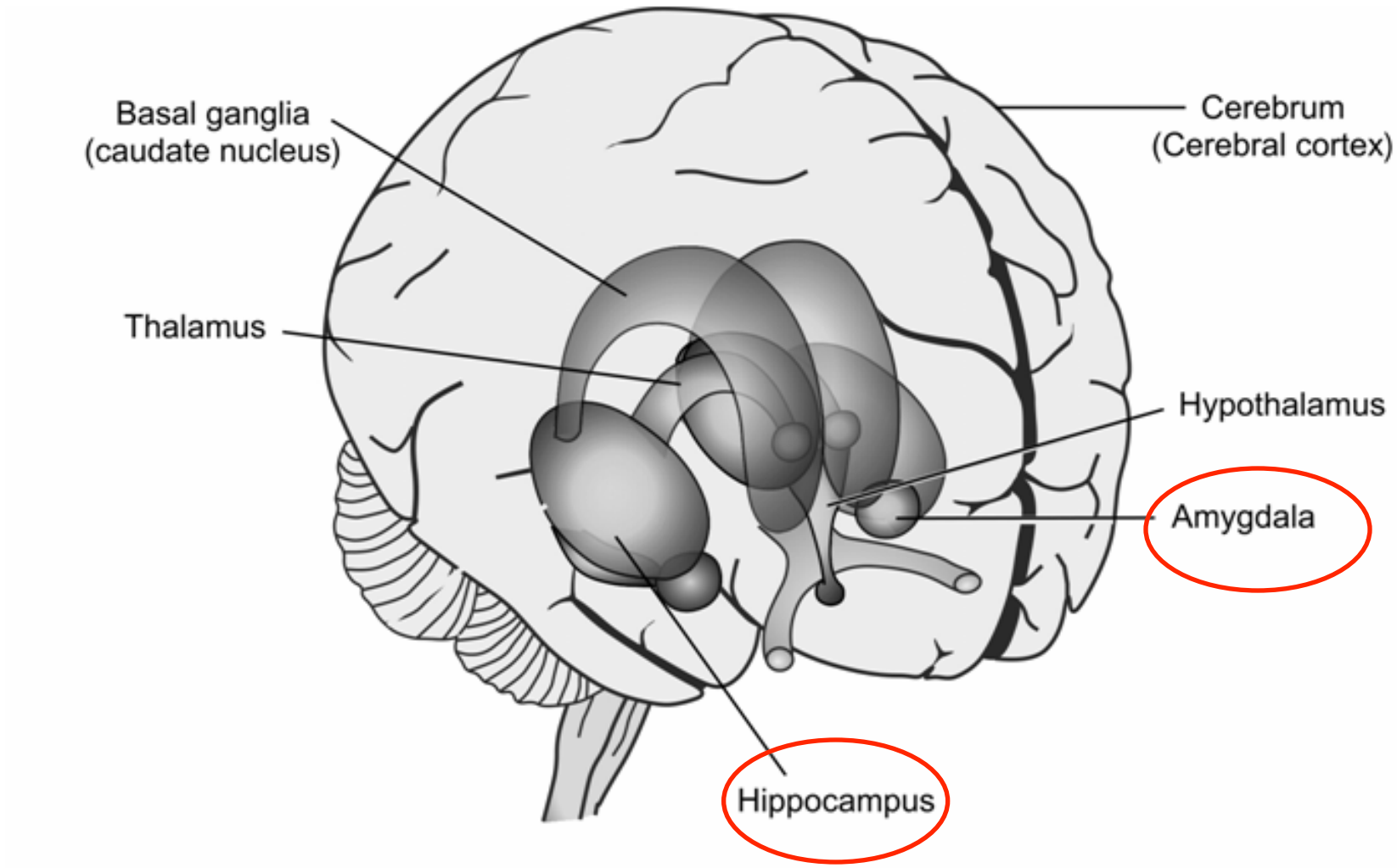
Dolan, R. J. *Emotion, cognition, and behavior*. Science. 298(5596): 1191-1194 2002

How the Brain Learns:
An Astonishing Error

A biological brain

and an emotional brain

Memory



Inner structure of the human brain, including the limbic system.

Attention and Input

- Think about a time you *wanted* to pay attention, but the noise level was ↑ (chaotic) preventing you from focusing/concentrating (not atypical).
- How did you respond?
- Did you pay attention or were you distracted and frustrated?
- To focus attention on one object/task/person, we must block out the conscious processing of extraneous incoming information (including internal info); "cocktail party" effect.
- However, we are constantly overwhelmed, distracted, over-scheduled, rushed, stressed, multi-tasking, and affected by a steady barrage of stimulation.

Emotions, Attention and the Brain

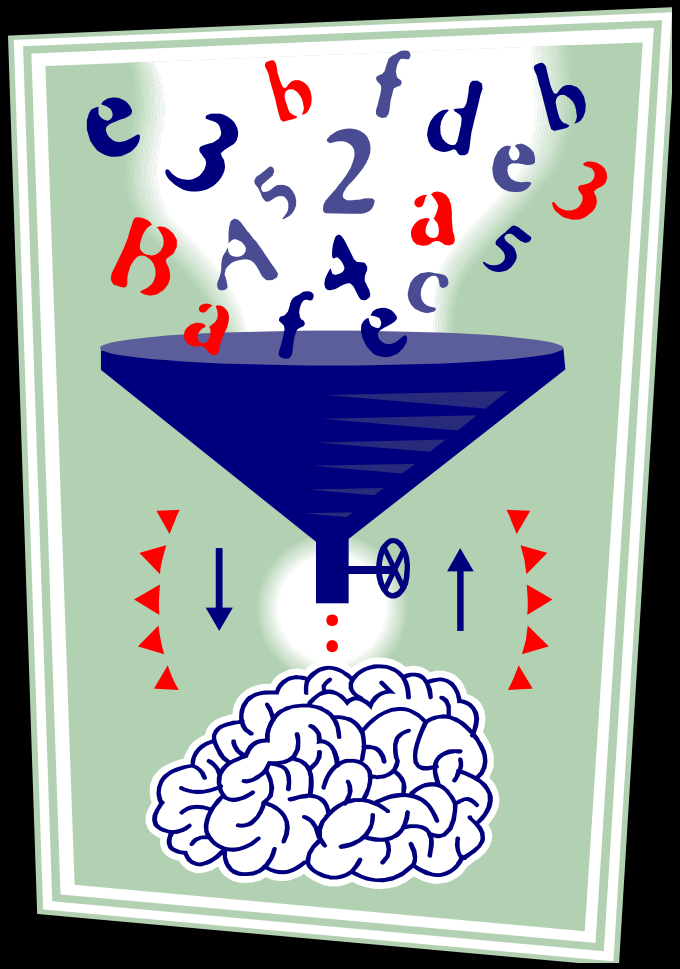
- Emotions → attention → learning → memory

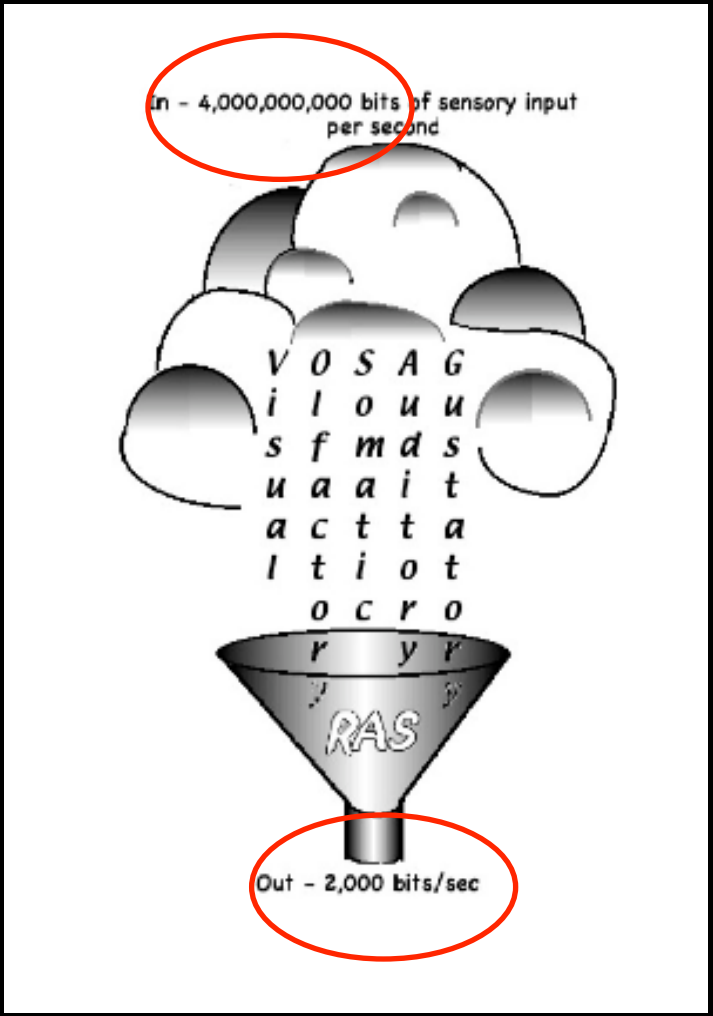
- It is neurologically impossible to learn and remember information to which the brain has *not* paid attention.

The Brain and "Input"

- Brain cells process approximately 4B bits stimuli/sec.
- Fortunately (unfortunately?) the brain cannot consciously attend to more than one dominant entry at a time. It can attend to (pay attention to) countless different types of information at one time -- the "Cocktail Party" effect.
- A vital responsibility of the developing brain is learning how to effectively attend to *relevant* environmental information and to simultaneously screen out unimportant stimuli.
- How do we distinguish the relevant from the trivial or superfluous?

Emotions, Attention and Input





Although there are numerous domains of STEM, they all rely on:

- Training students to make selective observations
- Questions (researchable questions about your ideas)
- Hypotheses (predictions and claims)
- Experiments (apply knowledge of discipline-related concepts, content and procedures; models; replicable)
- Data collection and analysis (standard units of measurement; "~~a lot of~~…"; deduction; *if-then* analyses)
- Evidence (data; patterns; pictures; oral/written reports)
- Communication (discourse, precise language; "Am I on the right course?"); explanations - logic, reasoning;
- Theories (create, refine, revise or extend)
- Problem-solving, engineering, and/or re-engineering

Deep and Long-lasting Learning

1. **Instructivism =** teacher tells and student listens (the *transmission* of knowledge that gets memorized in isolation).

2. **Constructivism** (Piaget) = the **student learns by doing** and making connections, as knowledge is constructed inside his/her head via new brain circuitry.

3. **Constructionism** (Papert): learning comes from actively constructing knowledge through the act of **constructing** a meaningful product. Doing/making a tangible/shareable artifact (public).

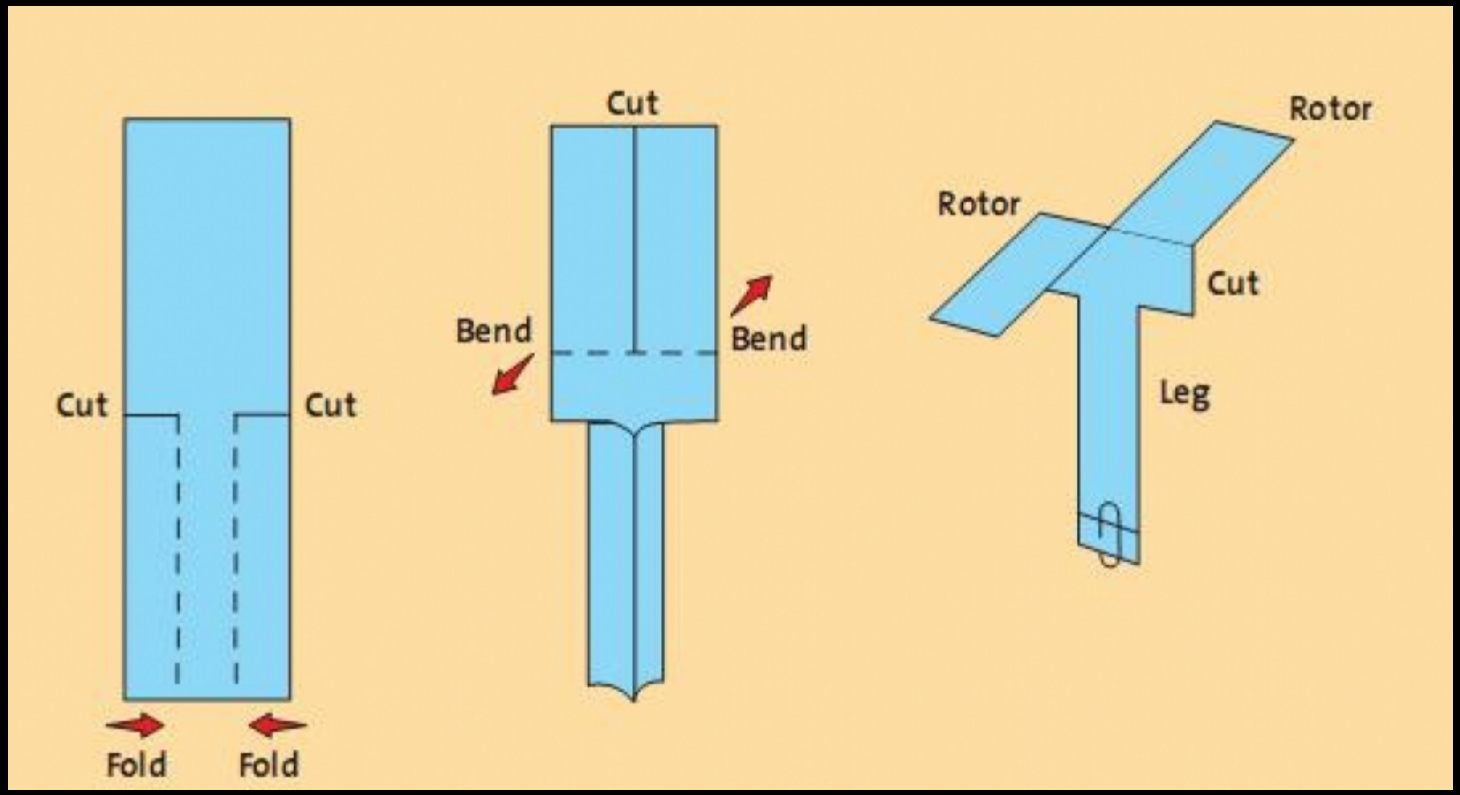
Academic Language Learning

So that students understand the learning goals, state *explicitly* what the language objective/science content goals are at the beginning of class.

Today we will engage in an experiment where we will investigate air resistance by constructing "twirly birds" (paper helicopters.)

- Who has *seen* a helicopter in flight?
- In what directions did that helicopter fly?
- What is different about how a helicopter flies and how an airplane flies? ("critical competitor")

Twirly Bird



Once this object is properly folded, predict what will occur when you hold it as high as you can and release it.

Question:

How do you **teach vocabulary** best?

Answer: In context

Full answer: In *the* context **of doing** (not in the context of **reading**) and through **speaking and writing.**

"Predict"

The Science of Learning

Instead of saying:	Use MINDFUL LANGUAGE by saying:
"What do you think will happen when…?"	"What do you **PREDICT** will happen when…?"
"Let's look at these two pictures."	"Let's **COMPARE** these two pictures."
"How can you put those into groups?"	"How can you **CLASSIFY**…?"
"Let's work this problem."	"Let's **ANALYZE** this problem."
"What do you think would have happened if…?	"What do you **SPECULATE** would have happened if…?"
"What did you think of this story?"	"What **CONCLUSIONS** can you draw about this story?"
"How can you explain……?"	"What **HYPOTHESES** do you have that might explain...?"
"How do you know that's true?"	"What **EVIDENCE** do you have to support…….?"
"How else could you use this…..?	"How could you **APPLY** this ……..?"

Patterns of Motion: Twirly Bird

Observation: STEM practitioners *pay attention*

1. In *what direction* did the propellers rotate, clockwise or counter clockwise?

2. What modification can you make to your twirly bird that would cause the propeller blades to rotate in the *opposite* direction (re-engineering)?

3. How would you modify the outcome if you added a second paperclip? Compare systems with (a) one paperclip, (b) 2 paperclips and, (c) no paperclip. Which is the optimal system? Why?

Patterns of Motion: Twirly Bird

4. If you were to extend the length of the rotary blades by 2 inches, can you predict how that might affect the outcome? What if you widened each blade 1 inch?
5. How would you design a twirly bird that will descend (drag) faster (with blades still rotating)?
6. What would occur if each blade was a different length?
7. If you had "teardrop-shaped" blades, how might that change the outcome of your flying system?
8. What other materials could we use to construct a similarly designed twirly bird that flies?
9. How large…?
10. How many variations of the original twirly bird design can you create that will fly in a similar manner?

(Teachers: Cognitively engaging discourse)

Specialized Talking and Writing → Thinking

There is a specialized way of talking and writing in science, technology, engineering and mathematics that is different from other disciplines. In STEM communities and STEM careers, language is one of the primary means of expressing and communicating ideas to build a personal understanding of the discipline and to share what is now understood (or newly discovered) with others.

Considerate Discourse

Prepare students to speak in front of others by teaching the academic words and grammatical features used to make observations in science.

- What did you notice? I noticed…
- When I increased the ____, then _____ occurred. The ____ also increased/decreased.
- What did you observe? I observed that…
- The more we_____, the more the _____ changed also.
- "I would like to describe/share my results/ experience." (Rather than "I'm going to talk about…")

Academic Language in Science a Context

Introduce/reinforce vocabulary in an *active context*.
(Constructive expression not phonics → vocab. dev.)

1. Helicopter
2. Experiment
3. Observe
4. Compare
5. Propeller
6. Gravity (force)
7. Rotary blade
8. Rotate
9. Descend
10. Drag
11. Model
12. Engineering
13. Affect
14. Friction
15. Slope
16. Predict
17. Modify
18. Re-engineering
19. Standard
20. Outcome
21. Extend
22. Stationary
23. Variable
24. Controlled variable
25. Manipulated variable
26. Increase/decrease
27. Clockwise/counter…
28. Gravitational pull
29. Mass
30. Axle
31. Modification
32. Length
33. Widen
34. Design
35. Materials
36. Drag
37. Twirl
38. Spin
39. Axis
40. Shaft
41. Resistance
42. Variation
43. Vertical
44. Optimal
45. System

Academic Language

- **Academic vocabulary knowledge is one of the single most important factors contributing to comprehension.**

- **Students need to add approximately 2000-3500 word meanings to their reading vocabulary a year.**

Source: National Reading Panel. 2002

Writing and Learning

Students should appreciate that learning was the ultimate goal not to memorize the discreet facts and vocabulary words.

Students should find that the new vocabulary is so useful and familiar that they begin to **use the new vocabulary words naturally** when they:

(a) **explain** their work

(b) **reflect on** their work

(c) **describe** what they do **personally** during the active learning process, and when they communicate their findings in the *future*

Vocabulary Development
(Blackowicz and Fisher, 2000)

There are four main principles guiding academic vocabulary development. Students should

1. **Be active participants in developing their understanding of words and ways to learn them**

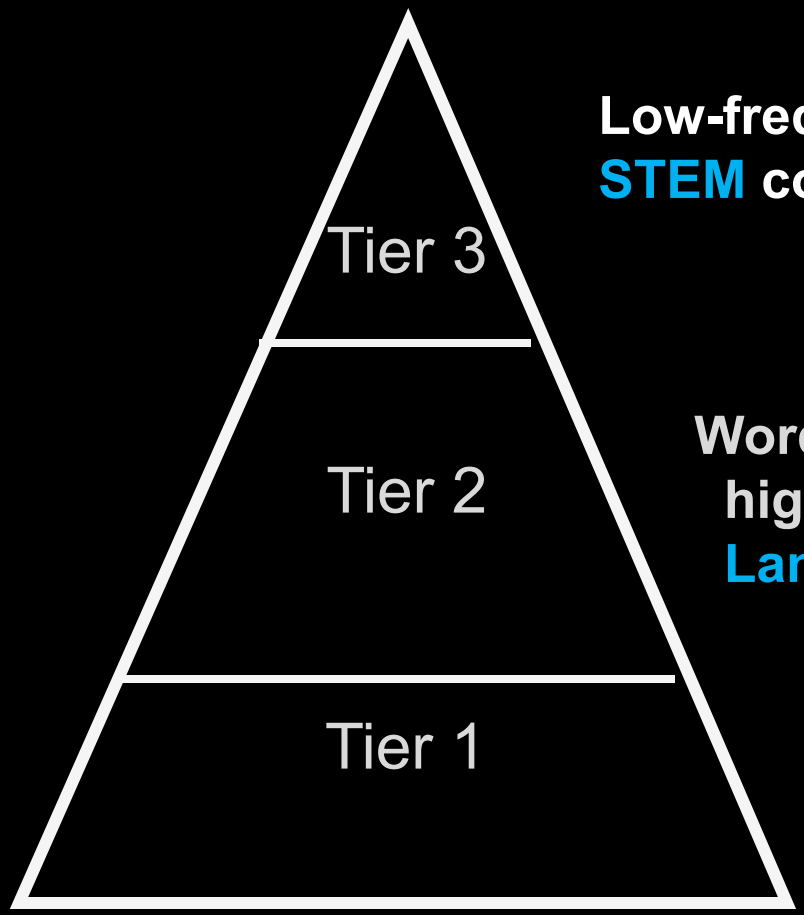
2. **Personalize word learning**

3. **Be immersed in words**

4. **Build on a variety of resources to learn words through multiple exposures**

Three-Tier Model for Vocabulary

Developed by Isabel Beck



Low-frequency discipline-specific words; STEM content area words

Words to Teach: high frequency, high utility sophisticated/Academic Language

Known, common words

What Does the Research Say About the Importance of Vocabulary?

- Good oral vocabulary (words a student uses in speaking and listening to others) is linked directly to later success in reading.
- Students with more vocabulary knowledge in K become better readers than those with a limited vocabulary (National Institute for Literacy, 2001).
- Vocabularies ↑ by spending ↑ time on speaking, listening reading, and writing on the same topic and engaging in discourse using the facts and ideas in them. This kind of "immersion" in a topic not only improves reading and vocabulary→ develops writing skills (Hirsch, 2003).

Science-centered Language Development

- **Highlight vocabulary *integration* rather than "vocabulary *acquisition"* across the curriculum (not in the traditional "silo insolation" or only during Language Arts)**
- **Learn vocabulary by means of a broad range of multidisciplinary language experiences**
- **Students learn to appreciate the *utility* of their growing vocabulary in the context of**
  - **√ doing and discourse**
  - **√ speaking and listening**
  - **√ writing and reading, and writing about your reading**
- **All teachers must develop a level of comfort in providing vocabulary instruction in their subject-area.**

Argument from Evidence

"One characteristic of high-performing schools is an emphasis on teaching non-fiction writing."

Reeves, D.B. (2003). High Performance in High Poverty Schools: 90/90/90 and Beyond. Center for Performance Assessment. Denver, Colorado)

The Neural Connections in Concept Development

"Brain-building" experiences

If I Can…	***Then I am Able To…***
1. Experience it first-hand *("Hands-on, minds-on, heart's-in" "Wow! experiences)*	Discuss it orally
2. Discuss it orally	Understand what others mean, when they talk about it
3. Understand when I discuss it and when and others discuss it	Communicate it in written form
4. Communicate it in written form	Read my own writing
5. Do it, see it, discuss it, hear about it and write about it	Explain it to others coherently/intelligently
6. Explain it to others	Ready to read other's writing
7. Understand the writings of others on the subject	Begin reading (the writing of others) within general content area

Excerpted from Memory and the Brain: How Teaching Leads to Learning. Wesson, K. The Independent School, Volume 63, Spring 2002

Cognitive Rehearsals

(→ consolidation)

When **playing with *objects,*** learners are simultaneously manipulating/*playing with* ***ideas*** (internal dialogues attach words and meaning to actions – the "mind's eye") building the brain's fundamental **circuitry**

Exploring and experimenting involve examining relationships, interactions and **systems,** where learners formulate their own personal **"theories"** (mental constructs)

Thinking is a cognitive ***rehearsal*** for **discourse**

Discourse is a cognitive ***rehearsal*** for **writing** (phonological loop or "inner voice")

Cognitive Rehearsals

"You can't make the *words* or *ideas*

come out of your *pencil,*

until you can get them

to come out of your *mouth.*"

Cognitive Rehearsals

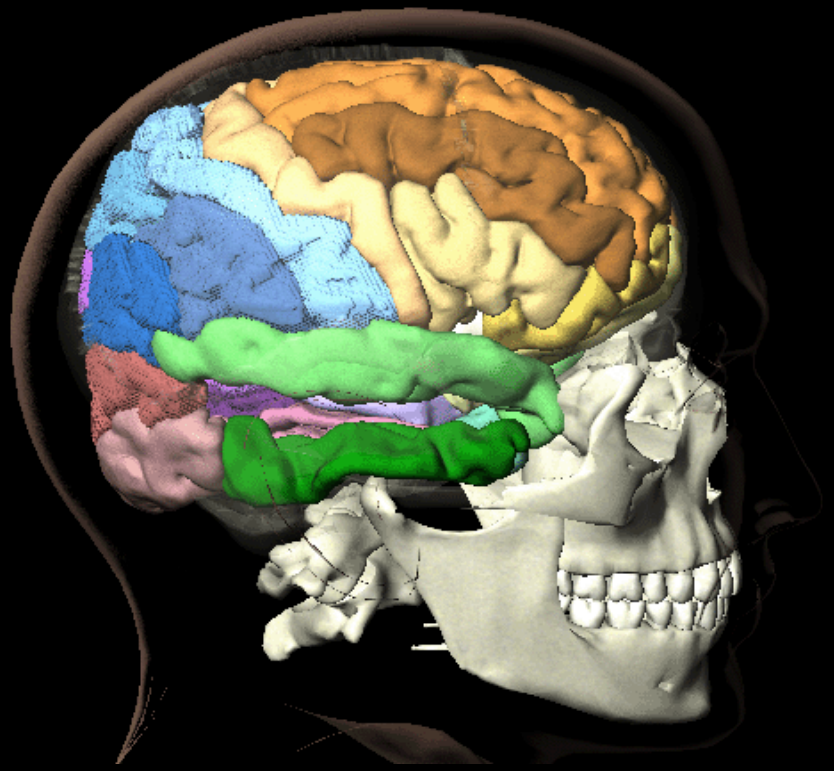
Playing with objects and ideas, exploring and experimenting, thinking, talking, and writing become cognitive rehearsals (background knowledge) for reading.

Writing and reading clarify one's thoughts, generate coherent thinking, and cultivate *precision* in expressing one's inner thoughts *(→ LT/P memory consolidation)*

Discourse and writing become cognitive *rehearsals* for assessment

Source: Kenneth Wesson (2011). *Education for the Real World: six great ideas for parents and teachers.* Brain World, Issue 2, Volume 2.

“How does the human brain *learn language best?*”



the magic of human language

by Kenneth Wesson

The significant problems we face cannot be solved at the same level of thinking we were at when we created them. —Albert Einstein

■ If a more complicated entity than the human brain exists on Earth, it has succeeded in maintaining its confidential nature. Not only is the brain the most multifaceted organ in the human body, and composed of the greatest number of diverse cell types in a single organ, it is also the most adaptable and complex single object in the known universe.

Prior to the 1990s, most information gathered about the human brain came largely by way of misfortune—brain-injured patients or disease. The balance of our knowledge was speculative or intelligent deductive conclusions. Brain injuries and postoperative behavior changes give us a peek into the nature of processes such as movement, memory and language.

Aristotle (384–322 BC), a leading thinker of his day, was an advocate of the cardiocentric view of cognition. He believed the heart was central to all cognitive responsibilities, including morality and higher intelligence. The brain was relegated to a more humble undertaking: cooling the warm blood circulated by the heart (demoted to the mental role of radiator). Today, we still refer to successfully memorized information as content we know "by heart."

Language Learning

■ When we look closely at the human cerebral cortex, it resembles an oversized quilt, bunched up to cover the subcortical structures busily operating beneath it. If one unfolded and stretched out the cerebral cortex, its surface area could cover a desktop (2,500 cm²). Six seamless paperlike layers, neatly stacked together, form the human cortex. The interactions between these neuron-rich layers foster the biological basis of our incredible catalog of human behavior, including language.

Language is one of the most crucial competencies mastered by the human brain, although learning to speak has the appearance of an ordinary phase in child development. Virtually any person can learn one or more of the 6,000 languages spoken today. Our 100 billion networked neurons actively seek external auditory stimuli in order for the brain's language systems to develop.

Multi-sensory experience is ideal for language development. It often takes four different exposures—seeing, hearing, touching, tasting—before information enters into long-term memory. Repetition also establishes all associations for a given word.

When a new concept is processed, its elements are stored in numerous interconnected neural networks throughout the brain. A memory is easier to recall when there are several routes back to the target concept. The definition for a word is coupled with other words to which it is experientially linked. Priming the memory of one word simultaneously awakens the memories of other connected words. "Word webs" are incredibly effective language-learning tools that demonstrate the power that a single word has in creating other words out of hiding during thinking, speaking, listening, reading, or writing. The more frequently that specialized language patterns in the brain fire together, the more they will permanently "hardwire" themselves together for increased usefulness.

What have we learned about teaching language from this research? Teaching any language should not begin with a sudden, formal immersion into the printed word. Human beings have always been born to **learn**, but not born to **read**—the brain's existing neural circuitry adapted itself to support the requirements of this new task. Unlike our five basic senses, proficiency in reading has to be taught and learned.

From Object Recognition to Word Recognition

■ Circles, spheres, squares, blocks, cylinders, and cones are among the 24 basic "geons" (geometric forms) that we see in our natural environment. Most letters mimic these forms. Simplistic representations of concrete objects elicit a mental resemblance of the "real thing." When one, two or three geons are combined, their orientation and arrangement can bring to mind over 10 million objects and patterns found in the world. For example, the image of an automobile is brought to life by two circles placed beneath two rectangles; a cone and two circles can suggest either a clown or an ice cream cone, depending on their size and orientation (see Figure 1: "Geons"). These patterns are ripe for modification into symbols. Oral and written language reflect the cognitive relationships that link objects, images, thoughts and words together into the single complicated event we experience as symbolic communication.

The theory of object recognition seeks to explain how stimuli entering the visual cortex are matched with internal representations of those same forms (now stored in neural pathways). This matching strategy helps us make sense of visual information. Since object-processing in the brain preceded symbolic-processing abilities, the "words" found in many languages were initially created directly from pictorial representations of objects. Symbolic imaging is, and has always been, easier for the human brain to digest than written words.

Brain-building experiences after the very architecture of the language-sensitive centers in the brain and craft clear passageways to school-readiness and success. But it is impossible to build extensively on weak foundations. Language should be learned through a sequence of events (see The Seven Steps to Language Learning). Informed by cognitive research, successful classrooms utilize this seven-step sequence for symbolic-language development, with plenty of opportunities along the way for expressive language.

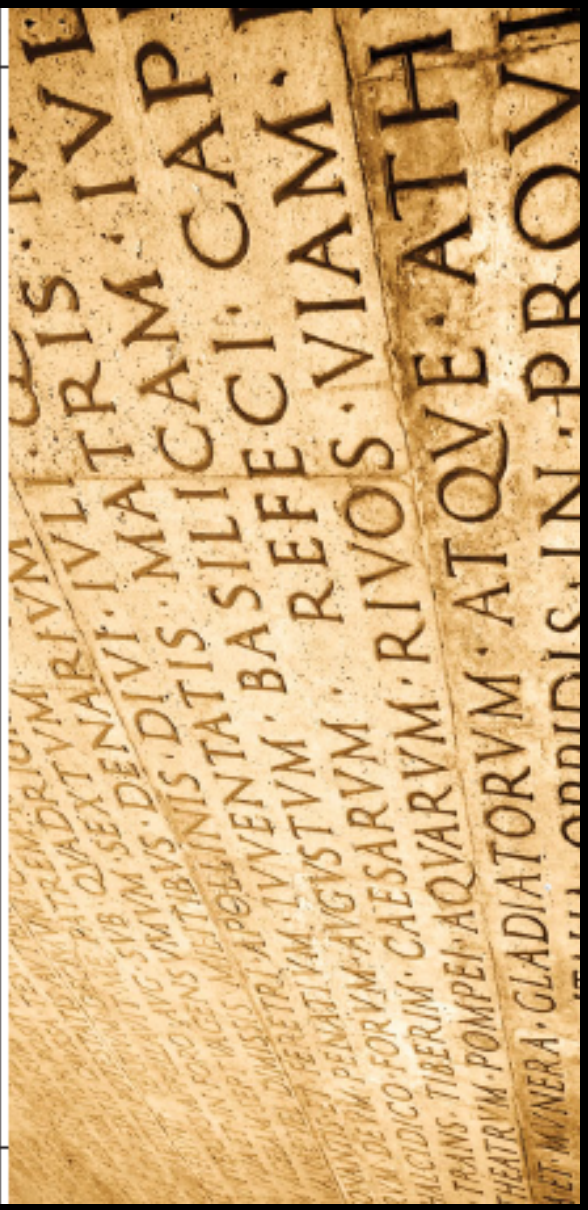
Active learning experiences provide the most substantive basis for language development: for example, a scenario involving objects that can later be used as catalysts for creating images in the mind's eye. Object imaging to reproduce a thought is easier than processing abstract ideas. The mental constructs derived from firsthand experiences, especially when verbalized, later serve as the foundational basis for processing symbols, abstractions and other forms of complex thinking. Oral language develops in a "phonological loop," where a child begins to listen to her own voice while speaking and, later, while reading. If she is fortunate enough to have others read to her, learning to read will be an easier transition.

Abstractions become less abstract to a young brain when there is a neural connection that takes one's mind back to the tangible and concrete basis for one's understandings.

Unfortunately, more often than not in our schools, formal language instruction begins at the seventh stage of this sequence. The rational push for "early literacy" standards runs counter to what we know from developmental neuroscience and research on how the young brain creates a capacity for processing language. Some say, "We don't have time to teach all of these steps." If time is not planned for the first six generative steps for language learning, in all fairness to the learner, we will need to lower our language-learning expectations.

The Language Connection to Art and Music

■ Most cultures introduce infants to informal language development by singing songs and lullabies to babies, later teaching them to move their bodies to the music, which adds another dimension to language development by connecting it with the brain-body circuitry. Music, typically correlated to right-hemispheric function, has historically been one of the most effec-



Academic Language

The Common Core State Standards (2010) call for students to be engaged in increasingly more rigorous academic inquiry — the ability to understand the language of academic texts, (also called 'academic language (AL), is fundamental to become academically successful.

How Children Learn Vocabulary Word/ Meaning

- Words are used to **think.** The more words we know, the finer our understanding of the world.

  -- Stahl, 1999

Words are also used to **process** incoming information, **to understand** and **evaluate other's ideas,** and **to understand** still *other* **words** ("this is similar to ___)

The Achievement Gap

- **Vocabulary =** proxy for knowledge. **Achievement gaps** are **knowledge gaps** primarily sponsored by ever-expanding **academic language gaps.**

- A highly developed vocabulary facilitates **precision,** not just in speaking, but in **thinking.**

- **Lack of vocabulary** can be a crucial factor underlying the **school failure** of disadvantaged students (Becker, 1977; Biemiller, 1999). (They can have a wealth of experiences, but still be poor in "linguistic capital")

Vocabulary Development

4,000 – 8,000 words when entering elementary school

40,000 avg. when they exit high school

36,000 word difference

For 13 school grades (K-12) = 2,769 words/year

178 days for 2,769 = 16 words/school day

4K- 8,000 words when entering elementary school

87,000 exposed to/should have mastered upon exiting HS

79,000 word difference

For 13 school grades (K-12) = 6,076 words/year

178 days for 6,076 = 34 words/school day

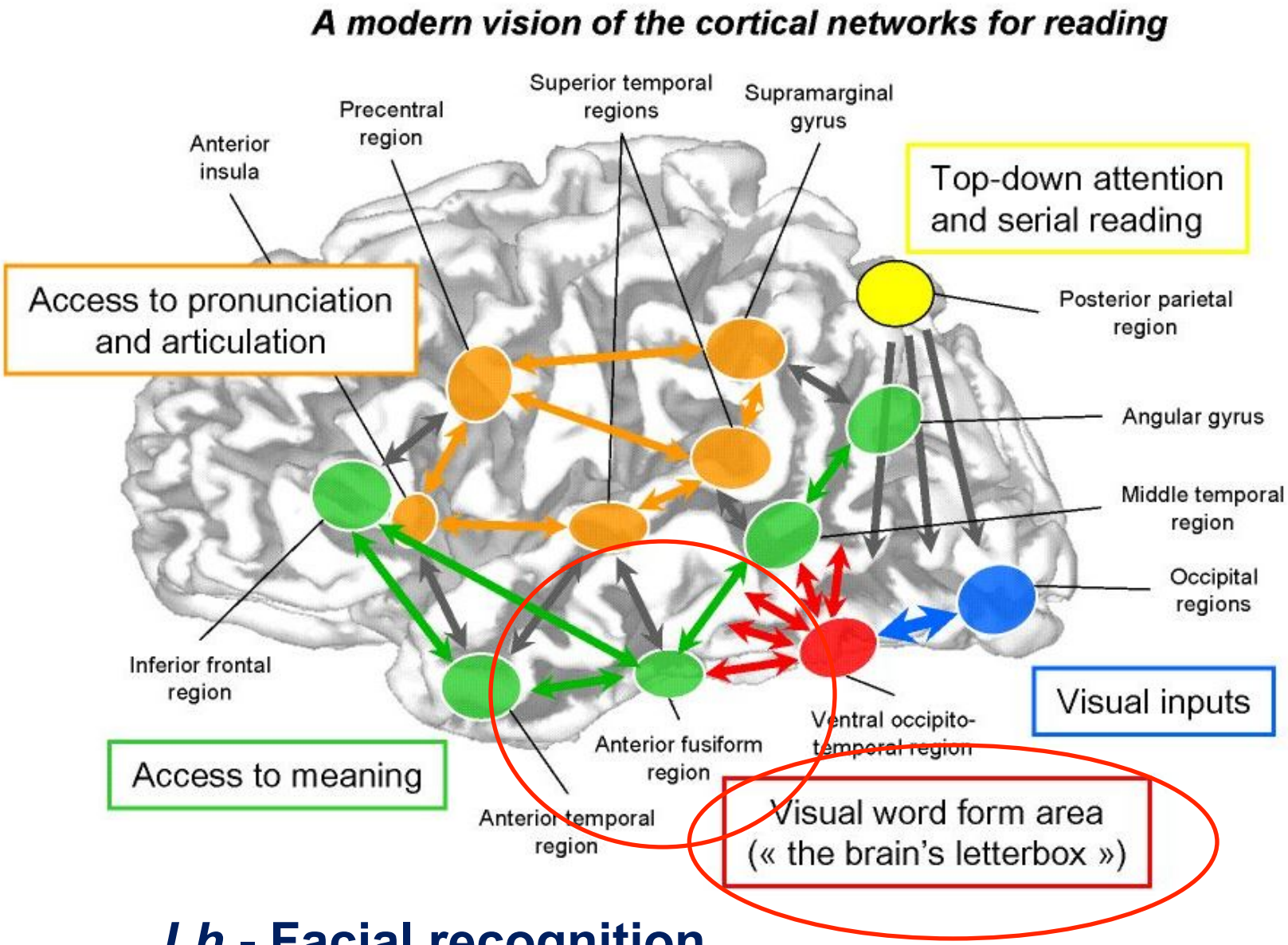
Four Types of Vocabulary Development:

Listening, speaking, writing, and reading

Two primary categories:

1. *Receptive vocabulary* refers to the words which are recognized and understood (listening/reading)
2. *Expressive vocabulary* refers to the words one knows well enough to use in order to communicate ideas (speaking/writing)

- It is more effective to support all four types of vocabulary for struggling students (NRP, 2001) by connecting them to authentic and personal experiences in the real world.



***Lh* - Facial recognition**

Academic Language

- AL is often cited as one of the key factors affecting the achievement gap that exists between high- and low-performing groups of students in our schools (Wong Fillmore, 2004).

- Students often perform poorly because they cannot meet the linguistic demands of school or the discipline rather than the difficulty of the content.

Language Learning: Academic Language

Academic Language

- Found in school contexts – books, texts, articles, research, and lectures
- The language of prestige and power in the U.S. that allows one to become academically successful → occupationally successful.
- Vital for careers, business, and commerce where academic language becomes the "local language"
- Precise language - richly *pre*scriptive formal language
- The language found in all formal assessments.
- One cannot be successful in academic settings without mastering academic Language (↓AL → ↑dropout)

Excepted from Dr. Robin Scarcella, *UC Irvine*

Language Background Experiences

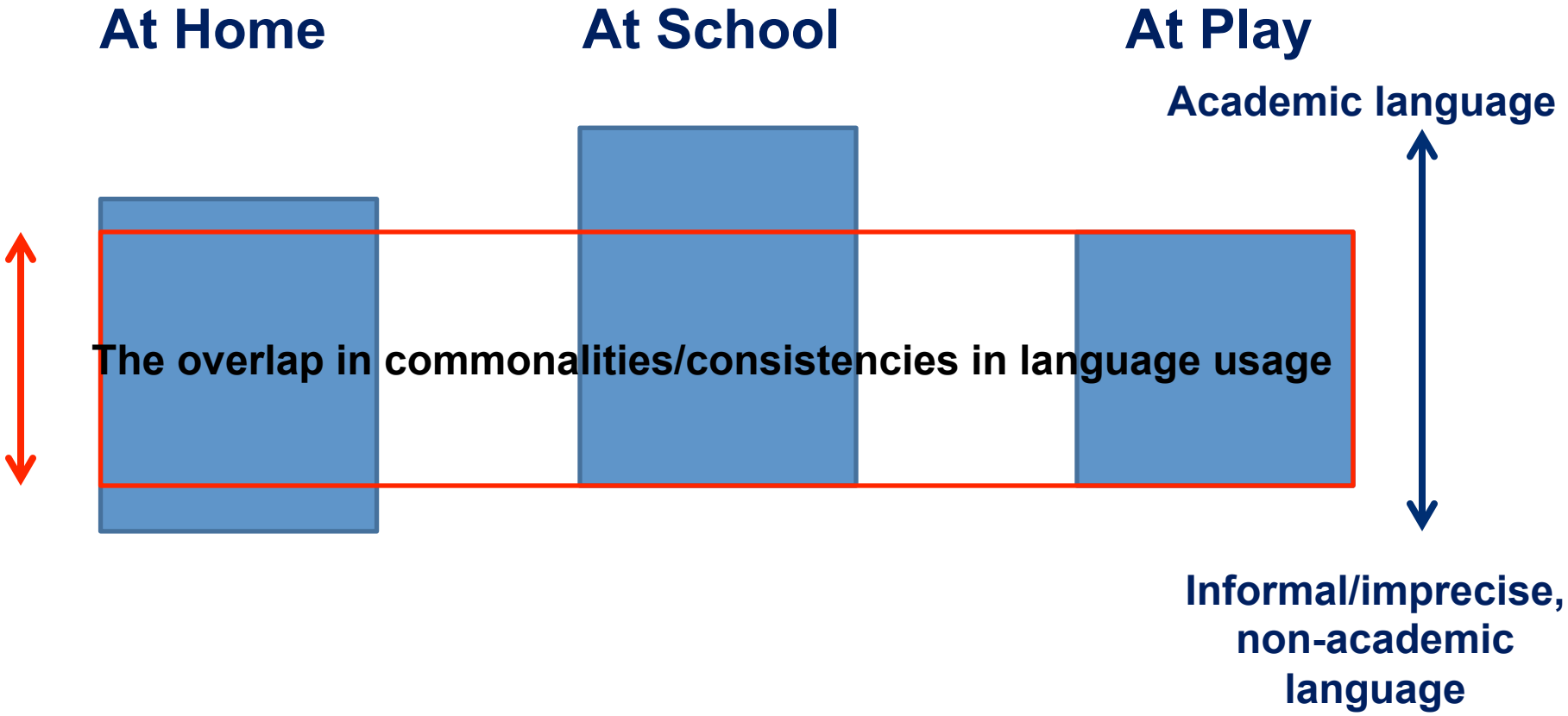
What is academic language? An example

The accelerating pace of technological progress means that our intelligent creations will soon eclipse us—and that their creations will eventually eclipse them. Sometime early in this century the intelligence of machines will exceed that of humans.

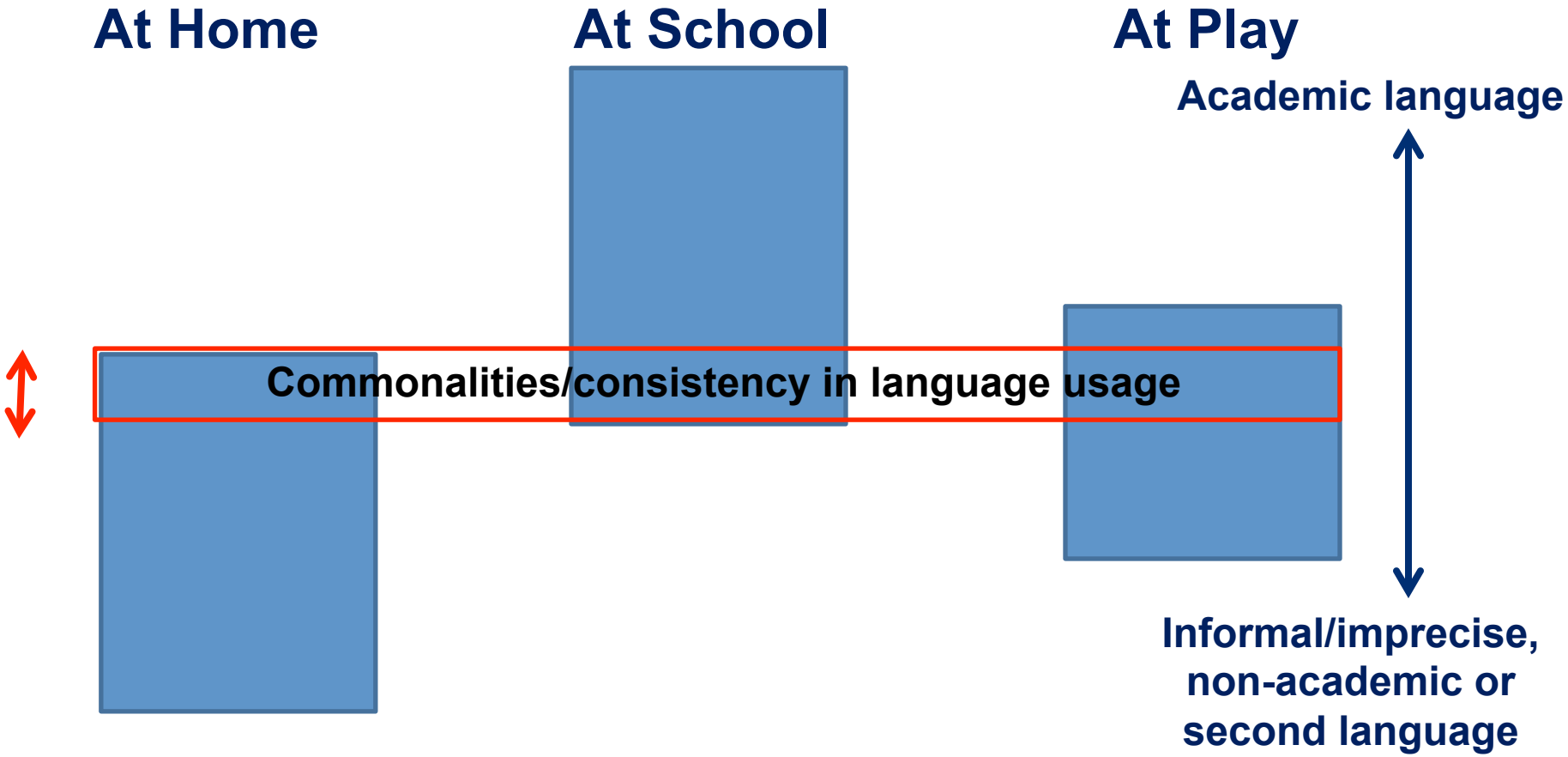
Linguistic Capital Experiences

- Non-mainstream students have not had the same conversations or literacy experiences (books and movies) that their mainstream middle-class peers have had.
- Middle-class students have had more school-aligned language experiences, rendering the language found in texts and classroom lectures more familiar. ("Disadvantaged" students – language disadvantage hurts them more than any other)
- When language mismatches occur, students struggle to learn the new rules of talk, content, and literacy, because the rules are sometimes implied or even invisible to them.

Linguistic Capital: Higher SES



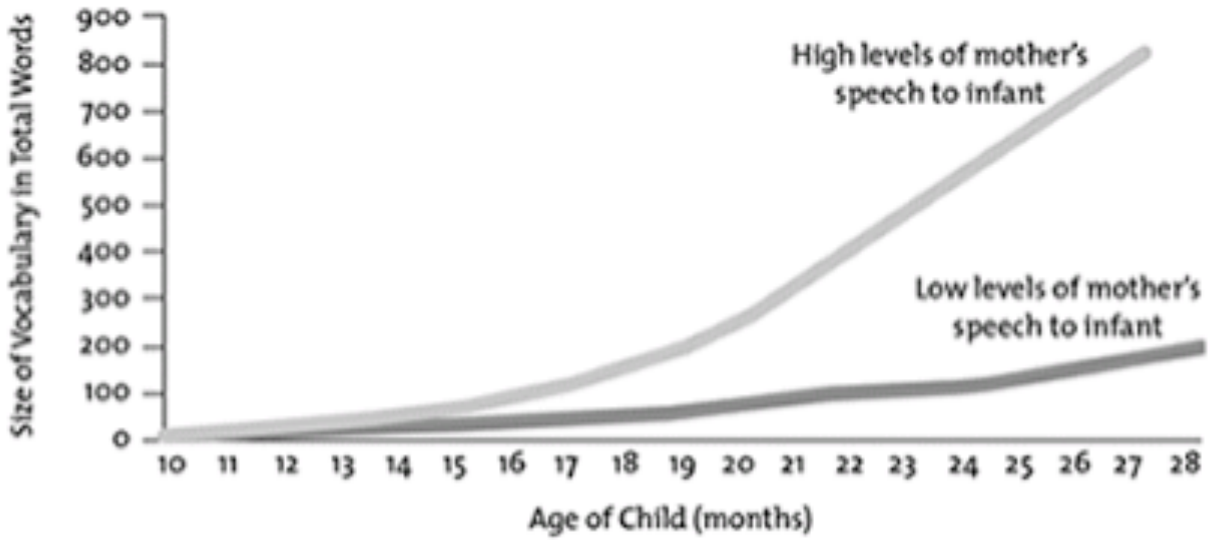
Linguistic Capital: Lower SES



Vocabulary Development

- Poverty can seriously restrict the vocabulary that children bring to school and it makes attaining an adequate vocabulary quite challenging task (Coyne, Simmons, & Kame'enui, 2004; Hart & Risley, 1995).
- Less advantaged students are likely to have substantially smaller vocabularies than their more advantaged classmates (Templin, 1957; White, Graves, & Slater, 1990).
- Lack of vocabulary can be a crucial factor underlying the school failure of disadvantaged students (Becker, 1977; Biemiller, 1999).

Talking to Infants: The Cumulative Effects of Mother's Speech on Vocabulary of 2-year-Olds



Haight, W., M. Seltzer, and R. Lyons. "Talking to Infants: The Cumulative Effects of Mother's Speech on Vocabulary of 2-year-Olds."

Chart. *Early Vocabulary Growth: Relation to Language Input and Gender*. Ed. J. Huttenlocher. 1991. 236-48. Print.

- **By age 4,** the average accumulated experience with words for children from
  - ✓ professional families = approx. 45M words
  - ✓ working-class families = 26M words
  - ✓ welfare families = only 13M words.

(Hart & Risley, 2003)

What Does the Research Say About the Importance of Vocabulary?

- Rupley, Logan & Nichols, 1998/99:
  - "Vocabulary is the glue that holds stories, ideas and content together making comprehension accessible."
  - Our students' word knowledge is linked strongly to academic success, because students with large vocabularies can understand new ideas and concepts easier/more quickly than students with ↓vocabularies.
- Chall & Jacobs: "The high correlation in the research literature of word knowledge with reading comprehension indicates that if students do not adequately and steadily grow their vocabulary knowledge, reading comprehension will be affected."

Take an Apple

- Touch it
- Feel it
- Hold it
- Smell it
- Cut it
- Taste it

Word Wall: Describe the Apple

Red
Smooth
Sweet
Moist
Wet (inside)
Rounded
Brown stem
Pointy
Yellowish
Some spots
Cold
Juicy
Rough on outside
White inside
crunchy
turning brown inside
shiny
waxy
hard

Plump
Speckled
Creamy pulp
Solid
Tart
Dark
Reflective
Chartreuse
Divot at stem
Divot at base
Internal green spots
Tangy smell
Leafy smell
Quiet/silent
Stationary
Sour
Bruised
Almond-shaped seeds
Tasty

Small
Blush
Height – 6 cm
Diameter – 7 cm
Base --3 cm
Leathery skin Ringed
Freckled
Fresh
Dry – externally
Satisfying smell
Rolls
Green
Delicious
Fibrous
Crunchy
Nutritious
Tart

Describe the Apple in this Picture

Word Wall: Describing the Apple

Red
Smooth X
Sweet X
Moist X
Wet (inside) X
Rounded
Brown stem
Pointy
Yellowish inside X
Some spots X
Cold X
Juicy X
Rough on outside X
White inside X
Crunchy X
Turning brown X
inside
Shiny
Waxy X
Hard X

Plump
Speckled X
Creamy pulp X
Solid X
Tart X
Dark
Reflective
Chartreuse
Divot at stem X
Divot at base X
Internal green spots X
Tangy smell X
Leafy smell X
Quiet/silent X
Stationary X
Sour X
Bruised X
Almond-shaped seeds X
Tasty X

Small X
Blush X
Height – 6 cm X
Diameter – 7 cm X
Base --3 cm X
Leathery skin X
Ringed X
Freckled X
Fresh X
Dry – externally X
Pleasant smell inside X
Rolls X
Green
Delicious X
Fibrous X
Crunchy X
Nutritious X
Tart X

What does reading this word tell a young learner, if he's never experienced an apple?

Apple

The Word: Eliminate the Following

Red X
Smooth X
Sweet X
Moist X
Wet (inside) X
Rounded X
Brown stem X
Pointy X
Yellowish X
Some spots X
Cold X
Juicy X
Rough on outside X
White inside X
Crunchy X
Turning brown X
Shiny X
Waxy X
Hard X

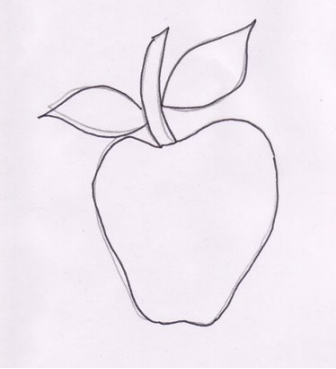
Plump X
Speckled X
Creamy pulp X
Solid X
Tart X
Dark X
Reflective X
Chartreuse X
Divot at stem X
Divot at base X
Internal green spots X
Tangy smell X
Leafy smell X
Quiet/silent X
Stationary X
Sour X
Bruised X
Almond-shaped seeds X
Tasty X

Small X
Blush X
Height – 6 cm X
Diameter – 7 cm X
Base --3 cm X
Leathery skin X
Ringed X
Freckled X
Fresh X
Dry – externally X
Pleasant smell inside X
Rolls X
Green X
Delicious X
Fibrous X
Crunchy X
Nutritious X
Tart X

Sensory experiences: the brain "maps" concrete objects found in the **external world**

↙

Neural pathways respond to ***pictures*** (visual and association cortices) of **the same object** via the same processing circuits used earlier for the concrete object.



↓

Brain circuits ***learn*** to also respond to man-made straight and squiggly lines (culturally agreed upon written symbols – **the "*word*"**) in the **visual, auditory and association cortices**. Eventually, the concrete object, its pictorial representation, and the word become mentally **indissociable**.

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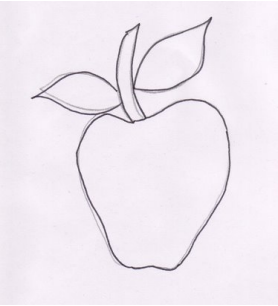

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The brain moves best from *meaning*-to-print, rather than from *print*-to-meaning

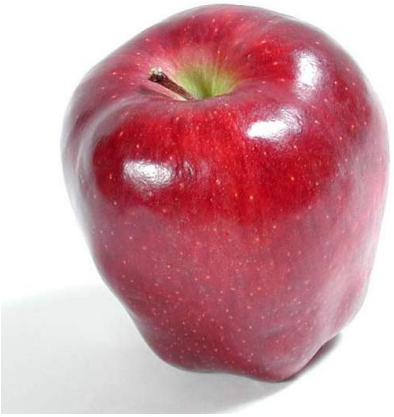
1st hand → **2nd hand** → **3rd hand**

CONCRETE

Visual represen-tation (VST)

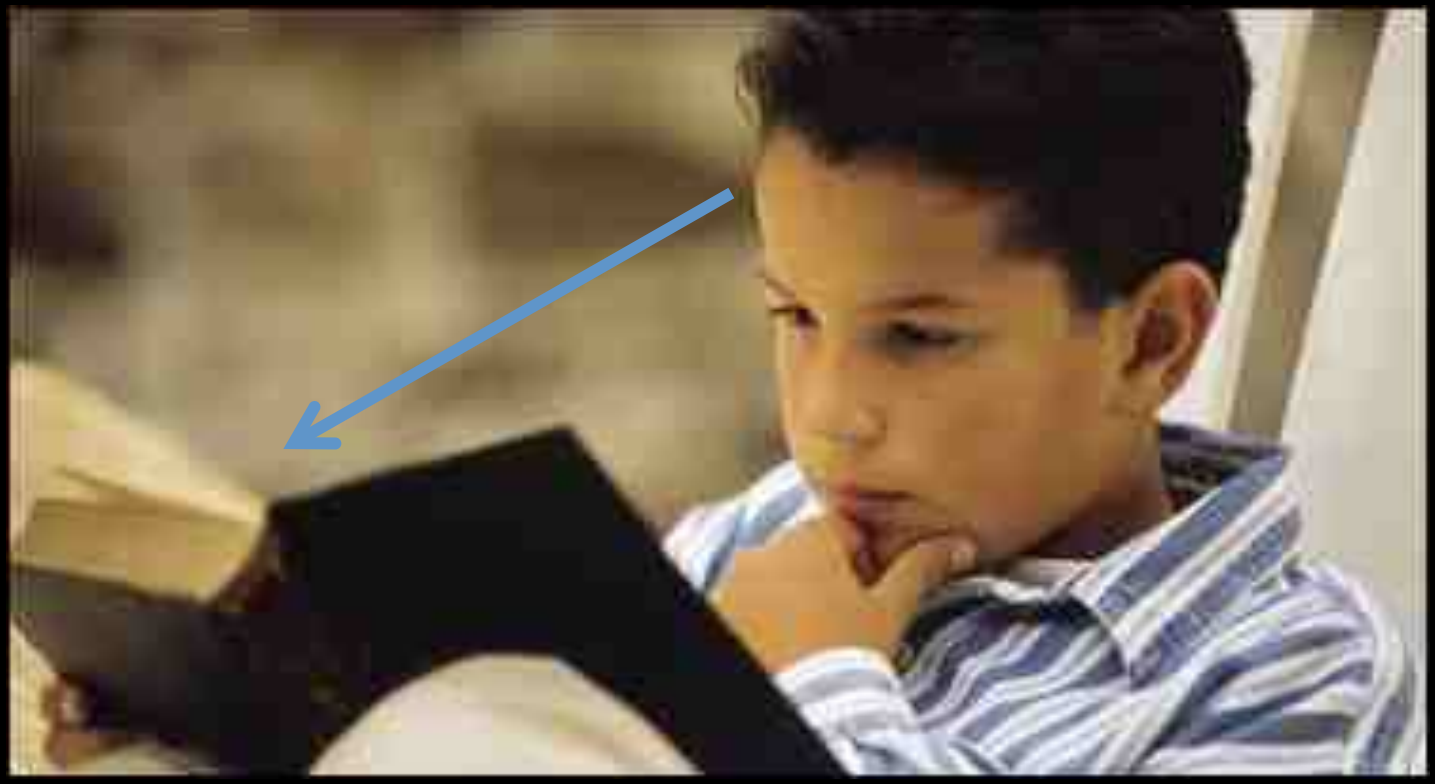
APPLE

SYMBOLIC/ ABSTRACT



most difficult means of learning for the developing brain

Reading comprehension goes from the learner *to* the page not from page → learner



What the learner *already knows* determines text comprehension.

Poor Vocabulary Development

- Problems with word meaning
- They repeatedly use "low information," (generic and imprecise) words
- They rarely have opportunities to expand the meanings, the contexts, or learn the multiple meanings of those words that they *do* know
- They have few in-class, content-related conversations
- They don't learn new or unfamiliar words quickly, because they often don't listen attentively when they are read to by adults
- They read and write less frequently and less proficiently than their peers, while in school or on their own time
- These problems collectively have a negative impact on their discourse skills and vocabulary development

The 3 Rs of Academic Vocabulary

Relevance to the learner (experience)
+ **R**ehearsal (cognitive rehearsals)
+ **R**everse direction decoding

…are how we assure **r**etention as they develop AL.

BBK - *Then* Reading

- Struggling readers focus their attention on decoding and accessing the meaning of individual words, thus leaving little attention free for reading comprehension.

- 81% percent of struggling readers struggle with vocabulary

- 100% percent of struggling readers struggle with comprehension

Reverse Direction Decoding

Dactyloscopy:

The practice of using fingerprints for personal identification

dak-tu-los'ku-pē

(-py) = **pē**
(-copy) = **ku-pē**
(-loscopy) = **los'ku-pē**
(-tyloscopy) = **tu-los'ku-pē**
dactyloscopy = **dak-tu-los'ku-pē**

Colorectal

adenocarcinoma

diverticulitis

australopithecus

microscopy

deoxyribonucleic

phenothiazine

Co-lo-rec-tal

A-de-no-car-ci-no-ma

Di-ver-tic-u-li-tis

Aus-tra-lo-pith-e-cus

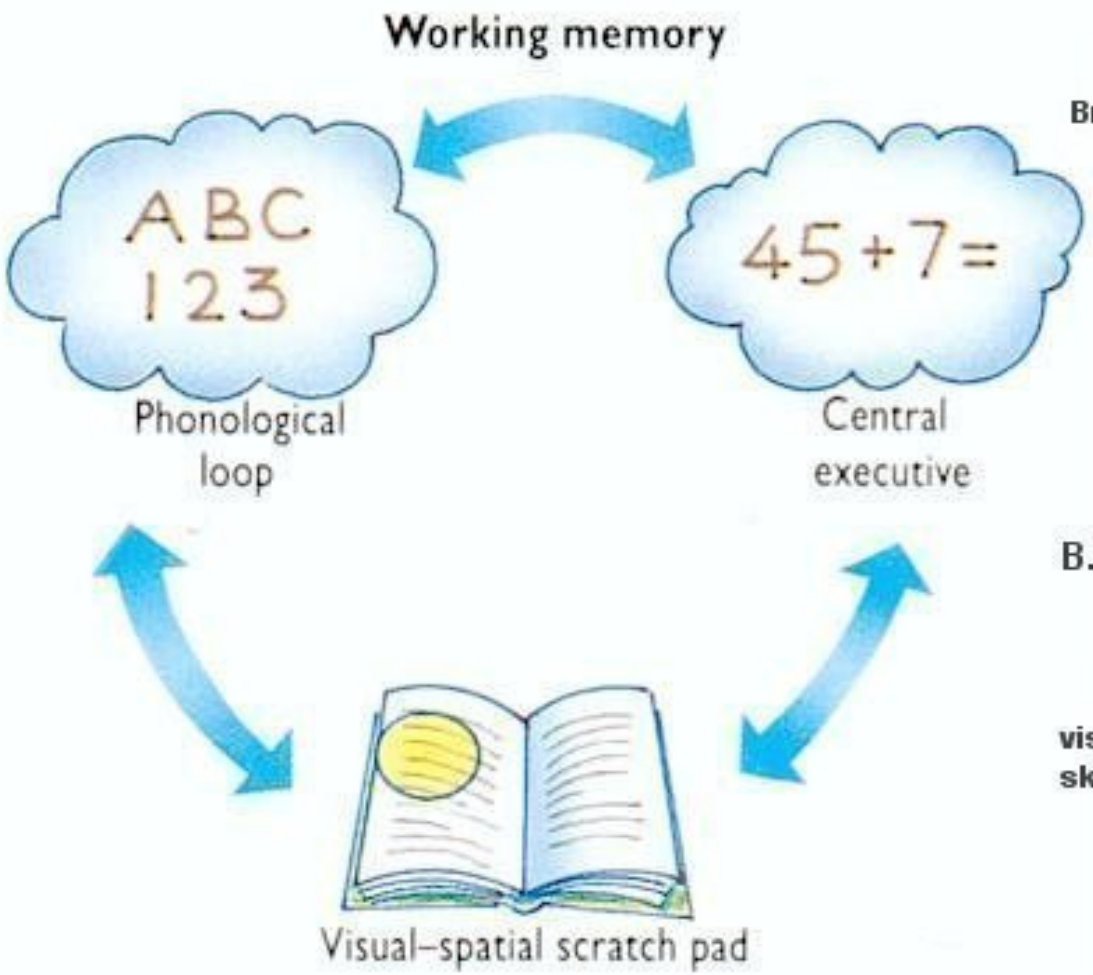
Mi-cros-co-py

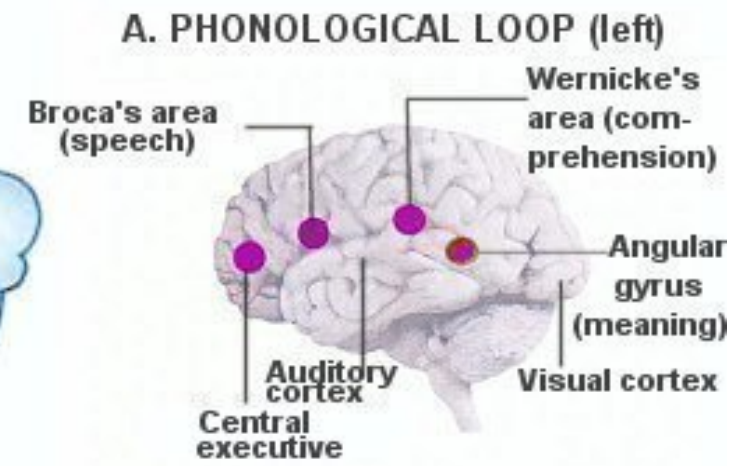
De-ox-y-ri-bo-nu-cle-ic

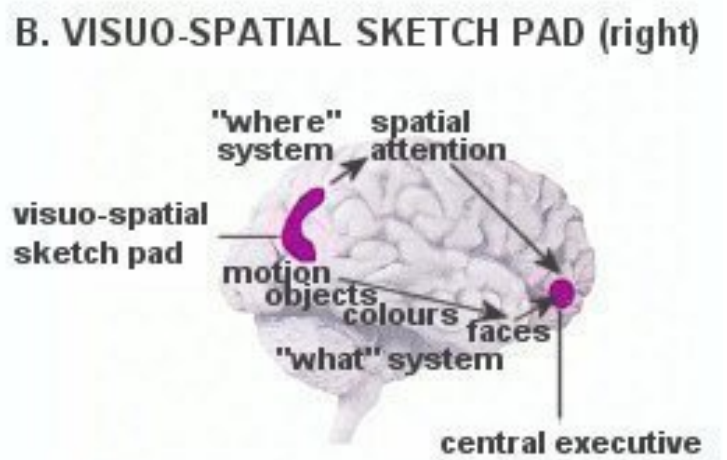
Phe-no-thi-a-zine

Diatomaceous = Di-a-tom-a-ceous

How Reverse Direction Decoding Works







Move Key into Sight Vocabulary ASAP

"In fact, the *automaticity* with which *skillful* readers *recognize* words is the key to the whole system…The reader's *attention* can be focused on the *meaning and message* of a text only to the extent that it's *free* from fussing with the *words and letters.*"

--Marilyn Adams

“It takes approximately 26 years before a significant finding in educational research actually reaches the classroom.”

Paul Hurd, professor emeritus (Stanford University)

By taking the information shared today and by applying the recommended teaching/learning strategies immediately, you can reduce that cycle by **25 years.**

BrainWorld

REVERSE DIRECTION DECODING

Posted on December 26, 2012 by admin

Revolutionizing How We Teach Reading
by Kenneth Wesson

A short list of humankind's greatest achievements would undoubtedly include the use of tools, language and technology. Reading and writing have become so second nature to educated individuals that reading is taken for granted; but by readers only. Literacy can not only alter the success-trajectory of our lives, but the process of learning how to read "literally" alters brain circuitry, the physiology and architecture of the human brain. In addition to listening to words, we read words, use words in speech, and even think in words.

Phonics is the popular reading strategy commonly taught in preschool, primary and upper elementary grades, and sometimes still in middle schools. However, shouldn't any technique used repeatedly for almost 10 consecutive years with only modest success warrant some suspicion? Worst of all, the word "phonics" does not conform to its own rules. The mere fact that it is not spelled phonetically should have generated suspicions about the theory! It has produced millions of "phonics-damaged children" according to some researchers.

Learning Science just got easier!

What is STEM/STEAM/S.T.^{2}R.E.A.M.?

Interdisciplinarity

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

---David Perkins

Cognition and Making Connections

Cognition – from *L.* base "know together" –

to make connections not to "silo"

knowledge (or memorize isolated facts)

Interdisciplinarity

- The human brain is the most sophisticated information-integration processing system on earth with over 40,000 miles of neural circuits connecting over 100 billion neurons and nearly 1 trillion other cells.
- As brain cells develop into circuits, the brain makes no distinction between <u>academic disciplines</u> (there was no evolutionary basis for such a "need".)

Standards from Which Discipline: Math or Science?

1. Asking questions and defining problems
2. Obtaining, evaluating, and communicating information
3. Look for and make use of structure
4. Planning and carrying out investigations
5. Attend to precision
6. Analyzing and interpreting data
7. Model with mathematics
8. Using mathematics and computational thinking
9. Constructing explanations and designing solutions
10. Make sense of problems and persevere in solving them
11. Reason abstractly and quantitatively
12. Construct viable arguments and critique the reasoning of others.
13. Developing and using models
14. Engaging in argument from evidence
15. Use appropriate tools strategically
16. Look for and express regularity in repeated reasoning

Standards from Which Discipline: Math or Science?

1. Asking questions and defining problems (NGSS)
2. Obtaining, evaluating, and communicating information (NGSS)
3. Look for and make use of structure (M)
4. Planning and carrying out investigations (NGSS)
5. Attend to precision (M)
6. Analyzing and interpreting data (NGSS)
7. Model with mathematics (M)
8. Using mathematics and computational thinking (NGSS)
9. Constructing explanations and designing solutions (NGSS)
10. Make sense of problems and persevere in solving them (M)
11. Reason abstractly and quantitatively (M)
12. Construct viable arguments and critique the reasoning of others. (M)
13. Developing and using models (NGSS)
14. Engaging in argument from evidence (NGSS)
15. Use appropriate tools strategically (M)
16. Look for and express regularity in repeated reasoning (M)

Practices in Mathematics, Science, and English Language Arts*

Math	Science	English Language Arts
M1. Make sense of problems and persevere in solving them.	**S1.** Asking questions (for science) and defining problems (for engineering).	**E1.** They demonstrate independence.
M2. Reason abstractly and quantitatively.	**S2.** Developing and using models.	**E2.** They build strong content knowledge.
M3. Construct viable arguments and critique the reasoning of others.	**S3.** Planning and carrying out investigations.	**E3.** They respond to the varying demands of audience, task, purpose, and discipline.
M4. Model with mathematics.	**S4.** Analyzing and interpreting data.	**E4.** They comprehend as well as critique.
M5. Use appropriate tools strategically.	**S5.** Using mathematics, information and computer technology, and computational thinking.	**E5.** They value evidence.
M6. Attend to precision.	**S6.** Constructing explanations (for science) and designing solutions (for engineering).	**E6.** They use technology and digital media strategically and capably.
M7. Look for and make use of structure.	**S7.** Engaging in argument from evidence.	**E7.** They come to understanding other perspectives and cultures.
M8. Look for and express regularity in repeated reasoning.	**S8.** Obtaining, evaluating, and communicating information.	

* The Common Core English Language Arts uses the term "student capacities" rather than the term "practices" used in Common Core Mathematics and the Next Generation Science Standards.

NGSS@NSTA
STEM STARTS HERE

Scientists, Mathematicians and Engineers

- Do scientists, mathematicians and engineers communicate with one another?
- Do scientists, mathematicians and engineers write summaries of their work?
- Do they write reports?
- Do they write research papers?
- Do they give oral presentations of their research at symposiums? Interviews?

"Reading and writing comprise over half of the work of scientists and engineers." (NRC 2011)

Similar Concepts, Discipline-specific Terminology

Reading	Mathematics	Science
Listening, speaking, reading/researching, writing	*Listening, speaking, reading, writing*	*Listening, speaking, reading/ researching, writing*
Predict	Estimate	Hypothesize, predict
Identify	Find the…	Observe, investigate
Compare and contrast	Difference, sorting, quantifying	Classify → sense-making
Sequence (chronology)	Order and magnitude	Organize and categorize
What is the main idea?	Solve for…	What is the key concept?
List the…	Chart/graph the	Record and interpret the data
Summarize the	What is the…?	What conclusion can you draw?
List your reasons for	Show your work	What evidence supports your claim?
Cause and effect	Ratios and relationships	Cause and effect, cycles, systems
Sense-making, reasoning	Number sense	Claims and evidence, reasoning
Argumentation	Proofs	Arguments and evidence
Questions	Problems	Investigations (and Inquiry)
Proposition-answer	Problem-solution	Question-experiment
Descriptive skills dev.	Quantitative skills dev.	Thinking skills dev.; applications
Content focus	Focus on Problem-solving	Focus on answering questions
Words for expression	Words, numbers, symbolic Expressions	Written, visual, numerical, symbolic Expression and applications
Critical thinking	Quantitative and logical thinking	Creative thinking

Patterns: S.T.^{2}R.E.A.M.

Science

Technology (and Thematic trans-disciplinary instruction to extend student learning)

Reading and Language Arts

Engineering ("Design *and* Engineering")

Art

Mathematics

(Maximizing connections and sensory experiences)

S.T^2.R.E.A.M.

Science

Technology

Engineering

Mathematics

Reading/Language Arts (Standards)

Reading, writing, discourse, argumentation, vocabulary development, comprehension, journals, note-booking, lab reports, summaries, oral presentations, recording interpreting and critiquing data and information

Visual Literacy

Art

Drawing/diagramming, visual spatial thinking, imagery, inferential thinking, 2/3-dimensional modeling, symbolic models, interpreting visual evidence, visual representations - illustrations, charts, etc.

<u>Convergent/Integrative</u> STEM T' & L'

"STREAM-posium":
Share Interdisciplinary Vocabulary Lists

- Prepare a list of the key vocabulary words for the month from each subject area/discipline
- Exchange those lists with colleagues and look for polysemous words (multiple meanings depending on their contexts) that also are germane to your discipline, your lessons plans for the year.
- If a word appears in multiple academic areas, it warrants your special attention
- Work these interdisciplinary (bonus) words often into your lectures, discussions, writing assignments, and assessments.

ICLE: Application Model

1. ~~Knowledge in one discipline~~
2. ~~Application within one discipline~~
3. Application *across* disciplines
4. Application to real-world *predictable* situations
5. Application to real-world *unpredictable* and/or creative situations ("improvisational intelligence")

Learning: When "More" Becomes "Less"

Question: ***"What*** **did you learn in school today?"**

Response: **"Nothing."**

Why???

Learning: When "More" Becomes "Less"

- Enrichment studies: Examine the effects of enrichment or deprivation on brain development, neurogenesis, neuronal growth and synaptogenesis.

- While neurons generally grew in size, measures of
  (a) increased dendritic density
  (b) increases in the number of glial cells
  (c) myelination of the axons
  (d) changes in brain weight and overall brain volume

- No toys or playmates ↓ all growth measures (impoverished)

- Playmates + a change of toys every other day ↑ (Enriched environments)

- Changing toys every hour: → similar ↓ neural connections in brain growth and development (your school day??)

The journal Brain World Fall 2014

(released in early October 2014)

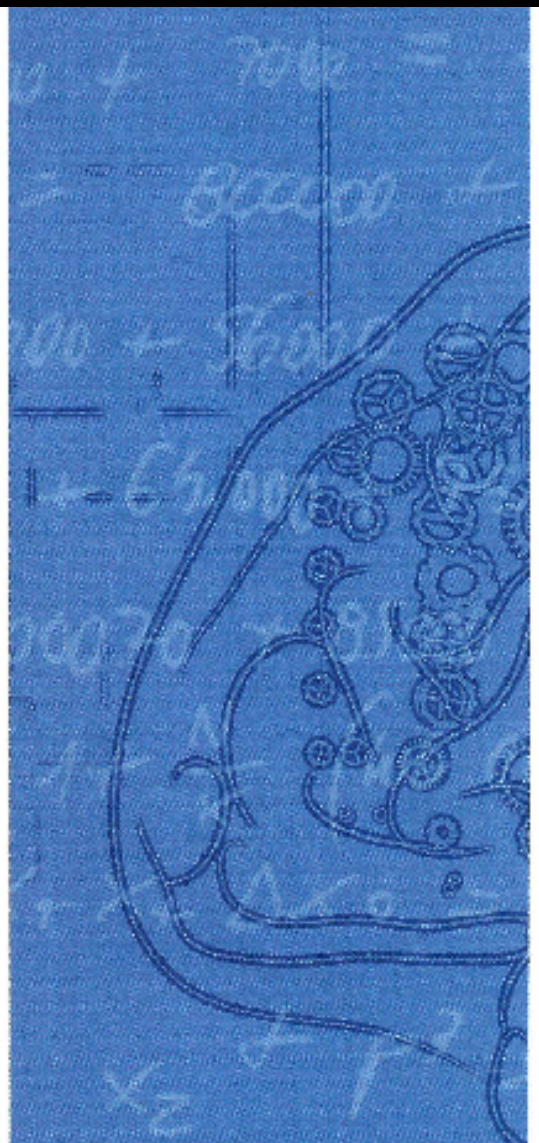
USING INTERDISCIPLINARITY
TO IMPROVE OUR MINDS AND OUR SCHOOLS
MERGING ACADEMIC DISCIPLINES
TO FIND THE ANSWERS

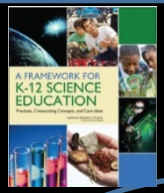
BRAIN-STEM

By Kenneth Wesson, Ph.D.

"The illiterates of the future are not those who cannot read or write, but those who cannot learn, un-learn, and re-learn." — Alvin Toffler, Futurist

■ Students beginning kindergarten this fall will likely retire around the year 2075. An unpredictable world awaits them. How do we prepare our children for the future, with such an uncertain economy and rapidly evolving technology? According to Microsoft CTO Cameron Evans, current educational approaches were designed to prepare students for careers that don't exist anymore, and may never exist again. It is estimated that this new generation of school-aged children may hold between five to eight different careers throughout their lives. The most recent projections by the U.S. Department of Labor indicate that 15 of the 20 fastest-growing professional occupations require a significant understanding of mathematics and science, two subjects where American students lag behind Euro-





3-Dimensions of Learning Science

NEXT GENERATION SCIENCE STANDARDS

❖ Eight Practices

- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing Explanations and Designing Solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

➢ Seven Crosscutting Concepts

- Patterns
- Cause and effect
- Scale, proportion, and quantity
- Systems and system models
- Energy and matter: Flows, cycles, and conservation
- Structure and function
- Stability and change

• Four Disciplinary Core Ideas:

- ✓ Life Science,
- ✓ Physical Science
- ✓ Earth and Space Science
- ✓ Engineering, Technology and Applications of Science

Engineering Practices

Human Brains Have Evolved Into "Doer" Brains Over the Millennia

***Homo* habilis**

Engineering Practices

- 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 science ("knowing")

Engineering Practices

We were never “born to read.”

We were born to

Invent,

Innovate,

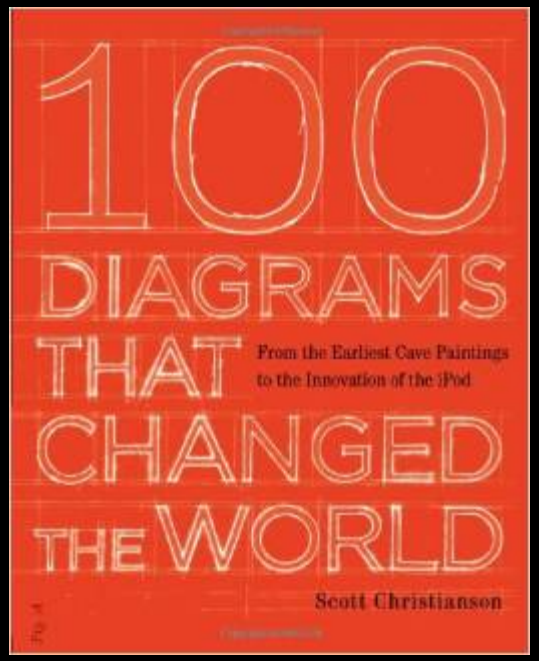
Improvise,

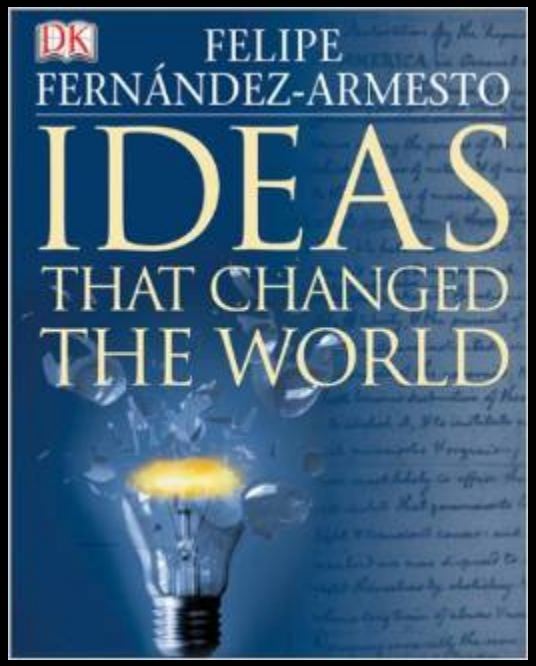
and

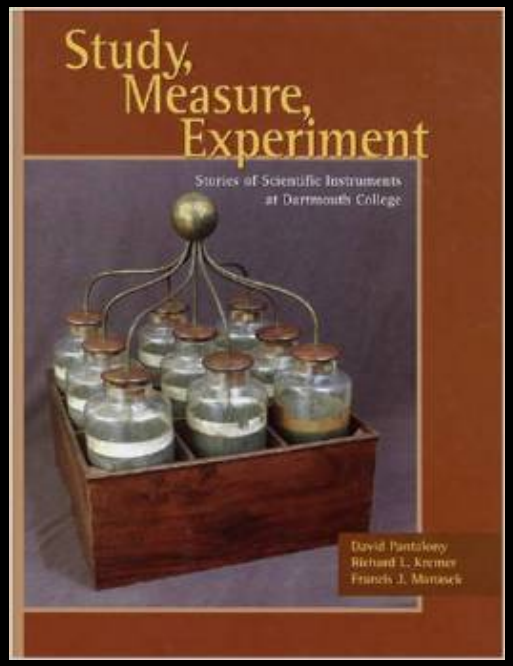
Improve

Innovation and Creativity

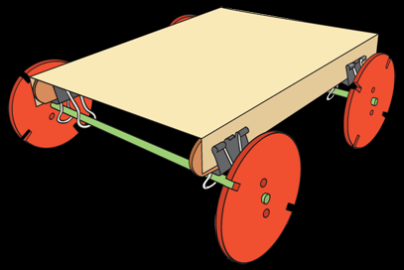
Human beings are the *only animal* on the planet that looks for problems and for problems to solve. In the late 1800s to the mid-20th century, highly creative minds were needed to solve contemporary challenges. If a problem that was frequently encountered, someone visualized, designed and produced a tool to solve that problem.







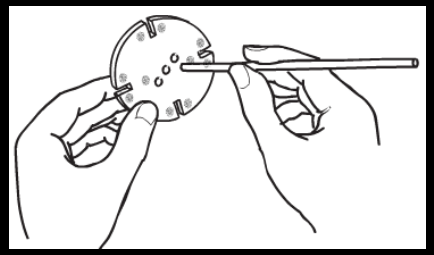
- All *ideas* begin with a vision/visual image (→ drawing).
- All *engineering* begins with a design (→ diagram = graphic representation of the visualization).



Learning Progressions

Learning progressions: **Conceptual understanding ("think scientifically") is derivative of in-depth, carefully-sequenced, relevant *experiences.*** (Each serves as a **building block** in a child's deeper understanding the **"core ideas"** in science)

Patterns of Motion:
Learning Progressions



1. **One disk** + straw → Spinning top

↓

2. **Two disks** + straw → a wheel-and-axle system

↓

3. **Four disks** + straws → a pair of two wheel-and-axle systems and a wheel bearing system

↓

Large disks vs small disks
Cardboard cart vs tongue depressor cart

↓

4. **Create your own cart** (applications, math, design, engineering, art)

Engineering: Wheel-and-Axle Systems

- **Creating solutions to *problems* (the work of *engineers* who "engage in a systematic practice of design to achieve solutions particular human problems" -** *NRC, A Framework for K-12 Science Education, 2012, page 11)*
- **The success of their solution(s) is determined by how well or satisfactorily it solves the problem *(criteria)***
- **Solutions are *limited* by *constraints* (e.g., the available materials, time, budget/costs, tools, conditions, etc.,) and solutions do not occur in a "light bulb experience." Instead, they require a deliberate, thoughtful, systematic design process**

Engineering: Wheel-and-Axle Systems

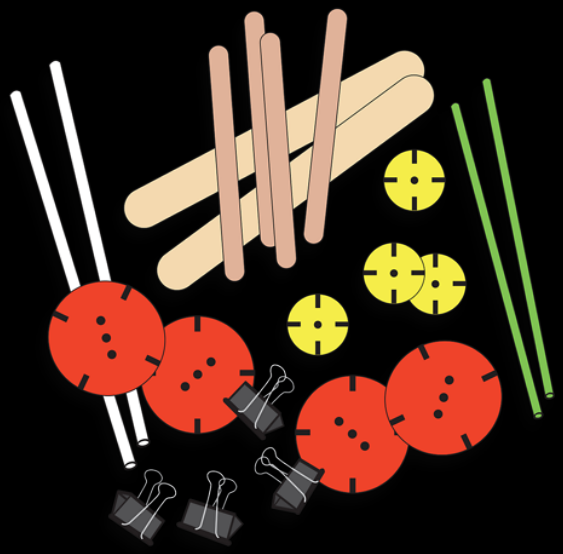
Engineering challenge: Build a spinning top.

1. Criteria: **construct a spinning top that spins for seven seconds or more.**

2. Constraints: **(a) use only the materials provided, (b) you can spin your top using only your hands, and (c) five minutes to construct and test your top.**

Use the following items:

- **Stirring straws**
- **Large plastic disks (red)**
- **Small plastic disks (yellow)**
- **Scissors**
- **stopwatch**



Engineering: Wheel-and-Axle Systems

Conduct a formal investigation to answer the following questions:

- Where should the disks be *placed* on the stirring straw in order for the system to spin?
- Will the top spin longer if the disk is placed closer or further away from the bottom of the system?
- How long will the disk spin if it is placed on the straw
  - ½ inch from the bottom
  - 1 inch from the bottom
  - 2 inches from the bottom
  - 3 inches from the bottom, or
  - 4 inches from the bottom?

  (record your data: What is the optimal design?)

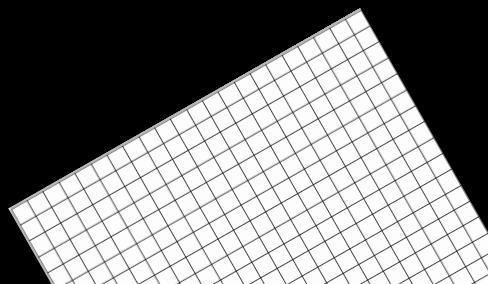
Engineering: Wheel-and-Axle Systems

1. What seems to be the optimal distance to place the disk from the bottom of the straw to get the top to spin the greatest amount of time?

2. Will a larger disk spin longer than a smaller disk placed the same distance from the bottom of the straw?

3. If additional disks are added (more mass) to the spinning system, will the amount of time that it will spin increase or decrease?

4. record your data

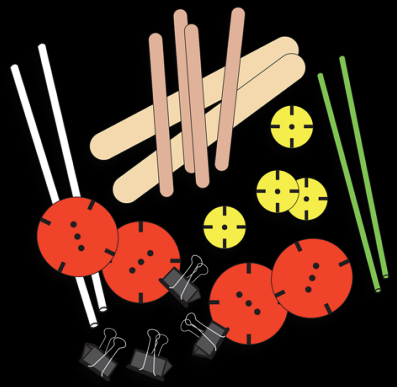


Engineering: Wheel-and-Axle Systems

Engineering challenge: Build a **wheel-and-axle system** (transferring your knowledge from the spinning tops).

1. ***Criteria:*** construct a wheel-and-axle system that rolls at least 24 inches with a slight push.

2. ***Constraints:*** (a) use only the materials provided, (b) your wheel-and-axle system must roll 24 inches on its own after one small push, and (c) you have 5 minutes to construct and test your wheel-and-axle system.



Engineering: Wheel-and-Axle Systems

Would you now be able to do the following (engineering practices/learner expectations)?

1. If you hear about an axel system, would you understand what it is?

2. Could you recognize an axel system?

3. Will you remember what an axel system is?

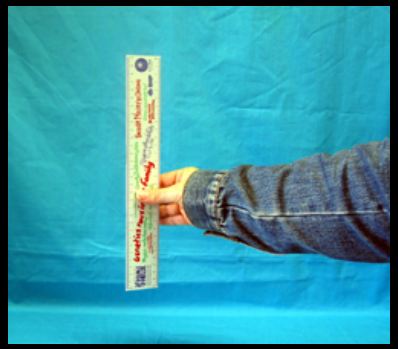
5. Could you reproduce an axel system?

6. Would you knows how to apply your knowledge about an axel system as you *designed* and *built* a toy car?

Brain-sight:

The Power of Visualization

Seeing With the Mind's Eye

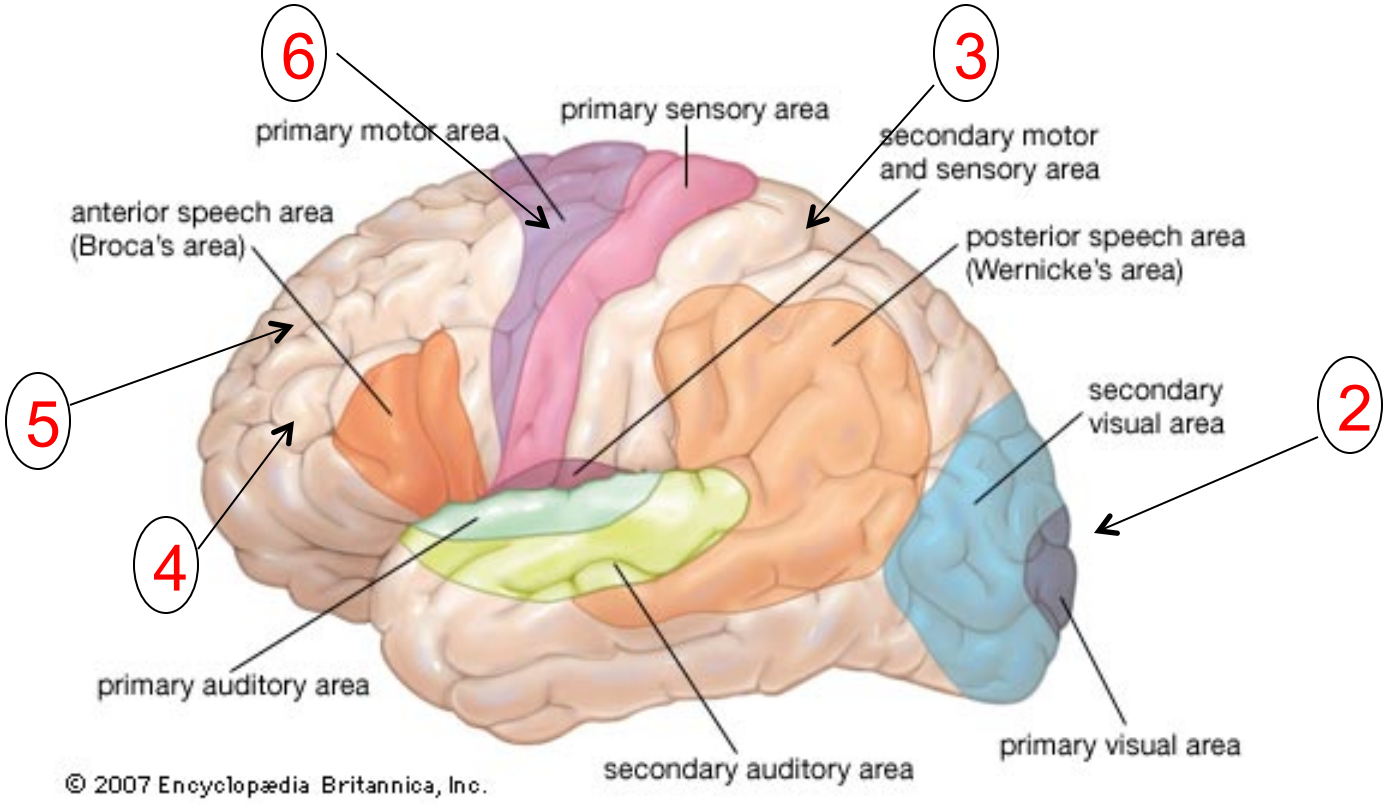


Abstract Thinking

Using your Reflexes

(Each takes 0.05 – 0.1 sec.)

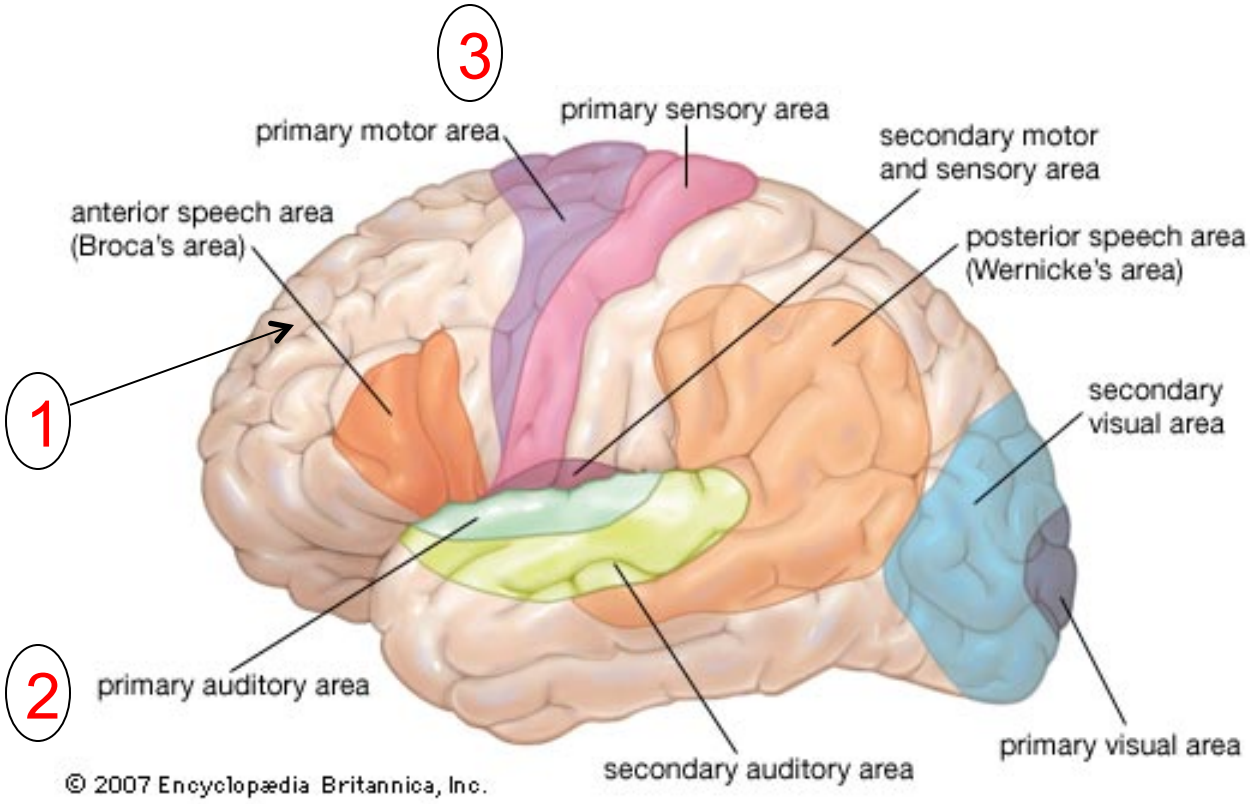
(1) Eyes → sight (2) visual cortex – vision → (3) association cortex - meaning → (4) frontal lobes – plan of action → (5) PfC – prepares response → (6) motor cortex – takes an action



Reflexes: In the Mind

(Each takes 0.05 – 0.1 sec.)

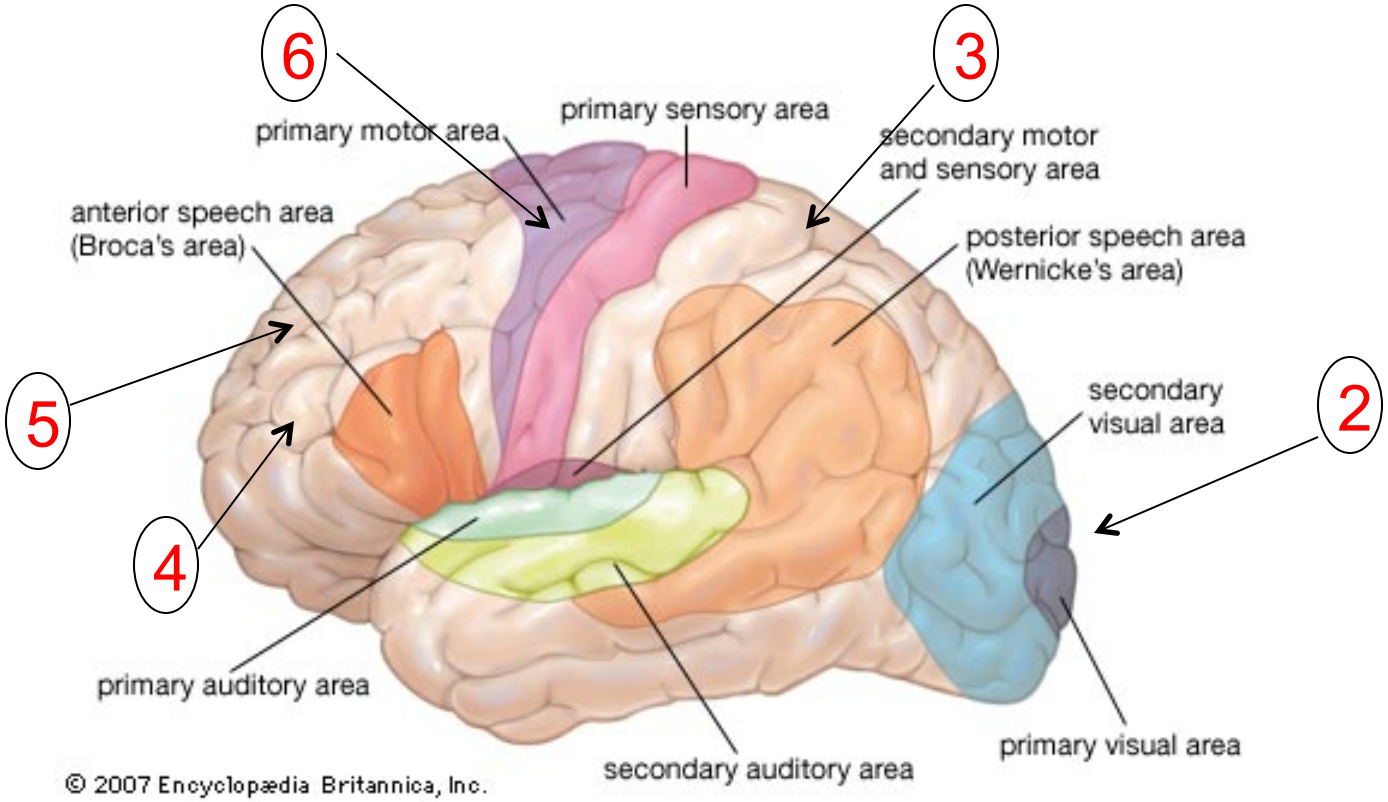
(1) PfC – prepares response (2) Ears → hearing → (3) motor cortex – takes an action



Reflexes: Visualization

(Each takes 0.05 – 0.1 sec.)

(1) ~~Eyes → sight~~ (2) ~~visual cortex – vision~~ → (3) ~~association cortex - meaning~~ → (4) frontal lobes – plan of action → (5) PfC – prepares response → (6) motor cortex – takes an action



The Brain-based Classroom: Making Connections

We say that our eyes "see" - vision is accomplished by specialized brain cells that convert light from the external world into an elaborate neural code for encoding, processing, storage and retrieval.

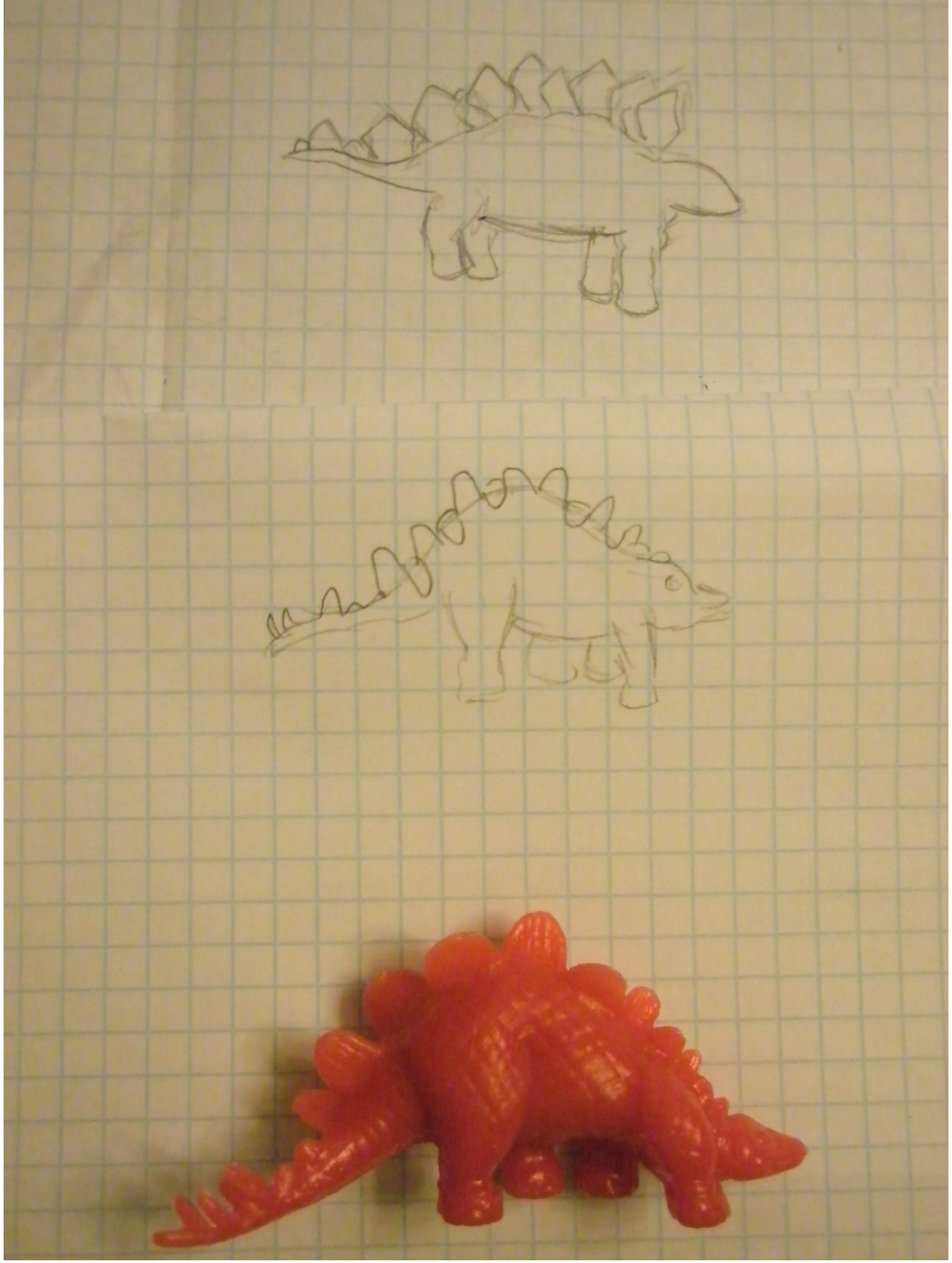
Beginning at birth, the eyes and the brain undergo a daily training regimen for understanding art and images well before any thoughts of school

For millions of years, vision has been our primary method of experiential data collection. Nearly 80% of the information we use enters our sensory world via the eyes -- our major doorway to initial discovery

“Brain-sight” vs. Eyesight

If you wanted to reproduce an object , which procedure should produce the most accurate representation of that object?

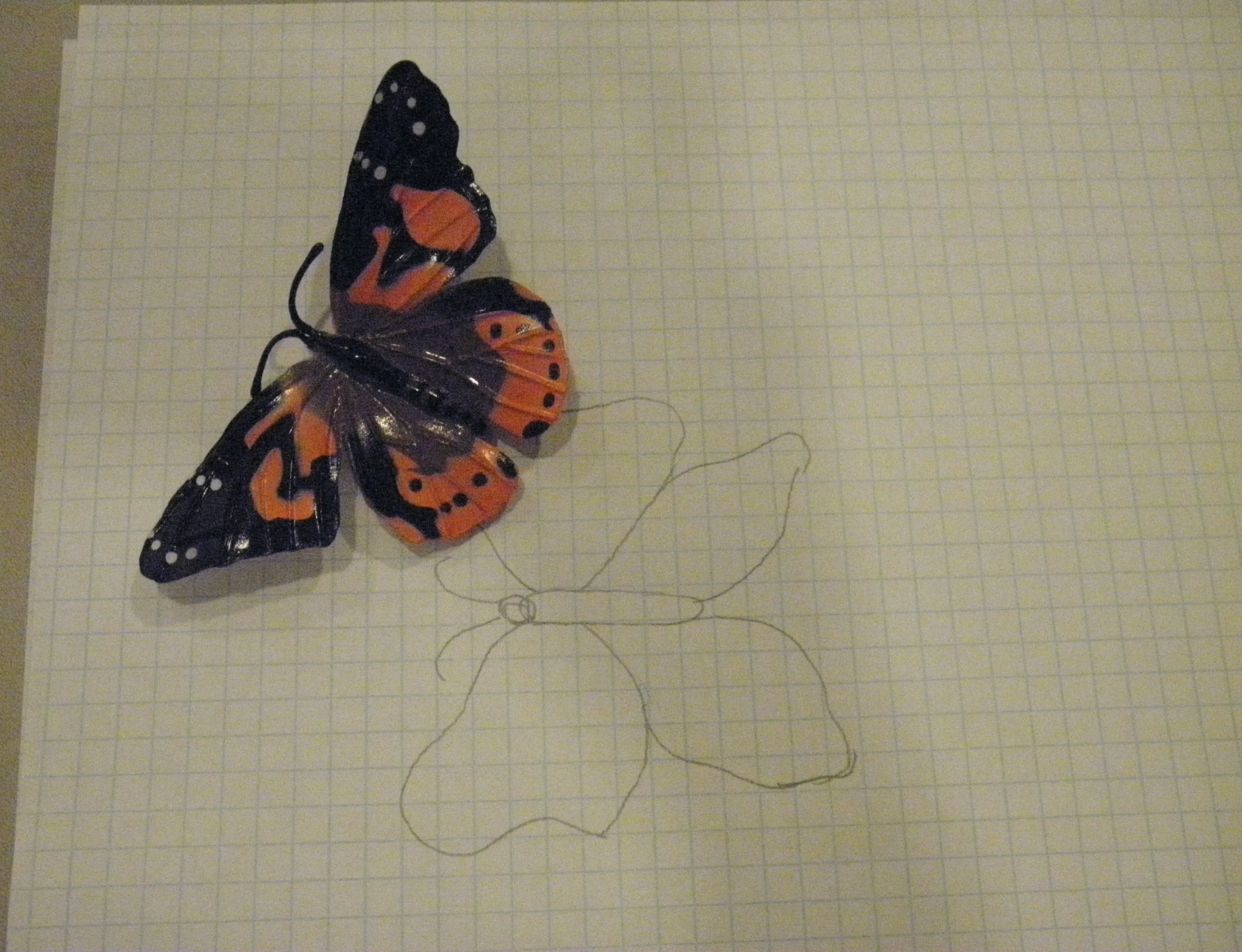
A. Tracing the object
B. Looking at the object while drawing it
C. With your eyes closed, touching and feeling the object followed by drawing it, although having never seen it.



Brain-sight

Eyesight

Object

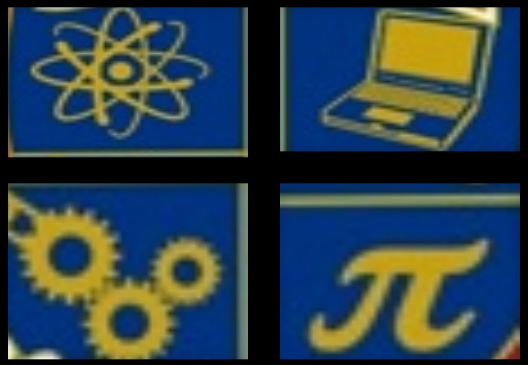


"Brain-sight" vs. Eyesight

If asked in the future, which procedure should produce the most accurate representation of an object…

A. Tracing the object
B. Looking at the object while drawing it
C. With your eyes closed, touching and feeling the object followed by drawing it, although having never seen it.

Only you will know that the range of *quality* for the 3 renditions will be the c-b-a order rather than the a-b-c order. Your colleagues will be surprised by this somatosensory shocker!



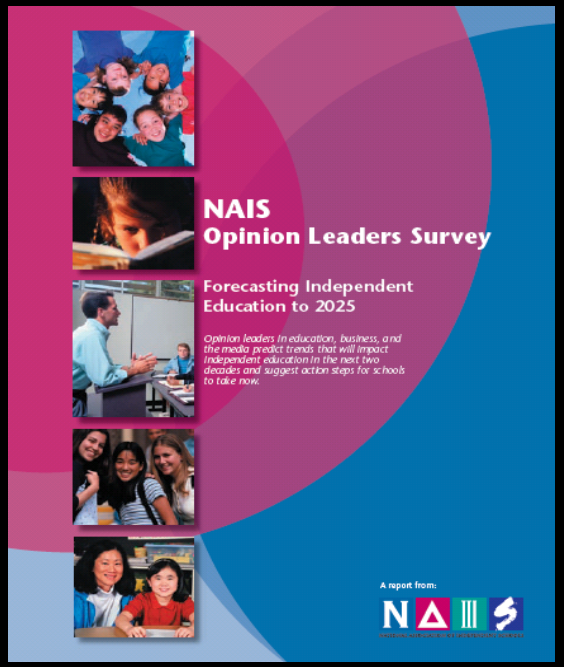
STEM:

Students and **T**eachers **E**njoying every **M**inute of the school day,

because it is finally **connected** and the

learning finally makes sense to me!

NATIONAL ASSOCIATION OF INDEPENDENT SCHOOLS



Each year, new findings in cognitive psychology and neuroscience will be infused into teacher preparation, curriculum, instruction, student assessment, and the classroom environment. The works of **Howard Gardner** *("Multiple Intelligences")*, **Daniel Goleman** *("Emotional Intelligence")*, **Kenneth Wesson** *("Brain-considerate Learning")*, and others have already been influential in reshaping the independent school classroom, while programs like **Mel Levine's** *Schools Attuned* are assisting educators in using neurodevelopmental content in their classrooms to create success at learning and to provide hope and satisfaction for all students.

Forecasting Independent Education to 2025

-- NAIS

"Reflect and Connect"

- What was the most valuable piece of information that *you learned* this morning? What *new question* is now on your mind?
- How did our conversation change your thinking?
- Write down two "I will" statements from this experience. (What will you look at differently/*do* differently in your school/district, program or institution?)

sciencemaster.com

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