KWL Strategy

The KWL strategy, developed by Donna Ogle, is one that teachers often use with students prior to a unit of study or a lesson.

K	W	L
What do I think I know?	What I want to know/wonder about ...	What I learned ...

Some teachers have added a fourth column ...

Q -- New questions I have ...

An Invitation to Practice Bracketing ...

Take a moment and jot down any thoughts, or things you must do later. This will enhance your ability to focus on our session today. After you have finished writing, simply fold up the paper. This will put distracting thoughts out of sight and, hopefully, out of mind. You will be able to come back to them later, should you want to.

[Bracketing]

Bracketing is the act of mentally blocking out troublesome thoughts. This allows one to clear the mind in order to focus on something else.

Bracketing can be taught to both staff and students. For example, to the classroom, students often bring thoughts that trouble them -- a fight between parents at home, an argument with a friend, being teased on the way to school, negative self talk, or losing a special friend. These thoughts drain mental energy away from learning opportunities. Sometimes, these thoughts need to be addressed directly, at the moment. At other times, bracketing may be appropriate.

Examples of how teachers have used bracketing:

- Students are asked to bracket troublesome thoughts on the corner of their papers and invited to fold the corner down to cover the thoughts.
- Students create "worry boxes" out of Kleenex boxes. When they feel a need to bracket, they write down thoughts or draw pictures and deposit these into the box.
- Students are taught that negative self talk may inhibit performance. They are encouraged to write down the negative self talk on 3 x 5 cards, place these in envelopes and "sit on them"!
- Primary students are asked to shrink their negative thoughts or pictures into a tiny "dot" and put the "dot" in their pockets.

How might you use bracketing with staff? In what contexts?

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Understanding the Brain and Brain Compatible Teaching Strategies

Principles of Learning

1. New learning is shaped by the learner's *prior knowledge.*

2. Much learning occurs through *social interaction.*

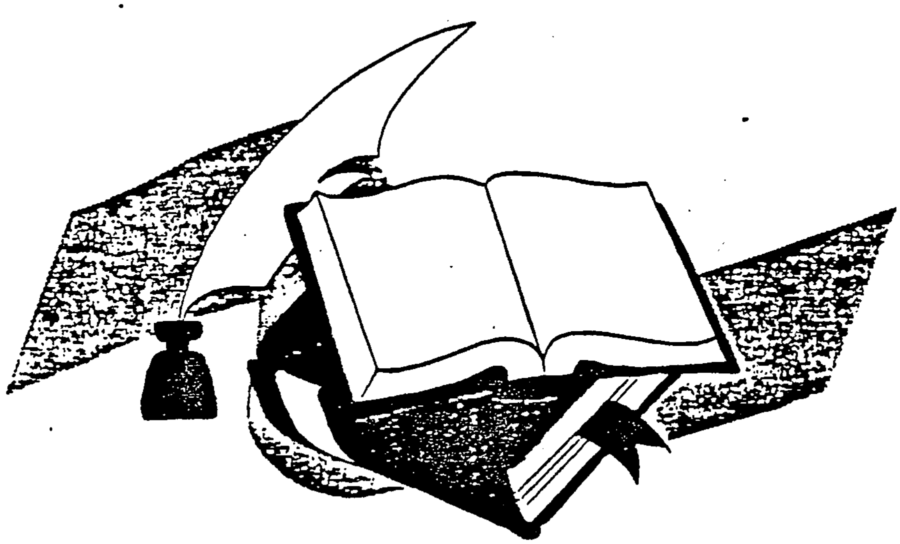
3. Learning is closely tied to *particular situations.*

4. Successful learning involves the use of *numerous strategies.*

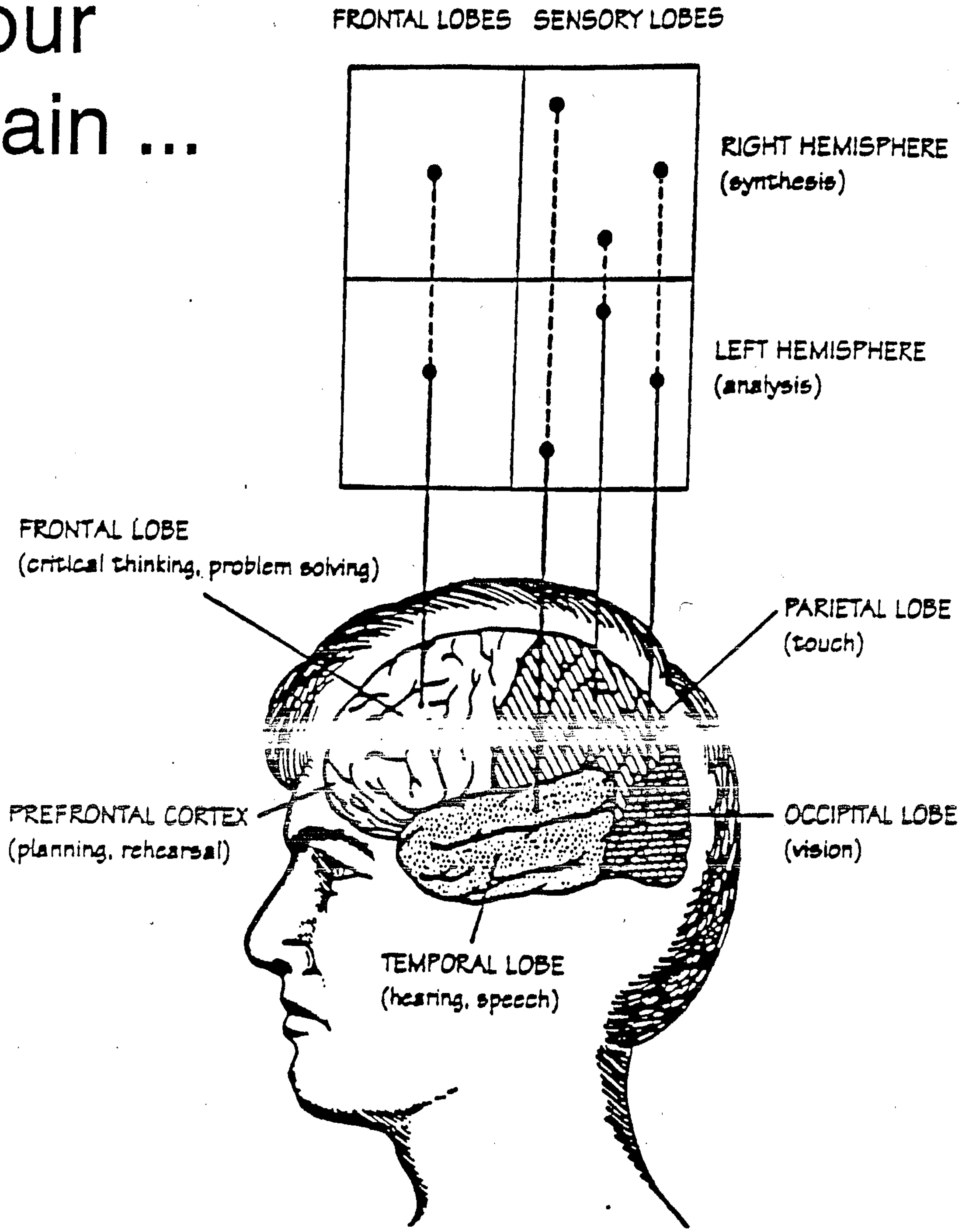
Source: R. Marzana, Pickering, D., Arredondo, D., Blackburn, G., and Moffett, C. Dimensions of Learning Trainer's Manual. Association for Supervision and Curriculum Development, Alexandria, VA 22314. (703) 549-9110.

W O W!!

Our average brain capacity is approximately ten million volumes (books) of a thousand pages each!!



Your Brain ...



- You have at least 100 billion nerve cells (neurons) in your brain.
- Each of these neurons makes between 5,000 and 50,000 contacts with other neurons.
- There are approximately one million billion connections in the cortex.

THE AMAZING BRAIN

- Our brain's cellular units are tiny, their numbers are immense, and everything is connected.

- Our brain's three-pint, three pound, mass is divided somewhat evenly between tens of billions of nerve cells, or neurons that regular cognitive activity, and the much smaller and ten-times-more-numerous glial cells that support, insulate, and nourish the neurons.

- Thirty thousand neurons can fit into a space the size of a pinhead.

Adapted from: A Celebration of Neurons, Sylwester, Robert, (1995) Alexandria, VA. ASCD.

BRAIN SYSTEMS

Various models of our brain's architecture have been proposed over the years:

- a holistic brain

- two cerebral hemispheres

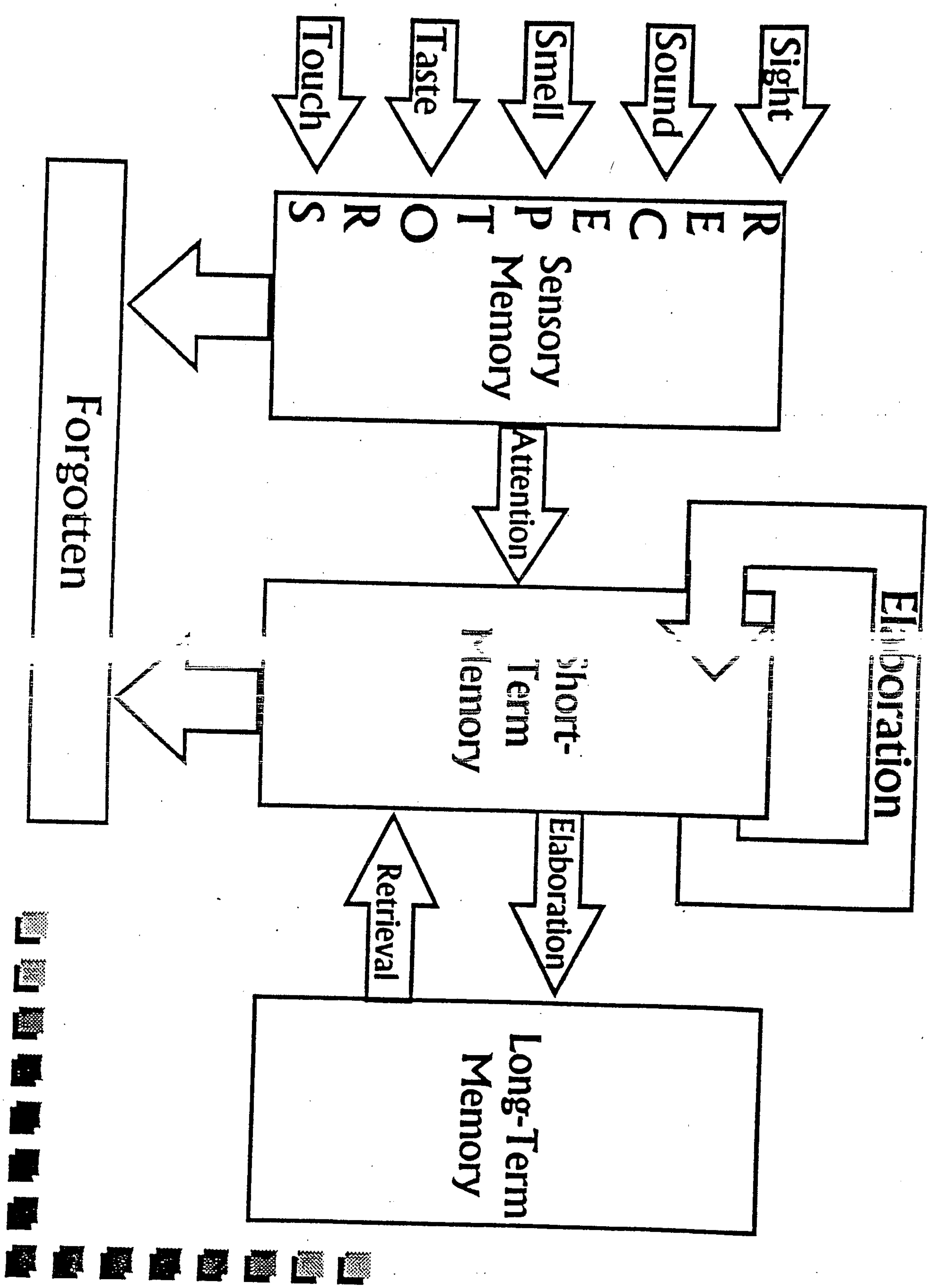
- Paul MacLean's (1978) model of the triune brain that evolved to process survival, emotional, and rational functions

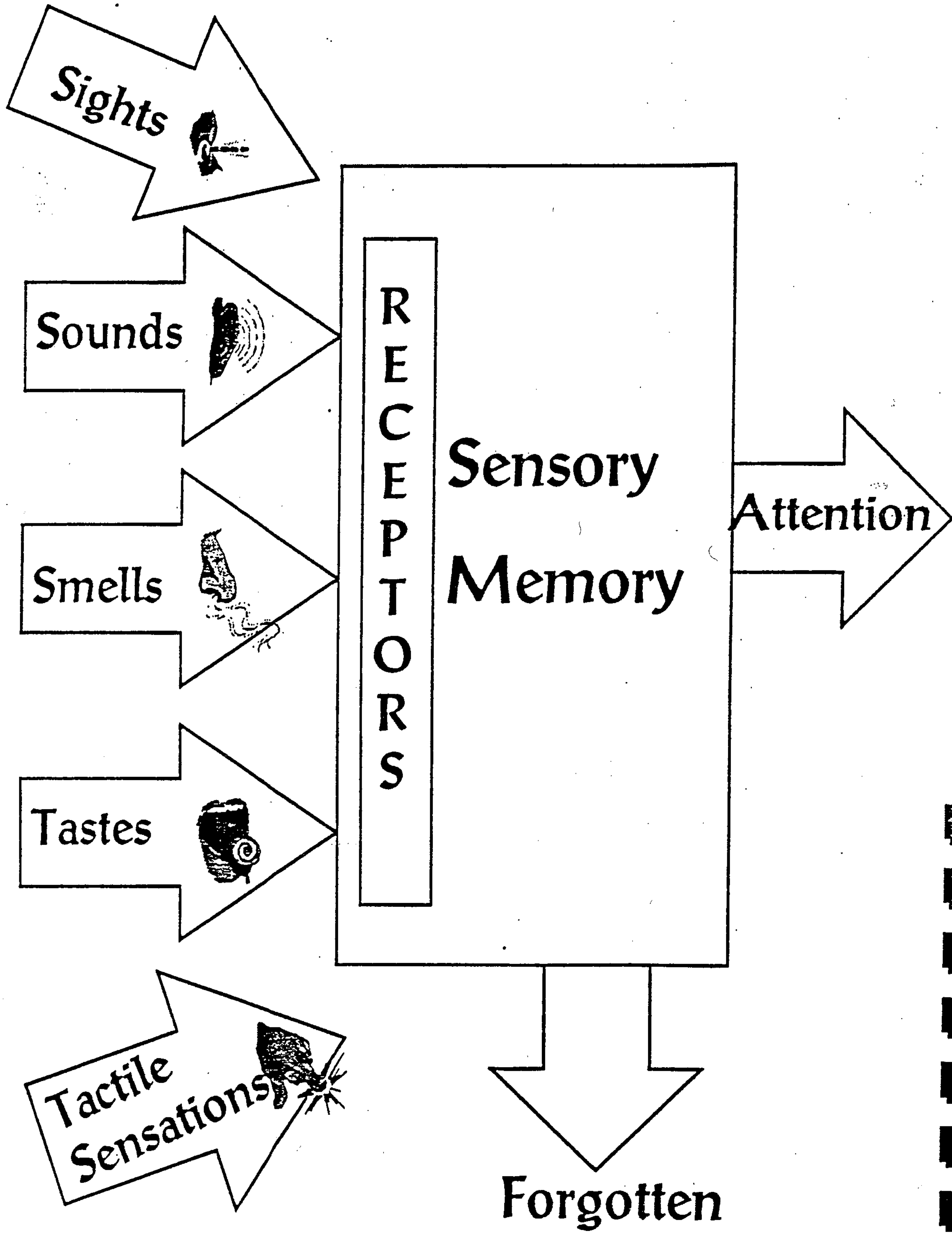
- Howard Gardner's (1983) suggestion that our conscious brain functions [illegible] intelligence processed in different brain areas

- Gazzaniga's (1985) conception of our brain as being divided into a vast number of interconnected, semi-autonomous networks of neurons called modules, each specializing in a limited cognitive function (such as face recognition). Groups of modules consolidate their activities to process more complex cognitive functions.

Adapted from: A Celebration of Neurons, Sylwester, Robert, (1995) Alexandria, VA. ASCD.

FIGURE 1.1. The earliest efforts to explore the brain arose from the same deep curiosity that draws researchers into neuroscience today. This Dutch woodcut from J. Dryander's *Anatomie* (1537) shows that the brain was already understood at this time as a structure composed of diverse parts. The woodcut identifies divisions between a frontal ("sinciput, anterior") and rear ("occipital, posterior") portion of the brain, and between lobes at the sides; these divisions still serve as landmarks for students of neuroanatomy. At the right, the letters A, B, C, D, F, and G distinguish the six layers of the cerebral cortex; in this century, observations down to the level of single cells make it possible to sort out the distinct functions of each of these layers. Source: The National Library of Medicine.


Sight
Sound
Smell
Taste
Touch
RECEPTORS
Sensory Memory
Attention
Short-Term Memory
Elaboration
Elaboration
Retrieval
Long-Term Memory
Forgotten


Sights
Sounds
Smells
Tastes
Tactile Sensations
RECEPTORS
Sensory Memory
Attention
Forgotten

Silk

Of the dozen platters artfully arranged on the luncheon table, only one commanded my attention — and apprehension — a dish of silkworms. Minutes before at the ... Scientific Research Institute near Dandong, I had watched a golden yellow silkworm crawl across the back of my hand. Now it was on my plate for lunch ... The eyes of my luncheon companions shift between me and the shiny brown beast, the size of a medium shrimp, [illegible] me. Clutching it with my chopsticks, I took a crunchy bite. A smooth, warm custard with a nutty flavor spilled over my tongue. I noticed my dinner partners spitting shells of the silkworm pupae on the tablecloth and the floor. I swallowed the thing whole.

— from "Silk, the Queen of Textiles," *National Geographic* (January 1984)

THE PROCESS OF MEMORY

"We remember what we understand; we understand only what we pay attention to; we pay attention to what we want."

(Bolles, Remembering and Forgetting: An Inquiry Into the Nature of Memory, (1988), p. 23)

Experience → Emotion → Attention

↙

Relate to what one already knows → Understanding

"Attention is like digestion. We do not store the food we eat; we break it down so that it becomes part of our body. Attention selects parts of experiences and uses it to nourish our memories. We do not store this experience, we use it. Of course, we eat many things that we do not digest and we also experience many things without paying them any attention."

Bolles (1988, p. 183)

Pam Robbins

The Cocktail Party Effect

> The mind can pay conscious attention to only one train of thought at a time.

... an experiment

What are the classroom implications of the Cocktail Party Effect?

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ATTENTION

An effective attentional system must be able to:

1. quickly identify and focus on the most important items in a complex environment.
2. sustain attention on its focus while monitoring related information and ignoring other stimuli.
3. access memories and experiences from the past that could be relevant to the current focus.
4. shift attention quickly when important new information arrives.

What are the implications for teaching?

Adapted from: A Celebration of Neurons, Sylwester, Robert, (1995) Alexandria, VA. ASCD, p. 78.

1. Am I aware of my own thinking about what I am trying to accomplish?

not aware				*very aware*
0	1	2	3	4

2. Have I made a plan for what I want to accomplish?

no plan				*complete plan*
0	1	2	3	4

3. Have I collected all the resources for what I want to accomplish?

no resources				*all necessary resources*
0	1	2	3	4

4. Am I aware of how well I am doing and if I need to change any of my actions or attitudes?

not aware				*very aware*
0	1	2	3	4

5. Am I evaluating how well this is going and what I would do differently next time?

not evaluating				*always evaluating*
0	1	2	3.	4

ATTENTION!

> The true art of memory is the art of attention.
>
> \- Samuel Johnson

> Anything that captures students' attention and gets their minds engaged, has the potential to produce learning; if there is not attention and no engagement, there will be no learning.

What influences what we pay attention to?

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How are perception and attention related?

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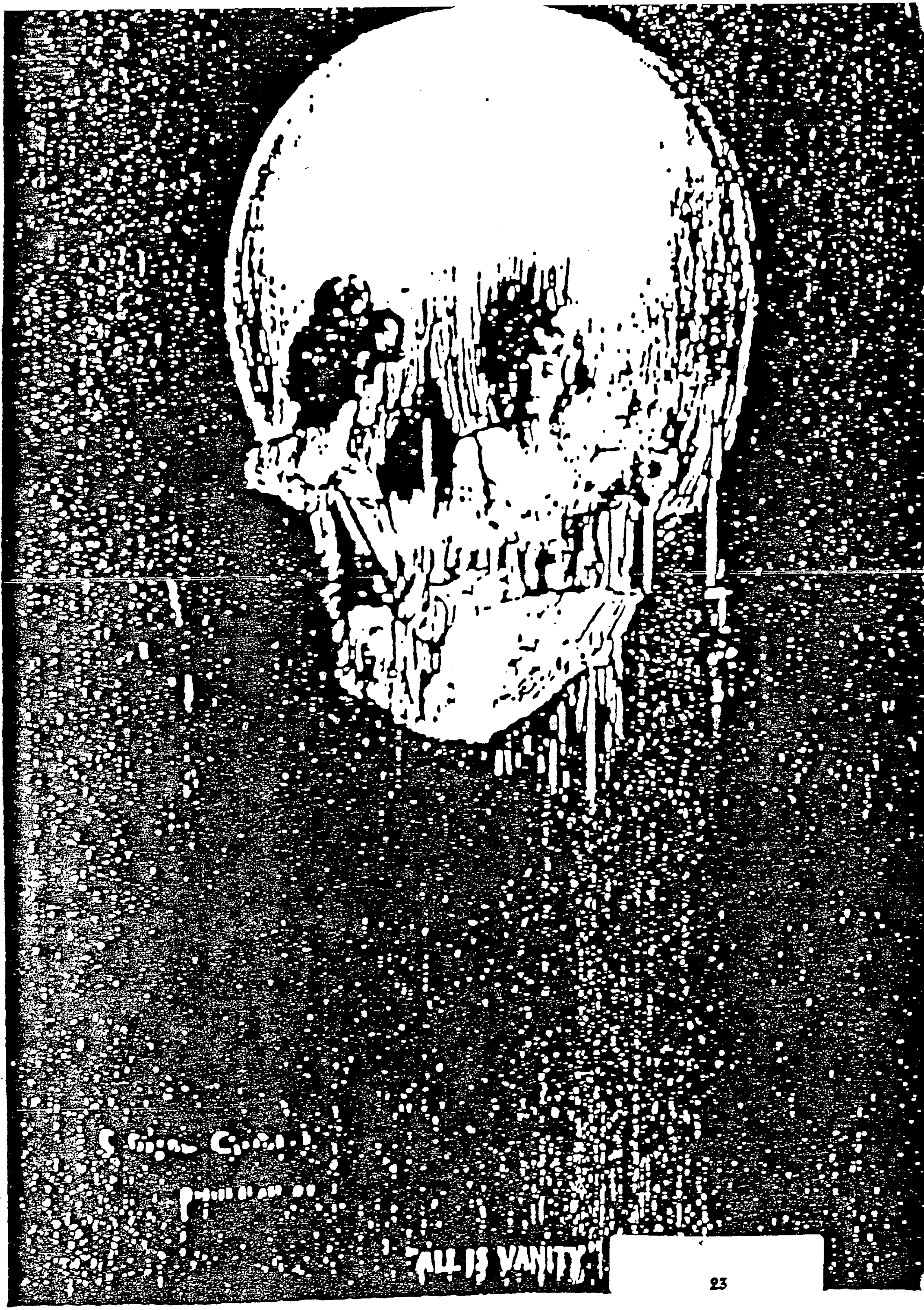
Pat Wolfe


ALL IS VANITY

PROMOTING ATTENTION

It's been said that "in small ways we can make big differences in learning." The following simple training tips will help learners focus their attention.

- Provide advance organizers
- Post outcomes or key results areas
- Use bracketing
- Eliminate distractors in the training room
- Ask for expectations
- Generate previous experiences that relate to the training topic
- Consider using K W L charts (What do you KNOW? What do you WANT to know? and after the session: What have you LEARNED?)
- Use one to three minute pauses

ADVANCE ORGANIZERS

What are they?

An advance organizer alerts the learner about the nature of a learning episode about to occur.

Why are they important?

They assist learners in calling up relevant schemas in order to prepare for a learning about to occur.

Applications:

- Send out reading materials ahead of time.
- Provide agendas or outlines before a session begins, and at the beginning of the session.
- Review the outcomes for the session, elicit participants' expectations.
- Let people know what you are going to ask them to do before you ask them to do it.
- Provide overviews of the entire session or session series, use flow charts or maps.

Pam Robbins

TESTING & LEARNING

- Learners who take pretests do better on their finals.
- Learners who take pretests with fill in the blank questions do better on finals than those who take pretests with multiple choice questions.
- Learners who take pretests with inferential multiple-choice questions do better on finals than those who take pretests with factual multiple-choice questions.

It is the act of taking a test that is helpful.

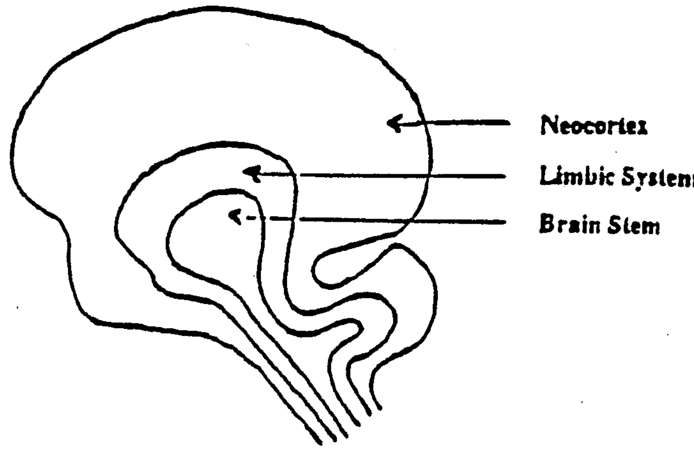
Testing Ideas

- When individuals have to remember a specific order of procedures, put each procedural step on a card. Ask learners to order these.
- Use sponge activities.
- Select tests that require the learner to identify a pattern.
- Use pretests to peak interest in the learning about to occur.

Ronald P. Fisher, Florida International University

EMOTION AND LEARNING

The Triune Brain



The **Brain Stem** regulates such basic life support systems as circulation and respiration. It governs instinctive behaviors... establishing territory, grooming, forming groups, etc. [R-Complex or Reptilian Brain]

The **Limbic System** houses the primary center of emotion, regulates homeostasis, and controls survival functions (the "fight or flight" response). It also plays a critical role in the storage of information in long term memory. [Old Mammalian or Primitive Brain]

The **Neocortex** is the "executive branch" of the brain. It is responsible for making decisions and judgements on incoming information. The neocortex regulates abstract thought, foresight, hindsight, and insight. It is the part of the brain that makes language and computing possible. [New Mammalian Brain]

MacLean, Paul (1978). "A Mind of Three Minds: Educating the Triune Brain." in the 77th Yearbook of the National Society for the Study of Education. Chicago: University of Chicago Press

ROLE OF EMOTIONS IN LEARNING

Paul MacLean describes the human brain as having three physiological layers. Each is geared toward separate functions but interacts with the others.

The Brain Stem - Closely related to actual physical survival. It regulates basic alertness; keeps our heart [illegible] "fight or flight" behavior.

The Limbic System - Like a limb, this part of the brain surrounds the brain stem. It houses the primary center of emotion and one of the critical parts of the brain (the hippocampus) which deals with memory. It has connections which allow it to communicate with the higher cortical areas.

The Neocortex - At least 70% of the neurons in the human central nervous system is in the neocortex. It is this part of our brain that makes language, writing and computing possible, that allows us to reason, worry, and plan for the future.

ROLE OF EMOTIONS IN LEARNING

1. Incoming sensory stimuli are relayed to the neocortex through the limbic system, therefore, the limbic system strongly influences what we pay attention to or find important.

2. Emotion and cognition cannot be separated. Memory is impossible without emotion of some kind. The subject we're teaching must have meaning for the trainees.

3. Under stress, we experience what Leslie Hart calls "downshifting" to the limbic system. We revert to more primitive behavior; our responses are more automatic and limited. There is less capacity for rational and creative thought.

When one is embarrassed, humiliated, ridiculed, or feeling threatened, there is a decrease in the ability to learn.

A nonthreatening environment is essential for the neocortex to operate most efficiently.

Material must have meaning for trainees.

1. Am I still working intensely even when the task becomes difficult, or am I withdrawing?

withdrawing ... *working intensely*

0 1 2 3 4

2. Am I pushing myself to my limits, or am I coasting?

coasting ... *pushing*

0 1 2 3 4

3. Am I continually identifying standards I want to meet?

0 1 2 3 4

4. Am I continually trying to see the situation in new and unique ways?

not trying ... *continually trying*

0 1 2 3 4

1. Am I actively seeking accuracy in the information I am receiving?

not active				*very active*
0	1	2	3	4

2. Am I actively seeking clarity in the information I am receiving?

not active				*very active*
0	1	2	3	4

3. Am I being open-minded about information I am receiving?

not open				*very open*
0	1	2	3	4

4. Am I stopping to think before I speak or act? Am I resisting impulsivity?

not stopping				*stopping*
0	1	2	3	4

5. Am I actively taking and defending positions when such action is warranted?

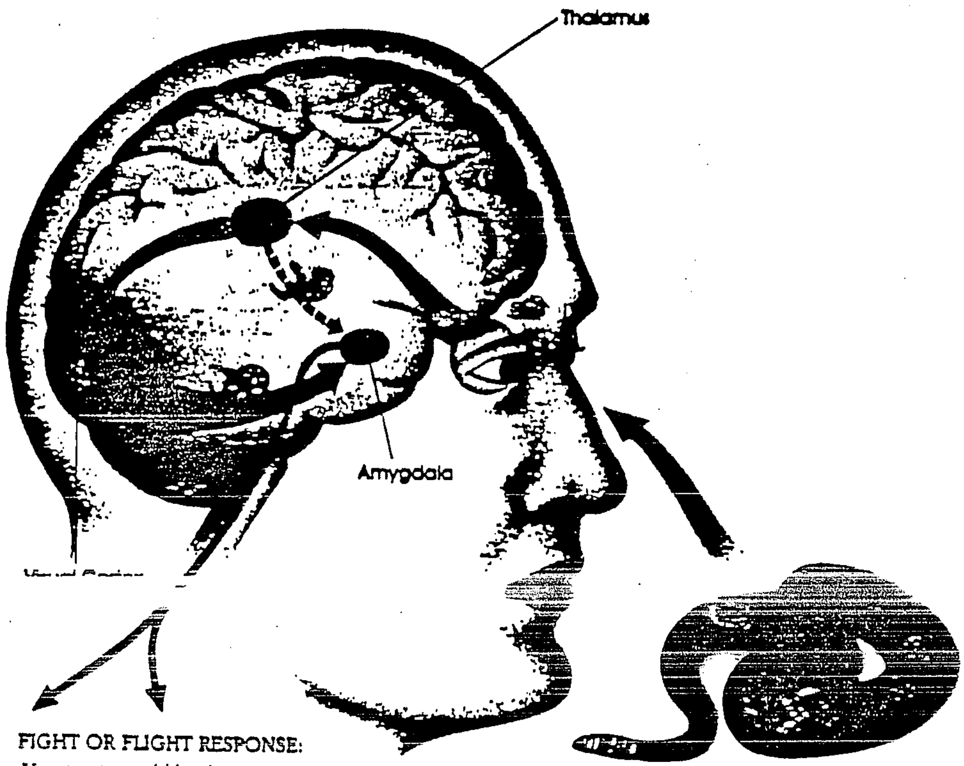
not active				*very active*
0	1	2	3	4

6. Am I being sensitive to the feelings and level of knowledge of others?

not sensitive				*very sensitive*
0	1	2	3	4

The Emotional Brain

Anatomy of an Emotional Hijacking



FIGHT OR FLIGHT RESPONSE:
Heart rate and blood pressure increase. Large muscles prepare for quick action.

"*A visual signal first goes from the retina to the thalamus, where it is translated into the language of the brain. Most of the message then goes to the visual cortex, where it is analyzed and assessed for meaning and appropriate response; if that response is emotional, a signal goes to the amygdala to activate the emotional centers. But a smaller portion of the original signal goes straight from the thalamus to the amygdala in a quicker transmission, allowing a faster (though less precise) response. Thus the amygdala can trigger an emotional response before the cortical centers have fully understood what is happening.*"

Source: Goleman, Daniel, Emotional Intelligence, Bantam Books, 1995.

Five Domains of Emotional Intelligence

1. Knowing one's emotions -- Self Awareness
2. Managing emotions -- Appropriate Handling of Feelings
3. Motivating oneself -- "Marshaling emotions in the service of a goal is essential for paying attention, self motivation and mastery, and for creativity (Goleman)." Emotional self-control underlies accomplishment.
4. Recognizing emotions in others -- Empathy
5. Handling relationships -- Managing Emotions in Others

Source: Peter Salovey as quoted in Emotional Intelligence by Daniel Goleman, p. 43.

THE EQ FACTOR

New brain research suggests that emotions, not IQ, may be the true measure of human intelligence

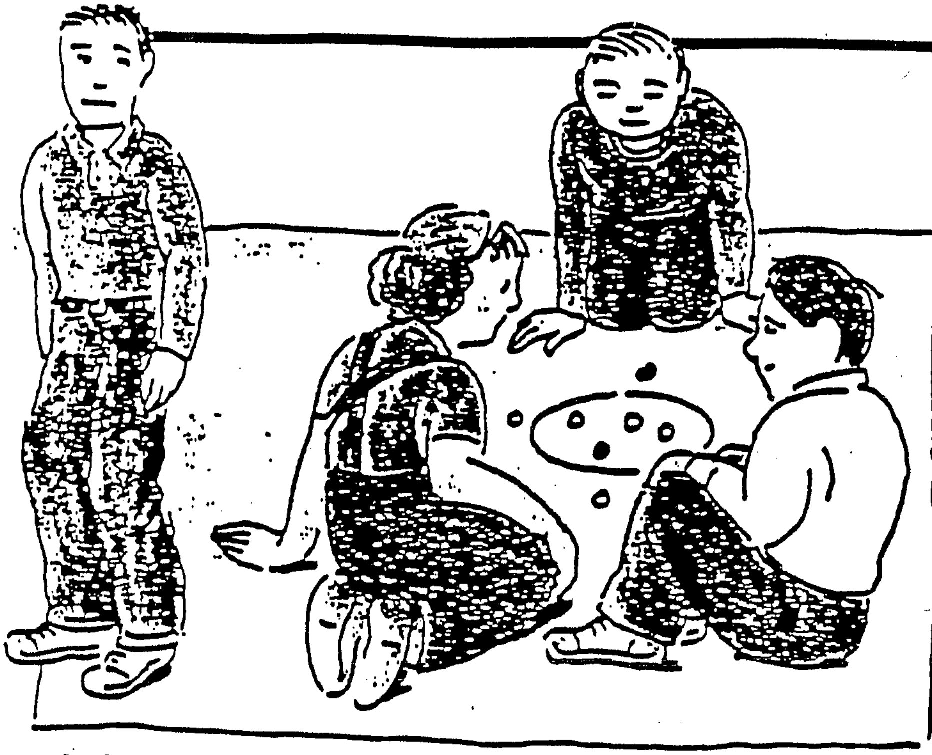
By NANCY GIBBS

IT TURNS OUT THAT A SCIENTIST can see the future by watching four-year-olds interact with a marshmallow. The researcher invites the children, one by one, into a plain room and begins the gentle torment. You can have this marshmallow right now, he says. But if you wait while I run an errand, you can have two marshmallows when I get back. And then he leaves.

Some children grab for the treat the minute he's out the door. Some last a few minutes before they give in. But others are determined to wait. They cover their eyes; they put their heads down; they sing to themselves; they try to play games or even fall asleep. When the researcher returns, he gives these children their hard-earned marshmallows. And then, science waits for them to grow up.

By the time the children reach high school, something remarkable has happened. A survey of the children's parents and teachers found that those who as four-year-olds had the fortitude to hold out for the second marshmallow generally grew up to be better adjusted, more popular, adventurous, confident and dependable teenagers. The children who gave in to temptation early on were more likely to be lonely, easily frustrated and stubborn. They buckled under stress and shied away from challenges. And when some of the students in the two groups took the Scholastic Aptitude Test, the kids who had held out longer scored an average of 210 points higher.

When we think of brilliance we see Einstein, deep-eyed, woolly haired, a thinking machine with skin and mismatched socks. High achievers, we imagine, were wired for greatness from birth. But then you have to wonder why, over time, natural talent seems to ignite in some people and dim in others. This is where the marshmallows come in. It seems that the ability to delay gratification is a master skill, a triumph of the reasoning brain over the impulsive one. It is a



Children who aren't accepted by classmates are up to eight times more likely to drop out

sign, in short, of emotional intelligence. And it doesn't show up on an IQ test.

For most of this century, scientists have worshipped the hardware of the brain and the software of the mind; the messy [illegible] but cognitive theory could simply not explain the questions we wonder about most: why some people just seem to have a gift for living well; why the smartest kid in the class will probably not end up the richest; why we like some people virtually on sight and distrust others; why some people remain buoyant in the face of troubles that would sink a less resilient soul. What qualities of the mind or spirit, in short, determine who succeeds?

The phrase "emotional intelligence" was coined by Yale psychologist Peter Salovey and the University of New Hampshire's John Mayer five years ago to describe qualities like understanding one's own feelings, empathy for the feelings of others and "the regulation of emotion in a way that enhances living." Their notion is about to bound into the national conversation, handily shortened to EQ, thanks to a new book, *Emotional Intelligence* (Bantam; $23.95) by Daniel Goleman. Goleman, a Harvard psychology Ph.D. and a New York *Times* science writer with a gift for making even the chewiest scientific theories digestible to lay readers, has brought together a decade's worth of behavioral research into how the mind processes feelings. His goal, he announces on the cover, is to redefine what it means to be smart. His thesis: when it comes to predicting people's success, brainpower as measured by IQ and standardized achievement tests may actually matter less than the qualities of mind once [illegible] began to sound quaint.

At first glance, there would seem to be little that's new here to any close reader of fortune cookies. There may be no less original idea than the notion that our hearts hold dominion over our heads. "I was so angry," we say, "I couldn't think straight." Neither is it surprising that "people skills" are useful, which amounts to saying, it's good to be nice. "It's so true it's trivial," says Dr. Paul McHugh, director of psychiatry at Johns Hopkins University School of Medicine. But if it were that simple, the book would not be quite so interesting or its implications so controversial.

This is no abstract investigation. Goleman is looking for antidotes to restore "civility to our streets and caring to our communal life." He sees practical applications everywhere for how companies should decide whom to hire, how couples can increase the odds that their marriages will last, how parents should raise their children and how schools should teach them. When street gangs substitute [illegible] families and schoolyard insults e[illegible] stabbings, when more than half of marriages end in divorce, when the majority of the children murdered in this country are killed by parents and stepparents, many of whom say they were trying to discipline the child for behavior like blocking the TV or crying too much, it suggests a demand for remedial emotional education. While children are still young, Goleman argues, there is a "neurological window of opportunity" since the brain's prefrontal circuitry, which regulates how we act on what we feel, probably does not mature until mid-adolescence.

And it is here the arguments will break out. Goleman's highly popularized conclusions, says McHugh, "will chill any veteran scholar of psychotherapy and any neuroscientist who worries about how his research may come to be applied." While many researchers in this relatively new field are glad to see emotional issues finally taken seriously, they fear that a notion as handy as EQ invites misuse. Goleman admits the danger of suggesting that you can assign a numerical yardstick to a person's character as well as his intellect; Goleman never even uses the phrase EQ in his book. But he (begrudgingly) approved an "scientific" EQ test [illegible] choices like "I am aware of even subtle feelings as I have them," and "I can sense the pulse of a group or relationship and state unspoken feelings."

"You don't want to take an average of your emotional skill," argues Harvard psychology professor Jerome Kagan, a pioneer

Why do some people remain buoyant in the fac

in child-development research. "That's what's wrong with the concept of intelligence for mental skills too. Some people handle anger well but can't handle fear. Some people can't take joy. So each emotion has to be viewed differently."

EQ is not the opposite of IQ. Some people are blessed with a lot of both, some with little of either. What researchers have been trying to understand is how they complement each other; how one's ability to handle stress, for instance, affects the ability to concentrate and put intelligence to use. Among the ingredients for success, researchers now generally agree that IQ counts for about 20%; the rest depends on everything from class to luck to the neural pathways that have developed in the brain over millions of years of human evolution.

It is actually the neuroscientists and evolutionists who do the best job of explaining the reasons behind the most unreasonable behavior. In the past decade or so, scientists have learned enough about the brain to make judgments about where emotion comes from and why we need it. Primitive emotional responses held the keys to survival: fear drives the blood into the large muscles, making it easier to run; surprise triggers the eyebrows to rise, allowing the eyes to widen their view and gather more information about an unexpected event. Disgust wrinkles up the face and closes the nostrils to keep out foul smells.

Emotional life grows out of an area of the brain called the limbic system, specifically the amygdala, whence come delight and disgust and fear and anger. Millions of years ago, the neocortex was added on, enabling humans to plan, learn and remember. Lust grows from the limbic system; love, from the neocortex. Animals like reptiles that have no neocortex cannot experience anything like maternal love; this is why baby snakes have to hide to avoid being eaten by their parents. Humans, with their capacity for love, will protect their offspring, allowing the brains of the young time to develop. The more connections between the limbic system and the neocortex, the more emotional responses are possible.

Anxiety is a rehearsal for danger. A little anxiety helps focus the mind; too much can paralyze it

It was scientists like Joseph LeDoux of New York University who uncovered these cerebral pathways. LeDoux's parents owned a meat market. As a boy in Louisiana, he first learned about his future specialty by cutting up cows' brains for sweetbreads. "I found them the most interesting part of the cow's anatomy," he recalls. "They were visually pleasing—lots of folds, convolutions and patterns. The cerebellum was more interesting to look at than steak." The butchers' son became a neuroscientist, and it was he who discovered the short circuit in the brain that lets emotions drive action before the intellect gets a chance to intervene.

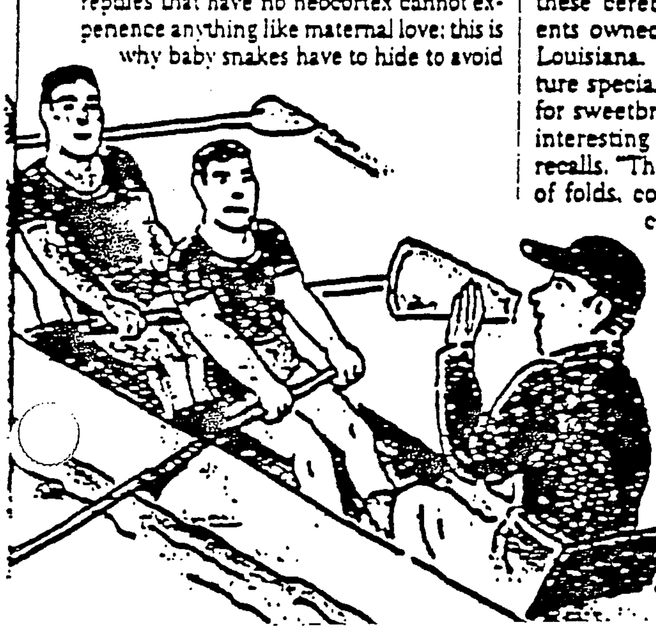
A hiker on a mountain path, for example, sees a long, curved shape in the grass out of the corner of his eye. He leaps out of the way before he realizes it is only a stick that looks like a snake. Then he calms down; his cortex gets the message a few milliseconds after his amygdala and "regulates" its primitive response.

Without these emotional reflexes, rarely conscious but often terribly powerful, we would scarcely be able to function. "Most decisions we make have a vast number of possible outcomes, and any attempt to analyze all of them would never end," says University of Iowa neurologist Antonio Damasio, author of *Descartes' Error: Emotion, Reason and the Human Brain*. "I'd ask you to lunch tomorrow, and when the appointed time arrived, you'd still be thinking about whether you should come." What tips the balance, Damasio contends, is our unconscious assigning of emotional values to some of those choices. Whether we experience a somatic response—a gut feeling of dread or a giddy sense of elation—emotions are helping to limit the field in any choice we have to make. If the prospect of lunch with a neurologist is unnerving or distasteful, Damasio suggests, the invitee will conveniently remember a previous engagement.

When Damasio worked with patients in whom the connection between emotional brain and neocortex had been severed because of damage to the brain, he discovered how central that hidden pathway is to how we live our lives. People who had lost that linkage were just as smart and quick to reason, but their lives often fell apart nonetheless. They could not make decisions because they didn't know how they felt about their choices. They couldn't react to warnings or anger in other people. If they made a mistake, like a bad investment, they felt no regret or shame and so were bound to repeat it.

If there is a cornerstone to emotional intelligence on which most other emotional skills depend, it is a sense of self-awareness, of being smart about what we feel. A person whose day starts badly at home may be grouchy all day at work without quite knowing why. Once an emotional response comes into awareness—or, physiologically, is processed through the neocortex—the chances of handling it appropriately improve. Scientists refer to "metamood," the ability to pull back and recognize that "what I'm feeling is anger," or sorrow, or shame.

Metamood is a difficult skill because



of troubles that would sink others?

emotions so often appear in disguise. A person in mourning may know he is sad, but he may not recognize that he is also angry at the person for dying—because this seems somehow inappropriate. A parent who yells at the child who ran into the street is expressing anger at disobedience, but the degree of anger may owe more to the fear the parent feels at what could have happened.

In Goleman's analysis, self-awareness is perhaps the most crucial ability because it allows us to exercise some self-control. The idea is not to repress feeling (the reaction that has made psychoanalysts rich) but rather to do what Aristotle considered the hard work of the will. "Anyone can become angry—that is easy," he wrote in the *Nicomachean Ethics*. "But to be angry with the right person, to the right degree, at the right time, for the right purpose, and in the right way—this is not easy."

Deficient emotional skills may be the reason more than half of all marriages end in divorce

Some impulses seem to be easier to control than others. Anger, not surprisingly, is one of the hardest, perhaps because of its evolutionary value in priming people to action. Researchers believe anger usually arises out of a sense of being [illegible] against—the belief that one is being robbed of what is rightfully his. The body's first response is a surge of energy, the release of a cascade of neurotransmitters called catecholamines. If a person is already aroused or under stress, the threshold for release is lower, which helps explain why people's tempers shorten during a hard day.

Scientists are not only discovering where anger comes from; they are also exposing myths about how best to handle it. Popular wisdom argues for "letting it all hang out" and having a good cathartic rant. But Goleman cites studies showing that dwelling on anger actually increases its power; the body needs a chance to pro[illegible] the adrenaline through exercise, relaxa[illegible] techniques, a well-timed intervention or even the old admonition to count to 10.

Anxiety serves a similar useful purpose, so long as it doesn't spin out of control. Worrying is a rehearsal for danger; the act of fretting focuses the mind on a problem so it can search efficiently for solutions. The danger comes when worrying blocks thinking, becoming an end in itself or a path to resignation instead of perseverance. Overworrying about failing increases the likelihood of failure; a salesman so concerned about his falling sales that he can't bring himself to pick up the phone guarantees that his sales will fall even further.

But why are some people better able to "snap out of it" and get on with the task at hand? Again, given sufficient self-awareness, people develop coping mechanisms. Sadness and discouragement, for instance, are "low arousal" states, and the dispirited salesman who goes o[illegible] for a run is triggering a high arou[illegible] state that is incompatible with [illegible] Relaxation works better for high-energy moods like anger or anxiety. Either way, the idea is to shift to a state of arousal that breaks the destructive cycle of the dominant mood.

The idea of being able to predict which salesmen are most likely to prosper was not an abstraction for Metropolitan Life.

One Way to Test Your EQ

UNLIKE IQ, WHICH IS GAUGED BY THE FAMOUS STANFORD-Binet tests, EQ does not lend itself to any single numerical measure. Nor should it, say experts. Emotional intelligence is by definition a complex, multifaceted quality representing such intangibles as self-awareness, empathy, persistence and social deftness.

Some aspects of emotional intelligence, however, can be quantified. Optimism, for example, is a handy measure of a person's self-worth. According to Martin Seligman, a University of Pennsylvania psychologist, how people respond to setbacks—optimistically or pessimistically—is a fairly accurate indicator of how well they will succeed in school, in sports and in certain kinds of work. To test his theory, Seligman devised a questionnaire to screen insurance salesmen at MetLife.

In Seligman's test, job applicants were asked to imagine a hypothetical event and then choose the response (A or B) that most closely resembled their own. Some samples from his questionnaire:

You forget your spouse's (boyfriend's/girlfriend's) birthday.
A. I'm not good at remembering birthdays.
B. I was preoccupied with other things.

You owe the library $10 for an overdue book.
A. When I am really involved in what I am reading, I often forget when it's due.
B. I was so involved in writing the report, I forgot to return the book.

You lose your temper with a friend.
A. He or she is always nagging me.
B. He or she was in a hostile mood.

You are penalized for returning your income-tax forms late.
A. I always put off doing my taxes.
B. I was lazy about getting my taxes done this year.

which in the mid-'80s was hiring 5,000 salespeople a year and training them at a cost of more than $30,000 each. Half quit the first year, and four out of five within four years. The reason: selling life insurance involves having the door slammed in your face over and over again. Was it possible to identify which people would be better at handling frustration and take each refusal as a challenge rather than a setback?

The head of the company approached psychologist Martin Seligman at the University of Pennsylvania and invited him to test some of his theories about the importance of optimism in people's success. When optimists fail, he has found, they attribute the failure to something they can change, not some innate weakness that they are helpless to overcome. And that confidence in their power to effect change is self-reinforcing. Seligman tracked 15,000 new workers who had taken two tests. One was the company's regular screening exam, the other Seligman's test measuring their levels of optimism. Among the new hires was a group who flunked the screening test but scored as "superoptimists" on Seligman's exam. And sure enough, they did the best of all; they outsold the pessimists in the regular group by 21% in the first year and 57% in the second. For years after that, passing Seligman's test was one way to get hired as a MetLife salesperson.

Perhaps the most visible emotional skills, the ones we recognize most readily, are the "people skills" like empathy, graciousness, the ability to read a social situation. Researchers believe that about 90% of emotional communication is nonverbal. Harvard psychologist Robert Rosenthal

In the corporate world, say personnel executives, IQ gets you hired, but EQ gets you promoted

developed the PONS test (Profile of Nonverbal Sensitivity) to measure people's ability to read emotional cues. He shows subjects a film of a young woman expressing feelings—anger, love, jealousy, gratitude, seduction—edited so that one or another nonverbal cue is blanked out. In some instances the face is visible but not the body, or the woman's eyes are hidden, so that viewers have to judge the feeling by subtle cues. Once again, people with higher PONS scores tend to be more successful in their work and relationships: children who score well are more popular and successful in school, even when their IQs are quite average.

Like other emotional skills, empathy is an innate quality that can be shaped by experience. Infants as young as three months old exhibit empathy when they get upset at the sound of another baby crying. Even very young children learn by imitation; by watching how others act when they see someone in distress, these children acquire a repertoire of sensitive responses. If, on the other hand, the feelings they begin to express are not recognized and reinforced by the adults around them, they not only cease to express those feelings but they also become less able to recognize them in themselves or others.

Empathy too can be seen as a survival skill. Bert Cohler, a University of Chicago psychologist, and Fran Stott, dean of the Erikson Institute for Advanced Study in Child Development in Chicago, have found that children from psychically damaged families frequently become hypervigilant, developing an intense attunement to their parents' moods. One child they studied, Nicholas, had a horrible habit of approaching other kids in his nursery-school class as if he were going to kiss them, then would bite them instead. The scientists went back to study videos of Nicholas at 20 months interacting with his psychotic mother and found that she had responded to his every expression of anger or independence with compulsive kisses. The researchers dubbed them "kisses of death," and their true significance was obvious to

You've been feeling run-down.
A. I never get a chance to relax.
B. I was exceptionally busy this week.

A friend says something that hurts your feelings.
A. She always blurts things out without thinking of others.
B. My friend was in a bad mood and took it out on me.

You fall down a great deal while skiing.
A. Skiing is difficult.
B. The trails were icy.

You gain weight over the holidays, and you can't lose it.
A. Diets don't work in the long run.
B. The diet I tried didn't work.

Seligman found that those insurance salesmen who answered with more B's than A's were better able to overcome bad sales days, recovered more easily from rejection and were less likely to quit. People with an optimistic view of life tend to treat obstacles and setbacks as temporary (and therefore surmountable). Pessimists take them personally; what others see as fleeting, localized impediments, they view as pervasive and permanent.

The most dramatic proof of his theory, says Seligman, came at the 1988 Olympic Games in Seoul, South Korea, after U.S. swimmer Matt Biondi turned in two disappointing performances in his first two races. Before the Games, Biondi had been favored to win seven golds—as Mark Spitz had done 16 years earlier. After those first two races, most commentators thought Biondi would be unable to recover from his setback. Not Seligman. He had given some members of the U.S swim team a version of his optimism test before the races; it showed that Biondi possessed an extraordinarily upbeat attitude. Rather than losing heart after turning in a bad time, as others might, Biondi tended to respond by swimming even faster. Sure enough, Biondi bounced right back, winning five gold medals in the next five races.

—*By Alice Park*

Nicholas, who arched his back in horror at her approaching lips—and passed his own rage on to his classmates years later.

Empathy also acts as a buffer to cruelty, and it is a quality conspicuously lacking in child molesters and psychopaths. Goleman cites some chilling research into brutality by Robert Hare, a psychologist at the University of British Columbia. Hare found that psychopaths, when hooked up to electrodes and told they are going to receive a shock, show none of the visceral responses that fear of pain typically triggers: rapid heartbeat, sweating and so on. How could the threat of punishment deter such people from committing crimes?

It is easy to draw the obvious lesson from these test results. How much happier would we be, how much more successful as individuals and civil as a society, if we were more alert to the importance of emotional intelligence and more adept at teaching it? From kindergartens to business schools to corporations across the country, people are taking seriously the idea that a little more time spent on the "touchy-feely" skills so often derided may in fact pay rich dividends.

In the corporate world, according to personnel executives, IQ gets you hired, but EQ gets you promoted. Goleman likes to tell of a manager at AT&T's Bell Labs, a think tank for brilliant engineers in New Jersey, who was asked to rank his top performers. They [illegible] they were the ones whose E-mail got answered. Those workers who were good collaborators and networkers and popular with colleagues were more likely to get the cooperation they needed to reach their goals than the socially awkward, lone-wolf geniuses.

When David Campbell and others at the Center for Creative Leadership studied "derailed executives," the rising stars who flamed out, the researchers found that these executives failed most often because of "an interpersonal flaw" rather than a technical inability. Interviews with top executives in the U.S. and Europe turned up nine so-called fatal flaws, many of them classic emotional failings, such as "poor working relations," being "authoritarian" or "too ambitious" and having "conflict with upper management."

At the center's executive-leadership seminars across the country, managers come to get emotionally retooled. "This isn't sensitivity training or Sunday-supplement stuff," says Campbell. "One thing they know when they get through is what other people think of them." And the executives have an incentive to listen. Says Karen Boylston, director of the center's team-leadership group: "Customers are telling businesses, 'I don't care if every member of your staff

Square Pegs in the Oval Office?

IF A HIGH DEGREE OF EMOTIONAL INTELLIGENCE IS A PREREQUISITE FOR OUTSTANDING achievement, there ought to be no better place to find it than in the White House. It turns out, however, that not every man who reached the pinnacle of American leadership was a gleaming example of self-awareness, empathy, impulse control and all the other qualities that mark an elevated EQ.

Oliver Wendell Holmes, who knew intelligence when he saw it, judged Franklin Roosevelt "a second-class intellect, but a first-class temperament." Born and educated as an aristocrat, F.D.R. had polio and needed a wheelchair for most of his adult life. Yet, far from becoming a self-pitying wretch, he developed an unbridled optimism that served him and the country well during the Depression and World War II—this despite, or because of, what Princeton professor Fred Greenstein calls Roosevelt's "tendency toward deviousness and duplicity."

FRANKLIN ROOSEVELT: First-class temperament

Even a first-class temperament, however, is not a sure predictor of a successful presidency. According to Duke University political scientist James David Barber, the most perfect blend of intellect and warmth of personality in a Chief Executive was the brilliant Thomas Jefferson, who "knew the importance of communication and empathy. He never lost the common touch." Richard Ellis, a professor of politics at Oregon's Willamette University who is skeptical of the whole EQ theory, cites two 19th century Presidents who did not fit the mold. "Martin Van Buren was well adjusted, balanced, empathetic and persuasive, but he was not very successful," says Ellis. "Andrew Jackson was less well adjusted [illegible] at controlling his own impulses, but he transformed the presidency."

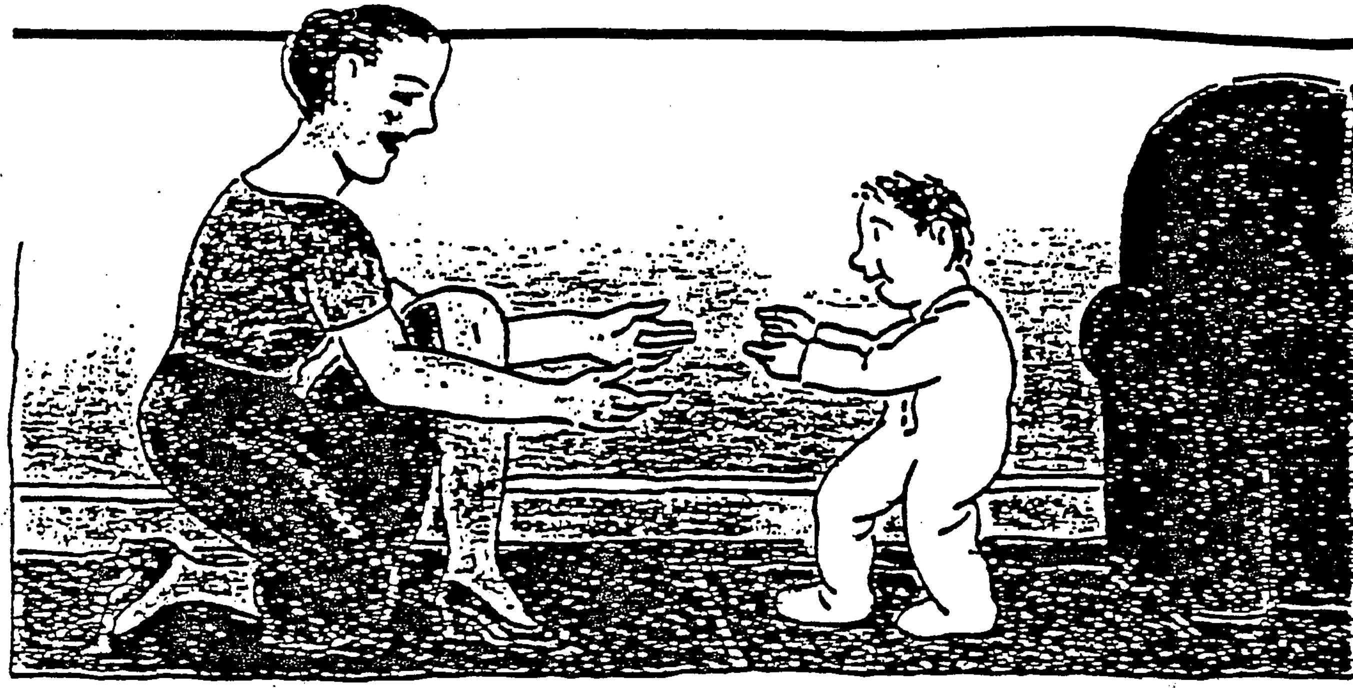
RICHARD NIXON: Political genius but an EQ disaster

Lyndon Johnson as Senate majority leader was a brilliant practitioner of the art of political persuasion, yet failed utterly to transfer that gift to the White House. In fact, says Princeton's Greenstein, L.B.J. and Richard Nixon would be labeled "worst cases" on any EQ scale of Presidents. Each was touched with political genius, yet each met with disaster. "To some extent," says Greenstein, "this is a function of the extreme aspects of their psyches; they are the political versions of Van Gogh, who does unbelievable paintings and then cuts off his ear."

History professor William Leuchtenburg of the University of North Carolina at Chapel Hill suggests that the 20th century Presidents with perhaps the highest IQs—Wilson, Hoover and Carter—also had the most trouble connecting with their constituents. Woodrow Wilson, he says, "was very high strung [and] arrogant; he was not willing to strike any middle ground. Herbert Hoover was so locked into certain ideas that you could never convince him otherwise. Jimmy Carter is probably the most puzzling of the three. He didn't have a deficiency of temperament; in fact, he was too temperate. There was an excessive rationalization about Carter's approach."

That was never a problem for John Kennedy and Ronald Reagan. Nobody ever accused them of intellectual genius, yet both radiated qualities of leadership with an infectious confidence and openheartedness that endeared them to the nation. Whether President Clinton will be so endeared remains a puzzle. That he is a Rhodes scholar makes him certifiably brainy, but his emotional intelligence is shaky. He obviously has the knack for establishing rapport with people, but he often appears so eager to please that he looks weak. "As for controlling his impulses," says Willamette's Ellis, "Clinton is terrible." —*By Jesse Birnbaum*.

Reported by James Carney/Washington and Lisa H. Towle/Raleigh



Some EQ is innate. Infants as young as three months show empathy

graduated with honors from Harvard, Stanford and Wharton. I will take my business and go where I am understood and treated with respect.' "

Nowhere is the discussion of emotional intelligence more pressing than in schools, where both the stakes and the opportunities seem greatest. Instead of constant crisis intervention, or declarations of war on drug abuse or teen pregnancy or violence, it is time, Goleman argues, for preventive medicine. "Five years ago, teachers didn't want to think about this," says principal Roberta Kirshbaum of P.S. 75 in New York City. "But when kids are getting killed in high school, we have to deal with it." Five years ago, Kirshbaum's school adopted an emotional literacy program, designed to help children learn to manage anger, frustration, loneliness. Since then, fights at lunchtime have decreased from two or three a day to almost none.

Educators can point to all sorts of data to support this new direction. Students who are depressed or angry literally cannot learn. Children who have trouble being accepted by their classmates are 2 to 8 times as likely to drop out. An inability to distinguish distressing feelings or handle frustration has been linked to eating disorders in girls.

Many school administrators are completely rethinking the weight they have been giving to traditional lessons and standardized tests. Peter Relic, president of the National Association of Independent Schools, would like to junk the SAT completely. "Yes, it may cost a heck of a lot more money to assess someone's EQ rather than using a machine-scored test to measure IQ," he says. "But if we don't, then we're saying that a test score is more important to us than who a child is as a human being. That means an immense loss in terms of human potential because we've defined success too narrowly."

This warm embrace by educators has left some scientists in a bind. On one hand, says Yale psychologist Salovey, "I love the idea that we want to teach people a richer understanding of their emotional life, to help them achieve their goals." But, he adds, "what I would oppose is training conformity to social expectations." The danger is that any campaign to hone emotional skills in children will end up teaching that there is a "right" emotional response for any given situation—laugh at parades, cry at funerals, sit still at church. "You can teach self-control," says Dr. Alvin Poussaint, professor of psychiatry at Harvard Medical School. "You can teach that it's better to talk out your anger and not use violence. But is it good emotional intelligence not to challenge authority?"

SOME PSYCHOLOGISTS GO further and challenge the very idea that emotional skills can or should be taught in any kind of formal, classroom way. Goleman's premise that children can be trained to analyze their feelings strikes Johns Hopkins' McHugh as an effort to reinvent the encounter group: "I consider that an abominable idea, an idea we have seen with adults. That failed, and now he wants to try it with children? Good grief!" He cites the description in Goleman's book of an experimental program at the Nueva Learning Center in San Francisco. In one scene, two fifth-grade boys start to argue over the rules of an exercise, and the teacher breaks in to ask them to talk about what they're feeling. "I appreciate the way you're being assertive in talking with Tucker," she says to one student. "You're not attacking." This strikes McHugh as pure folly. "The author is presuming that someone has the key to the right emotions to be taught to children. We don't even know the right emotions to be taught to adults. Do you really think a child of eight or nine really understands the difference between aggressiveness and assertiveness?"

The problem may be that there is an ingredient missing. Emotional skills, like intellectual ones, are morally neutral. Just as a genius could use his intellect either to cure cancer or engineer a deadly virus, someone with great empathic insight could use it to inspire colleagues or exploit them. Without a moral compass to guide people in how to employ their gifts, emotional intelligence can be used for good or evil. Columbia University psychologist Walter Mischel, who invented the marshmallow test and others like it, observes that the knack for delaying gratification that makes a child one marshmallow richer can help him become a better citizen or—just as easily—an even more brilliant criminal.

Given the passionate arguments that are raging over the state of moral instruction in this country, it is no wonder Goleman chose to focus more on neutral emotional skills than on the values that should govern their use. That's another book—and another debate. *—Reported by Sharon E. Epperson and Lawrence Mondi/New York, James L. Graff/Chicago and Lisa H. Towle/Raleigh*

How Emotions Affect Learning

Robert Sylwester

New developments in cognitive science are unraveling the mysteries of emotions; the findings have much to teach us about how students do—or do not—learn.

John Dewey began this century with an eloquent plea for the education of the *whole child*. If we get around to that kind of education by the end of the century, emotion research may well provide the catalyst we need.

Our profession pays lip service to the whole student, but school activities tend to focus on measurable rational qualities. We measure spelling accuracy, not emotional well-being. And when the budget gets tight, we cut curricular areas like the arts, expressive subjects that are difficult to measure.

We know emotion is important in education—it drives attention, which in turn drives learning and memory. But because we don't fully understand our emotional system, we don't know exactly how to regulate it in school, beyond defining too much or too little emotion as misbehavior. We have rarely incorporated emotion comfortably into the curriculum and classroom. Further, our profession hasn't fully addressed the important relationship between a stimulating and emotionally positive classroom experience and the overall health of both students and staff.

Recent developments in the cognitive sciences are unlocking the mysteries of how and where our body/brain processes emotion. This unique melding of the biology and psychology of emotion promises to suggest powerful educational applications. Current emotion theory and research bring up more questions than answers. Still, educators should develop a basic understanding of the psychobiology of emotion to enable them to evaluate emerging educational applications.

Following is a basic introduction to the role our emotional system plays in learning, and the potential classroom applications of this research.

Emotion and Reason

Studies show that our emotional system is a complex, widely distributed, and error-prone system that defines our basic personality early in life, and is quite resistant to change.

Far more neural fibers project from our brain's emotional center into the logical/rational centers than the reverse, so emotion is often a more powerful determinant of our behavior than our brain's logical/rational processes. For example, purchasing a lottery ticket is an emotional, not a logical decision. (The odds are terrible, but where else can one buy three days of fantasy for $1?) Reason may override our emotions, but it rarely changes our *real* feelings about an issue. Our emotions allow us to bypass conscious deliberation of an issue, and thus to respond quickly based on almost innate general categorizations of incoming information. This may lead to irrational fears and foolish behavior. Often we don't consciously know why we feel as we do about something or someone.

Emotion, like color, exists along a continuum, with a wide range of

> A joyful classroom atmosphere makes students more apt to learn how to successfully solve problems in potentially stressful situations.

gradations. We can easily identify many discrete emotions through their standard facial and auditory expressions, but the intensity and meaning of the emotion will vary among people and situations. Moreover, emotional context, like color hue, may affect our perception of emotion. To understand our constantly shifting emotional system and its affect on our capacity to learn, we must understand the system's two parts:

- the molecules (*peptides*) that carry emotional information, and
- the body and brain structures that activate and regulate emotions.

Peptides: Molecular Messengers of Emotion

Traditionally, we've tended to think in terms of a body-brain split: Our brain regulates body functions, and our body provides support services for our brain. However, scientists now think in terms of an integrated body/brain system. Our emotional system is located principally in our brain, endocrine, and immune systems (which now are viewed as an integrated biochemical system), but it affects all other organs, such as our heart, lungs, and skin. Think of our emotions as the glue that integrates our body and brain, and peptide molecules as the physical manifestation of the process.

Peptide molecules are the messengers of our emotional system. We know a peptide molecule is a chain of amino acids that is shorter than a protein, and that more than 60 types are involved in emotions. But it's not yet clear how these molecules carry information, or even what that information is. Peptides developed within body/brain cells are called hormones and neuropeptides. (When similarly shaped molecules are developed outside our body, we call them drugs.)

To modulate our broad range of pleasure and pain, peptides travel throughout our body/brain via our neural networks, circulatory system, and air passages. They powerfully affect the decisions we make within the continuum of emotionally charged approaching and retreating behaviors, such as to drink-urinate, agree-disagree, and marry-divorce. In effect, the shifts in the body/brain levels of these molecules allocate our emotional energy—what we do, when we do it, and how much energy we expend.

At the cellular level, peptides synthesized within one cell attach to receptors on the outside of another,

sparking increased or decreased cellular actions. If this occurs in large populations of cells, it can affect our emotional state. Cell division and protein synthesis are two such actions; both are heavily involved in the emotion-charged body changes during adolescence (Moyers 1992).

A peptide's message can vary in many different body/brain areas, just as a two-by-four can be used in many different ways in the construction of a house. In this way peptides are similar to many drugs. Alcohol, for example, can excite or sedate, [illegible] drinker's emotional state and the amount ingested.

We should seek to develop forms of self-control among students and staff that encourage nonjudgmental, [illegible]

Cortisol and the endorphins are two good examples of peptide molecules that can affect students' behavior in the classroom. When our inability to fend off danger triggers a stress response, *cortisol*—a sort of all-purpose wonder drug—is released by our adrenal glands. It activates important body/brain defensive responses that vary with the nature and severity of the stressor. Developed eons ago when physical dangers most threatened our survival, our stress responses do not differentiate between physical and emotional danger.

Because most contemporary stress results from emotional problems, these responses are often maladaptive. For example, a 2nd grader refuses to complete an arithmetic assignment. The irritated teacher's stress system inappropriately responds by releasing clotting elements into the blood, elevating cholesterol levels, depressing the immune system, tensing large muscles, increasing the blood pressure—and much more. It's a response that makes sense only if the recalcitrant student is also threatening with a knife or gun.

We pay a high price for chronic emotional stress. While low levels of cortisol produce the euphoria we feel when we're in control, high levels triggered by the stress response can induce the despair we often feel when we've failed. Moreover, chronic stress can also lead to a variety of circulatory, digestive, and immune disorders.

Chronic high cortisol levels can eventually destroy hippocampal neurons associated with learning and memory (Vincent 1990). Even short-term stress-related elevation of cortisol in the hippocampus can hinder our ability to distinguish between important and unimportant elements of a memorable event (Gazzaniga 1989). Thus, stressful school environments reduce the school's ability to carry out its principal mission.

More positively, *the endorphins* are a class of opiate peptides that modulate emotions within our pain-pleasure continuum; they reduce intense pain and increase euphoria. Endorphin levels can be elevated by exercise and by positive social contacts—hugging, music, a friend's supportive comments, among other things—thereby making us feel good about ourselves and our social environment (Levinthal 1988). A joyful classroom atmosphere that encourages such behaviors produces internal [illegible] in students that make them more apt to learn how to successfully solve problems in potentially stressful situations.

The Emotion Regulators

Although the endocrine and immune systems participate in processing our emotions, two interrelated brain systems share the regulating task:

1. The finger size *brain stem* at the base of our brain and the *limbic system* structures surrounding it focus inward on our survival, emotional, and nurturing needs. The brain stem monitors involuntary activity, like breathing.

2. The cerebral cortex, which regulates higher functions, addresses our interactions with the external world (Edelman 1992).

Regulator I: The Brain Stem and Limbic System

Extensively connected in looped circuits to body organs and systems, the brain stem and limbic system responds relatively slowly (from seconds to months) as it regulates basic body functions, cycles, and defenses. The system is loaded with peptide receptors. The *reticular formation* at the top of the brain stem integrates the amount and type of incoming sensory information into a general level of attention (Vincent 1990).

The *Limbic system*, composed of several small interconnected structures, *is our brain's principal regulator of emotion and plays important roles in processing memory.* This may explain why emotion is an important ingredient in many memories. The limbic system is powerful enough to override both rational thought and innate brain stem response patterns. In short, we tend to follow our feelings.

Memories formed during a specific emotional state tend to be easily recalled during a similar emotional state later on (Thayer 1989). For example, during an argument, we easily recall similar previous arguments. Thus, classroom simulations and role-playing activities enhance learning because they tie memories to the kinds of emotional contexts in which they will later be used.

The limbic system influences selection and classification of experiences that our brain stores in two forms of long-term memory—*procedural* (unconsciously processed skills, such as walking and talking) and *declarative* (conscious recall of facts, such as names and locations).

Limbic system structures that process emotion and memory are the amygdala complex, the hippocampus, and the thalamus and hypothalamus.

■ *Amygdala complex.* This is the principal limbic system structure involved in processing the emotional content of behavior and memory. It is composed of two small almond-shaped structures that connect our sensory-motor systems and autonomic nervous system (which regulates such survival functions as breathing and circulation). The amygdala is also richly and reciprocally connected to most other brain areas. Its principal task is to filter and interpret sophisticated incoming sensory information in the context of our survival and emotional needs, and then help initiate appropriate responses. Thus, it influences both early sensory processing and higher levels of cognition (for example, ignoring the feel of a comfortable shoe, but responding to one with a tiny pebble in it).

■ *Hippocampus.* The amygdala adjoins the hippocampus, two finger-size structures that convert important short-term experiences into long-term declarative memories that are stored in the cortex. Think of the amygdala as processing the subjective feelings you associate with an event, and the hippocampus as processing the objective location, time, and actions that defined the event.

The brain's amygdala and the adjoining hippocampus can modulate the subjective and objective strength of a memory. Kandel and Kandel (1994) suggest that this helps explain, for example, the repressed memories of sexual abuse. The fearfulness of the abusive experience can lead to the release of certain substances (noradrenaline neurotransmitters) that strengthen the connections processing the emotional memory of the event. Conversely, the painfulness of the experience can lead to the release of *opiate endorphins* that weaken connections processing the conscious memory of the factual circumstances surrounding the event. Subsequently, the victim tends to avoid anything that triggers the fearful emotion, but doesn't consciously know why. Years later, a chance combination of similar characters, location, actions, and emotions may cause the strong emotional memory to trigger the rec of the weak factual memory of the original circumstances of the abuse.

■ *Thalamus and hypothalamus.* Th walnut-size thalamus and adjoining pea-size hypothalamus are two other important related limbic system structures that help regulate our emotional life and physical safety.

The *thalamus* is our brain's initial relay center for incoming sensory information; it informs the rest of our brain about what's happening outside our body. The thalamus has direct connections to the amygdala, which permits it to send a very rapid but factually limited report on a potential threat. This can trigger a quick, emotionally loaded (but perhaps also life-saving) behavior before we fully understand what's happening. And it is the mechanism that underlies many explosive emotional outbursts during a typical school day.

The *hypothalamus* monitors our internal regulatory systems, informing our brain what's happening *inside* our body. When our brain has no solution to a threatening situation, the hypotha-

lamus can activate a fight-flight stress response through its [illegible] with the endocrine gland system.

Pheromones are a newly discovered but poorly understood addition to our sensory system (although they've long been known to regulate many animal behaviors). They are molecules that are released into the air from the skin, entering a tiny vomeronasal organ in our nose, although they are not part of our sense of smell. This triggers neural activity in areas of the hypothalamus that regulate sexual behavior, levels of comfort, and self-confidence. The cheek area next to our nose is rich in pheromones, which may explain why we humans like to kiss while nuzzling our nose in that area.

Regulator II: The Cortex

The cerebral cortex, which occupies 85 percent of our brain's mass, is a large sheet of neural tissue that's deeply folded around the limbic system. It is organized into myriad highly interconnected and outwardly focused neural networks that respond very rapidly (in milliseconds to seconds) to various *space-time* [illegible]

1. receives, categorizes, and interprets sensory information;
2. makes rational decisions; and
3. activates behavioral responses.

Space: Viewed from the unfolded top, the neocortex is divided into right and left hemispheres along a line that goes directly back from our nose. A simplified view of tasks of the two hemispheres suggests that they focus on different perspectives of an object or event. The right hemisphere *synthesizes* the background or contextual information (the forest); the left hemisphere *analyzes* the foreground information (a tree in the forest).

Although the research isn't conclusive on the roles the hemispheres (or lobes) play in emotion, some general patterns are apparent (Corballis 1991). The right hemisphere seems to play the more prominent role overall in processing emotions. It processes the important emotional content of faces, gestures, and language (intonation, volume)—*how* something was communicated; while the left hemisphere processes much of the objective content of language—*what* was said.

The right hemisphere processes the negative aspects that lead to withdrawal behaviors (for example, fear and disgust), while the left hemisphere processes the positive aspects of emotion that lead to approaching behaviors (for example, laughter and joy).

Moir and Jessel (1991) have suggested that the average male brain appears to follow this pattern of hemisphere specialization, while the average female brain may diffuse more emotional processing across the two hemispheres. If true, these organizational differences may help to explain [illegible] differences in emotional processing.

Time: The neocortex is divided into sensory and frontal lobes along an imaginary line drawn along our skull from ear to ear. Sensory lobes in the back store sensory memories (the past). Frontal lobes focus on critical thinking and problem-solving strategies (the present), with the front part of the lobes in charge of planning and rehearsal activities (the future).

The frontal lobes play an important role in regulating our emotional states and judgments. Our frontal lobe's regulation of critical thinking and problem solving permits it to override the execution of automatic behaviors, and of potentially destructive illegal or immoral behaviors that are sparked by emotional biases.

Classroom Applications

Although the educational applications of emotion research are still quite tentative, several general themes are emerging—and they tend to support a perspective that many educators have long advocated. This isn't surprising, since we're continually learning what

Emotionally stressful school environments are counterproductive because they can reduce students' ability to learn.

does and doesn't work when dealing with students' emotions. What this research may provide, however, is biological support for the profession's beliefs.

Here are some general principles and their applications to the classroom:

1. Emotions simply exist; we don't learn them in the same way we learn telephone numbers, and we can't easily change them. But we should not ignore them. Students can learn how and when to use rational processes to override their emotions, or to hold them in check. *We should seek to develop forms of self-control among students and staff that encourage nonjudgmental, nondisruptive (and perhaps even inefficient) venting of emotion* that generally must occur before reason can take over. We all can recall past incidents that still anger us because we were not allowed to freely express our feelings before a decision was imposed on us.

Integrating emotional expression in classroom life is not difficult. Try drawing a class into a tension-releasing circle (after a playground fight, for example) and playing a game of circle tag before talking out the problem. Once the students' collective limbic systems have had their say, rational cortical processes can settle the issue. If that doesn't work, sing a song. (As British playwright William Congreve suggested, "Music hath charms to soothe a savage breast.") In other words, when trying to solve a problem, continue the dialogue with continuous emotional input.

2. Most students already know quite a bit about the complexity of emotions and the ways they and others experience them (Saarni and Harris 1991), although they may not be able to articulate what they know. *Schools should focus more on metacognitive activities that encourage students to talk about their emotions, listen to their classmates' feelings*, and think about the motivations of people who enter their curricular world. For example, the simple use of *why* in a question turns the discussion away from bare facts and toward motivations and emotions. *Why* did the pioneers settle where the two rivers came together? is a much more emotionally loaded question than *Where* did the pioneers settle?

3. *Activities that emphasize social interaction and that engage the entire body tend to provide the most emotional support.* Games, discussions, field trips, interactive projects, cooperative learning, physical education, and the arts are examples. Although we've long known that such activities enhance student learning, we tend to think of them as special rewards, and so withdraw them when students misbehave, or when budgets are tight, eliminate them altogether.

4. Memories are contextual. *School activities that draw out emotions—simulations, role playing, and cooperative projects, for example—may provide important contextual memory prompts* that will help students recall the information during closely related events in the real world. This is why we tend to practice fire drills in an unannounced, emotionally charged setting: in the event of a real fire, students will have to perform in that kind of setting.

5. *Emotionally stressful school environments are counterproductive because they can reduce students' ability to learn.* Self-esteem and a sense of control over one's environment are important in managing stress. Highly evaluative and authoritarian schools may promote institutional economy, efficiency, and accountability, but also heighten nonproductive stress in students and staff.

In short, we need to think of students as more than mere brain tissue and bodies. Powerful peptides convert that body and brain tissue into a vibrant life force—the whole child that John Dewey urged us to educate. ■

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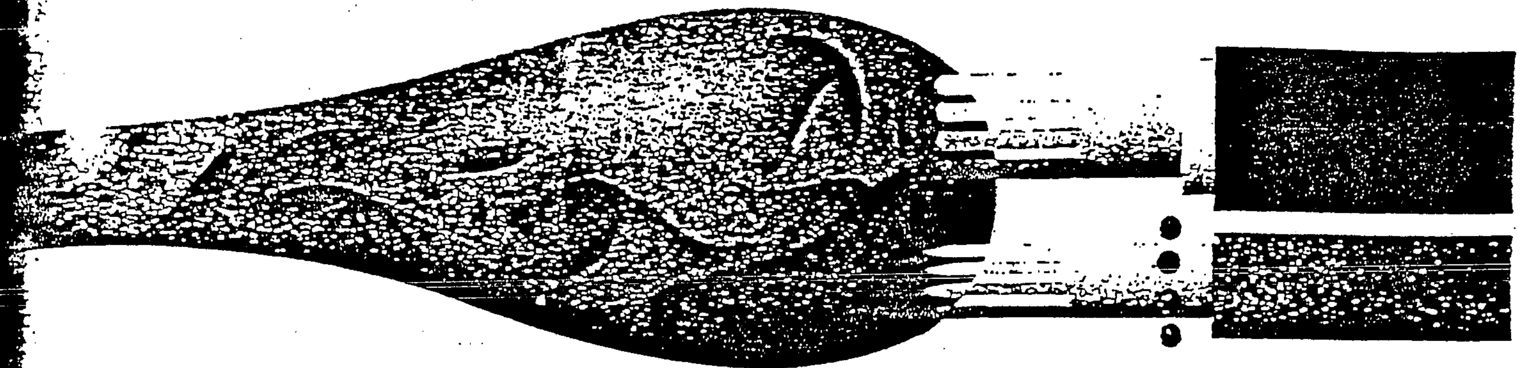
A baby's brain is a work in progress, trillions of neurons waiting to be wired into a mind. The experiences of childhood, pioneering research shows, help form the brain's circuits—for music and math, language and emotion.



Your Child's Brain

BY SHARON BEGLEY

YOU HOLD YOUR NEWBORN SO HIS SKY-blue eyes are just inches from the brightly patterned wallpaper. *ZZZt:* a neuron from his retina makes an electrical connection with one in his brain's visual cortex. You gently touch his palm with a clothespin: he grasps it, drops it, and you return it to him with soft words and a smile. *Crackle:* neurons from his hand strengthen their connection to those in his sensory-motor cortex. He cries in the night: you feed him, holding his gaze because nature has seen to it that the distance from a parent's crooked elbow to his eyes exactly matches the distance at which a baby focuses. *Zap:* neurons in the brain's amygdala send pulses of electricity through the circuits that control emotion. You hold him on your lap and talk . . . and neurons from his ears start hard-wiring connections to the auditory cortex.

And you thought you were just playing with your kid.

When a baby comes into the world her brain is a jumble of neurons, all waiting to be woven into the

ILLUSTRATIONS BY TERRY ALLEN

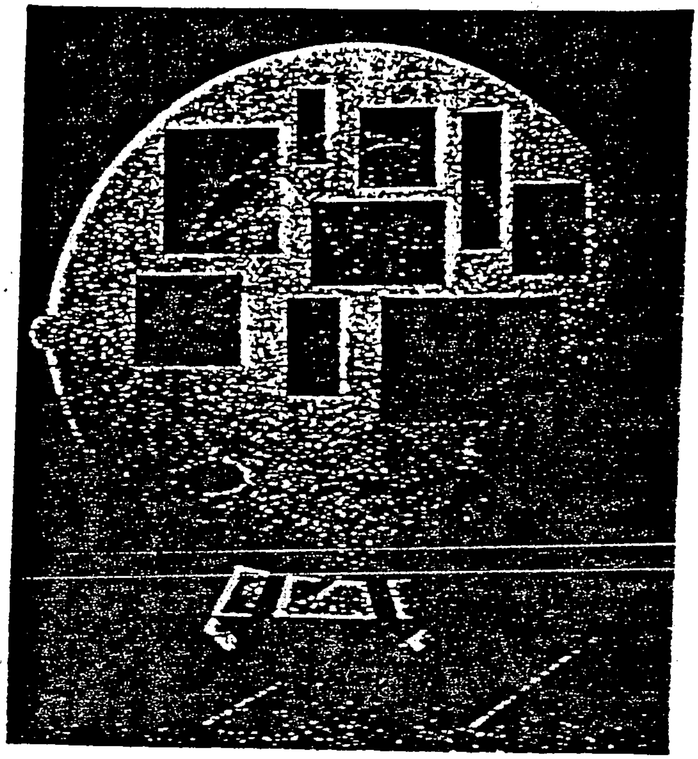
intricate tapestry of the mind. Some of the neurons have already been hard-wired, by the genes in the fertilized egg, into circuits that command breathing or control heartbeat, regulate body temperature or produce reflexes. But trillions upon trillions more are like the Pentium chips in a computer before the factory preloads the software. They are pure and of almost infinite potential, unprogrammed circuits that might one day compose rap songs and do calculus, erupt in fury and melt in ecstasy. If the neurons are used, they become integrated into the circuitry of the brain by connecting to other neurons; if they are not used, they may die. It is the experiences of childhood, determining which neurons are used, that wire the circuits of the brain as surely as a programmer at a keyboard reconfigures the circuits in a computer. Which keys are typed—which experiences a child has—determines whether the child grows up to be intelligent or dull, fearful or self-assured, articulate or tongue-tied. Early experiences are so powerful, says pediatric neurobiologist Harry Chugani of Wayne State University, that "they can completely change the way a person turns out."

By adulthood the brain is crisscrossed with more than 100 billion neurons, each reaching out to thousands of others so that, all told, the brain has more than 100 trillion connections. It is those connections—more than the number of galaxies in the known universe—that give the brain its unrivaled powers. The traditional view was that the wiring diagram is predetermined, like one for a new house, by the genes in the fertilized egg. Unfortunately, even though half the genes—50,000—are involved in the central nervous system in some way, there are not enough of them to specify the brain's incomparably complex wiring. That leaves another possibility: genes might determine only the brain's main circuits, with something else shaping the trillions of finer connections. That something else is the environment, the myriad messages that the brain receives from the outside world. According to the emerging paradigm, "there are two broad stages of brain wiring," says developmental neurobiologist Carla Shatz of the University of California, Berkeley: "an early period, when experience is not required, and a later one, when it is."

Yet, once wired, there are limits to the brain's ability to create itself. Time limits. Called "critical periods," they are windows of opportunity that nature flings open, starting before birth, and then slams shut, one by one, with every additional candle on the child's birthday cake. In the experiments that gave birth to this paradigm in the 1970s, Torsten Wiesel and David Hubel found that sewing shut one eye of a newborn kitten rewired its brain: so few neurons connected from the shut eye to the visual cortex that the animal was blind even after its eye was reopened. Such rewiring did not occur in adult cats whose eyes were shut. Conclusion: there is a short, early period when circuits connect the retina to the visual cortex. When brain regions mature dictates how long they stay malleable. Sensory areas mature in early childhood; the emotional limbic system is wired by puberty; the frontal lobes—seat of understanding—develop at least through the age of 16.

The implications of this new understanding are at once promising and disturbing. They suggest that, with the right input at the right time, almost anything is possible. But they imply, too, that if you miss the window you're playing with a handicap. They offer an explanation of why the gains a toddler makes in Head Start are so often evanescent: this intensive instruction begins too late to fundamentally rewire the brain. And they make clear the mistake of postponing instruction in a second language (page 58). As Chugani asks, "What idiot decreed that foreign-language instruction not begin until high school?"

Neurobiologists are still at the dawn of understanding exactly which kinds of experiences, or sensory input, wire the brain in which ways. They know a great deal about the circuit for vision. It has a neuron-growth spurt at the age of 2 to 4 months, which corresponds to when babies start to really notice the world, and peaks at 8 months, when each neuron is connected to an astonishing 15,000 other neurons. A baby whose eyes are clouded by cataracts from birth will, despite cataract-removal surgery at the age of 2, be forever blind. For other systems, researchers know what happens, but not—at the level of neurons and molecules—how. They nevertheless remain confident that cognitive abilities work much like sensory ones, for the brain is parsimonious in how it conducts its affairs: a mechanism that works fine for wiring vision is not likely to be abandoned when it comes to circuits for music. "Connections are not forming willy-nilly," says Dale Purves of Duke University, "but are promoted by activity."



The Logical Brain

SKILL: Math and logic

LEARNING WINDOW: Birth to 4 years

WHAT WE KNOW: Circuits for math reside in the brain's cortex, near those for music. Toddlers taught simple concepts, like one and many, do better in math. Music lessons may help develop spatial skills.

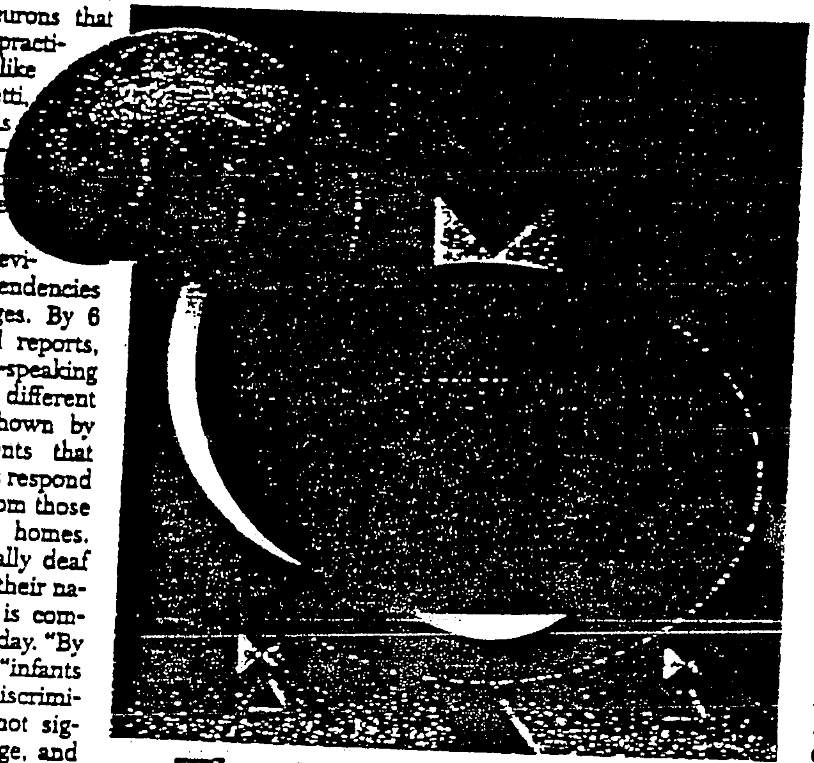
WHAT WE CAN DO ABOUT IT: Play counting games with a toddler. Have him set the table to learn one-to-one relationships—one plate, one fork per person. And, to hedge your bets, turn on a Mozart CD.

Language: Before there are words, in the world of a newborn, there are sounds. In English they are phonemes such as sharp ba's and da's, drawn-out ee's and ll's and sibilant sss's. In Japanese they are different—barked *hi's*, merged rr/ll's. When a child hears a phoneme over and over, neurons from his ear stimulate the formation of

... connections in his brain's auditory cortex. This "perceptual map," explains Patricia Kuhl of the University of Washington, reflects the apparent distance—and thus the similarity—between sounds. So in English-speakers, neurons in the auditory cortex that respond to "ra" lie far from those that respond to "la." But for Japanese, where the sounds are nearly identical, neurons that respond to "ra" are practically intertwined, like L.A. freeway spaghetti, with those for "la." As a result, a Japanese-speaker will have trouble distinguishing the two sounds.

Researchers find evidence of these tendencies across many languages. By 6 months of age, Kuhl reports, infants in English-speaking homes already have different auditory maps (as shown by electrical measurements that identify which neurons respond to different sounds) from those in Swedish-speaking homes. Children are functionally deaf to sounds absent from their native tongue. The map is completed by the first birthday. "By 12 months," says Kuhl, "infants have lost the ability to discriminate sounds that are not significant in their language, and their babbling has acquired the sound of their language."

... findings help explain why learning a second language after, rather than with, the first is so difficult. "The perceptual map of the first language constrains the learning of a second," she says. In other words, the circuits are already wired for Spanish, and the remaining undedicated neurons have lost their ability to form basic new connections for, say, Greek. A child taught a second language after the age of 10 or so is unlikely ever to speak it like a native. Kuhl's work also suggests why related languages such as Spanish and French are easier to learn than unrelated ones: more of the existing circuits can do double duty.



The Language Brain

SKILL: Language

LEARNING WINDOW: Birth to 10 years

WHAT WE KNOW: Circuits in the auditory cortex, representing the sounds that form words, are wired by the age of 1. The more words a child hears by 2, the larger her vocabulary will grow. Hearing problems can impair the ability to match sounds to letters.

WHAT WE CAN DO ABOUT IT: Talk to your child—a lot. If you want her to master a second language, introduce it by the age of 10. Protect hearing by treating ear infections promptly.

With this basic circuitry established, a baby is primed to turn sounds into words. The more words a child hears, the faster she learns language, according to psychiatrist Janellen Huttenlocher of the University of Chicago. Infants whose mothers spoke to them a lot knew 131 more words at 20 months than did babies of more taciturn, or less involved, mothers; at 24 months, the gap had widened to 295 words. (Presumably the findings would also apply to a father if he were the primary caregiver.) It didn't matter which words the mother used—monosyllables seemed to work. The sound of words, it seems, builds up neural circuitry that can then absorb more words, much as creating a computer file allows the user to fill it with prose. "There is a huge vocabulary to be acquired," says Huttenlocher, "and it can only be acquired through repeated exposure to words."

Music: Last October researchers at the University of Konstanz in Germany reported that exposure to music rewires neural circuits. In the brains of nine string players examined with magnetic resonance imaging, the amount of somatosensory cortex dedicated to the thumb and fifth finger of the left hand—the fingering digits—was significantly larger than in nonplayers. How long the players practiced each day did not affect the cortical map. But the age at which they had been introduced to their muse did: the younger the child when she took up an instrument, the more cortex she devoted to playing it.

Like other circuits formed early in life, the ones for music endure. Wayne State's Chugani played the guitar as a child, then gave it up. A few years ago he started taking piano lessons with his young daughter. She learned easily, but he couldn't get his fingers to follow his wishes. Yet when Chugani recently picked up a guitar, he found to his delight that "the songs are still there," much like the muscle memory for riding a bicycle.

Math and logic: At UC Irvine, Gordon Shaw suspected that all higher-order thinking is characterized by similar patterns of neuron firing. "If you're working with little kids," says Shaw, "you're not going to teach them higher mathematics or chess. But they are interested in and can process music." So Shaw and Frances Rauscher gave ... preschoolers piano or singing lessons. After eight months, the researchers found, the children "dramatically improved in spatial reasoning," compared with children given no music lessons, as shown in their ability to work mazes, draw geometric figures and copy patterns of two-color blocks. The mechanism behind the "Mozart effect" remains murky, but Shaw suspects that when children exercise cortical neurons by listening to classical music, they are also strengthening circuits used for mathematics. Music, says the UC team, "excites the inherent brain patterns and enhances their use in complex reasoning tasks."

Emotions: The trunk lines for the circuits controlling emotion are laid down before birth. Then parents take over. Perhaps the strongest influence is what psychiatrist Daniel Stern calls attunement—whether caregivers "play back a child's inner feelings." If a baby's squeal of delight at a puppy is met with a smile and hug, if her excitement at seeing a plane overhead is mirrored, circuits for these emotions are reinforced. Apparently, the brain uses the same pathways to generate an emotion as to respond to one. So if an emotion is reciprocated, the electrical and chemical signals that produced it are reinforced. But if emotions are repeatedly met with indifference or a clashing response—Baby is proud of building a skyscraper out of Mom's best pots, and Mom is terminally annoyed—those circuits become confused and fail to strengthen. The key here is "repeatedly": one dismissive harrumph will not scar a child for life. It's the pattern that counts, and it can be very powerful: in one of Stern's studies, a baby whose mother never matched her level of excitement became extremely passive, unable to feel excitement or joy.

Experience can also wire the brain's "calm down" circuit, as Daniel Goleman describes in his best-selling "Emotional Intelligence." One father gently soothes his crying infant, another drops him into his crib; one mother hugs the toddler who just skinned her knee, another screams "It's your own stupid fault!" The first responses are attuned to the child's distress; the others are wildly out of emotional sync. Between 10 and 18 months, a cluster of cells in the rational prefrontal cortex is busy hooking up to the emotion regions. The circuit seems to grow into a control switch, able to calm agitation by infusing reason into emotion. Perhaps parental soothing trains this circuit, strengthening the neural connections that form it, so that the child learns how to calm herself down. This all happens so early that the effects of nurture can be misperceived as innate nature.

Stress and constant threats also rewire emotion circuits. These circuits are centered on the amygdala, a little almond-shaped structure deep in the brain whose job is to scan incoming sights and sounds for emotional content. According to a wiring diagram worked out by Joseph LeDoux of New York University, impulses from eye and ear reach the amygdala before they get to the rational, thoughtful neocortex. If a sight, sound or experience has proved painful before—Dad's drunken arrival home was followed by a beating—then the amygdala floods the circuits with neurochemicals before the higher brain knows what's happening. The more often this pathway is used, the easier it is to trigger: the mere memory of Dad may induce fear. Since the circuits can stay excited for days, the brain remains on high alert. In this state, says neuroscientist Bruce Perry of Baylor College of Medicine, more circuits attend to nonverbal cues—facial expressions, angry noises—that warn of impending danger. As a result, the cortex falls behind in development and has trouble assimilating complex information such as language.

SCHOOLS

Why Do Schools Flunk Biology?

BY LYNNELL HANCOCK

BIOLOGY IS A STAPLE AT MOST American high schools. Yet when it comes to the biology of the students themselves—how their brains develop and retain knowledge—school officials would rather not pay attention to the lessons. Can first graders handle French? What time should school start? Should music be cut? Biologists have some important evidence to offer. But not only are they ignored, their findings are often turned upside down.

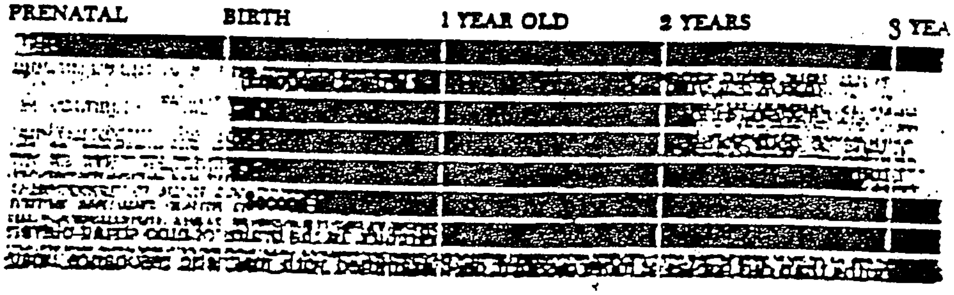
Force of habit rules the hallways and classrooms. Neither brain science nor education research has been able to free the majority of America's schools from their 19th-century roots. If more administrators were tuned into brain research, scientists argue, not only would schedules change, but subjects such as foreign language and geometry would be offered to much younger children. Music and gym would be daily requirements. Lectures, work sheets and rote memorization would be replaced by hands-on materials, drama and project work. And teachers would pay greater attention to children's emotional connections to subjects. "We do more education research than anyone else in the world," says Frank Vellutino, a professor of educational psychology at State University of New York at Albany, "and we ignore more as well."

Plato once said that music "is a more potent instrument than any other for education." Now scientists know why. Music, they believe, trains the brain for higher forms of thinking. Researchers at the University of California, Irvine, studied the power of music by observing two groups of preschoolers. One group took piano lessons and sang daily in chorus. The other did not. After eight months the musical 3-year-olds were expert puzzlemasters, scoring 80 percent higher than their playmates did in spatial intelligence—the ability to visualize the world accurately.

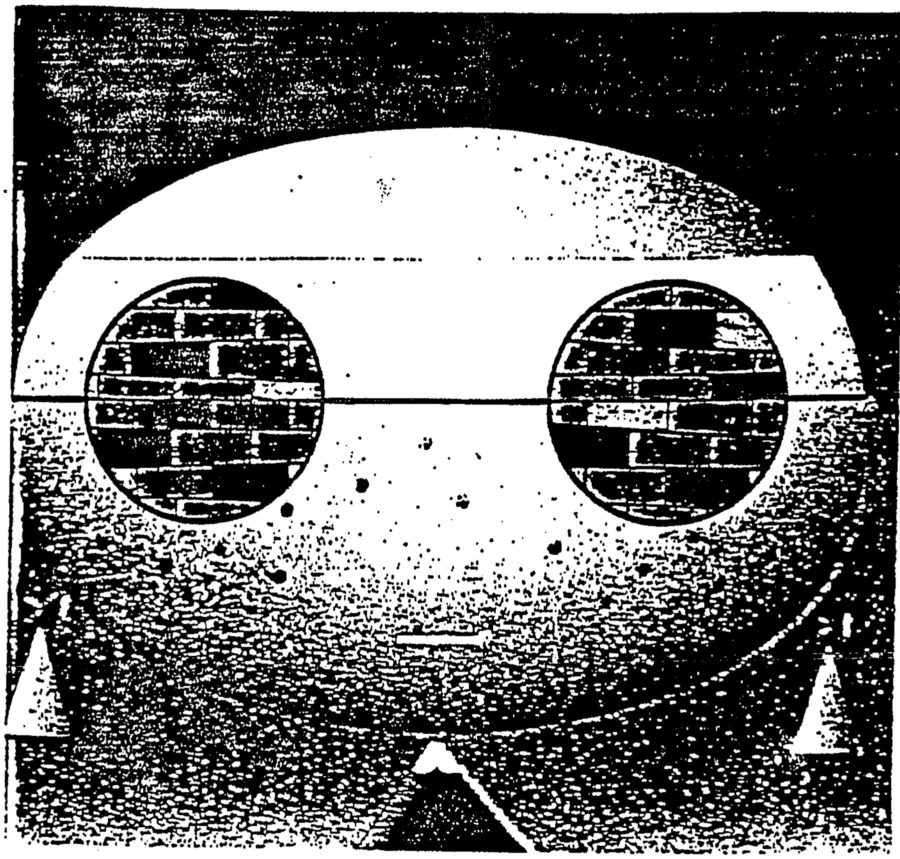
This skill later translates into complex math and engineering skills. "Early music training can enhance a child's ability to reason," says Irvine physicist Gordon Shaw. Yet music education is often the first "frill" to be cut when school budgets shrink. Schools on average have only one music teacher for every 500 children, according to the National Commission on Music Education.

Then there's gym—another expendable hour by most school standards. Only 36 percent of schoolchildren today are required to participate in daily physical education. Yet researchers now know that exercise is good not only for the heart. It also juices up the brain, feeding it nutrients in the form of glucose and increasing nerve connections—all of which make it easier for kids of all ages to learn. Neuroscientist William Greenough confirmed this by watching rats at his University of Illinois at Urbana-Champaign lab. One group

The Windows of Opportunity



information such as language.



did nothing. A second exercised on an automatic treadmill. A third was set loose in a Barnum & Bailey obstacle course re- [illegible] These "supersmart" rats grew "an enormous amount of gray matter" compared with their sedentary partners, says Greenough.

Of course, children don't ordinarily run such gantlets; still, Greenough believes, the results are significant. Numerous studies, he says, show that children who exercise regularly do better in school.

The implication for schools goes beyond simple exercise. Children also need to be more physically active in the classroom, not sitting qui- [illegible] ning subtraction tables. Knowledge is retained longer if children connect not only aurally but emotionally and physically to the material, says University of Oregon education professor Robert Sylwester in "A Celebration of Neurons."

Good teachers know that lecturing on the American Revolution is far less effective than acting out a battle. Angles and dimensions are better understood if children chuck their work sheets and build a complex model to scale. The smell of the glue enters memory through one sensory sys- [illegible] wood blocks another, the sight of the finished model still another. The brain then creates a multidimensional mental model of the experience—one easier to retrieve. "Explaining a smell," says Sylwester, "is not as good as actually smelling it."

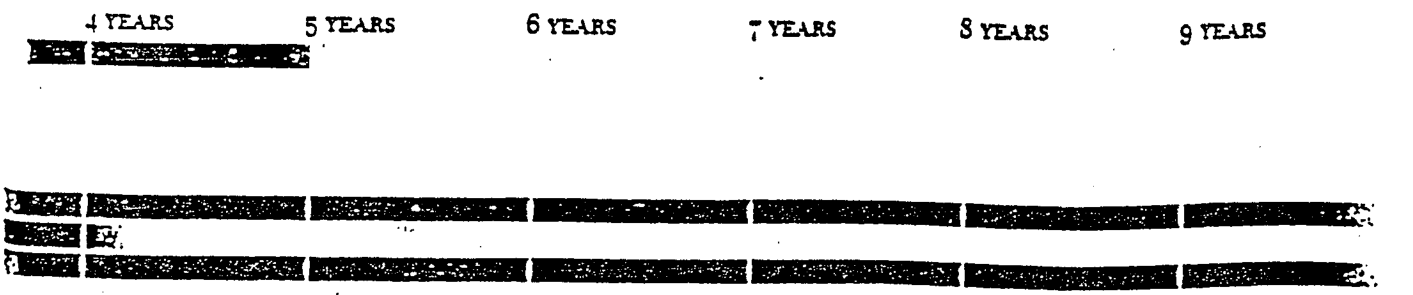
Scientists argue that children are capable of far more at younger ages than schools generally realize. People obviously continue learning their whole lives, but the optimum "windows of opportunity for learning" last until about the age of 10 or 12, says Harry Chugani of Wayne State University's Children's Hospital of Michigan. Chugani determined this by measuring the brain's consumption of its chief energy source, glucose. (The more glucose it uses, the more active the brain.) Children's brains, he observes, gobble up glucose at twice the adult rate from the age of 4 to puberty. So young brains are as primed as they'll ever be to process new information. Complex subjects such as trigonometry or foreign language shouldn't wait for puberty to be introduced. In fact, Chugani says, it's far easier for an elementary-school child [illegible] ond language—and even speak it without an accent. Yet most U.S. districts wait until junior high to introduce Spanish or French—after the "windows" are closed.

Reform could begin at the beginning. Many sleep researchers now believe that most teens' biological clocks are set later than those of their fellow humans. But high school starts at 7:30 a.m., usually to accommodate bus schedules. The result can be wasted class time for whole groups of kids. Making matters worse, many kids have trouble readjusting their natural sleep rhythm. Dr. Richard Allen of Johns Hopkins University found that teens went to sleep at the same time whether they had to be at school by 7:30 a.m. or 9:30 a.m. The later-to-rise teens not only get more sleep, he says; they also get better grades. The obvious solution would be to start school later when kids hit puberty. But at school, there's what's obvious, and then there's tradition.

Why is this body of research rarely used in most American classrooms? Not many administrators or school-board members know it exists, says Linda Darling-Hammond, professor of education at Columbia University's Teachers College. In most states, [illegible] to know much about how children learn in order to be certified. What's worse, she says, decisions to cut music or gym are often made by noneducators, whose concerns are more often monetary than educational. "Our school system was invented in the late 1800s, and little has changed," she says. "Can you imagine if the medical profession ran this way?"

With PAT WINGERT *and* MARY HAGER *in Washington*

Circuits in different regions of the brain mature at different times. As a result, different circuits are most sensitive to life's experiences at different ages. Give your children the stimulation they need when they need it, and anything's possible. Stumble, and all bets are off.



Movement: Fetal movements begin at 7 weeks and peak between the 15th and 17th weeks. That is when regions of the brain controlling movement start to wire up. The critical period lasts a while: it takes up to two years for cells in the cerebellum, which controls posture and movement, to form functional circuits. "A lot of organization takes place using information gleaned from when the child moves about in the world," says William Greenough of the University of Illinois. "If you restrict activity you inhibit the formation of synaptic connections in the cerebellum." The child's initially spastic movements send a signal to the brain's motor cortex: the more the arm, for instance, moves, the stronger the circuit and the better the brain will become at moving the arm intentionally and fluidly. The window lasts only a few years: a child immobilized in a body cast until the age of 4 will learn to walk eventually, but never smoothly.

There are many more circuits to discover, and many more environmental influences to pin down. Still, neuro labs are filled with an unmistakable air of optimism these days. It stems from a growing understanding of how, at the level of nerve cells and molecules, the brain's circuits form. In the beginning, the brain-to-be consists of only a few advance scouts breaking trail: within a week of conception they march out of the embryo's "neural tube," a cylinder of cells extending from head to tail. Multiplying as they go (the brain adds an astonishing 250,000 neurons per minute during gestation), the neurons clump into the brain stem which commands heartbeat and breathing, build the little cerebellum at the back of the head which controls posture and movement, and form the grooved and rumpled cortex wherein thought and perception originate. The neural cells are so small and the distance so great, that a neuron striking out for what will be the prefrontal cortex migrates a distance equivalent to a human's walking from New York to California, says developmental neurobiologist Mary Beth Hatten of Rockefeller University.

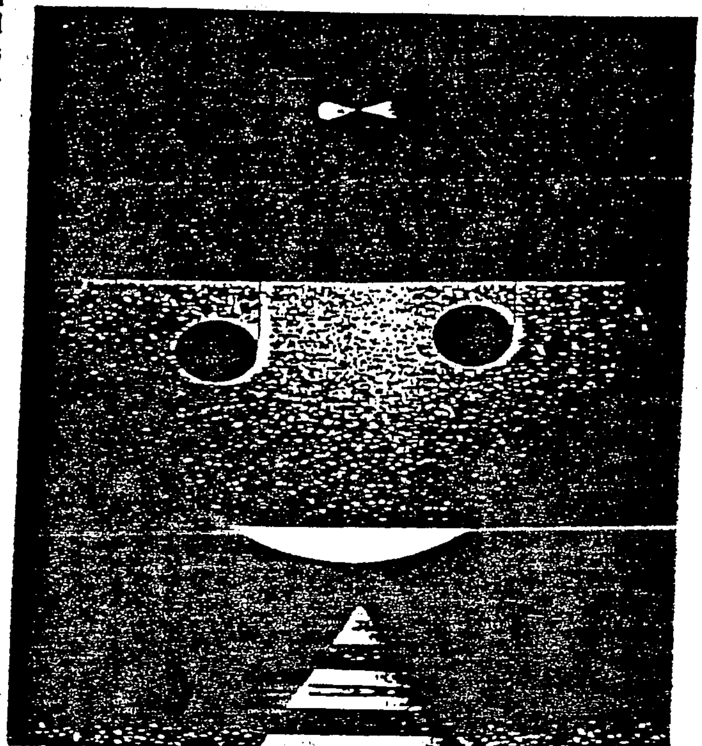
Only when they reach their destinations do these cells become true neurons. They grow a fiber called an axon that carries electrical signals. The axon might reach only to a neuron next door, or it might wend its way clear across to the other side of the brain. It is the axonal connections that form the brain's circuits. Genes determine the main highways along which axons travel to make their connection. But to reach particular target cells, axons follow chemical cues strewn along their path. Some of these chemicals attract: this way to the motor cortex! Some repel: no, *that* way to the olfactory cortex. By the fifth month of gestation most axons have reached their general destination. But like the prettiest girl in the bar, target cells attract way more suitors—axons—than they can accommodate.

How does the wiring get sorted out? The baby neurons fire electrical pulses once a minute, in a fit of what Berkeley's Shatz calls auto-dialing. If cells fire together, the target cells "ring" together. The target cells then release a flood of chemicals, called trophic factors, that strengthen the incipient connections. Active neurons respond better to trophic factors than inactive ones, Barbara Barres of Stanford University reported in October. So neurons that are quiet when others throb lose their grip on the target cell. "Cells that fire together wire together," says Shatz.

The same basic process continues after birth. Now, it is not an auto-dialer that sends signals, but stimuli from the senses. In experiments with rats, Illinois's Greenough found that animals raised with playmates and toys and other stimuli grow 25 percent more synapses than rats deprived of such stimuli.

Rats are not children, but all evidence suggests that the same rules of brain development hold. For decades Head Start has fallen short of the high hopes invested in it: the children's IQ gains fade after about three years. Craig Ramey of the University of Alabama suspected the culprit was timing: Head Start enrolls 2-, 3- and 4-year-olds. So in 1972 he launched the Abecedarian Project. Children from 120 poor families were assigned to one of four groups: intensive early education in a day-care center from about 4 months to age 8, from 4 months to 5 years, from 5 to 8 years, or none at all. What does it mean to "educate" a 4-month-old? Nothing fancy: blocks, beads, talking to him, playing games such as peek-a-boo. As outlined in the book "Learningames,"* each of the 200-odd activities was designed to enhance cognitive, language, social or motor development. In a recent paper, Ramey and Frances Campbell of the University of North Carolina report that children enrolled in Abecedarian as preschoolers still scored higher in math and reading at the age of 15 than untreated children. The children still retained an average IQ edge of 4.6 points. The earlier the children were enrolled, the more enduring the gain. And intervention after age 5 conferred no IQ or academic benefit.

*Joseph Sparling and Isabelle Lewis. 226 pages. Walker. $8.95.



The Musical Brain

SKILL: Music

LEARNING WINDOW: 3 to 10 years

WHAT WE KNOW: String players have a larger area of their sensory cortex dedicated to the fingering digits on their left hand. Few concert-level performers begin playing later than the age of 10. It is much harder to learn an instrument as an adult.

WHAT WE CAN DO ABOUT IT: Sing songs with children. Play structured, melodic music. If a child shows any musical aptitude or interest, get an instrument into her hand early.

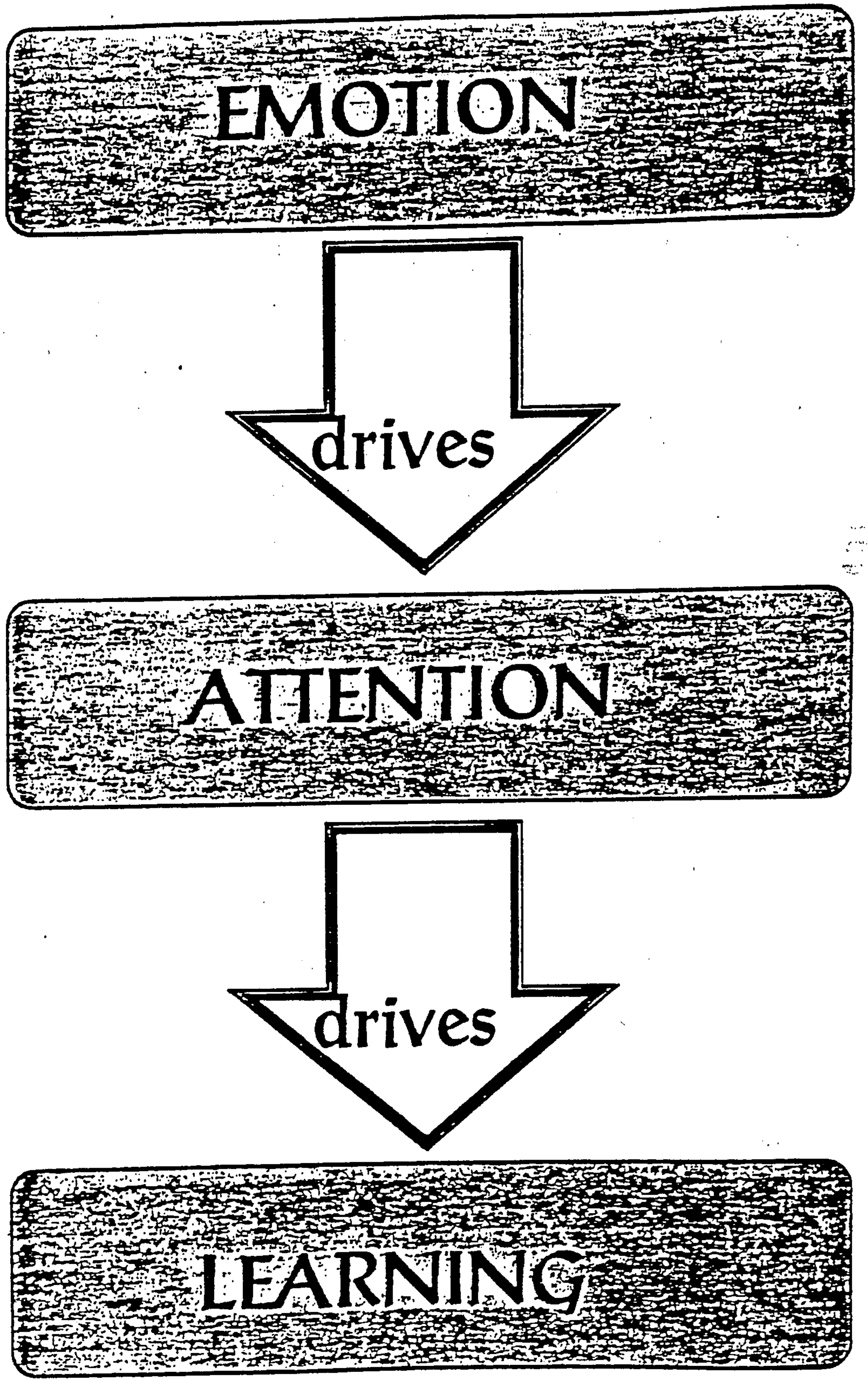
If the windows of the mind close, for the most part, before we're out of elementary school, is all hope lost for children whose parents did not have them count beads to stimulate their math circuits, or babble to them to build their language loops? At one level, no: the brain retains the ability to learn throughout life, as witness anyone who was befuddled by Greek in college only to master it during retirement. But on a deeper level the news is sobering. Children whose neural circuits are not stimulated before kindergarten are never going to be what they could have been. "You want to say that it is never too late," says Joseph Sparling, who designed the Abecedarian curriculum. "But there seems to be something very special about the early years."

And yet ... there is new evidence that certain kinds of intervention can reach even the older brain and, like a microscopic screwdriver, rewire broken circuits. In January, scientists led by Paula Tallal of Rutgers University and Michael Merzenich of UC San Francisco described a study of children who have "language-based learning disabilities"—reading problems. LLD affects 7 million children in the United States. Tallal has long argued that LLD arises from a child's inability to distinguish short, staccato sounds—such as "d" and "b." Normally, it takes neurons in the auditory cortex something like .015 second to respond to a signal from the ear, calm down and get ready to respond to the next sound; in LLD children, it takes five to 10 times as long. (Merzenich speculates that [illegible] middle-ear infections in infancy; the brain never "hears" sounds clearly and so fails to draw a sharp auditory map.) Short sounds such as "b" and "d" go by too fast—.04 second—to process. Unable to associate sounds with letters, the children develop reading problems.

The scientists drilled the 5- to 10-year-olds three hours a day with computer-produced sound that draws out short consonants, like an LP played too slow. The result: LLD children who were one to three years behind in language ability improved by a full two years after only four weeks. The improvement has lasted. The training, Merzenich suspects, redrew the wiring diagram in the children's auditory cortex to process fast sounds. Their reading problems vanished like the sounds of the letters that, before, they never heard.

Such neural rehab may be the ultimate payoff of the discovery that the experiences of life are etched in the bumps and squiggles of the brain. For now, it is enough to know that we are born with a world of potential—potential that will be realized only if it is tapped. And that is challenge enough.

With MARY HAGER


EMOTION
drives
ATTENTION
drives
LEARNING

CLASSROOM CLIMATE

I. Climate

- peer acceptance
- instructor acceptance

II. Comfort and Order

- physical
- psychological

III. The Task

- value
- ability
- clarity

THE LEARNING ENVIRONMENT

Hart (1983) suggests that any learning environment must be characterized by:

- High Expectations
- A Nonthreatening Ambiance
- A Goal of 100% Mastery
- An Air of Reality

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COLOR

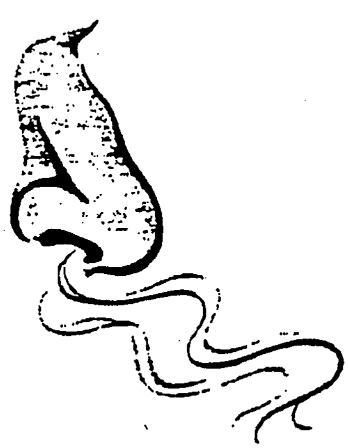
Faber Birren, in Color and Human Response (1978) reports specific tendencies in people's responses to various colors.

Color	Response
Red	Good for creative thinking, short-term high energy
Green	Good for productivity, long-term energy
Yellow, Orange, Coral	Conducive to physical work, exercising; elicits positive moods
[illegible]	Slows pulse and lowers blood pressure; conducive to studying, deep thinking, concentration; accent with red for keener insights
Purple	Tranquilizing; good for appetite control
Pink	Restful, calming
Light Colors	All-purpose; provides minimum disruptions across all moods and mental activity
White	Disrupting; like snow-blindness--avoid

SCENTS AND EFFECTS

Scent	Effect
Lavender, chamomile	* reduces stress
Lemon, jasmine, cypress	* induces a positive mood
Basil, peppermint, pine, eucalyptus, clove	* refreshing, invigorating
Spiced apple	* relaxed brain waves drop in blood pressure

Using Scents



Consider providing chamomile, spiced apple, lemon, jasmine or peppermint teas in the break room.

Place fragrant natural objects (bowl of pine cones, apples) in reception areas to relax visitors.

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Smell and the Limbic System

Smell is the only one of the five senses that has direct link-ups with the limbic system. Hence, smell can have an effect on the level of relaxation or agitation that one experiences.

Though there are exceptions, as a rule, females tend to be more sensitive to odors than males.

Odors and Productivity

On a forty-minute test of vigilance (like that needed for air traffic control), thirty-second bursts of peppermint or lily of the valley scent every five minutes resulted in a 15 to 25 percent improvement in performance. Workers receiving scented bursts showed less decline in performance as the task continued over time.

(William Dember of the University of Cincinnati and Raja Parasuraman of the Catholic University of America)

Shimizu Technology Center America, Inc. reports Keypunch operators improving 21 percent with lavender bursts, 33 percent with jasmine and 54 percent with lemon.