What Is A Traumatic Brain Injury?

DONALD STEIN

Brain Repair

Fall, 2025

A Well-documented Case Of Penetrating TBI

Is TBI An Important Health Issue In The United States?

- Every 15 seconds in the USA someone suffers a TBI.
- TBI causes more deaths in men under 35 than all other diseases combined.
- TBI can lead to long-term deficits in cognitive, memory, sensory and motor functions.
- Costs for long term care estimated at $40-50 billion each year.

Head Injury In Daily Life:
A Close to Home Example

Each year there are approximately 1,000,000 cases of sports-related injuries in the United States


© Splash News

Bicycling: Does Wearing A Helmet Make A Difference?

- An analysis in the *International Journal of Epidemiology* reviewed 40 separate studies and found helmet use significantly reduced the odds of head injury. They also found the odds of a fatal head injury to be lower when cyclists wore a helmet.

- The *New York Times* reported that cycling had the highest concussion rate among all sports, including American football.

- A report by the National Highway Traffic Safety Administration found that 70 percent of cyclist deaths occurred in urban areas. Only 3 percent of those fatalities took place in a bike lane.

- If you really want to make your road rides safer, joining your local advocacy group, or organizing one to push your city and state for better bike networks, is a great place to start. Simply donning a helmet is no substitute for safer streets.

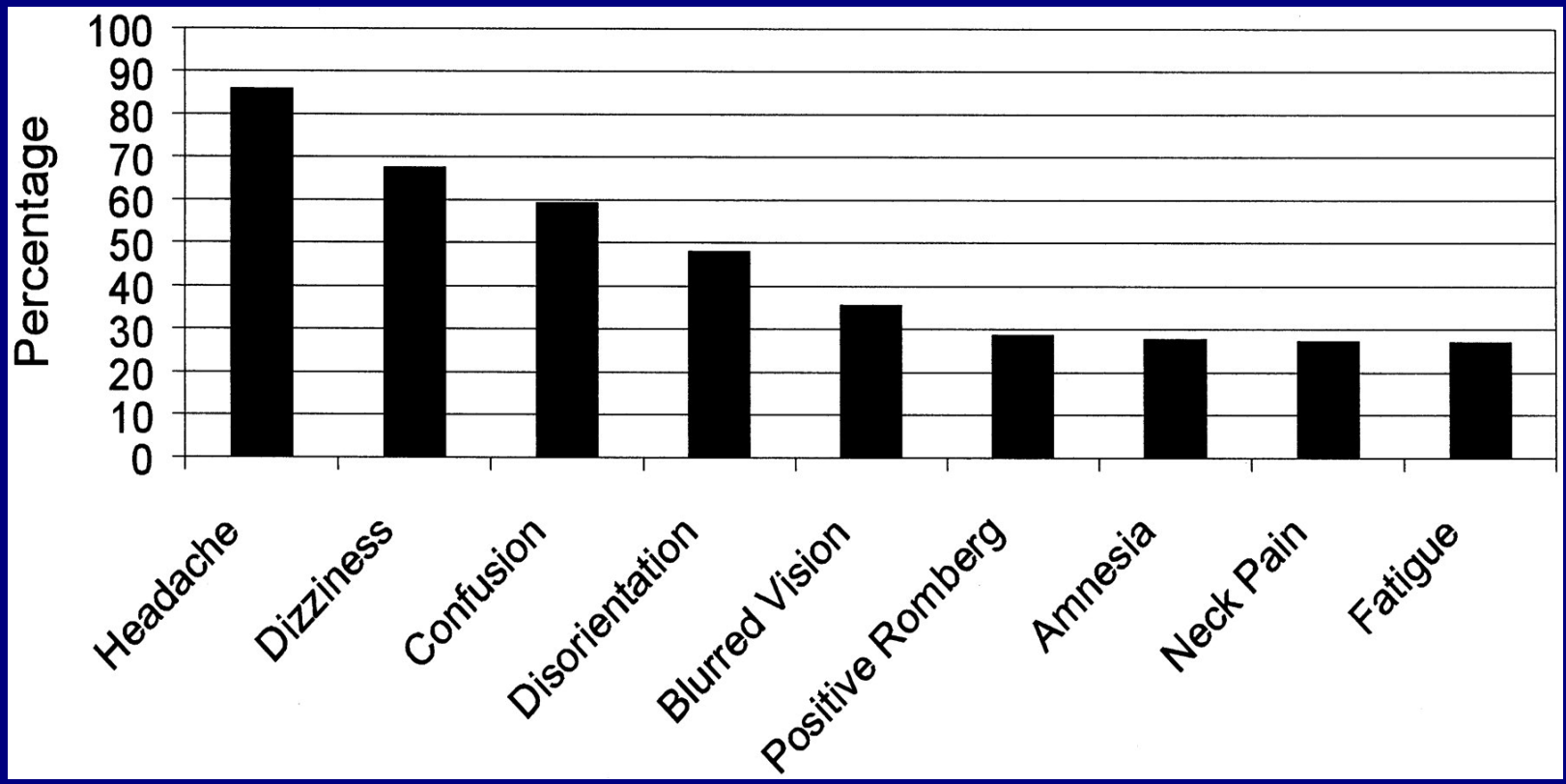
Are "Mild" Repetitive Head Injuries Dangerous?

Much Is At Stake For School and Professional Sports

Competitive Sports and Head Injuries

These Are Not Just Games For Adults

% Injured Players With Symptoms Of Brain Injury



“A football player’s real issue isn’t simply with repetitive concussive trauma. It is, as the concussion specialist Robert Cantu argues, with repetitive *subconcussive trauma*. *It’s not just the handful of big hits that matter. It’s lots of little hits, too.*”


TITANS

Symptoms of ‘Mild’ Concussion

- 40% of athletes return to their sport too soon after injury (should remain out 2 mo?)
- Persistent Headaches
- Loss of balance and slowed reflexes
- Depression
- Disrupted memory and attention
- Brain swelling and secondary neuronal loss
- Early onset dementia

“Heading In Soccer”

Can ‘Heading” Cause A Brain Injury?

- Head to head contact can generate enough of the forces required to cause brain injury as in any conventional head injury.

- Recent biomechanical research has found that commercially available soft helmets fail to reduce even this degree of head trauma to a safe level, which implies that these helmets have only a limited protective role in this setting.[5]”

New Concussion Guidelines Stress Individual Treatment

- The American Academy of Neurology has revised its guidelines for handling concussions to emphasize treating athletes case by case rather than according to a predetermined scale (article appears in *Neurology*).

- Report essentially acknowledges that concussions are too idiosyncratic to be categorized neatly.

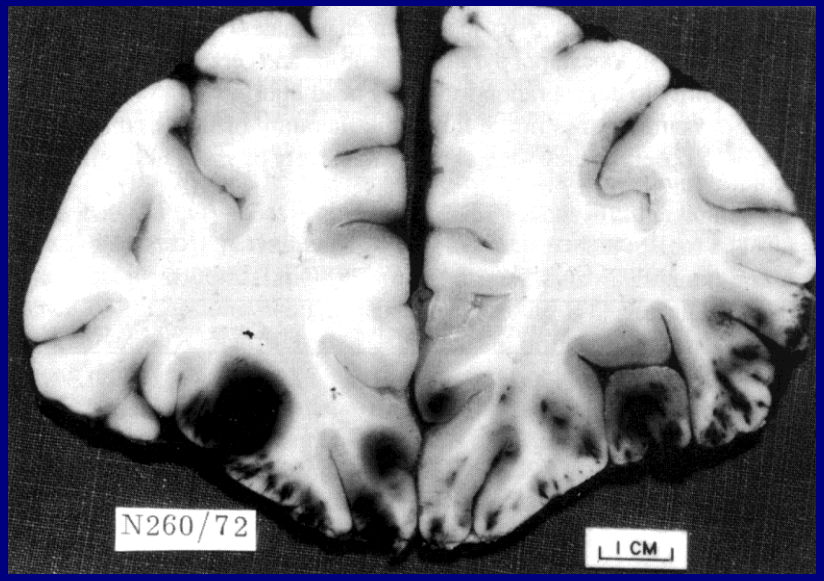
- Now recommending concussion and return to play be assessed in each athlete individually."

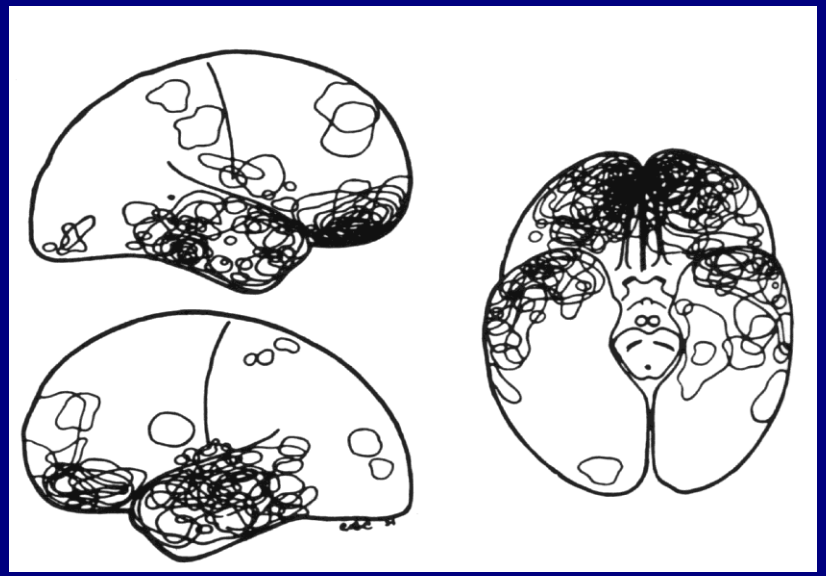
- More than a million American athletes experience concussions each year.

- Guidelines recommend that athletes suspected of having a concussion should be immediately removed from play.

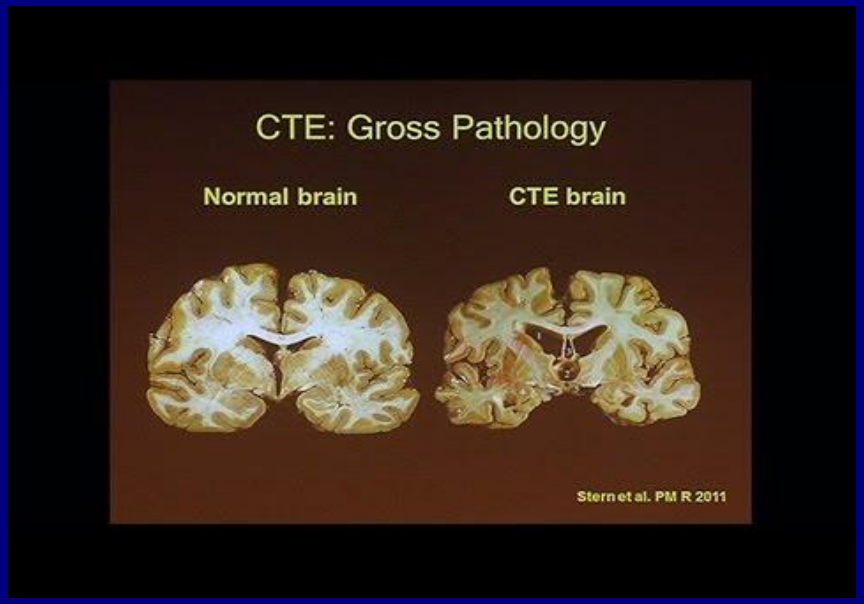
The Initial Injury



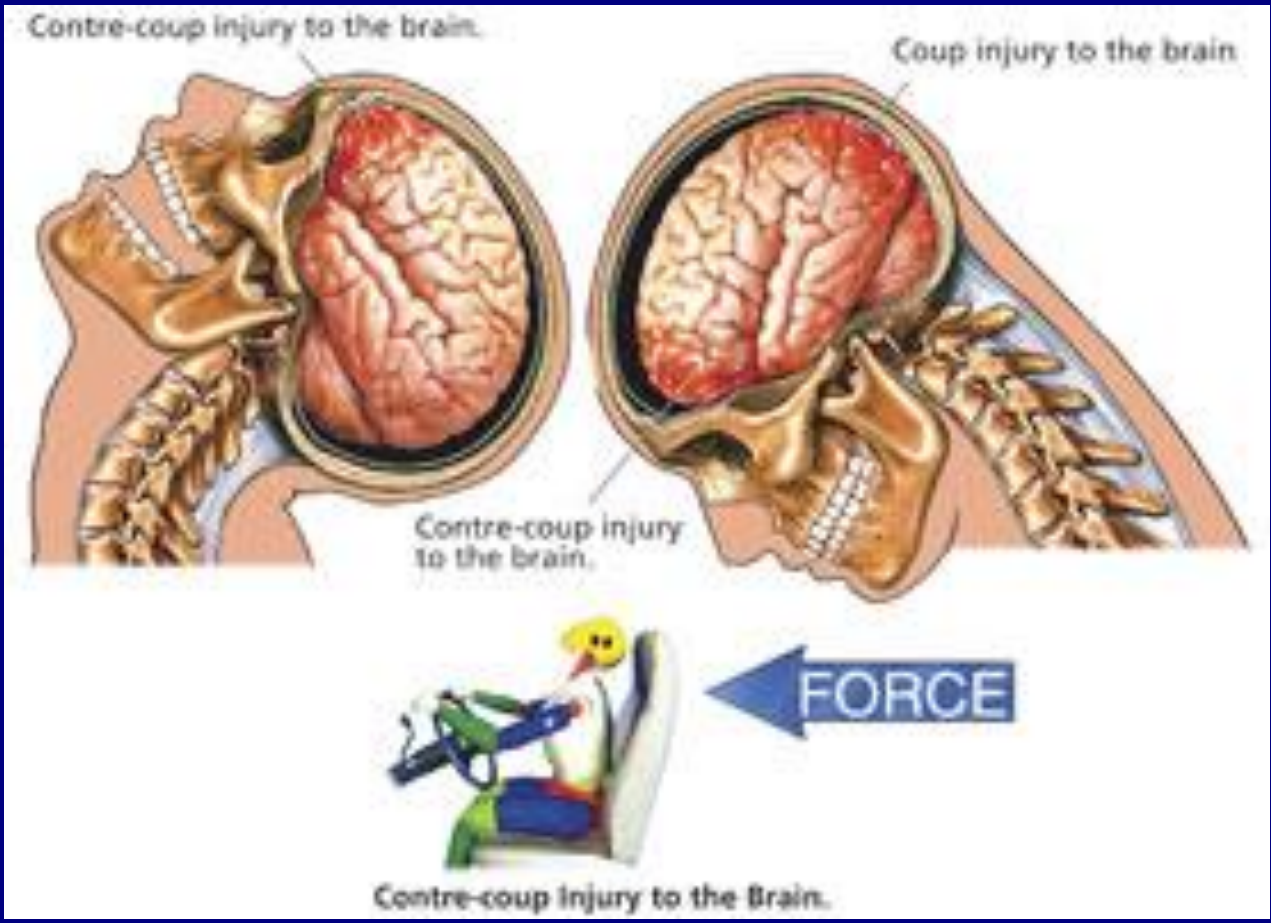





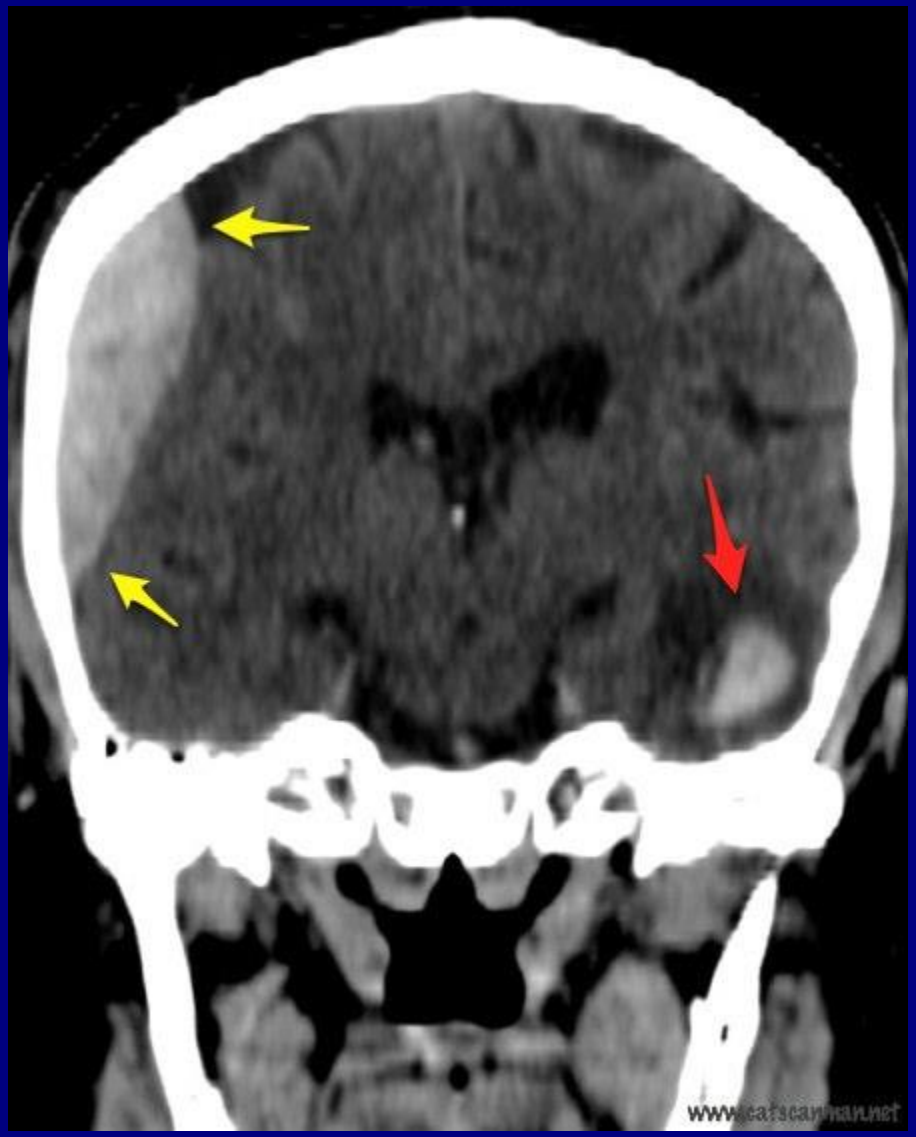
Chronic Traumatic Encephalopathy



Common Contrecoup Injury



Contrecoup Injury



Contrecoup Injury On Purpose

Early Diagnosis of TBI In The Field and In The Clinic

Early Diagnosis Is Critical

- Many athletic organizations now recommend establishing a baseline picture of an athlete's brain function at the beginning of each season, ideally before any head injuries occur. Baseline testing should begin as soon as a child begins a competitive sport. [Anyone see a problem with this?]
- Baseline screening tools for coaches and athletic trainers can help to identify the most concerning concussions for further medical evaluation.
- *All* suspected TBIs require immediate assessment by a professional who has experience evaluating head injuries.
- A full neurological exam should judge motor and sensory skills and test hearing and speech, coordination and balance, mental status, and changes in mood or behavior, among other abilities.
- Neuropsychological tests to gauge brain *functioning* should be used along with imaging in people who have suffered TBI.
- Tests involve performing specific cognitive tasks that help assess memory, concentration, information processing, executive functioning, reaction time, and problem solving.
- When necessary, medical providers will use brain scans to evaluate the extent of the primary brain injuries and determine if surgery will be needed to help repair any damage to the brain.
  - *Quotes are from the latest NINDS Health Information Guide on TBI*

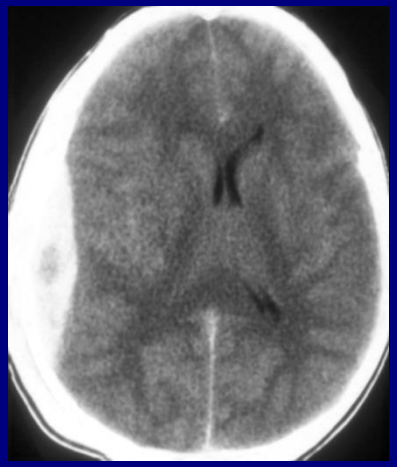
The Glasgow Coma Scale

Mild: 13-15
Moderate: 9-12
Severe: ≤8

EYES OPEN	
Never	1
To pain	2
To verbal stimuli	3
Spontaneously	4
BEST VERBAL RESPONSE	
No response	1
Incomprehensible sounds	2
Inappropriate words	3
Disoriented and converses	4
Oriented and converses	5
BEST MOTOR RESPONSE	
No response	1
Extension (decerebrate rigidity)	2
Flexion abnormal (decorticate rigidity)	3
Flexion withdrawal	4
Localizes pain	5
Obeys	6
Total	3–15

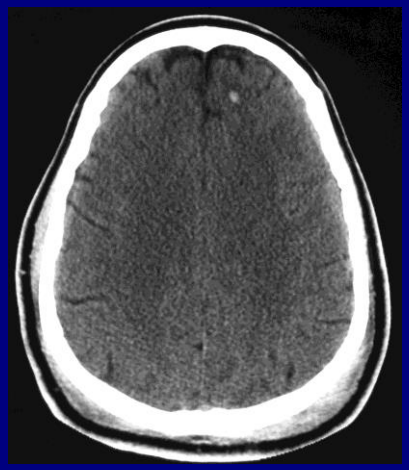
A Problem: TBI Is a Heterogenous Disease

All These Patients Have The Same GCS Score

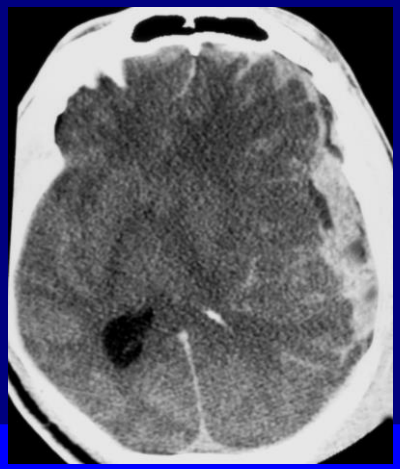


Epidural hematoma

Contusion/Hematoma



Diffuse axonal injury



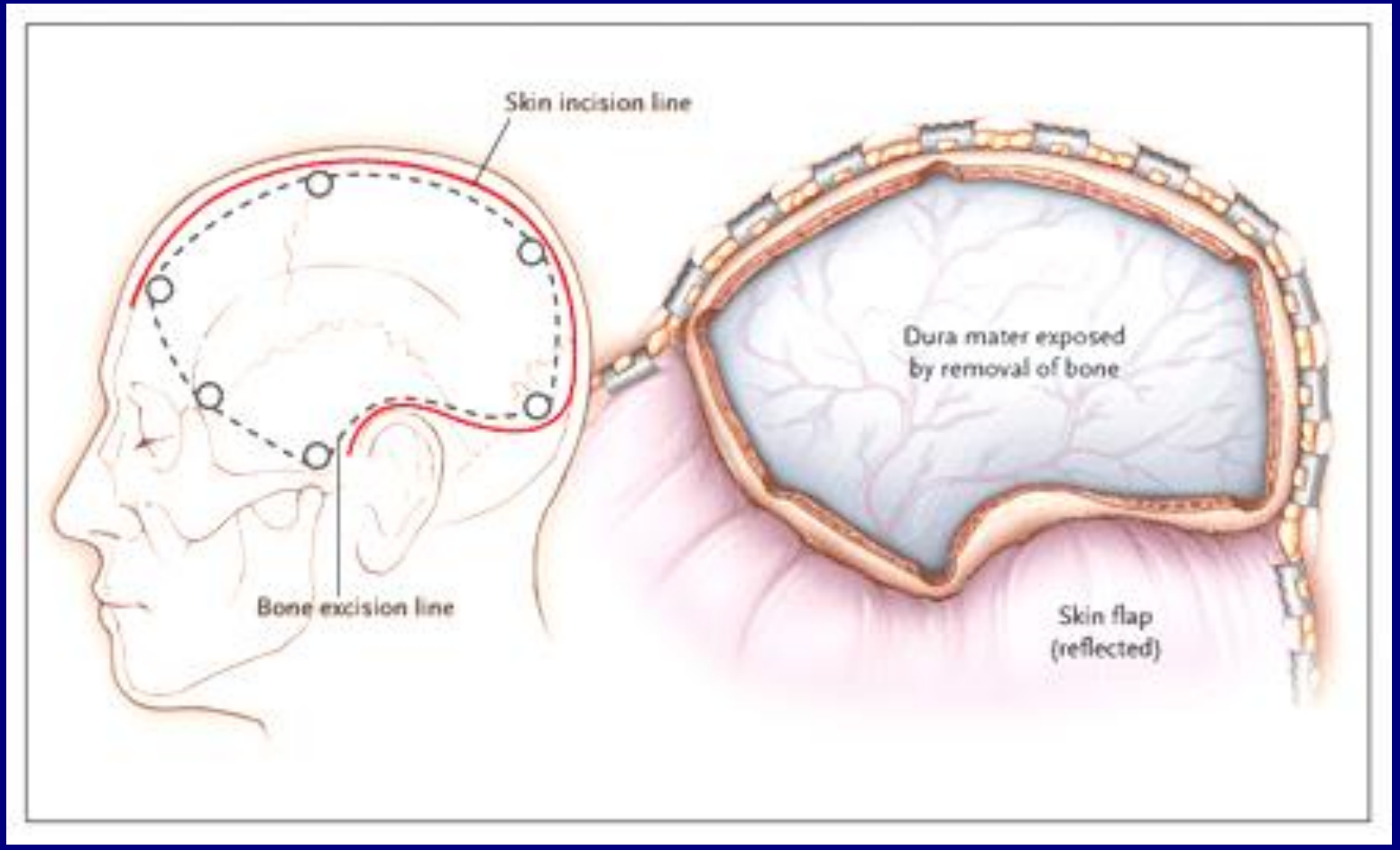
Subdural hematoma

Subarachnoid hemorrhage

Diffuse swelling

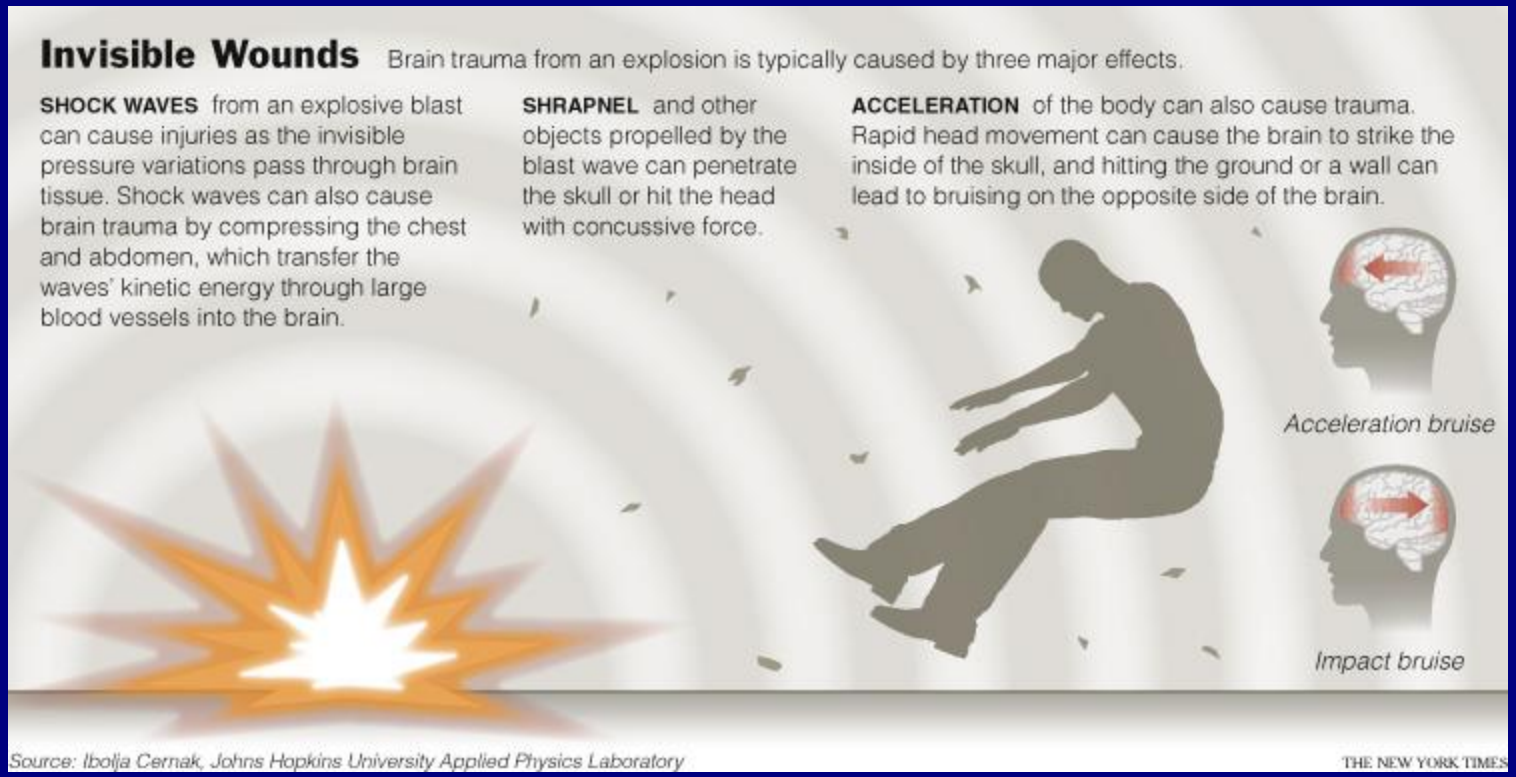
Battlefield TBI

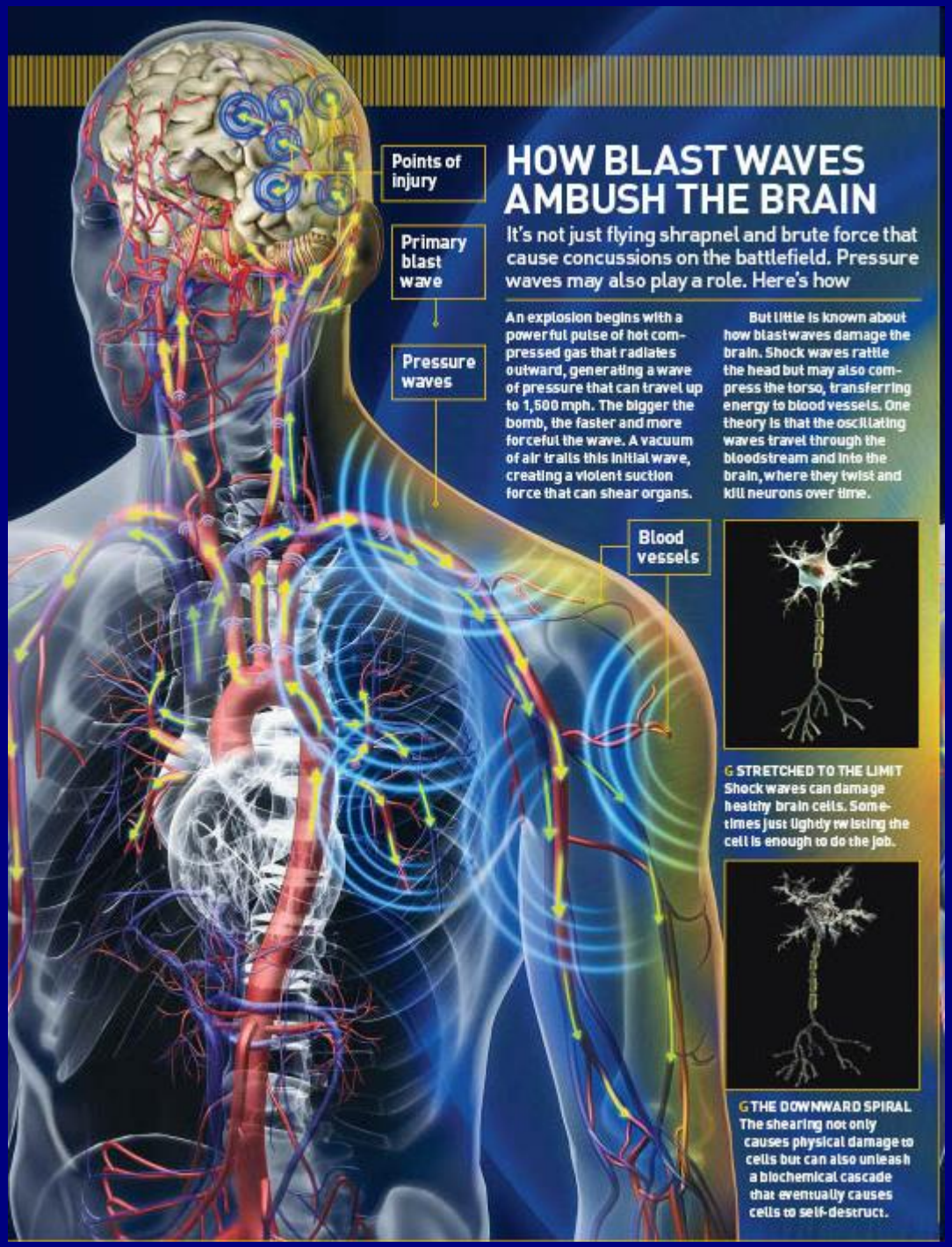
TBI: The Signature Injury Of The Iraq War But Not Much Available For Immediate Treatment



IEDs Caused 60% Of Casualties In Iraq

BLAST-RELATED TBI





HOW BLAST WAVES AMBUSH THE BRAIN

It's not just flying shrapnel and brute force that cause concussions on the battlefield. Pressure waves may also play a role. Here's how

An explosion begins with a powerful pulse of hot compressed gas that radiates outward, generating a wave of pressure that can travel up to 1,500 mph. The bigger the bomb, the faster and more forceful the wave. A vacuum of air trails this initial wave, creating a violent suction force that can shear organs.

But little is known about how blast waves damage the brain. Shock waves rattle the head but may also compress the torso, transferring energy to blood vessels. One theory is that the oscillating waves travel through the bloodstream and into the brain, where they twist and kill neurons over time.

STRETCHED TO THE LIMIT Shock waves can damage healthy brain cells. Sometimes just lightly twisting the cell is enough to do the job.

THE DOWNWARD SPIRAL The shearing not only causes physical damage to cells but can also unleash a biochemical cascade that eventually causes cells to self-destruct.

Repetitive Small Blast Waves

Mild Traumatic Brain Injury in U.S. Soldiers Returning from Iraq

Charles W. Hoge, M.D., Dennis McGurk, Ph.D., Jeffrey L. Thomas, Ph.D., Anthony L. Cox, M.S.W., Charles C. Engel, M.D., M.P.H., and Carl A. Castro, Ph.D.

***NEJM* 358:453-463 2008 Number 5**

- Surveyed 2525 U.S. Army infantry soldiers 3 to 4 months after their return from a year-long deployment to Iraq.

- 43.9% met criteria for post-traumatic stress disorder (PTSD), compared with 27.3% reporting altered mental status, 16.2% with other injuries, and 9.1% with no injury.

- *Conclusions Mild traumatic brain injury (i.e., concussion) occurring among soldiers deployed in Iraq is strongly associated with PTSD and physical health problems 3 to 4 months after the soldiers return home.*

- PTSD and depression are important mediators of the relationship between mild traumatic brain injury and physical health problems.

Repetitive Use Of Civilian Firearms On A Firing Range Can Be Just As Dangerous –*NYT, Nov 3rd 2025*

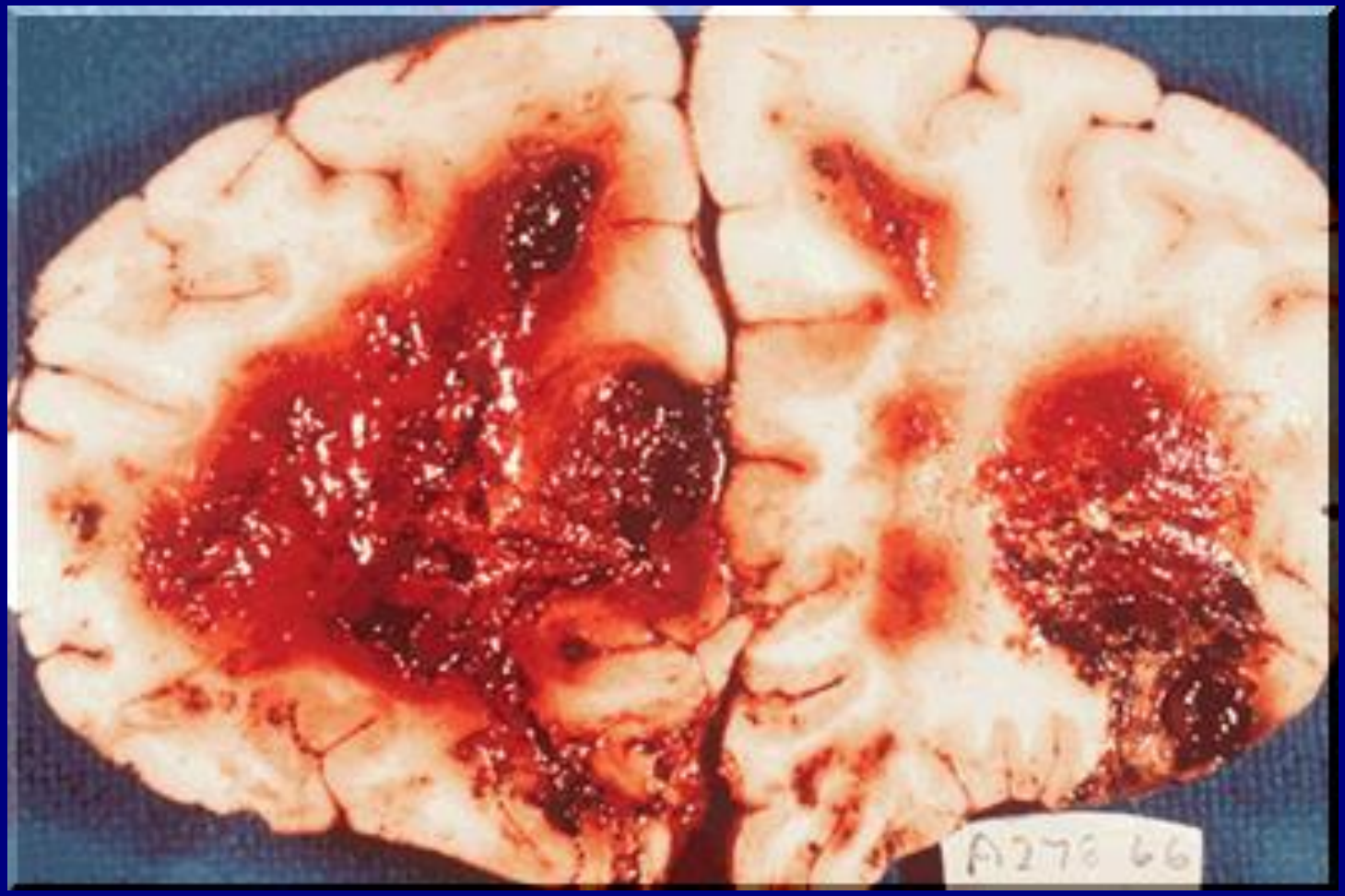
- NYT did its own testing with popular civilian guns at an indoor range using the same sensors as the military.
- Results showed that large caliber civilian rifles ”delivered a blast wave that exceeds what the military says is safe for the brain”.
- Firing small-caliber guns repeatedly add up to potentially harmful disclosure.
- Indoor shooting ranges designed to be safe actually can make blast exposure more severe-doubling and tripling the amplitude of the blast.

Shooter's Brain Damage

- Card had traumatic brain injury that resembled the brain damage seen in veterans exposed to blasts. Despite that he never saw combat.
- Card's role as a grenade instructor would have exposed him to thousands of blasts over the eight years he served.
- The findings, released by the Card family, showed profound brain damage, including missing white matter; white matter with "moderately severe" damage; "disorganized clumps" of myelin (fatty sheaths surrounding axons); damage to axons; and scarring and inflammation throughout the brain.
- However, because he never deployed, the military never tested him for symptoms of brain injury. (Such testing is standard practice for all soldiers deployed to war zones.)[73]

Pentrating Injury

Penetrating Brain Injury



More Details On What Happens When A TBI Occurs

Brain Injury Is A Complex & Systemic Cascade Of Events

The Molecular and Cellular Aspects of Traumatic Brain Injury

The Perils of Systemic Inflammation

- Systemic inflammation occurs when the immune system is constantly defending the body against ‘harm’.

- Stress, infection, or chronic diseases can put the body in a proinflammatory state. When this happens, the immune system becomes primed and ready to create an inflammatory response.

- Immune cells increase production of proinflammatory proteins such as cytokines and chemokines. These agents serve as immune mediators that stimulate inflammatory responses throughout the body.

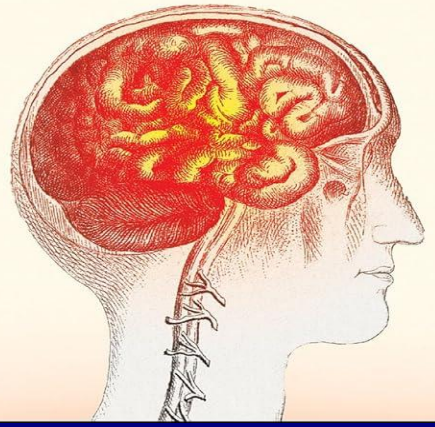
- The changes to the blood-brain barrier allow proinflammatory cytokines to gain access to the brain and interfere with its balanced environment. As a result, the brain’s inflammatory response may kick in, causing cognitive and behavioral symptoms.
-

The INFLAMED MIND

A RADICAL NEW APPROACH TO DEPRESSION

EDWARD BULLMORE

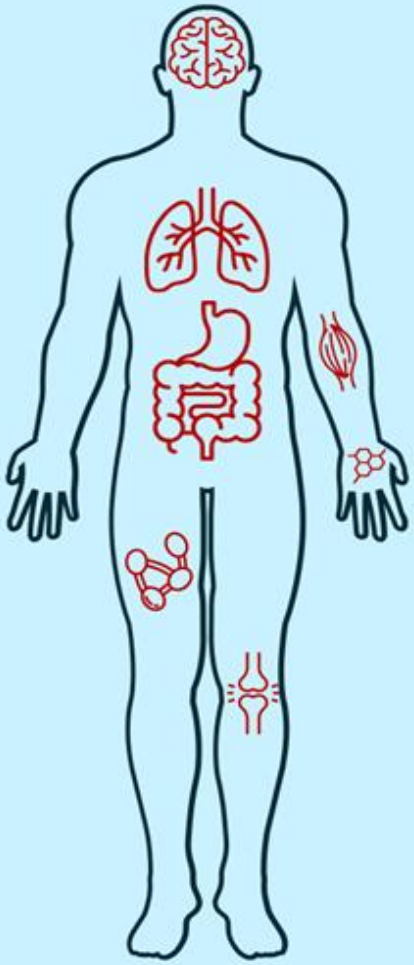
"This is an important book, a hopeful book,
for anyone who wants to think about depression in a new way."
—TOM INSEL, CEO and president, Mindstrong Health



PICADOR

Signs of Systemic Inflammation

saventiccare.com



Nervous System
Fatigue, Balance Problems, Brain Fog, Numbness, Tingling

Respiratory System
Shortness of breath, Wheezing

Digestive System
Nausea, abdominal pain, diarrhea

Skin
Rashes, hives, swelling

Lymph Nodes
Swelling, Inflam-mation

Body Temperature
Mild Fever, Night Sweats

Muscles and Joints
Pain, Inflammation

Defining ATraumatic Brain Injury Still Remains A Serious Medical Challenge

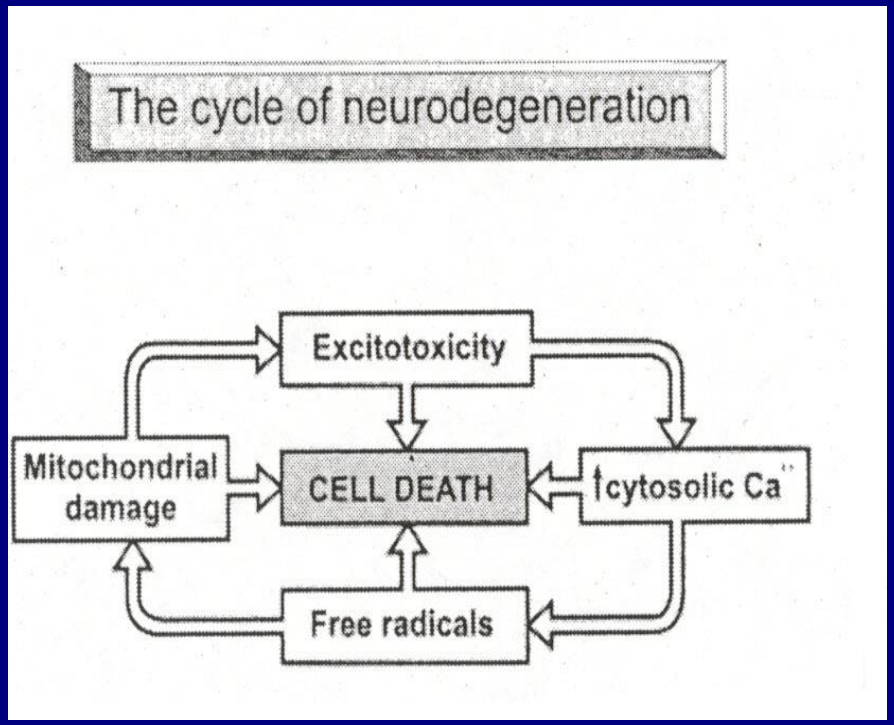
- Despite recent progress in understanding what happens in the brain following TBI, no clinical trials have identified specific treatments that make a dependable and measurable difference in people with TBI.

- A key challenge facing doctors and scientists is the fact that each person with a TBI has a unique set of circumstances based on such multiple variables as the location and severity of the injury, the person's sex, age and overall heath, and the time between the injury and the initiation of treatment.

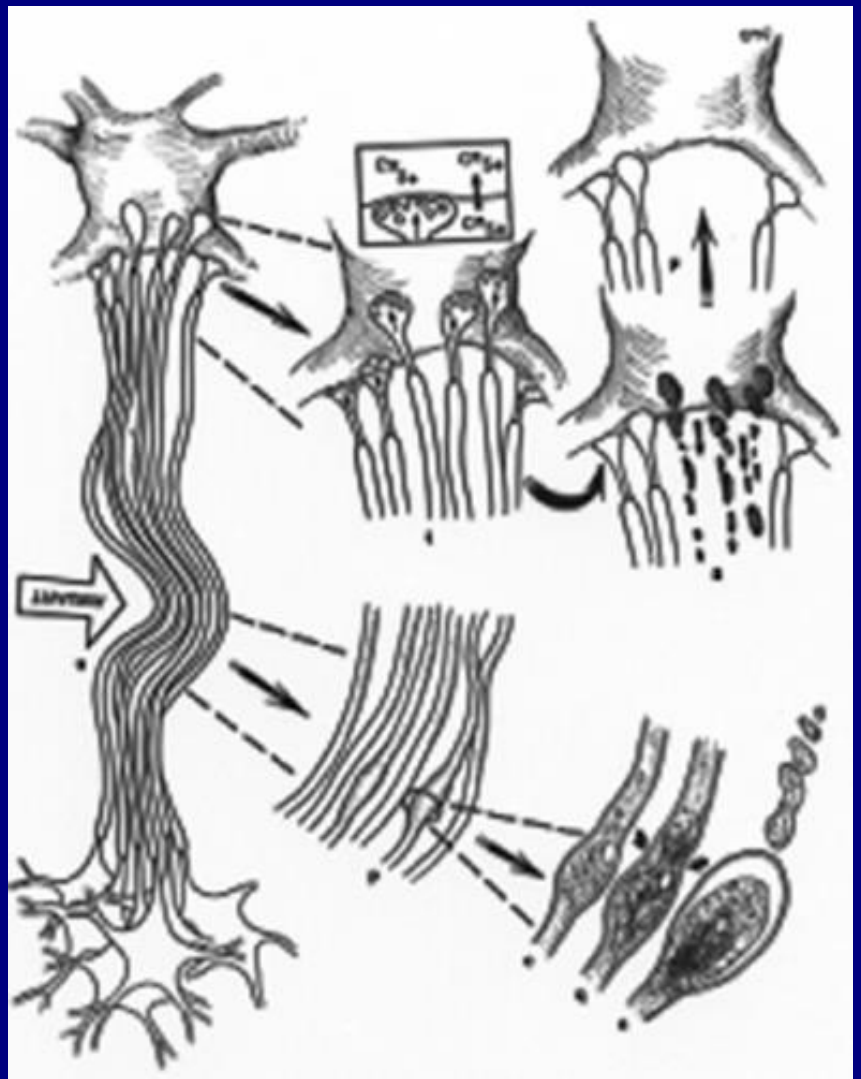
- Despite much better imaging techniques, standardized functional testing of the severity of brain jury remain a problem for the field.

- *These factors, along with differences in care across treatment centers, highlight the importance of coordinating research efforts so that the results of potential new treatments can be confidently measured.*

Schema of Degeneration



Deafferentation



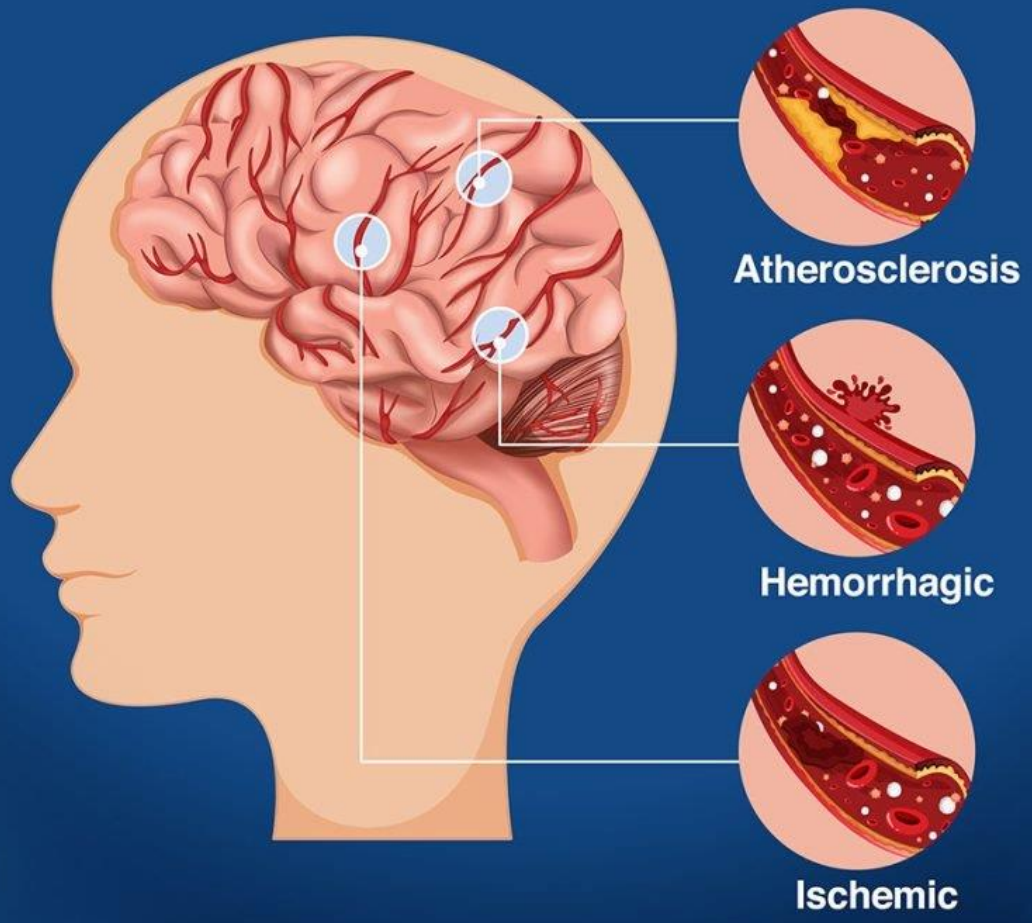
- *Stretch*
- *Disconnection*
- *Degeneration*
- *Deafferentation*
- *Loss of inter-neuronal communication*
- *Behavioral morbidity*

Is Stroke A ‘Traumatic’ Injury?

Outcomes of TBI and Stroke Can Often Be Very Similar

COMMON TYPES OF STROKE

is a condition in which blood flow to the brain is disrupted, leading to brain cell death and potentially severe neurological deficits, often caused by a blood clot or a ruptured blood vessel in the brain.



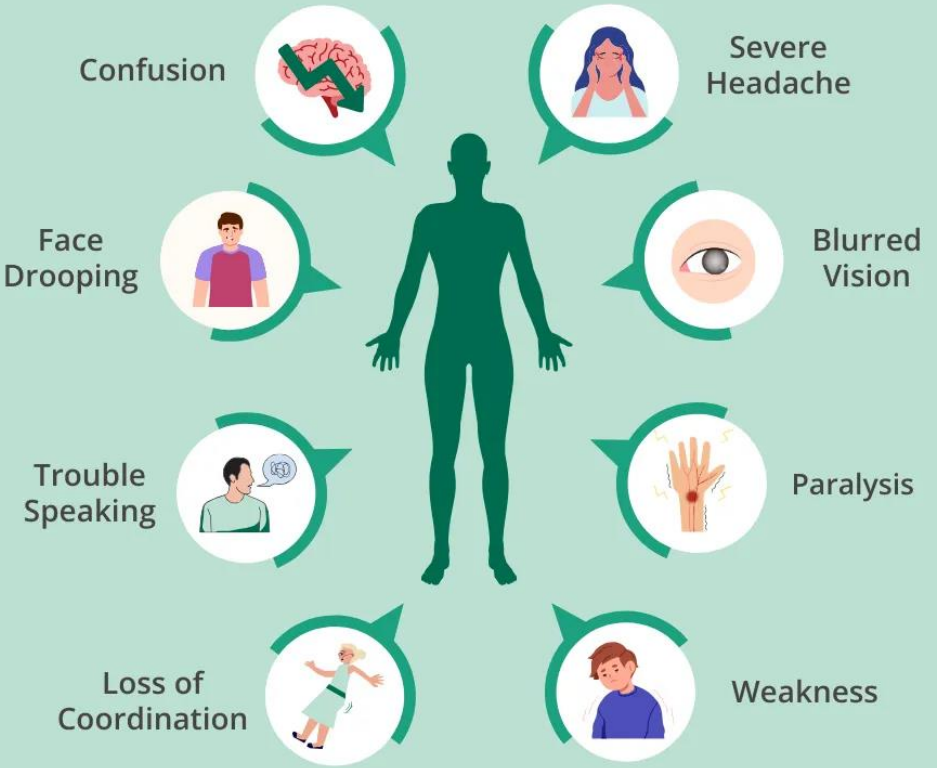
CEDARS-SINAI

Spot the signs of a stroke **F.A.S.T.**

During a stroke, every minute counts. You could save a life by recognizing these signs of a stroke:

FACE	Ask the person to smile. Is one side of the face drooping?
ARMS	Ask the person to raise their arms. Is one arm weak?
SPEECH	Ask the person to speak. Is their speech slurred?
TIME	Call 911 right away at the first sign of a stroke.

How Stroke Affects the Body

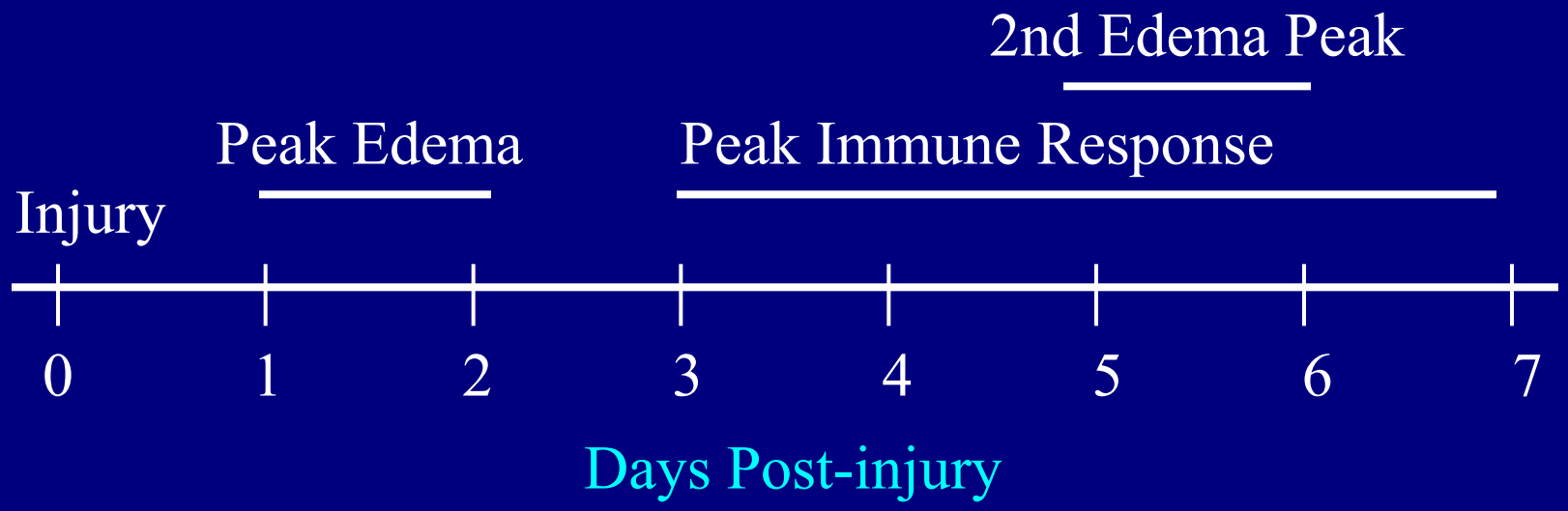


EVERYDAY HEALTH

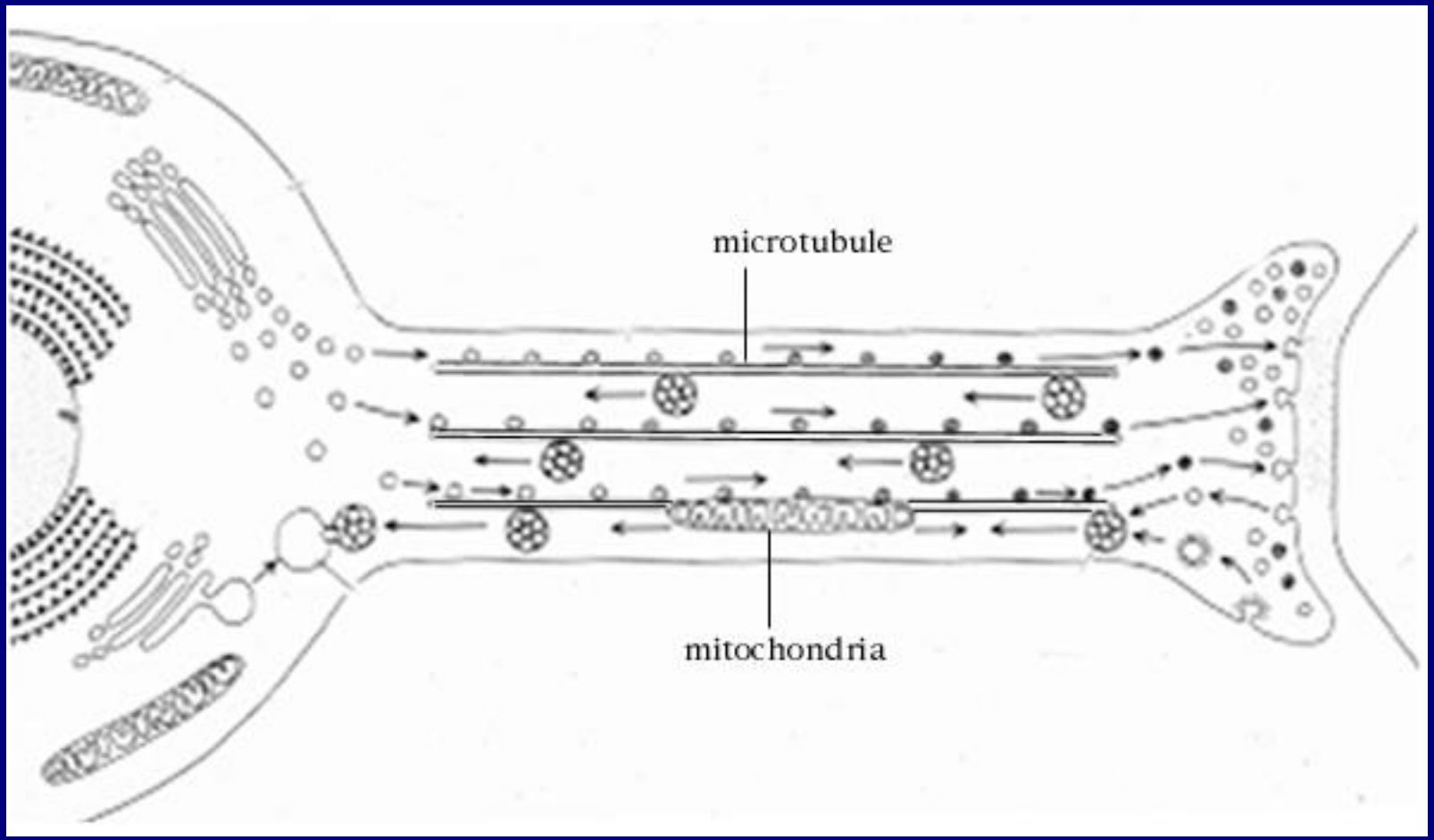
Cerebral Edema

- Increased water content of brain tissue.
- Increased intracranial pressure.
- Decreased blood flow.
- Death of nervous tissue.
- Pressure on critical brain areas, leading to dysfunction.

Time Course for Edema after TBI



Axonal Transport



What Are Glia And What Do They Do

- Neuroglia, glial cells or, to their family and friends, simply glia are the connective tissue cells of nervous system. The term “glia” comes from the Greek for glue.
- Glia maintain the ionic environment surrounding neurons.
- Control the rate of neuron signal propagation.
- Establish, maintain and repair synapses.
- Assist (or hamper!) the recovery neurons post damage.

How Are Glia Different From Neurons?

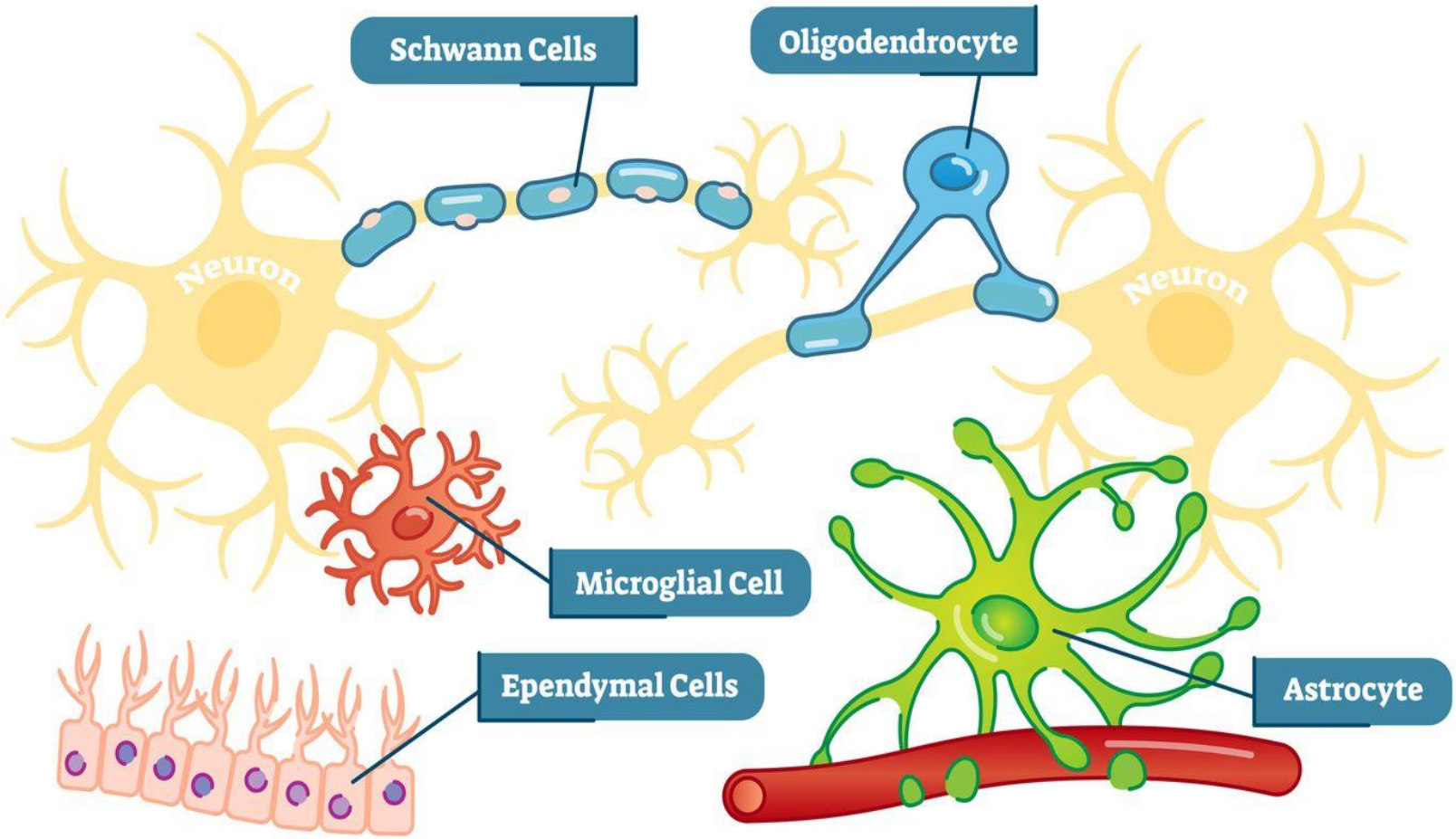
Glia can't generate electrical impulses.

There are far more glia than neurons. In fact, 90% of the cells of the CNS are glia.

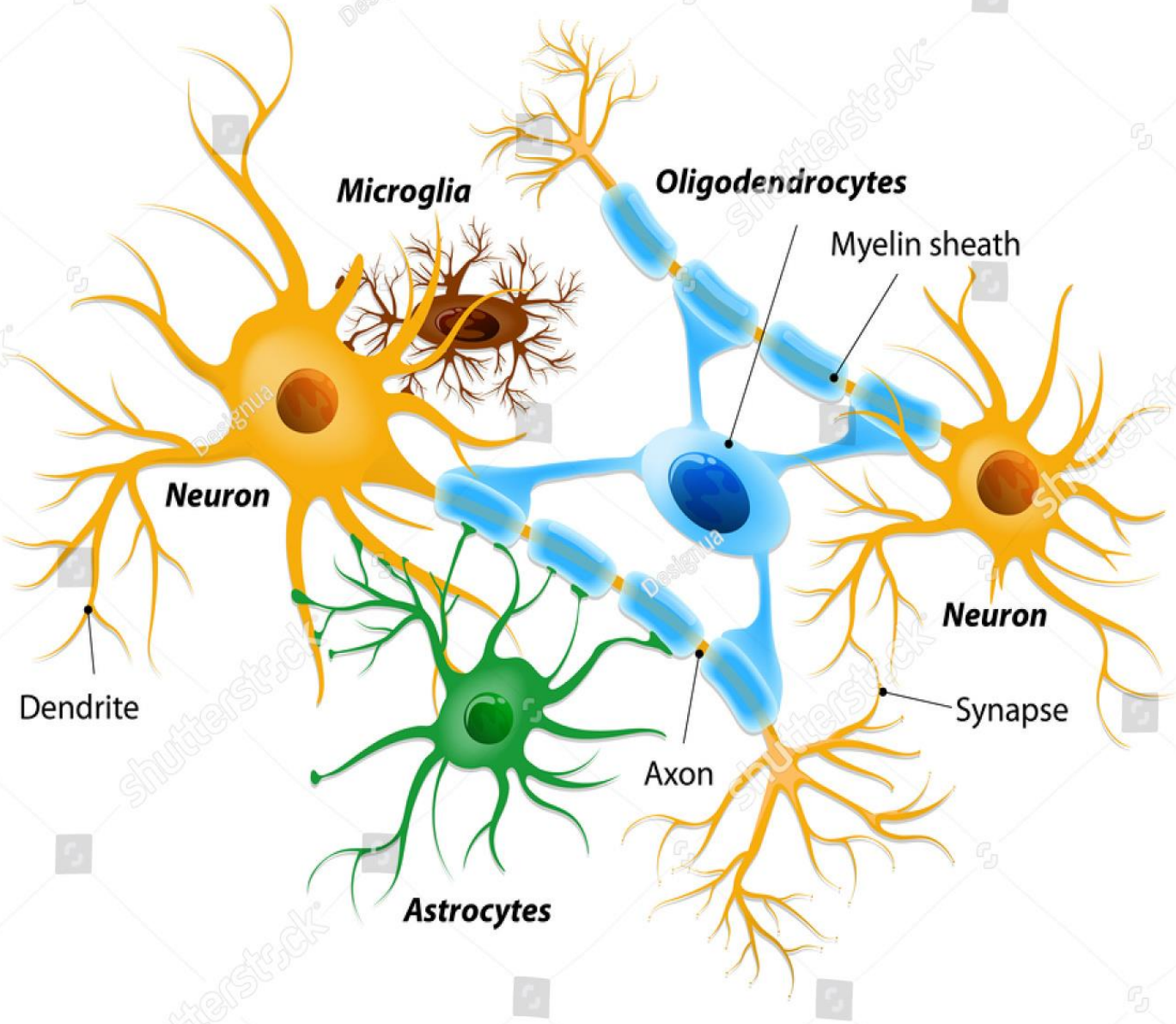
Even with the long tendrils that extend from glia, they're generally smaller than neurons.

Glia lack axons and dendrites.

Glial Cells

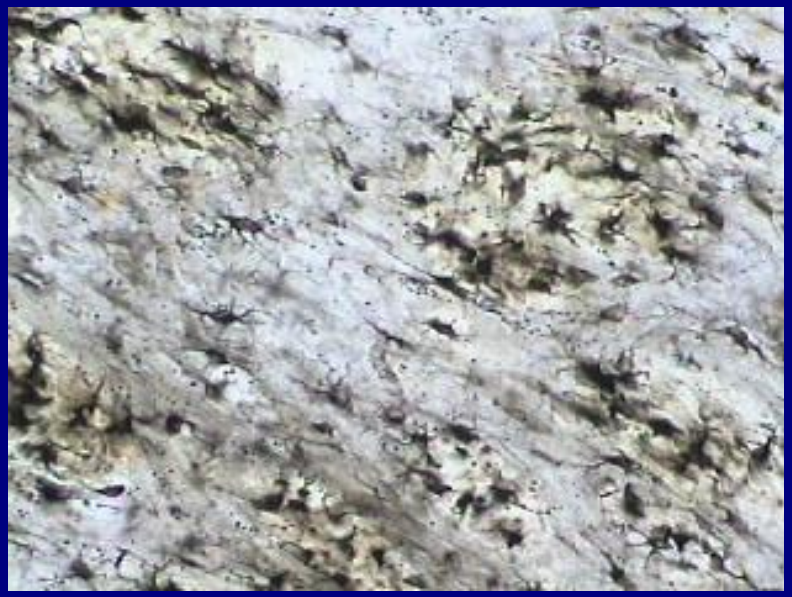

Schwann Cells
Oligodendrocyte
Neuron
Neuron
Microglial Cell
Ependymal Cells
Astrocyte

NEURONS AND NEUROGLIAL CELLS



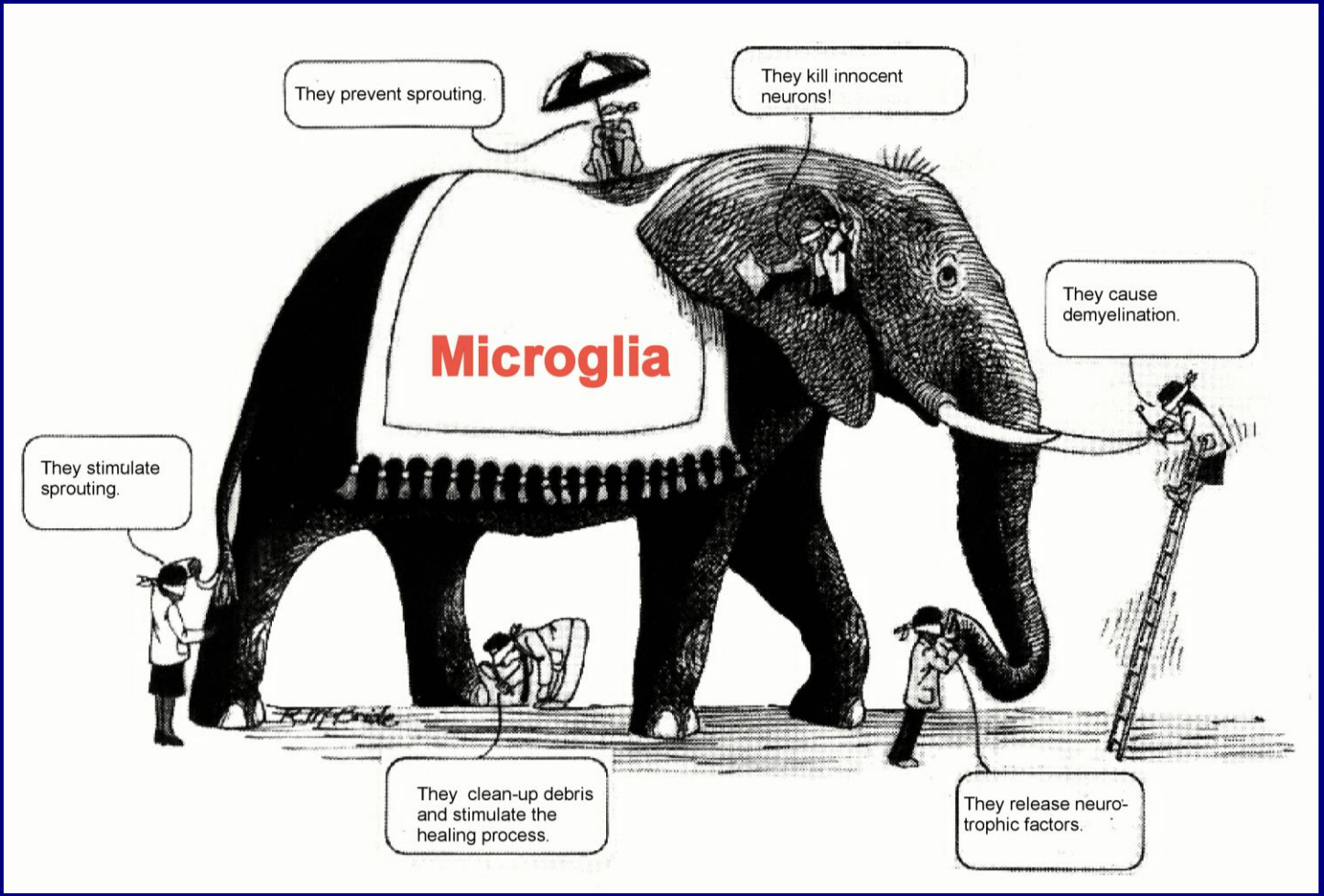
Microgliosis

Normal



Injured

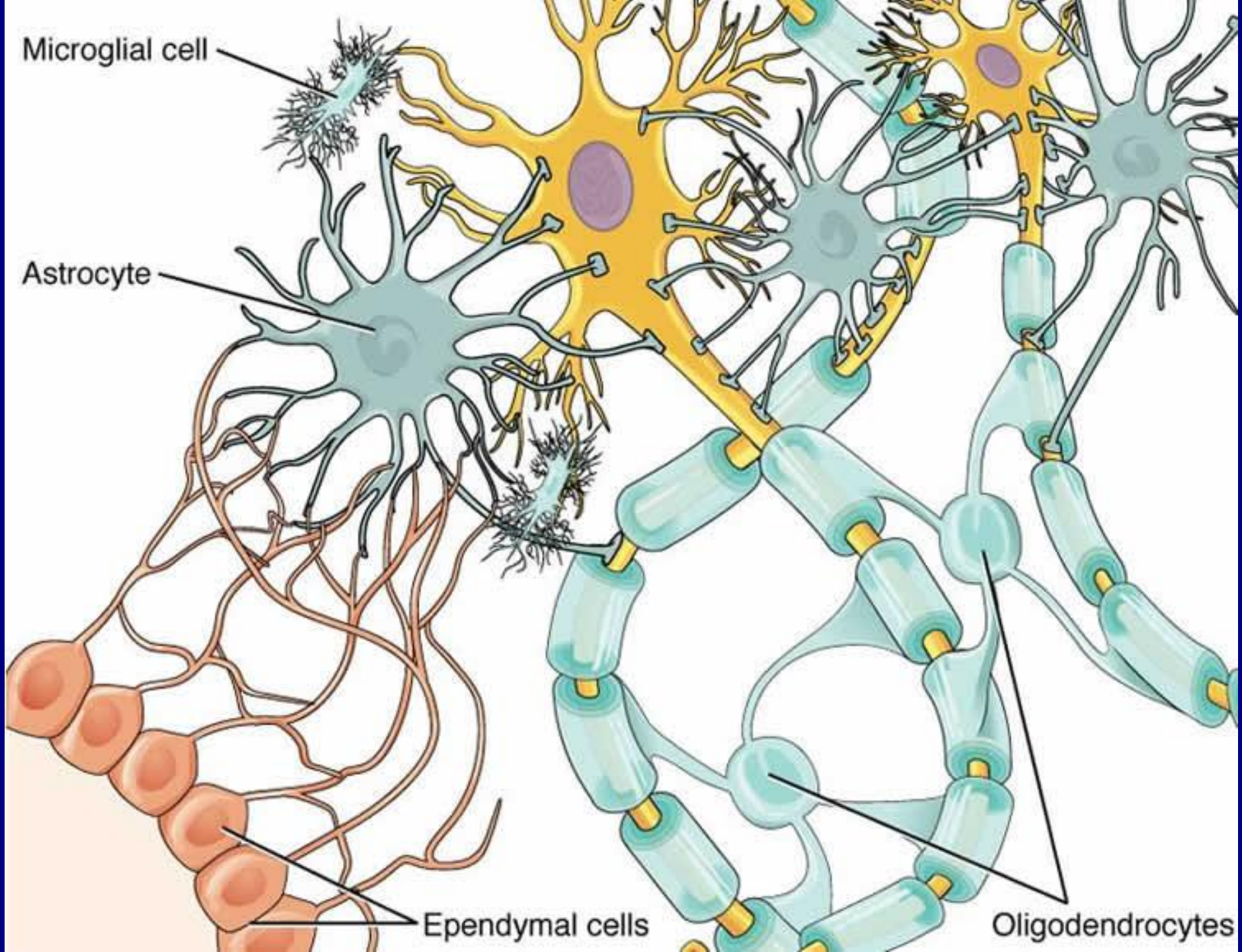
The Double Edge Sword

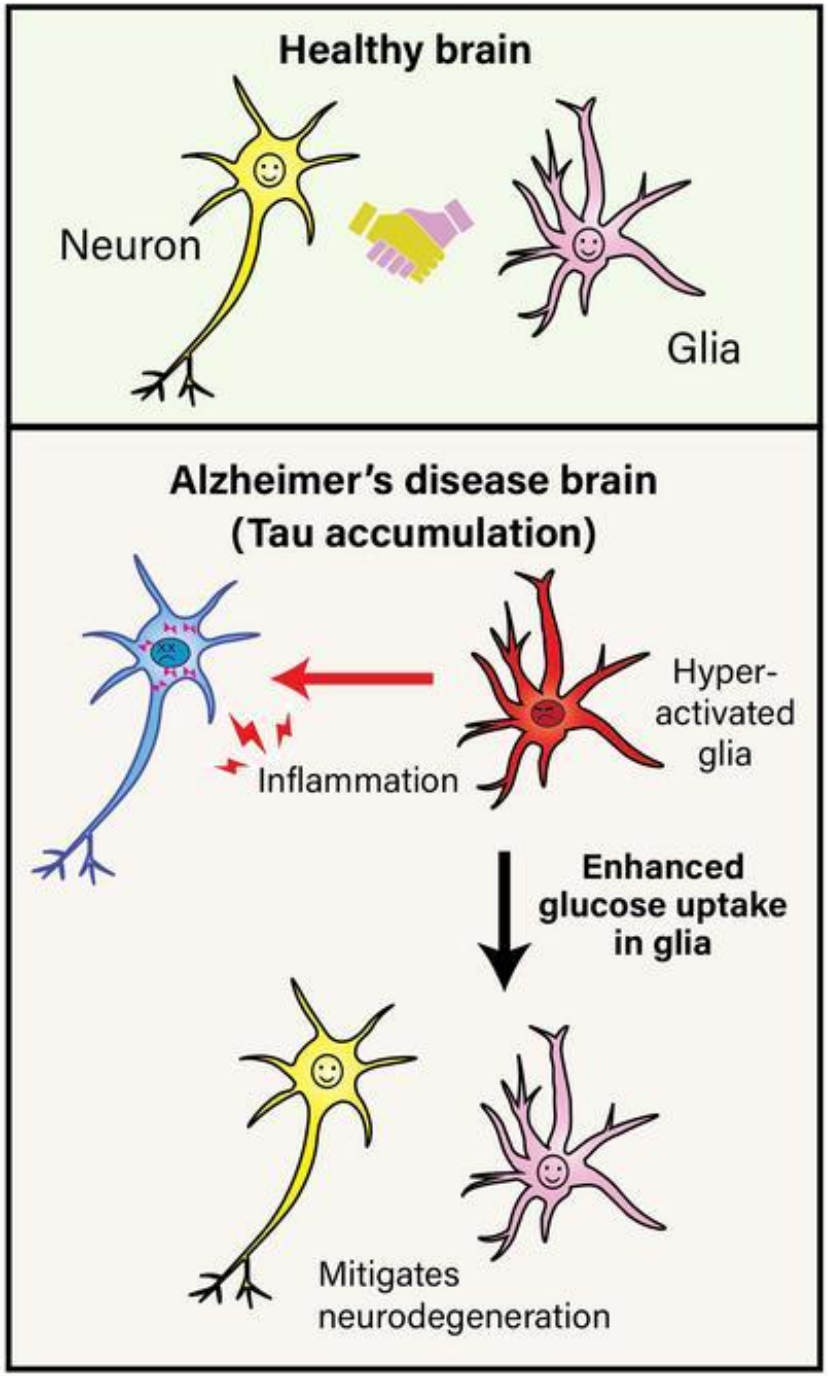


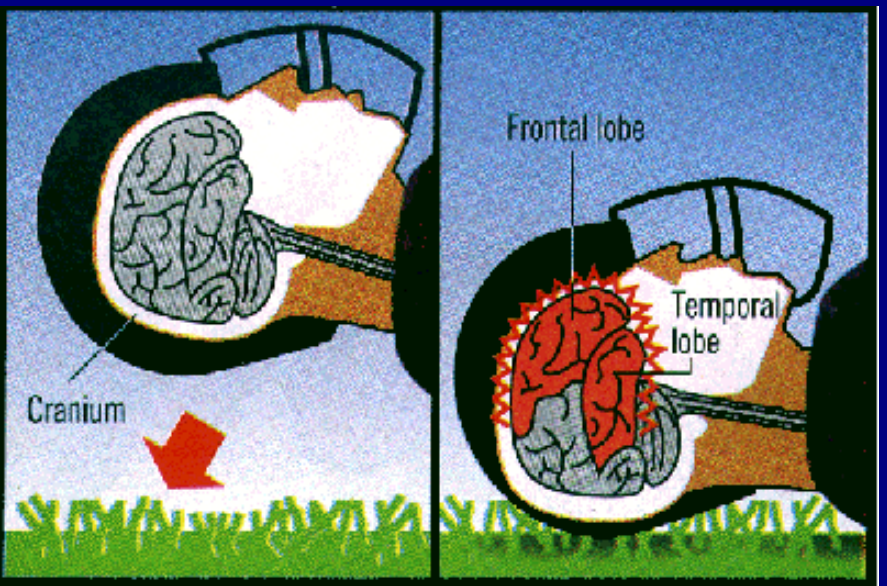
IMPORTANT TAKE HOME MESSAGE:
Prevention Is The Best Treatment

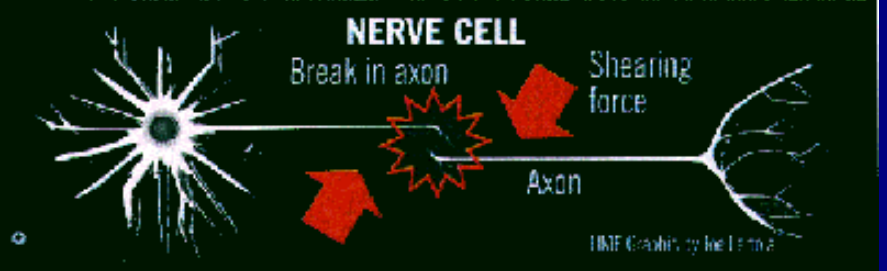
"IT TAKES VERY LITTLE ENERGY TO SCRAMBLE AN EGG, AND ALL OUR SCIENCE IS INCAPABLE OF REVERSING THAT TRANSACTION!" *RICHARD FEYNMAN,*

END


Microglial cell
Astrocyte
Ependymal cells
Oligodendrocytes


Healthy brain
Neuron
Glia
Alzheimer's disease brain
(Tau accumulation)
Inflammation
Hyper-
activated
glia
Enhanced
glucose uptake
in glia
Mitigates
neurodegeneration





- A concussion is a temporary loss of consciousness caused by a blow to the head. The brain shifts violently, sometimes smashing into the skull. Many nerves cells may break, producing such symptoms as headaches, slurred speech and loss of balance or memory

  – *Time Magazine 12/12/94*