What Is A Traumatic Brain Injury?

DONALD STEIN

Brain Repair 2020

AWell-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?

- A February 2017 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 2015 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.

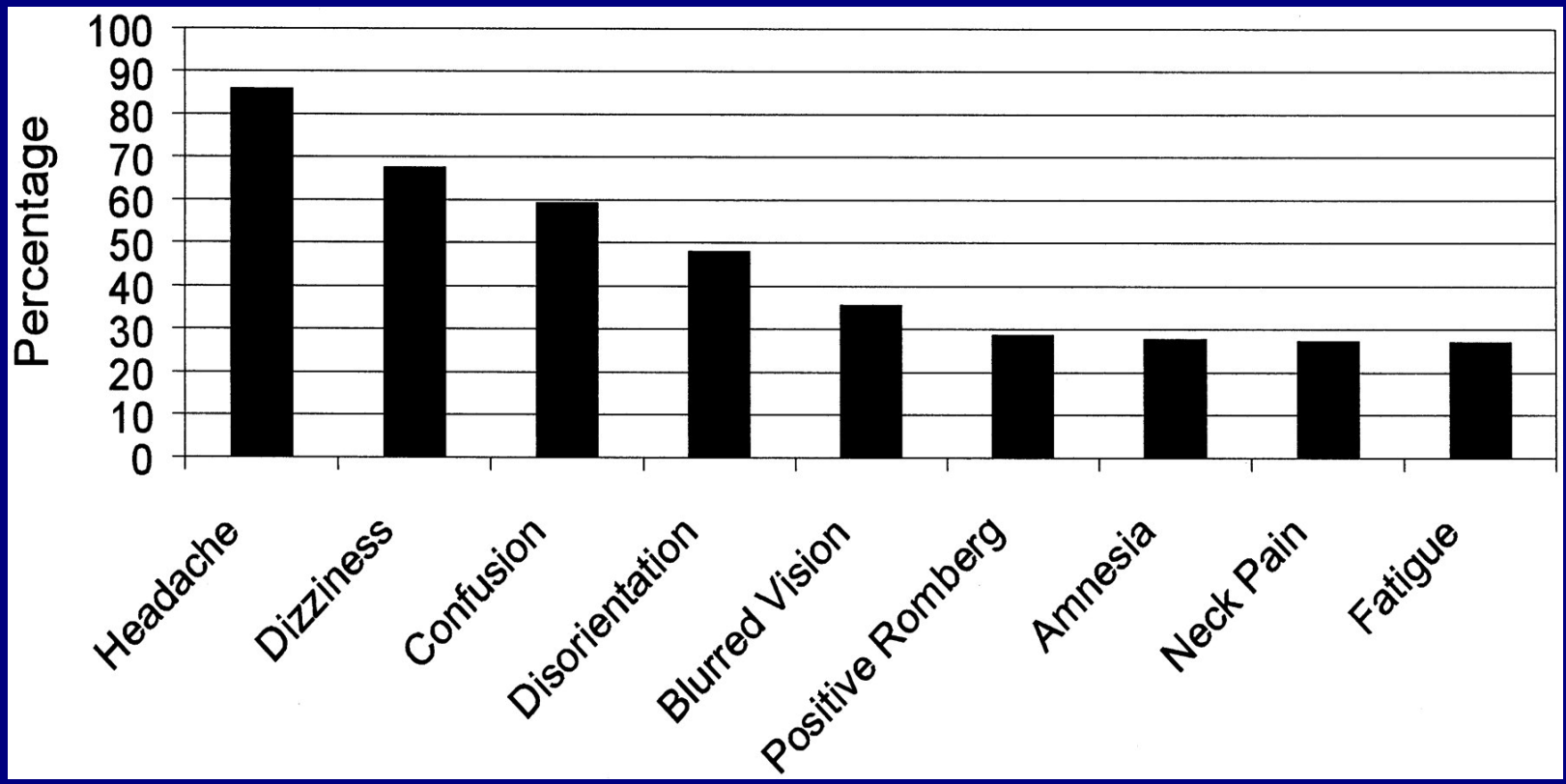
Are "Mild" Repetitive Head Injuries Dangerous?

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?

- “Heading a soccer ball results in head accelerations of less than 10 g (or less than 1000 rad/second^2) whereas the minimum values for the development of sport related concussion are 40-60 g (or 3500-5000 rad/second^2).[3 4] In contrast, 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]”

A Small Study Shows New Worries About Heading The Soccer Ball

- A brain-scan study of experienced, adult soccer players found subtle structural changes in certain parts of the brain that might be associated with repeated slight impacts.
- “Female soccer players are second only to football players in the number of concussions” that they develop each year, suggesting that head trauma is a common problem in the sport. Girls are also more likely than boys to sustain injuries during soccer heading.
- The more years a girl had played, the slower she tended to be on cognitive test. Similarly, the more hours per week a girl played, the worse she performed.

Data on Repetitive Concussions Are Controversial

- “There is no evidence that sustaining several concussions over a sporting career will necessarily result in permanent damage.[6] Research on experimental animals provides some supporting evidence against the concept that recurrent concussive injuries alone cause permanent damage. In studies of experimental concussion, animals have been subjected to repeated concussion 20-35 times in a two hour period. Despite the unusually high number of injuries no residual or cumulative effect was shown.[7]”

But, What About “Second Impact Syndrome (SIS)”?

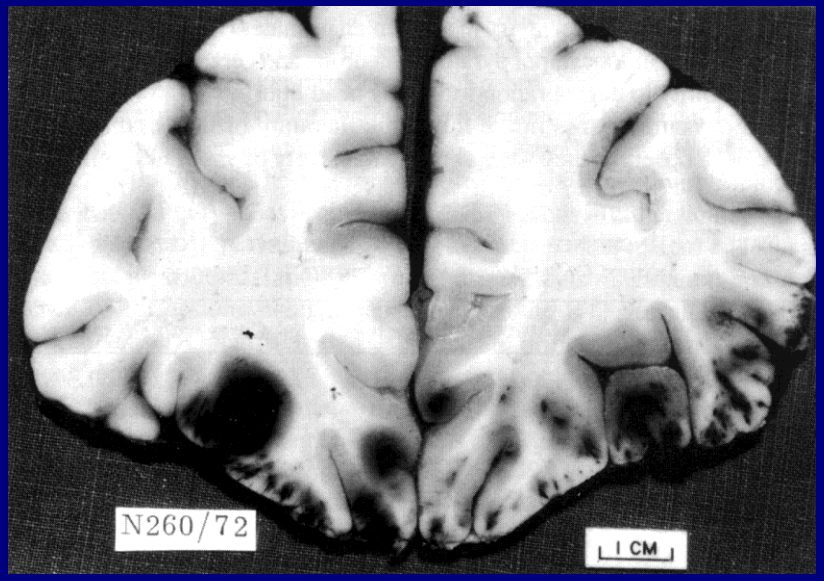
- “Importantly, even if the effects of the initial brain injury have already resolved (6-18 mo post injury), the effect of multiple concussions over time remains significant and can result in long-term neurologic and functional deficits. These multiple brain insults can still be termed repetitive head injury syndrome, but they do not fit the classification of SIS. True SIS would most likely have a devastating outcome.”

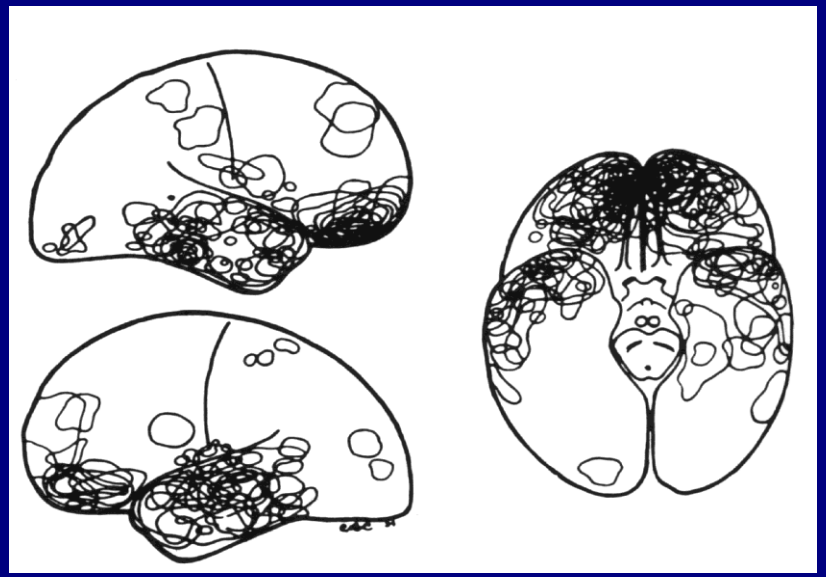
New Concussion Guidelines Stress Individual Treatment

- 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.

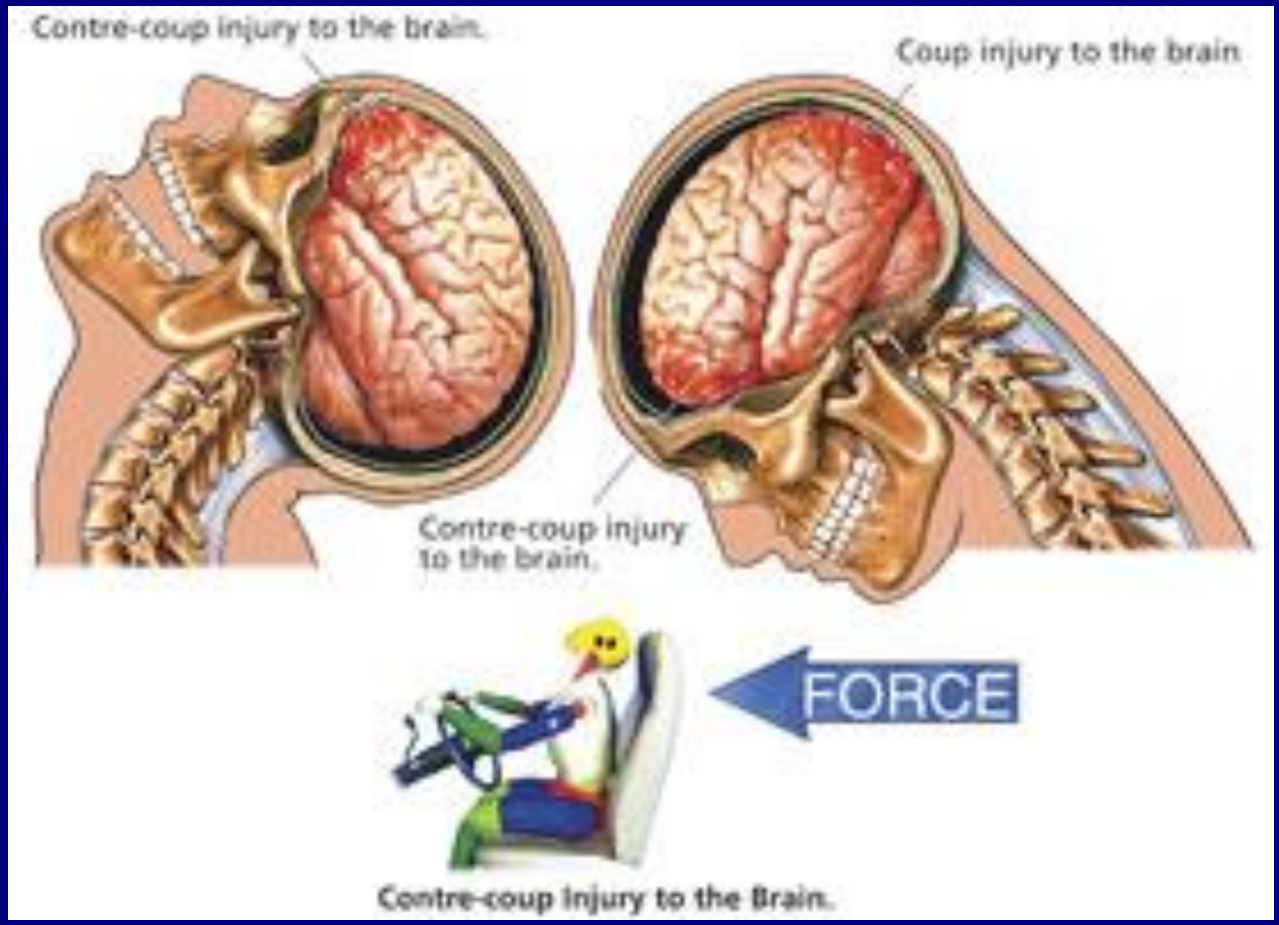
The Initial Injury



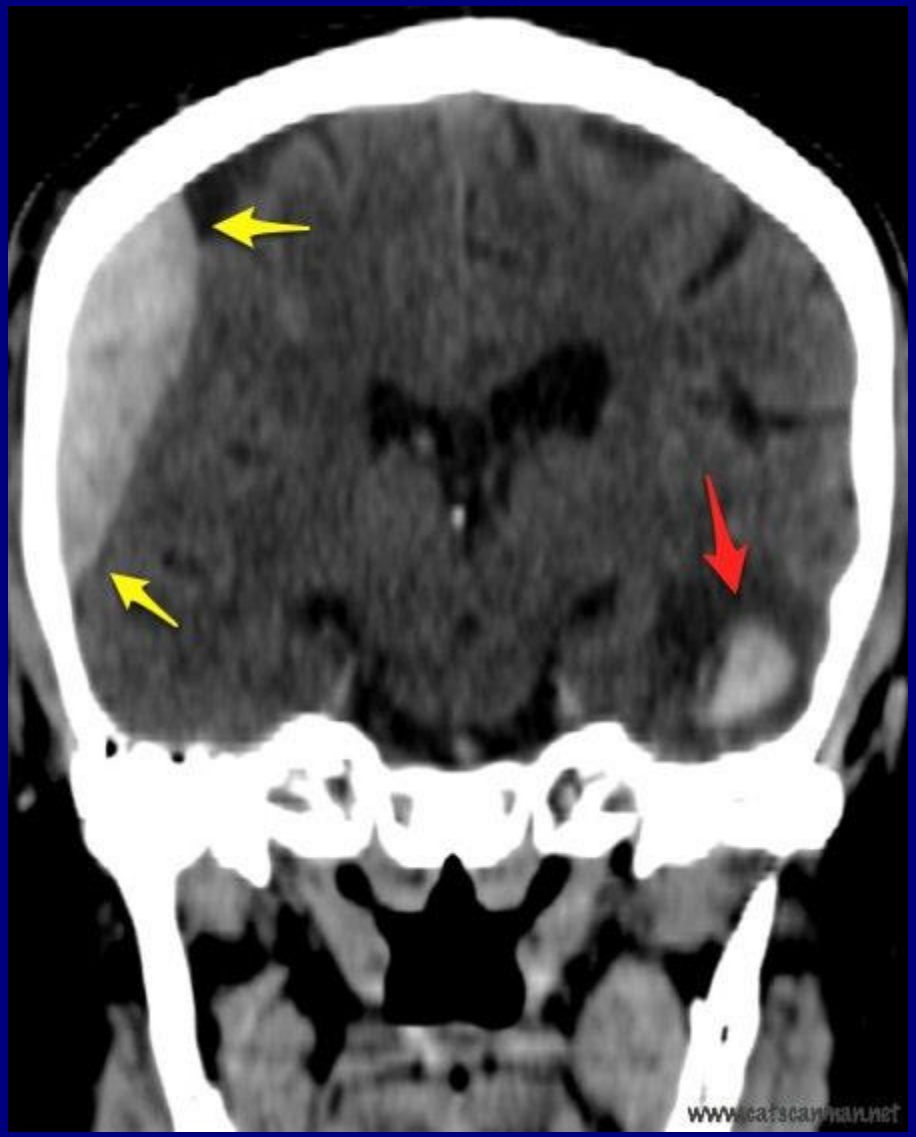





Common Contrecoup Injury



Contrecoup Injury



Contrecoup Injury On Purpose

Early Diagnosis of TBI In The Field and In The EM

Early Diagnosis Is Critical

- All TBIs require immediate assessment by a professional who has experience evaluating head injuries. *A full neurological exam will judge motor and sensory skills and test hearing and speech, coordination and balance, mental status, and changes in mood or behavior, among other abilities.*
- *Baseline screening tools for coaches and athletic trainers can help to identify the most concerning concussions for further medical evaluation.*
- 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. The need for imaging is based on a physical examination by a doctor and a person's symptoms.
- Neuropsychological tests to gauge brain functioning should be used along with imaging in people who have suffered TBI. Such tests involve performing specific cognitive tasks that help assess memory, concentration, information processing, executive functioning, reaction time, and problem solving.
- 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.
  - *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
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Spontaneously	4
BEST VERBAL RESPONSE	
No response	1
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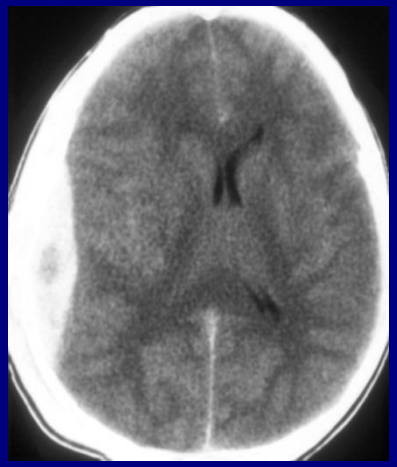
Flexion withdrawal	4
Localizes pain	5
Obeys	6
Total	3–15

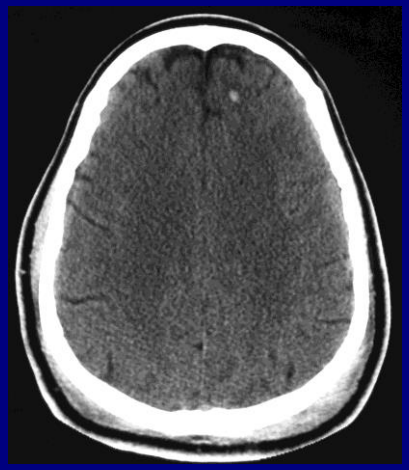
A Problem: TBI Is a Heterogenous Disease

All These Patients Have The Same GCS Score

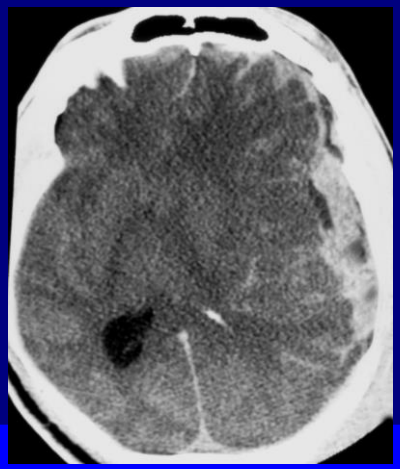


Epidural hematoma

Contusion/Hematoma



Diffuse axonal injury



Subdural hematoma

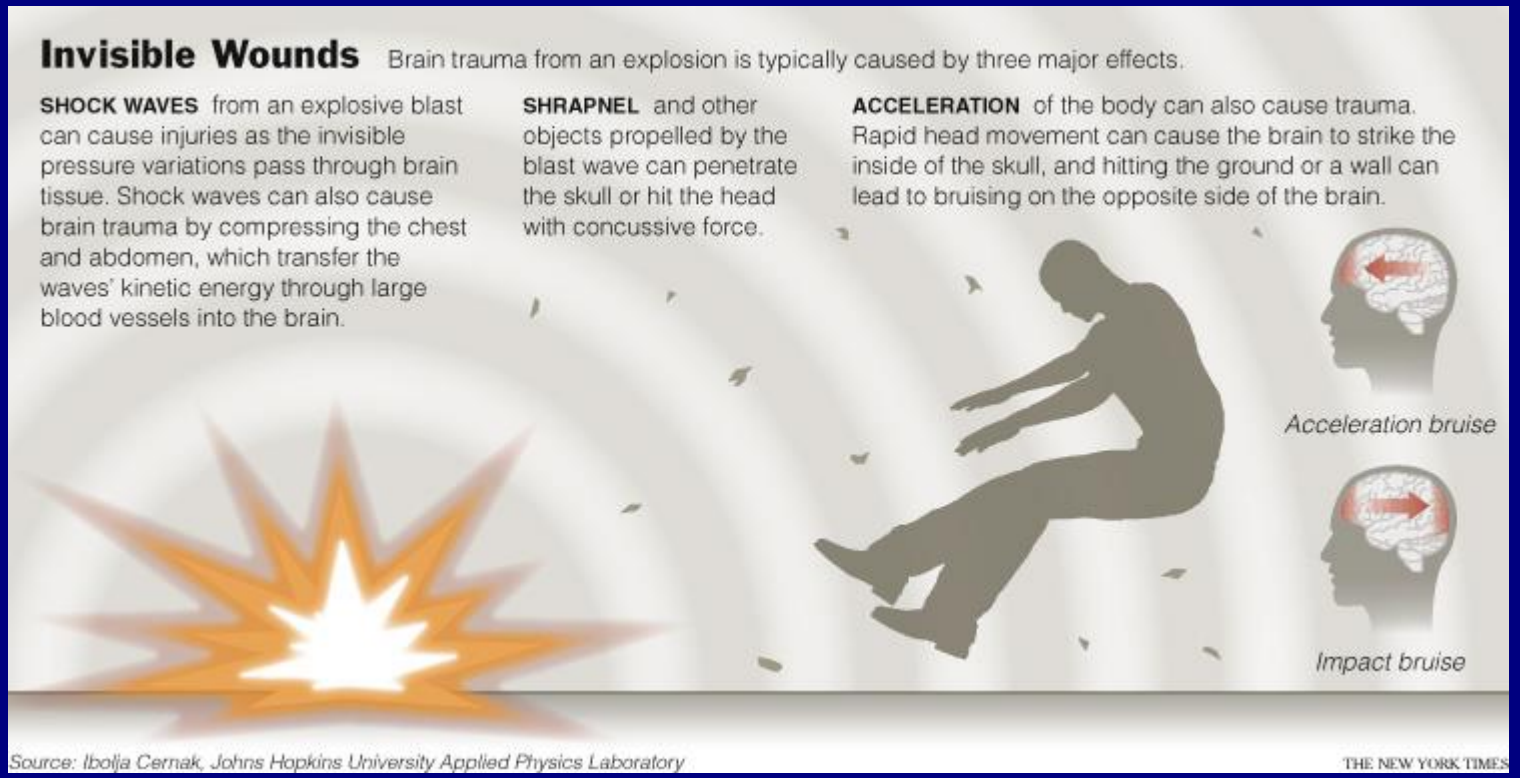
Subarachnoid hemorrhage

Diffuse swelling

Battlefield TBI

IEDs Caused 60% Of Casualties In Iraq

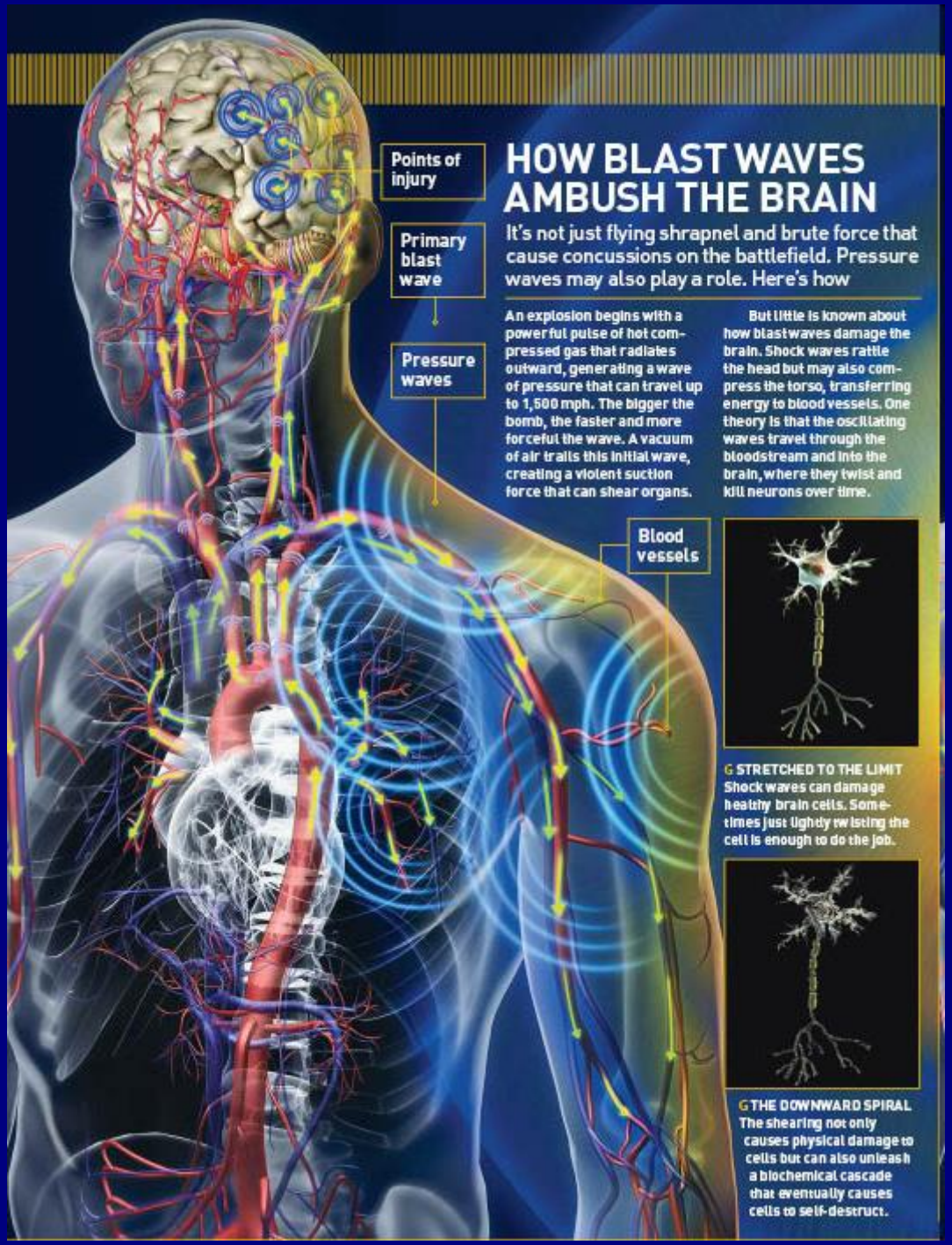
BLAST-RELATED TBI



Repetitive Small Blast Waves

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.

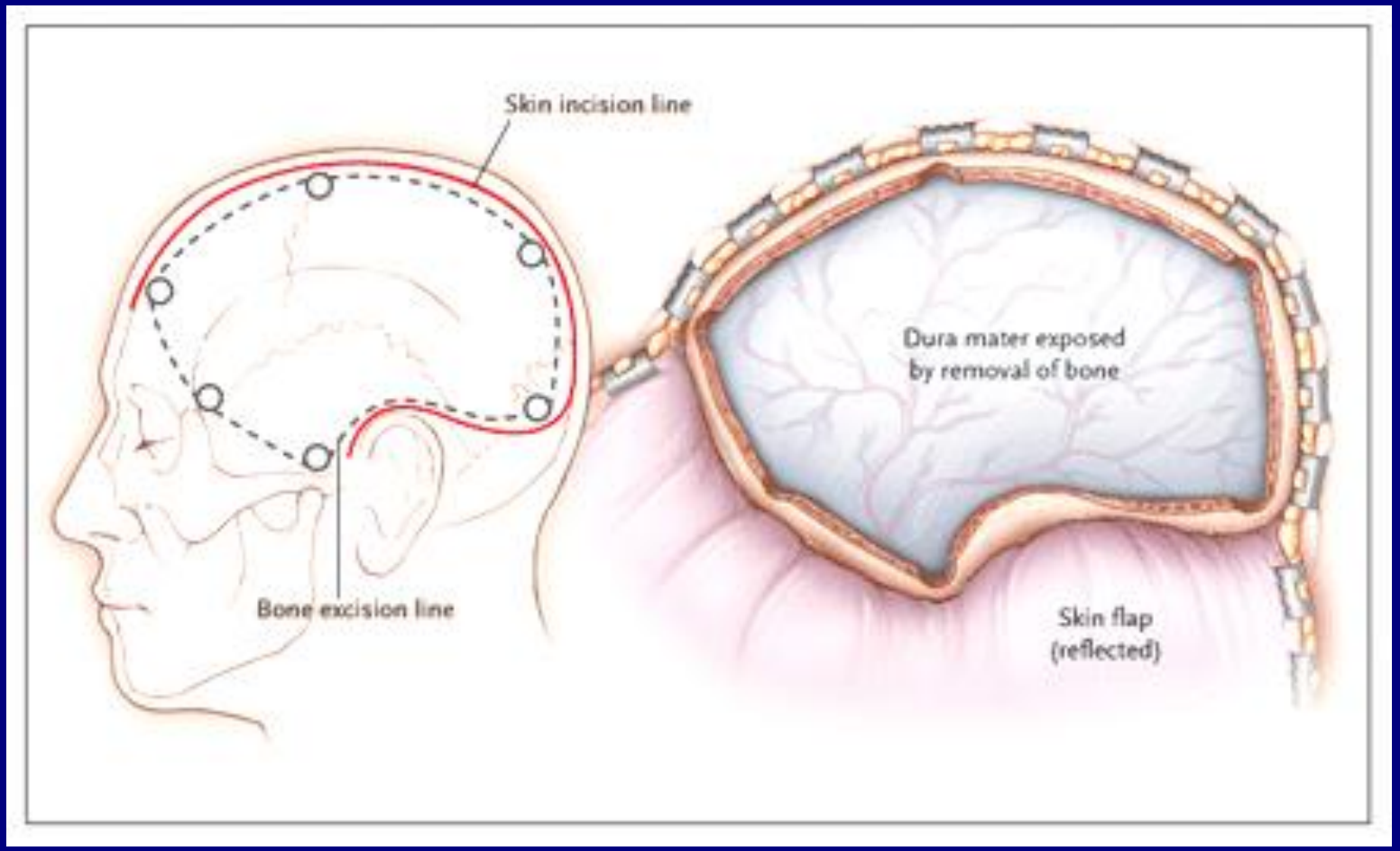
Mild Traumatic Brain Injury in U.S. Soldiers Returning from Iraq

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**

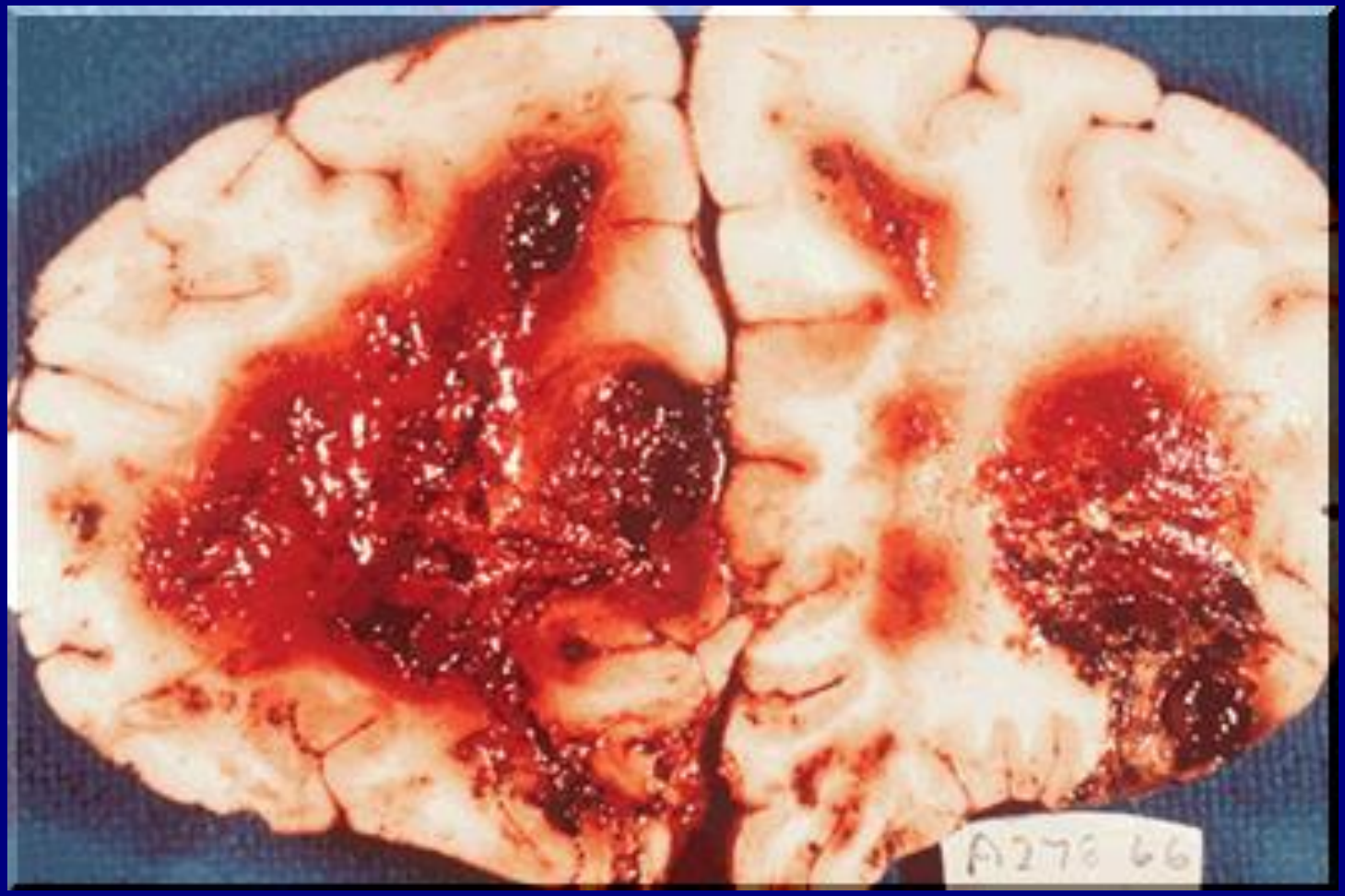
- Surveyed 2525 U.S. Army infantry soldiers 3 to 4 months after their return from a year-long deployment to Iraq.
- 43.9% met criteria for post-traumatic stress disorder (PTSD), compared with 27.3% reporting altered mental status, 16.2% with other injuries, and 9.1% with no injury.
- *Conclusions Mild 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.

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



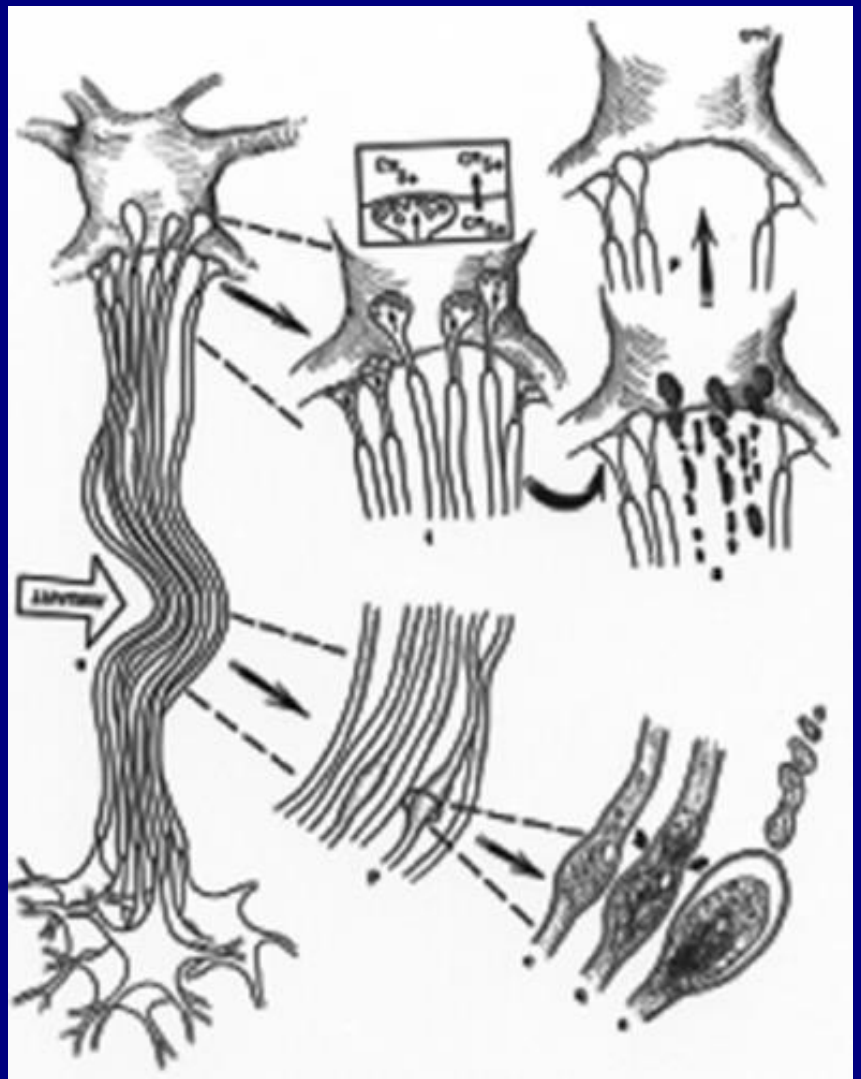
Pentrating Injury

Penetrating Brain Injury



More Details On What Happens When A TBI Occurs

Deafferentation

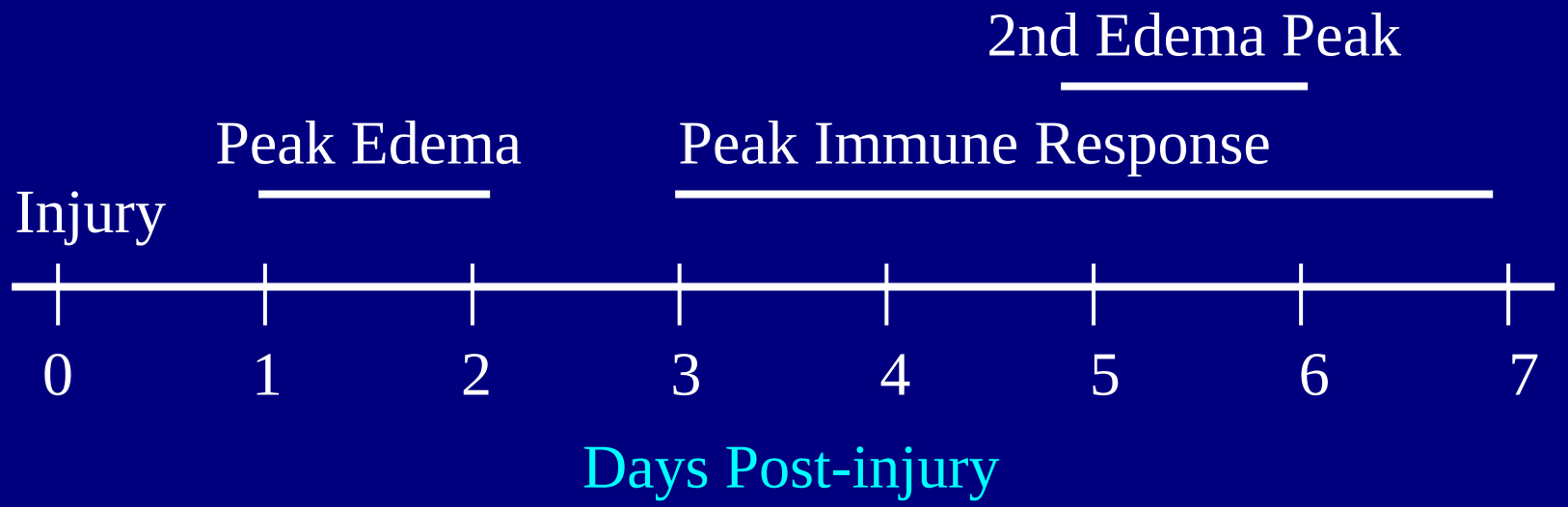


- *Stretch*
- *Disconnection*
- *Degeneration*
- *Deafferentation*
- *Loss of inter-neuronal communication*
- *Behavioral morbidity*

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



Brain Injury Is A Complex & Systemic Cascade Of Events

The Molecular and Cellular Aspects of Traumatic Brain Injury

IMPORTANT TAKE HOME MESSAGE:
Prevention Is The Best Treatment

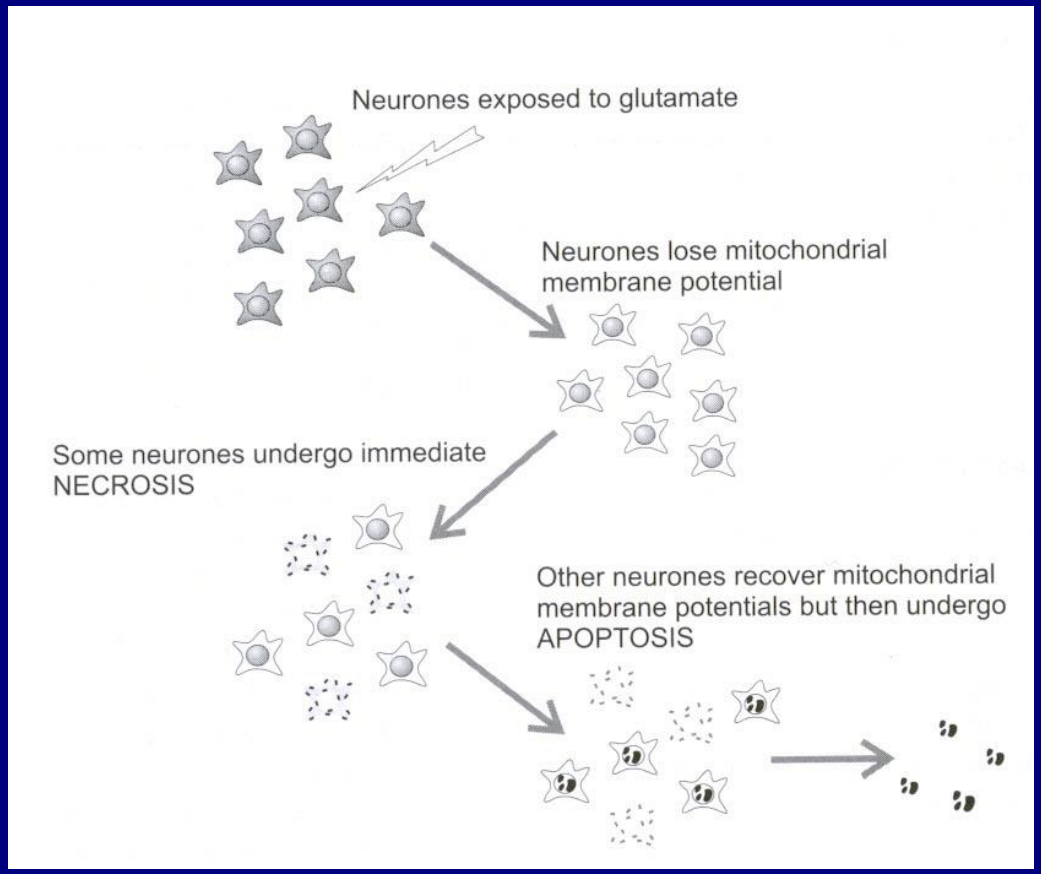
"IT TAKES VERY LITTLE ENERGY TO SCRAMBLE AN EGG, AND ALL OUR SCIENCE IS INCAPABLE OF REVERSING THAT TRANSACTION!" *RICHARD FEYNMAN,*

END

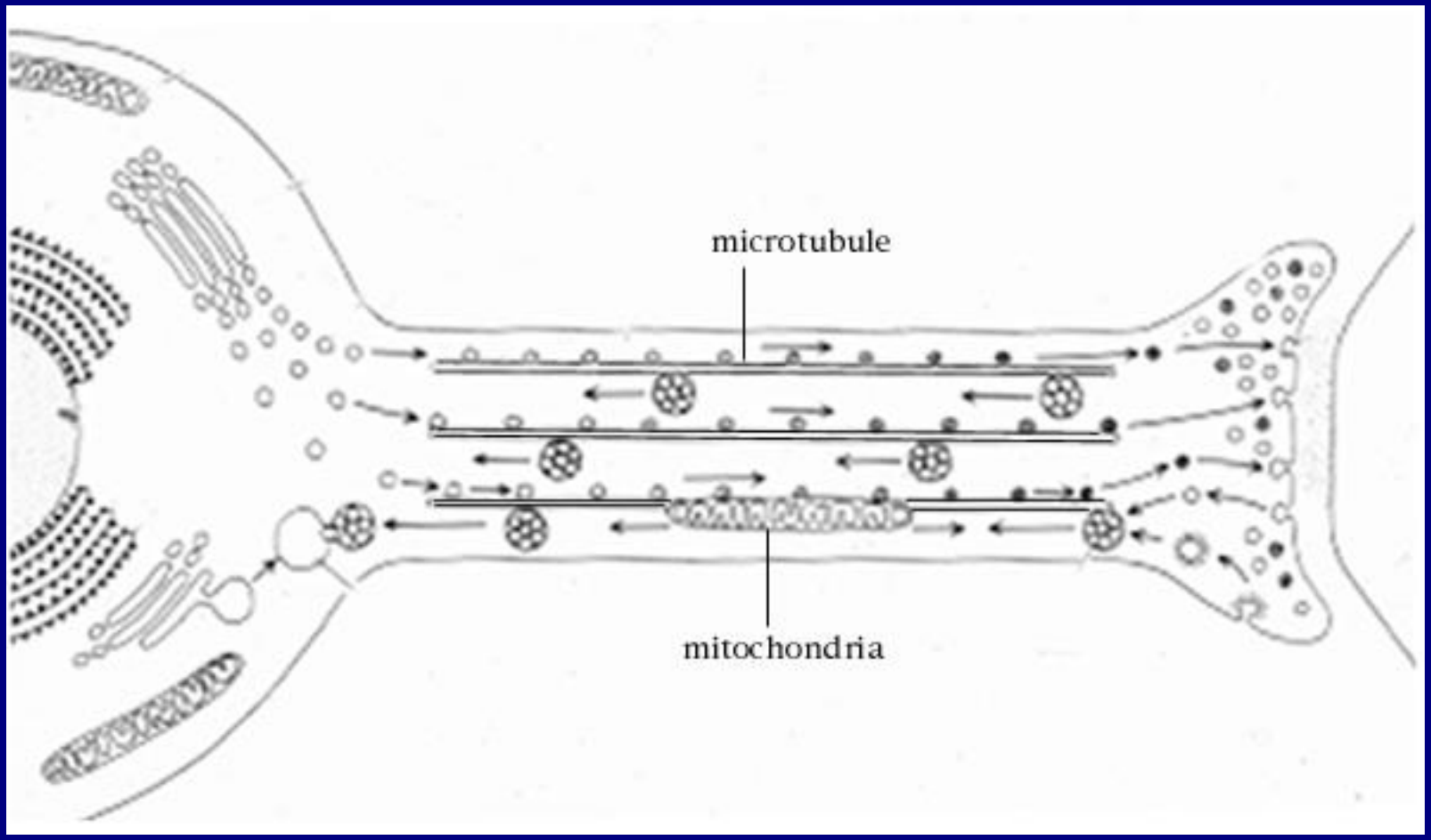
Traumatic Brain Injury Still Remains A Serious Medical Challenge

- Despite recent progress in understanding what happens in the brain following TBI, more than 30 large clinical trials have failed to identify 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 age and overall heath, and the time between the injury and the initiation of treatment.
- *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.*

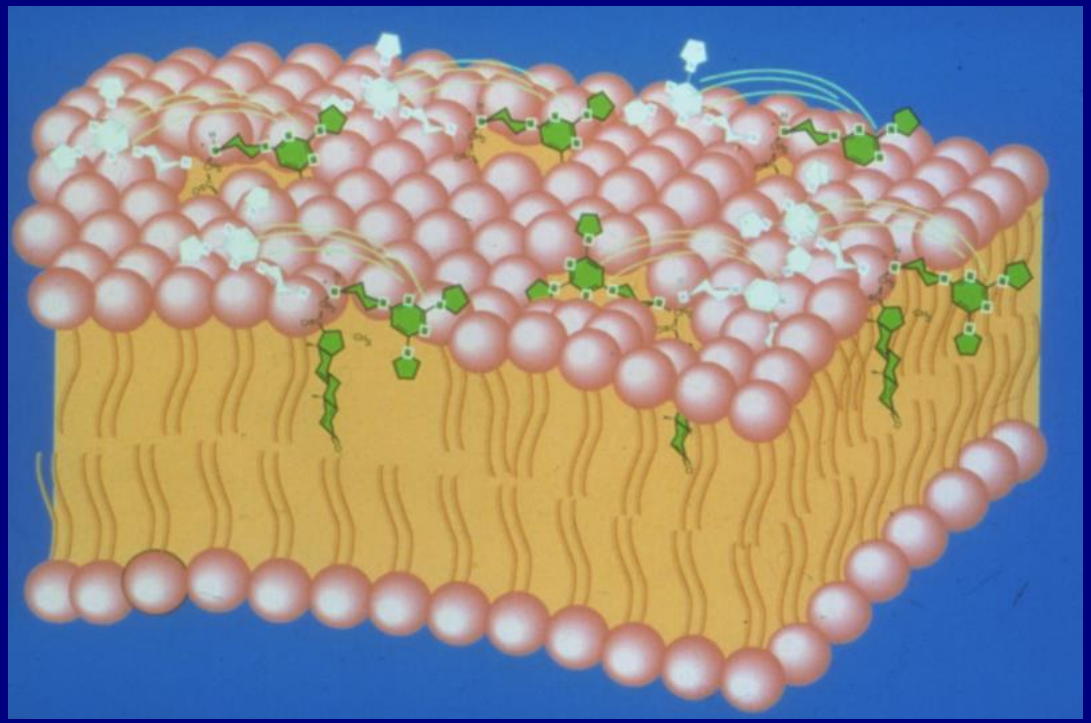
How Neurons Die



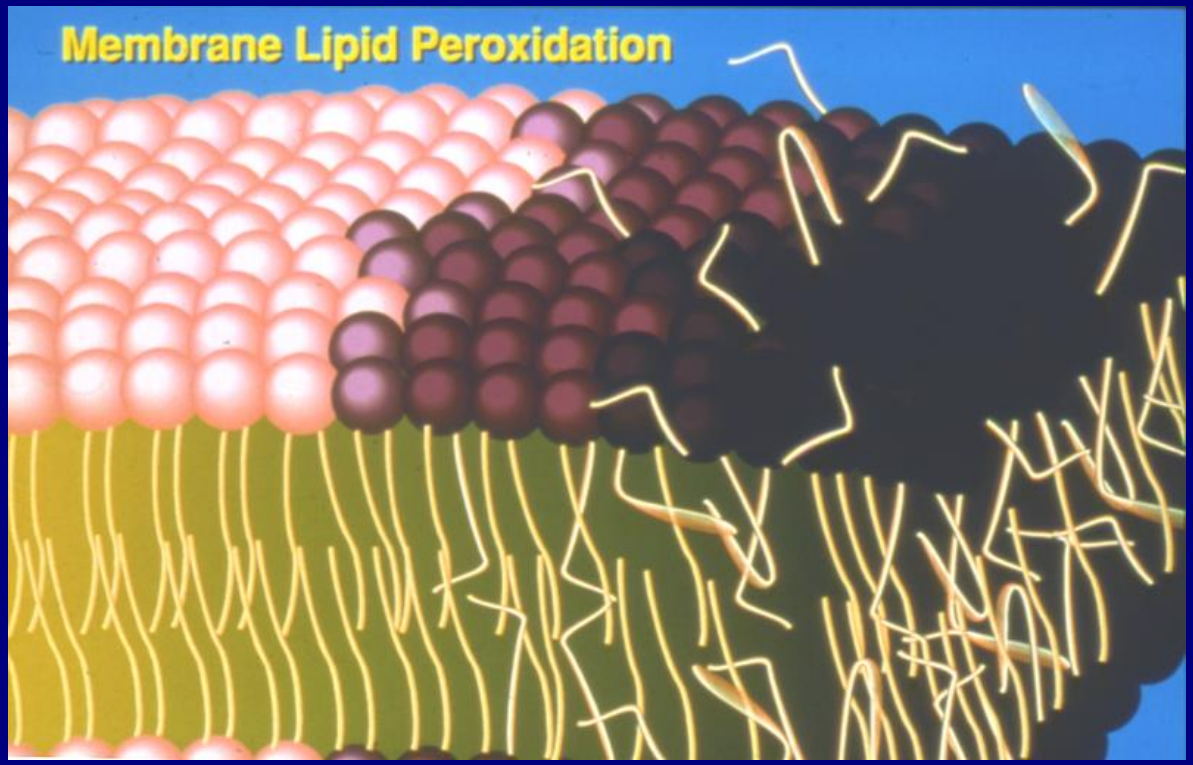
Axonal Transport



Normal Cell Membrane



Cellular Membrane After Free Radical Damage



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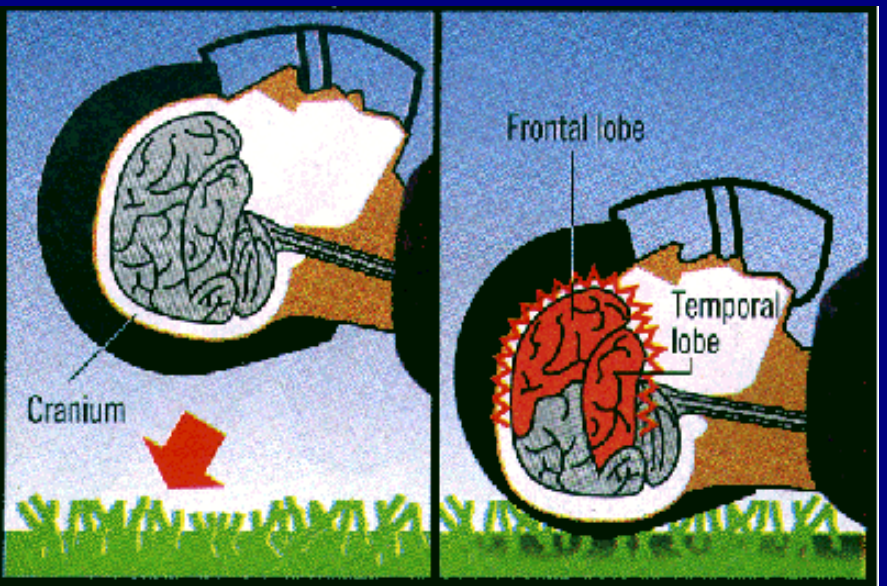
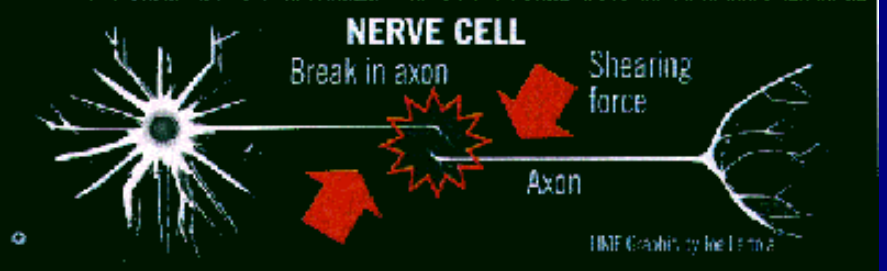
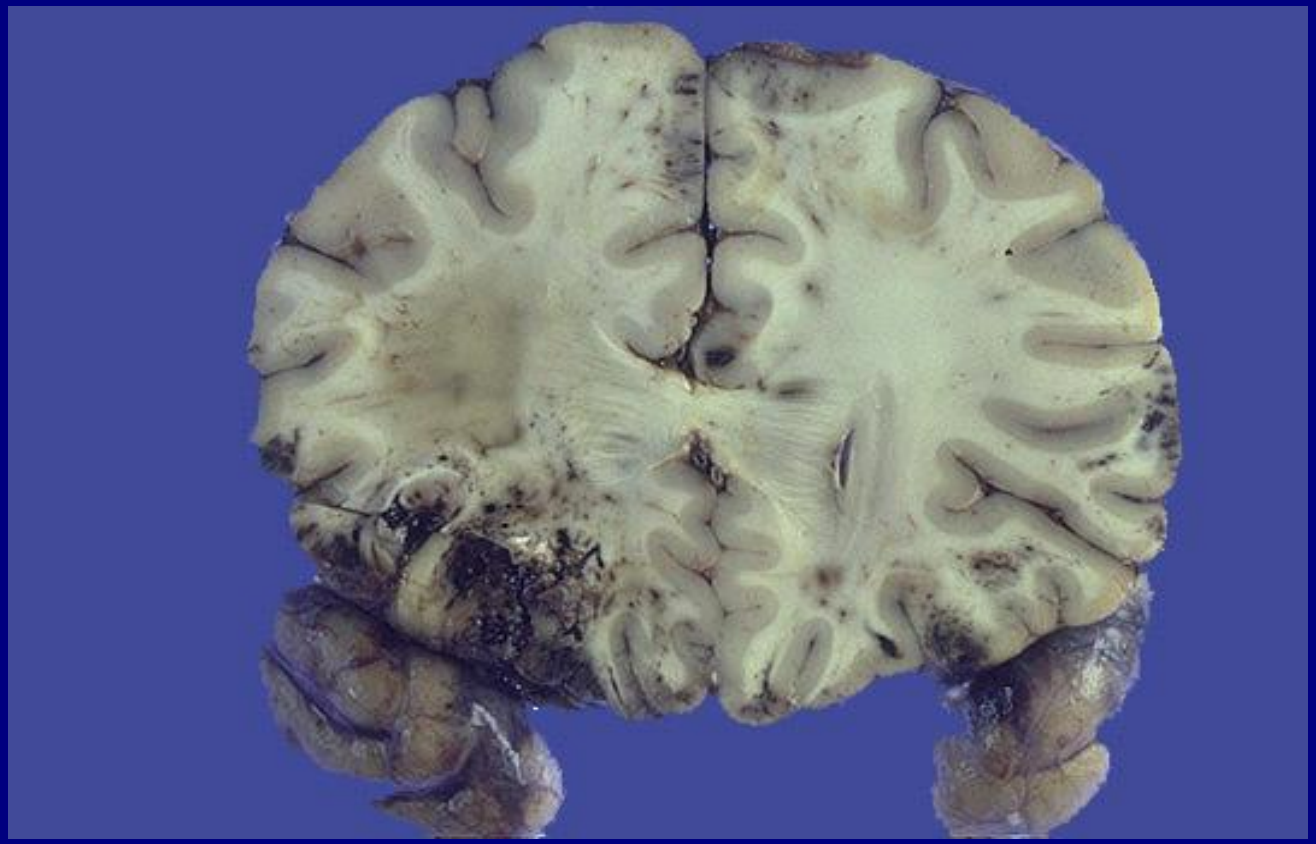


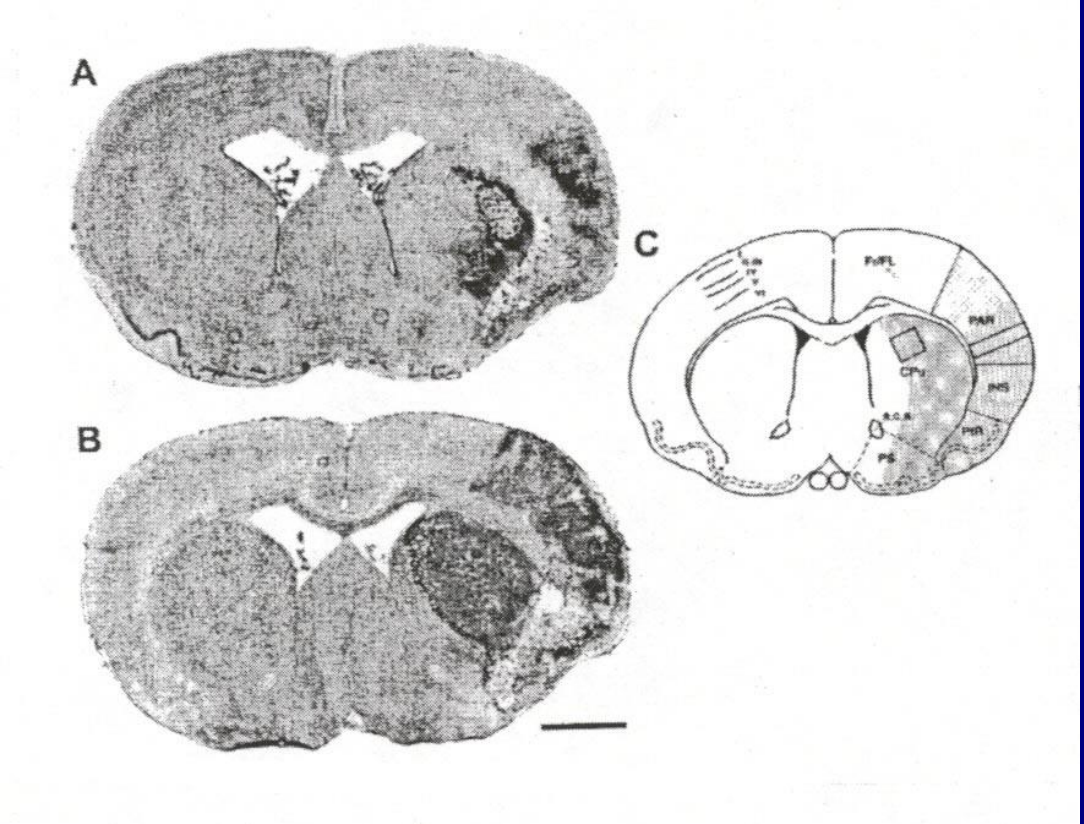


- A concussion is a temporary loss of consciousness caused by a blow to the head. The brain shifts violently, sometimes smashing into the skull. Many nerves cells may break, producing such symptoms as headaches, slurred speech and loss of balance or memory

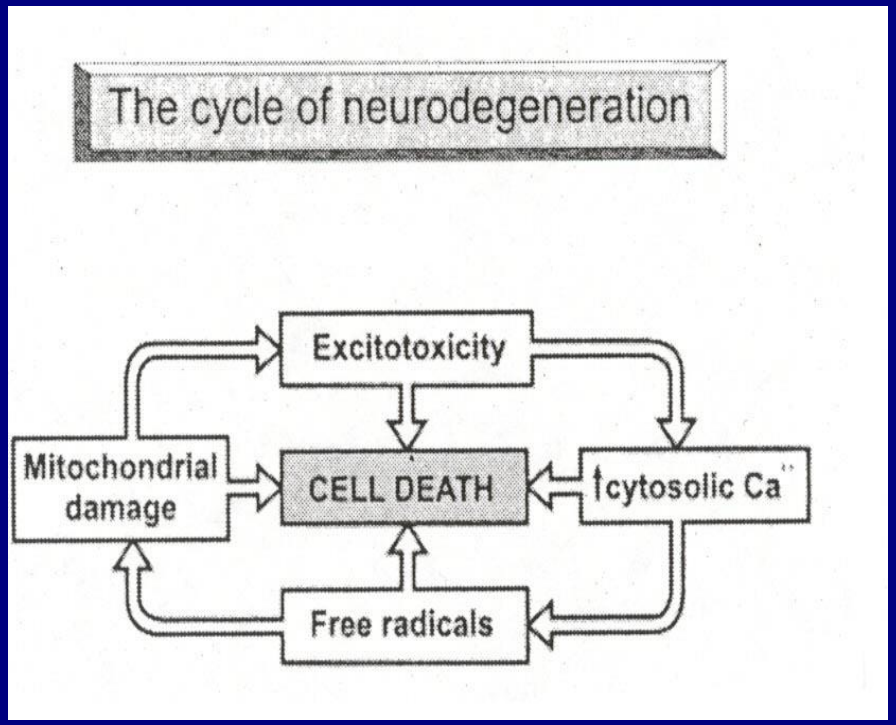
  – *Time Magazine 12/12/94*



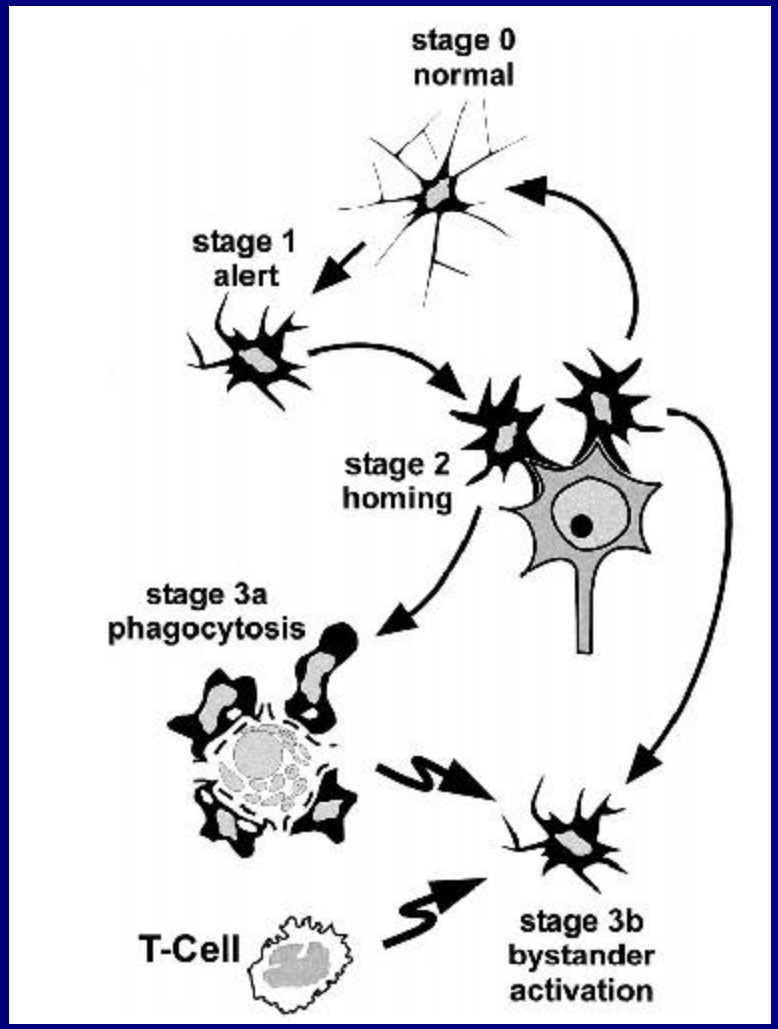
Trauma & Ischemia in Brain Injury



Schema of Degeneration

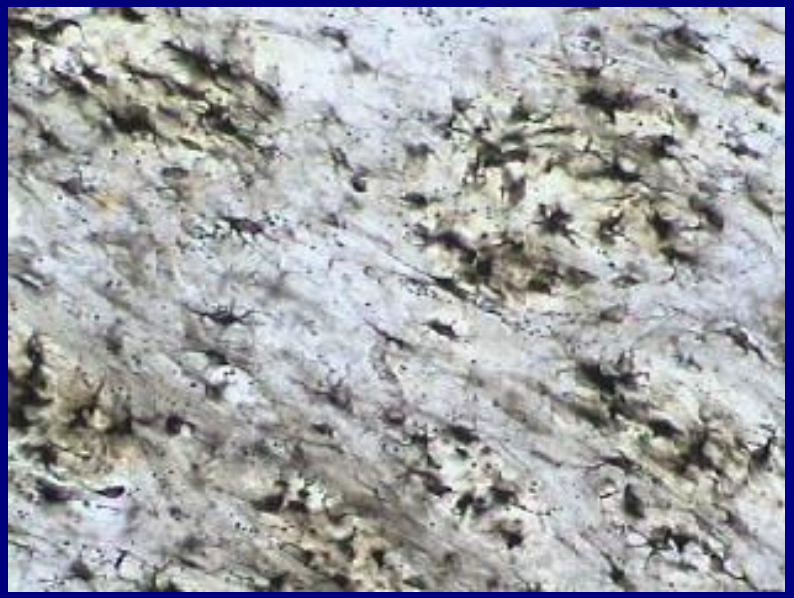


Microglial Activation



Microgliosis

Normal



Injured

The Double Edge Sword