Pulsed electromagnetic fields (PEMFs) for cell injury and repair:
how PEMFs promote longevity and reduce the rate of aging

By: William Pawluk, MD, MSc

At the cellular level aging is a process of declining capacity for and effectiveness of repair of cell injury. With aging there is cumulative, unrepaired or poorly repaired natural or unnatural cell injury. This is "death by a 1000 cuts." Promoting longevity requires facilitating cell recovery and repair at the earliest stages of cell injury. With about 70 trillion cells in an adult body, cell injury is common and repair is ongoing. Wherever there is pain, suffering and dysfunction there is cell injury.

Cell injury results when:

- cells can no longer adapt to stress,
- have unrecoverable exposure to damaging agents or
- suffer from intrinsic abnormalities, whether genetic or nutrient-based.
- the limits of adaptive responses of cells are exceeded or

Cell injury can progress from milder reversible states through more severe irreversible conditions leading to tissue and or organ failure of varying degrees, and finally senescent apoptotic or necrotic cell death.

In the stages of reversible injury there is:

- reduced oxidative phosphorylation with depletion of ATP,
- cellular edema caused by changes in ion and water flows,
- mitochondrial and cytoskeleton alterations and
- DNA damage.

Aging can be slowed or reversed by ongoing health maintenance, including mitigating known causal circumstances, and also proactive use of low intensity, low frequency, (LI/ELF) PEMFs.
PEMFs improve the rate of aging by reducing and/or reversing various degrees of cell injury.
PEMFs are known to pass uninhibited through the body, while inducing charge in cells and tissues, consequently affecting biochemical and physiologic processes in the direction of reducing cell injury, and therefore aging.

PEMFs improve various physiologic processes including

- production of nitric oxide,
- reducing pain and inflammation,
- improving circulation,
- enhancing cellular membrane function and metabolism, communication and replication and growth and repair.

PEMFs improve biochemical activity at the cellular level and allow nutrients and other life extending chemistry in the body to migrate more freely to be more functionally useful.
PEMFs should be part of a comprehensive program to reduce suffering and enhance higher quality longevity.

The normal cell handles physiologic demands, maintaining a steady state called *homeostasis*.

Adaptations are reversible functional and structural responses to more severe physiologic stresses and some pathologic stimuli.

With adaptation new but potential, nonetheless altered steady states still happen, allowing the cell to survive and continue to function. Call this balanced imbalance.

Cell Injury progresses through a reversible stage and may end in cell death.
The hallmarks of reversible injury are

- reduced oxidative phosphorylation with depletion of ATP,
- cellular swelling caused by changes in ion concentrations and water influx
- mitochondria and cell skeleton alterations
- and DNA damage.

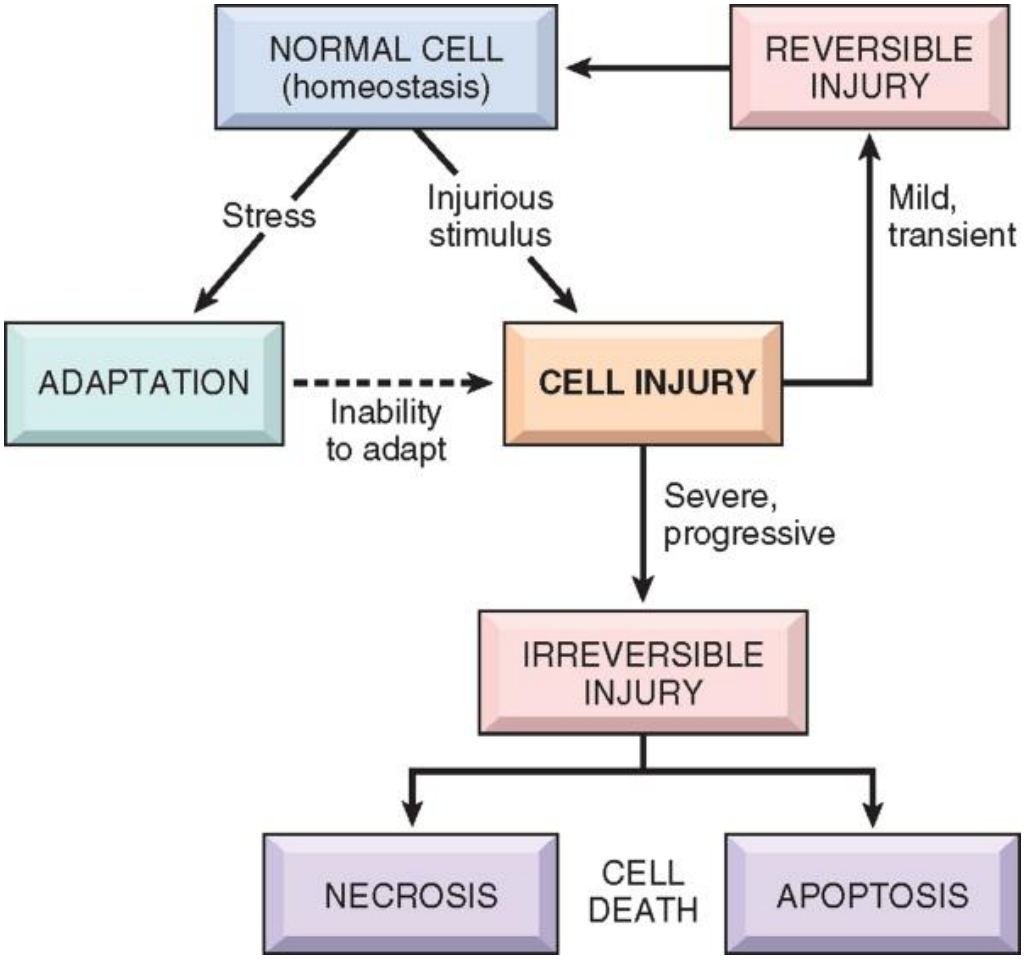


FIGURE 1-1 Stages of the cellular response to stress and injurious stimuli.
From Kumar: Robbins and Cotran Pathologic Basis of Disease, Professional Edition , 8th ed.

All disease starts with micro-molecular or structural alterations in individual cells.

Injury to sufficient numbers of cells and to the matrix between cells ultimately leads to *tissue and organ injury*. The cumulative burden of these unrecovered cells and cell functions, leads to aging.

The end results of genetic, biochemical, or structural changes in cells and tissues are functional abnormalities, which lead to clinical manifestations (symptoms and signs) and then may become disease.

Within limits, the cell can repair these derangements and, if the injurious stimulus goes away, can return to normal.

With continuing damage, the injury

- becomes irreversible,
- the cell cannot recover and
- it dies, either through necrosis or apoptosis.

The major causes of cell injury are:

- Oxygen Deprivation
- Physical Agents
- Chemical Agents and Drugs
- Infectious Agents
- Immunologic Reactions
- Genetic Derangements
- Nutritional Imbalances

Physical agents causing cell injury include

- mechanical trauma,
- extremes of temperature (burns and deep cold),
- sudden changes in atmospheric pressure,
- radiation, and electric shock.

Cell injury progresses through various stages, during any of which repair may be possible if adequately facilitated, either naturally or by the application of various treatments.

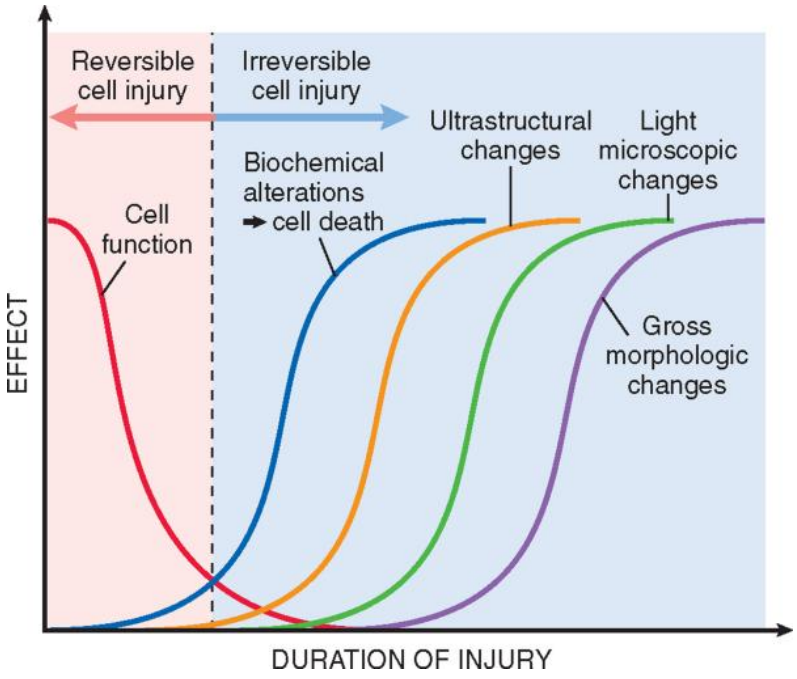
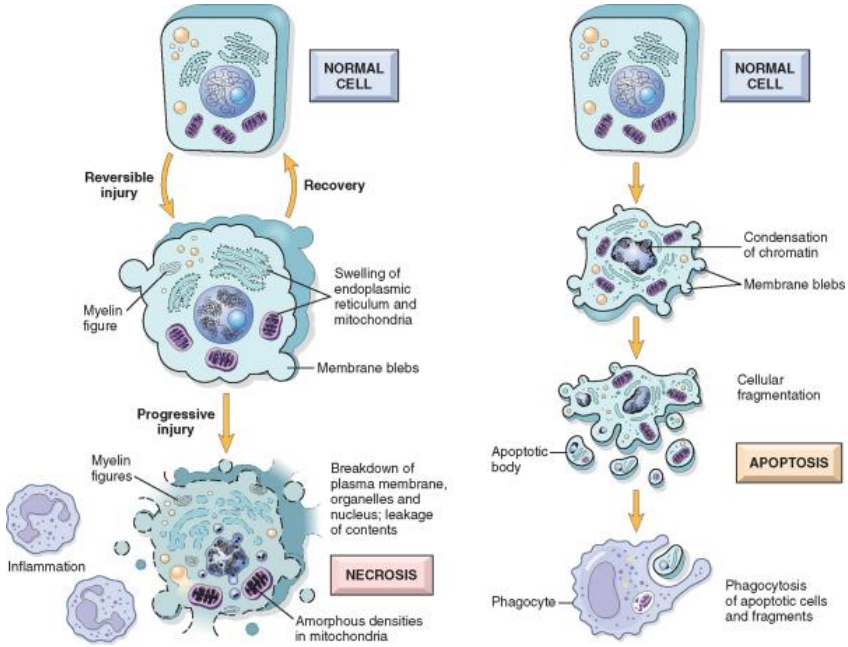


FIGURE 1-7 Sequential development of biochemical and morphologic changes in cell injury. Cells may become rapidly nonfunctional after the onset of injury, although they are still viable, with potentially reversible damage; a longer duration of injury may eventually lead to irreversible injury and cell death. Note that irreversible biochemical alterations may cause cell death, and typically this precedes ultrastructural, light microscopic, and grossly visible morphologic changes.
From Kumar: Robbins and Cotran Pathologic Basis of Disease, Professional Edition , 8th ed.



Persistent or excessive injury, causes cells to pass a nebulous “point of no return” into irreversible injury and *cell death*.

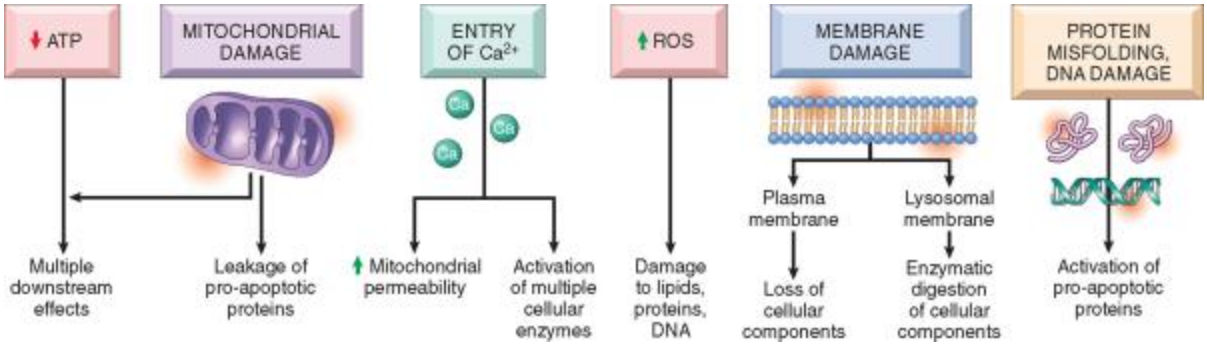


FIGURE 1-16 The principal mechanisms of cell injury, and their biochemical and functional effects, are shown.
From Kumar: Robbins and Cotran Pathologic Basis of Disease, Professional Edition , 8th ed.

The consequences of cell injury depend on the type, state, and adaptability of the injured cell, including nutritional and hormonal status, vulnerability of the cell, eg, to hypoxia, degree of toxic exposure.

Any injurious stimulus simultaneously triggers multiple interconnected mechanisms that damage cells.

Treatment and prevention approaches should address multiple mechanisms of cell injury.

Poor natural apoptosis (“too little or too much”) can also explain aspects of a wide range of diseases. Increased apoptosis results in excessive premature cell death causing neurodegenerative diseases, ischemic injury, eg, heart attack or stroke; and the premature death of virus-infected cells. Too little may lead to cancer.

So-called natural aging is contributed to by progressive reductions in many hormones, loss of muscle mass, reductions in GI tract neurons, Stomach acid production, clouding of lenses, etc. With age there are physiologic and structural alterations in almost all organ systems.
Cellular aging is therefore the progressive accumulation over the years of chronic sublethal cell injury that may or may not lead to cell death but does lead to a diminished capacity of the cell to respond to injury.

PEMFs can be used to improve body function and reduce the effects of cell injury.

Low-frequency pulsed electromagnetic fields or PEMF's, at the right intensities penetrate through the entire body affecting every cell in their path. Either whole body or smaller more intense PMFs affect all the cells in the body.

The book *Magnetic therapy in Eastern Europe* reviews the use of PEMFs for various medical applications and some of the known mechanisms of how PEMF's work in biology.

The classic effects of PMFs touch almost all aspects of cell injury, especially early in the injury process.

They work to:

- reduce edema,
- improve circulation,
- open cell membrane channels,
- increase production of ATP,
- stimulate repair mechanisms, and
- enhance apoptosis of chronic inflammatory cells
- reduce pain and nerve cell firing.

Only cells that are out of balance, are affected by PEMF energy.

No other single technology has both the range and depth of action that clinically directed PMFs can have, with no harm to healthy cells.

Low intensity PMFs have long been approved by the US FDA for healing nonunion fractures.

There is the question of field intensity. There are various systems that provide a wide range of field intensities, up to the level to produce muscle contraction.

There are now at least two FDA approved commercially available PEMF systems. One application is specifically used for muscle contraction and the other is transcranial magnetic stimulation.

Because of the level of intensities available with some systems, I have been able to see improvements, particularly with musculoskeletal and neurologic conditions, more rapidly than with any other therapeutic approach, without simply masking the underlying condition. Accelerating repair slows aging. Chronic pain accelerates aging.

Most people with any injury or disability usually benefit by being able to rehab and get back to work much faster and frequently reduce dependence on drugs.

PEMFs have great results for tendinitis, strain, arthritis and over-use of muscles.

Because PEMF's penetrate through all biologic tissues, equally well, unlike laser, electrical stimulation and ultrasound, they may be used through clothing, shoes, casts, wraps, bandages and splints, decreasing prep time.

References

Bassett CA. Beneficial effects of electromagnetic fields. J Cell Biochem. 1993 Apr;51(4):387-93.

Jerabek, J and Pawluk, W. Magnetic therapy in Eastern Europe: a review of 30 years of research. Pawluk. 1998.

Bioelectromagnetic Medicine. Rosch, PJ and Markov, MS., eds. Marcel Dekker, New York. 2004.

Funk RH, Monsees T, Ozkucur N. Electromagnetic effects – from cell biology to medicine. Prog Histochem Cytochem. 2009;43(4):177-264.