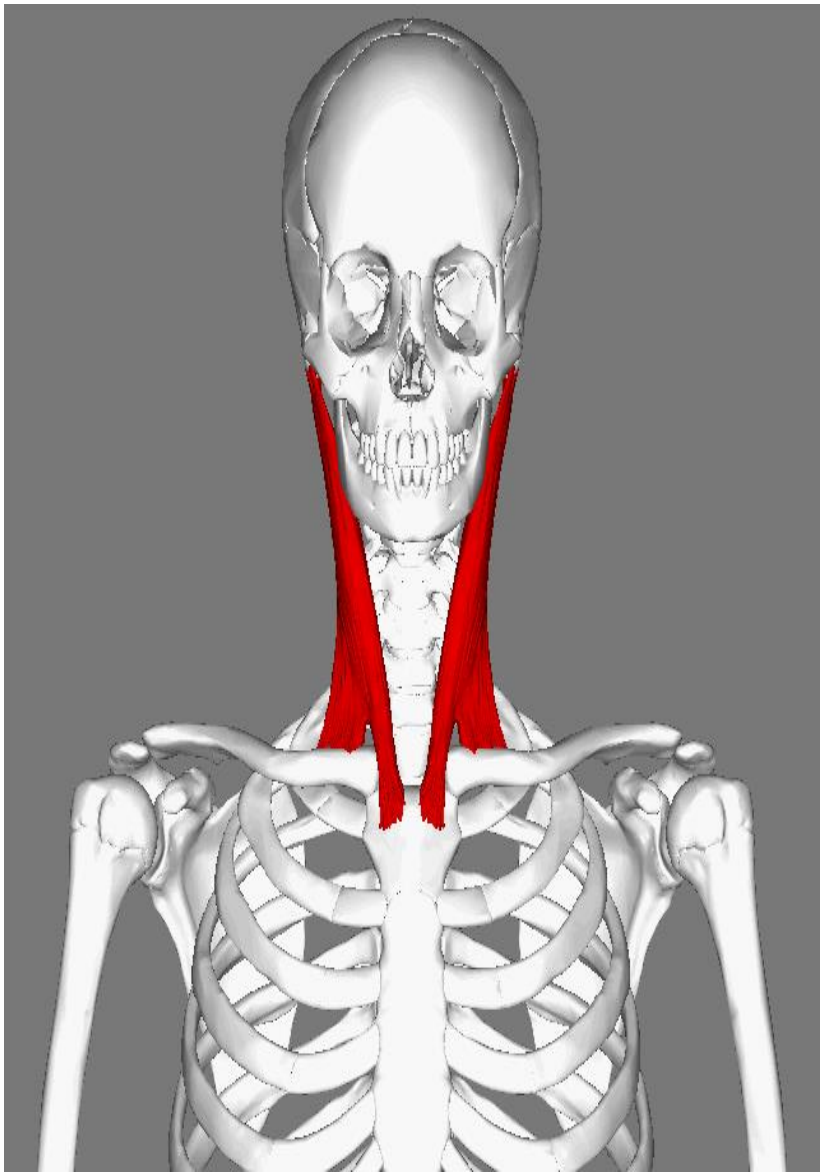
Terms Related to Stress and Strain

- **Elastic** – A material that bounces back into its original shape quickly.

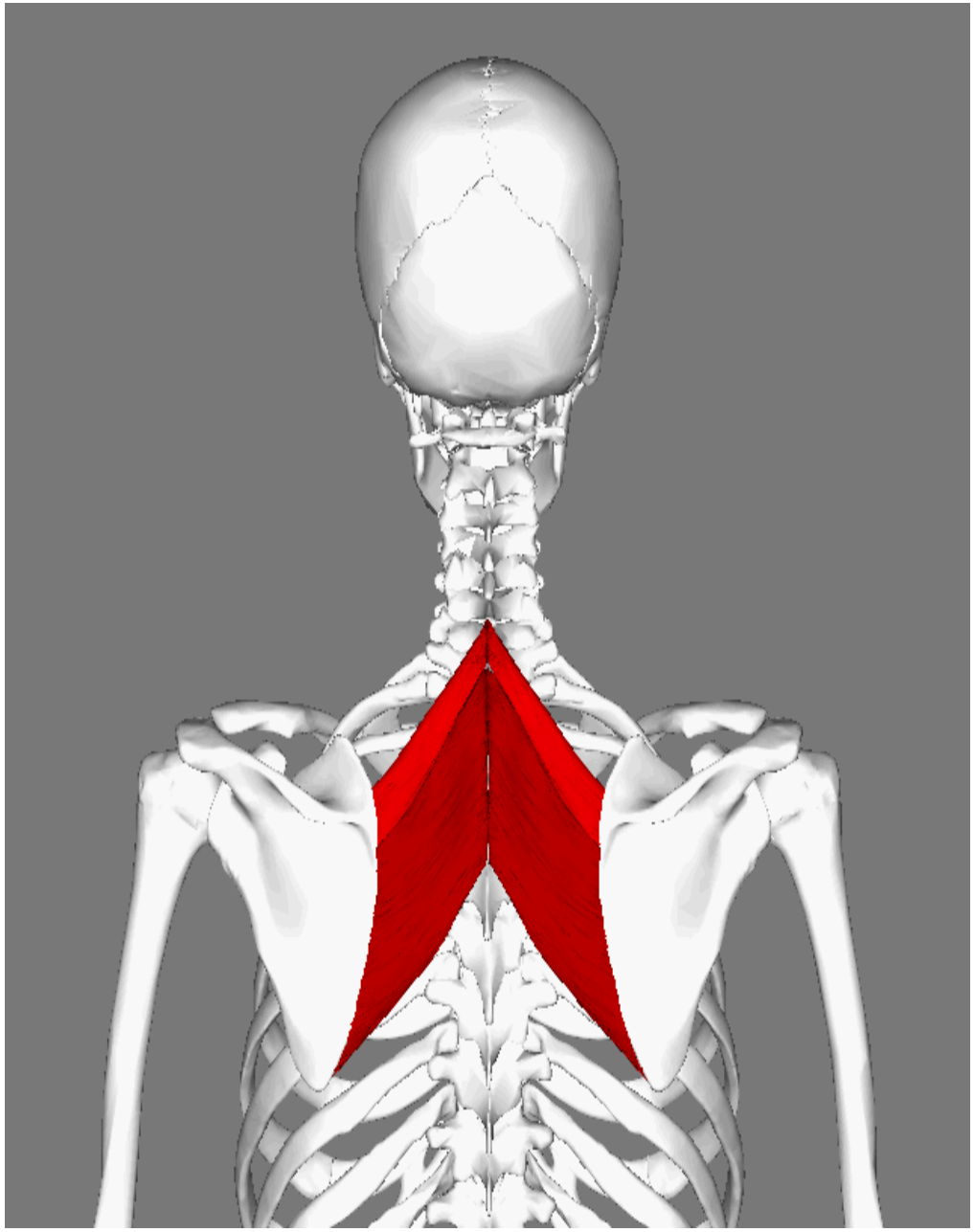
- **Viscous** – A thick material which flows slowly.

- **Viscoelastic** – A material which exhibits viscous and elastic qualities
  - Ex. Skeletal muscle is elastic when stretched fast, and viscous when stretched slowly



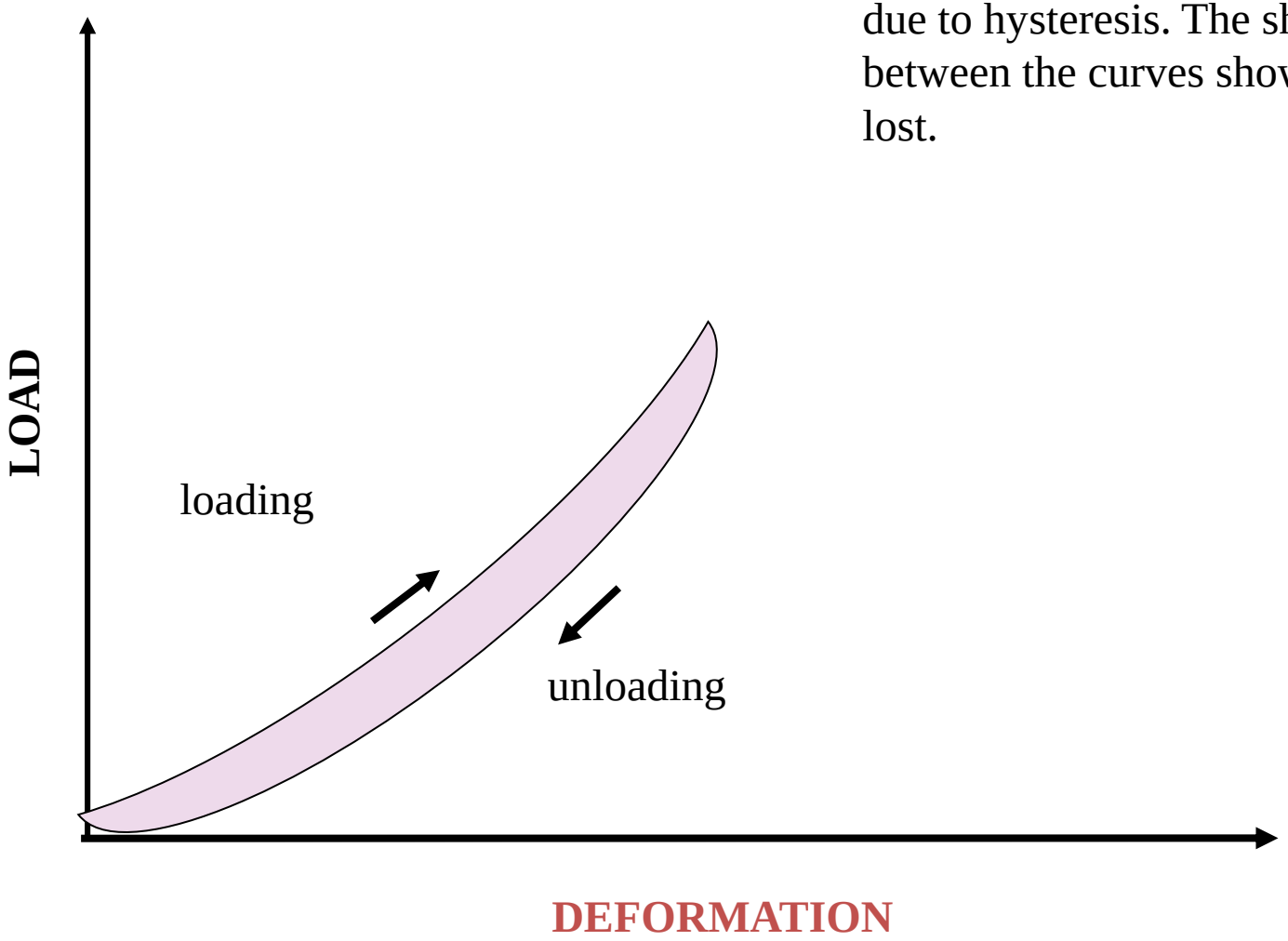
hysteresis.”

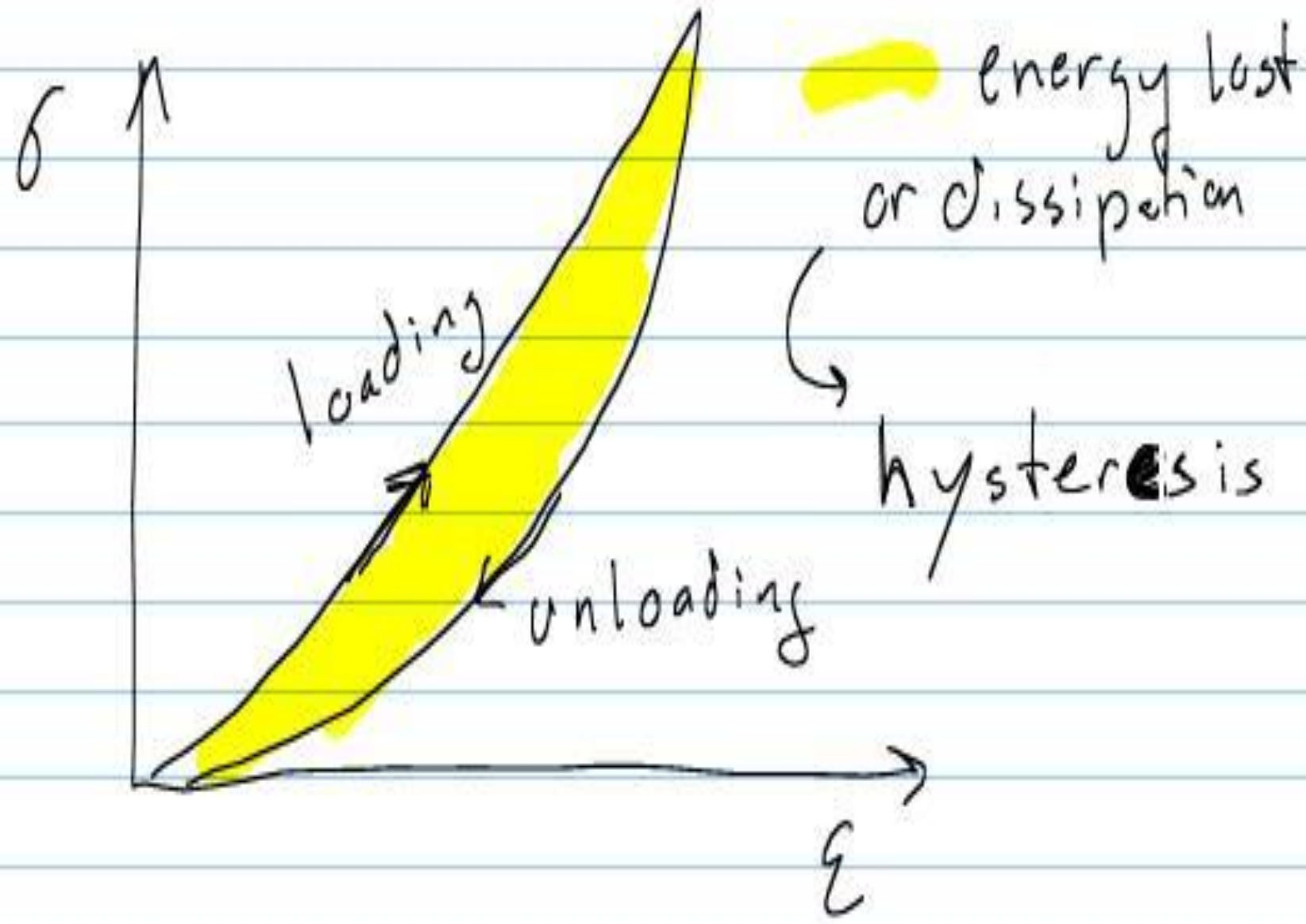
- Viscoelastic materials undergo “hysteresis.” This means they lose a lot of energy when a load is lifted.



Cyclic Loading and Unloading of a Muscle

As the ligament unloads it loses energy due to hysteresis. The shaded area between the curves shows the energy lost.




σ
loading
unloading
ε
energy lost
or dissipation
hysteresis

Terms Related to Stress and Strain

- Creep –
- The increase in strain over time with a constant loading. This principle is applied when using a series of casts to reshape limbs (clubfoot) or the spinal column (treatment of scoliosis).

- Relaxation –
- A decrease in stress which occurs in a material when a constant deformation is present.

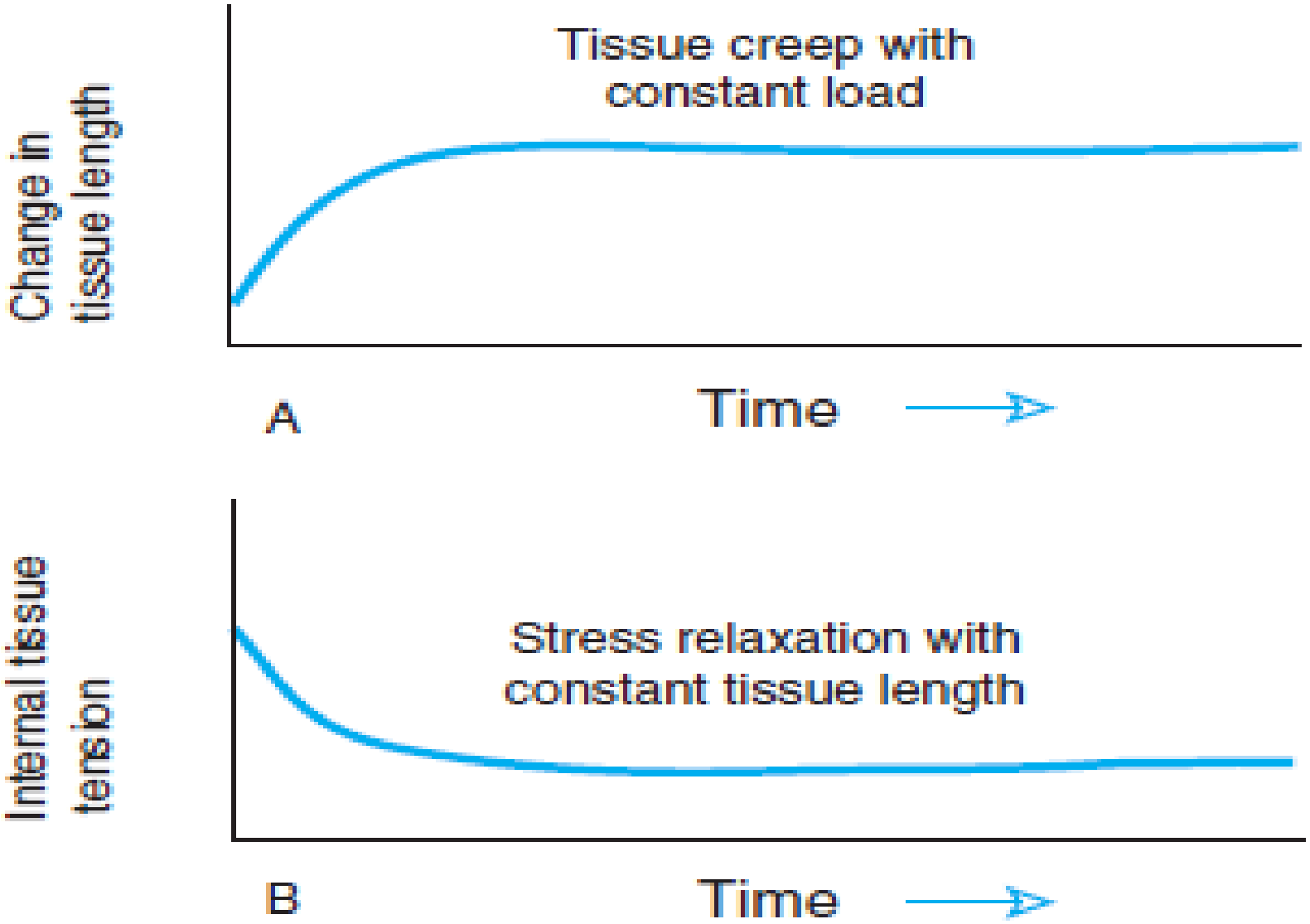
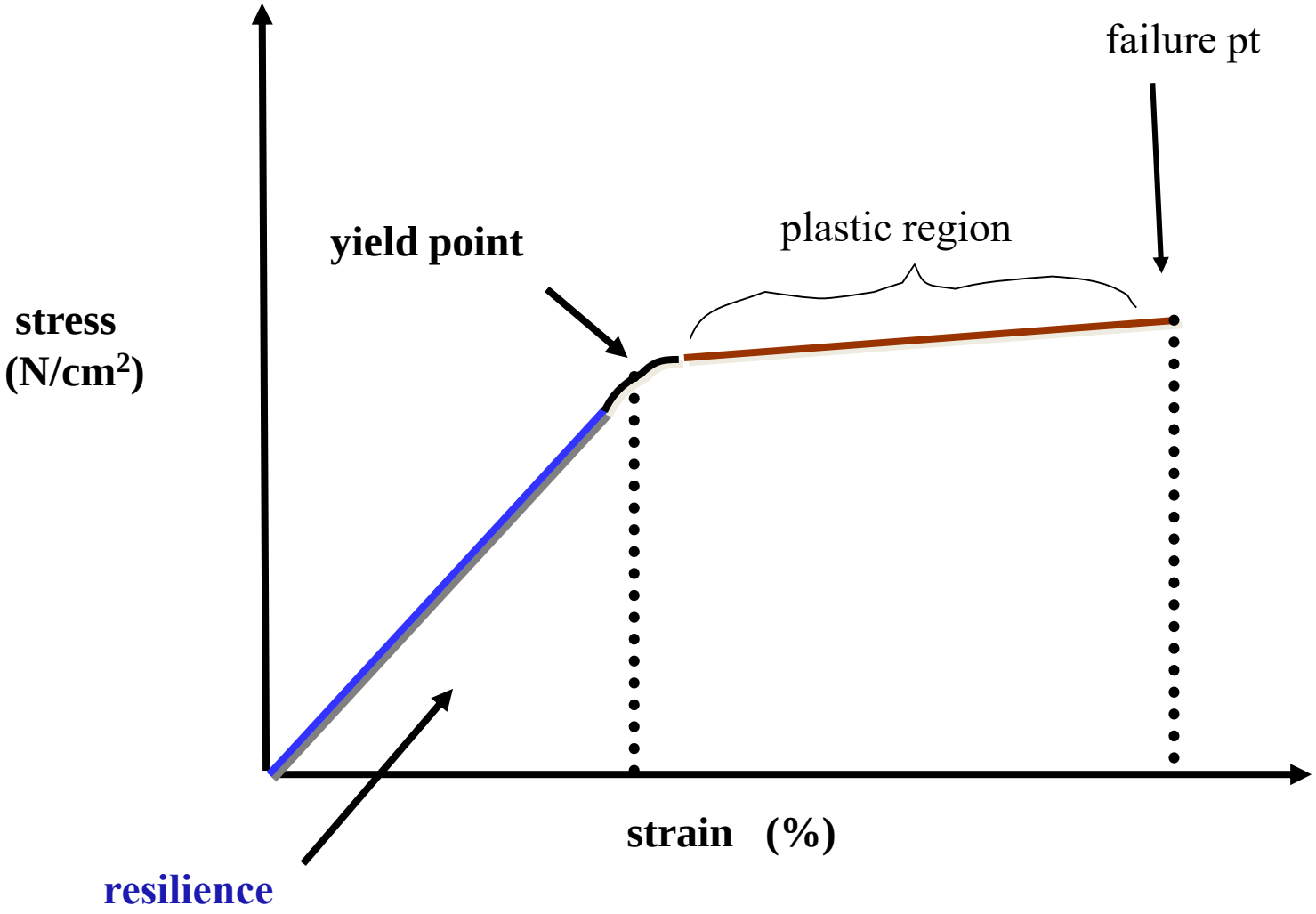


FIGURE 4.7 Tissue response to prolonged stretch forces as a result of viscoelastic properties. (*A*) Effects of creep. A constant load, applied over time, results in increased tissue length until equilibrium is reached. (*B*) Effects of stress–relaxation. A load applied with the tissue kept at a constant length results in decreased internal tension in the tissue until equilibrium is reached.

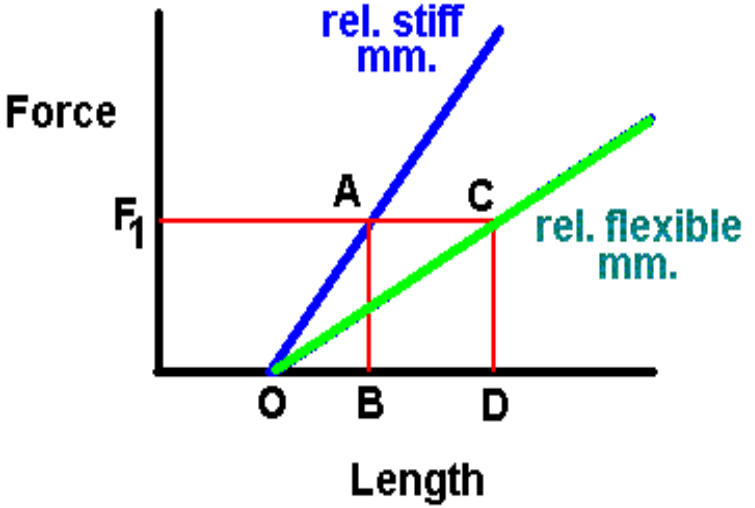
- **Resilient** – An object which has a tendency to rebound from a surface or another object or to return to its original shape **quickly** when stress is suddenly applied and then removed without damage.
- (A person or animal) able to withstand or recover quickly from difficult conditions
- A tennis ball or golf ball would be resilient. Lead would be a non-resilient material.
- **Damped** – A material or object which returns to its original shape **slowly** when stress is removed. The opposite of resilient.

Stress-strain curves
Energy absorption (area under curve)

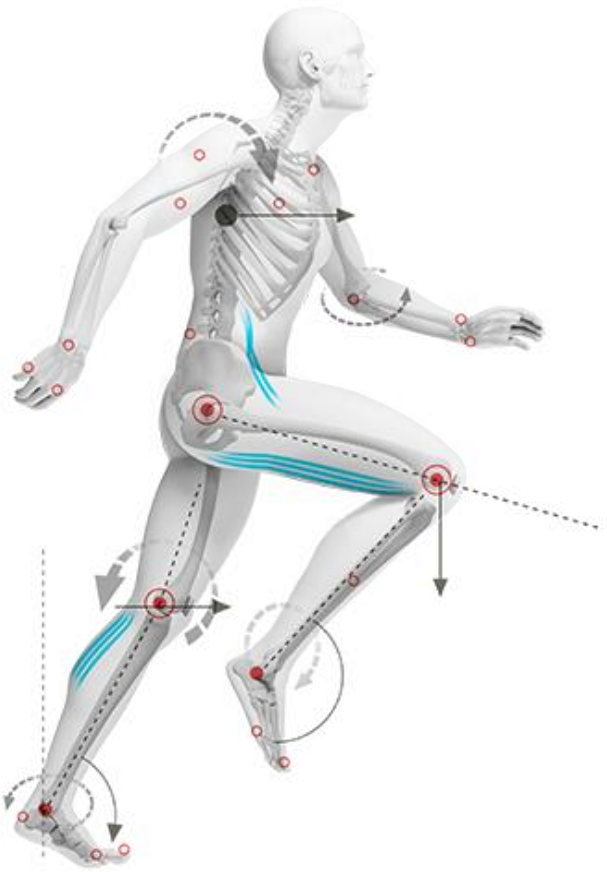


Material Properties

- **Stiffness** – The ratio of stress to strain - the resistance of a loaded material to deformation. Stiff materials do not change their shape easily when a load or stress is applied.
  - (ex. iron bar, glass, bone)
- **Pliability** – materials are pliable if they are easily deformed. pliable materials bend or stretch or compress easily
  - (ex. rubber band, twig in Spring)

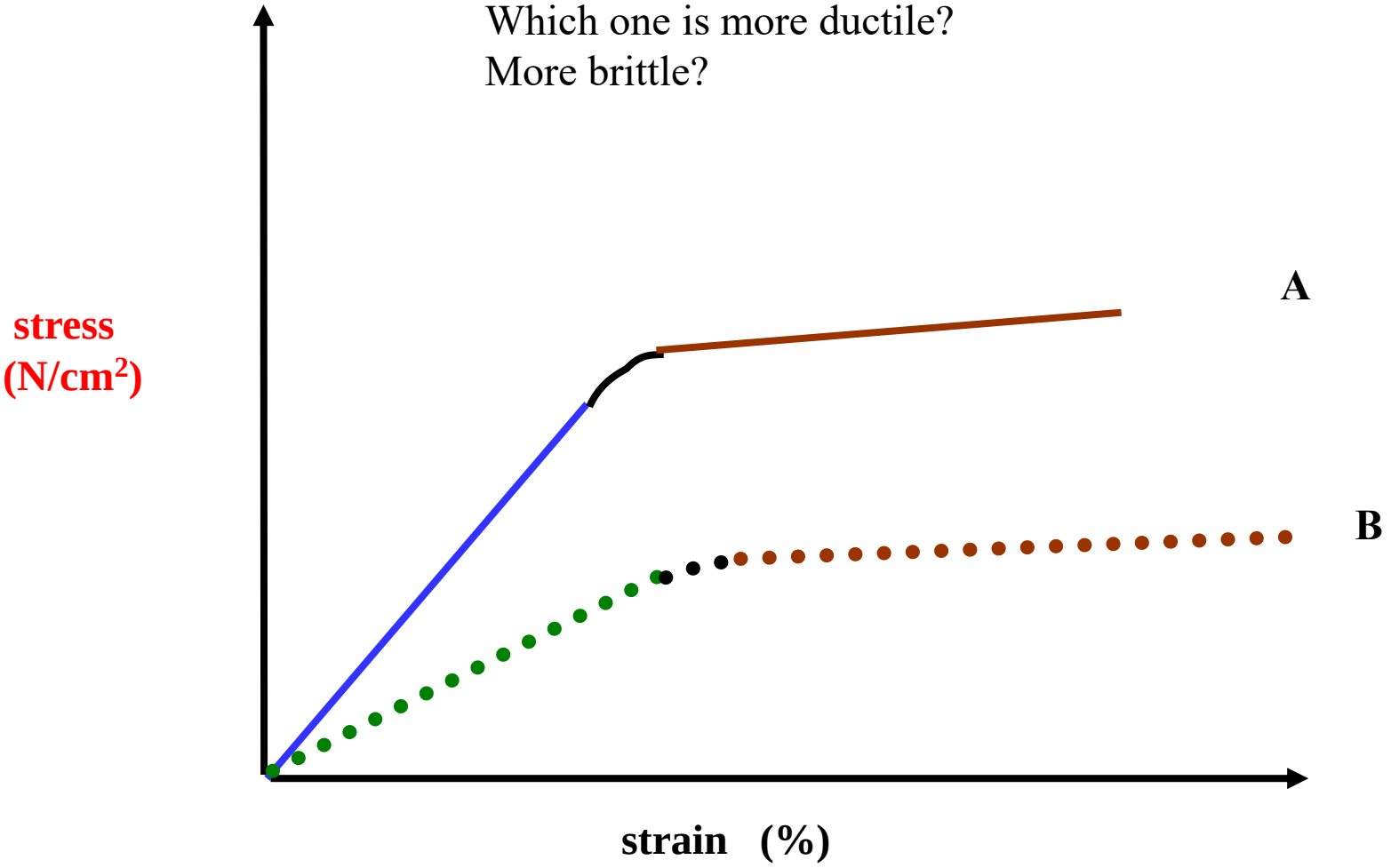


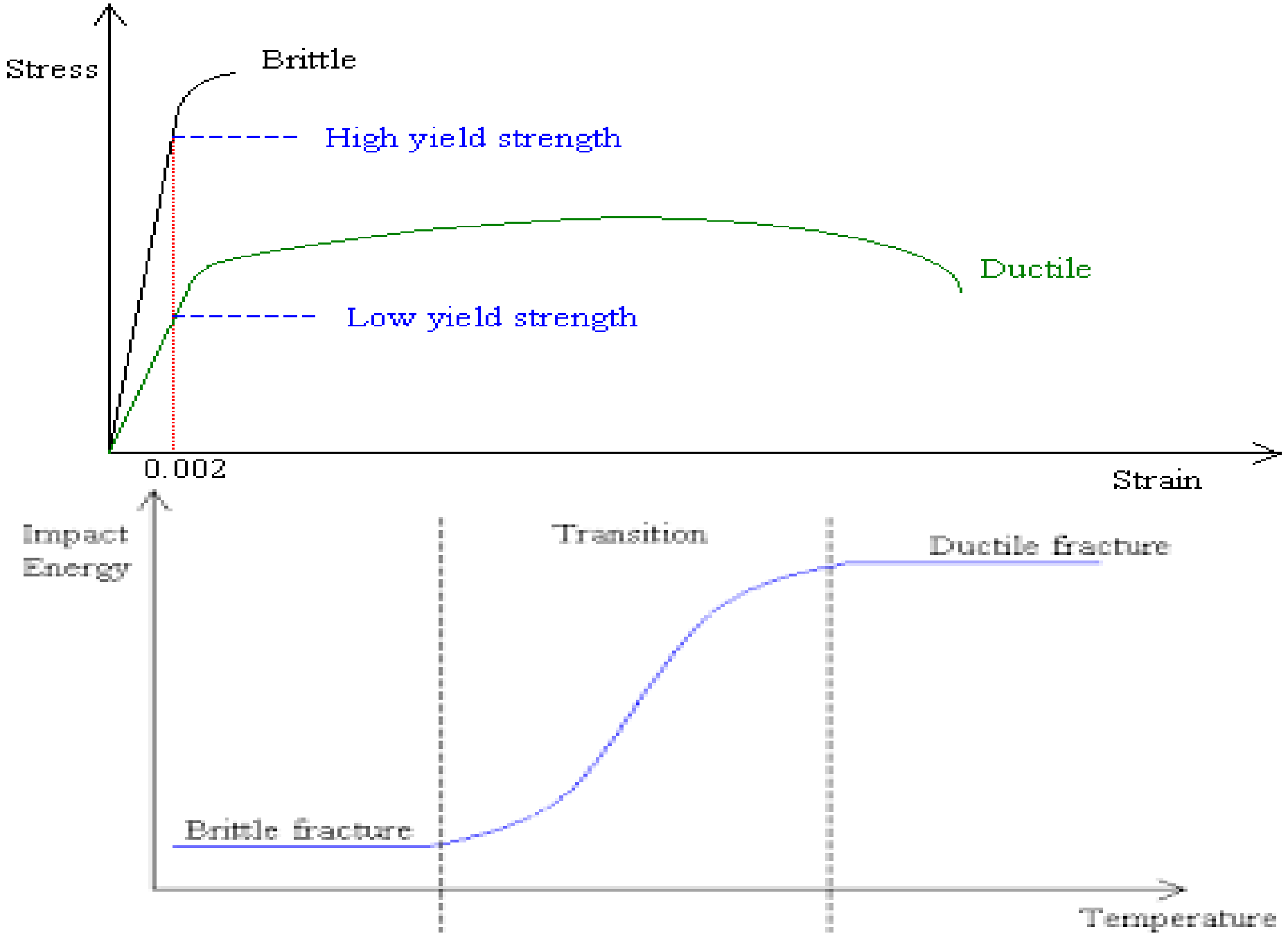
- **Ductility** – The ability of a material to undergo large deformation or strain before failure.
  - (ex. rubber band, iron bar, skeletal muscle)
- **Brittleness** – The tendency of a material to break with little deformation or strain
  - (ex. glass, dead tree branch, bones in elderly).



Stress-strain curves

Which one is more ductile?
More brittle?




Stress
Brittle
High yield strength
Ductile
Low yield strength
0.002
Strain
Impact Energy
Transition
Ductile fracture
Brittle fracture
Temperature

Load and Injury

- The body is designed to adapt to certain levels of mechanical stress.
- This adaptation is necessary for normal development of strength and structural integrity.
- A certain amount of loading (usually encountered allows **individuals to improve such qualities as strength and endurance)** beyond which more loading leads toward injury either major or minor injury called load induced or stress induced injuries or failures.

- Loads that may not cause failure of the structures in single application may cause fracture when applied repeatedly.
- Failure may occur after few or many cycles of loading and unloading.
- Fracture resulting from repeated loading is called fatigue or stress fractures
- **Factors** = amplitude, mechanical properties of the material, size of the structure, operational conditions.

Fatigue or endurance limit

- **Fatigue limit**, **endurance limit**, and **fatigue strength** are all expressions used to describe a property of materials: the amplitude (or range) of cyclic stress that can be applied to the material without causing fatigue failure. , called the endurance limit, which is the **amplitude of completely reversed bending stress below which** there appears to be no number of stress cycles that will cause failure.
- The stress at which fatigue curve levels off is called endurance limit of the material.
- Below the endurance limit there is no fatigue. Or no injury zone
- .

Fatigue of endurance limit

- Stresses above the endurance limit showed fatigue failure.
- Different structures have different endurance limit or level of fatigue failure.
- Structures do not have a distinct limit and will eventually fail even from small stress amplitudes. In these cases, the term endurance strength is used.
- **Endurance strength** is defined as the maximum reversed bending stress that a material can withstand for a finite number of cycles without a fatigue failure

- Fatigue depends on several factors like temperature, surface imperfections or discontinuities.
- Appearance of small crack- then rupture or fracture of biological tissues called fatigue failure.
- Orthopaedic devices- under the effect of normal daily activities may also face fatigue failure of device.

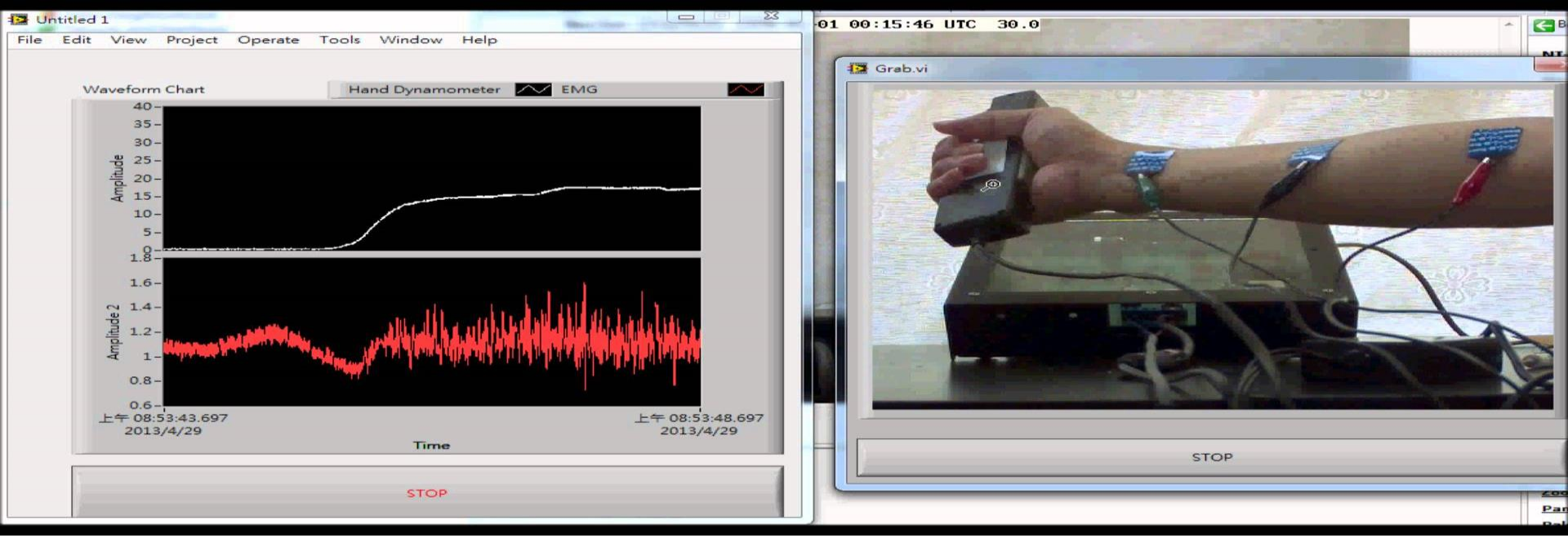
A broken stem of Austin Moore's hip prosthesis

Terms related to load & injury

- **Repetitive loading** – repeated application of subacute load that is usually of relatively low magnitude
- **Acute loading** – application of a single force of sufficient magnitude to cause injury
- **Microtrauma** – when repeated or chronic loading over a period of time produces an injury called micro-trauma.
- **Macrotrauma** – a single force large enough to cause injury in single impact on biological tissue called macrotrauma

Tools for Measuring Kinetic Quantities

- Biomechanic researchers use equipment for studying both muscle forces and forces generated by the feet against the ground during gait and other activities.
- Knowledge gained through the use of this apparatus is often published in professional journals for teachers, clinicians, coaches, and other interested in human movement.



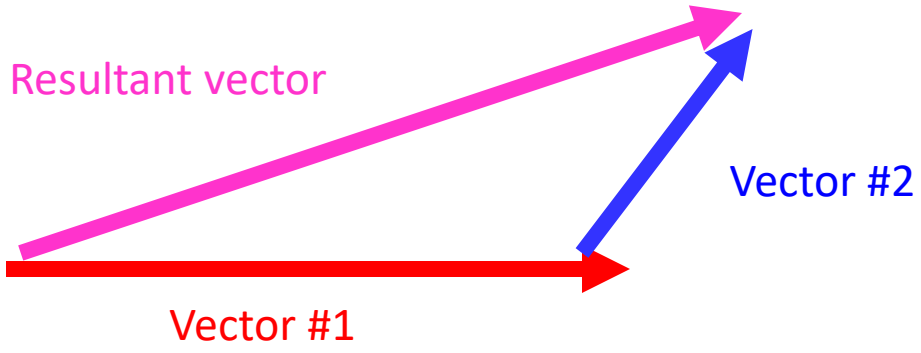
- **Electromyography (EMG):**
  - A technique for recording electrical activity produced by muscle, or myoelectric activity.
  - To study neuromuscular function
- **Dynamography:** The use of platforms and portable systems for the measurement of forces and pressure on the plantar surface of the foot.
  - Primarily employed in gait research
  - Starts, takeoffs, landings, baseball & golf swings, and balance

Vector Algebra

- **Vector quantities–** any physical quantity that posses both magnitude and direction
- Kinetic vector quantities
  - force weight, pressure, specific weight & torque
- Kinematic vector quantities
  - Displacement, velocity & acceleration
- **Scalar quantities** – magnitude only
  - Mass, volume, length & speed

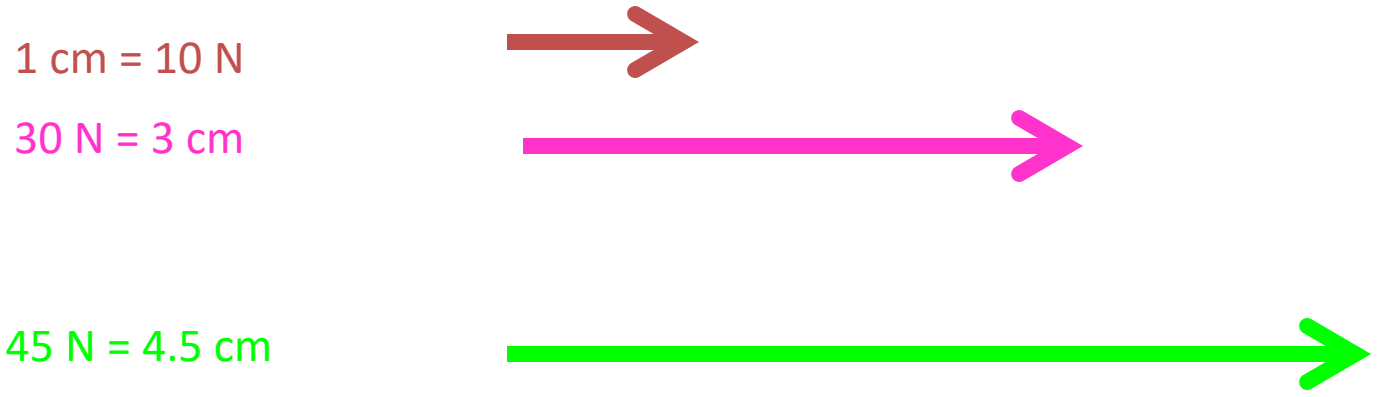
Vector Composition

- Resultant vector: single vector that result from vector composition
- When vectors are coplanar, contained in the same plane, a procedure that may be used is the “tip-to-tail” method,
- in which the tail of the second vector is placed on the tip of the first vector, and the resultant is then drawn with the tail on the tail of the first vector and its tip on the tip of the second vectors.
- “Tip-to-tail” vector composition



Vector composition

- When vector quantities are uniplanar, vector manipulations may be done graphically to yield approximate results.
- Graphic solution of vector problems requires the careful measurement of vector orientation and lengths to minimize error.
- **Vector lengths**, which represent the magnitude of vector quantities, must be drawn to scale.
- **Example:**
- 1 cm of vector length could represent 10 N of force
- A force of 30 N would then be represented by a vector of 3 cm in length
- A force of 45 N would be represented by a vector of 4.5 cm length

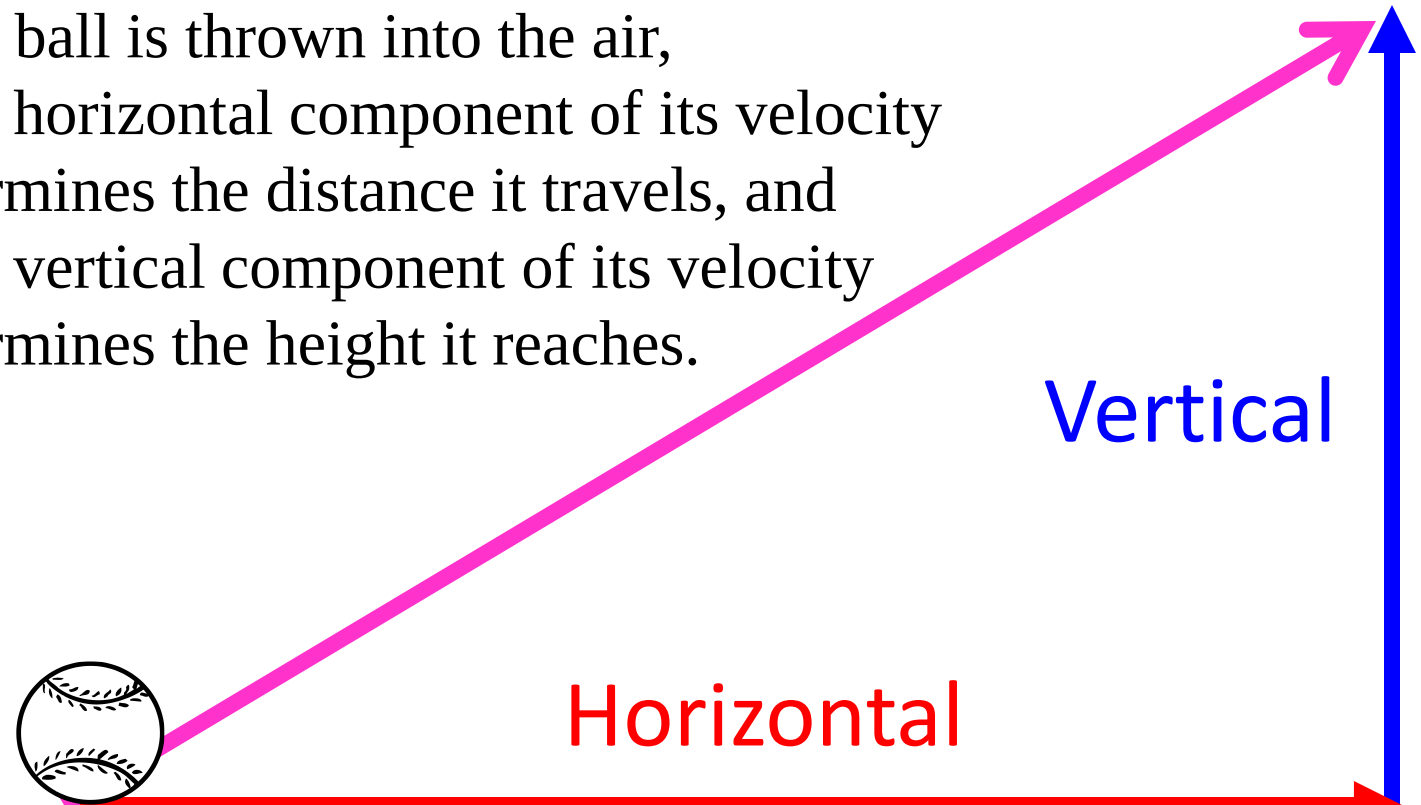


Vector Resolution

An operation that replaces a single vector with two perpendicular vectors such that the vector composition of the two perpendicular vectors yields the original vector is called vector resolution

Example:

- When a ball is thrown into the air,
  - The horizontal component of its velocity determines the distance it travels, and
  - The vertical component of its velocity determines the height it reaches.



Thank You Thank You Thank You!!!!