The earth is a living body. Its soul is its ability to grow. This soul, which also provides the earth with its bodily warmth, is located in the inner fires of the earth, which emerge at several places as baths, sulfur mines or volcanoes. Its flesh is the soil, its bones are the strata of rock, its cartilage is the tufa, its blood is the underground streams, the reservoir of blood around its heart is the ocean. The systole and diastole of the blood in the arteries and veins appear on the earth as the rising and sinking of the oceans.
Civil Engineers and Tissue Mechanics
Example: Bone

How does the mechanosensory system in bone work?

Why is that important?
STATEMENT OF THE PARADOX

(a) mechanical load

(b) strain on the bone surface (0.04 to 0.2%)

(c) strain on the cell process membrane for biochemical response (1-10% in vitro)
Amplitude of normalized fluid pressure ($p/\sigma_0$)

Fluid pore pressure induced by mechanical loading (0 to 20 MPa)

Radial coordinate (R)

Shear stress on osteocytic membrane induced by mechanical loading

Radial coordinate (R)
THE MODEL, NO FLOW -> FLOW
\[ \sigma_0 \text{ (hoop stress)} \]

\[ p_{\text{equiv.}} \]

(equivalent pressure, applied by the fibers)

**osteoctic process**

\[ \rho_1 \]

**cell process membrane**
\[ \varepsilon : \text{bone surface strain, } \sigma : \text{load on bone} \]

- \( \varepsilon = 0.005\%, \sigma = 1\text{MPa} \)
  
  (50 microstrain)

- \( \varepsilon = 0.025\%, \sigma = 5\text{MPa} \)
  
  (250 microstrain)

- \( \varepsilon = 0.05\%, \sigma = 10\text{MPa} \)
  
  (500 microstrain)

- \( \varepsilon = 0.1\%, \sigma = 20\text{MPa} \)
  
  (1000 microstrain)
Bone adaptational sensitivity to frequency of mechanical loading

(McLeod and Rubin, 1995)

Bone mass change ratio vs. frequency (Hz)

Microstrain vs. Number of Occurrences

- sheep tibia
- turkey tibia
- dog tibia