Wolff's law (vôlfs)
*n.*
The principle that every change in the form and the function of a bone or in the function of the bone alone, leads to changes in its internal architecture and in its external form.

## Wolff's law

Also known as:
Delpech's law

Associated persons:
Jacques Mathieu Delpech
Julius Wolff

Description:
Wolff's law stated that every change in form and function of a bone, or in its function alone, is followed by certain definite changes in its internal architecture and equally definite secondary alteration in its mathematical laws (Morton's Medical Bibliography).

A shorter version: Bone is deposited and resorbed in accordance with the stresses placed upon it.

We thank Bernard McCartan, Trinity College, Dublin, for information submitted.

Bibliography:

- J. Wolff:
  *Das Gesetz der Transformation der Knochen.* Berlin, A. Hirschwald, 1892.
  Published wit support from the Royal Academy of Sciences in Berlin.
  English trnslation by P. Maquet and R. Furlong. Belin, Springer-verlag, 1986.

- Jeremy M. Norman, editor:
  *Morton's Medical Bibliography. An annotated Check-list of Texts Illustrating the History of Medicine (Garrison and Morton).* Fifth edition. Scolar Press, 1991.



**"In the 19th century, surgeon Julius Wolff proposed that mechanical stress was responsible for determining the architecture of bone...." (Forwood & Turner, 1995, p. 197).**

**"Remodeling of bone ... occurs in response to physical stresses - or to the lack of them - in that bone is deposited in sites subjected to stress and is resorbed from sites where there is little stress" (Salter, 1970, p.7).**

**References**


**Forwood, M.R., & Turner, C.H. (1995). Skeletal adaptations to mechanical usage. Bone, 17, 197s-205s .**

**Salter, R.B. (1970). Textbook of disorders and injuries of the musculoskeletal system (1st ed.). Baltimore: Williams & Wilkins.**

**Wolff, J. (1891). Das gesetz der transformation der knochen. Berlin: A Hirschwald.**


# Applied biomechanics **Updated:**



**Skeletal Tissue properties:**

**Bone:** We have seen before that bone is uniquely structured to be lightweight and strong at the same time. This purposeful construction to efficiency is evident the more we look into it. Biomechanically, bone is akin to a biphasic composite structure, of organic and inorganic phases. Organic component gives it flexibility and the inroganic component provides rigidity. The composite structure is far stronger than the original constituents alone. Microscopically bone is composed of cortical and cancellous bone. Cortical bone is stiffer than cancellous bone.

Bone being viscoelastic shows loading rate sensitivity and becomes stiffer, stronger and more brittle at higher loading rates. Bone responds to load by deformation. This ability depends on its ability to store energy. Older bone has low ductility, is less able to store energy than a young one and fails at a lower level of load.

Low energy loading results in clean cut fracture. High energy loading results in comminuted fracture.

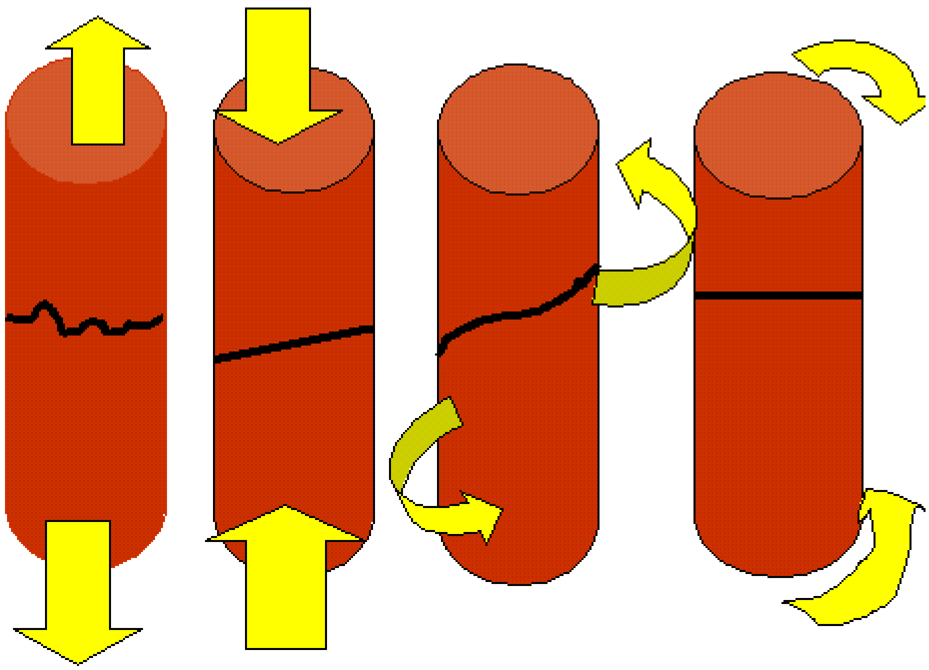
Muscle contraction is important to regulate bone loading. They can neutralise tensile load and allow bone to carry increased load. Fatigue failure can result from muscle weakness.

Bone behaviour is also influenced by its geometry. Bone response to bending and torsion follows the same principle, so distribution of bone mass away from the neutral axis is helpful. This is why long bones are tubular in shape. Bending moment is also influenced by its length. The longer a bone, the more its bending moment and resultant stress.

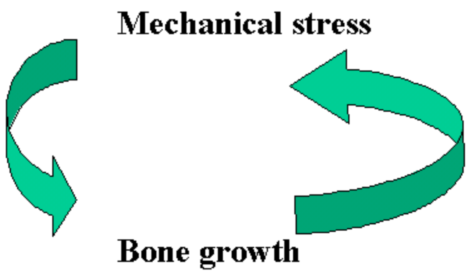
A long bone can act as a column, supporting compressive load along its long axis. or as a shaft, to resist torsion or as a beam , resisting bending moments. Tibia acts as a column to support body weight , neck of femur resists bending moments. When the foot is twisted, tibia resists torsion.

Bone structure is dissimilar in longitudinal and transverse directions, this results in anisotropic behaviour.

Bone behaves differently under different loading conditions. It is stronger in compression than tension than shear. Different types of loading also produces different types of fracture.



*Wolff's Law*: Bone is a living structure and adapts itself to its suroundings and demands placed on it. This was elegantly described by Julian Wolff in 1892. In simple terms, bone grows in response to mechanical stress. The law helps us understand how to encourage bone remodelling and avoid bone stock loss.




Bone undergoes regular remodelling to recover from loading, but if the amount of repeated loading is far above power of remodelling , then this results in *fatigue* or *stress fracture*.

Muscle contraction is important to regulate bone loading. They can neutralise tensile load and allow bone to carry increased load.

Bone behaviour is also influenced by its geometry. Bone response to bending and torsion follows the same principle, so distribution of bone mass away from the neutral axis is helpful. Bending moment is also influenced by its length. The longer a bone, the more its bending moment and resultant stress.