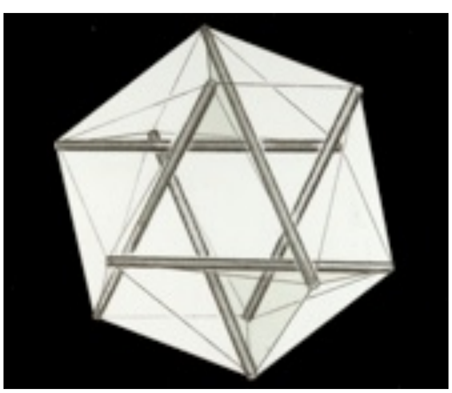
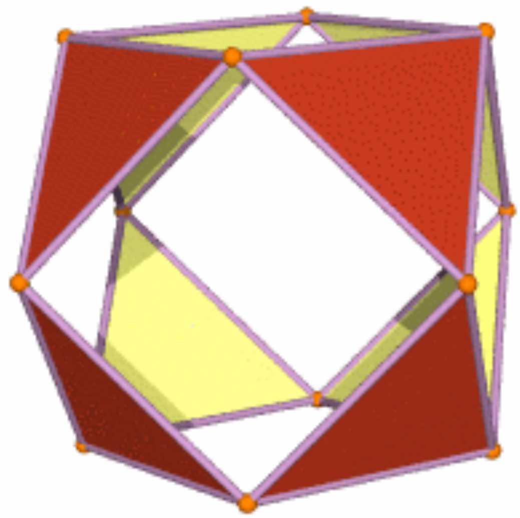
Shear or Not to Shear

It is not my wont to be critical of others in the tensegrity field. We are struggling with a new concept, and every day I catch myself making errors in understanding concepts or particulars, and what I preach today may not be what I believe tomorrow. However, one apparent error seems to be permeating the biologic tensegrity field and I need to comment. I have seen what I perceive as a misrepresentation on prestigious websites, in print in recent, otherwise excellent, books, and witnessed it in presentations and seen it cited many times on multiple websites. It is exemplified by the illustrations of Eddy Y. Xuan of Biomedical Communications, University of Toronto, Canada, on the **Children's Hospital, Boston's** website, reproduced here:

They are pretty pictures, but do not represent the mechanics of tensegrity structures. Xuan depicts linear deformations, standard **Poisson Ratio** stuff, but that is not how tensegrity structures respond to stress. To quote Fuller, "...if concentrated load is applied from without, the whole system contracts symmetrically, i.e., all vertices move toward their common center at the same rate." [***Synergetics 724.32-34***]. This phenomenon is a sine qua non of tensegrity structures and is illustrated by the works of **Rossiter**, **Burkhardt**, **Wolfram** and so many others who know, understand and love tensegrity.

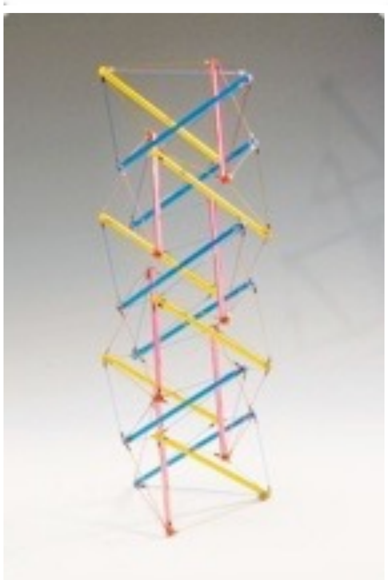


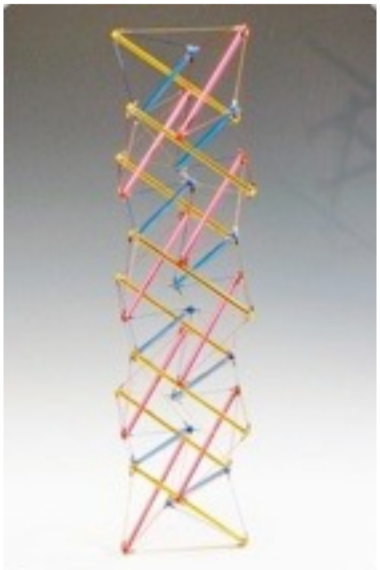


Rossiter

Leonard Dubovoy, a seventh grade student in Richmond, VA, and prize winner in the Virginia Junior Academy of Science, has been kind enough to share his science project with us. It reenforces the principle of tensegrities that tensegrities contract and expand symmetrically, they do not distort.

The error occurs when the model used to understand tensegrity uses weak elastics as the tension elements. In true tensegrities, the tension elements get stiffer as the structure is loaded, but not so in the rubber band models. If you use nylon fishing line, as does **Hamilton**, the response to loading more closely represents true tensegrities.





Hamilton

Check out Phil Earnhardt's Youtube video on this.

The next question has to be, "Does the cell deform as a tensegrity or as a linear material?" No doubt, when individual cells are tested on a slide, the appear to have the linear deformities as in Xuan's illustrations, but cells in biologic tissues are never alone, they interact in concert. The mechanical response may be quite different when cells are crowded together interacting with their buddies, much like a single isolated bubble reacts differently than a bubble acting as part of a foam (Wikipedia: **Foam**, and **Soft Matter**). I don't know if any one has actually studied this. I am open to see further research.

In my experience with tensegrities constructed from many sub-tensegrity units as a hierarchical construction, when stressed, the individual units behave as Fuller describes, and the whole structure realigns and changes shape. As cells are hierarchical constructs, and their cytoskeletons are continually realigning themselves, reforming and disappearing, is seems likely that the cell reshapes as a tensegrity and not as a linear structure. This type of reshaping is wonderfully illustrated in **Guimberteau's** DVD, *"Strolling Under the Skin"*, in the fascial tissues, and I can envision the same phenomenon occurring at the cell, where the connections break and reform, always maintaining the triangular symmetrical pattern of tensegrities. (The self similarity of fractal constructions).

Guimberteau

A single cell organism may look as if it is deforming, but it may keep its tensegrity sub-units in perfect symmetry while realigning its body shape. What we are looking at may appear to us as a single tensegrity, but it is really a composite of many tensegrities functioning as a single tensegrity unit, which may be configured more as a tensegrity column than a dome or sphere. To quote Fuller, "Geodesic domes can be either symmetrically spherical, like a billiard ball, or asymmetrically spherical, like pears, caterpillars, or elephants" (Synergetics 703.01). Tensegrity columns as demonstrated in Hamilton's models, function as a single tensegrity. (Fuller. ***Synergetics:740.00***)

This issue has become too pervasive for me to be able to ignore it without comment. I am willing to listen to counter arguments. I hope we can resolve it and move on.