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## SUGGESTED MECHANICAL MODEL OF ELEPHANT TRUNK MUSCLE TISSUE AND ITS SHEER CONJECTURE

by Norris Whitehill

The problem is to explain how a mass of tissue lying within an elephant's trunk and consisting entirely of flexible material can resist externally applied bending and twisting movements, and at the same time be capable of changing the curvature of the trunk and its axial twist at the will of the elephant.

Imagine that you have 24 round toy balloons inflated to 15 cm diameter. First cement them together (1 cm diameter of contact) in 6 groups of 4 each arranged in a square pattern. Then cement each balloon of a first group to a table top. Next, cement each balloon of a second group to and directly above the balloons of the first group. Continue in that manner, finishing with a vertical stack of balloons 6 high by 2 wide by 2 deep. The structure resists bending and twisting.

Then imagine that you would like to have that structure curve toward you with an inside tangential radius of 100 cm, and that the curved structure is to have the same total volume of balloon that the straight structure had. After suitable calculations, you deflate each balloon in the columns nearest you to 13.96 cm diameter and inflate each balloon in the columns farthest from you to 15.90 cm diameter. The resulting curved structure still resists bending and twisting.

Next imagine that the necks of the balloons have been cut off and sealed, that the rubber material of the balloons has been replaced by what I like to think of as PUMP MUSCLE, that the balloons have been replaced by what I like to think of as PUMPS, that the air in the balloons has been replaced by what I like to think of as TRUNK FLUID, that there is a hole through the center of each cemented area, that each hole is surrounded by a sphincter muscle that can close the hole, and that the entire system of pump muscle and sphincters is under the control of your will.

Thus, due to your ability to forcibly control the volume of trunk fluid within each pump, you have at your disposal the means to alter and maintain any curvature of the structure that you wish, and to resist any external efforts to alter it that you wish, limited only by mathematical considerations of total trunk fluid volume and total pump muscle volume and the strength of the pump muscle.

I think of pump muscle under magnification as appearing identical to cardiac muscle. As to how an arrangement of cardiac muscle fibers can possibly enclose and compress an essentially spherical volume, about all I can do is to think of the pattern of spherical pentagons and hexagons that make up the surface of a soccer ball. The reason for the sphincters is to prevent loss of hydraulic pressure throughout the trunk in case of a wound, or to isolate a pump while its pump muscle takes a rest and its neighbors shoulder its load.

For simplicity, an orthogonal arrangement of pumps has been described. Actually, I think it much more likely that the pumps are arranged in the densest spacial array possible, in which each pump has twelve neighbors - six around it, three above and three below. I theorize that a specimen cut at just the right place and at just the right angle from an elephant's trunk muscle while it is straight, would appear as is shown in the figure.

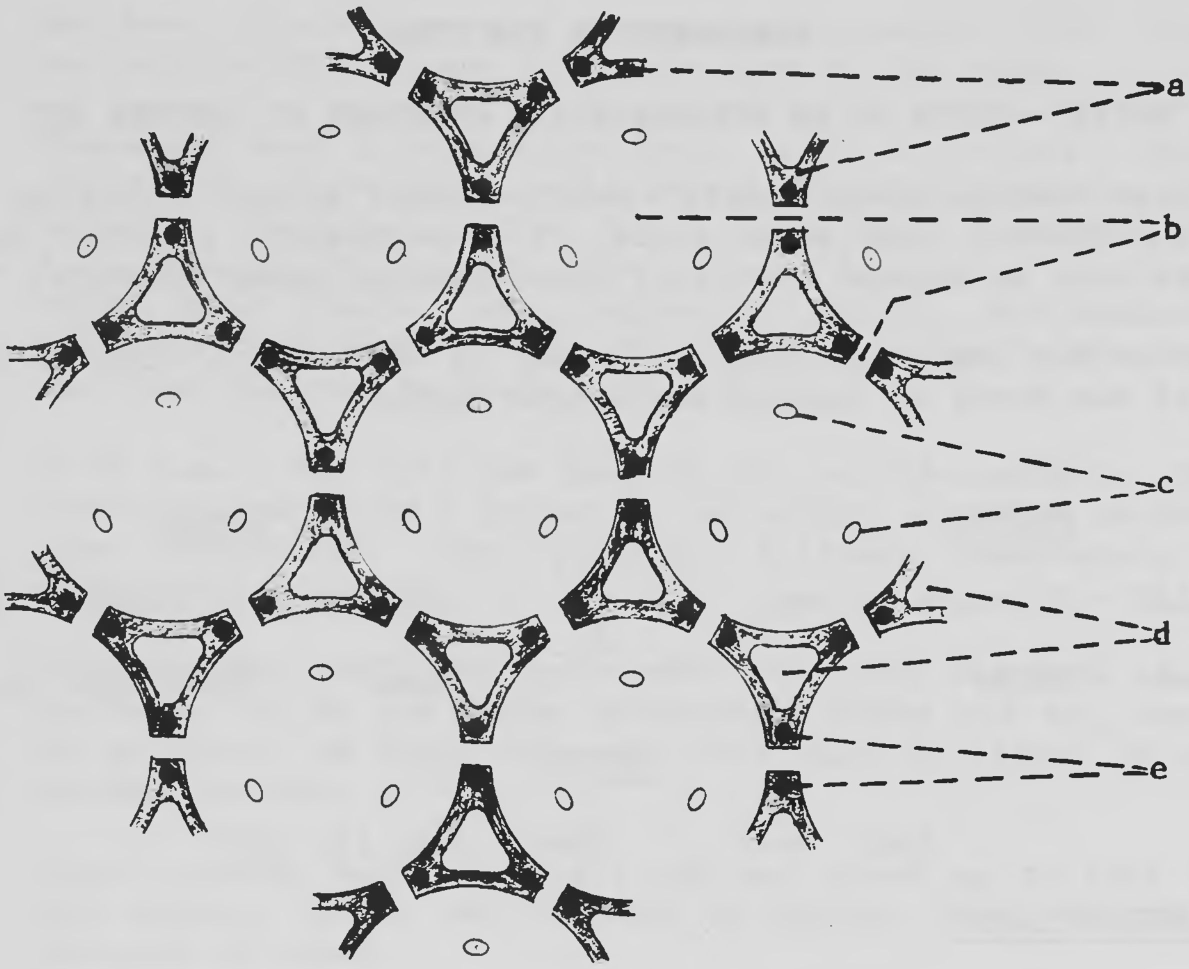


Figure of a section through the centers of neighboring pumps of elephant trunk tissue. See explanation below.

a. Lightly shaded area represents pump muscle.
b. White area inside of pumps and interconnecting holes represents active trunk fluid.
c. The small ellipses shown within the pumps represent the ends of holes that connect to other pumps directly beyond the plane of the section.
d. White area outside of pumps is believed to be filled with blood vessels, nerves, passive (reservoir) trunk fluid, and an occasional trace of membrane material.
e. The small black circles represent the cross sections of sphincter muscles surrounding each hole.

The figure is drawn approximately 16 X size, based on my guess of 1.8 mm for the inside diameter of a pump. The ratio of pump muscle volume to active trunk fluid volume is based on my guess as to how sharply an elephant can bend its trunk at a particular trunk thickness. I speculate that the entire volume of pump muscle and active trunk fluid within the trunk constitutes one closed hydraulic system. The ability of an elephant to twist its trunk to a limited degree may be explained in two ways:

(1) Pump muscle is capable of actively twisting and distorting the pumps.
(2) Striated muscles connect between "rigid" main and ventral trunk muscles spirally at an angle of perhaps between 10° and 45° to the axis of the trunk.