Lack of Supporting Structures Result in Spheres

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Rule-to-Build-By:
In order to build a structure that has a shape other than a sphere, one needs a rigid skeletal structure to dictate that desired shape.

What:
Micelles and cells that are in mitosis can be observed to be spherical in shape due to a disassembly or lack of skeletal filaments. A human made structure that follows this same principle is the igloo found in artic environments, which also has no skeletal support system.

How:
A sphere is a perfectly round geometrical shape and can easily be formed naturally or architecturally by a series of repeating units that fit together. Spheres are often used in architecture in the form of a dome, half of a sphere. However in nature it most often exists as a complete spherical shape. An example of this complete spherical shape existing in nature is the micelle. A micelle is a cluster of phospholipids that is formed when a collection of phospholipids are forced to cluster together outside of the plasma membrane due to the excluding nature of water (Alberts, et al. 2010). These structures have their hydrophobic tails pointed in towards the center of the cluster and their hydrophilic heads form a protective outer shell. Micelles can vary in size depending on the number of phospholipids present; however, they always have at least one thing in common. Micelles are always perfectly spherical in shape (Morris, 2012). This is because a micelle contains no cytoskeletal filaments; it is just a series of repeating phospholipids. It is this lack of an internal rigid, supporting structure that results in micelles forming no other shape than spheres.

When imaging a cell it is easy to observe when the cell is progressing through mitosis. This is because when the cell is not in mitosis it can have a variety of shapes depending on function and location; however, when a cell begins progressing through the cell cycle it can be observed to have a spherical shape. This is due to the fact that during prophase the cells microtubules begin to disassemble and form the mitotic spindle on which the proceeding steps of mitosis occur (Szewczyk & Oakley, 2011). When not in mitosis, a cell’s microtubules are assembled and aid in determining cell shape due to their stiff, rigid nature. Without these microtubules to help support and dictate a specific cell shape the cell becomes spherical (Rosenblatt, 2008). Even more noticeable is the fact that microtubules are also responsible for giving cilia its structure. Cilia are small hair like projections that protrude from many eukaryotic cells. In eukaryotes, cilia are used to propel the cell or to sweep fluid over the cell surface (Alberts, et al. 2010). Cilia are comprised of microtubules that act as an underlying skeletal support system on which the phospholipid bilayer stretches over to form thin protruding structures (Sun, et al. 2011). Comparing identical cells with the exception that one cell has cilia and the other cell does not have cilia it is easy to see that it is just the presence of these microtubules that cause the cilia to form. If one were to take away the microtubule structures in the cell that has cilia, the membrane would have no structure to push and support it in the long hair like protrusions and the cell membrane would retract and form the shape dictated by the underlying skeletal structure that is still present. Without the microtubules to act as a skeletal structure on which the cell forms structures such as cilia, the cell would have a permanent spherical shape as seen by the cells that are in mitosis.

In human built architecture, for example when building a house, the architect designs a blueprint of how the house will
structurally be built. Then he has his builders construct a foundation and as part of that builds the frame, which will support the house, after it is finished. This frame dictates what the house will look like and what shape each of the rooms will have. This frame is very important to the stability and therefore safety of the house. This is because most houses are square or rectangular. The only house that has no skeletal support system is the igloo found in the artic regions of the world. The igloo is a dome shaped structure with a small arch shaped opening to act as a door. This structure is able to stand up without a skeletal support system because a dome is half of a sphere.

**Why:**

In a biological setting cell and molecules are constantly surrounded by water and other matrices that are constantly pushing on the molecules (Morris, 2012). According to the laws of physics these particles are also pushing back on their surroundings. It is this principle that indicates why when a cell’s microtubules disassemble during prophase the cell becomes spherical. The sphere is identical from every angle to every surface. This means that when an outside force acts on the sphere, it distributes the force all over all of the molecules in the sphere and does not cave in (Goodman, 2012). Water, which is abundant in the human body, supplies most of the pressure that our cells are under. In a biological setting water completely surrounds the cell and pushes in at it from every direction and the sphere is the only shape that can handle strong forces from every direction and push back with equal force and not compromise its shape. When a mitotic cell’s microtubules disassemble the rigid force of the microtubules to keep the cell in a certain shape is lost and the water pushes the cell into the highly stable spherical shape. This also explains why when the microtubules are removed from a cell’s cilia the phospholipid bilayer “smooths out” and the cell becomes more round in appearance. This also applies to the appearance of the micelle. Since micelles have no internal rigid skeletal structure to provide an addition support against the forces of the water, they form the highly staple spherical shape.

In human built structures a majority of the time they do not need to combat the forces of being surrounded by water however they do need to be able to withstand the forces of gravity and the occasional weather related forces. They combat these forces with the skeletal support system in the original foundation plans of the house. An igloo does not contain these support systems but rather relies on its spherical shape just as the cells do. However unlike in the cells the igloo does not need to worry about forces pushing from below it, which is why the half of a sphere is strong enough to support the structure. In essence a continuous and rigid sphere has no weak points and can withstand great amounts of force due to its geometric nature (Goodman, 2012), which is what makes it a great building technique for nature and human made structures.

**Figures:**

Figure 1: This is an image of a micelle. Note the lack of an internal cytoskeletal structure and the spherical shape of the molecule as a result (2012, Micelle).
Figure 2: This is a series of images that depicts a mitotic cell completing one cell cycle. Notice that the final two daughter cells are angular and have a diamond-like shape. This is the shape of this type of cell during G phases. Compare to A and you notice that A is rounder and more spherical. A is in prophase. Also notice B, which is in prometaphase, is completely spherical (Moisescu, 2008).

Figure 3: Notice the long hair-like protrusions from this cell called cilium. In addition notice that the green skeletal structure that gives them this shape are microtubules (Alberts, et al. 2010).

Figure 4: This is a type of shelter found primarily in the artic regions of the world. Notice the dome-like appearance and the lack of skeletal structure supporting it due to the half-spherical shape of its design (2012, Igloo).

References:


Images:

