Scaling up organisms, modeling with blocks, what happens to surface area? Volume? (3D)

Part of what we are trying to do in these institutes is to connect algebra to geometric ideas and, where possible, give you some ideas about how algebra, geometry, and other mathematical concepts connect more broadly to STEM contexts.

I was originally trained as a marine biologist and later as a neurobiologist….both fields use mathematics to model the kinds of systems seen in physical, environmental, and living systems.

To work on the next problem, I want you to imagine yourself as an organism (plant, animal, fungus, single celled bacteria)….I'm going to place you in some extreme environments and I want you to think about 2 things:

1. What kinds of environmental stresses might you face?
2. What are some adaptations you have to deal with those stresses that have allowed you to survive?

Adaptations to hot, dry environments; cold environments; need for supplies (food, oxygen; nutrients), What creatures or plants survive in these environments?

3. What physical characteristics in an organism or part of an organism are adaptive traits for these environments? Can you test some designs with blocks that will be good candidates for survival in certain environments?
4. Surface area of a plant or animal? What does that involve?
5. Volume or weight of an animal?

6. Let's make some different "animals" out of blocks (12)….which ones are well-adapted for which kinds of environments? Are all the organisms the same "size?" Do they all have the same "exposure" to the environment? How do we get large surface area? How do we get small surface area? Why would each of these situations be adaptive?

    a. Make sure we discuss different ways to "count" the surface area….it's not as easy as it might seem.
    b. Long "snake" of cubes…12x4 = 48; plus the 2 faces on the ends.
    12x6 = 72; but on each of the 10 in the middle, 2 faces are removed, so -20 and the 2 blocks on the end each have one face removed: 72-20-2=50
    c. What about a lizard shape? How can we count the surface area for a more complicated creature? For block animals, is the SA always an even number? Why?

7. Now, we will just take one creature each (start with 1-8 cubes) and scale it up in all 3 dimensions…the cube is the easiest, but maybe others in your group can try other shapes…how does SA change? How does Volume change? What about the ratio?

Scaling up – bamboo skewers to garden poles; biology implications
On shape and form. Playdoh (quickly, before bamboo). Double playdoh does not get you twice as tall. Grow creatures segue into patterns growth and change unit.

Issues / Goals
With height there are problems of torque/twist and balance/stability (center of gravity) and load (how much weight can a structure support?)
Strength of structure depends on the design (triangle vs. rectangle; spherical/ arches /geodesic vs. rectangular).