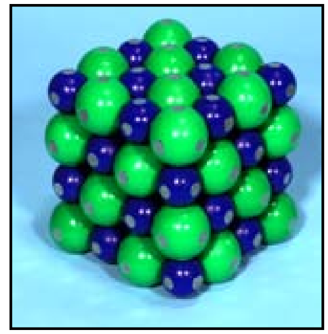
Patterns in Crystal Structures

STEM: The Math, Science, and Art of Crystals Using a Salt Lattice Model

Teacher Notes — Math

A Guided-Inquiry Approach — Using the 3D Molecular Designs' NaCl Lattice Model
Grades 3-5



Learning Objectives
Students will:
- Recognize multiple ways of solving a problem.
- Practice pattern recognition.
- Make and test predictions.

Vocabulary
We have chosen to use the term ***sphere*** to describe Na and Cl ions. If the term ***ion*** is included in your school's standards, then the term ***ion*** may be substituted throughout.

Time
Activity will take 20-30 minutes.

Classroom Activity
Set Up
Provide each group of students with a 4x4x4 NaCl Lattice (cube) consisting of smaller blue and larger green spheres held together with magnets.

1. Discuss the shape of a cube.
2. Are there equal numbers of green and blue spheres on each face? **(Yes)**
3. Ask students how many spheres are in the cube. **(64)**
4. How can you figure it out without counting? (See possible answers on next page.)
5. Poll students for their answers.
6. Ask students how they determined their answer.

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7. Ask other students if they used a different method. Explore alternate ways to determine the number.

- Count the number of blue spheres on one face (8), and multiply by 2 to get the total number of blue and green spheres on one face. Add this number 4 times since there are 4 layers.

8 x 2 = 16 16 + 16 + 16 +16 = 64

- Count the number of blue spheres on one face, then multiply by 2 to get the total number of blue and green spheres on one face. Multiply this number by 4 since there are 4 layers.

8 x 2 = 16 16 x 4 = 64

- Count the total number of spheres on one face, and add this number 4 times – one for each layer.

16 + 16 + 16 + 16 = 64

- Count the spheres along two edges (length and width), then multiply to get the total number of spheres on one face. Add this number 4 times since there are 4 layers.

4 x 4 = 16 16 + 16 + 16 + 16 = 64

- Count the spheres along two edges (length and width), then multiply to get the total number of spheres on one face. Multiply this number by 4 since there are 4 layers.

4 x 4 = 16 16 x 4 = 64

- Count the total number of spheres on one face, then multiply this number by 4 since there are 4 layers.

16 x 4 = 64

- Count the spheres along each of the edges (length, width and height), then multiply.

4 x 4 x 4 = 64

The Math, Science, and Art of Salt Cubes

8. Ask students to predict how many cubes with 3 spheres on a side they can get from a 4x4x4 cube.

9. Ask students how they determined their answer.

   Some students visualize removing 1 layer from each dimension of the cube and then use layers to build a second cube.

   Others might calculate that a 3x3x3 cube needs 27 spheres. Since they have 64 spheres, they can get 2 3x3x3 cubes, with 10 left over.

10. Have the students use the 4x4x4 cube to build as many 3x3x3 cubes as they can, then use the remaining spheres to build as many 2x2x2 cubes as they can.

    Students will be able to build:
    - 2 3x3x3 cubes
    - 1 2x2x2 cube, with
    - 2 spheres left over

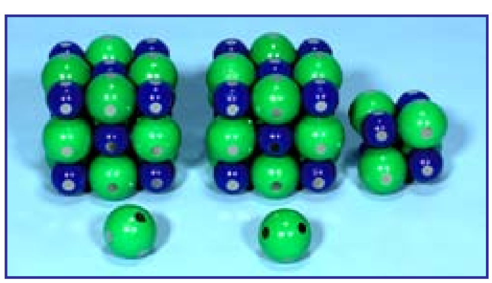
11. Ask students to hold up their leftover spheres and compare with other teams. Ask whether everyone has the same color(s) for the leftover spheres (see photos on next page).
    - Some will have 2 blue spheres.
    - Some will have 2 green spheres.
    - Some will have a blue sphere and a green sphere.

12. Ask students to propose a reason why they have different spheres left over. Once a student describes their reason for different colored leftovers, test their hypothesis:

    Cover the remaining spheres from one group so students can't see them. Hold up the 2 cubes for all the class to see. Ask the students to describe the colors of the remaining spheres, then show the spheres to verify their prediction.

Pattern recognition is the key to identifying the differences:

If each 3x3x3 cube has blue spheres in the corners, the 2 leftover spheres will both be green.



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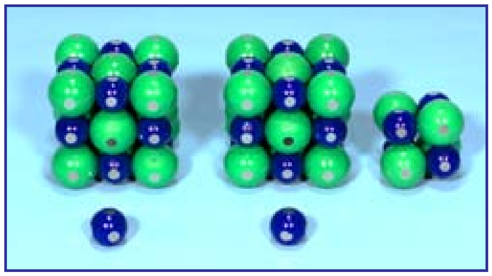
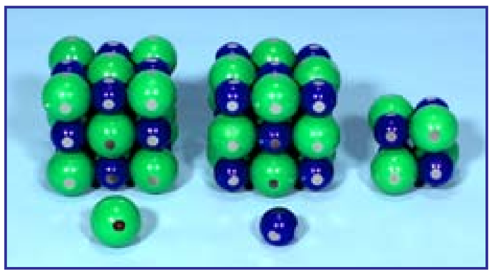
If each 3x3x3 cube has green spheres in the corners, the 2 leftover spheres will both be blue.



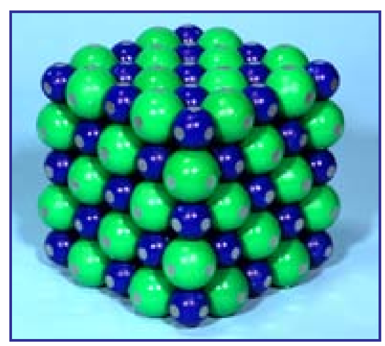
If one 3x3x3 cube has green spheres in the corners, and the other 3x3x3 cube has blue spheres in the corners, there will be 1 blue and 1 green sphere left over.



Extensions

(Beyond the scheduled 30 minute time frame.)

Extension — Math



Predict whether a 5x5x5 cube can produce more than 1 4x4x4 cube.

There aren't quite enough spheres to make 2 smaller cubes; the larger cube has 125 spheres, and 2 smaller cubes would require 128 spheres.

Predict how many 3x3x3 cubes can be made from a single 5x5x5 cube.

4 smaller cubes, with 17 spheres left over.

Predict how many 2x2x2 cubes can be made from a single 3x3x3 cube.

3 with 3 left over

Predict how many 2x2x2 cubes can be made from a single 4x4x4 cube.

8 with none left over

The Math, Science, and Art of Salt Cubes

Cross-Cutting Concepts that May Apply to Your Lessons*

Patterns. Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

Scale, proportion, and quantity. In considering phenomena it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

Structure and function. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

Stability and change. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

For more information about the MSOE Center of BioMolecular Modeling visit our website at: http://cbm.msoe.edu. The MSOE Library, MSOE Center for BioMolecular Modeling and 3D Molecular Designs collaborate to make the MSOE Lending Library available.

*National Research Council. (2012) *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* http://www.nap.edu/catalog.php?record_id=13165