Discover art and science at play with Zometool; the intelligence-building toy made for kids and used by Nobel-Prize winners!

- Guaranteed for life
- All components are inter compatible.
- More parts = more fun!

"The mind, once stretched by a new idea, never regains it's original dimensions."
- Oliver Wendell Holmes

Ice Crystals and Stars

• Discover • Marvel • Create

START HERE!

Parts: 90
18 — 30
30
12

Snow is made up of a limitless number of tiny frozen works of art - crystals! Each crystal is unique in itself. Ice crystals form different structures, depending on the surrounding temperature. With this Zometool kit, you can

discover

- *that ice crystals have a six-sided basic structure,*

marvel

- *that, due to the composition of water molecules, only angles of 60° und 120° are possible and*

create:

- *elegant stars, crystals and hybrid forms of many crystal structures. With Zometool, you'll experience these sparkling works of art in a completely new way.*

MADE IN USA
from kid-safe materials

7 097432 006604

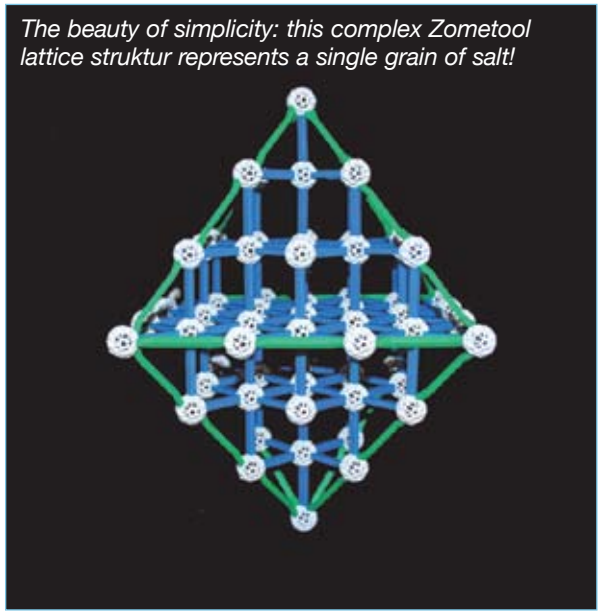
WARNING: CHOKING HAZARD
This produkt contains small parts, which could be swallowed.
NOT for children under 3 years.

art and science at play
ZOMETOOL®

Crystals

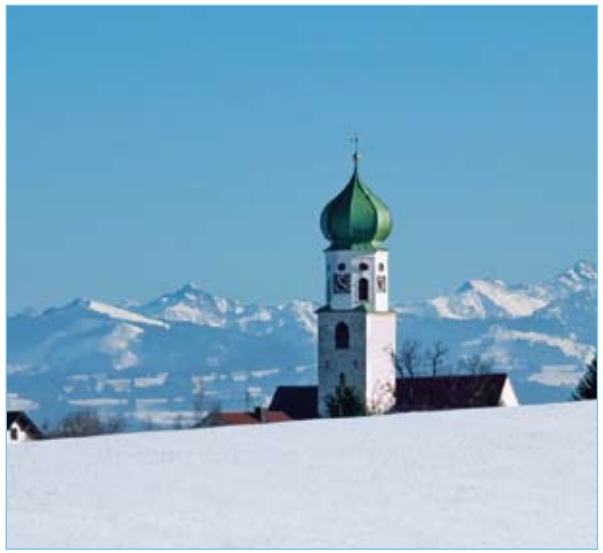
In our day to day life, we are surrounded by crystals. For example, well-known types of crystals are sugar, salt - and, of course, snow - but more about that later.

The atoms or molecules in a crystal are not randomly arranged, in fact, they always follow regular patterns: so-called crystal lattices. These are 3-dimensional patterns of (mathematical) points, whose sub-unit is called a “unit cell”. There are about 1.25 x 10^{18} unit cells in a single grain of salt. We can depict these structures with Zometool:



The beauty of simplicity: this complex Zometool lattice struktur represents a single grain of salt!

Snow

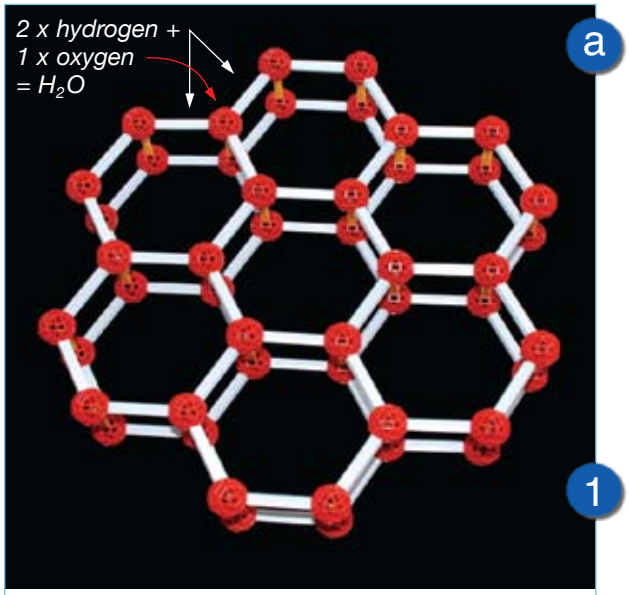


When we see a beautiful winter landscape, with white mountain tops and ski slopes, we know that snow has fallen. But what is snow?

Snow is “solid” rain. It forms when fine drops of very cold water attach themselves to dust particles or to bacteria and then freeze. This situation occurs within clouds, at or below -12° Celcius. The minute ice crystals become heavier and heavier and begin to fall. The surrounding temperature and humidity influence how each crystal develops. If it is very cold, with a high level of humidity, six-sided hollow columns will form - if the weather is warmer, six-sided stars will appear. Each and every crystal follows its own particular path on its way downwards and the tiniest fluctuations in temperature and humidity will have an effect on its appearance.

The Hexagon

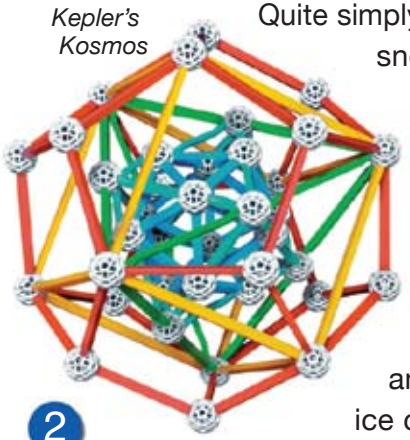
The water molecules in an ice crystal form themselves into a six-sided lattice, as in the Zometool model below:



In picture a each red ball represents a hydrogen atom and the white struts depict the oxygen atoms. There are always two hydrogen atoms to each oxygen atom, thus giving us the chemical formular H_2O. The symmetry of an ice crystal develops from the sixfold symmetry of an (ice) crystal lattice and this is the reason why the basic structure of an ice crystal is always six-sided.

Almost 500 years ago, Johannes Kepler (1571-1630) wrote a paper on the symmetry of snowflakes, in which he described the fact that a snowflake always looks the same when rotated 60° (sixfold symmetry). The Zometool kit “Kepler’s Kosmos”, explores Kepler’s view of the planets and their orbits.

Kepler’s Kosmos



2

Quite simply, snowflakes and snow crystals are made of ice: a snow crystal comprises only one single ice crystal, whereas a snowflake is made up of an amalgamation of ice crystals.

Therefore we can see that snowflakes are not frozen drops of water. Of course, some drops of water do freeze as they fall to earth - these are called ice pellets, or sleet and have no particular symmetry.

Ice crystals

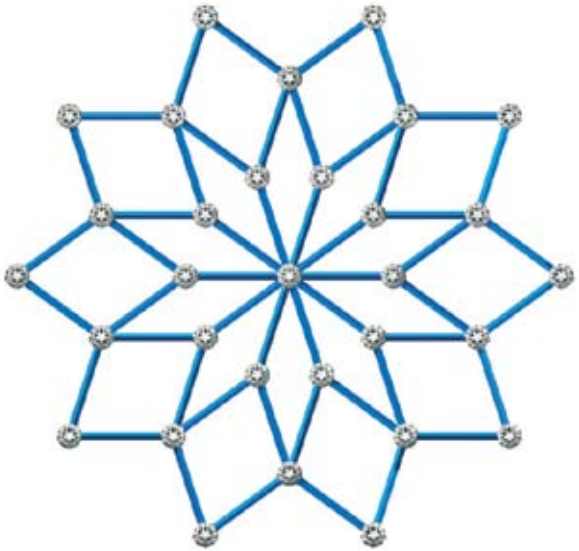
When we observe ice crystals closely, we become aware of the unbelievable beauty of their structures - millions of individual works of art, all falling from the sky. Their development is determined by temperature and humidity: the greater the humidity, the more delicate the “arms” of each crystal.

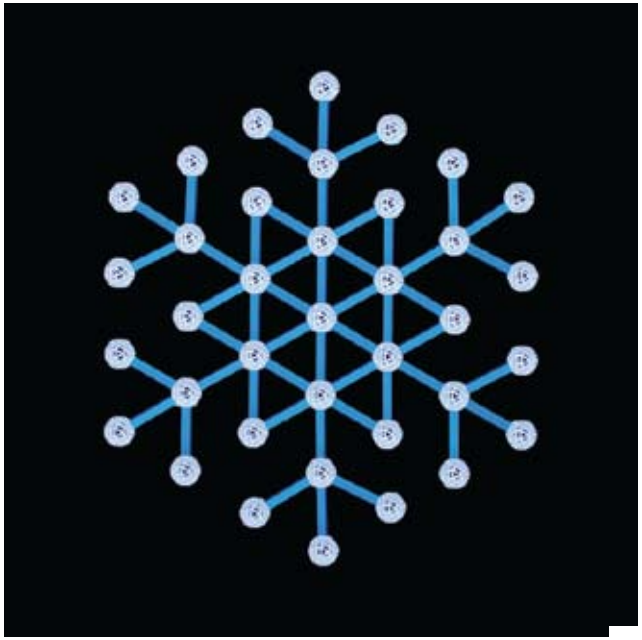
The movement of the ice crystals through the air causes them to melt and recrystalise again and again, which leads to the “growth” of increasingly complex hybrid forms. This growth only comes to a halt when the ice crystals have reached a point about 100 m. above the ground, with temperatures of around 0° C. The wind whirles the many ice crystals through the air and they collide with each other, causing their “arms” to get tangled and stick together. A snowflake is born!

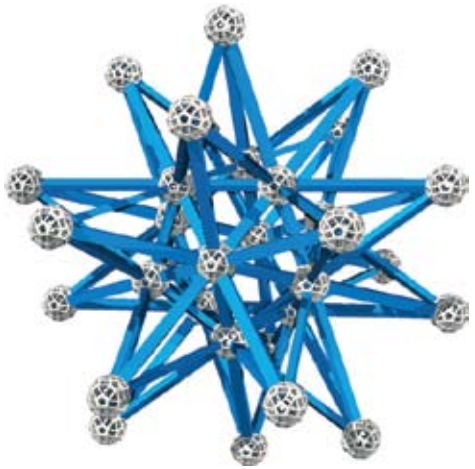
Each crystal is unique. As long ago as 1895, Wilson A. Bentley, a Canadian farmer, took photos of around 5,000 different forms. The probability is that there have never been two identically-shaped complex snowflakes, the reason lying in the great variety of possible combinations of all the different features of crystals. The number of possible forms of complex ice crystals is greater than the number of atoms within the universe.

Apropos the universe:
Don’t the ray-shaped “arms” of an ice crystal remind you of stars?

We can build 2-dimensional ice crystals and observe the sixfold symmetries which occur.

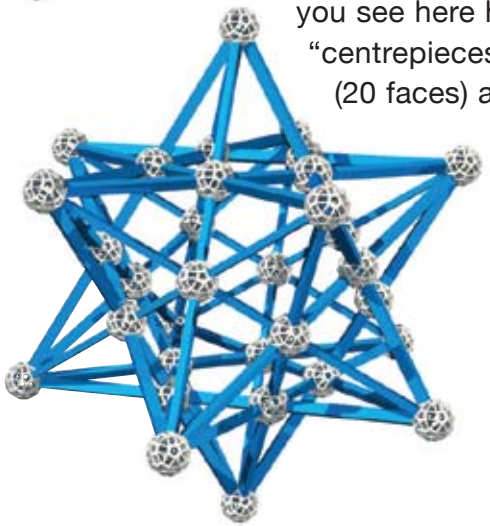






You can create interesting shadows with the 3-dimensional models.

Maybe your ice crystal will develop into a beautiful star? Use two Ice Crystals sets to continue building in 3-D. The stars you see here have two different "centrepieces": an icosahedron (20 faces) and a dodecahedron (12 faces).



Dodekahedron star *- in the middle we have a regular Platonic solid; a dodecahedron. We can attach the 12 "rays" of the star onto this centrepiece.*

Use the blue struts to create 2-D crystals, making sure to note the position of the Zometool ball, with either a rectangle, a pentagon or a triangle pointing upwards:

ZOMETOOL RULES

1 If it works, it works perfectly ...

... and if it doesn't work, it doesn't work at all. Don't force Zometool components. You can bend a strut to fit it into a tight spot, but struts in finished models are always straight, never under tension.

Hint: you can tell which strut fits between two balls in a model by lining up the balls and looking through the holes. The holes show you the shape of the strut which fits!

2 Don't break it apart, take it apart!

Take models apart by grasping a strut with your fingers and pushing the ball straight off with your thumb. Twisting balls or pulling models apart or crushing them can cause parts to break!*

To disassemble a large model quickly, remove all the longest struts of one colour first and work your way down!

3 Leave the place cleaner than you found it.

It's always a good idea to clean up when you're done, so the next person can enjoy Zometool too. If we work together, we can make the world better for all.

**We replace accidentally broken parts for free:*
Europe:** contact **service@zometooleuropa.eu
***Outside Europe:** visit: **www.zometool.com/warranty** for details.*

art and science at play
ZOMETOOL®

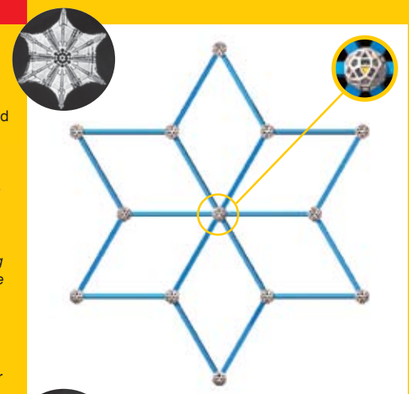
Our mission:
- **Make learning fun**
- **Create value**
- **Build a better world**

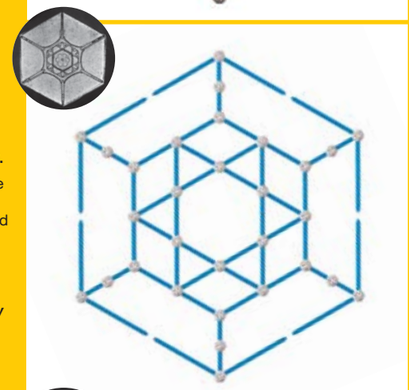
Whether you want to ask better questions or learn better answers, Zometool is your ticket to discovery and fun. From numeracy to nanotechnology, quasicrystals to quantum mechanics, the destination is always the same: understanding our amazing universe.

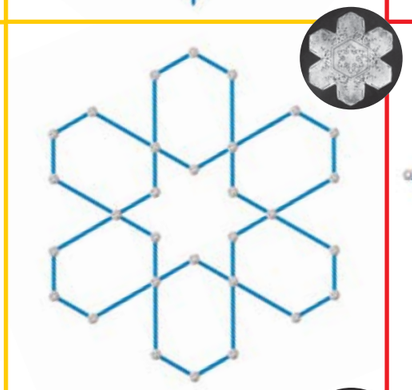
More under **www.zometool.com**

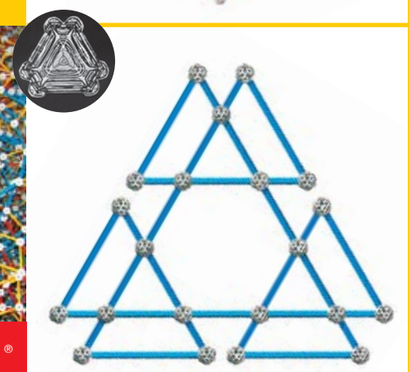
Zometool Project 'Ice Crystals and Stars': A-B. Paschen, idea; Paul Hildebrandt, Erwin Kotzab, concept and text; Dr. Scott Vorthmann, software for illustrations; Photomicrographs of Snow Crystals, W.A. Bentley and W.J. Humphreys, Dover Pub., New York, USA; Lyn Taylor, Anni Wildung, graphic design; Paul Hildebrandt, concept und project management. Based on the 31-zone system, discovered by Steve Baer, Zomeworks Corp. USA. Contact: service@zometooleuropa.eu.

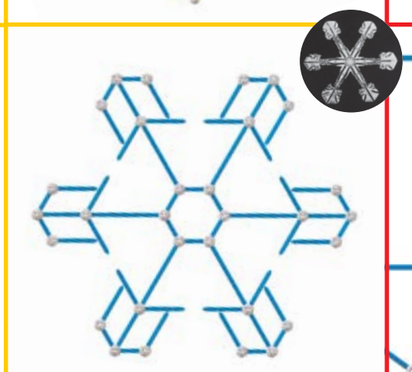
ICE CRYSTALS (2-D)



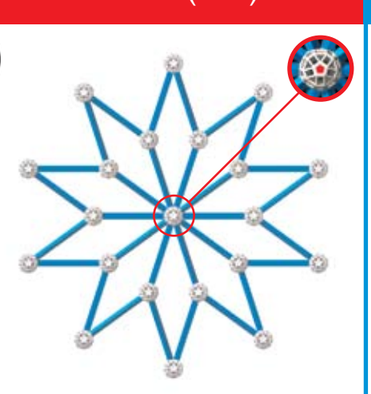


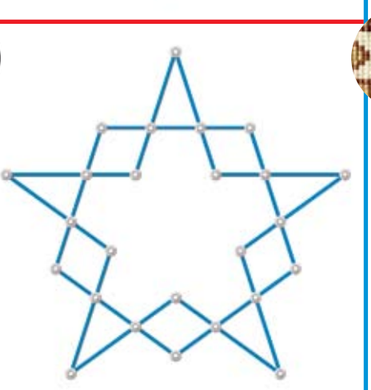


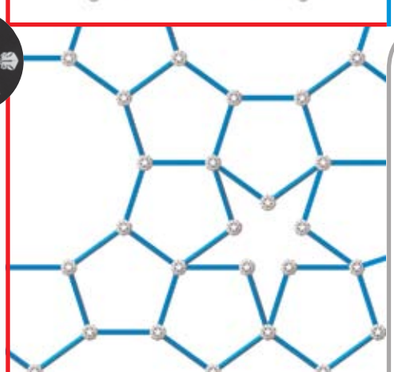




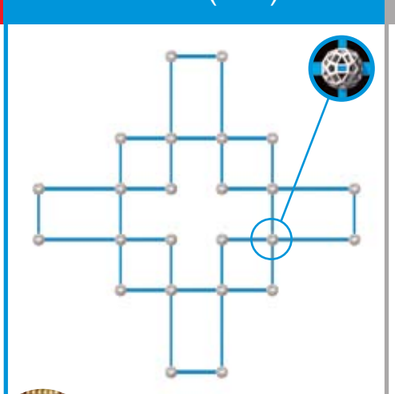
STARS (2-D)

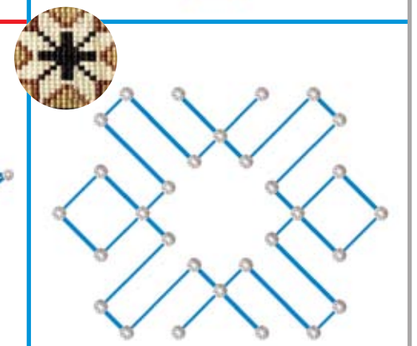


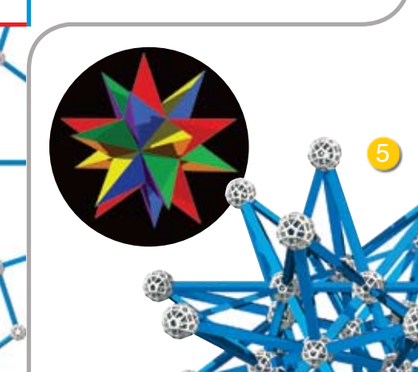




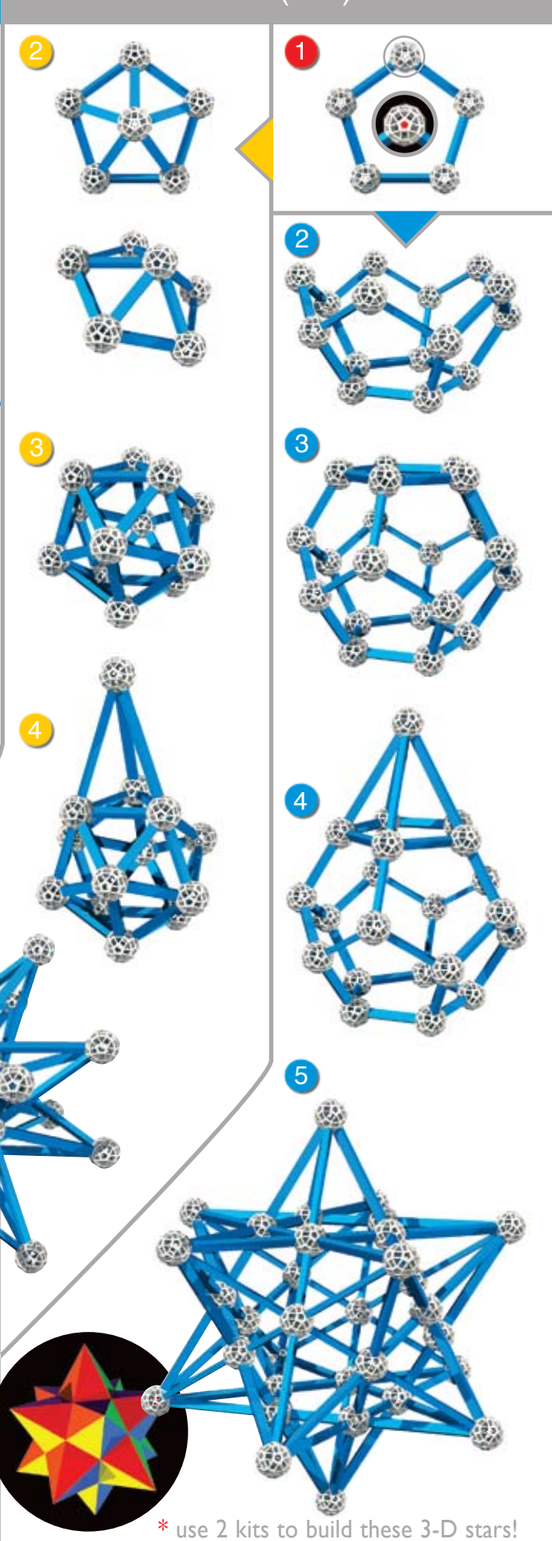
STARS (2-D)







STARS (3-D)*



* use 2 kits to build these 3-D stars!

SHADOWS

1. Depending on the shadow you wish to project, stick either a blue (2-fold), yellow (3-fold), or red (5-fold) strut in the appropriate hole of one ball of the completed 3-D model.

2. Turn the strut in the direction of the light source.

3. Make sure that the projection surface is at 90° to the light source.