In this unit, we will talk about the unit cell - one of the most fundamental concepts in the area of crystallography!

And we will do this in the following way - I give you a task:

I'll show you a body, a particular space, a volume element - and you are supposed to divide this body into identical pieces, identical building blocks that will in turn constitute this volume element if you re-assemble these units together.

- but there are 2 constraints / rules:
  - firstly, you should only use regular building blocks
  - and secondly: you should only use a single sort of building blocks

Let's start - with this big cube! Consider a while how you can divide this cube into smaller, identical pieces...

Well, I think a quite natural, first intuitive approach is, to divide this big cube into a lot of smaller cubes.

→ so, the deconstruction process ends with such a tiny cube - and a cube is characterized by the lengths of the edges -they are all the same (a equals b equals c) - and the angles between the faces, which are all orthogonal, ninety degrees!

This is of course not the only possibility.

Another possibility is to slice this big cube into horizontal slices - or vertical slices that would be the same in the end.

And this results in these thin square plates as building blocks - as in the case before with orthogonal faces, all angles are ninety degrees but now with a square basal plane and rectangular lateral planes...

Yet another possibility to divide this big cube into identical building blocks is shown here…
This ‘deconstruction process’ leads to rectangular prisms as building blocks - everything is orthogonal but all edges differ in length...

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Let’s change the initial body / the starting volume that we want to divide into identical sub-units…

- look at this piece - from what sub-units could this shape be built?

- think about it for a few seconds - did you get it? -

- right, this shape can be subdivided into hexagonal columns or prisms -

- a hexagonal prism consists of 8 faces - and this is different to the other building blocks that we have seen so far… all were composed of only 6 faces, they are hexahedra…

And the question is: is it possible to generate a smaller body out of this hexagonal column that is a) regular, b) that constitute via assembling this hexagonal prism and c) in turn this overall big shaped volume here…and d) is composed of only 6 faces?

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In principle, there are two conceivable possibilities …

Firstly: we can divide this hexagonal column in such a way that we cut it along this long axis into two identical halves - if we look from above onto this column then we see this shape… as a cross-section.

There is a second possibility: we can divide it into three identical pieces like this -

Then a single block would have a basal plane whose length are equally and a longer edge along this side here -

- the angle between these two edges is then 120 degrees

- if we look again from above onto this then we see such a cross-section…

What possibility is preferable?

Well, two aspects - firstly, this shape is obviously not as regular as this, because there are three different faces - here we have only two…

- secondly –
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And this is even more important - if we want to build-up our initial shape by assembling these building units, then it is not possible if we consider only one orientation.

If we use this shape and translate this again and again and push them together, voids will be remaining - this means it is not possible to fill the space completely by this translation operation only.

Only if we use this shape in two different orientations the space would be filled completely!

And this is different to the second case: here we can build a completely space-filling form if we translate this shape and push them together! Only one oriented version of this shape is needed!

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And now we are able to generalize the concept of the unit cell - namely, by finding an answer to this question:

Which geometrical regular bodies fill the space completely (without remaining voids) by joining them together by translation along all three spatial directions only?

And the very general answer to this question is: these are parallelepipeds! - What is a parallelepiped??

Here you see a parallelepiped in its’ general form… and the definition is as follows:

- “epipedo” is Greek and means “face” - and a parallelepiped is a geometrical body, which is confined by six parallelograms, of which two of each are congruent (superimposable) and lie in parallel planes.

- look at this sketch of a parallelepiped again: there is one pair of parallelograms here in red, which are superimposable and lie in parallel planes - one in the front, one in the back..

- then there is this pair in green, the side faces - also lying in parallel planes and being superimposable

- and finally there is the basal plane and the top surface, also parallel and superimposable

- in general, the length of the edges of such a parallelepiped are different to each other and the angles between the faces are oblique…
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Now we can define the unit cell of a crystal:

The unit cell is the unit, which builds up the whole crystal structure by repeating translations along all three spatial directions!