

Lina Kara'in | Chitin and Butterflies

### Chitin in Butterflies:

Like any other insect, the butterfly's soft interior is supported by a hard exoskeleton made of chitin and a matrix of fats and proteins. A butterfly's head and chest are covered with plates of hard chitin, while the abdomen is covered with soft chitin. The wings also made of an extremely thin, transparent chitinous material that takes the form of long strands or fibrils with a diameter of 3 nanometers.

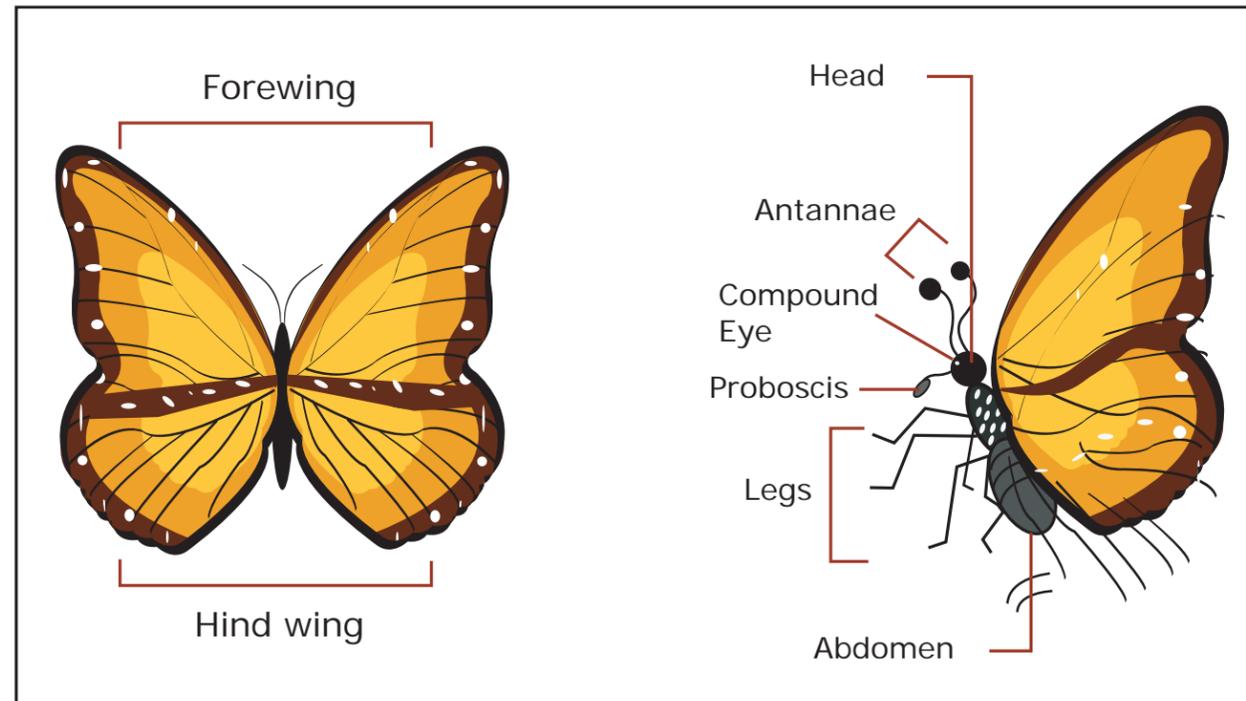
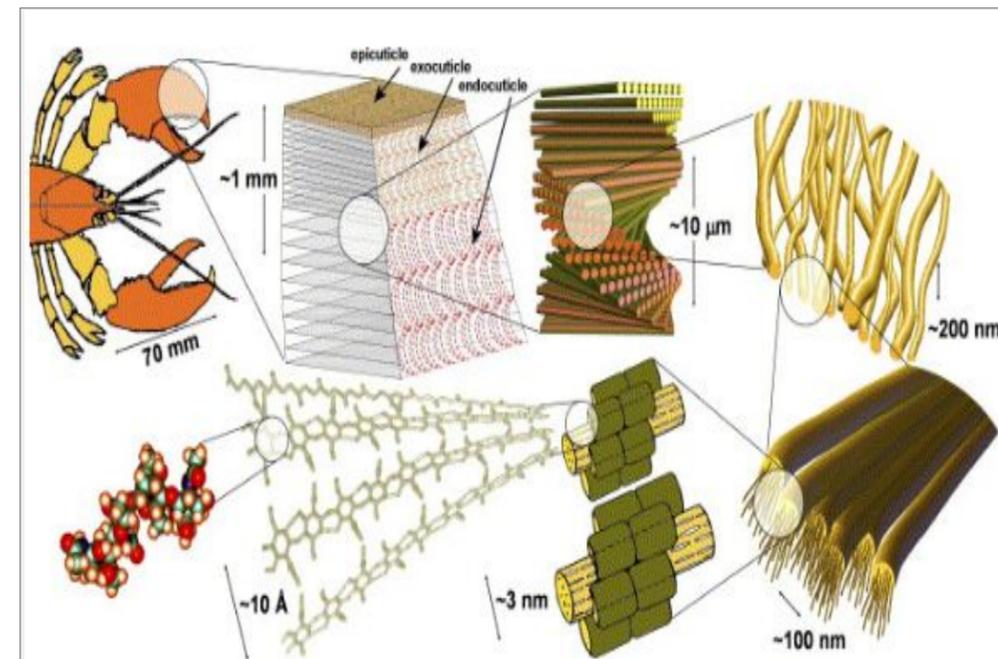


Image by MIT OpenCourseWare.

Butterfly Anatomy

Composite of photographs of Morpho butterflies removed due to copyright restrictions. Source: AskNature. "Wing scales diffract and scatter light: Morpho butterflies."

Zoom into a Butterfly's wing



Chitin Fibrils made of Chitin chains.

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### What is Chitin?

Chitin is a long-chain polymer of N-acetylglucosamines, that are joined in a reaction catalyzed by an enzyme called chitin synthase.

Chitin is found in many places throughout the natural world. It is the main component of the cell walls of fungi, the exoskeletons of arthropods such as crabs, lobsters and shrimps and insects such as butterflies, in addition to the beaks of squids and octopuses. In terms of structure, chitin may be compared to the polysaccharide cellulose and, in terms of function, to the protein keratin.

### What are Chitin Fibrils?

Chitin fibrils are composed of chains of Chitin. Strong hydrogen bonds between the chains give chitin its exceptional toughness. However, this also means that chitin doesn't stretch with growth, so insects and other arthropods periodically shed their exoskeletons.

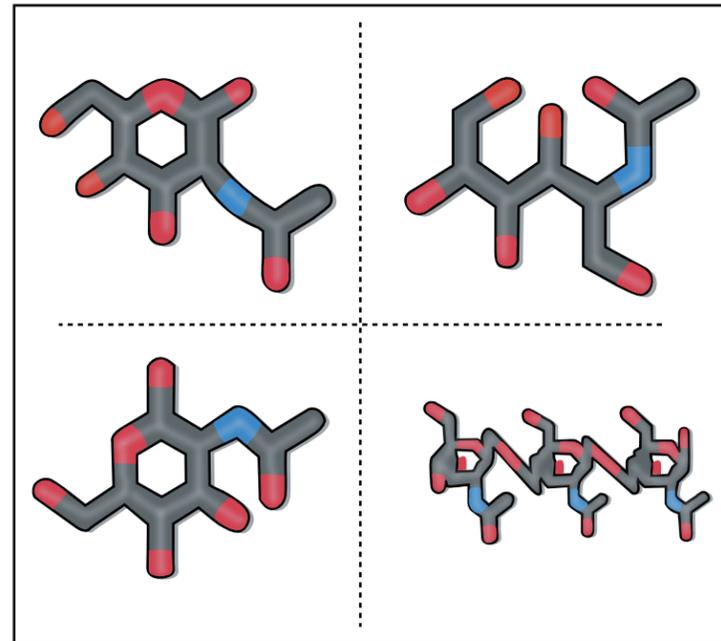
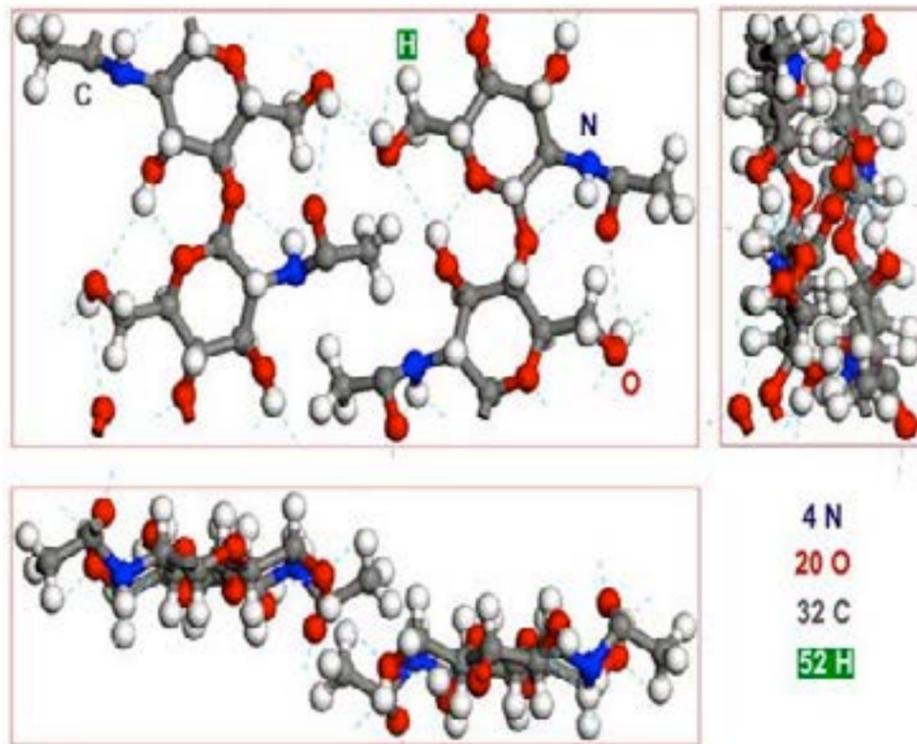


Image by MIT OpenCourseWare.  
The Different Structural Formuli of N-acetylglucosamines and Chitin Polymer.



The formation of Chitin Polymer.

Source: M. Petrov et. al. "Atomistic calculations of the mechanical properties of chitin molecules." *Biopolymers* 99 (2013) 22. Used with permission.

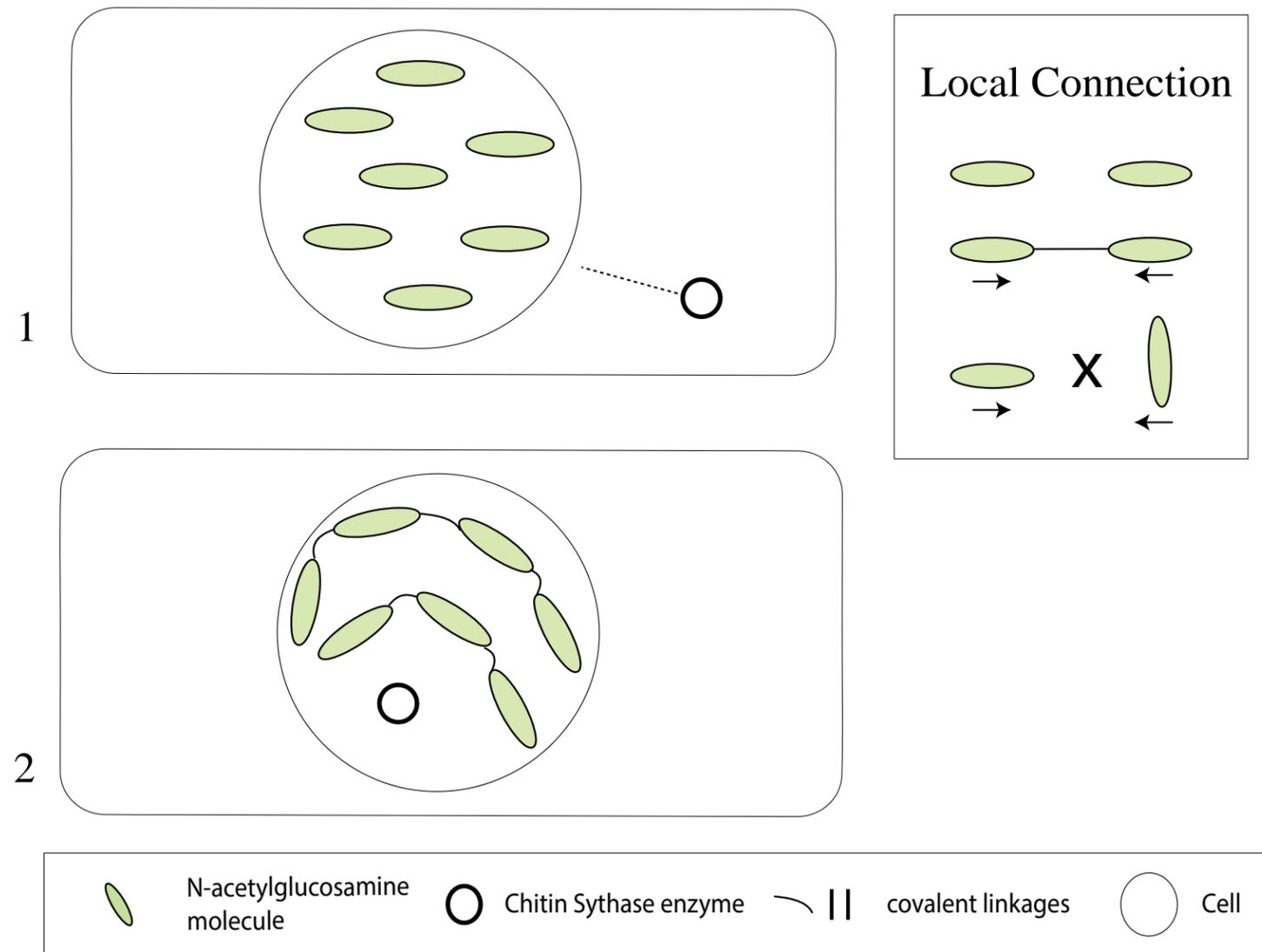
### How are Chitin Fibrils Formed?

Chitin fibrils formation can be divided into four simple steps:

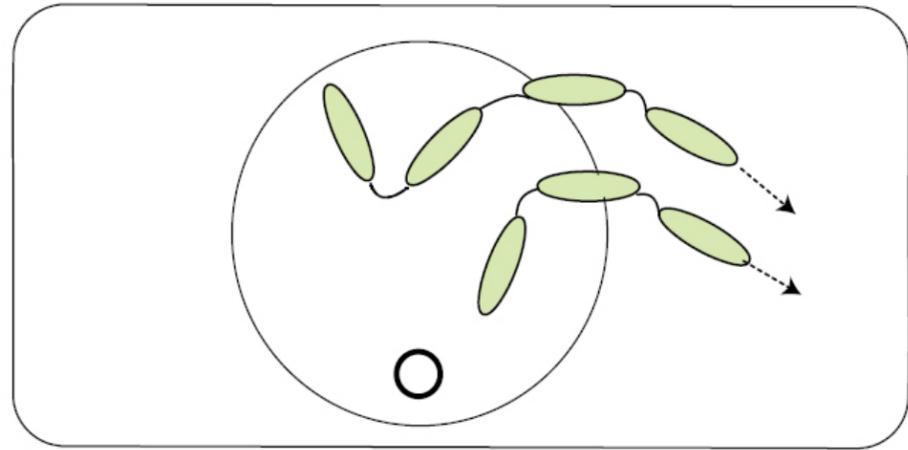
1. Chitin synthase is placed into the interior side of the cell membrane and then activated.
2. Chitin synthase catalyzes the reaction to form Chitin.
3. Chitin is moved across the cell membrane and released into the extracellular space.
4. Chitin single polymers assemble to form Chitin fibrils.

The following diagram shows the formation of Chitin Fibrils from N-acetylglucosamines molecules in a cell.

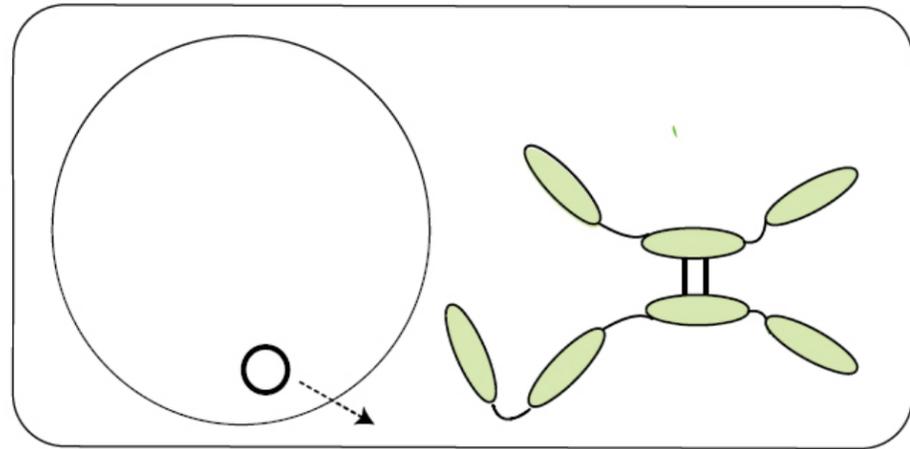
## Chitin Synthesis



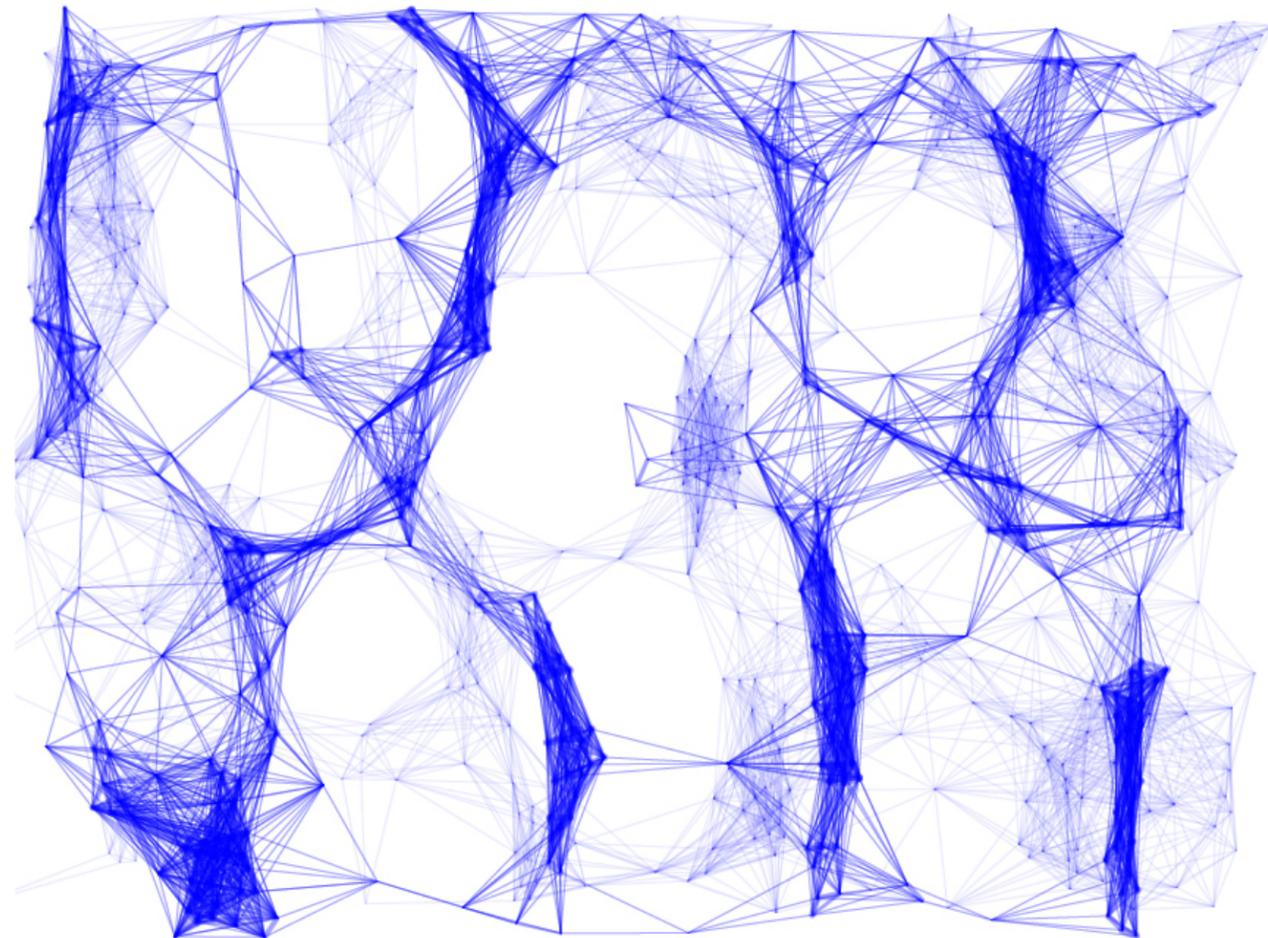
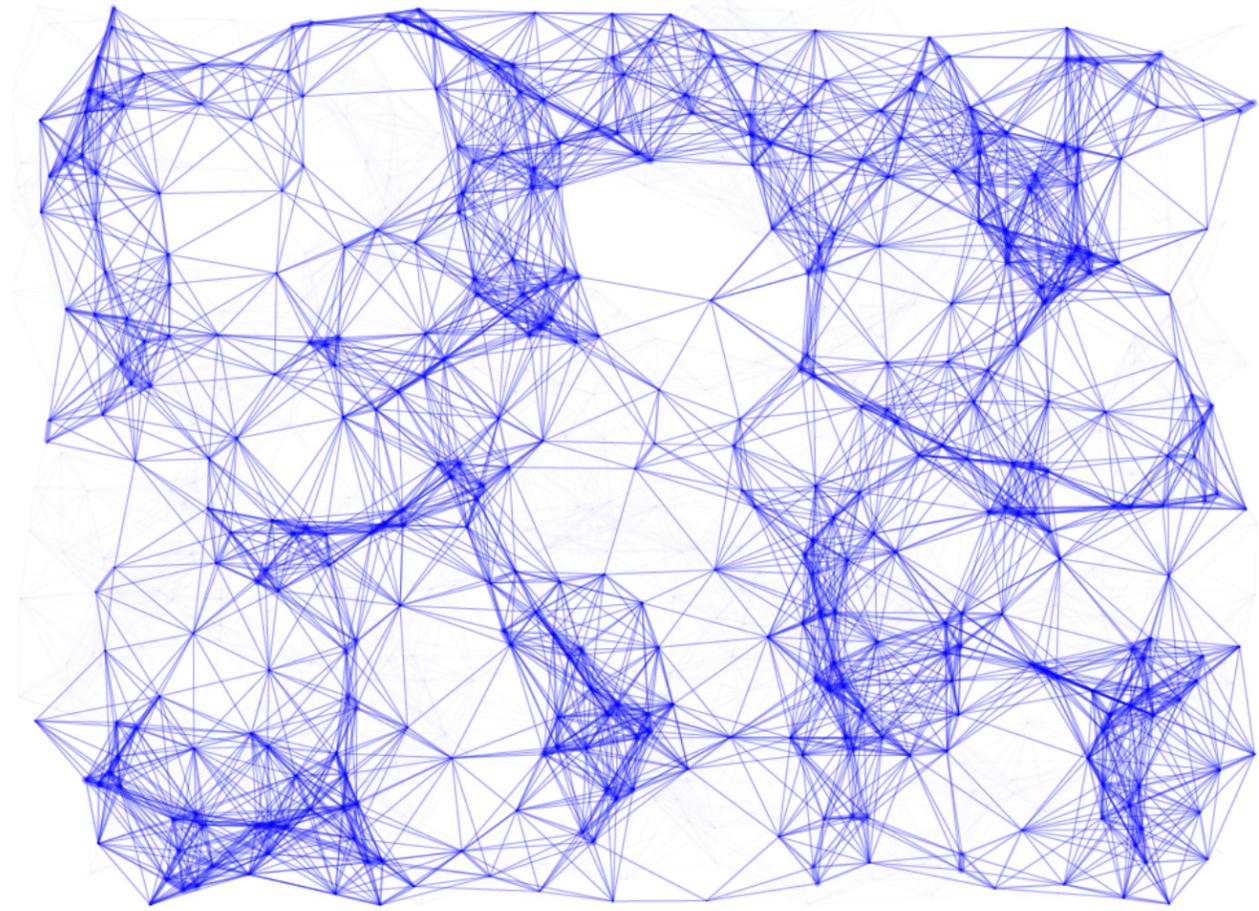
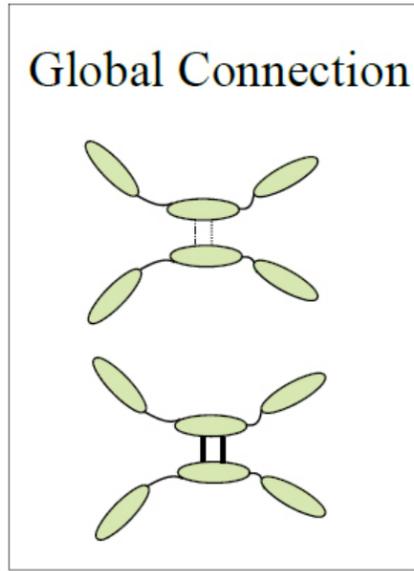
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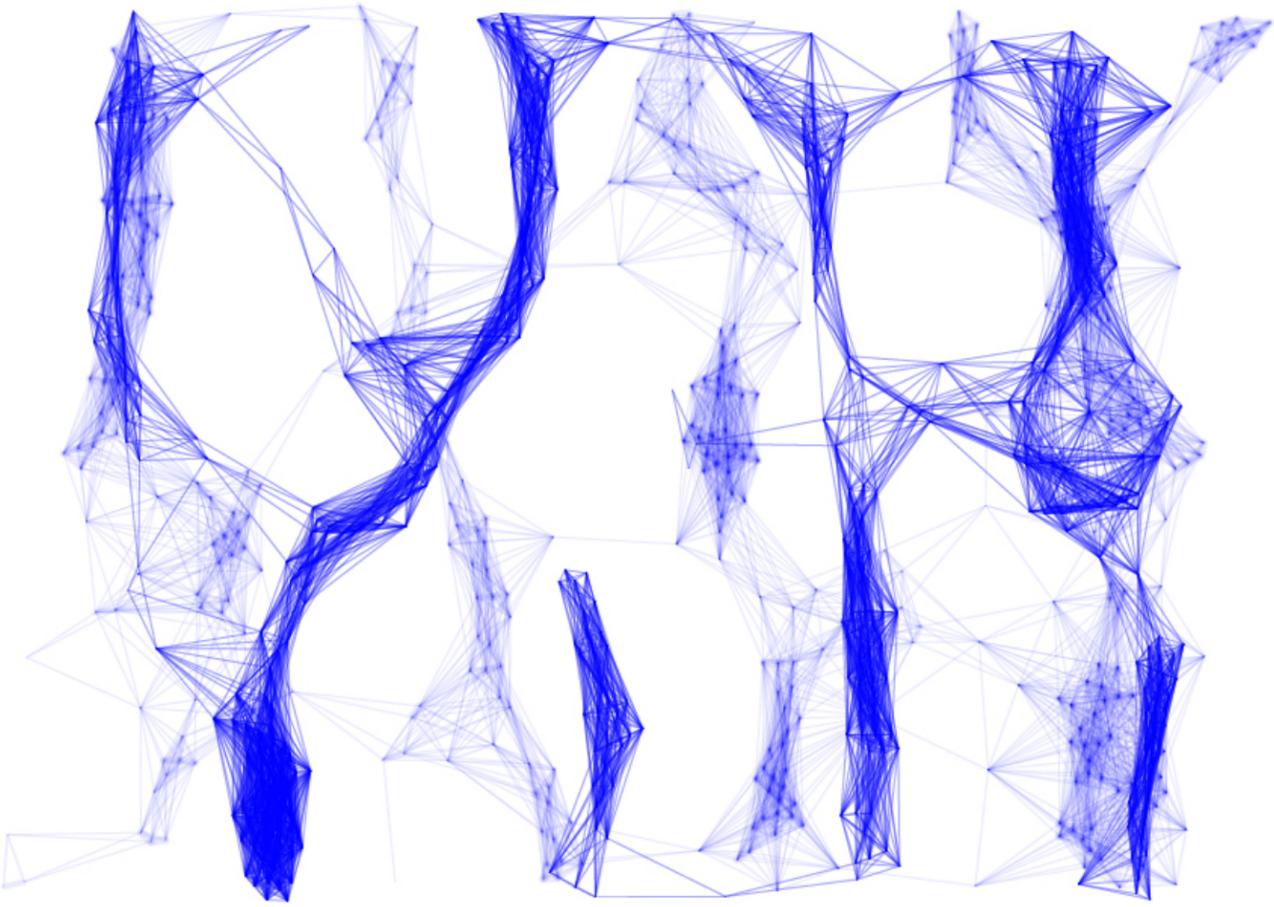


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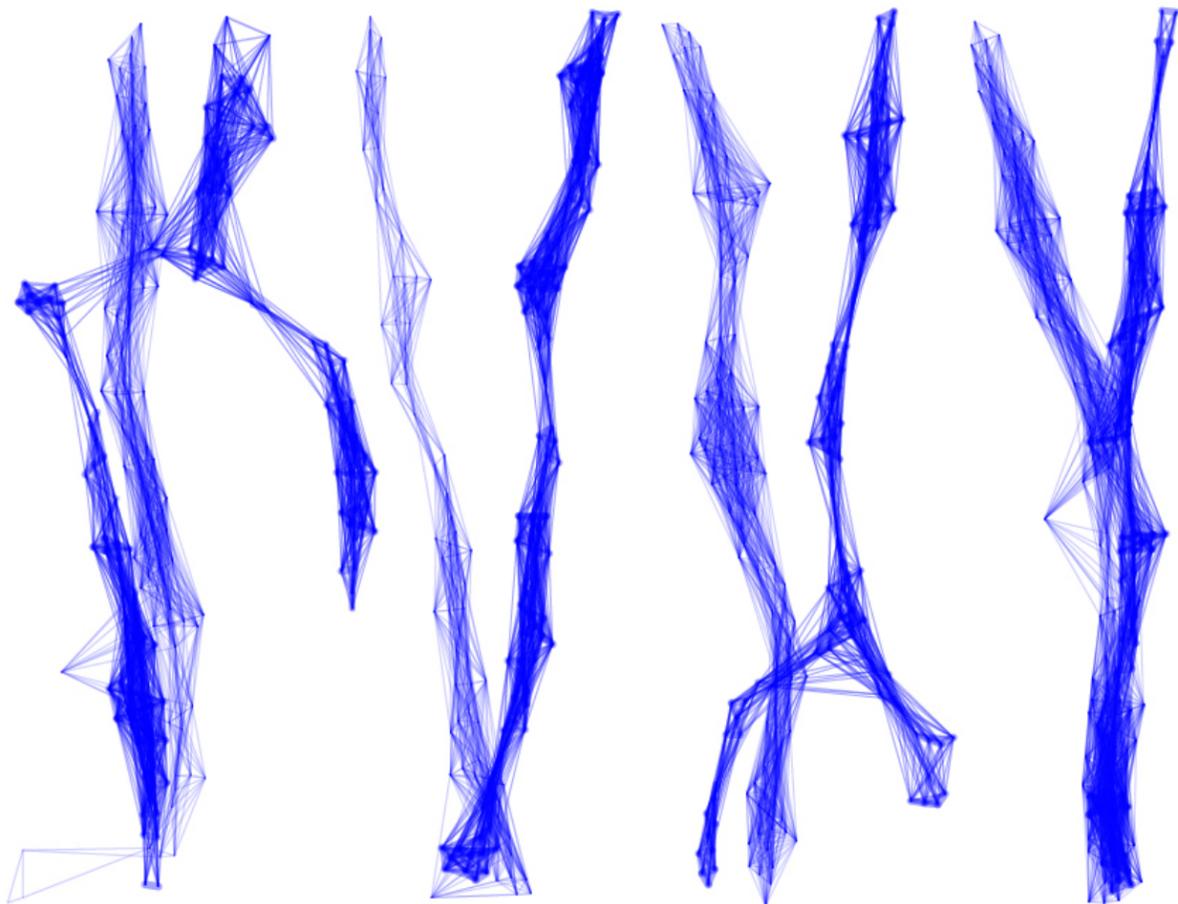
Global Connection





## Bibliography

- Nanoscale Informal Science Education:  
[http://www.nisenet.org/catalog/media/zoom\\_butterfly\\_wing\\_poster](http://www.nisenet.org/catalog/media/zoom_butterfly_wing_poster)
- The College of Earth, Ocean, and Environment at the University of Delaware website:  
<http://www.ceoe.udel.edu/horseshoecrab/research/chitin.html>
- The European Chitin Society (EUCHIS) :  
<http://www.euchis.org/>
- Wikipedia :  
<http://en.wikipedia.org/wiki/Chitin>  
<http://en.wikipedia.org/wiki/Chitinase>



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