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From mechanism to material: how to block, shape and nucleate ice crystals

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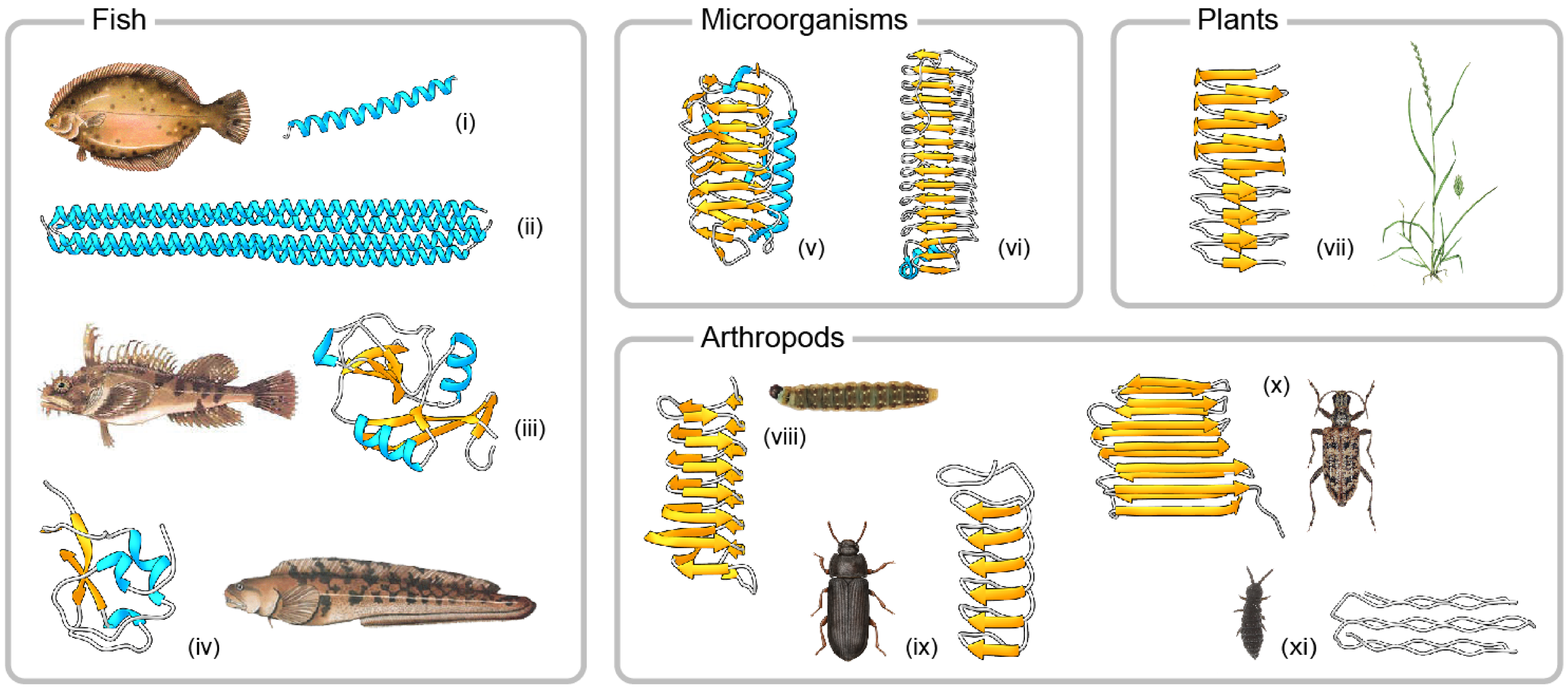
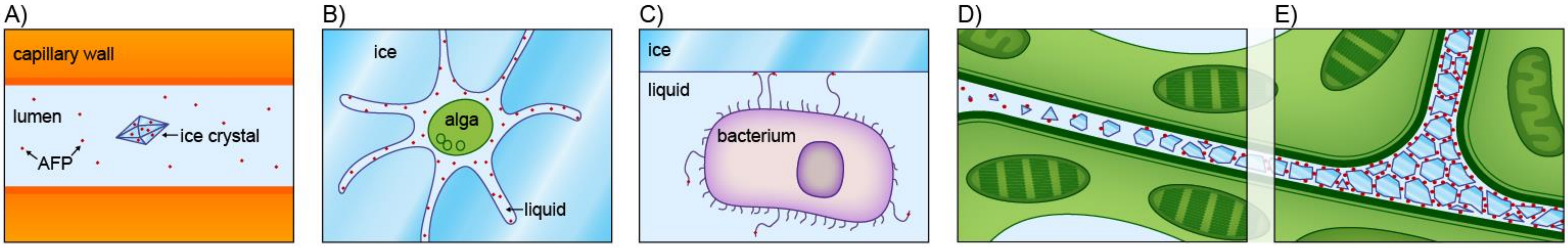
Ice binding proteins

Ice binding proteins (IBPs) are produced by various cold-adapted organisms to protect their body tissues against freeze damage. IBPs are widely studied out of fundamental and applied interests for potential use in water-based materials, such as foods, waterborne paints, and cell suspensions.[1] Instead of commonly used colligative antifreezes such as salts and alcohols, the advantage of using IBPs as an additive is that very low concentrations can be used which do not alter the physicochemical properties of the water-based material.[2]



Ice crystal nucleation and growth modification



Freezing point depression

AF(G)Ps in freeze-avoiding species like fish lower the freezing point of blood serum, thereby blocking the growth of circulating, embryonic ice crystals, within a narrow temperature range.[1]

Ice-structuring

Ice bacteria and algae secrete IBPs to keep a liquid environment in brine channels, by stopping ice growth around them, which is essential for their survival.[3]

Ice adhesion

Ice-binding domains are used by an Antarctic bacterium to adhere to ice on the sea and lake surfaces to gain access to oxygen and nutrition released by photo-synthetic organisms.[3]

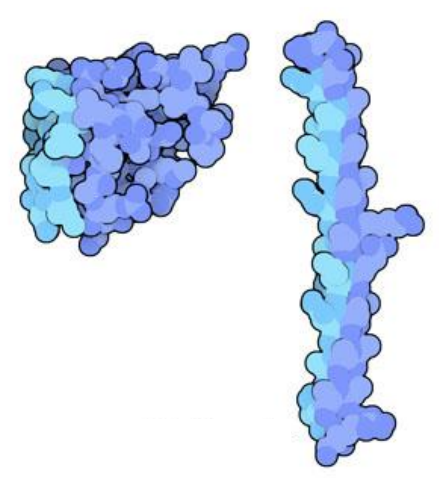
Ice nucleation

Ice nucleating proteins promote the nucleation of ice crystals extracellularly in freeze-tolerant plants at high subzero temperatures to prevent extensive supercooling.[1]

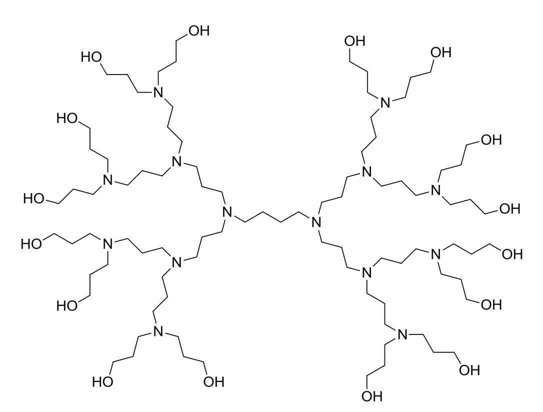
Ice recrystallization Inhibition (IRI)

IBPs inhibit ice recrystallization processes during which large ice grains grow at the expenses of smaller one.[1]

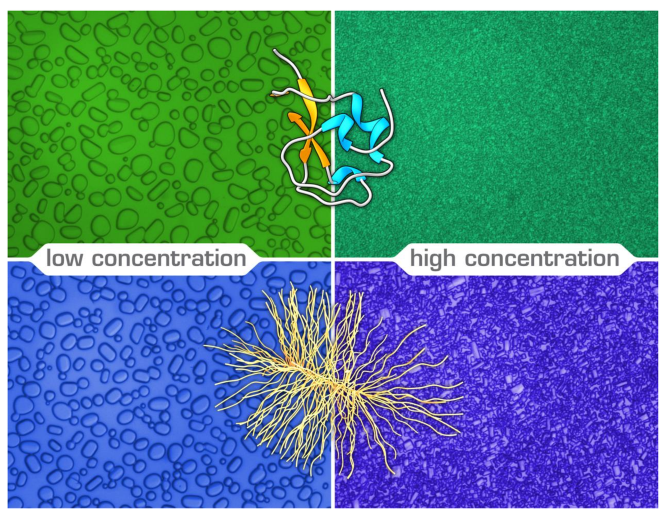
Food technology, non-polluting de-icing agents, cryopreservation, crystal growth modifiers



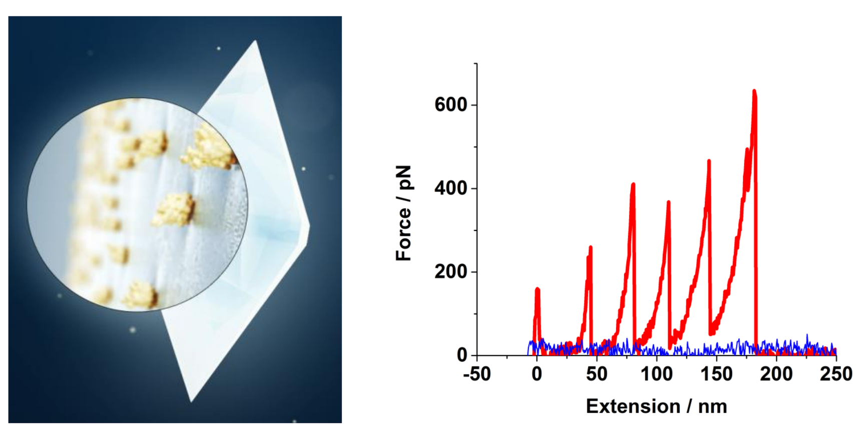
Protein engineering



Polymer chemistry[4]

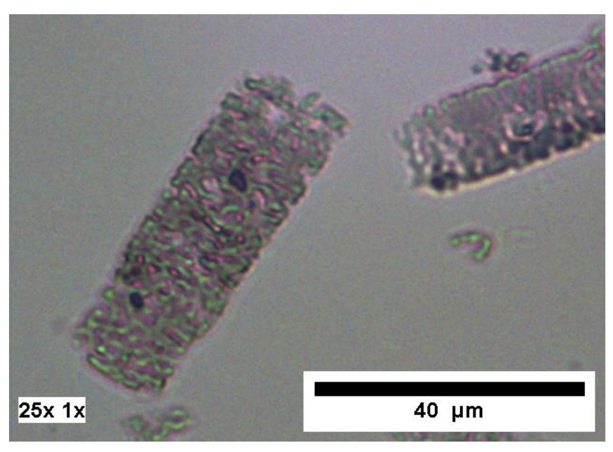


Activity assays



Adsorption & adhesion

De-icing technology



Biomaterials

(Bio)polymers — Physical Chemistry — Materials

References:

1) Oude Vrielink et al., *Biointerphases*, **11**, 2016, DOI: 10.1116/1.4939462.
2) Olijve et al., *PNAS*, 2016, DOI: 10.1073/pnas.1524109113.
3) Davies, *TiBS*, **39**, 2014, DOI: http://dx.doi.org/10.1016/j.tibs.2014.09.005.
4) Olijve et al., *Macromol.Chem. Phys.*, 2016, DOI: 10.1002/macp.201500497.