BLUE WATERS
SUSTAINED PETASCALE COMPUTING

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Biology, Chemistry & Health

STRETCHING THE CADHERIN MOLECULAR VELCRO® OF CELL–CELL JUNCTIONS

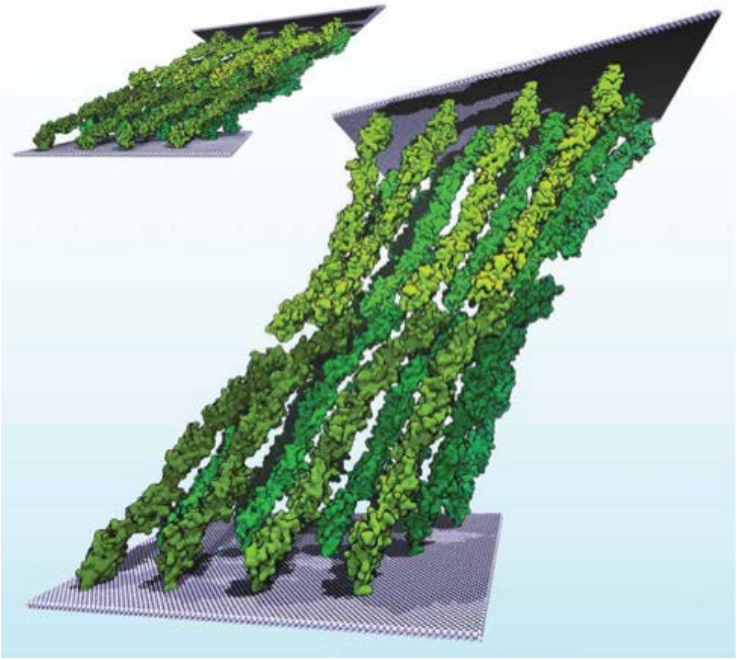
Research Challenge

Selective and robust adhesion between cells is essential for multicellular life, and is a basic molecular mechanism in the development, function, and repair of tissues in the human body.

Cadherin molecules protrude from cell surfaces to engage with cadherin molecules on adjacent cells.

Previous work has described detailed interactions between only a single pair of molecules .

Strong adhesion requires a strong and robust lattice of cadherin molecules as studied here.



Atomic-resolution simulation of cell–cell adhesion by a lattice of cadherin molecules, shown without tension (top left) and after stretching (center).

Methods & Codes

The mechanical properties of cadherin proteins are best studied in simulations where all atoms, including water and ions, are explicitly modeled.

The programs NAMD and VMD were used to build and simulate the large models of up to 3.7 million atoms required for this work.

The steered molecular dynamics (SMD) technique was used to test the mechanical response of the cadherin complexes to inter-cellular tension.

Results & Impact

Cadherins at cell–cell junctions act as molecular shock absorbers, straightening at low force without breaking their links to the neighboring cell.

At higher tension, links separate without unfolding the cadherin proteins.

Cadherin chains are disordered and floppy when calcium ions are absent.

These simulations provide an unprecedented atomistic view of the mechanisms of cellular adhesion.

Why Blue Waters

Molecular dynamics simulations of large atomistic systems are computationally demanding and cannot be divided into smaller independent simulations to be distributed among poorly networked computational resources. Only a fast networked and massively parallel system like Blue Waters can be used.