Cell measures stiffness of its environment using special protein bonds

September 12 2013

Researchers from the FOM Foundation and Eindhoven University of Technology have discovered how a cell feels whether its environment is stiff or soft. It is becoming increasingly evident that such pure physical information – besides the chemical information – can be a decisive factor for the health of stem cells, for example. However up until now how a cell obtained this information was not clear. FOM PhD researcher Liza Novikova demonstrated with calculations and simulations that special protein compounds play a key role in this. Her work will be published on 17 September as a New & Notable article in *Biophysical Journal*, accompanied by a supporting article from a fellow expert.

What does a cell know about its external environment? It gathers chemical information with the help of receptors or channels in the cell membrane. For example, that is how a cell in the pancreas knows whether there is too much sugar in the blood and therefore whether insulin must be made. However, a cell also needs information about the mechanical properties of its environment to determine where a surface is located or so that it can slip through an opening. Recently it has also become known that stem cells use this information to determine what type of cell (bone cell, brain cell, muscle cell) they will become. However, what the cell uses as a 'sensor' for these external mechanical properties is still not clear.

Molecules on the boundary

Novikova is searching for the answer to this question at the boundary between the cell and its external environment. Proteins are located there that link the skeleton of the cell to its external environment: the integrins. Recent experiments have indicated that some of these integrins can form 'catch bonds', bonds that become stronger the harder they are pulled on. As these proteins are directly sensitive for mechanical signals, Novikova suspected that they might play a role in the mechanical sensing. So she formulated a model that describes both the characteristics of a single catch bond as well as the collective behaviour of several catch bonds. Her calculations revealed that the stiffer the external environment the greater the number of catch bonds that develop.

Measuring is knowing

The cell therefore has a very useful instrument. An internal measurement unit – the number of bound catch bond integrins – proved to be a direct measure of the mechanical stiffness of the external environment. Based on this Novikova proposes that the first and crucial step of mechanosensing takes place at the molecular level. This insight provides new starting points for influencing the processes in a cell by manipulating the external environment. A correctly chosen environment could, for example, force cells to move in a certain direction or force stem cells to choose a certain outcome.

Fundamental Research on Matter (FOM)