A New Study Finds That Chiral Gold Nanoparticles Enhance Immune Response

2022-02-01
Scientists always thought that gold nanoparticles are as different from protein molecules as chalk and cheese. Although they could be similar in size, gold nanoparticles are often spherical while the protein molecules are intricately shaped. This news is being released by Index of Sciences

The sophisticated shape and surface chemistry of the protein molecules is essential in their interactions with each other that enable the finely tunes physiology of living organisms including the immune response. A recent discovery by international team of scientists from Jiangnan University, University of Michigan, and the University of São Carlos showed the biomimetic gold nanoparticles can mimic very complex protein molecules that can selectively interact with proteins on the surfaces of immune cells and drastically enhance the production of antibodies to the H9N2 influenza virus by more than 1200 times.

The protein have shapes with a special property – they are chiral. Although they may look similar, the chiral objects are not identical with their mirror image – just like our hands – and one of these objects is named right and the other one is left. Chirality is a ubiquitous property in living matter that can be found, for instance in the helical shape of DNA. Transfer of signals between cells relies on the lock-and-key interaction of mirror-symmetrical molecules. In the past, Professor Nicholas Kotov from University of Michigan found that chirality of nanoparticles can be imparted from chiral photons with helical shapes. The author of the recent paper in Nature titled Enantiomer-dependent immunological response to chiral nanoparticles, used this technology to create gold nanoparticles with variable degree of chirality. When one illuminates the nanoparticles with left-handed helical light, the particles become left-handed. When the light has a right-handed twist, they become right-handed. They are nearly perfect mirror images of each other as was established by strict mathematical measures and optical parameter called g-factor. The longer one illuminates the particles, the more chiral they become, which is essential for 'tuning' their shape to maximize the interactions with specific receptors on the cells.

The scientists from USA, China, and Brazil, found that the complex chiral shape of the synthesized gold nanoparticles matches very well with the receptors that have long chiral 'tails' on the surface of immature dendritic cells found in bone marrow . When the nanoparticles attach to these tails, the sophisticated machinery inside these cells become activated and in presence of antigens – the pieces of the virus or other infection, they mature into dendritic cells with cells spiky shapes. In other words, the chiral nanoparticles launch the biological program of the immune system to fight the infection. This complex biological process eventually results in the B lymphocyte cells that produce antibodies that neutralize the virus, concurrently, promote cytotoxic CD8+ T cells maturation that kill the infected cells.

The team of Prof. Chuanlai Xu from Jiangnan University injected H9N2 influenza vaccine mixed with nanoparticles into mice – a model organism to test the vaccines. These experiments revealed that the change from normal (that is non-chiral) to complex chiral shape of the nanoparticles dramatically increased influenza-specific antibody titer. Professor Chuanlai Xu says "We observed a large difference in the immune response in mice to nanoparticles of different chirality – more than 1200 times, which is remarkable." This difference reflects the big role of twisted shapes of nanoparticles in mimicking protein-protein interactions and amazing precision of engineering of the biomimetic nanostructures achieved by the authors. Professor Nicholas Kotov highlights "Notwithstanding the known challenges of practical implementation of inorganic nanoparticles in medicine, their nanoscale chirality is a potent tool to modulate the immune response and, perhaps, some other responses at the cellular and organisms levels that we were not aware of so far."