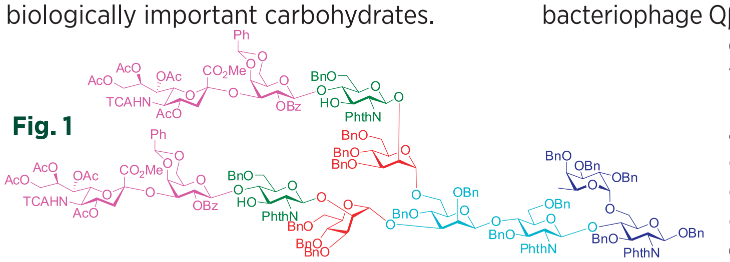
The chemistry of carbohydrates and their biology is the major emphasis of our research. Carbohydrates play important roles in many biological processes such as inflammation, tumor metastasis, bacterial and viral infections. Detailed understanding of many of these processes is still lacking. Building on our strength in synthetic chemistry, we take a multi-disciplinary approach to study this important class of molecules. Our research encompasses several areas including ***synthetic organic chemistry***, ***nanoscience*** and ***chemical immunology***.

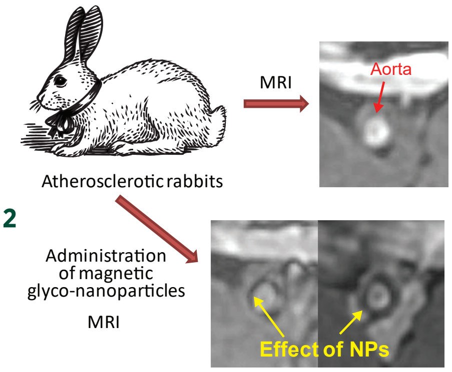
In the ***synthetic chemistry*** area, we are developing novel methodologies for assembling biologically active oligosaccharides and glycoconjugates. Traditional carbohydrate synthesis is very tedious and time-consuming. In order to expedite the synthetic process, we have developed novel one-pot glycosylation methodologies, where multiple sequential glycosylation reactions are carried out in a single reaction flask to yield desired oligosaccharides without time-consuming intermediate purifications. One of the methods we developed, the pre-activation based iterative one-pot method, has achieved higher synthetic efficiencies in several syntheses compared to the automated solid phase based method. We are applying the methods we developed to total synthesis of a wide range of highly complex oligosaccharides and glycoconjugates. A representative example of the molecules we have synthesized is shown in **Fig. 1**. We are continuing to synthesize biologically important carbohydrates.

Fig. 1



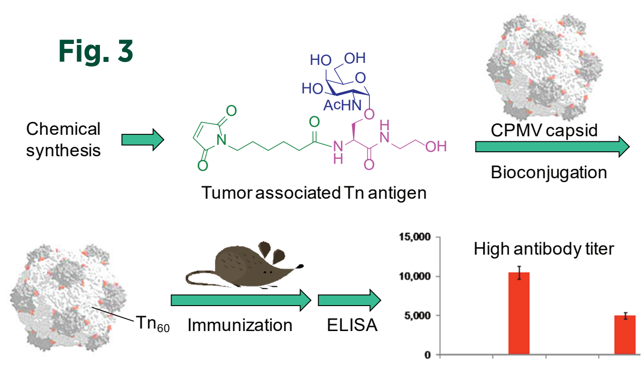
In our ***nanoscience*** program, we combine the multifaceted properties of carbohydrates with the unique functions of nanoparticles by immobilizing carbohydrates onto the external surface of magnetic nanoparticles. The magnetic glyco-nanoparticles (MGNPs) produced retain the biological recognition of carbohydrates and at the same time enhance the avidity of carbohydrate-receptor interactions by thousands of times. The magnetic nature of the nanoparticles enables us to use magnetic resonance imaging (MRI) as a non-invasive method for disease detection. An example of this is shown in **Fig. 2**, where the presence of atherosclerotic plaques (the major cause of heart attack and stroke) in rabbits can be easily detected by MRI after injection of the MGNPs. Besides detection and imaging applications, we are exploring the utility of MGNPs for targeted drug delivery. We found that by incorporating drugs onto MGNPs, the cytotoxicity of the drugs towards cancer cells can be significantly enhanced. We are continuing to develop magnetic glyco-nanoparticles for non-invasive detection and treatment of diseases such as cancer, atherosclerosis and Alzheimer's disease.

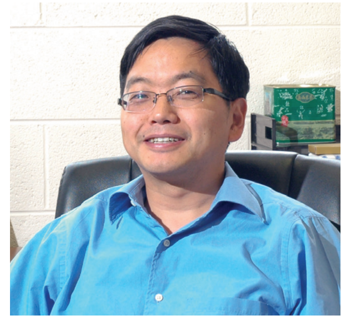
Fig. 2



In the ***immunology*** area, harnessing the awesome power of body's immune system to fight cancer is an attractive strategy to cancer treatment. It is well known that many tumor cells have unique carbohydrate structures over-expressed on the cell surface. However, the low immunogenecities of these tumor associated carbohydrate antigens present a formidable challenge for the development of carbohydrate based anti-cancer vaccines. To overcome this obstacle, we are developing novel carrier systems such as cowpea mosaic virus capsid (CPMV) and bacteriophage Qβ to deliver tumor associated carbohydrate antigens to the immune system and to boost the immune responses against carbohydrates as diagrammed in **Fig. 3**. We discovered that antigens displayed in a highly organized manner can elicit much stronger immune responses. Vaccination with our constructs successfully protected the immunized mice from tumor development in several tumor models. This is an excitingly new direction for the development of anti-cancer vaccines.

Fig. 3





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Selected Publications

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