Near-infrared (NIR) biophotonics-based smart photon-converting systems (PCSs) have made great process in recent biomedical applications, such as optical imaging and phototheranostics. Owing to the versatile manipulability, superb spatiotemporal precision and minimal tissue invasiveness in practical operations, these NIR-responsive platforms provide opportunities to deeply investigate the physiopathological and therapeutic aspects from cells to the organism level. In principle, the design of NIR-biophotonic PCSs is primarily based on the photophysical process and physicochemical properties of the optical materials upon light irradiation, and the mechanisms include the radiative/nonradiative transitions-mediated photon emission, heat generation as well as the cascade energy transfer. In this thesis, I focus on the development of smart NIR PCSs on the basis of upconversion nanoparticles (UCNPs), cyanine dyes and charge-transfer nanocomplexes (CTNs) for multipurpose biophotonic applications, including liver pathological/pharmacological screening, tumor phototheranostics, bacterial infection imaging and optogenetic regulation of insulin resistance.

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Supervisor: Prof Xing Bengang