Herein, we fabricated a novel electrochemical-photoelectrochemical dual-mode cholesterol (Ch) sensor based on graphene sheets (GS) interconnected titanium dioxide nanowires (TiO$_2$-NWs) 3D nanostack (GS/TiO$_2$-3DNS) and exploited the beneficial characteristics of GS and TiO$_2$-NWs. As a proof of concept, TiO$_2$-NWs provide large surface area for enzyme immobilization, light absorption, fast charge separation, charge transport pathway and form a platform for photoelectrochemical sensing. The interconnected GS stack architectures contributes to the independent electrochemical sensing. The GS/TiO$_2$-3DNS was fabricated by alternate deposition of functionalized GS and TiO$_2$-NWs to build up the 3D stack. The morphology and composition of GS/TiO$_2$-3DNS was examined by field emission scanning electron microscopy, energy dispersive X-Ray analysis and X-Ray diffraction analysis. To establish 3D network connectivity, the TiO$_2$-NWs were pre-embedded with GS. Cholesterol oxidase (ChOx) was immobilized in GS/TiO$_2$-3DNS using chitosan (CS) binder and the dual mode GS/TiO$_2$-3DNS/CS/ChOx bioelectrode was fabricated. The electro-optical properties of the GS/TiO$_2$-3DNS/CS/ChOx bioelectrode were characterized by cyclic voltammetry, electrochemical impedance spectroscopy and UV-Vis diffuse reflection spectroscopic measurements. The GS/TiO$_2$-3DNS/CS/ChOx bioelectrode was selective to Ch with a remarkable sensitivity and a lower detection limit. Also, GS/TiO$_2$-3DNS/CS/ChOx functions as photoelectrode and exhibits sensitive detection of Ch under low bias voltages and light irradiation. The amperometric and photocurrent responses of GS/TiO$_2$-3DNS/CS/ChOx bioelectrode were independently correlated to the concentration of Ch. We envisage that GS/TiO$_2$-3DNS, with its prospective features would be a promising material for wide range of biosensing applications.