Engineering the Future of Medicine

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ABSTRACT

Technical: The prospect of implementing measurement and control systems, concepts familiar to engineering, is often viewed as applicable but challenging in medicine. Three vignettes of on-going research will be used to illustrate the concept of measurement and feedback control to achieve physiological stasis: i) the use of minimally invasive, implantable, wireless, bioanalytical microsystems to measure biomarkers associated with the pathophysiology of trauma induced hemorrhage (glucose, lactate, acidosis, PO2, K+) for triage and stratification. Here feedback control is via the trauma physician. ii) The development of biologically responsive hydrogel microspheres for the programmed delivery of drugs that serve to modulate the release profile via molecular feedback control. This engineered material system is being developed for the treatment of chronic wounds and exploits the elevated levels of matrix metalloproteinases (MMPs) to cleave a tethered peptide that is conjugated to an MMP inhibitor. The inhibitor once released, modulates MMP to targeted activity levels within the chronic wound environment. Iii) The synthesis of carbon nanotube-enzyme conjugates used in direct biosensors and advanced biofuel cells. Here, direct electron transfer between a carbonaceous electrode and an enzyme's redox cofactor allows control of enzyme activity. These three systems each encompass the notion of integration of the measurement of a gap between an actual and a reference level and a mechanism to close that gap via feedback – a control loop. These systems are integrated, the first at the level of discrete sub-systems acting through an operator, the second at the level of molecular events acting through molecular phenomena of mass transport and reaction kinetics, and the third at the level of electronic transport and redox events.