Toward smart drugs : convergence between biology and nanosciences

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Many realize that the hope of rapidly multiplying the number of new drugs with the progress of genomics, based on the oversimplified concept “a disease results from one dysfunctional gene” was a dream developed by scientists insufficiently in contact with in vivo reality. Most diseases (type, stage, severity, evolution, complications) are related to complex changes at the cell, tissue and organ levels. Whereas archaic therapy - a single drug molecule to treat a disease based on prior clinical and biological diagnosis - still dominates medicine, we can predict that medicine will evolve toward better mimicking nature within 20-30 years. Certainly antibiotics to destroy a bacteria, an exogenous factor, is an example of the “one disease – one drug molecule” model. However normal physiology and absence of diseases involve each second that we live thousands of biological parameters, complex cell to cell and tissue to tissue interactions where “self” detection of biological changes trigger cascades of biological and cellular responses. This, coupled with a desire for improvement of diagnostic and therapeutic reliability and lower dependence on health professional interventions, should open the era of “smart therapies” that attempt to mimic or restore normal physiological processes. We already know that substituting an organ or a tissue via transplantation is the most effective therapy for kidney, heart, liver, and bone marrow failure, or that vaccines are based on the host’s own immune system to prevent infections. Unfortunately donation of organs is limited and vaccines can only address infectious diseases and possibly some cancers. We therefore need to develop *advanced implantable therapeutic units* which can combine biological monitoring and cell signaling as well as various cellular functions. Certainly treatment would be more effective if a “device” could both monitor glycemia in vivo and release insulin as needed for diabetic patients, if self detection of cancer cells in vivo could trigger an adequate immune response, if a failed liver could be substituted by different implants, each carrying one of the normal liver functions. The progress of cell biology, cell therapy, biocompatible polymers, cell targeting technologies, and biological chips should lead to many “smart therapies”. Near term, many new drugs will be based on advanced drug delivery technologies that improve their pharmacokinetics, potency, safety profile (for example Conjuchem technology: using the patient’s own albumin as a natural carrier of drug molecules). Drug release will be coupled to biological monitoring. Vaccines will find new applications to treat inflammatory diseases, cancers, viral infections (for example Neovacs technology : inducing antibodies against cytokines). Cardiac valves will be tailor made using biodegradable polymers and tissue engineering (for example using Symetis technolo gy). Medium term, converging progress of nanosciences - biomaterials, chips - , of computational modeling, and of cell engineering will lead to complex implantable, functional, and biocompatible tissues which will carry one or more functions of a natural tissue or organ. These “smart therapies” will be more effective than today’s archaic medicine as they better mimic human physiology, the result of 5 billion years of effective evolution.