'Doctor in a Cell': Vision and Accomplishments

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Abstract

The "holy grail" of medical treatment is early detection and in situ cure, or destruction of malfunctioning cells. Such task could be achieved by intelligent nanometer devices capable of operating *in vivo*, sensing disease markers, correctly identifying the abnormal cells, and curing them or causing their destruction.

Our laboratory's long-term objective is to develop a 'Doctor in a cell': molecular-sized device that can roam the body, equipped with medical knowledge and treatment potential. It would diagnose a disease by analyzing the data available in its biochemical environment, and treat it by synthesizing, or activating, the appropriate drug molecules *in situ*. This kind of device might, in the future, be delivered to all cells in a specific tissue, organ or the whole organism, and cure or kill only those cells diagnosed with a disease.

As an important milestone towards realizing this desirable long-term goal, we have developed a molecular system shown to perform the abovementioned tasks *in vitro* (Benenson *et al*.). Although this system was initially limited to mRNA based disease indicators as input, we are now developing new input mechanisms that expand the spectrum of possible inputs. One input mechanism enables the detection of microRNA and almost any protein or small molecule. Another input mechanism enables the sensing of active DNA binding proteins, such as transcription factors. These new abilities may facilitate the detection of important intracellular and intercellular disease markers.

While operating this system inside living cells remains a major challenge, expanding the capabilities of molecular computers and investigating their theoretical and practical attributes might be rewarding in the long term.

Reference

Yaakov Benenson, Binyamin Gil, Uri Ben-Dor, Rivka Adar and Ehud Shapiro (2004). An autonomous molecular computer for logical control of gene expression. *Nature,* 429:423-429.