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# Editorial: Bioinformatics and economics

Sydney Brenner has always claimed that 'Ideas are cheap' but he has also spent much of his life proving just how valuable some of his own ideas can become. He may have started life with barely enough money for a train ride to school in provincial South Africa, but he progressed through his love of science to become famous, respected and so valuable to medical research that he could fly on Concorde and send someone else the bill. This year he shares a Nobel prize<sup>1</sup> with Sir John Sulston and Robert Horvitz for their work in establishing *Caenorhabditis elegans* as a model organism<sup>2</sup> for genetic research and then discovering some of the genetics behind cell replication control and programmed cell death. The Nobel award is for just one part of Sydney's life's work; his contributions to science (including some early bioinformatics) are spread over many years in both public academic science and, less visibly, guiding biotechnology and pharmaceutical companies in their pursuit of wealth. Sir John is similarly famous for a variety of contributions to science including, most recently, the Human Genome Project and his televised exhortations to keep the genome open for both academic researchers and for exploitation by the world's pharmaceutical companies for drug development: 'Both are needed', commented Sir John at his first Nobel prize party.

Scientific research takes time, effort and significant amounts of money. Bioinformatics is one of the more applied sciences and it is particularly dependent on the priorities of funding agencies, venture capitalists and established businesses. Bioinformatics changes rapidly because of easy communication via Internet technologies, open source software, the general advances in the genomics field and the way that money is flowing around biotechnology research. For an individual or a company with an interest in bioinformatics, it is worth knowing not just the latest research, but also the financial situation of whichever group is providing you with your essential software or services.

The harsh world of business and economics has interesting parallels with biology from its most famous theory: evolution by natural selection, down to lesser details of organisms and ecosystems corresponding to Ronald Coase's Nobel prize-winning work<sup>3</sup> on why companies form and how large they can grow. Recently, fraudulent accounting at Enron and Worldcom has been described by one CEO<sup>4</sup> as a corporate cancer that cut the growth of both firms, and their accountants Anderson, or more soberly by Alan Greenspan<sup>5</sup> discussing problems for the whole US economy. Biology is more than a source of metaphors for economics,<sup>6</sup> and academics have seen different links<sup>7</sup> before and now offer dual honours courses.<sup>8</sup> Learning is one thing; however, public discussion of business economics in front of biologists has real dangers as I witnessed when a new director arrived at Cereon Genomics and organised a whole-site meeting to explain what he thought we needed to do as a company to be successful: to keep the company financially secure, and to give our customers what they wanted. While I sat listening with rapt attention, delighted to be trusted to hear a business case being openly and honestly explained to me, a woman next to me quietly remarked, 'He is so evil'!

It has been noticed that the returns on investment in the second half of the 20th century were much better than those in the first half and it has been concluded<sup>9</sup> that 'innovation accounts for any growth that cannot be explained by increases in capital or

labour'. *The Economist* gave Leroy Hood an award this year for his invention of the fluorescence sequencing machine, and co-authorship of the 1996 paper 'A new strategy for genomic sequencing'. With another award going to Stephen Fodor for his Affymax gene chip work, it is clear that *The Economist* thinks that these bioinformatics-dependent technologies matter in the real world.

Even introductory courses on retailing economics should stress that the customer is always right. Ultimately, Cereon Genomics was closed down despite its successful work studying natural disease resistance in plants, hard labour from the staff and all the financial clarity of its leaders. The closure was due more to anxieties over an EU moratorium on new genetically modified (GM) crop approvals<sup>10</sup> and consumer perceptions that even properly tested GM food might somehow still be especially dangerous. It is clear that supermarket shoppers are ignorant of the thousands of years of genetic modification and selection that has traditionally fed us all: polyploidy is common<sup>11</sup> in commercial crops – wild wheat varieties can be tetraploid or hexaploid,<sup>12,13</sup> bananas are triploid<sup>14</sup> and the apple<sup>15</sup> (that keeps the doctor away) is actually a genetic fusion of eight pairs of chromosomes from a plum member of the rose family, and nine pairs from meadowsweet! For more information on crops genetics maps and bioinformatics see Dicks *et al.*<sup>16</sup> or the UK CropNet web site.<sup>17</sup>

The most pointed advice that I have heard on bioinformatics and economics was offered by my boss at Cereon: 'Never work for a pure bioinformatics company!' So what's next? Sydney Brenner interested me and many others in all aspects of partially sequenced cDNAs (before the term 'Expressed Sequence Tag' or EST was invented) but the next boom may be harder to predict. Looking for other guidance, perhaps, Adam Smith's invisible hand<sup>18</sup> is pointing in the same direction as Willie Sutton's first principle of economics: 'I rob banks because that is where the money is' and it has long been obvious how bioinformatics can help increase the efficiency of the already wealthy pharmaceutical companies. However, following the money has two different limitations: firstly, much of the best research is precompetitive and can be done on a shoestring by academics, and secondly, there is a limit to how much even Americans are prepared to spend on drugs.

Clear examples of excellent precompetitive academic work include the NCBI's Entrez system<sup>19</sup> and the joint EBI/Sanger Institute's ENSEMBL databases.<sup>20</sup> The NCBI is generously contracted to share with everyone worldwide and without charge its great work linking DNA, proteins, publications and disease databases. Similarly, the ENSEMBL project has made its highly respected derived database of the finished genomes available to everyone but also enabled the databases to be mirrored (not just as flat files) inside each individual pharmaceutical company, saving them all the enormous effort of duplicating ENSEMBL's calculations and expert editing.

President Bush recently announced<sup>21</sup> a proposed change in the law to limit how often pharmaceuticals companies can extend their patents on lucrative drugs to allow cheaper generic drugs (average US\$17 per prescription) to replace branded drugs (average US\$72 per prescription). Pharmaceutical companies typically estimate a drug's worth by looking at its market in the USA which is bigger and pays more for the same product than do other economies, even Europe. Both the total GDP of the USA and the proportion spent on healthcare have been growing since 1945 and currently exceed 15 per cent, but there must be some limit even here. The market is finite and, ultimately, everyone will still die, just like before, so it makes sense to leave some money for other purposes, and

ration healthcare. For now, the money is flowing through the pharmaceutical companies, and the economics suggests that they should be the most valuable place, in every sense, to be a bioinformatician.

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