BOOKS & ARTS

The world at your fingertips

The rise of the Internet search engine Google as guardian, gate-keeper and guide to a wealth of information.

The Search: How Google and its Rivals Rewrote the Rules of Business and Transformed Our Culture
by John Battelle
Portfolio/Nicholas Brealey: 2005. 320 pp. $25.95/£16.99
The Google Story: Inside the Hottest Business, Media and Technology Success of Our Time
by David Vise & Mark Malseed
Delacorte/Macmillan: 2005. 336 pp. $26/£14.99

Jon Kleinberg

Thirteen years ago, the release of a set of basic network protocols and browsing software ignited a combustible mixture of bandwidth, computing power and communication media. It was the beginning of the World Wide Web's dizzying rise from a small research project to a technological, economic and social force of global proportions.

Even in the early stages of the web's development, the notion of searching was seen as crucial, given the vast quantities of information available. But the true power of searching as an interface became apparent only more gradually, through the emergence of highly sophisticated tools such as Google, Yahoo and others. Searching is now our primary point of contact with the virtual world: we search to find out about people we are to meet, places we will visit, products we're about to buy; we search as a precursor to communicating and transacting business; and we search because it's the easiest way to get to almost anywhere we want in cyberspace.

The Search by John Battelle and *The Google Story* by David Vise and Mark Malseed are two recent books that develop this topic for a general audience. They adopt rather different approaches — Vise and Malseed focus primarily on Google, whereas Battelle ponders the idea of searching more generally — but each provides powerful illustrations of the extent to which searching has slipped free of its technological moorings and become a force in both the information economy and in everyday life.

Battelle's book is appealingly organized around a story and a big idea. The story is the history of web searching, with Google as its hero and dominant character; the big idea is what Battelle calls the "database of intentions", the archived queries and actions of users at sites such as Google, Yahoo, AOL, Amazon and eBay. The database of intentions is not simply a thought experiment designed for the purposes of the book; such archives exist among the massive data sets maintained by these companies. And they form a cultural record, capturing our era's collective interests and desires at a scale and resolution unprecedented in human history.

Sign of the times: Google co-founders Larry Page (left) and Sergey Brin have an icon on their hands.

B. MARGOT/AP PHOTO

The story and the big idea are inextricably linked, of course. To begin with, the search industry became profitable, and hugely so, thanks to advertising targeted directly at the intentions of its users. For example, Google's AdWords service, based on a methodology introduced by its competitor Overture, displays ads that are targeted to the current query. This monetization of intent is the basis of the search economy — advertisers can pitch their messages to a user at precisely the moment the user has expressed a concretely formulated interest.

Battelle follows the many strands of this notion, including the tension between paid listings and the 'pure' algorithmic search results that are the staple of Google and other search engines; the businesses that live or die based on traffic from search engines; and the new legal and economic terrain into which these developments have led us. Battelle also asks us to consider the dangers inherent in consolidating so much sensitive, highly personal information in the hands of any company — even one that, like Google, promises in its public statements not to be "evil". He offers illuminating discussions and hypothetical scenarios covering the many ways such data could potentially be used and misused, and this leads to an inescapable conclusion: if you aren't at least a little bit afraid of this future, you probably haven't thought about it hard enough.

Vise and Malseed address several of these economic, legal and social issues as well, but with more of an emphasis on Google specifically. This approach limits their consideration of certain broader directions, but it leads them more deeply than Battelle into other topics. Of particular interest is their emphasis on Google's stunning computational resources — a customized system built on more than 100,000 commodity-level personal computers — and on some of the future projects, including potential forays into bioinformatics and

genomics, that this technology makes possible.

Each book contains, as a core element, the story of Google itself, from the initial meeting of the founders, through its intellectual and technological evolution as a university research project, and on to its emergence as a public company, a verb and a potent icon of pop culture. It is a fascinating and compelling story, even for those who know its broad outlines. And given the company's origins, it can be read as a parable on the value of fundamental research — on the way the pursuit of long-range, scientifically challenging goals can have pay-offs that extend to the public at large and can ultimately change the world. ■

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The bright side of life

Aglow in the Dark: The Revolutionary Science of Biofluorescence
by Vincent Pieribone & David F. Gruber
Belknap Press: 2006. 288 pp
$24.95, £15.95, €23.10

Thomas G. Oertner

Creatures that glow in the dark have evolved independently many times in various branches of the phylogenetic tree, and it is safe to assume that it has always been for communication of one kind or another. Whether you are trying to lure prey at the bottom of the sea, startle or confuse attackers, keep your swarm together, or signal your availability to potential mates, being able to send out light in a controlled fashion will give you an edge, especially in deep-sea environments. But although the evolutionary value of bioluminescence seems obvious, the question of how it works has proved difficult to answer.

The first clue was found 120 years ago by the French physiologist Raphaël Dubois. From his experiments with the light organ of the beetle *Pyrophorus*, he concluded that it must contain a two-component system: a heat-sensitive catalyst that he termed luciferase, and a fuel component, luciferin. Purifying the components turned out to be quite difficult, however, and it was only 50 years ago that a young Japanese scientist, Osamu Shimomura, finally succeeded in producing crystals of pure luciferin.

A few years later, Shimomura managed to reveal the light-production machinery of the jellyfish *Aequorea*, in which luminescence is tightly controlled by the concentration of intracellular calcium. He also noted that the light emitted by aequorin molecules in a test tube is bright blue, whereas the jellyfish glows with a greenish hue. The green fluorescent protein (GFP) responsible for this energy conversion received little attention at the time but revolutionized biology 30 years later. Today, customized fluorescent proteins are used as reporters of gene activation and cell identity, to visualize the subcellular localization of tagged proteins, and to monitor cellular activity by tapping in to various second-messenger systems. The most spectacular emerging application is probably the visualization of nerve-cell activity in the brains of living animals.

Given its multitude of uses, I was surprised to learn that the publication announcing the complete sequence of GFP (D. C. Prasher *et al. Gene* **111,** 229–233; 1992) was greeted by just two requests for the complementary DNA clone. The second clone, however, ended up in the hands of a man who not only immediately realized its scientific (and economic) potential, but also had the creativity and skills to transform it into the powerful tool it is today. Even if you can already guess his name (it was Roger Tsien), you will probably still enjoy *Aglow in the Dark*, Vincent Pieribone and David Gruber's well-narrated and beautifully illustrated book. It combines character studies of the people involved with a thoroughly researched story of the unlikely events that led to the main discoveries. The authors interviewed many of the key players, including the Russian scientists who were first to discover a red fluorescent protein. The book's journalistic style gives it a more 'real' feel than its forerunner *Glowing Genes* by Marc Zimmer (Prometheus, 2005), which relies mostly on secondary information.

Interspersed with the main narrative are chapters that explain basic concepts, including the nature of light and the genetic code. Although these excursions might help to reel in readers from other disciplines, in some cases the authors go off on a tangent to cover subjects with no obvious relevance to the central theme, such as Schrödinger's cat. The authors' lengthy explanation about the brevity of laser pulses used for two-photon microscopy seems designed to 'wow' an unsophisticated audience with far-out facts. Not only do they get the calculation wrong, but why should we care about it anyway?

These quibbles aside, the main narrative is riveting, and the authors capture the sometimes curious way that science progresses through an alternation of chance discoveries and systematic, goal-directed experiments. Students wondering whether they are cut out to become scientists ought to be encouraged by the diverse cast of characters involved in solving the mystery of bioluminescence.

Obscure marine invertebrates have been a significant resource for discoveries of fundamental importance, from Alan Hodgkin and Andrew Huxley's first recording of action potentials in the squid to the highly specific neurotoxins that Baldomero Olivera found in Pacific cone snails. In this sense, the story of fluorescent proteins is another timely reminder of the value of biodiversity. The discovery in 2003 of light-activated ion channels from the photosensor of the green alga *Chlamydomonas* makes one wonder what else is out there waiting to be found and put to use. It also suggests that the optical brain–machine interface that the authors discuss in the final 'sci-fi' chapter of the book could soon become a reality, using light not only as a readout of activity, but also for the precise stimulation of individual nerve cells.

These are exciting times for biology, and this accessible and lively introduction conveys the sheer pleasure of discovery, as well as the enormous technological potential of fluorescent proteins. ■

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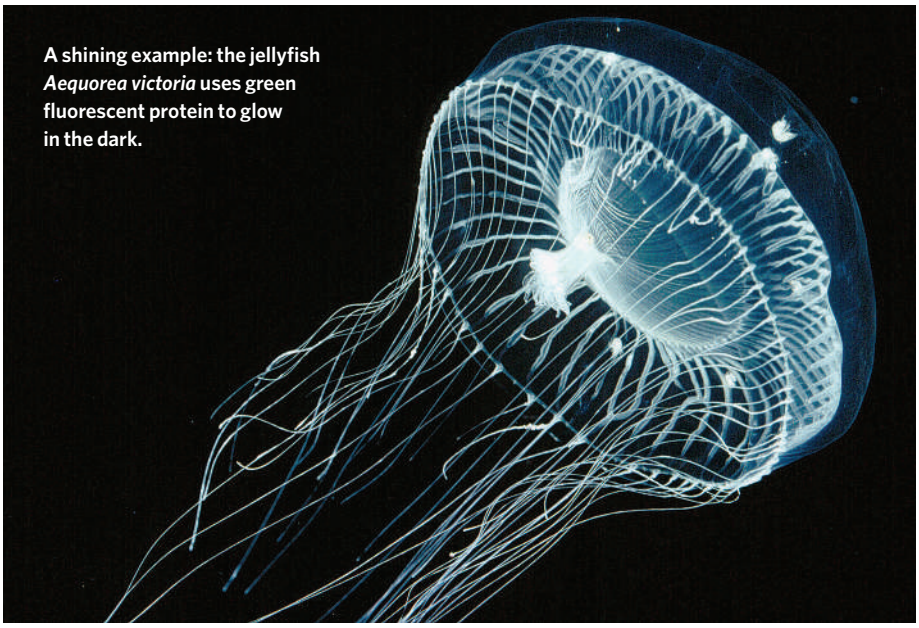

A shining example: the jellyfish *Aequorea victoria* uses green fluorescent protein to glow in the dark.

C. MILLS