

The New Innovation: Rethinking Intellectual Property for the ONE



by Anthony Williams

New Paradigm



Themes of the

Open Networked Enterprise

addressed in this report:

- ▶ 1. World View
- ▶ 2. Corporate Boundaries
- ▶ 3. Value Innovation
- ▶ 4. Intellectual Property
- 5. Modus Operandi
- 6. Business Processes
- 7. Knowledge and Human Capital
- 8. Information Liquidity
- 9. Relationships
- ▶ 10. Technology

This report is an analysis of a Big Idea, presented as part of New Paradigm's *Information Technology and Competitive Advantage* Program (IT&CA). The program, sponsored by 22 companies including yours, is investigating new business designs and strategies for competing in the networked business world.

Specifically the program examines how a new business model—The Open Networked Enterprise—is emerging as the foundation of competitiveness, growth and sustained success.

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The New Innovation: Rethinking Intellectual Property for the ONE

The Idea In Brief

Intellectual property management is moving into the center of competitive strategy. Globalization, digitization, componentization and monetization are placing new demands on business leaders to harness IP in ever more intricate and strategic ways.

To stay globally competitive, companies must monitor exponentially growing scientific and technological developments and tap global talent pools. No single company, whatever the industry, can create all the innovations needed to compete. Individuals and companies are deploying new knowledge in unpredictable ways. To harness this innovation you need a lot of partners, and a lot of people developing designs and putting them together as customer solutions. This means tapping into a broad ecosystem, and it means opening up some of your IP.

Optimizing for competition means harnessing openness. Some companies create and share IP in large communities of collaborators to enhance the scale, scope and speed of innovation. Others use cross-licensing, patent pools and marketplaces to lower the costs of exchanging IP. Some industries embrace open standards to enhance interoperability and encourage collaboration. Others invest in pre-competitive “information commons” to boost the productivity of downstream product development.

The life sciences industry illustrates the new realities of 21st century innovation. Against a backdrop of major achievements such as the sequencing of the human genome and rapid advances in the industry’s science base and supporting technologies, the new product pipeline seems to be drying up. Case studies show how pharmaceutical and biotechnology firms are mixing open and closed IP strategies to improve productivity and competitiveness. These powerful lessons apply to any industry.

There are six urgent priorities:

- **Master the art of strategic openness.** Competitive strategy now means making smart decisions about IP acquisition/licensing (what/how) and openness/sharing (or not). Licensing or legal departments should not make such decisions alone. You need to involve stakeholders across your organization and act on those decisions at the business unit level.
- **Harness the power of modular and collaborative innovation.** Concentrate R&D in areas where you have the greatest competitive advantage in developing valuable innovations, and use cross-licensing, partnerships and alliances to acquire the rest. Licensing, cross-licensing and open innovation webs can help you focus on your core strengths.
- **Use IP to build partnerships.** Conventional IP strategies try to maximize direct revenues from every patent, but do not overlook less tangible opportunities to maximize value-creating relationships. Turn cross-licenses into strategic partnerships. Leverage your IP with b-web partners to generate follow-on products and services. Share IP to foster relationship capital with a community of collaborators.
- **Focus on orchestration.** The ability to orchestrate complex value creation webs gives you competitive advantage. Use co-creation and co-appropriation partnerships to help you focus your value-add on IP orchestration—the shaping and reshaping of intellectual property clusters in unique combinations that serve ever-changing customer needs.
- **Support open infrastructures.** Open standards and shared IP are foundations for collaboration and value creation. They can deliver large collective benefits. But they can also enhance

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competitive advantage if you hone your capabilities to develop relationships, sense important developments, add new value and turn nascent knowledge into compelling customer value propositions.

- **Balance your IP portfolio.** Just as good personal investment strategies diversify assets across a range of low and high risk opportunities, good IP strategies diversify intellectual property holdings across a range of open and closed offerings. Do not give away your crown jewels, but be prepared to share when the opportunities are there.



1.0 The Changing Intellectual Property Landscape

1.1 A thought experiment¹

Imagine that two firms starting from zero in the same market conditions are developing an equivalent technology. The firms are equals: they both have access to equivalent physical, human and financial capital. Both have the same competitive philosophy. Starting simultaneously, both firms should get to market at the same time and earn the same return on investment.

Now let us assume one difference. Imagine that Firm A and Firm B have radically different models for creating and managing intellectual capital.

Firm A has a *value capture* mentality. It develops all its intellectual capital in proprietary contexts — either in-house or through licensing and exclusive outsourcing relationships. It does not share IP. When a potential partner proposes a co-development opportunity, Firm A imposes the

maximum royalty rate. It subjects joint ventures to rigorous legal scrutiny that strictly delineates IP rights. Firm A is known to capture value by any means and, if necessary, at a partner's expense, which means that partners distrust Firm A and keep it at arm's length. Firm A gets products to market, but its customers and channel partners are wary of its lock-in effects and predatory tactics. Follow-on innovation is limited because lopsided licensing conditions mean potential partners cannot reap a fair share of the value.

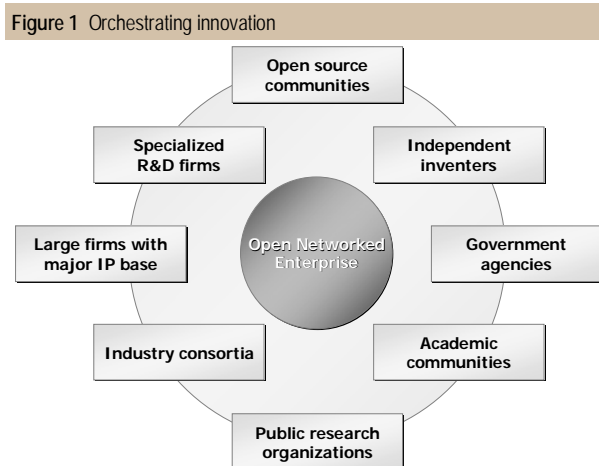
Firm B has a *value creation* mentality. Like Firm A, it creates intellectual capital in-house and pursues all the same proprietary avenues to source external technologies. But Firm B does more. It engages and collaborates by tapping into research universities and non-profits, open source development communities, and other like-minded firms. To build enduring, value-creating relationships, Firm B selectively shares its IP. It embraces open standards and releases a prototype of its technology early on to its network of collaborators. It shares improvements openly in the network and all collaborators benefit from early access to new technology. Non-profit partners earn free or discounted licenses for the end product. For-profit partners work out a reciprocal sharing agreement involving complementary technologies. Soon, Firm B has received thousands of improvements to its prototype. It dedicates some resources to filtering and aggregating these suggestions. It does not control —and cannot monetize —all the intellectual capital in its offering. In the end, it has a more robust, user-defined, fault tolerant product in half the time and for less than half the development expense. The network effects of its open development approach give the product a strong lead in the marketplace and an ongoing stream of rapid

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incremental innovation. Firm B leverages its complementary capabilities to continue offering value-added services.

Now: which firm is likely to earn better return on investment? Which firm will thrive in the new environment of “coopetition?” Which technology will win in a world of open standards and systems?

The balance of evidence suggests that Firm B will win. Firm B is the Open Networked Enterprise (see Figure 1).



1.2 The new IP strategy agenda

History teaches us to expect the regular arrival of major technological shocks. And though they all seem unprecedented, technological revolutions usually evolve in three predictable periods. First is the period of invention, optimization and incremental improvement. Then comes a lagging but overlapping period of institutional accommodation, as market rules adjust to new economic realities. In the final period, the new techno-economic paradigm and the institutional framework align and generate sustained growth and productivity.

In 1947 at Bell Laboratories, William Shockley, John Bardeen, and Walter Brattain invented the first transistor—and, arguably, triggered the information revolution. Years of incremental improvement brought the integrated circuit in 1958, the first silicon microprocessor in 1971, the first personal computer in 1974, and the first MSDOS operating system in 1981. The rest is recent history.

But we are still just beginning a profound institutional adjustment. A hyper-competitive global economy is reshaping economic enterprises and political and legal shifts loom. The changes in how we create and manage intellectual property require a new approach to competition and new legal and political foundations.

As we confront this changing reality, we must ensure we can continue to be innovative. The Washington-based Council on Competitiveness warns that, “The where, how and why innovation occurs are in flux, across geography, economic sectors, speed, scope of impact—and even who is innovating. Whenever such a shift occurs, there are always realignments of competitive advantage and new measures of success and value. To succeed in this new world, it will not be enough—indeed, it will be counterproductive—simply to intensify current stimuli, policies, management strategies and curricular approaches.”²² Remaining innovative requires us to understand both the shift and also the new IP strategy agenda that follows.

1.2.1 From closed to open innovation

In the industrial age model, innovation happened inside the firm. Companies worked internally to turn the latest scientific and technological breakthroughs into products and services the market wanted. They rarely looked outside their walls for

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new ideas or inventions—and they did not need to. The important advances in technology were already happening inside AT&T, Bell labs, Xerox Parc and the research labs of HP and IBM. These large, well-funded industrial research laboratories attracted the most talented PhD graduates from the world's leading universities.

For the most part, only large enterprises had the financial and human resources to absorb the risk of long-term R&D projects. Only large enterprises had economies of scope and scale to bring new inventions to market. Proprietary standards and technologies, patent protection and secrecy helped them realize returns from deep investments in R&D.

This internal innovation strategy worked in the days when innovators worked alone on discrete and entirely novel inventions. But the classic image of innovation proceeding from the investments of a lone firm seeking standalone technological prizes is not today's reality.

Science and technology is evolving at great speed and delving into ever more complex domains. Even the largest companies can no longer research all the fundamental disciplines that contribute to their products. Nor can they control an end-to-end production process. In most industries, innovation

“Innovation today is happening at a different pace, in a different place and with a different face.”

—Council on Competitiveness

increasingly depends on dense networks of public and private actors and large pools of intellectual property that routinely combine to create end products.

In the emerging model, innovation is collaborative, distributed and increasingly open. To be competitive, firms need a dynamic network of partners and contributors. Innovative activities cut across national and organizational boundaries. Vertically integrated R&D is giving way to joint ventures, licensing, outsourcing and peering.

Four challenges—globalization, digitization, componentization, and monetization—confront R&D-intensive industries. These forces are transforming the intellectual property landscape and forcing us to rethink competitive strategy.

1.2.2 Globalization

Until recently, most firms operated within national borders. Today, the playing field is global. To be just nationally competitive, is to not be competitive at all.

Barriers to innovation are falling. The knowledge and tools required to innovate are increasingly accessible, and in industry after industry, small, specialized firms are carving out viable R&D niches where their agility and cost-effectiveness enable them to outperform incumbents. What is more, these upstarts come from everywhere: from Bangalore to Beijing to Bucharest.

Science and knowledge are also global. Countries like India and China are producing large pools of skilled scientists and engineers (see Figure 2). These countries are no longer just catching up; they are doing breakthrough research in areas such as regenerative medicine (China) and IT (India).

The upshot is a new international and intra-industry division of labor. Innovations that once germinated in the R&D labs of large firms now flourish in a variety of settings. G8 countries can no longer expect to monopolize advanced scientific research.

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Yesterday's corporate leaders can no longer dominate their fields or dictate the pace of development.

As the Council on Competitiveness says, "Innovation today is happening at a different pace, in a different place and with a different face."³ Science and technology will move faster and become more cross-disciplinary. Competition will be fiercer and the geography wider. Leadership will be harder and harder to sustain.

Staying globally competitive means monitoring scientific developments internationally and tapping a much larger global talent pool. Global alliances will provide access to new markets and new technologies. Intellectual assets will need to be managed across a multitude of national regimes. Winning companies will need to know the world — both its technologies and its peoples.

Competing globally also means cooperating. We need a rules-based foundation for a sound economic order. A global framework of rules and institutions for issues such as intellectual property, competition and capital flows will provide the stability, transparency and predictability that business needs to operate globally. International organizations like the WTO or the IMF will set some of the rules. Others will be based on voluntary agreements and business self-regulation. All rules should help create a level playing field and be adaptable to fast changing realities.

Collectively, these are big challenges. But the opportunities are greater than the threats. Larger, more open and competitive markets means the more profits for those who stay ahead and more opportunities for boundary-crossing collaborations.

Figure 2 Number of researchers, national comparisons

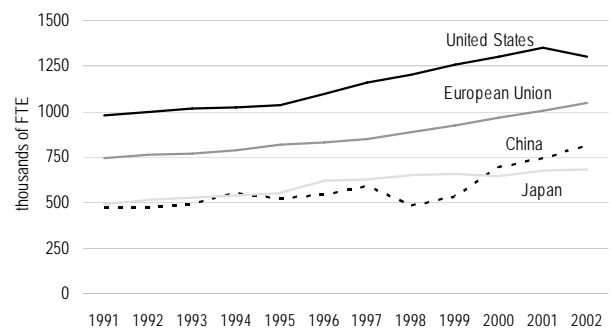
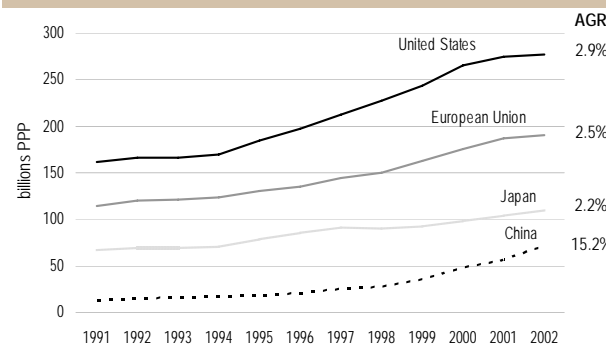


Figure 3 Gross national expenditures on R&D



1.2.3 Digitization

Information and knowledge are innovation's raw materials and, in the past, we have relied on closed entities to produce these raw materials. Increasingly, though, knowledge is the product of networked entities looking for new solutions to specific problems and needs. This way of producing knowledge and sharing information is nothing new: academic research in the sciences has been circulating and building on discoveries for centuries. But it is new territory for firms. Collaboration, interaction, peer review and publication: these distributed innovation models are becoming keys to success in the knowledge-based economy.

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The driving force behind this shift is digitization. The digitization of information, combined with advances in computing and communications, is changing the way value is created throughout the economy. Digitization means information can be shared, cross-referenced and re-purposed like never before. Knowledge can build more quickly within networks of firms and institutions and across borders.

At the same time, digitization introduces tough new appropriation problems for the creators of digital content. Digital inventions are easy to share, and just as easy to replicate. On the plus side, this means industries with zero marginal cost (e.g., software, digital entertainment) can gain incredible economies of scale. But if your invention can be replicated at no cost, why should anyone pay? And if no one pays, how do you recoup your fixed-cost investment?

One solution has been to expand the scope and effectiveness of IP protection. New anti-piracy technologies make knowledge more excludable—information can be metered and owners of intellectual property can extract a fee for access. Walled gardens of content, proprietary databases and closed source software, all promise healthy returns for knowledge producers. But at the same time, they all restrict access to the essential tools of a knowledge-based economy.

How much protection is enough or too much? Whose interests are served by strong rights? What is the impact of strong rights on the organization of knowledge production?

As knowledge becomes more important, so do our choices about how to manage and motivate knowledge production.⁴ The challenge? Designing an incentive system that rewards inventors and

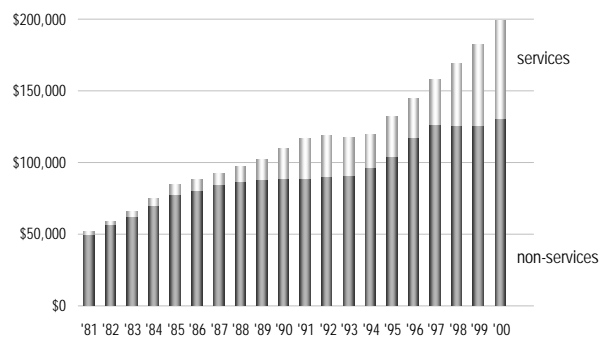
knowledge producers *and* encourages dissemination of their output.

“Few innovations are sufficiently fundamental to permit exclusion. With time and money, most high-tech innovations can be engineered around. Patents are more like speed bumps than concrete barriers.”

— Daniel McCurdy, CEO, Thinkfire,
Intellectual Property Licensing Advisory

Conventional wisdom says companies should hoard their technology and with large monopoly rents on offer, it is no wonder that many firms still subscribe to this view. But in today’s networked economy, your proprietary knowledge is less likely to be subject to incremental improvement and more likely to be invented around. Companies who do not share may find themselves ever more isolated—by-passed by the networks that are sharing, adapting and updating knowledge to create value.

Figure 4 Total business expenditure on R&D, 1981–2000 (all US firms)



Source: OECD, measured in millions of dollars

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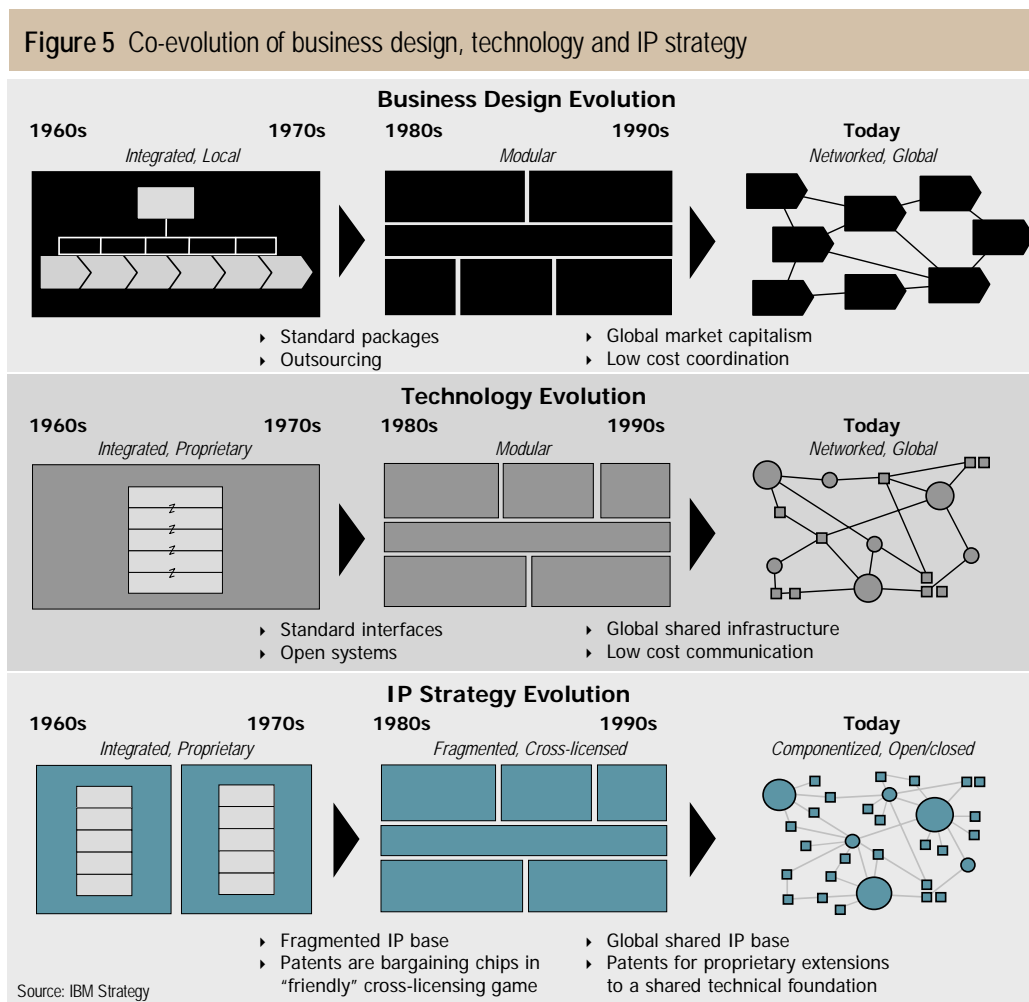
1.2.4 Componentization

Not long ago, firms developed all their differentiating technology in-house. Today, it is less about inventing and more about orchestrating or coordinating good ideas. Everything from a Nokia mobile phone to an Airbus A380 to an Intel chipset combines components from multiple firms. Sometimes hundreds of patented inventions are combined to make a single end product.

Componentization in the IT industry is the outcome of thirty years of increasing standardization, specialization and disaggregation.⁵ Today,

the shift from integrated to modular products and processes is increasingly pervasive. Industries ranging from automobiles to life sciences are undergoing similar vertical to horizontal transitions.

The new reality is that most firms rarely obtain proprietary control over all the essential components of the new products they bring to market. Firms hold intellectual property rights over technologies that others need, and vice versa, which creates a condition of mutual dependence where no firm can develop and commercialize a new product without first gaining access to complementary



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intellectual property. As one executive at a communications equipment firm says: “In our industry, things all build on each other. We overlap on each other’s patents. As a result, your patents are mostly used in horse-trading. You come together and say ‘here’s our portfolio.’ Eventually we come to some agreement: ‘you can use ours and we can use yours.’”⁶

“There’s only a certain amount of ways that you can connect transistors together in new, unique and non-obvious ways, and people are tripping over each other’s patents right and left. The consequence of Moore’s Law is that you’re going to be tripping on a lot more patents tomorrow.”

— Peter Detkin, Intellectual Ventures, formerly with Intel⁷

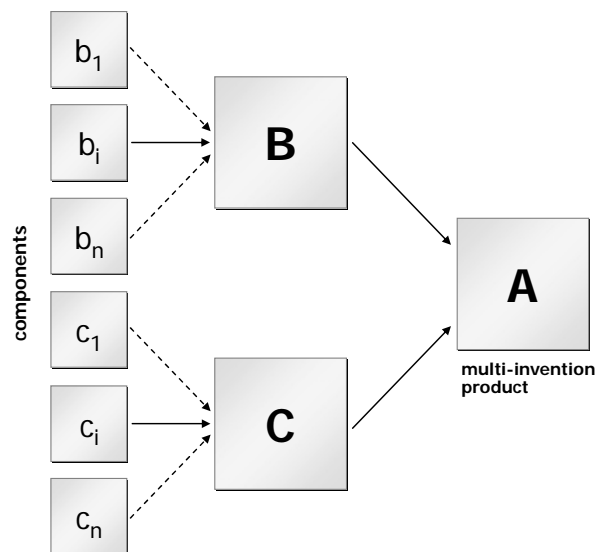
Integrating disparate intellectual property rights is especially tough in standards-based industries. In the next 12 years, for example, the mobile device industry will spend \$80 to \$100 billion in royalties on 3G-related patents.⁸ Royalties on patents held by companies such as Qualcomm, Nokia, Motorola and Ericsson could significantly hurt the industry, particularly smaller vendors. Qualcomm has set its royalty rate at between 4.65 and 6%. If other holders of essential patents charge similar rates, the total royalty rate could add up to 25 to 30 % of a device vendor’s selling price, which in turn could drive small vendors—and potentially valuable innovations—out of the market.

Open standards and collaboration are the keys to solving this problem.

Open standards enable components to interoperate. By reducing barriers to entry, they provide the infrastructure for broad collaboration and market adoption. And they encourage innovation.

Collaboration creates freedom of action. By cross-licensing patent portfolios, or creating a centralized patent pool, competitors create a mutually agreed zone of non-assertion—a zone in which firms can operate and pursue joint opportunities. These zones strip away wasteful costs and free firms to compete on other dimensions. As IBM consultants Vivek Kapur, John Peters and Saul Berman argue, “Collaboration is the glue that will virtually ‘re-aggregate’ this network—bringing partners together, deepening relationships, providing economic motivation, integrating technologies and maintaining visibility across the network.”⁹

Figure 6 Multi-product inventions



1.2.5 Monetization

Patents started as a way to protect the intellectual property embodied in a physical invention. Today, a weightless idea can be more valuable than a physical product. This is a big shift in the economics of IP. Patents have been unbundled from products. New inventions are now fungible

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assets that can be traded and licensed in disembodied form. Indeed, new and potentially lucrative revenue streams can now flow from intellectual property as intangible as $E=mc^2$.

“If you look back to the mid-1980s . . . there was a lot of freedom of action and everybody just competed and it was the same group of players. After that you see a lot of growth and a lot of new companies coming in. And I think the focus turned more from making a reasonable amount of money and moving forward with your business to a new group of CFOs coming in saying ‘I’m going to make money off every asset I have.’ Patents became one more asset that we had to generate revenue from.”

— Harry Wolin, VP of Intellectual Property,
Advanced Micro Devices

The opportunity to profit has never been greater. Patent licensing is a high margin and highly scalable business. Worldwide licensing revenues in 2000 were estimated to be over \$100 billion.¹⁰ And with a new growth industry emerging to facilitate patent licensing across industries and regions, these revenues will increase.¹¹ Many firms are taking advantage: mining their portfolios, looking for out-licensing opportunities and taking technologies off the shelf that can bring in revenue. At the same time, firms are sourcing—scouring the globe for the greatest and most complementary technologies.

This new marketplace for innovation has tremendous competitive and economic advantages. An organization cannot successfully market all the good ideas it creates. Firms that are net innovators can increase their return on R&D by licensing inventions that fit poorly with their existing business models. Firms with out comparative advantage in innovation can license leading-edge technologies for much less than it would cost to develop in-house.

With the right approach to IP, industries can cross-fertilize. One industry’s technologies may create unanticipated efficiencies in other industries. The licensor gains a virtually free revenue stream, and the licensee gains a welcome efficiency.

Small firms can win too. Those without the marketing muscle to take on large firms can still earn healthy returns by licensing patented technologies. The potential productivity and efficiency gains to be won from all this win-win activity are substantial.

1.3 Managing the innovation commons

Competition through free enterprise and open markets are at the heart of a dynamic economy, but we cannot rely on competition and short-term self-interest alone to promote innovation.

Vibrant markets rest on robust public foundations: a shared infrastructure of rules, institutions and knowledge provided by a mix of public and private sector initiative. It is easy to take these elements of the public foundation for granted. But the dismal economic record of many developing nations demonstrates why legal institutions like independent judiciaries, infrastructures for communication and transportation and public fixtures like leading research universities are essential to economic prosperity.

The intellectual property system is among the most important public institutions for promoting innovation. Protecting intellectual property guarantees that inventors have the opportunity to benefit from their creations, and thus guarantees a sustained investment in innovation.

Equally important are public science programs that contribute to economic and technological

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Eight principles of IP strategy

1. **Strategic openness.** Openness is not altruism. It is about managing context and making the field of play more amenable to your competencies and competitive strategy. Smart firms use openness to strategically shift the locus of competition in their industry.
2. **Speed.** Speed is paramount—in evaluating projects, pursuing advances, adopting outside technologies, and creating novel products. If you cannot innovate fast, you will be knocked out of the market in a heartbeat.
3. **Freedom of action.** Freedom of action is about gaining flexibility, lowering transaction costs, cutting through patent thickets and getting to market faster. It means avoiding mutually blocking patents and instead making deals to swap intellectual property rights so that all parties are free to design and deliver the products and services that customers want.
4. **Collaboration.** Coopetition is the new norm. Ad-hoc cooperation, strategic alliances, joint ventures, peer production and user-driven innovation: collaboration will happen at all levels and with all types of partners. Harnessing collaborative innovation means taking a less proprietary approach to IP—and reaping the new knowledge that results.
5. **Orchestration.** Great inventions are just as likely to emerge from someone's garage as they are from a corporate R&D lab, so orchestrating

and leading global innovation webs is the new value-added. Tomorrow's leading companies will be IP aggregators. They will both create and assemble the world's best innovations to transform them into compelling customer value propositions.

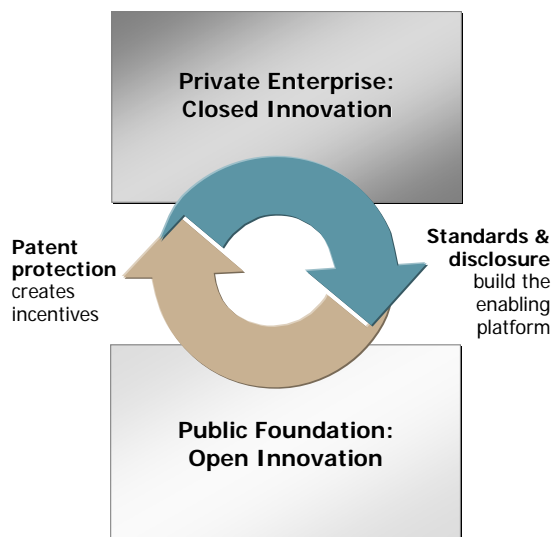
6. **Tacit capabilities.** Patents do not confer competitive advantage—they simply protect what is already been created.¹² Real competitive advantages come from the uncodified and hard-to-replicate tacit capabilities that allow companies to apply new knowledge in unique and surprising ways.
7. **Utility.** In the past, firms engaged in a lot of invention for invention's sake. R&D proceeded at a leisurely, academic-like pace.¹³ Today, R&D activities have to be tight and earn a clear return. Innovators will still need to know the underlying sciences, but their aim will not be to further the science. Research teams will use their knowledge to move quickly to practical application.
8. **Balanced portfolio.** No company would intentionally place all of its IP in the public domain. But neither can firms afford to keep all their best ideas secret. From IP marketplaces to open standards, and from open innovation webs to concepts like the Creative Commons, winning firms will blend open and closed innovation strategies and public and private intellectual property regimes.

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progress. Universities, in particular, provide vast repositories of public scientific and technical knowledge. Sometimes this knowledge translates directly into marketable inventions. But in most fields, academic research is exploratory, generating the underlying understandings and techniques that feed into private enterprise. Industries rooted in biology, chemistry, computer science, electrical engineering and material sciences might not exist today without the modern research university and government-sponsored R&D.

In today's economy, we need an intellectual property system that rewards invention *and* encourages openness—one that fuels private enterprise *and* sustains the public domain. The existing intellectual property system is not working as well as it could.

Figure 7 Public foundation, private enterprise



Increasingly vocal critics argue that our knowledge economy has become over-privatized. Scholars such as James Boyle point out that in recent decades, intellectual property rights have been consistently strengthened, while the public domain

has become dangerously constricted.¹⁴ Others say that questionable business practices are perverting the virtues of patent protection.

The critics may have a point. Since the mid-1980s, questionable patents have flooded the U.S. Patent Office, many of them issued in new and complex domains such as biotechnology, software and business methods.¹⁵ Low quality patents give holders unwarranted legal and economic leverage. And newfound leverage has sparked a torrent of patent litigation, abetted by the courts' willingness to impose injunctions and large patent infringement awards. Some firms play the system like a lottery—patenting things that other companies will unknowingly infringe, waiting for those companies to bring products to market, and threatening an injunction to extract hefty fees.

Research in Motion (RIM), makers of the BlackBerry, knows the heavy toll of such tactics. For years, RIM was dogged by NTP, a holding company that acquired patents that RIM's product allegedly infringes. RIM spent tens of millions of dollars over the years fighting NTP, only to settle for \$450 million and then see one of the patents at the center of the NTP lawsuit overturned.¹⁶

"Obtaining patents has become for many people and companies an end in itself, not to protect an investment in research and development, not to license technology to others who need it, but to generate revenue by 'holding-up' other companies that actually make and sell products without even being aware of their patents. They try to patent things that other people or companies will unintentionally infringe and then they wait for those companies to successfully bring products to the marketplace. They place mines in the minefield. The people and companies who file these patents and extract license fees from successful businesses play the patent system like a lottery."

— Robert Barr, Cisco

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“An unknown but undoubtedly significant number of invalid patents are issued every year; an unknown but undoubtedly significant number of patents generate lawsuits or threatened lawsuits involving overly broad claims. Both phenomena create serious impediments to competition, both from existing products on the market and from new products in the development stage. Litigation has become a poor means of addressing these problems, in part because of the unacceptably high cost and length of the litigation process and in part because of the ... unpredictability of litigation outcomes. This is a serious drag on the technological and scientific progress that the patent system was designed to promote.”

—Stephen Fox, Hewlett-Packard

Patent shakedowns like these undermine the spirit and function of the patent system. They bring higher transaction costs, excessive royalties and uncertainty about legal rights, both in terms of enforcing one's own patents and avoiding infringement claims. And patent hassles add new risk to already risky R&D investments. It is easy to see how they could undermine innovation and commercial-ization.

While innovators fear shakedowns, scientists worry about the “creeping propertization” of the public domain. Since the Bayh-Dole Act extended patent eligibility to public research organizations in 1980, property rights have been migrating further upstream into the realm of basic science. On one hand, property rights in basic research offer the promise of substantial economic gain from increased commercialization of inventions. On the other hand, commercialization could erode the culture of open science that has fuelled centuries of scientific discovery.

Science depends upon the ability to observe, learn from, and test the work of others. Without

effective access to data, materials and publications, the scientific enterprise becomes impossible. But recent studies show a disturbing trend: increasing secrecy, pressures to patent, cumbersome technology transfer agreements and complex licensing structures are making it hard for scientists to share research data. In a recent *Journal of the American Medical Association* survey, 28% of geneticists reported that they had been unable to confirm published research because they were denied access to data, and that is just *published* research.

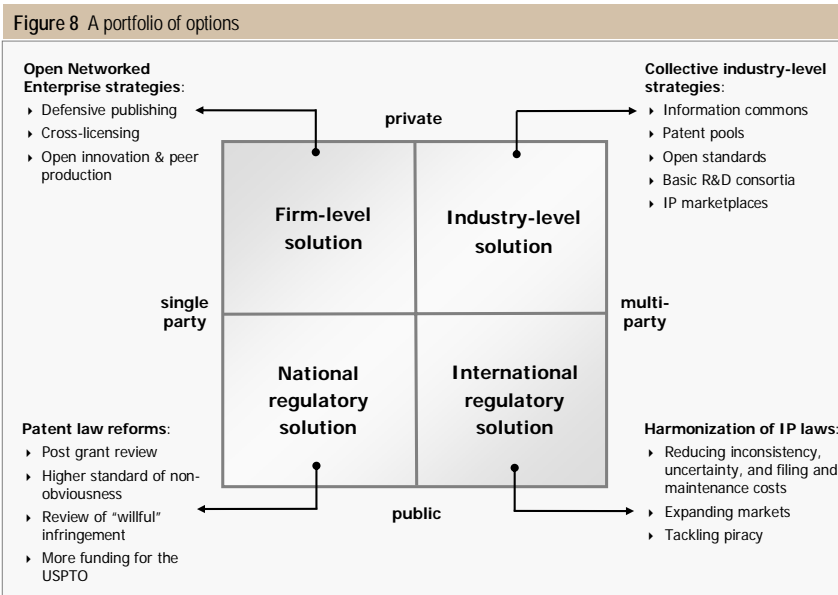
Finding the right balance between the public foundation and private enterprise is key to the long-term competitiveness of firms and economies. We have to be able to apply *existing* knowledge to generate *new* knowledge. At the same time, society must elicit the private investment needed to translate new knowledge into economic and technological innovations that contribute to social well-being. In short, we must encourage innovation without eroding the vitality of the scientific commons.

The hard questions are as follows: What is the right balance between private enterprise and the public domain? What will best achieve that balance—market mechanisms or government intervention?

Reforms in the patent system are undoubtedly warranted. Many academics are calling for the courts, Congress, or international treaties to roll back—or at least counterbalance—property rights. Well-targeted legal measures could significantly reduce some of the current costs and uncertainties. We list our priorities in the accompanying sidebar (see “Reforming the patent system” on page 14).

But curbing the perverse incentives in the intellectual property system will require a broader

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portfolio of initiatives. And while policy measures are being debated, smart firms are taking action. Some companies are creating and sharing IP within large communities of collaborators to enhance the scale, scope and speed of innovation. Others are using cross-licensing, patent pools and marketplaces to lower the costs of exchanging IP. Some industries embrace open standards to enhance interoperability and encourage collaboration. Others invest in a pre-competitive “information commons” to boost the productivity of downstream product development.

These private strategies and investments show that public lawmaking is not the only arena for addressing the excesses of intellectual property. And they demonstrate the handsome public and private rewards for investing in a shared infrastructure for innovation. In fact, our case studies point to an important lesson about the potential for private institutions. In environments of rapid and cumulative invention, cross-licensing, patent pools and open standards emerge to circumvent ubiquitous litigation and production-choking injunctions.

Firms place valuable IP in the public domain to cut through patent thickets and enhance freedom of action.

These strategies tend to be more efficient than many forms of state intervention. They are flexible and adaptive and they’re usually shepherded by knowledgeable industry insiders. Indeed, they offer a unique compromise: they address the mushrooming transactional hurdle of new and stronger property rights, and still preserve most of the economic incentives that accompany strengthened rights.

- Figure 9 Emerging strategies and institutions**
- **Basic research consortia:** CableLabs, SNP consortium, Flybase consortium
 - **Defensive publishing:** IP.com, researchdisclosure.com
 - **Digital libraries & databanks:** Public library of science, SourceForge.net, Open Archives Initiative
 - **Marketplaces & IP brokers:** Yet2.com, pharmlicensing.com, CollabNet
 - **Non-assertion pledges:** IBM’s, Nokia’s and Sun’s patent donations to open source
 - **New legal constructs:** Creative commons, GPLs and OSI
 - **Standards organizations:** OSDL, W3C, OMA
 - **Patent pools:** MPEG-LA, DVD-6C
 - **Peer production:** Linux, Apache, BIOS, Wikipedia, Open Source Intelligence, etc.

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Reforming the Patent System

The U.S. patent system has fuelled invention since the first three patents were granted in 1790. Patent protection helped drive epoch-defining technological innovation around inventions such as the electric dynamo, the combustion engine, and the transistor. Without the patent system, industries that depend on IP protection (chemicals and pharmaceuticals for example) might never have flourished. Aggregate investment in research and development in the U.S. would certainly not be nearly \$300 billion a year.

But just as other public institutions need periodic reform to keep up with economic and technological changes, so too does the patent system. Today, the overburdened U.S. patent system is struggling to cope with rapid and cumulative invention in new and increasingly complex technological domains that, in some cases, did not exist a decade ago. Reforms are urgently needed. Among the most important of these are changes that would:

- Curtail expensive legal proceedings by implementing a system of post-grant, third party review that would allow qualified members of an industry to contest patent grants without resorting to litigation.
- Reduce opportunism and eliminate disincentives to monitor the patent landscape by reviewing the policy of awarding treble damages for “willful infringement”—perhaps by requiring prior written notice for a finding of liability.
- Alleviate submarine patents and “evergreening” by curtailing the use of continuations to game the patent application process.¹⁷

- Improve patent quality in areas such as biotechnology, software and business methods by raising the standard of non-obviousness applied by the USPTO and the Federal Circuit Court.
- Reduce pendency (the time it takes to review/issue patents) and improve quality in new and complex subject domains by providing more resources and funding to the USPTO.
- Boost cross-fertilization and collaboration in cutting edge research domains such as biomedicine, computer science, materials science and other relevant areas by dedicating more public funding to “open science.”

Reforms are also required on the international front, including changes that would:

- Increase harmonization across patent systems to reduce inconsistency, uncertainty, and filing and maintenance costs, which are currently expensive and difficult for companies that protect their intellectual assets in global markets.
- Encourage governments in emerging economies to adopt intellectual property systems that would create a sound environment for international investment, while simultaneously encouraging domestic invention by allowing entrepreneurs to unlock the value of their intellectual capital.
- Address the need to incorporate a “development agenda” into international intellectual property law that would help the world’s poorest countries obtain *legitimate* access to medicines, educational textbooks, software, computer equipment and other tools needed to promote growth.
- End tacit government collusion with firms that routinely ignore or violate patents and copyrights.

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2.0 Open and Closed Innovation in the Life Sciences: A Delicate Balance

A global biomedical research budget greater than \$100 billion per year now supports the pharmaceuticals, diagnostics and medical devices industries. Pharmaceuticals in particular have enjoyed very handsome social and private returns to R&D and knowledge creation—studies have shown a significant correlation between improvements in mortality and other health indicators and the number of new drugs introduced for a variety of diseases and health problems.¹⁸ But after decades of building on revolutionary advances in basic science, pharmaceutical companies face a productivity crisis.

In 2002, the FDA approved only 17 new molecular entities (NMEs) for sale in the U.S.—the lowest since 1983 and a fraction of the 15-year high of 56 NMEs approved in 1996.¹⁹ In 2003, the FDA approved 21 NMEs, of which only nine were designated as “significant improvements” over existing drugs. This decline occurred despite a substantial increase in R&D: between 1995 and 2002 U.S.-based pharmaceutical companies roughly doubled their R&D expenditures to about \$32 billion.²⁰ The trends are the same around the world: the annual number of New Active Substances approved in major markets fell by 50% over the 1990s while private sector pharmaceutical R&D spending tripled to \$47 billion.²¹ Numbers like these have the popular press and trade journals talking about “dry,” “weak,” or “strangled” pipelines and a productivity crisis with dire consequences for investors (who can expect “permanently lower multiples”) and also the taxpayers, patients and insurers who will have to pay an ever-higher bill to maintain the pace of technological progress in the industry.

These concerns about productivity are overblown. The costs of R&D have been rising rapidly,²² which means that growing R&D expenditures do not reflect the real increase in resources applied to drug discovery and development. Some analysts argue that we need to be patient—today’s R&D spending will bring us new drugs over the next 3–10 years. But as increased research spending collides with pressure to contain health care costs, the factors that affect the efficiency of the drug discovery and development process come under scrutiny. Chief among these factors are the institutions that govern the creation and use of biomedical knowledge, and their impact on the performance of the industry as a whole, including for-profit companies, philanthropic institutions, government labs and academic science and medicine.

Our lighthouse cases reveal opportunities for openness and collaboration to increase productivity and competitiveness in the life sciences industry. According to Dr. Frank Douglas, former executive vice president and chief scientific officer of Aventis, there are many concerns to address: “The productivity of large pharmaceutical innovation has decreased. We lack the ability to properly predict the side effects of new compounds, and we don’t have good ways to monitor and assess them once they are in the market. Pricing models have become untenable. So has the ‘blockbuster’ mentality. Across the board, a lot of old models really need to be examined.”²³

For an industry that has relied on secrecy and intellectual property rights protection, increased openness and collaboration is a breakthrough model. But the case studies urge caution. Managing the delicate balance between open and closed innovation will be key to realizing the true potential

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of the genomics revolution. The insights pertain not just to the life sciences, but to any industry where open and closed innovation models could be fused to create powerful combinations.

The backdrop for these cases is an industry that has profoundly reorganized over the past 30 years.²⁴ Small firms have disappeared as leading players have merged and consolidated, and worldwide research activity has gravitated to a handful of locations. Relationships between non-profit and for-profit sectors have changed, and a new class of competitors—the biotechnology companies—has entered the industry at the interface between academic and commercial research. Along with this “vertical dis-integration” (most visible in the rise of the biotechnology sector) has come a realignment of institutional frameworks that govern knowledge creation and exchange, and the blurring of the boundary between non-commercial and for-profit research in biomedical science.

One important factor driving structural change is the extension of intellectual property into the domain of basic science. Pharmaceutical and

“Even the largest pharmaceutical companies cannot diversify the underlying research and development-based investment risk. They must rely upon a handful of flagship products for the majority of their sales, and the commercial life of a drug is generally less than seven years. Consequently, even major companies must develop a blockbuster every two to three years or face massive financial contraction. The frequency of mergers of research-based companies is a direct consequence of this basic market dynamic. As market conditions have continued to become increasingly competitive, this dynamic has become even more significant.”

— Greg Glover, M.D., J.D., Pharmaceutical Research and Manufacturers Association²⁵

biotechnology companies have become important participants in basic biomedical research, obtaining large numbers of patents on fundamental scientific knowledge. In parallel, universities and other nonprofit entities have become enthusiastic participants in the patent system. Though conducted far from actual sales of drugs to patients, intense market-based competition centered on proprietary rights over biomedical knowledge now helps determine the overall rate and direction of innovation in this area. The nature of patent rights and their role in supporting for-profit research have therefore been highly controversial.

On one hand, court rulings and Patent Office changes that have allowed patent rights over genetic information promise substantial economic gains. The gains may come from the emergence of markets that drive investment and resource allocation in the creation of upstream technology, higher productivity through increased specialization and tailored incentives and efficient unbundling and decentralization of risk among investors.

On the other hand, “locking up” significant portions of molecular biology through proprietary rights may be raising costs and lowering the efficiency of research. In pursuit of these patents, R&D budgets may rise to inefficient levels, and biotechnology companies, pharmaceutical firms, universities, government entities, purchasers of health care and the legal system could get into expensive and damaging struggles for associated economic benefits.

The “creeping proprietization” of basic biomedical research is just one way in which the boundaries between for-profit commercial research and academic science are shifting. At the same time that exclusionary property rights have come into

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conflict with rules and norms governing “open science,” aspects of classic “Mertonian” values have entered commercial research.²⁶

Many commercial entities increasingly manage the production and exchange of knowledge in ways that closely resemble academic research: they emphasize collaboration, interaction, peer review and publication. As biology becomes increasingly focused on computational methods, “open source” software development practices are increasingly important in the development of databases and software tools used in bioinformatics. In one case we examine, open source techniques are being successfully extended to “web lab” biology—a discipline previously considered unsuitable for modularization.

2.1 The changing structure of biopharmaceutical innovation

In the pre-biotech era (prior to the late 1970s) there was a clear division of effort between upstream not-for-profit institutions, which did curiosity-driven basic research, and downstream for-profit companies that did market-oriented applied research.

In the for-profit sector, almost all firms were large and integrated from drug discovery through clinical development, regulatory affairs, manufacturing and marketing. Most commercial drug discovery activity was in-house, and was dominated, at least in the early part of this period, by large scale “random screening” programs with limited requirements for molecular-level physiological knowledge. By and large, downstream concerns drove licensing. To maintain efficient levels of manufacturing or marketing asset utilization (or, in the international context, to take advantage of local knowledge and access to regulators and distribution channels),

firms would acquire rights to sell drugs that were already approved. Firms usually acquired upstream technology “for free” by reading journals and attending conferences or by buying tangible inputs and services, such as scientific instruments or skilled graduates.

A combination of factors allowed pharmaceutical firms to appropriate returns from R&D: extensive patenting of production processes and end products, proprietary know-how, brands, regulatory barriers to entry and favorable product market conditions. Most of these firms were long lived, mature organizations, tracing their roots back as far as the nineteenth-century chemical industry. They usually financed their large and sustained investments in R&D, marketing assets and human and organizational capital with internal cash flow. The ability to manage interactions with regulators and end-users and to “fill the pipeline” with a succession of blockbuster drugs determined competitive advantage. In turn, internal R&D productivity was driven by economies of scale and scope in conducting research, efficient allocation of resources in internal capital markets and the ability to capture internally and externally generated knowledge spillovers.

In the upstream not-for-profit sector, taxpayers supported curiosity-driven research inside government labs, universities, research institutes and teaching hospitals. Legal constraints and social norms limited commercial or contractual contacts between the world of open science and pharmaceutical firms. Peer-reviewed competition for merit-based grants drove resource allocation in the not-for-profit sector. The need to establish priority and reputation drove early and extensive publication of results, and social norms (and granting agencies’ requirements) promoted routine sharing of research

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materials. Not-for-profit researchers concentrated largely on fundamental science and filed very few patents.

The industry structure in the biotech era is more complicated. After decades of stability and consolidation, the for-profit side of the industry experienced significant entry in the late 1970s as an intermediate sector emerged between academic research institutions and Big Pharma. By the mid-1990s, several thousand biotechnology ventures had been launched, and several hundred survived to become an important force in the industry. Existing vertical relationships were disrupted and reformed, with consequences that are still unclear.

Though most of these firms were overtly profit-oriented, they have much closer and more explicit links to non-profit research institutions, including close personal, geographical, cultural and contractual ties to universities, research institutes and government labs. Academic scientists have played a particularly significant role in the founding of these companies, either by moving out of academic employment, or by participating in both worlds.

Some of the new companies are now horizontal competitors with Big Pharma. Amgen, Genentech and Human Genome Sciences leverage their

command of new techniques and insights from molecular biology to develop products for end users. Most biotech firms, however, have become specialist suppliers of leading edge technology (including research and diagnostic tools) to a less science-intensive clinical development, manufacturing and marketing sector.

A variety of interlinked economic and legal factors affect this transition. Most salient are the legal and administrative changes that brought much of molecular biology and the life sciences within the ambit of the patent system. Indeed, without patent rights in areas such as isolation and purification of proteins, DNA sequences, monoclonal antibodies, transgenic organisms and gene expression systems, etc., many biotechnology companies could not exist. Product companies would have been unable to compete directly with Big Pharma. And, while tool companies might well have been able to compete on the basis of cost advantages, execution, know-how, or trade secrets, they would be in a much weaker bargaining position.

The rise of a venture capital industry (and ultimately a stock market) that was willing and able to support inexperienced companies entering a market with a seven- to ten-year product development cycle has been pivotal.

Pressures on the not-for-profit research world have also been a factor. Increasing resource requirements and societal pressure to justify budgets are pushing public institutions to focus more on applied research, patent discoveries and generate licensing revenue. The expense and complexity of academic research projects have also forced successful scientists to acquire managerial and organizational skills—giving them the skills and appetite for business ventures. Universities and

“For a long time we were known as Immunex University, because our scientists were dedicated to the proposition of publishing papers and sharing materials with pretty much anybody who would ask, and I think even today we are viewed in the academic community as being one of the easiest companies from which to gain reagents and materials.”

— Michael Kirschner, vice president for Intellectual Property at Immunex Corporation (acquired by Amgen)²⁷

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other government funded institutions have become not merely more tolerant of “off-campus” commercial activity, but active encouragers of it.

“While Aventis does an awful lot of research and development, we bring in an awful lot from the biotech industry. We are constantly looking for new technologies, not just from within but also from the outside in biotechnology.”

— Ross Oehler, vice president for U.S. Patent Operations at Aventis Pharmaceuticals²⁸

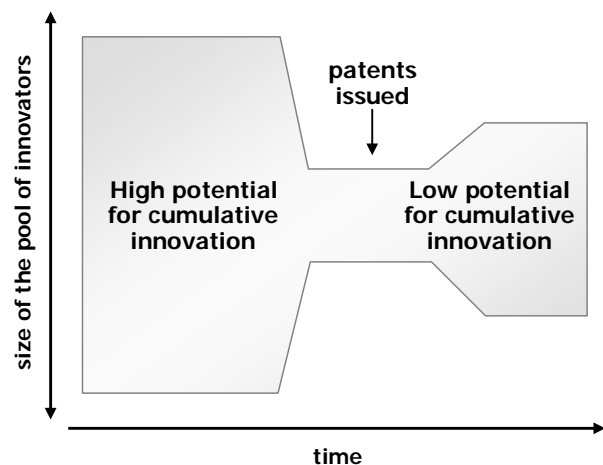
Equally significant, however, are the pressures for pharmaceutical research organizations to behave more like universities. Drug discovery has become progressively more science-intensive, with increased emphasis on exploiting “deep” understanding of molecular-level physiological processes. And basic research projects have ballooned in cost and scale. In response, drug companies have begun to emphasize collaboration, publication, and exchange of pre-competitive information. They have also come to rely on external sources of research and technology, whether through joint ventures, university-industry alliances, strategic partnerships or simply outsourced contract research. Both changes have created an environment in which specialist research firms prosper.

2.2 The “Strategy of the Commons”

The new structure of innovation in the biopharmaceutical industry came with new costs and risks. In the 1990s, researchers and industry participants feared that patents on large amounts of DNA sequence data would confer potentially very broad rights to exclude other researchers from working on the genes encoded by these sequences,

the proteins expressed by them, and “downstream” diagnostic and therapeutic applications. As tens of thousands of patent applications on “ESTs” and “SNPs” were filed in the U.S. and E.U. patent offices, debate erupted over the patentability of isolated gene fragments or single base-pair mutations without well-defined functions.²⁹ Biomedical researchers feared that access issues would erode the culture of open science and impede scientific progress.³⁰ Pharmaceutical firms worried that they would have to license many discrete, independently held patents before they could bring to market an effective therapeutic drug aimed at the product of that gene. Both the academic and commercial communities warned that royalty-stacking and high transaction costs could plug Big Pharma’s drug pipeline (see Figure 10).³¹

Figure 10 The bottleneck effect



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“I think we’re getting a taste of the anti-commons problem when for every vial of our product we sell we have to pay six or seven other entities. And this was in the era before what are now called research tool patents and reach-through royalties. Now with everybody wanting reach-through royalties, and with research tools being defined as broadly as they are, any cell line that’s used within your research program, any target, any reagent or molecule that you have screened against to see if there is cross-reaction, any particular assay type that you have used, and of course you end up in the course of researching the biological properties of a molecule using a wide variety of assays, you’re going to start to attach reach-through royalties to each of those research tools. I think you have a severe risk of a problem of the anti-commons.”

— Michael Kirschner, vice president for Intellectual Property at Immunex Corporation (now acquired by Amgen)³²

2.2.1 Merck’s Gene Index

In 1995, Merck Pharmaceuticals and the Genome Sequencing Center at the Washington University School of Medicine announced the creation of the Merck Gene Index: a public database of gene sequences corresponding to expressed human genes. Merck immediately released 15,000 expressed human gene sequences into the public domain and announced that it would characterize and make freely available as many gene sequences as quickly as possible.

Under the terms of the agreement, no one could gain advance access to—or delay or restrict the release of—any of the sequence data from Merck and Washington University. This included Merck researchers, who gained access to the data via the same public databases available to all interested researchers.

By 1998, Merck and Washington University had published over 800,000 gene sequences. The strategy appears to have worked: recent evaluations of the threat of gene sequence patents to biomedical research progress suggest that the Gene Index (with similar public efforts) has significantly eased the anti-commons threat.³³ But, why would Merck make this investment, which, according to one estimate, cost them several million dollars?

Dr. Alan Williamson, former VP of Research Strategy with Merck, explains it in philanthropic terms: “Merck’s approach is the most efficient way to encourage progress in genomics research and its commercial applications. By giving all research workers unrestricted access to the resources of the Merck Gene Index, the probability of discovery will increase. The basic knowledge we and others gain will lead ultimately to new therapeutics for a wide range of disease, while providing opportunities—and preserving incentives—for investment in future gene-based product development.”³⁴

But a subtle element of competitive sabotage underlies this apparently soft strategy. Merck sees gene sequences as inputs rather than end products. By placing gene sequences in the public domain, Merck precludes patents for any sequence published before another firm’s isolation of the sequence. Merck is pre-empting the anti-commons dynamic that threatened to encumber one of its key inputs with licensing fees and transaction costs.

In other words, it was worth it for Merck to pay for a public good, as long as the blocking value of defensively publishing a gene sequence was greater than its immediate use value. As long as no one succeeds in patenting, everyone is better off. But if one firm succeeds then the usual logic of the prisoner’s dilemma exerts its corrosive effect: all

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firms will want to obtain the same blockade positions.

2.2.2 *The SNP Consortium*

Others share Merck's concern about patents on upstream genetic information. Similar projects that build on Merck's approach have since been launched on a much larger scale.

In 1999, the SNP Consortium was established as a collaboration of eleven pharmaceutical companies, a non-profit institution, and two IT firms.³⁵ This unique joint venture brings together highly competitive companies—which rarely share any information, let alone information from a potentially path-breaking basic science initiative—to produce what the founders call “a public biological blueprint for all human life.” Their common goal: to spur a new era of “personalized medicine” in which treatment is tailored to an individual's unique genetic profile.

Many pharmaceutical executives believe that thanks to advances in gene technology, the key to future blockbuster therapies is identifying which drugs work best for which patients. Scientists are increasingly convinced that minute inborn genetic differences largely account for people's different health traits and explain why a drug works for one person but has no effect—or ill effects—in another.

In the mid-1990s, scientists discovered that tiny chemical landmarks inside or near genes are posted at regular intervals along the DNA molecule, like road signs and mile markers on a stretch of highway. These landmarks, called single nucleotide polymorphisms (SNPs), could be used to create a catalog of the ever-so-slight genetic variations that make some individuals susceptible to disease. As

Francis Collins, a director at the National Human Genome Research Institute, put it, “SNPs serve as a blinking light on DNA sequences showing there is something very interesting here—for example, something that is contributing to diabetes.”³⁶

The SNP Consortium set out to identify the hundreds of thousands of chemical landmarks along human DNA. Alan Williamson, then recently retired from Merck, helped organize the initial talks among the Consortium's partners. He recalls the excitement: “Suddenly, there was going to be a genetic map powerful enough to define which patients respond to a given drug vs. which don't respond to a given drug...It would allow doctors to tailor treatments to patients more exactly than ever before.”³⁷

The initial goal was to map 300,000 common SNPs. At completion of the project in 2001, 1.8 million had been mapped. To achieve this goal, the Consortium invested approximately \$50 million to pay university researchers to discover SNPs and place them in the public domain. The Consortium also filed patents to establish priority and obtain legal standing to contest other filings. Applications were abandoned once the SNPs were securely in the public domain.

The SNPs have been mapped, but the harder interpretive discovery work leading to new diagnostics and therapies is just beginning. As a testament to its effectiveness, a generous flow of follow-on innovation is proceeding in the wake of the SNP project.

Commercial and academic scientists are currently using the map to sift rapidly through the genetic material from thousands of patients to uncover which of the 100,000 or so genes that make up human DNA (the majority of which

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remain unknown) predispose people to such common but hard-to-treat ills as diabetes, depression, cancer, arthritis, memory loss and cardiovascular problems. The underlying biological causes of these illnesses remain largely mysterious, but if uncovered, they could lead to a treasure trove of new medicines.

The SNP project has also spawned additional open and collaborative efforts to extend the basic science. One follow-on project, the International HapMap Project, predicts that it will make the search for genes associated with diseases twenty times faster.³⁸ The resulting data is once again being made freely available to all-comers.

“The idea here isn’t to restrict the ability of biotech firms or anyone else to patent genes. The idea is to make sure the underlying SNP map we all need to find genes is available to anyone who wants to use it.”

— Dr. Alan Williamson, former VP of Research Strategy with Merck

But why collaborate when competition would let the winner extract proprietary gains? And why put this valuable information in the public domain? Why not limit disclosure to the Consortium’s members?

As with Merck’s initiative, there is blocking value in making public valuable but non-core information. The Consortium’s initiative competed directly with the biotech companies (including Incyte Genomics, Millennium Pharmaceuticals, and France’s Genset) that were making their own proprietary catalogs of genetic landmarks. Though wary of sharing their valuable data with rivals, the Consortium’s members worried even more about biotech companies’ projects. Daniel Cohen, lead

scientist at Genset, claimed at the time that Genset’s plan to patent SNPs and sell them to the highest bidder would net \$50 million to \$100 million a patent.³⁹

SNP members deny any concerted attempt to sabotage biotech competitors. “The idea here isn’t to restrict the ability of biotech firms or anyone else to patent genes,” says Williamson. “The idea is to make sure the underlying map we all need to find genes is available to anyone who wants to use it.”⁴⁰ It is in the interests of Big Pharma to level the playing field for gene-hunting biotech firms, large drug companies and academic scientists. The competencies of consortium members overwhelmingly lie in drug development, approval and marketing. They are collectively better off competing to bring valuable end products to market than competing with the biotech firms in upstream research. Lawyers also reportedly advised consortium members that making the map public would help the companies avoid antitrust problems.

In the end, however, Consortium members’ big prize for collaborating is not the blocking value, but the benefits of speeding the industry toward personalized medicine. Before agreeing to collaborate, many Consortium members were already building their own proprietary SNP maps. Under the leadership of Alan Williamson, they realized that a common map was crucial to the success of personalized medicine.

As Allen D. Roses, then vice president and worldwide director of genetics research at Glaxo Wellcome, explains, “It was crucial that we had something whose accuracy we all agree upon. If each of us had produced our own map, it would, for one thing, have taken much longer to create, and it would have been very unlikely that the

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companies would have accepted one another's map as being valid."⁴¹ Among other things, the Food and Drug Administration also needed to know that the map was accurate, reliable and accepted by the scientific community.

By fusing corporate resources with the relatively low-cost contributions of academic scientists—which after all could only be bought for a low price if the data remained public—the Consortium was able to discover many more SNPs than it imagined: 1.5 million more! And they did so in a fraction of the time it would have taken a single firm. This, of course, also means that resources that may have been wasted pursuing duplicate research could be redirected toward other goals, namely the pursuit of follow-on diagnostics and therapeutics.

2.2.3 *Balancing open and closed innovation in bioinformatics*

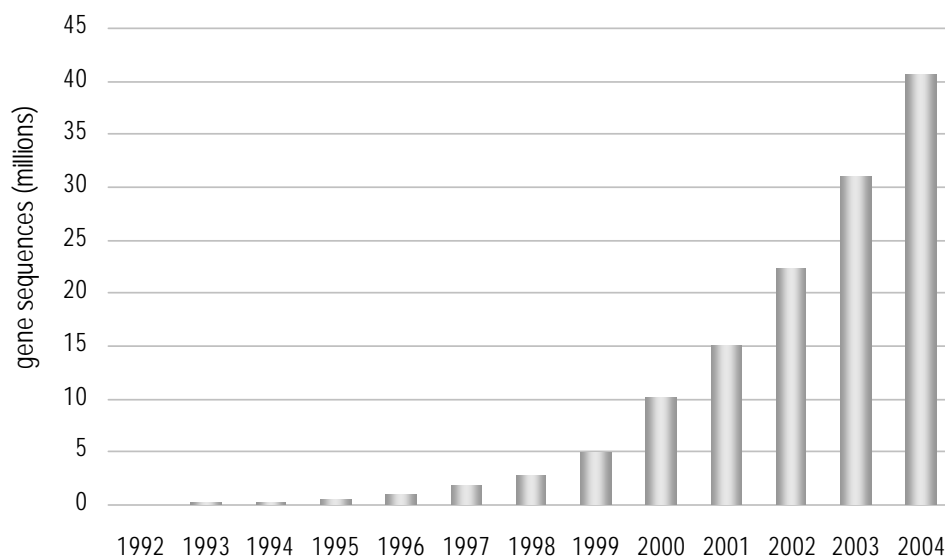
The race to sequence the human genome bequeaths

an impressive legacy. GenBank, the National Institute for Health's repository of gene sequences and other related information, is now the world's largest public database of genetic information. It is the culmination of a myriad of public and private efforts that placed genetic information in the public domain.

This public resource promises to be enormously valuable. It provides an infrastructure of freely available scientific information for millions of biomedical researchers and will spur follow-on innovation for decades. Recent GenBank statistics already demonstrate its growing value (see Figures 11 and 12). Impressive growth and usage statistics, in turn, lend credibility to those who argue that a robust scientific commons is the best way to ensure we realize the full potential of the genomics revolution.

The central challenge now is to turn raw genetic information into usable medical knowledge.

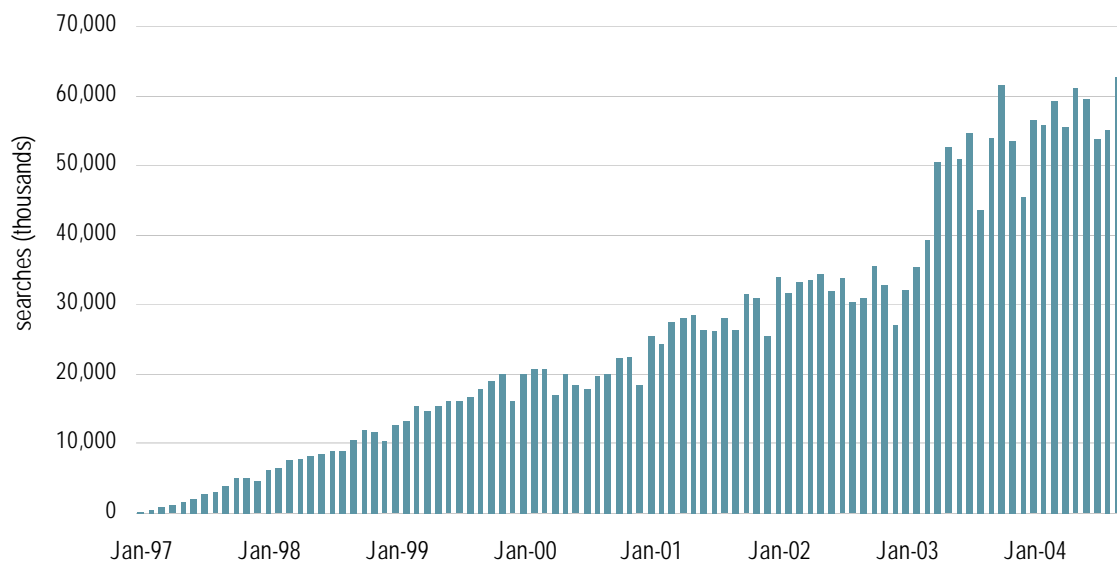
Figure 11 Growth of Genbank (1992–2004)



Source: NIH, February 15, 2005

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Figure 12 Monthly searches of Genbank (1997–2004)



Source: NIH, February 15, 2005

Bioinformatics—the burgeoning scientific discipline of computational biology—will play a lead role. By applying computer science and mathematics to DNA and protein sequence information databases, this new discipline has already made important contributions to modern biology. It seems likely to play a critical role in the development of biomedical science.

The “new” bioinformatics, conducted in computers rather than in test tubes, now plays a vital role in realizing benefits from the raw data generated by genes and other kinds of biomolecular (e.g., protein) sequencing. Without bioinformatics tools, the vast amount of new data generated by the biomedical research community is useless. Insight into the genetic basis of disease, for example, depends on the ability to identify meaningful patterns in these data, which is enabled by the development of search and comparison algorithms,

“gene chips” and a bundle of other complementary technologies.

Given this gargantuan task, and the potentially enormous payoffs, it seems unthinkable that bioinformatics firms such as Celera and Incyte, once rock stars in a rising biotech industry, would find themselves falling on hard times. But Incyte and Celera are still fighting to achieve profitability, along with legions of other less famous firms whose business models were initially based on the exploitation of proprietary genetic information.

Having for the most part failed to recoup their deep investments in genomic research as stand-alone tool companies, many firms are revamping their business models. Some are emphasizing on product development, while others are moving toward much closer relationships with Big Pharma—relationships that emphasize long term

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mutual interests, proprietary non-disclosed information and close coordination. No one knows how this drama will end, but some worry that the growing tide of openness may be driving out some of the private investment required to make significant leaps forward in exploiting the genomics revolution. These shifting dynamics illustrate the difficulty of balancing open and closed innovation strategies.

Wind the clock back to the early 1990s, however, and things looked very different. The bioinformatics space was virgin territory. Only a handful of firms had mastered the technologies to synthesize, analyze and annotate the escalating volumes of data produced by public and private gene-sequencing projects. Big Pharma was eager to mine this information for potential blockbusters but lacked the requisite capabilities. Thus with few suppliers and everyone moving quickly in the race to prospect the genome, biotech firms could command premium prices for the latest information and tools. Many firms used this leverage to negotiate reach rights that allowed them to lay claim to future discoveries.

Incyte Genomics was among the early entrants into the bioinformatics industry, and one of the first companies to engage in high-throughput computer-aided gene sequencing. Incyte's strategy was to offer nonexclusive licenses to its growing database of gene sequences, which others could use to identify potential drugs or drug targets.⁴² Incyte's approach was initially quite successful, with many pharmaceutical firms paying up to \$15 million for non-exclusive licenses. As Lee Bendekgey, former general counsel for Incyte, observes, "Incyte's initial success launched off of the introduction of a product for which there was no comparison. [We] managed to become the 800-pound gorilla..."⁴³

Competition increased when a new wave of startups launched in the late 1990s. Bendekgey recalls when, "Perkin Elmer announced that they were creating a new company, Celera, whose role was to, among other things, put Incyte out of business,"⁴⁴ hundreds of other firms vied for the same business.

Celera's unique competitive advantage came from its radical new "shotgun" approach to gene sequencing and its ability to manage relationships with academic partners. Led by Craig Venter, a former government scientist with the NIH, one of Celera's first moves was to partner with academic collaborators at Berkeley to sequence the fruit-fly genome—by then the largest genome yet sequenced. Why bother? Tapping into Berkeley's resources helped Celera validate Venter's controversial whole-genome shotgun method, which, if successful, promised to overtake the methodical, piecemeal approach of the Human Genome Project.⁴⁵

When the project succeeded, the sequenced data was placed in the public domain where other scientists could observe Celera's success. In 1998 Celera moved on to apply its new technique to the more complex—and potentially lucrative—human genome. The company declared that it would sequence the human genome in three years (i.e., by 2001) for \$300 million, which would put Celera a full four years ahead of the original completion date set by the public Human Genome Project.

In addition to sequencing genes, Celera and Incyte were building a layer of proprietary research tools on top of the burgeoning reservoir of untapped knowledge.⁴⁶ By the spring of 2000, market valuations were skyrocketing, thanks to growing patent portfolios. Incyte boasted a stock

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market capitalization of \$2.4 billion. Celera was trading for around \$250 a share. Many predicted that either company could become “the Microsoft of the human genome.” But it did not happen. Today, both Celera and Incyte have sold or hived-off their database businesses.⁴⁷ Celera shares now trade for about \$10.⁴⁸ Incyte’s stock market capitalization is just \$548 million.⁴⁹

What happened? Like their Internet startup cousins, biotech firms were overvalued. As with any gold rush, the excitement of the prospecting stage led to a speculative bubble. When the bubble burst, the true viability of biotech business models became clearer. But there’s more to it than that. Falling stock market valuations across the board appeared to reflect deep problems in the IP economics that were driving the success of the biotech sector.

“One thing that competition does is that it sure makes you hurry up. We successfully defended our franchise and really didn’t lose any customers to Celera. But we lost money and, to a significant degree, for the next couple of years trying to keep ahead of them.”

— Lee Bendekgey, former general counsel for Incyte Corporation⁵⁰

For one, the biotech space was getting crowded. Heightened competition drove rapid innovation and therefore rapid obsolescence. Companies that relied solely upon selling proprietary information and tools had to upgrade their technologies constantly to stay competitive. Short product life-cycle made recouping deep investments difficult.

“One thing that competition does,” notes Bendekgey, “it sure makes you hurry up... We successfully defended our franchise and really

didn’t lose any customers to Celera... But we lost money and, to a significant degree, for the next couple of years trying to keep ahead of them.”⁵¹

Patents on DNA sequences and research tools, meanwhile, did not, as many expected, translate into the ability to extract a significant share of the profits of downstream incumbents. In fact, licensing revenues are for the most part confined to one-time payments or periodic user fees, and any royalties eventually realized from sales of downstream products are shared with other tool providers. The reach-through royalties that promised a big piece of blockbuster revenues never materialized.⁵²

In part, this shutout reflects the superior bargaining position of downstream firms, which have largely been able to dictate contractual terms to tool companies. This in turn reflects the degree to which Big Pharma is consolidating its position and using long-term alliances and acquisitions to move quickly down the learning curve. It also reflects Big Pharma’s greater proximity to the ultimate source of value creation in the life sciences industry: the ability to translate biomedical knowledge into marketable drugs. And it reflects the high barriers to entry into the complex and costly process of moving a drug through the regulatory approvals process and into the marketplace.

The standalone tool companies’ demise is to some degree what Richard Nelson calls “the simple economics of basic scientific research”—patents or no patents, capturing the value that ultimately derives from fundamental early-stage research is extraordinarily difficult for profit-oriented organizations.⁵³ Those firms that have succeeded have been large, stable, highly integrated firms, sufficiently

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diversified in product markets to capture spillovers and financially strong enough to be able to effectively manage risk internally; i.e., Big Pharma.

Above all, disappointing returns for biotech tool and database companies signal the growing success of public and private efforts to establish a biomedical commons. Publicly funded researchers, often in collaboration with key industry players, have been quite successful at limiting biotech's ability to patent large amounts of basic biological data and a variety of crucial research tools.

Meanwhile, open source alternatives to proprietary bioinformatics platforms are becoming increasingly robust in certain niches. Bioinformatics.org, one of several hubs for open source activity in the biomedical community, has more than 14,000 members and hosts over 200 active projects. Freely available search and comparison algorithms such as BLAST are quickly becoming de facto standards.⁵⁴ Web-enabled searches of sequence information using BLAST now exceed 60,000 per day, illustrating the degree to which this technology has become an essential tool for biomedical research.⁵⁵ Much of this activity is grassroots, but what could happen if billions were invested in open source bioinformatics—the way IBM and others have invested in Linux?

The growing accessibility of high quality data and tools in the public domain has crowded out some of the space available for private investment. The once sky-high market value of proprietary IP has been radically undercut. This crude economic fact creates an urgent need for adjustment in the for-profit side of the bioinformatics sector.

One sure sign of a maturing industry is when the end products become relatively undifferentiated. In the bioinformatics service model, the

ready availability of genetic information in the public domain has accelerated commoditization. With public data and annotation now widely available, the added value that Celera and others could bring was primarily service-related. As Lee Bendekgey puts it, “Having exclusive intellectual property rights in the information you’re selling makes for a potentially more attractive business model than reselling public domain information, or information that’s otherwise publicly available.”⁵⁶ Although a significant number of firms and academic institutions did subscribe to the Celera and Incyte databases for these services, the availability of the public data limited what they could charge. The ceiling was sufficiently low that both Celera and Incyte moved out the database business and into drug development.

Affymetrix: Harnessing proprietary technology for competitive advantage.

With so many dismal failures in the biotech tool sector, a true winner is like a rare species: there is a great deal to learn from analyzing its ability to survive. Affymetrix is a good example.

Affymetrix is a small biotech tool company with 900 employees and a market leading gene chip array product used by all the major universities in the United States and a number of top biotech and pharmaceutical firms.

In the past, researchers proceeded painstakingly one gene at a time through the human genome. Gene chips enable researchers to analyze massive quantities of genetic data in a fraction of the time. As Barbara Caulfield, executive vice president and general counsel for Affymetrix, explains, “We invented a biological testing device where you can put 100,000 genes on a single glass slide the size of your fingernail. The slide contains half the DNA in

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a genetic sequence. Researchers add additional DNA sequences, and where there's a match, it lights up. Software is used to analyze those sections that light up, and the output can be emailed to collaborators around the world.”⁵⁷

Medical researchers use the chips to monitor genetic mutations that correlate with specific diseases. The technology is also becoming a vital tool further downstream in personalized molecular diagnostics and clinical trials, where the profits for firms like Affymetrix are potentially much larger.

The benefits of gene chip technology are already being realized. “Analysis that used to take a post-doc in the laboratory approximately six months with proper front-end research can now be done in 20 minutes,” says Caulfield. “The reason why this is so critically important,” Caulfield argues, “is that you can now see how much more quickly biotech research and genetics is moving.”⁵⁸

“We invented a biological testing device where you can put 100,000 genes on a single glass slide the size of your fingernail. ... Analysis that used to take a post-doc in the laboratory approximately six months with proper front-end research can now be done in 20 minutes.”

— Barbara Caulfield, executive vice president and general counsel, Affymetrix⁶⁰

In some cases, the improved ability to analyze complex data translates directly into the ability to save lives. Caulfield provides the following example: “There are two kinds of leukemia. Both are very difficult to cure. You have a very short life span once you're diagnosed. But you can increase the possibility that a person will live through these two different kinds of leukemia if you can tell which one is which, because they have very

different chemotherapy interventions. If they use the wrong one, it can increase the death rate.”

Such analysis used to be done with a microscope and took tremendous time and expertise. But “with the gene chip,” explains Caulfield, “you can take it down to the level of DNA to discover which kind of leukemia is at work. That test can now be administered to people with leukemia and a chemical intervention strategy can be created within minutes.”⁵⁹

Affymetrix considered but never ended up trying to profit from patented gene sequences. “As the data becomes more real, more effective, more rapidly developed,” says Caulfield, “it is our position that it should stay in the public domain.” In fact, Affymetrix’s tools are more valuable when genetic data is widely accessible. As Caulfield put it, the real value added “is not how you collect the data, but how you release the data, package the data and help medical researchers analyze the data.”⁶¹

Affymetrix is one of a very small number of biotech firms that have managed to become profitable. Its success is largely due to its early start in developing a market for proprietary technology that has since become the gold standard for analyzing complex genetic information.

Affymetrix was launched in 1992 and its gene chip technology was first commercialized in 1994. Once established, Affymetrix used patents and its first-mover advantage to defend its gene chip franchise. Six years of losses gave way to profits in 2001. It even managed to drive deep-pocketed players such as Corning and Motorola out of the gene chip market.

Today Affymetrix is venturing into China. In April 2005, the company announced a joint venture

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with CapitalBio, a leading Chinese life science company based in Beijing. The partnership marries Affymetrix proprietary GeneChip technology to CapitalBio's expertise in designing and manufacturing medical equipment. The companies intend to jointly pursue a number of complementary products for research and molecular diagnostics for worldwide markets. As one analyst put it, "Affymetrix is building a moat so wide, the crocodiles won't be able to swim across it."⁶²

2.2.4 Open source biology: leveraging the benefits of large-scale collaborations

Having demonstrated what most never thought possible—that thousands of volunteers could collaborate over the Internet to produce a highly complex and integrated product—the open source software community has kicked off a revolution in economic production. Growing numbers of "innovation communities" are trying to replicate the open source community's achievements. Scholars such as Yochai Benkler have proclaimed that "commons-based peer production" is becoming a viable alternative to production through markets and vertically-integrated firms.⁶³ But how transferable is commons-based peer production to the life sciences industry?

We have already seen the emergence of open source bioinformatics platforms, databases, and applications. So it looks like there is an enormous opportunity to harness peer production to tap the collective knowledge of the life science community. Notwithstanding impressive advances on many fronts, progress has been disappointing in many areas of biomedical research. No new broad-spectrum antibiotics have been marketed in almost 40 years, and many forms of cancer, as well as chronic diseases and disorders such as diabetes,

Alzheimer's, Parkinson's and schizophrenia still lack effective and well-tolerated treatments. There has been almost no research on tropical diseases such as malaria whose burden falls almost entirely on the world's poorest populations. A flurry of open source activity could enable a more coordinated and comprehensive attack on complex problems that have so far stymied traditional small lab biology. But peer production has not been widely applied outside the context of computational biology. Why not?

There are several reasons. Software is highly modular; "wet lab" biology generally is not. Software production has low physical capital costs; wet lab biology requires access to complex and expensive laboratory instruments. Software projects can be completed in months, even days and weeks; wet lab biology projects typically unfold over years. Commercializing software inventions is easy and inexpensive; commercializing biological inventions can be complex and highly expensive. All these factors make wet lab research less suited to peer production than software (see Figure 13).

Figure 13 Peering in software and life sciences

	Software	Life sciences
Value proposition	Accessible, interoperable software	Accessible, life-saving medicines
People	Volunteer programmers	Grad students, professional researchers
Drivers	Reputation, learning	Reputation, learning
Community ethic	Reciprocal sharing	Collaborative discovery
IP regime	Copyright, patents, licensing	Patents, public domain
Task structure	Granular	Granular and complex tasks
Timelines	Months	Years
Cost structure	Low capital/sunk costs Low marginal costs	High capital/sunk costs Low marginal costs
Infrastructure	Computer networks	Complex, online/offline networks
Regulation	Minimal, inexpensive compliance	Stringent, costly compliance

On the other hand, there is much that unites open source programmers and the biomedical research community. Both communities share

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similar value propositions and similar intrinsic and extrinsic motivations such as reputation and learning. They share strong community ethics, such as reciprocal sharing and collaborative discovery. Most of the people who contribute to collaborative projects in software and biomedicine are either paid to do so directly, or earn a living in some facet of the industry.

These factors suggest that peer production could thrive in wet lab research if the public and private sector community can overcome technical barriers, solve coordination problems around modular production and avoid bargaining breakdowns over intellectual property.

The National Institute of Health has recently started to facilitate the large-scale collaborative projects that could help solve complex biomedical problems. The first of five “glue grants” for projects requiring cooperation among multiple institutions, the Alliance for Cellular Signaling (“AFCS”) promises significant breakthroughs in our understanding of the inner workings of cells. It also promises a breakthrough in institutional design—blazing the path for a new collaborative approach to tackling large-scale research problems.

The goal of the project is to map what biologists call complex signaling networks—the pathways that transmit different molecules as a form of communication within the cell. Signaling networks are at the root of the unintended side effects that cause promising drugs to fail in clinical trials. The experimental work of the AFCS will codify this “vast uncharted territory” by generating a computational model of signaling within the cell.

Nobelist Alfred Gilman at the University of Texas leads the Alliance. The NIH provides the bulk of the annual budget of ten million dollars.

The remaining 35% comes from companies such as Lilly, Johnson & Johnson, Merck, Novartis, Chiron and Aventis.

The Alliance is highly coordinated. There are three levels of membership. “The first group,” says Gilman, “consists of around fifty participating investigators who will monitor and direct progress of the Alliance laboratories.”⁶⁴ The second big group is the PhD staff and technical personnel who are doing the actual work in the eight Alliance labs (including UT Southwestern; California Institute of Technology; San Francisco Veterans Affairs Medical Center; Stanford University; and the University of California, San Diego). They are employees of their host institution, but their time is 100 % devoted to Alliance research. Salary support for this second group is by far the biggest item in the Alliance budget.

Together, these two groups run seven “wet labs” and one bioinformatics lab. Each wet lab measures a distinct aspect of the cell signaling network. The bioinformatics laboratory is responsible for integrating the data produced by the eight labs.

“Each discovery has to be validated as to whether it’s real, physically, and whether it is important, physiologically. And we don’t begin to have the manpower or the talent to do that. So we need to enlist the whole signaling research community to be aware of what’s going on in the Alliance, to look at our Web site, to see what’s happened with their favorite molecules and to follow up on those leads.”

— Al Gilman, founder of the Alliance
for Cellular Signaling⁶⁵

The third group, explains Gilman, “is a cadre of people—our members—who take responsibility for one or two or three molecules...Members are

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our consultants, our experts,” says Gilman. “If we have questions about handling certain molecules experimentally, we turn to members for help.”⁶⁶ This strategy enables the AFCS to tap the thousands of cell signaling researchers worldwide.

As Gilman explains, “We’ll do experiments to identify pieces of the ‘cell signaling puzzle,’ and if the results satisfy pre-defined statistical criteria of reliability, then the data will automatically be placed in the public domain on the Internet.” But each discovery, explains Gilman, “has to be validated as to whether it’s real, physically, and whether it is important, physiologically. And we don’t begin to have the manpower or the talent to do that. So we need to enlist the whole signaling research community to be aware of what’s going on in the Alliance, to look at our Web site, to see what’s happened with their favorite molecules and to follow up on those leads.”⁶⁷

Much of the set-up work entailed working out standardization issues between labs and members. All laboratory inputs (e.g., cell lines) and procedures had to be standardized to ensure the output could be meaningfully compared and aggregated across labs. External participants work to the same standards.

Close coordination is essential at all stages. Each experimental step must be determined collaboratively, based on the data that emerged from the previous experimental step. AFCS laboratories remain in constant communication, through videoconferencing and face-to-face meetings.

Eschewing conventional peer-reviewed scientific journals in favor of a more expeditious Web-based publishing model was a controversial decision.⁶⁸ But the AFCS wants to get the data in

the hands of interested researchers within days instead of months—or possibly years. To ensure high standards, AFCS investigators replicate experiments, cross-analyze data to reduce error and publish those reviews on the Web.⁶⁹

Why do researchers contribute their time and data to the AFCS? “If everybody will put in just a little bit of time, the community will have a great resource. You know...an appropriate, academic, scholarly, non-ego-driven, generous type of behavior,” says Gilman.⁷⁰

But the AFCS wisely decided to allow contributors to publish independent papers. “We’re not completely naïve here—we’re doing our best to give to these Molecule Pages the properties of a scholarly publication. And they should be appropriate for presentation on the member’s CV and should have the appropriate impact on promotion committees, granting agencies and the like.” Furthermore, says Gilman, “We don’t want unpublished information [from our members]. We want literature information. Purely literature information. We don’t want them to give up any of their secrets.”⁷¹

Perhaps even more controversial, AFCS participants agreed to not patent their research, which helps maximize access and eliminates potential friction among participants. “We forgo all intellectual property rights because we totally appreciate that researchers in the signaling community at large will follow up on the leads that we provide only if they are assured of a level playing field,” says Gilman, “Insiders have *no* special advantage.” “After all,” notes Gilman, “the real intellectual property ultimately lies in identifying the genes and gene products that will hopefully become drug targets, and then finding the drugs that will

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alter the behavior of these molecules appropriately.”⁷²

How did the private supporters react to this decision? “We have tried to convince the pharmaceutical industry that our results will be enormously useful to all of them and that if they all were to participate their financial contribution could be relatively modest,” says Gilman. “After all, a proper virtual cell will be an incredible drug discovery engine.”

Private sector partners do get some private benefits. Gilman says, “Companies who are not sponsors will still have access to our data on our Web site. But we will work hard with our sponsoring companies to help them interpret our data and realize value from it. They also get preferential access to new Alliance technology.”

Does private involvement in any way influence the direction of the research? According to Gilman, “No...But do I feel eyes on us? You bet. I surely feel the gaze of our sponsors. They are paying the bills with the public’s money or the stockholder’s money or their own money. They deserve to watch closely and they deserve results. I hope the scientific community is watching closely, because we need their interest and participation.”⁷³

Gilman is confident that the investments will pay off. With the project still about five years from completion, it is too early to judge. But the AFCS is a useful model for public and private sector players seeking to leverage the benefits of large-scale collaborative efforts in embryonic research domains.

2.3 Is the “Strategy of the Commons” effective?

Smart firms should implement the IP strategy that maximizes competitiveness. It is worth considering

the long-run effects of alternative IP strategies; i.e., those relying on proprietary IP and those relying on shared IP. After all, a strategy that seems optimal at first may have unanticipated and unwanted effects over time.

Consider, on one hand, that prompt publication of data, methods, source code etc. appears to have been a powerful constraint on patenting. With a few exceptions, there is little concrete evidence that patents have blocked the broader research community from pursuing areas of inquiry (or been priced out of the market for tools or data) to any substantial extent. To the extent that this “push back” preserves commercial freedom of action on one hand, and freedom of inquiry on the other, it contributes to the long run performance of biomedical research and the pharmaceutical industry. Indeed, if academics were to be squeezed out of a patent-laden field, industry would be cutting off its most important lifeline.

On the other hand, the scorched earth strategy of placing data, methods and source codes in the public domain or under copyleft licenses may have undesirable consequences. If patents become more difficult to obtain, commercial researchers may become secretive to protect their investments, thereby limiting access to important knowledge and making duplicated research more likely. Even worse, fundamental aspects of the industry’s infrastructure may suffer due to chronic underinvestment.

Balancing these concerns is critical to maintaining the health of the life sciences industry ecosystem. Analogous concerns arise in any industry where R&D activities are distributed among upstream and downstream firms and, at some stage, a non-profit research community—a

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scenario that describes almost all science-intensive industries today. Strategic decisions in these industries must balance the following issues: competition, innovation, access and efficiency.

Competition. Limiting proprietary rights in basic research reinforces the competitive position of incumbents. So it could also slow the commercialization of new discoveries. Incumbents may want to slow down technology development to avoid cannibalizing existing products. They may shelve or abandon new technologies that threaten other sources of market power. Or, as with Merck and the SNP Consortium, incumbents may seek to deter entry by placing new technologies in the public domain. By denying entrants the ability to establish patent rights, we sharply curtail their ability to raise capital and establish a proprietary market position.

From the point of view of an incumbent, this may sound great. It is worth remembering, however, that competitive races finish faster. The absence of competition can reduce efficiency and may threaten the overall health of an industry ecosystem.

Non-profit research needs competition, too. Under fire from Celera and others, the public Human Genome Project had to work more efficiently.⁷⁴ Given that Celera's large investment in sequencing the human genome has failed to pay off, we may see fewer such challenges in the future.

Innovation. By extension, the absence of incentives could reduce innovation. The prospect of obtaining broad patent rights in early-stage technologies may stimulate R&D in areas that might otherwise be too risky or too remote from a marketable end product. Patents in early-stage technologies can also stimulate rapid innovation by

encouraging second movers to invent around the first round of patents on a new technology. Models of sequential innovation highlight the importance of balancing the division of profits between first movers and second movers to maximize R&D.

So the reluctance to grant strong rights to early innovators—or strategic pre-emption of those rights—may have ill effects. Celera, for example, made legitimate what was once considered a radical “shotgun” approach to genome sequencing. Without Celera's challenge, this approach, which is significantly cheaper and faster than the Human Genome Project's initial approach, might not have achieved legitimacy as quickly. Indeed, without patent protection, many such tools might never have received the investment required to enhance the efficiency of biomedical research.

The absence of attractive ROIs may drive out private investment in the next generation of bioinformatics tools produced by companies such as Affymetrix—tools that could significantly reduce the cost of drug discovery and development. Robert Blackburn, former Chief Patent Counsel for Chiron Corp argues, “If there's anything you want to protect and incent with patents it's the research tool technology. If you don't protect that research tool technology, I don't think you'll get the next generation of tools... Small startups are working on research tools that will address the toxicology side of drug development, maybe shorten it by six months and several million dollars. That's a little increment, but that's marching down that development pathway.”⁷⁵

To what degree have patents helped create a vibrant biotech tool sector? “Of the significant research tools that have really made a difference,” says Blackburn, “all have come as a result of

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venture capital investment that was premised on patent protection, and have been acquired by larger corporations.”⁷⁶ Chiron is a net buyer of research tools. Blackburn worries that, “We won’t get that second and third and fourth generation company coming in and trying to work on this high cost of drugs.”⁷⁷ Indeed, today’s successful bioinformatics firms are those that have carved out a unique technological niche and aggressively protect it with patents and trade secrets (see Affymetrix sidebar).

Any justification for the non-proprietary Strategy of the Commons rests on two foundations: access and efficiency.

Access. The challenge from Celera, Incyte and others raises the question of whether publicly funded research is necessary when (absent from the public effort) small firms could have successfully marketed their databases as research inputs. Public spending on the Human Genome Project totaled more than \$3 billion.⁷⁸ Celera claims it spent only \$300 million to sequence the genome. Given the enormous range of public health needs, there are many other ways to spend scarce public dollars. So was the expenditure justified?

Public officials justify this expenditure in terms of access. Paying subscription fees to private firms, they argue, could seriously restrict access, and that in turn would inhibit scientific progress and ultimately restrict the potential to improve public health. Equally, it could erode the quality of an important source of essentially free R&D for the for-profit sector.

These access concerns are serious. Strong, well-funded academic research institutions in the United States are a pillar of the nation’s commercial success. The National Science Foundation figures show that while academic institutions in the United

States perform 13% of national R&D (spending about \$36 billion), they perform 54% of all basic research.⁷⁹ A significant portion of this basic research (50% in 2001) goes into the biological and medical sciences.

By comparison, a large, research-driven pharmaceutical firm like Merck with an annual R&D budget of about \$3 billion conducts only 1% of the biomedical research in the world.⁸⁰ To gain access to the remaining 99% of biomedical research, pharmaceutical firms tap into the research conducted in universities and public research organizations around the world. If royalties or restrictive licensing conditions inhibit public researchers’ access to patented research tools, then the industry’s opportunity to harvest this research diminishes.

Efficiency. Though they have increased the efficiency of upstream research, biotech companies may have reduced the efficiency of downstream product development. Indeed, some economists argue that biotech companies may even have reduced current and future total value creation by contributing to the flood of questionable patents on gene sequences. Bargaining, litigation and other transaction costs are one way in which value creation is reduced. These transaction costs add excess risk, uncertainty and expense to the extraordinarily risky and costly process of pharmaceutical R&D. Smaller players in the industry claim these costs inhibit their ability to operate in otherwise profitable research areas.

David Earp, vice president of Intellectual Property at Geron, offers the following scenario: “So if you’re looking to move into a particular area of technology as a small biotechnology company, and you identify potentially blocking patents which

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your analysis shows may be invalid ... you have two choices. You can either walk away from that area and decide not to engage in development in that technology, or you can take the risk and start investing the dollars, usually millions of dollars even early on, to move into that technology area and risk getting sued by the company that holds the patent. For companies such as small biotechnology companies it's often not a choice. You will avoid that area."⁸¹

"It's one thing," notes Earp, "to have an opinion letter from outside counsel saying the patent is invalid, go ahead; all that does is it insulates you potentially from the threat of treble damages from willful infringement down the road. It doesn't insulate you from, first of all, the jury deciding that your patent counsel gave you the wrong opinion and, secondly, what's more problematic for small companies, is the actual process and the cost of engaging in the litigation in the first place. Litigation is truly a horrifying option to smaller companies."⁸² Deadweight costs such as these militate in favor of upstream data being publicly available, even if such availability requires public funding and undermines private database companies.

The flip side of this equation, however, is that firms operating in frontier industries will necessarily resort to trade secrets. Development of tool technologies in secret is less desirable than patent protection, given the constraint secrecy places on subsequent innovation. Indeed, disclosure of new inventions is among the primary reasons for having a patent system.

Reliance on trade secrets can make it much more difficult to transfer technology among firms. As Lee Bendekgey explains, "In the early nineties,

Incyte relied almost exclusively on trade secret protection because the patent landscape was very uncertain. If you look at Incyte's original database agreements, we had this very lengthy, essentially glorified confidentiality agreement... And the transaction costs associated with doing something like that versus a transaction involving patented inventions where the content is well-documented and the property rights are well-specified are very different. We now do licensing on the Internet, which would have been impossible in the days when we had to rely on trade secrets."⁸³

These competing concerns about efficiency are difficult to assess in practice. But efficient outcomes, in theory, depend on the ability of the upstream and downstream parties to contract with each other. If one upstream firm holds rights that one downstream firm needs, bargaining is likely to be easy and efficient as long as both participants can agree on the payoffs and neither has an informational advantage. But the question is whether the two parties can agree on a division of surplus and whether bargaining costs will eat up any efficiency gains.

In reality, both parties will have incentives to act opportunistically. Biotech firms will use their asymmetric information about their technology to misrepresent its true value. Pharma firms will use their asymmetric information about market prospects to downplay future returns. Opportunism raises the cost of contracting even in the simple case. But more importantly, fragmented ownership of gene sequences and research tools means that most bio-pharmaceutical end products will require access to multiple rights held by multiple parties. Given the costs of coordinating contracts with multiple tool vendors, potential anti-commons problems created by overlapping rights and

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uncertainty about the ultimate validity and enforceability of broadly written patents, it becomes increasingly difficult to believe that licensing negotiations can reach efficient outcomes.

2.3.1 The R&D productivity paradox

The argument in favor of openness and collaboration in the life sciences and other similar industries boils down to R&D productivity. For an industry as a whole, productivity is a function of both the efficiency of its component institutions and of the organization of the industry; i.e., the numbers and types of institutions, the allocation of effort among them and the relationships between them (particularly those involving exchanges or transfers of knowledge). In searching for an optimal allocation of effort, science-based, R&D-intensive industries with a complex division of labor between upstream and downstream firms confront a paradox.

Property rights promote competition and innovation by contributing to the viability of standalone research firms. Too many upstream patents, however, leads to over-fragmentation of rights and decreases the efficiency of downstream product development. Open collaboration, on the other hand, enhances access and leads to efficient pooling of resources. Too much openness, however, inhibits the ability to generate healthy returns and drives out further investment.

Firms should harness openness when collaborative R&D in pre-competitive areas produces better outcomes than those produced by a competitive market.⁸⁴ Sometimes this will be the case. Other times it will not. For individual firms, it depends on factors that we discuss in Section 3.0, such as the product/market focus, timeframes and

positioning within the industry ecosystem, and the shape of the ecosystem itself.

At the ecosystem level, open and collaborative approaches can help provide a shared, lower-cost industry infrastructure to enhance innovation and competitiveness. Many more minds can be allocated more productively to complex tasks than can be achieved through vertical integration or competitive races. The SNP Consortium and the Alliance for Cell Signaling are just two examples where an emphasis on openness ensures that the benefits of collaboration around the shared knowledge infrastructure of an industry can yield large collective benefits.

Indeed, it is interesting to speculate on where modern biology would be today if broad patents covering the BLAST algorithm had been obtained by a for-profit company that was unwilling to license them widely. A sufficiently broad blocking patent might have limited the number of individuals and institutions participating in developing methods for compiling and searching genome data and slowed technological progress. Similarly, it could have resulted in a fragmented and inefficient infrastructure built on incompatible workarounds, or even a relocation of bioinformatics activity to jurisdictions that did not recognize the patent. On the other hand, such an attempt to monopolize a critical resource might have resulted in redoubled efforts to develop alternate methods and sped up the development of superior non-infringing technology.⁸⁵

If peer-to-peer collaborations in bioinformatics and wet lab biology are to be successful, however, they need ongoing funding and support. Large-scale collaborative projects such as the AFCS and openly accessible public repositories of sequence data such

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as GenBank rely heavily on taxpayer money and the support of non-profit foundations such as the NIH and the International Nucleotide Sequence Database Collaboration. Collaborative efforts depend on community norms and the policies of granting agencies and academic journals, which have enforced prompt and regular deposits of data. Without guarantees of government funding, however, these initiatives are hard to sustain, and they are subject to the usual difficulties in motivating and coordinating collective action. For example, since the Swiss government dropped its support, the long-established Swiss-PROT database has struggled to find a commercial business model that both covers maintenance and distribution costs and also satisfies demands for open access by the public sector researchers who largely created the data.

Furthermore, just as the most widely known open source software projects (Linux and the GNU applications) are to a large degree the creatures of Linus Torvalds and Richard Stallman, ongoing development of many critical bioinformatics databases and applications relies heavily on the vision, values and commitment of single individuals or small groups. For example, much of the value of the SWISS-PROT database is attributed by the community to its founder, Amos Bairoch. The Alliance for Cell Signaling is Al Gilman's creation. These models are fragile.

There are important differences, however, between "open" and "open source" development of databases and software. The "open source" development model emphasizes both the integration of collective effort from independent contributors and also unrestricted access. It depends on the ability to restrict modification and reuse to assure open access to ongoing results.

"Open" projects, such as BLAST software and the GenBank database, release source code and data into the public domain with no restrictions on use or modification. Thus nothing prevents for-profit entities from incorporating this public domain code and data in closed, proprietary products.

In contrast, "open source" projects are typically distributed under the "copyleft" model, using the GNU Public License (GPL) or variants on it. Some important examples of bioinformatics applications or application suites licensed under the GPL or similar provisions are EMBOSS, Ensembl, BioPerl, and Rasmol and there are many smaller or more specialized open source bioinformatics applications. Under most forms of these licenses, access is unrestricted—any entity can use, copy, redistribute, resell or modify the source code—but only on the condition that the provisions of the license are retained. Modifications or additions to the source code are therefore automatically made available to the public.

This "viral" property effectively prevents the output of open source projects from being incorporated into closed proprietary products: commercial developers would find it difficult to recoup the costs of making any additions or improvements if they were obliged to provide unrestricted access to them. The Human Genome Organization reportedly considered, but did not implement, the open source model for sequence data. Had it done so, it would have been nearly impossible for Celera, Incyte and others to add unique proprietary value to the reservoir of public data.

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2.3.2 *An emerging equilibrium*

These dilemmas are hard to solve, but two decades of turmoil are gradually yielding to a stable equilibrium as both the public and private sectors make adjustments. Both sides should continue making adjustments that promote competition and innovation and increase access and efficiency.

On the public sector side, the National Institute for Health should continue to pour money into basic research while promoting healthy debate about fair-use exemptions for non-commercial research. Academic institutions should continue to patent and license inventions with significant commercial potential while emphasizing open source efforts in technologies that have become de facto standards and in early-stage basic research, particularly those that the for-profit sector has neglected. The USPTO and the courts should continue taking steps to improve patent quality and compensate for some of the flagrant excesses in patent litigation.

At least some industry players think the track record of past public sector reforms is reason for optimism, including David Beier, who represents the Biotechnology Industry Organization. “Essentially,” says Beier, “The consensus is that if you look at the broad sweep of the last 25 years, the patent system has remarkably been self-correcting. You think about everything that’s happened in the Congress, in the PTO and in the courts, it’s gone in the direction of improving the patent quality and the ability to obtain higher quality and appropriate scope.”⁸⁶

Adjustments on the private sector side are likewise driving toward a healthy coexistence between Big Pharma and biotech. The “gold rush” and “land grab” dynamics are largely over. The

emphasis is shifting from value capture to value creation. Truly innovative and valuable biotech tool companies will continue to invest in labor-saving technologies. Some firms, like Affymetrix, will use patents and trade secrets to eke out an independent existence. Others are likely to be acquired by downstream firms. Biotech firms pursuing product development will seek to replicate the success of Amgen and Genentech.

Big Pharma, on the other hand, should continue to focus on driving down R&D costs and restocking their pipelines. There is progress to be made on many fronts. Sharing fundamental research or collaborating in an all-out war on diseases such as cancer could replicate the success of the SNP Consortium. Costs can be squeezed out as more pieces of the drug research, development and manufacturing puzzle become viable in countries such as China. Partnerships and strategic alliances with the biotech and non-profit sector can help firms cost-effectively scale up their R&D and leverage the latest insights from the biomedical research world.

Whatever the intellectual property strategy pursued, one thing is certain: the growing scale, scope and complexity of R&D will demand an unprecedented level of collaboration and knowledge sharing among distributed networks of not-for-profits, Big Pharma and biotech firms.

3.0 IP and Competitive Advantage in the Open Networked Enterprise

Our study of the life sciences provides rich insights into the complex dynamics between open and closed innovation. In this section we turn these insights into a more general framework for designing a winning IP strategy. We build on the

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case study lessons and the eight principles of IP strategy introduced in Section 1.0 to evaluate a spectrum of innovation models. We conclude with foresight on management practices for the emerging IP management discipline.

3.1 A spectrum of innovation models

The life sciences study shows there is no single winning model for managing intellectual property. A portfolio of models works best. Diverse innovation challenges require diverse configurations of human, financial and intellectual capital. Strategic factors drive firms to adopt one model or another.

We examine four models on a private-public continuum.

- **Vertically-integrated R&D.** The human, financial and intellectual capital needed to develop a product or service exists within a unified structure.
 - **Modular innovation.** R&D activities are unbundled and distributed among distinct entities that focus on various components of an end product. There is no central coordination or direction apart from market forces. Acquiring the components to assemble a marketable product means engaging in arms-length contracting, licensing and cross-licensing.
 - **Proprietary collaboration.** The human, financial and intellectual capital for tackling a particular R&D problem are re-aggregated in a federated structure—a consortium, joint venture or private research network, for example. Participants agree to coordinate resources temporarily. There may be various levels of coordination, from self-organized to tightly managed, but the intellectual property remains proprietary to the partners.
- **Open innovation.** A federated structure adopts various coordination mechanisms as appropriate. Participants place knowledge in the public domain where it is free for all to modify and appropriate.

3.1.1 Vertically-integrated innovation

A world with perfect information, competitive markets and no transaction costs would need no vertical integration. But in the real world, large vertically integrated firms are an efficient response to a number of problems. These include the inability to diversify risk where capital markets are incomplete or imperfect, the inability to minimize transaction costs when complete contracts cannot be written, the inability to capture spillovers or other externalities and a variety of familiar difficulties that arise from flaws in markets for information. In fact, there is a strong presumption that vertical integration is the first best solution to economic problems such as the financing and management of multiple projects that are: long-term, risky, complex, involve activities which are costly to monitor, require substantial and unrecoverable project-specific investments and have shared costs and vertically complementary outcomes—pretty much an accurate description of contemporary R&D!

Most twentieth-century innovation took place in closed, vertically-integrated firms, and for good reasons. R&D was closely aligned with the firm's existing proprietary product and process technologies, its strategy for staying ahead and its market opportunities as it saw them. Effective lab

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work often required not just industry-specific knowledge, but also firm-specific knowledge. Much of this knowledge was uncodified, and a great deal of learning and refinement occurred in the course of doing business, not in the lab. Moreover, the difficulty of knowing in advance how an R&D project will turn out made it necessary to rethink and respecify objectives frequently. These indeterminate relationships are inherently difficult to govern by contract.

In-house R&D also made it much easier to control intellectual property. Much firm-specific information—both the motivation for the R&D and the content of the project itself—was regarded as proprietary. Since firms profit from R&D largely by exploiting a head start, the details of R&D needed to be kept private until ready for practice.

Many of the rationales for closed, vertically integrated R&D remain valid today.

As always, tomorrow's technology will still largely grow out of today's, and, as a consequence, durable competitive advantages in IP-intensive industries will still be rooted in the cumulative growth of deep domain-specific knowledge. Firms will still need to invest resources in internal R&D to be able to recognize a commercial opportunity and exploit it quickly. Companies that expect to be players will still require broad, high quality portfolios of proprietary IP for trading and cross-licensing.

These factors suggest that a core R&D and IP function will be integral to any Open Networked Enterprise. But the function will operate differently. Increasingly, the corporate R&D process will look two ways: towards its internal projects and capabilities and towards the external marketplace to monitor opportunities and threats.

Collaboration will work in many ways. Firms will outsource routine or well-codified R&D functions to specialized suppliers. Much basic scientific knowledge will come from academic partnerships and/or research literature. Customers and external collaborators will proffer a growing number of product and service ideas. Many proprietary systems and technologies will give way to open and interoperable infrastructures. Increasingly, complex cross-disciplinary challenges will require large-scale cooperation.

Harnessing collaboration means shifting down the public-private continuum and spanning a wide scope of emergent and applied activities. Some of these collaborative activities, such as licensing and private R&D consortia, will take place in the proprietary domain. Others, like open source development and industry-university partnerships, will take place in the public domain. Open and closed approaches to collaboration each have unique advantages and disadvantages that we explore below.

3.1.2 Modular innovation

The most prolific form of proprietary cooperation today is the increasingly active trade in technology and intellectual property rights. Liberal licensing and cross-licensing of patents, in particular, help provide access to complementary technologies, boost the return on R&D and build partnerships.

Licensing. In the simplest licensing model a patent is licensed for money: typically up-front payments balanced by a royalty on the licensed technology's revenue. A large share of patent licensing takes place between a firm and its affiliates and subsidiaries in different countries. But with the growing interconnectedness of technologies,

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companies are making intellectual property available on a non-exclusive basis and licensing partners and direct competitors equally.

Decisions to license intellectual property hinge on a number of factors. The relative importance of the technology to your present and future business should be high on the list. While licensing can bring in revenue, you must weigh any negative impact that may result from the licensee's activities. Firms are rightfully loath to license a core invention to a direct competitor and risk eroding their competitive advantage.

In the early days of television, RCA successfully leveraged its patents, dominating the sector by refusing to license essential TV components like picture tubes so that competing manufacturers would have to buy them instead. If RCA needed patents, it used its financial muscle to buy them up, and invented around patents that could not be acquired for cash. RCA's strategy gave it a decades-long stranglehold on the industry.

The turning point came post-WWII, when RCA licensed its patents to emerging Japanese manufacturers like Sony, assuming they were better positioned to serve the Japanese market. But RCA did not count on new and improved Japanese televisions making their way to the U.S. market. In the next wave of competition starting in the 1960s, RCA—having failed to keep up with the pace of technological innovation—was overrun. The lesson is that opening up IP can unleash formidable competitors. If you are not furthering internal capabilities at the same time, you could wake up one morning to a nasty surprise.

Contrast this story with Matsushita's ability to slip in and eventually dominate the market with its VHS standard after Sony failed to widely license the

superior Betamax format, and one can see that licensing decisions need to be carefully calibrated to specific industry conditions.

A decision to exit a particular technology field, on the other hand, presents an opportunity to license valuable IP without any threat to your existing or future business. Licensing technologies to firms in adjacent non-competitive markets presents similar win-win opportunities.

In just one of many examples, Sharp Corporation recently formed Sharp Technology Ventures to commercialize, among other things, its video summarization technology. While the technology does not meld with Sharp's business strategy, company officials think the technology can be used to create a searchable summary of key moments in sports events, and could also be extended to security and surveillance applications.

In other cases, the licensee's use of the technology can enhance the value of the original invention by increasing its utility or the sales of complementary products or services. In the early stages of standards development for the wireless Internet, Nokia licensed its WAP technology widely to IT and telecom vendors, software developers, and system integrators to ensure that ecosystem partners could develop compatible technologies and applications. Nokia also created a software development toolkit for WAP application developers. Nokia's strategy boosted the adoption of the WAP standard, sped up the development of the mobile Internet services and ultimately increased demand for its mobile phones.

Despite these and other successes, licensing fees may extract only a small portion of the value of the technology to the new user. Smart firms will judge whether they are forgoing opportunities that

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they could profitably pursue themselves. Apple's decision to go with a closed iTunes architecture to leverage synergies with its popular iPod is a case in point. RealNetworks may cry foul. But, as Steve Jobs put it, "with iTunes, we decided to work with the most popular music player—and that's by far the iPod. Rather than support all these other guys, we'd rather use the engineering to innovate."⁸⁷

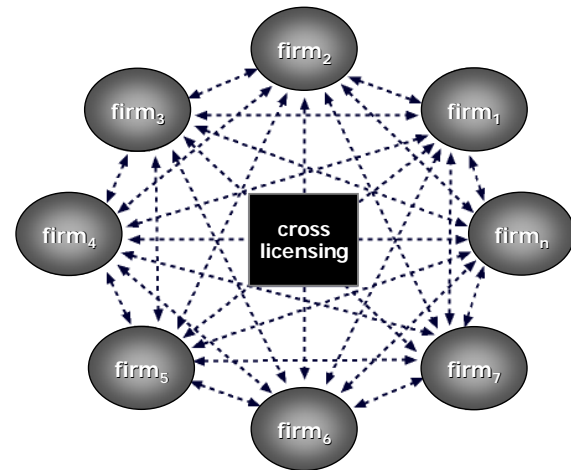
Decisions must ultimately be based on a realistic assessment of the market and your potential to beat out competitors. Where the market is difficult to tap, licensing will be a better option. But where licensing gives away easy wins to competitors, openness for the simple sake of preserving interoperability is just martyrdom.

Cross-licensing. Licensing has become increasingly complex. Highly modular innovation environments make it too cumbersome and expensive to license specific patents for specific products. Top innovators own thousands of patents, used in literally tens of thousands of products, and may add hundreds if not thousands of patents to their portfolio each year. Bargaining gets difficult, and it is simply infeasible to identify every individual infringement.

The use of patents as bargaining chips or "currency" in cross-licensing negotiations is a practical response to this problem. Cross-licensing proceeds on a portfolio-to-portfolio basis, granting reciprocal rights to practice IP in a field-of-use without making specific reference to individual patents.⁸⁸ Desirable portfolios have excellent patents covering technology used widely throughout the industry. Owning a quality portfolio is a powerful lever in negotiating access to required technology and may lead to significant royalty

earnings or, at minimum, reduced payments to others.

Figure 14 Cross licensing equilibrium



Firms caught in a mutually interdependent cycle of rapid and cumulative research and development are right to forego full enforcement of property rights in exchange for reciprocal forbearance from competitors. Companies that contribute roughly equally to the state of the art are much better off creating shared pools of technical knowledge than engaging in costly litigation (see Figure 14). Some of the earliest cross-licensing agreements dating back to the early twentieth century helped break through legal dead-locks in then emerging industries such as aviation, automobiles, sewing machines, and radio and television. This pattern continues today as new cross-licensing deals in the IT, electronics and life sciences industries are announced almost weekly.⁸⁹

Until recently, such reciprocal sharing arrangements among major portfolio holders—particularly those in IT and electronics—rested on largely implicit agreements not to license patents explicitly, but not to enforce them either. Today, it

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is more common for money to change hands as balancing payments to reflect the relative quality of different portfolios.⁹⁰

Critics tend to see balancing payments as a formidable barrier to entry, especially for small firms lacking legal resources and a war chest of IP. Realistically, the apparent imbalance reflects the natural barriers to entry that exist in industries where technological depth and sophistication are baseline requirements. Balancing payments, after all, provide a mechanism for net takers of IP to compensate net contributors. They provide some protection against free riders who would otherwise use an industry's stock of proprietary knowledge without contributing to its development. In the end, balancing payments increase the incentive for innovation: firms must either invest in R&D to develop patentable technology, or pay to license the patent portfolios of others.

Cross-licensing is not just about reducing transaction costs. It is also about competing. Cross-licensing offers a flexible way to enhance the leverage gained from R&D expenditures, to solidify alliances and expand into new markets and to deliver more comprehensive customer solutions.

As with the simple licensing model, strategic considerations must guide cross-licensing. If a firm is a significant contributor in a shared field, you are likely to need a cross-license from it. But reciprocal cross-licensing need not mean giving away core IP that is critical to competitive advantage. HP, for example, cross-licenses extensively, but it does not license patents covering its printer technology, where it has competitive leadership. Instead, it leverages its portfolio in a range of other important, but less mission-critical, technologies.

Decisions about royalty fees and balancing payments cannot simply reflect "what the market will bear." They must also emphasize longer-term considerations such as the likelihood that one will deal with the same partners repeatedly, in several different markets and in a variety of circumstances. A competitor in one field may be a supplier or customer in another. Your heavy-handed negotiations in one product group may affect you in negotiations for others. Managing intellectual property should be more about building strategic relationships than about opportunistically capturing value.

Companies that engage in active licensing markets, however, must also remember that markets are great levelers. Whenever a market is open to all qualified comers, competitive advantage will not flow directly from participation in that market. Competitors can simply enter the same market. These facts suggest that the domains in which unique value can be built are likely to shrink as licensing markets become increasingly open and competitive.

As markets for know-how and intellectual property grow, competitive advantage will depend on the combined ability to create, transfer, assemble, integrate and exploit knowledge assets. Superior technology alone will not produce competitive advantage. With just a little time and effort, most patented technology can be invented around.

3.1.3 Proprietary collaboration

Licensing and cross-licensing are not the only forms of cooperation available to firms that want to stay in the proprietary domain. R&D consortia,

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joint ventures and b-web innovation are other options.

B-web innovation. Much proprietary collaboration occurs within b-webs and among firms with complementary products and capabilities. Firms in an upstream-downstream interaction may produce complementary goods and have different but highly complementary expertise. Thus airframe manufacturers cooperate with electronics firms and engine manufacturers to design and develop new aircraft. Computer, semiconductor and software manufacturers collaborate to optimize their products. Biotech firms blend their strong research capabilities with the complementary production and marketing machines of established pharmaceutical firms. Much of this joint R&D work is now routine, and these types of arrangements tend to be easier to work out than collaborations among direct rivals.

Industry-wide collaboration. That said, even ardent competitors can collaborate on certain areas of research, particularly those where results are hard to keep proprietary or where certain objectives are widely shared. One particularly fruitful area for collaboration is in pre-competitive upstream R&D. Our life sciences case studies show that sharing responsibility for basic research among firms and academic contributors is often faster and more efficient than each firm pursuing a proprietary program.⁹¹

Like licensing, the benefits of both b-web and industry-wide R&D collaboration are potentially large. Depending on the type of venture, they include:

- a) Identifying and acting on scientific discoveries with commercial potential more quickly
- b) Pooling the competencies of diverse organizations, allowing participants to focus on their area of research competence
- c) Facilitating mutual learning and knowledge exchange
- d) Spreading the costs and risks of pre-competitive research
- e) Lowering transaction costs associated with technology exchange by placing these cooperative development activities under a unified governance structure.

Problems related to ownership and exploitation of intellectual property, however, can make proprietary research consortia and joint ventures difficult. Before research in an inchoate area has begun, it is difficult to know how rights should be assigned to collaborators. Even as joint collaborations proceed, participants will have trouble clearly defining the boundaries of their intellectual contributions. Concerns about public disclosure of proprietary information and disputes over future patent rights can create friction.

Resorting to the default rules of ownership in intellectual property law is equally unattractive. Under the default rule, any inventor who contributes to a single patent claim is considered a full owner of the patent. Even a small contribution makes the contributor a co-owner. Patent doctrine also allows each owner to exploit fully the patent without permission from the other owners and without any duty to account. Collaborators rightly avoid the default situation.

An alternative to intricate contracting is to form a new entity and assign all rights to it. But determining equity shares in this new entity raises the same kind of multilateral bargaining scenario.

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Avoiding these problems is one reason why a growing number of firms are moving further down the public-private continuum to embrace more open models of collaborative innovation.

3.1.4 Open innovation

Many of the same lessons that apply to collaboration in the closed innovation model apply equally to collaboration in the open innovation model. It extends the basic premise that companies can achieve a lot more when they make some of their IP available to others to build on. The difference is that the opportunities for engagement and collaboration in the open model are potentially much wider.

The conventional wisdom says putting IP in the public domain creates a public good. Everyone automatically shares in the benefits and there is no way to generate private returns. But conventional wisdom oversimplifies openness.

Openness is not altruism. It is about managing context and making the field of play more amenable to your competencies and competitive strategy. Smart firms use openness in many ways: to strategically shift the locus of competition in their industry, to get to market faster, to reduce R&D costs, to generate valuable follow-on inventions, to boost demand for complementary offerings and to develop relationship capital with a community of collaborators.

Openness does come with costs. It means less control and requires practitioners to learn and abide by the rules of scientific and creative communities. It means investing in infrastructures for collaboration, while carefully considering issues such as IP diligence and indemnity.

To be most effective, openness should be combined with proprietary techniques and collaborations. When carefully calibrated, opening up IP provides a powerful avenue for innovation and competition. We explore some of the unique advantages of openness below.

Strategic blocking and shifting. Putting IP in the public domain has long been a way to salvage research of marginal value. If it was not worth patenting an invention, firms could publish the IP and prevent competitors from patenting.⁹² But as the value of IP has increased, so too has the blocking value of preempting competitor's property rights.

Publishing in non-core areas that are core to a competitor can undermine your rival's ability to monopolize a resource that you depend on. When science and technology are evolving rapidly, firms such as Merck have shown that publishing gene sequences to maintain freedom of action can be more valuable than engaging in a patent race to monopolize the resource yourself.

But publishing does more than pre-empt property rights. It also shifts the locus of competition. In the pharmaceutical industry, putting genetic information in the public domain shifted competition from upstream research to downstream product development. In the software industry, publishing code is largely about fighting entrenched rivals. By creating an open and interoperable technology infrastructure, competition migrates to applications, integration and services.

Follow-on innovation. Earlier we emphasized the power of licensing to encourage partners to build follow-on inventions that increase the utility of the licensor's IP. What open innovation does

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that closed innovation cannot, however, is remove a great deal of the friction and barriers to entry that accompany the need to bargain for intellectual property rights.

Sometimes valuable follow-on innovations will come from customers, the way LEGO's Mindstorms product became more valuable when opening up the source codes enabled users to create their own Mindstorm applications.⁹³ Sometimes innovations will come from collaborators in a community of practice, the way IBM and others leverage contributions from the open source community. None of these innovations will occur if all your intellectual property is hidden.

This means revealing some IP in an appropriate network, socializing it with participants, letting it spawn new knowledge and invention and keeping plugged into the community so that you can leverage new contributions. It means dedicating some resources to filtering and aggregating contributions. It is a lot of work, but these types of collaborations can produce more robust, user-defined, fault tolerant products in less time and for less expense than the conventional closed approach.

In the life sciences industry, pharmaceutical firms abandoned their proprietary projects to back open collaborations such as the SNP Consortium and the Alliance for Cell Signaling. Both projects put IP in the public domain to harness resources and insights from the for-profit and not-for-profit research worlds. Both large-scale research efforts are speeding the industry toward fundamental breakthroughs in molecular biology—breakthroughs that promise an era of personalized medicine and treatments for intractable disorders.

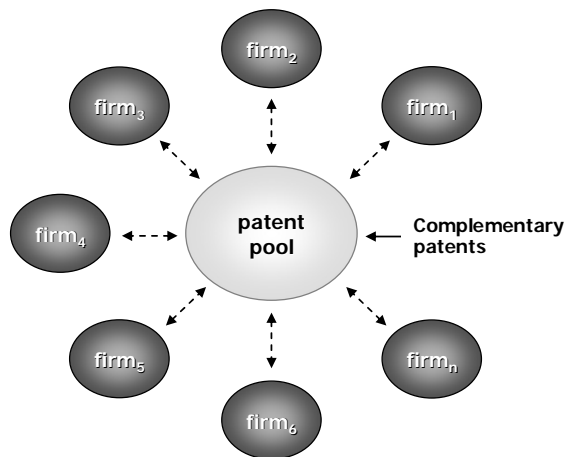
These collaborations are not producing end products, but they are providing the scientific infrastructure that will enable companies to get there faster than they could alone. And better still, they help focus proprietary efforts downstream, closer to the ultimate source of customer value.

Open standards. An analogous example in the software world is the open standards phenomenon. Standards are inherently complex creations. To create a standard, the knowledge and needs of multiple entities have to be pooled. Inevitably this means pooling intellectual property as well.

Conventionally, firms with IP covered by a standard license their essential patents to those wishing to practice the standard. Sometimes this means licensing a lot of different patents from a lot of different firms. One solution is a patent pool, where patents are pooled in a collective organization offering uniform terms for their use. This lowers the costs of exchange with users and other producers by providing one location for purchasing rights and by regularizing the valuation of individual patents.⁹⁴ MPEG-LA, for example, was founded in 1997 to license patents covering the MPEG-2 video standard. It started with 27 patents from companies such as Hitachi, JVC, Lucent, Matsushita, Mitsubishi, NTT, Philips and Sony. Today, it licenses over 2,000 patents to over 14,000 licensees.

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Figure 15 Patent pools



Patent pools can vastly increase the efficiency of patent licensing and lead to a lower royalty rate than would independent pricing of the patents. The cumulative royalties can still price out small vendors and not-for-profits. Some critics claim that MPEG-LA's licensing terms are too onerous. One small vendor argues that MPEG-LA boils down to "a move by a few very large companies to dominate a market and fix prices."⁹⁵ This has led to a call for producers to support open standards that eliminate royalties altogether. In fact, open standards may need little help if draconian licensing rules steer content creators and electronics firms toward an array of other open source video formats.⁹⁶

Classic examples of open standards include the royalty-free protocols underlying the Internet. In the early 1990s, TCP/IP, FTP (file transfer), SMTP (e-mail), NNTP (newsgroups) and HTTP (the Web) were novelties in a space dominated by proprietary standards. Because anyone could develop and embed these applications without paying license fees, they disseminated widely and rapidly approached a level of robustness rarely seen in commercial software.

Today, open and royalty-free standards lower barriers to entry in a broad range of collaborative opportunities. Open bioinformatics standards are boosting technological progress by increasing the number of individuals and institutions developing methods for compiling and searching genome. And just as interface standards promote interoperability, standards in biomedical research ensure that data will be comparable across projects and institutions.

Successful standards are those that gain universal acceptance and lower system design and assembly costs for everyone, broadening niches into mass markets. Developers realize the upside through the scale, speed and lower cost of development activities, the reduced royalty costs, and the potential for network effects to accelerate market adoption. Customers can benefit too. Open standards reduce prices and lower the risk of stranding. And, since vendors cannot rely on lock-in effects, they need to offer premium service to earn business.

Complementary capabilities. Many argue that while open infrastructures can bring collective benefits to an industry and its customers, they cannot help individual firms create competitive advantage. One analyst complains, "Today the TCP/IP stack, a piece of open source code, lives on every desktop as part of the operating system, affording no value-adding or OEM licensing opportunities... The problem with basing business strategy on open standards is that, like a fire stoked with home furnishings, it eventually leaves everyone homeless."⁹⁷

This argument misses the point and underestimates the potential to develop differentiated capabilities based on open infrastructures. Indeed, the real advantage comes from being well-

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positioned to take advantage of an open infrastructure when one emerges.

As emphasized earlier, no one company can create all the innovations needed to compete in information technology or any other industry. Science and technology are advancing fast and individuals and companies are using and deploying new knowledge in unanticipated ways. To harness this innovation you need an ecosystem that includes lots of partners and lots of people participating, developing designs and putting them together as customer solutions.

The ecosystem around open source software is huge. The ecosystem around biomedical research is huge. The ecosystem around agricultural biotechnology is huge. Open infrastructures and robust knowledge-creating communities are emerging in all of these spaces and more. These are growing and still largely untapped resources that could be harnessed more effectively to create commercial and social value. Indeed, the value that can be unlocked in these relationships will offer far more opportunities than any single company can seize.

As Jim Stallings, vice president of Standards and Intellectual Property for IBM says, “Our vision has always been to broaden the opportunity for lots of people and broaden the opportunity to solve problems...So the open source, open standards and proprietary IP—they all work together. It’s an innovation web of partners that come together to create something new, because some of the challenges for customers are really big and tough and no one company can solve it. Given some of the health care problems and some of the issues with hunger and food, it’s not going to get solved by a company, but by lots of companies that work together.”⁹⁸

Although open infrastructures do have system-wide benefits, it is not true that open infrastructures benefit all companies equally. Companies need unique capabilities to work in these environments and to leverage the benefits faster and more effectively than competitors: capabilities to develop relationships, sense important developments, add new value and turn nascent knowledge into compelling customer value propositions.

Furthermore, as some firms have found, opening up IP can boost demand for complementary offerings and provide new opportunities to create additional IP. Firms that engage with the open source community, for example, generate returns from increased services, support, and hardware sales, and this in turn opens up an opportunity to create more IP. As Stalling puts it, “First of all customers need reliable vendors. They need technology that’s original and solves problems. And customers are willing to pay vendors for reliable, advanced technology and solutions. That’s intellectual property. Customers recognize that companies that create this warrant some form of compensation or recognition. That’s what IP is; it’s value for an invention.”⁹⁹ In the life sciences community, Merck and members of the SNP Consortium are tapping into the wealth of knowledge emerging from biomedical research by being co-creators in this research, and while the basic research goes into the public domain, they strengthen their capabilities to generate even more valuable intellectual property in the form of new breakthrough drugs.

Relationship capital. Finally, as members of a community, scientists, programmers, engineers and other professionals are expected to share knowledge. Companies that are deeply enmeshed in

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these communities need to abide by the expectations inherent in them. Sharing helps build and sustain better relationships. Sharing does not mean giving away the crown jewels. It may mean sharing more foundational R&D discoveries that are of interest to a scientific community. Or, as is typical in the life sciences community, it may mean granting fair-use research exemptions and royalty-free licenses to deploy certain proprietary research tools.

At a minimum, sharing is the continued price of admission to the community from which the firm derives various benefits. Companies that demonstrate a willingness to share extensively may find that they encounter less friction on occasions when they want to appropriate private returns from knowledge generated in non-profit collaborations. In the Alliance for Cell Signaling, we found that pharmaceutical sponsors such as Lilly and Genentech will not gain proprietary access to the computational model of human cells that founder Al Gilman claims will be “an incredible drug discovery engine.” But they are working alongside the project’s researchers, obtaining inside knowledge and perhaps a lead time advantage in leveraging the tools that emerge. Gilman has promised that the team will work hard to help sponsoring companies interpret the data and realize value from it.

In addition, publishing research findings signals that one is technologically current, and a reputation for leading edge research helps attract talented employees, good partners and perhaps investment capital. Many scientists prefer to work for firms that encourage them to engage in research communities.

The basic lesson is that to reap you must sow. This is why IBM, Sun, Nokia and others are putting software patents in the public domain. Firms that share obtain a “license to operate” in creative and scientific communities—a form of permission to harvest some of the value created in collaboration with community members. By doing so, they ensure an ongoing steady and predictable flow of benefits. By the same token, a firm that misappropriates community IP may find itself shut out.

Collectively, these examples suggest a range of benefits from open innovation, some of which accrue to all comers and others that can boost the competitiveness of firms positioned to leverage them. Like the closed model, however, openness has its limitations.

Control. The nice thing about property rights is that they give you an inalienable asset: an exclusive right to market or license your creation. Once you have a patent, you are free to do what you like with it. You can donate it, practice it, license it, litigate it or use it as a bargaining chip. When you share property rights with hundreds or thousands of co-owners, you cannot easily do any of these without running into community-defined restrictions.

Engaging in collaborative communities means ceding some control, sharing responsibility, embracing transparency, managing conflict and accepting that successful projects will take on a life of their own. This can be awkward for companies accustomed to a command and control system. It means learning new skill sets that emphasize building trust, honoring commitments and sharing decision-making.¹⁰⁰

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Openness does not mean firms need to abandon control of their destiny. It does mean having well-developed and well-understood internal goals to guide external engagement strategies. If firms cannot realize these goals, they should not invest their resources. Open innovation is not a panacea but a complement to proprietary approaches.

Sustainability. Open innovation projects require regular care and feeding. Although the explosion of self-organizing activity looks impressive at the outset, few projects survive without ongoing funding and support and leadership that provides guidance and manages interactions. Companies need to invest in innovation communities the way they would invest in their own R&D operations.

Yet, the investment needed to sustain resources like these could be small compared to the benefits that companies receive. Better still, the costs could be spread across a group of companies that collectively stand to benefit.

Intellectual property diligence. Developing products and services with a distributed and largely anonymous community of contributors poses considerable legal risks. Any company building into its products technology or ideas not invented or authored by its employees needs to ensure it has the licenses to use that technology. If it does not, it risks infringement suits that could quickly derail its product.

Take the case of open source software development. Linux is built on thousands and thousands of independent contributions of code. How can one be sure these contributions are non-infringing without doing the proper diligence? How can users of the software protect themselves if no one can

offer indemnity? One flagrant abuse could stop the entire Linux enterprise in its tracks, at least temporarily. Yet the prospect of screening each independent contribution raises the equally troublesome prospect of inviting the lawyers to get in the middle of a fluid and self-organizing development process.

Notwithstanding the SCO lawsuit facing IBM and Microsoft's not-so-subtle rumblings that Linux software cannot be indemnified against IP litigation, open source software has been more successful than proprietary software at flying under the infringement radar. So far this is not surprising. Patent litigation is expensive. One million dollars in legal fees is the baseline for a lawsuit. As one IP lawyer recently explained, "the trick to being an IP infringement plaintiff is to issue threats rather than file suits, and to go after the choke points that will yield the biggest damages: developers and distributors. Going after individuals is too expensive. But most of the distributors in the open source space are not good targets for money damages."¹⁰¹

Nevertheless, the threat of liability can be too much for some customers to bear. Some organizations have said they will curtail their adoption of Linux until the legal uncertainties are resolved. Moreover, the dynamics that have thus far sheltered open source may change with bigger players entering the fray and considerably more revenue at stake in the near future. Worst-case scenario: the open source community is forced to re-engineer some products to invent around infringed patents. This, after all, is not that bad.

3.2 Key lessons and emerging IP management practices

The innovation models described above provide some foresight into an emerging IP discipline. But

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we are only at the beginning of a historic shift in the way firms create and manage intellectual property. Gone are the days of plan and push. Now firms need to focus on IP integration and orchestration—the shaping and reshaping of clusters of intellectual property to serve ever-changing customer needs.

The greatest payoffs will come from rapidly sensing and seizing opportunities to combine complementary IP assets. The most talented managers will discern the shape of play and then act on it. This ability to orchestrate complex webs of value creation will provide one of the few inimitable sources of competitive advantage. It is significant that these skills are tacit. Aside from poaching key individuals, imitation may well be impossible.

In this environment, recurrent reorganization around intellectual property will be the norm, not the exception. Mastering key IP strategy principles such as speed, freedom of action and collaboration will be integral to your success. It is too early to be defining best practices. But we can offer concluding thoughts and some practical guidance from the lighthouse practices uncovered in our research (see Figure 16).

Model your innovation ecosystem. Effective IP strategy starts with a comprehensive map of your innovation ecosystem that positions you in the web of value creation and assesses the interdependencies that will determine the flow of benefits and your ability to capture a significant share of them. This is not a traditional competitive landscape or value chain analysis but an “ecosystem analysis” of the participants creating knowledge pertinent to your existing and future business. While this includes business partners and competitors, it extends to academia, public research institutes, think tanks, creative communities, and contract research organizations. The map needs to be global and cover all of the relevant disciplines that intersect with your strategy.

This map will help resolve important questions. For example: Are there potential patent thickets or fences that could block our entry into key markets or increase our R&D costs? Where are our competitors innovating and how should we focus our R&D resources to increase freedom of action across our business lines? Are there potential partners we should be cross-licensing? Do we have access to the internal and external knowledge and resources we need to lead the path of incremental innovation? Are our employees plugged into the right knowledge-creating networks? Could we be investing in open infrastructures or academic partnerships to reduce our R&D costs and enhance our access to knowledge resources? Is the IP in our portfolio generating complementary licensing, sales, and manufacturing opportunities?

Balance your portfolio of IP. Remember: just as good personal investment strategies diversify assets across a range of low and high risk

Figure 16 Innovation ecosystem

	Definition	Physical world	Intangible world
Resource system	Resource systems generate a flow of benefits over time	Fishery	Corporate R&D team or network
Resource units	Resource units are the benefits that appropriators or users withdraw from the system	Fish	Inventions (e.g., semiconductor design)
Inputs	Resource units may be inputs for a product or process	Frozen fish dinner	Chips in PCs and iPods
Outputs	Resource units may also be end-product in themselves	Fresh fish at the local market	Licensable or saleable form of disembodied IP

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opportunities, good IP strategies diversify intellectual property holdings across a range of open and closed offerings.

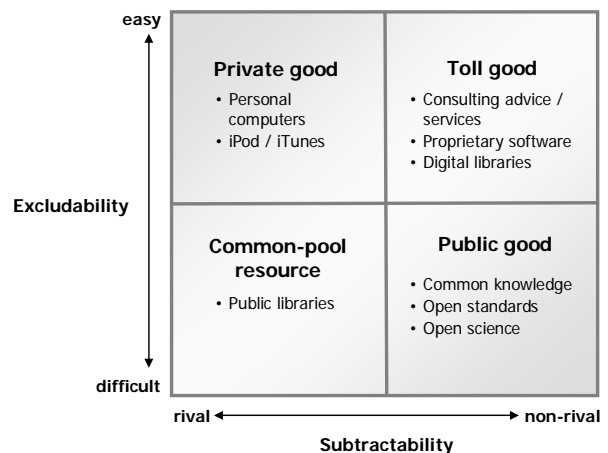
Open up your IP when:

- Opening up IP can boost demand for complementary offerings and provide new opportunities to create additional IP.
 - You need to lower barriers to entry or enlarge the pool of talent addressing a particular R&D problem.
 - The advantages of pooling competencies and reducing R&D costs exceed the benefits of having exclusive rights in the knowledge produced.
 - A shared infrastructure will encourage innovation and interoperability with ecosystem partners.
 - A latent pool of knowledge could be tapped with a modicum of organization.
 - Reciprocal sharing relationships will develop relationship capital with collaborators.
 - Pre-empting the property rights of competitors shifts the locus of competition or enhances your freedom of action.
 - Openness removes unnecessary friction in collaborative projects.
- Keep your IP closed when:
- Your end-products—and particularly your crown jewels—are at stake.
 - Proprietary IP gives you needed leverage in cross-licensing and trading relationships.

- IP rights are essential to stimulate and reward investment, particularly when investment in the next generation of technology would otherwise be underprovided.
- Your technology or IP alone provides the gold standard for your industry.

Consider the following taxonomy (Figure 17) where the economic properties of a good are defined by excludability (the ease or difficulty of excluding potential beneficiaries) and subtractability (whether one individual's consumption of the good diminishes the supply available to others).

Figure 17 Taxonomy of economic goods



Use this taxonomy for scenario planning by shifting different “families of IP” into different quadrants. What resources would be more valuable as public goods? Are resources treated as excludable when they actually are not? Conversely, are there public goods that could be harnessed more effectively if they were treated as proprietary goods?

Harness innovation marketplaces. Use licensing and cross-licensing opportunities to play to your core strengths. Concentrate R&D in those areas where you have the greatest competitive advantage in developing valuable innovations, and

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use cross-licensing to acquire the rest. In particular, emphasize the following four capabilities.

- *External sensing.* Hone your external sensing capability to identify new markets, new technologies, and emerging competitive threats. No one can know everything about a given opportunity or threat, but scenario planning and strong business intelligence can aid external sensing and “sensemaking.” Plug into Internet-enabled market-places such as Yet2.com, Pharamlicensing.com and Eureka Medical that ease the process of finding buyers and sellers of intellectual property. And remember that absorbing external technology or IP depends on the ability to relate what you learn to what you already know. Internal R&D and external acquisitions are complements, not substitutes.
- *Creative design.* Sensing opportunities leads to the need for creative design—conceiving the ultimate customer offerings and the technical/business architectures for delivering them. Creative design starts with the ability to make smart decisions about licensing (what/how) and openness/sharing (or not). Following some of the guidelines outlined above, carefully assess what IP you are putting on the table in exchange for IP you need to fulfill your grand designs.
- *Deal-making.* When speed is the essence of success, dexterous deal-making is exceedingly important. Place emphasis on structures and processes that support rapid and low-cost contracting. Cross-licensing can provide this flexibility on a bilateral level, but most of these agreements are highly customized. In today’s climate, agreement can take up to two years to

negotiate—not fast enough! Though none yet exist, standardized intellectual property agreements that can be executed more quickly would be a boon for IP-intensive industries.¹⁰²

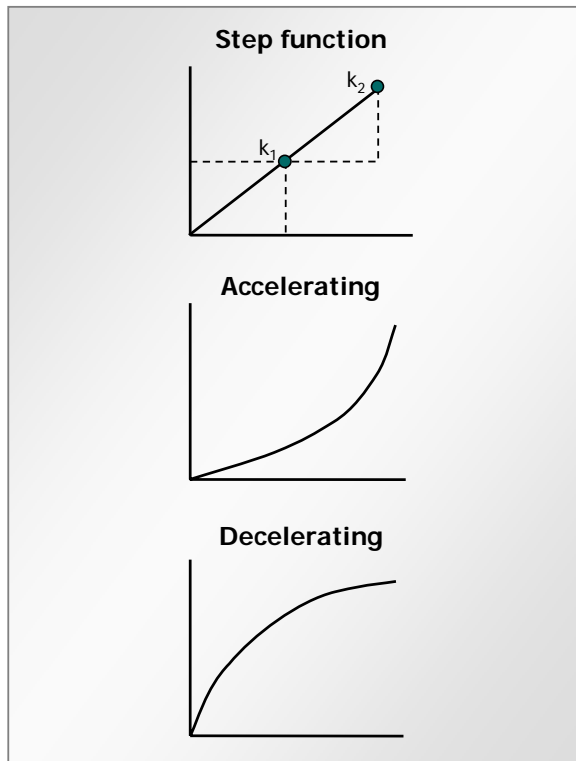
- *Agile orchestration.* Organizational agility allows firms to move strongly and rapidly into a latent market when new IP emerges. More than ever, this means leveraging both internal and external competencies through partnerships and alliances, many of which can be solidified by acquiring and trading IP. Firms that have these dynamic capabilities are most likely to be entrepreneurial, with flat hierarchies, clear vision, effective incentives and employee autonomy.

Support open infrastructures for collaborative innovation. Sustaining an open innovation ecosystem means cooperating to supply the open standards, shared IP and collaborative infrastructures that will kick-start the open innovation process. Cooperating means overcoming the problems of motivating and coordinating collective action. The secret to collective action is building critical mass. Behind just about any successful instance of collective action are a few highly interested and highly resourceful actors that contribute to a common resource. This critical mass may take different forms, including:

- Large, IP-rich firms with the incentive and resources to make contributions to the public domain (e.g., Merck’s Gene Index, IBM’s non-assertion pledge for 500 patents).
- Private entrepreneurs or intermediaries that provide collective goods in exchange for payments from potential beneficiaries (e.g., IP

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Figure 18 Production functions for public goods



intermediaries such as Yet2.com and CollabNet).

- Networks of well-connected individuals or firms that invest in startup costs and adopt ongoing administrative and maintenance responsibilities (e.g., Linus Torvalds, the Apache Foundation, Al Gilman of the AFCS).

These actors provide the social capital and technical infrastructure that other participants build on. To extract long-term benefits from shared resources, you need to identify or help create this critical mass.

Keep in mind that collective action problems come in different shapes and sizes:

- *Step-functions.* Standards alliances and patent pools, for example, are “step goods” and require a minimal number of participants. For a

standard to take off you need at least a majority of users and producers to adhere to the standard. A patent pool needs the vast majority of firms holding essential patents to join the collective licensing organization. In such cases, collective action is about convincing contributors that the group objective is important enough to warrant their participation.

- *Accelerating production functions.* Many collaborative projects with large fixed or set-up costs have what economists call accelerating production functions: the first contributions make only a small difference, but each contribution increases the probability of success, which encourages subsequent contributions. Getting the ball rolling requires a critical mass that will invest in a foundation or infrastructure for collaboration. Once this infrastructure is established, other participants can be coaxed in to make contributions. The closer the project gets to completion, the larger the payoffs from making additional contributions and a snowballing effect will see the project to completion.
- *Decelerating production functions.* Watch out for decelerating production functions, in which initial contributions make the biggest difference, but each additional contribution makes a smaller marginal impact. Startup costs for an information commons, for example, are negligible—potential beneficiaries need invest little to provide a simple infrastructure for sharing knowledge. Initial contributions in an area where public knowledge is scarce will have a significant impact, but contributions made much later when knowledge is abundant will be less valuable. As contributions begin to add less

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value, participation may tail off. Projects that require continuous, long-term provision may have a hard time sustaining contributions.

Situations like these can give rise to strategic gaming: those that value the good highly are more likely to contribute first and make the most significant contributions, while more opportunistic and less interested members will free ride. Big Pharma faced a situation like this when the industry was threatened by a proliferation of patents on upstream research. All clearly stood to benefit from a publicly accessible pool of biomedical knowledge. Yet gene patents accumulated for a decade before Merck stepped in with its Gene Index, investing millions of its own R&D dollars while competitors reaped the benefits. Perhaps it is telling that the next major project of its kind, the SNP Consortium, did not go forward until it had much wider participation.

All collective action problems have solutions. But you must understand the dynamics of the knowledge communities and collective goods that you are investing in and apply this knowledge in your strategic planning.

Work with partners to design ecosystem governance. Innovation ecosystems require rules that govern contributor's interactions. Property regimes are not the only relevant element of governance, but they are central. They provide a framework for interaction by clearly defining group boundaries, delineating acceptable behavior and mediating between self-interest and collective interests. They shape the management and coordination of people, resources and activities, and define rights over the outputs of the value creation process.

Figure 19 Property rights regimes

Legal regime	Definition	Examples	Cost/benefit
Private property	Property rights are assigned to private individuals or firms	<ul style="list-style-type: none"> • Patents • Copyright • Trade secrets • Trademarks 	Benefits: high-powered incentives; potential to harness markets; extensive system for enforcement Costs: potential for over-fragmentation of rights; potential deadweight costs from monopoly
Common property	Shared property rights are managed by a clearly defined group of individuals or firms	<ul style="list-style-type: none"> • General public licenses • Codes of conduct • Norms 	Benefits: flexible; adapted to local needs; free-riders and predators can be excluded Costs: participants bear the cost of rulemaking and enforcement; legal uncertainty
Public property	Property rights are held/ allocated by a government authority	<ul style="list-style-type: none"> • State property • Compulsory licenses 	Benefits: reduced private transaction costs; potential economies of scale Costs: less flexible, dynamic; reduced incentives; rent-seeking
Open access	Nobody has the right to exclude anyone from using or appropriating a resource	<ul style="list-style-type: none"> • Public domain • Unregulated commons 	Benefits: broad access; no monitoring and enforcement costs Costs: little incentive for private investment

- *Balance public and private activities.* The life sciences industry study shows that a healthy innovation ecosystem needs a mix of public and private activities. This means respecting boundaries on both sides. As a for-profit partner, you will need to respect the need to maintain a foundation of the knowledge in the public domain, especially when non-profit participants have been important contributors. Equally, non-profit participants will need to respect the need for commercial partners to monetize some of the intellectual property in order to justify their continued investment.
- *Adopt “common-property” regimes.* New legal institutions like the Creative Commons and the growing number of open source licensing regimes provide an opportunity for innovation in the way that intellectual property rights are managed in collaborative environments. Adopt a more granular and strategic approach to allocating property rights in collaborative innovation to manage tensions that arise in co-creation and co-appropriation environments. In particular, be creative in the way you assign

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property rights to various value contributors by thinking about five levels of rights:

1. **Access:** the right to enjoy non-subtractive and non-commercial benefits
2. **Appropriation:** the right to appropriate private returns
3. **Management:** the right to regulate use patterns and transform the resource system by making improvements or codes of conduct
4. **Exclusion:** the right to determine who will have access and appropriation rights and how those rights may be transferred
5. **Alienation:** the right to sell or license access, appropriation, management and exclusion rights

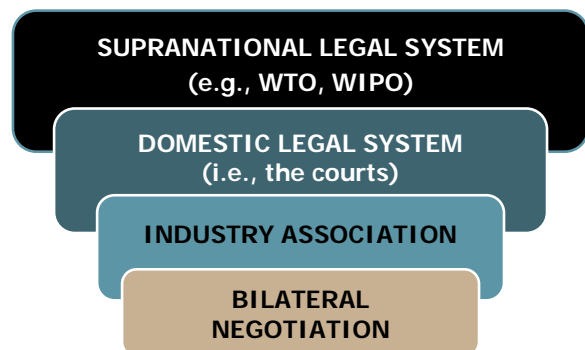
Use this more granular approach to ensure that all contributors in your innovation ecosystem can obtain some benefits. In an industry-university partnership like the SNP Consortium, for example, give academic contributors access and management rights, while reserving appropriation, exclusion and alienation rights for yourself and other for-profit funding partners.

- *Create independent governance bodies.* Where no foundation of rules exists, you can expend a great deal of energy trying to design and enforce effective intellectual property rules. Create independent entities, like standards or steering bodies, to shift some of the burden of governance to a small but representative group of participants. Groups like the Open Mobile Alliance and the Open Source Development Labs are taking up this task on a sector-based level. An independent governance body frees

up resources so that collaborators can focus on value creation.

- *Build in multiple levels of governance.* Lower the costs of resolving disputes over intellectual property by creating a nested governance arrangement that allows participants in collaborative innovation to apply graduated sanctions. Where possible, industry or community-level solutions are often the best place to seek redress since they are most likely to be familiar with community norms and local conditions. Obtaining more secure legal status for common-property regimes such as the Creative Commons or open source licensing regimes is an important part of this equation. But it is not always realistic—given the high stakes surrounding IP disputes—to assume that community members can mete out effective enforcement. Disputes will sometimes need to be elevated to domestic courts and perhaps, in our global economy, even international institutions.

Figure 20 Multiple levels of governance



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4.0 Conclusion

The new, networked world of IP is complex and uncertain. There are tough challenges, such as preserving the public foundation and stimulating private investment. Leaders will need new capabilities to orchestrate and integrate intricate webs of IP creation. And there will be hard choices between putting IP out in the public domain and keeping it close to your chest.

We must manage this delicate balance. From IP marketplaces to open standards to innovation webs and an industry-wide information commons, leading firms and organizations will pioneer models that blend open and closed innovation strategies and public and private intellectual property regimes. Open Networked Enterprises that adopt these strategies can leverage value from their IP while also ensuring robust technological progress and a sustainable supply of innovation.

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Endnotes

¹ Thanks to Joel Cawley of IBM for this idea.

² Council on Competitiveness. “Innovate America: Thriving in a world of challenge and change.” *National Innovation Initiative, Interim Report*, July 23, 2004.

³ Ibid.

⁴ The stakes are very high indeed. More economic activity is dedicated to knowledge production; more of the market value of firms is linked to intangibles like intellectual property; and more of the competitive levers available to firms are linked to innovation and time to market. In the U.S., approximately 40% of R&D is performed in the knowledge-intensive service sector alone. Knowledge-intensive industries account for roughly 70% of GDP in OECD countries. Intangible assets like intellectual property are estimated to account for between 50% and 75% of the market value of all publicly traded firms.

⁵ Today, the requisite knowledge and skills to compete in the IT industry are abundant. Thousands of specialized firms have emerged to supply competitively priced components ranging from integrated circuits to software solutions that were previously supplied by vertically-integrated firms. This is a stark change from the early days when only a small handful of dominant firms had capabilities to develop proprietary mainframe computing platforms for large enterprises and government clients.

⁶ Interviewee requested anonymity. Interview conducted November 8, 2004.

⁷ Interview with Peter Detkin November 10, 2004.

⁸ Informa Research Services.

⁹ Vivek Kapur, John Peters and Saul Berman, “High-tech 2005: The horizontal, hyper-competitive future,” *Strategy & Leadership*, Vol. 31, No. 2, 2003, pp. 34-47.

¹⁰ Eric Krell, “Patently Correct IP Risk Management,” *Business Finance*, January 2002. Krell also notes that in recent years IBM has consistently received over \$1 billion annually in licensing fees for its patent portfolio. Texas Instruments has reportedly received over \$3 billion in cumulative patent royalties since the 1980s, and cash flow from royalties was able to help the company weather financial troubles.

¹¹ This industry includes legal firms obviously, but also a growing number of cross-disciplinary firms that help companies map their patent portfolios, understand the patent landscape, identify licensing opportunities, spin off new companies, carry out negotiations, monitor infringement, launch suits, and a number of other intellectual property transactions.

¹² Conventional economic thinking about intellectual property is based on the notion that knowledge is a public good in that it is easy and inexpensive to teach and learn compared with the

cost of invention and discovery in the first place. This premise may reasonably apply to easily codified generic scientific or technical knowledge. It is much less applicable to the techniques and processes required to operationalize this knowledge in a competitive context. After all, even a license to exploit patented knowledge is not a transfer of the innovator’s know-how—it’s merely a blueprint. And just as tomorrow’s technology often grows out of experience creating and working with today’s, a competitive advantage gained by a firm in one particular nook of today’s technology is likely to lead to an advantage tomorrow in the same or adjacent nooks.

¹³ Large firms have historically invested substantial resources in basic science in industries where the underlying sciences are advancing rapidly. In part, this was due to the culture of R&D departments heavily staffed with PhD graduates accustomed to an academic research environment. In part, it was strategic: firms needed to understand the underlying science to recognize and quickly exploit a commercial opportunity. Some of this basic research yielded large dividends for society and their stockholders: think of DuPont’s investments in basic chemistry that led to the invention of synthetic rubber, or the invention of the transistor in AT&T’s Bell Labs. But much of it did not translate into immediate opportunities to market new products and services. Lack of a clear ROI led to a dramatic scaling back of basic science in corporate R&D departments beginning in the late 1980s and early 1990s.

¹⁴ James Boyle, “The Second Enclosure Movement,” *Law and Contemporary Problems*, Vol. 66, Winter/Spring 2003.

¹⁵ Some of these patents reach far upstream into the domain of fundamental science—a space traditionally unencumbered by property rights. This has raised concerns over impeded access to research with consequences for progress in basic science (see life sciences industry study).

¹⁶ David Mock, “The Low Down on Patent Shakedowns,” *The Motley Fool*, April 26, 2005.

¹⁷ The basic scenario is that a patent applicant allows its application to languish in the PTO while watching another company make substantial investments in a technology or product that will infringe the yet-to-be-issued patent. Once the other company’s sunk costs are large, the patent applicant obtains the patent, asserts infringement, and “holds up” the other company, demanding supracompetitive royalties for a license to the submarine patent. This problem of submarine patents is particularly controversial in the context of standard-setting, in which case the submarine patent is used to hold up *all* firms embracing a particular standard.

¹⁸ F. R. Lichtenberg, “The impact of new drug launches on longevity: evidence from longitudinal, disease level data from 52 countries, 1982-2001,” NBER Working Paper No. 9754, 2003.

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¹⁹ FDA CDER Web site <<http://www.fda.gov/cder/rdmt/pstable.htm>>.

²⁰ EFPIA, "The Pharmaceutical Industry in Figures, 2003 Update."

²¹ Ibid.

²² PhRMA (Pharmaceutical Research and Manufacturers of America) estimates the average cost of bringing a new drug to market is approximately \$800 million.

²³ Quoted in "MIT launches center for biomedical innovation," *i-NewsWire*, April 29, 2005.

²⁴ The following simplified overview of the pharmaceutical industry draws on a much more thorough treatment in I. Cockburn, R. Henderson, L. Orsenigo, and G. Pisano, "Pharmaceuticals and Biotechnology," Chapter in D. Mowery (ed.) *U.S. Industry in 2000: Studies in Competitive Performance* (Washington: National Research Council, 1999) pp. 363-398.

²⁵ Interview with Greg Glover, January 4, 2005.

²⁶ Mertonian values are named after Robert Merton, a sociologist of science now famous for identifying the key norms underlying public science. Those values included communalism (results are the common property of the community), universality (all can participate regardless of nationality, culture differences, etc.), disinterestedness (scientists should present results as if they had no personal interest in their acceptance), originality (research claims must be novel), and skepticism (all claims should be subject to critical scrutiny).

²⁷ Interview with Michael Kirschner, March 25, 2005..

²⁸ Interview with Ross Oehler, April 1, 2005.

²⁹ Early in the gene patent "goldrush" the U.S. Patent Office was flooded with what some observers described as ultimately fruitless applications on ESTs (expressed gene sequences), straining its resources and likely lowering the quality of examination. Anecdotal reports suggest that some genomics companies had "more than 60,000" applications pending. Given the very long pendency period for complex molecular biology patents, many of these may still be "in the pipeline."

³⁰ Rising costs and pressures to patent cut against the traditional norms of open science and provide incentives for academic scientists to be much more guarded in sharing their research results—particularly where lucrative licensing opportunities are at stake. In many cases, contractual obligations to corporate research sponsors place embargoes on publishing and require universities to grant exclusive licenses.

³¹ One pharmaceutical executive noted that when a non-exclusive license to a "must have" technology averages between 1-4% of net sales and an exclusive license averages between 6-10%, royalties can easily stack up to 20% of net sales. On the other hand, Robert Blackburn, former Chief

Patent Counsel, Chiron Corp, notes that, "All parties in a negotiation tend to be fairly sensitive about the royalty stacking issue. If the licensor in that instance is about to propose a royalty that's going to kill the product they're not going to make any money. And most of the players in this field are sophisticated enough to understand that." Interview with Robert Blackburn, March 25, 2005..

³² Interview with Michael Kirschner, March 25, 2005.

³³ These concerns have also been eased by strengthened examination criteria requiring applicants to demonstrate "specific, substantial, and credible" utility and legal decisions that have narrowed the scope of patent claims on genetic sequences by establishing fairly stringent standards for disclosure and enablement in biotechnology patents.

³⁴ Interview with Dr. Alan Williamson, March 8, 2005.

³⁵ Members of the Consortium include APBiotech, AstraZeneca, Aventis, Bayer, Bristol-Myers Squibb, Hoffmann-La Roche, GlaxoSmithKline, Wellcome Trust, IBM, Motorola, Novartis, Pfizer, and Searle.

³⁶ Interview with Dr. Francis Collins, March 10, 2005.

³⁷ Interview with Dr. Alan Williamson, March 8, 2005.

³⁸ The project is a partnership of scientists and funding agencies from Canada, China, Japan, Nigeria, the U.K. and the U.S. that aims to map the patterns of common SNP variation across the globe by identifying combinations of SNPs that are inherited together, known as haplotypes.

³⁹ IMS Health, "Genetic Database Could Revolutionise Disease Treatment," <http://www.ims-global.com/insight/news_story/news_story_990925a.htm>.

⁴⁰ Interview with Dr. Alan Williamson, March 8, 2005.

⁴¹ Interview with Allen D. Roses, March 22, 2005.

⁴² This approach contrasts with that taken by Human Genome Sciences (another early entrant into the database business), which opted for a large upfront payment by offering a three-year exclusive license to SmithKline Beecham.

⁴³ Interview with Lee Bendekgey, March 26, 2005.

⁴⁴ Ibid.

⁴⁵ Roughly speaking, the "whole-genome shotgun strategy" randomly breaks DNA into segments of various sizes and uses a genome assembly program to thread contiguous pieces together by looking for "bridging links" where DNA sequences in one contiguous fragment can be matched to DNA sequences in another contiguous fragment.

⁴⁶ The Celera Discovery System offered regularly updated and curated mouse and human genome data from proprietary and public sources, along with analysis tools and super-computing power. At the time of launch, pharmaceutical companies could buy a license for \$850/user/month. Academics were granted

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discounted licenses for \$175/user/month. Incyte was likewise hocking its own proprietary research platform.

⁴⁷ The 2002 Annual Report for Appera, Celera's parent company, reveals that Celera generated merely \$72M in gross revenue from its discovery system in 2002. It has since shifted all sales and service responsibilities for the platform to its sister company, Applied BioSciences. Incyte sold its BioKnowledge Retriever platform to BIOBase, a German firm specializing in commercial biological databases.

⁴⁸ Share price last checked on April 21, 2005.

⁴⁹ Market cap last checked on April 21, 2005. See Incyte's investor site <<http://investor.incyte.com/phoenix.zhtml?c=69764&p=irol-fundTradingStatistics>>.

⁵⁰ Interview with Lee Bendekgey, March 26, 2005.

⁵¹ Ibid.

⁵² Robert Blackburn observes that, "You tend to see the reach-throughs in more unique tool technology, you don't see it in, say, fungible research tools...including a number of different array technologies, high-throughput screening machinery and other equipment which are fungible today."

⁵³ Richard Nelson, "The Simple Economics of Basic Research," *Journal of Political Economy*, Vol. 67, 1959, pp.297-306.

⁵⁴ BLAST, the Basic Local Alignment Search Tool, is a widely used algorithm and software implementation for searching for matches or homologies in sequence information, developed at the National Center for Biotechnology Information.

⁵⁵ See the National Center for Biotechnology Information's BLAST site <<http://www.ncbi.nlm.nih.gov/BLAST/>>.

⁵⁶ Interview with Lee Bendekgey, March 26, 2005.

⁵⁷ Interview with Barbara Caulfield, March 21, 2005.

⁵⁸ Ibid.

⁵⁹ Ibid.

⁶⁰ Ibid.

⁶¹ Ibid.

⁶² Karl Thiel, "Affymetrix raking in the chips," *The Motley Fool*, January 28, 2005.

⁶³ Yochai Benkler, "*Coase's Penguin, or, Linux and the Nature of the Firm*," *Yale Law Journal*, Vol. 112, Winter 2002-03.

⁶⁴ Interview with Al Gilman and Alex Brown, March 21, 2005.

⁶⁵ Ibid.

⁶⁶ Ibid.

⁶⁷ Ibid.

⁶⁸ See <<http://www.signaling-gateway.org/data/Data.html>> (AFCS data center, hosted by AFCS and Nature).

⁶⁹ See <<http://www.signaling-gateway.org/reports/ReportCover.html>>.

⁷⁰ Interview with Al Gilman and Alex Brown, March 21, 2005.

⁷¹ Ibid.

⁷² Ibid.

⁷³ Ibid.

⁷⁴ When Celera announced its ambitious sequencing schedule, the U.K.-based Wellcome Trust doubled its support for the HGP to \$330 million, taking on responsibility for one-third of the sequencing. The NIH and DOE in the U.S. also threw their projects into overdrive, setting a new goal of creating a "working draft" of the human genome by the spring of 2000.

⁷⁵ Interview with Robert Blackburn, March 25, 2005.

⁷⁶ Ibid.

⁷⁷ Ibid.

⁷⁸ Source: National Institute for Health.

⁷⁹ NSF figures are available online at <<http://www.nsf.gov/statistics/seind04/c5/c5s1.htm#p3>>.

⁸⁰ Merck's estimate, reported on its Web site <<http://www.merck.com>>.

⁸¹ Interview with David Earp, March 17, 2005.

⁸² Ibid.

⁸³ Interview with Lee Bendekgey, March 26, 2005.

⁸⁴ For a discussion of the factors that drive research productivity in the pharmaceutical industry, see Rebecca Henderson and Iain Cockburn, "Scale, Scope, and Spillovers: Determinants of Research Productivity in the Pharmaceutical Industry," *RAND Journal of Economics*, Spring 1996, 27(1), pp. 32-59.

⁸⁵ In many ways, these costs and benefits mirror those faced by industries that routinely make choices between adopting open or proprietary interoperability standards. Where would the Internet be if Tim Berners-Lee had patented TCP/IP and sought royalties from everyone practicing the standard?

⁸⁶ Interview with David Beier, April 11, 2005.

⁸⁷ Quoted in an interview with the Guardian's Neil McIntosh, June 17, 2004 <http://blogs.guardian.co.uk/online/archives/digital_music/2004/06/more_on_steve_jobs.html>.

⁸⁸ This is a generalization. For example, a licensor may withhold patents that are strategically important in a field-of-use. In the recent Sony/Samsung cross-licensing agreement, for example, critical technologies such as Sony's PlayStation technology architecture and Samsung's liquid crystal displays were omitted from the deal.

⁸⁹ Thus far in 2005, high profile deals have been struck between Intel and Nvidia over chipset technologies for servers,

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mobile phones, and graphics cards; NEC and FlipChip over semiconductor manufacturing techniques; Microsoft and InterTrust over digital rights management technologies; Samsung and Sony over a combined portfolio of roughly 24,000 electronics patents; GlaxoSmithKline and Merck over the human papillomavirus (“HPV”) vaccine; and HP and EMC over data storage technologies. The list could go on.

⁹⁰ Balancing payments will typically reflect consideration such as the likely value of the patent infringement that will take place over a period of time, the expected R&D spending of each firm, the number of patents held by each party, and the determination of value of a limited number of highly pertinent patents (sometimes as little as between 5 and 15 patents). According to Dan McCurdy, CEO of Thinkfire and former president of Lucent’s licensing business, “The process [of negotiating balancing payments] takes one-and-a-half to two years on average where you have given them some patents to look at. The next meeting they give you some patents to look at... You say in the end, ‘Look we think that at “X” royalty rate you owe us \$40 million a year.’ They’ll say, ‘Well, at an equivalent rate on our patents, your products are worth \$30 million a year.’ You have a \$10 million differential and you settle for something less than that and try to get a settlement without having to sue each other.”

⁹¹ Similar examples abound in industries that rely heavily on the applied sciences such as semiconductors, software, and telecommunications. Semiconductor Research Corporation was founded in 1982 to help fight the threat from Japanese semiconductor manufacturers. More recently, CableLabs, a non-profit industry R&D consortium began working to establish a cable transmission standard analogous to the Internet protocol; its members include AOL Time Warner, AT&T Broadband, and Comcast. Even companies in extractive industries reportedly work on industry-wide problems like inadequate procedures for testing raw materials, the solution to which might give little durable competitive advantage to a particular firm, but would significantly benefit the industry as a whole.

⁹² One reason to publish rather than patent is that maintaining large patent portfolios is costly. Average filing and maintenance costs over the lifetime of a single patent add up to between \$200,000 and \$500,000. Experienced firms recoup these costs through licensing and legal assertion. Publishing nevertheless alleviates some of the cost of growing and maintaining a patent portfolio across an increasing number of national markets.

⁹³ When Lego Mindstorms made their debut in 1998 after a lengthy product development cycle, Lego marketing officials were surprised to discover that the robotic toys were popular not only with teenagers but with adult hobbyists eager to improve on them. Within three weeks of their release, user groups had sprung up and tinkerers had reverse engineered and

reprogrammed the sensors, motors, and controller devices at the heart of the Mindstorms robotic system—and sent their suggestions to Lego. The company, at first uncertain how to respond, ultimately incorporated user ideas.

⁹⁴ When patent pools take shape, they collect a host of beneficial transactions under one roof. They result in reduced haggling over the valuation of property rights, given the need for repeat dealings. Firms that join patent pools may enjoy the benefits of centralizing administrative and reducing litigation costs. There is the advantage of the potential for expert tailoring and flexibility in rule design and implementation as circumstances change. And, since industry participants often succeed in managing the process without outside intervention, there is the benefit of reduced political economy costs of rent-seeking which may arise under a legislative solution.

⁹⁵ Douglas McIntyre, head of On2 Technologies, quoted in “Goodbye to the video store,” *The Economist*, September 19, 2002.

⁹⁶ Among practitioners, the consensus is that open standards obey the following principles. Availability: standards are available for all to read and implement. Maximize end-user choice: standards do not lock the customer in to a particular vendor or group. No royalties: standards are free for all to implement, with no royalty or fee. No discrimination: standards do not favor one vendor over another. Extensions and subsets: standards may be extended or offered in subset form as long as interoperability is preserved. No predatory practices: license terms must protect against subversion of the standard by embrace-and-extend tactics.

⁹⁷ Gordon Bennet, “Build Systems, Not Companies, On Open Standards,” Intranet Journal, February 20, 2002.

⁹⁸ Quoted in Nandini Lakshman, “Microsoft is reacting to the market,” *Business Standard*, May 4, 2005.

⁹⁹ Ibid.

¹⁰⁰ See New Paradigm’s study of self-organization for an in-depth treatment of these issues.

¹⁰¹ Heather Meeker, “Open Source: Chicken Little and Age-Appropriate Explanations,” *TechNewsWorld*, May 4, 2005.

¹⁰² Standardized agreements would entail some loss in flexibility and dynamic pricing of IP, but the gains in speed and efficiency could be worth it in many circumstances. Patent pools and open standards provide additional solutions but can also entail extensive haggling and less flexibility for participants.

The Rise of the Open Networked Enterprise

Strategy Domain	Closed Corporation	Open Networked Enterprise
1. World View	National Engine – US, Japan, Europe Protectionist	Global Engine – China, India, Emergent Free Trade
2. Corporate Boundaries	Vertically-integrated Non-porous Content M&A	Focused on Core Business Web Context, Agency + Fasttrack Business Models
3. Value Innovation	Closed Innovation Do It Yourself	+ Open Innovation + Co-Creation
4. Intellectual Property	Proprietary Protected	+ Open + Shared
5. Modus Operandi	Plan and Push Hierarchical Power over ... Lumbering	Engage and Collaborate Self-organizing Power through ... Agile
6. Business Processes	Internal (Enterprise Integration) Complex Hardwired	External (Inter-enterprise Integration) Modular Reconfigurable
7. Knowledge and Human Capital	Traditional Demographics Containerized Knowledge Internal	+ Global N-Generation Collaboration + Across the B-web
8. Information Liquidity	Opaque Asynchronous Processing Traditional BI	+ Transparent Real Time Networked Intelligence
9. Relationships	Transactions Product/Services	+ Relationship Capital + Experiences
10. Technology	Proprietary Monolithic Silos Enterprise Dumb Networks	+ Standards-based Service-oriented Interoperable + Inter-enterprise Intelligent Networks

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