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Business-Model Innovation: General Purpose Technologies and their Implications for Industry Structure

Alfonso Gambardella and Anita M. McGahan

This article describes a business model that is growing in prevalence and that carries novel implications: the development of general-purpose technologies for licensing to downstream specialists. In their archetypical format, these general-purpose technologies are constructed in ways that can be employed by different potential downstream licensees, and can accommodate their different strategies. This strengthens the hand of innovative firms in the rising markets for knowledge-based assets, and can be expected to improve their ability to capture a greater share of the value their technology creates. The innovation of business model designed for licensing such technologies will have unpredictable, but inevitable, consequences for industry structure and organizational capabilities, as well as for the content and context for the upstream science.

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Introduction

All firms have business models, but legendary firms that shape their industry structures — those such as Google and Apple Computer — are business-model innovators that organize themselves and their interactions with customers and suppliers in unprecedented ways. These

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firms have inspired others both to direct imitation and to further innovation efforts on their own account.

A business model is an organization's approach to generating revenue at a reasonable cost, and incorporates assumptions about how it will both create and capture value.[1] Teece identifies a business model as reflecting '*management's hypothesis about what customers want, how they want it, and how an enterprise can best meet those needs, and get paid for doing so*'.[2] Whenever a business model generates profit, it is because the firm has developed activities and accumulated resources that drive a wedge between operating costs and revenues by making the firm more efficient than rivals (thus lowering total costs) and/or more effective than rivals at raising revenues either through higher prices or greater volumes. The asset or resource base and activity profile of the firm is integrally tied to its business model, and the success of a business model in generating profit – at driving the wedge between costs and revenues – depends on the accumulation within the organization of strategically important resources. In today's economy these are increasingly grounded in intangibles such as scientific knowledge and intellectual property. The essence of a firm's strategy is its business system (or activity set) for controlling these resources and adapting them over time to ensure their continuing relevance to the firm's customers (i.e., the constituents that generate revenues) and suppliers (i.e., those that generate costs).[3]

In this conceptualization, business-model innovation occurs when a firm adopts a novel approach to commercializing its underlying assets. One arena in which many firms with important knowledge assets are currently innovating is in the rising 'markets for technology',[4] where firms sell rights to their intellectual property rather than themselves directly commercializing products and services based on their knowledge capital. While markets for technology have grown in recent years,[5] companies electing to license their technologies confront a number of thorny issues – e.g., how to convince potential licensees to buy a technology that the supplier is not themselves using; and how to enforce their patents or otherwise gain sufficient compensation from the licensee. Markets for technology are evolving quickly, through a phase of intensive experimentation, to address these questions:[6] their resolution – and the potential for their further growth into adjacent markets and industries – is at the centre of a major set of entrepreneurial and industrial opportunities.

general-purpose technologies [are] a novel alternative to applied, specialized, commercially mature technologies, [featuring] business-model innovation and the evolution of technology markets

This article focuses on one issue arising among this broad set of opportunities: the development of general-purpose technologies as a novel alternative to applied, specialized, commercially mature technologies.[7] This approach has all the features of business-model innovation, but it also suggests an important trajectory in the evolution of technology markets that may ultimately facilitate further entrepreneurship involving general-purpose approaches in a wider range of application industries.

Business-model innovation and technology licensing

Historically, licensing technology has tended to occur across national boundaries and reflected the geographic limits of the licensing firm's market reach.[8] Companies issued licenses in foreign countries because they had no concrete *a priori* intention of entering them directly, finding it more profitable to extract rents from licensees with local downstream advantages than to enter such (often geographically remote) markets directly.

But the technology licensing wave of the 1980s and 1990s took on a different character than this 'norm', with firms selling property rights over their ideas to other companies operating in the same geographic markets and industries. This new approach to licensing was particularly salient in the United States, and many of these new types of licenses were offered by small technology specialist suppliers (in, e.g., biotech, semiconductors, nanotechnology and several other high-tech industries) to much bigger operating companies that controlled the downstream assets needed for their large-scale production and commercialization. For example, many small applications software start-ups developed specialized programs in the hope that they would become 'killer' applications, but ultimately, instead of commercializing them directly, licensed their programs to established companies with far greater experience in interface design, retail distribution, after-sales servicing, reputational capital and marketing. Once the precedent of a market for this type of licensing had been established, many other software companies entered business with the express intention of selling 'half-polished' applications at intermediate development stages, rather than of entering the applications-software industry directly as fully integrated entities.

One general consequence of the rise in these intermediate technology markets has been an increase in downstream product-market competition: applications-software companies, for example, compete more vigorously than ever. The phenomenon is a special case of the mechanism described by Dierickx and Cool, where the existence of markets for intellectual-property assets *per se* reduces the competitive advantages of firms that rely on them.[9] Downstream enterprise software firms that rely heavily on independent software vendors for promising application modules no longer base their advantages on their own direct R&D efforts - rather, their competitive advantages now accrue from their capabilities in commercializing, marketing, installing and selling integrated applications. When a factor market exists where technology can be bought and sold – not without friction, but at lower cost than having to develop it in house – purchasing firms can no longer rely on having unique technologies with which to beat the competition. The market makes such technologies available to more firms – and even if only one company obtains a license, the competition to obtain it in the first place disseminates knowledge about the technology. (It also bids up its price to reflect its value to the winning firm, thus ensuring greater returns to the innovators.). Downstream competitors then have to seek other sources of competitive advantage, or more generally, to devise ways of creating value that they can appropriate uniquely. The mechanisms they devise must account for the diffusion of technology across other firms through the market, either because the upstream innovator makes the technology widely available, or because the licensing process disseminates technical information. Thus the market for intellectual property now involves a wider range of firms in the innovation, regardless of whether they are direct licensees.

The development of markets for technology (such as the licensing of applications-software modules or chunks of code by independent software vendors) may therefore prompt additional business-model innovation in complementary markets. The history of several sectors is marked by upstream specialist companies that have focused on developing narrow technologies for well-defined applications. A classical example is the small biotechnology concern conducting research on a specific drug compound. In the 1980s, the ultimate goal of the prototypical biotech entrepreneur was to become a full-fledged drug manufacturer, but, for many firms, this ambition was obstructed by several sets of problems. Becoming a fully integrated pharmaceutical manufacturer required commercializable science as well as the capacity for considerable downstream development: many small biotech companies lacked the skills, resources and financial capacity to acquire the required complementary assets and, as a result, accepted the revised goal of selling their drug compounds to - or in some cases, arranging profit-sharing alliances with - larger drug firms.

Yet even this revised approach had a major drawback. Because almost all biotechnology molecules were dedicated to specific applications, each could be sold to only limited numbers of downstream firms with co-specialized assets, which limited the profitability of the biotech innovator in two ways. First, the rents to the innovating firm were constrained by the success of the downstream manufacturer as a competitor in its own therapeutic category. Second, few of these biotech entrepreneurs – who were generally small, inexperienced and specialized - had sufficient bargaining power in negotiations with the downstream manufacturer. The combined effect of these two factors often left such technology specialists – vulnerable in negotiations.

The move towards technologies of general applicability

As a result of this vulnerability, many technology-based firms have engaged in business-model innovation by pursuing strategies in which they invest in *technologies with more general applicability*. Especially in the 1990s, biotech companies such as Affymetrix, ECI Biotech and others no longer sold specific compounds for commercialization, but instead licensed research tools such as bioinformatics devices, screening technologies, simulators for testing drugs, and 'laboratories-on-a-chip', tools which were useful for a range of drug applications. For example, Affymetrix's Gene Chip could be reprogrammed to test different types of compounds or proteins for various diseases or targets.

The twist – the lever in negotiations – for the innovating entrepreneur comes from supplying applications to numerous ultimate customers.

The goal of this business-model innovation is to avoid the problems of only being able to license to specialists by exploiting applications that may be commercially viable across a range of markets. The twist – the lever in negotiations - that arises for the innovating biotech entrepreneur comes from being able to supply applications that satisfy the requirements of perhaps numerous ultimate customers. When an innovator delivers a general-purpose technology to multiple downstream markets, it is no longer as vulnerable in one-on-one negotiations with potential downstream manufacturers as it would be in a narrow sub-segment While the bargaining power of the licensee may continue to squeeze the innovator's profits somewhat for each application, the innovating firms can increase their overall profits by expanding the number of applications to which their technology can be applied. The generality of their technology may also mean that the innovator is less constrained to be oriented toward a single, co-specialized licensee as a potential downstream partner, and therefore less dependent on the success of any specific partner. At the same time, the downstream licensee is compelled to complete development for its own commercial purposes by adapting the general technology into an application that is specifically relevant to its customer set, thus incurring development costs that might otherwise be incurred by the general-purpose innovator. Thus, in this model, the downstream partner is compelled to invest to create value, which also tends to commit it to the partnership, and these factors are likely ultimately to lead to a better alignment of investments with profit opportunities.

As an innovating firm seeks multiple markets in which to deploy its technology, it may choose to accept relatively small profits in each market niche, but accrue returns across many market niches (see Figure 1). The business model in this instance involves maximizing the number of downstream applications, so returns will hinge on *breadth,* given that the firms can rely on downstream partners for the *depth* of each individual application. An important aspect of this approach is that the supplier of the technology can escape the constraint that it does not control any co-specialized downstream strategic asset. The innovator also no longer seeks to maximize bargaining power in each interaction, where it may only have limited success due to external factors such as industry conditions and the characteristics of the partner. Instead, the innovator focuses on maximizing the *number* of high-value applications that may involve its technology, which it can affect by investing in skills, resources and capabilities that tie upstream technology to insights about the needs of ultimate consumers across a broader front. Potential conflicts of interest in the innovator-licensee

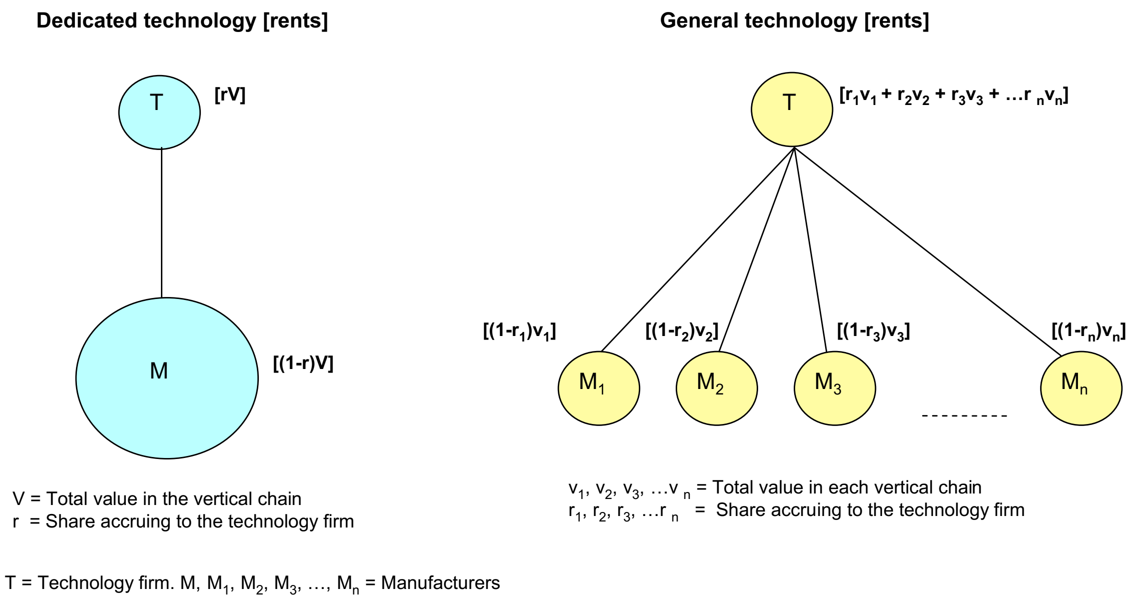

Figure 1. Dedicated vs general technologies: shares of industry rents

partnership are also minimized, because such innovators are unlikely to bring products to market that are in direct downstream competition with those of the technology licensee.

The business-model innovation compelled by technology licensing has not been confined to biotechnology or enterprise applications: this generalist-specialist phenomenon has arisen in many technology industries. For example, in the software security industry, which began with business model innovation by McAfee and Norton in the early 1990s, general-purpose technologies have proliferated in downstream applications such as firewalls, authentication software, digital signatures and PC antivirus utilities. Today, software security firms typically develop basic algorithms that are sold in the form of intellectual property to downstream developers who then deploy them in commercializable products.[10] Certicom, a leader in this business, has profited from patenting general-purpose tools in security keys, fast processing methods, and other security mechanisms, which it then, typically, licenses to applications developers who embed them, together with additional algorithms, in their commercial products.

The commercialization of knowledge-based assets as business-model innovation

Technology licenses — and the business-model innovations that they have spawned — are an early indicator of a broad range of opportunities based on general-purpose knowledge-based assets such as the broad patents at the heart of Certicom's competitive advantage. In many science-based industries, upstream innovators are now focusing on areas of scientific discovery in efforts to develop patentable insights that can form the basis of technology licenses for commercialization in market niches by downstream partners.

Ironically, the scramble among innovators to pursue this strategy is creating two new types of challenges that are compelling yet a further new wave of business-model innovation. The first challenge arises from the breadth of the potential applications of general-purpose technology. As new tools arise for generating basic scientific insights, greater numbers of firms are competing to produce them. The proliferation of design and simulation techniques for generating general-purpose technologies within the life and engineering sciences has increased the productivity of research and innovation processes quite considerably. Many more ideas and designs - and thus technological opportunities - can be produced than in the past.

Accurate forecasting of commercially viable products [depends on increased] innovation in technologies to test whether and how licensed ideas work in practice.

The second challenge arises from the absence of predictability as to whether this range of innovations can create what will go on to be commercializable opportunities for downstream licensees. Accurate forecasting of commercially viable products has been constrained by a slower pace of innovation in the technologies for testing whether and how licensed ideas work in practice than in the upstream scientific discoveries themselves. Forecasting the willingness of customers to pay for niche products based on general-purpose scientific breakthroughs remains difficult. As a result, the next major breakthrough in business-model innovation in relation to technology licensing may well be in the field of faster and more effective application development.

These phenomena are evident in a wide range of sectors. For example, historically, the impediment to productivity improvements in manufacturing was often in equipment technology, and production or commercial managers faced with problems on the factory floor (or in distribution, marketing or sales) often had to call on R&D personnel for solutions. Over the last twenty years, the development of competitive advantages grounded in intellectual-property assets has meant that technologists have generated many concepts that require consultation with downstream operations and marketing managers to analyze whether and how they might be commercialized. To put it succinctly: in the past, commercial opportunities or technological problems called for innovations and technological solutions; today, technological solutions are seeking commercial opportunities to trigger, or technological problems to solve. More than ever before, breakthrough products and services based on technological insights are being subsequently commercialized via long and costly processes in which companies invest to understand what the technology can be used for, whether the prospective applications are profitable, and how they can be most effectively pursued.

Commercializing general purpose technologies

The newest kinds of business problems raised by these trends are arising from the distance between general-purpose scientific technologies and the techniques required for understanding how to put them into use effectively. Typically, the development of technology - especially general-purpose technology - requires skills, assets and investments in engineering and scientific disciplines and knowledge, in research, and the like. Understanding which product or service might become commercially successful requires sociological and marketing insights, experimentation with users, and the ability to match needs with technological solutions. Thus the capabilities required to be effective in commercialization differ quite significantly from those required to develop new science. For example, Bresnahan and Greenstein note that the development of innovations in information technology requires the mastery of computer science and related skills, which — among other things — can create significant economies of scale and scope across downstream product or service applications.[11] By contrast, discerning which product or service users require calls for idiosyncratic understanding, marketing relationships and sometimes even ethnographic investments to extract information about needs that may be as yet incompletely identified or articulated.

Companies such as IDEO have specialized in the development of processes to make these kinds of translations. Examples also arise from less well-known contexts: Maine and Garsney's stories of two nanotechnology companies - Hyperion Catalysis and Cambridge Display Technology (CDT) — are illustrative here.[12] Hyperion Catalysis has developed special applications of fullerenes, a carbon allotrope discovered in 1985 that represent a general technology with many potential applications based on basic nanotechnology materials research. Initially Hyperion struggled to find applications for its new materials, and ultimately explored applications via alliances with manufacturers, automotive, aerospace and power generation companies. This has proved a successful strategy, and Hyperion has commercialized more than 40 products in these four distinct markets. CDT has developed polymers that emit light, another general technology with potential applications in semiconductors, consumer electronics and toys. Again, licensing and alliances with several manufacturers have provided the company with paths towards downstream markets.

Another example is Yogitech, a semiconductor start-up founded in 2000 in Pisa, Italy, which began as a producer of software simulators for verifying the functioning of chips before the construction of physical prototypes. In a breakthrough general innovation, Yogitech subsequently developed a technology called Fault-Robust that can recognize problems in electronic devices in cars, medical devices and other domains. The breadth of applications stemmed from the basic science behind the technology. Yogitech has allied with major car manufacturers worldwide to co-develop technology applications, and is now seeking partners in other industries for further extensions.

In the Enterprise Resource Planning (ERP) industry, general-purpose technology companies have advanced techniques for commercializing knowledge-based assets. Pollock and Williams describe a company that developed a general solution for an ERP system that was at first used widely by private companies.[13] The key problem was how to adapt the template the company had developed for use in higher education institutions. Versions of the information system where presented in pilot tests with large numbers of University users, with the aim of eliciting information about: a) which were the common needs of the community that could be standardized, and b) which needs were specific to individual Universities. This enabled the devloper to identify general-purpose functions that could be designed into the system - in other words, how to design a generic template that could be employed for an 'ideal' university, and sold to them as a standard package - leaving the specifications that were truly idiosyncratic either to the users themselves or to one-to-one, customized applications developed independently through contracted relationships with each University.

This process is suggestive of the types of business-model innovations that technology producers might make to remove 'bottlenecks' in the successful commercialization of applications. The critical element from this example is pilot testing with representatives of the broader community (rather than with individual users) to define a template: investigation via narrower focus groups of users might have obscured opportunities to develop common modules. The development process also led to efficiencies in marketing to the potential users by allowing the company to appreciate how to make tradeoffs between standardized modules for the whole market sector and custom solutions for each client. The story also highlights how the investments, assets and resources needed by the supplier to identify a focused application accurately were quite different from those required to develop the technology in the first place, or to refine its technical features once the specifications of the design were clarified. Rather than computer science or programming skills, meetings with user representatives called mainly for marketing and sociological skills and assets.

The ERP example demonstrates the advances in business-model innovation that can occur when an innovating firm invests to bridge across from general technology to user needs. Hyperion, CDT and Yogitech each worked with downstream manufacturers on a one-to-one basis on specific solutions for their needs, but the ERP supplier employed a bridging strategy that accounted for the economies that could be obtained through common modules that would be inexpensive, and thus attractive to large numbers of University users. We do not argue that either approach to commercialization is superior - in the cases of Hyperion, CDT and Yogitech, the users may well have been large enough to warrant such customized development. But the innovation in the ERP supplier's approach was in balancing the advantages of customization with the economies of standardization by interacting with communities of users to extract information about both the standard and the idiosyncratic elements of their preferences.

Business-model innovation through the development of general technologies and the construction of market-specific standard modules that can be customized subsequently has occurred in other situations. Thoma discusses the case of Echelon, a company that developed a universal electrical controller technology called LonWorks - a general-purpose technology with potential applications in manufacturing and commercial construction.[14] The technology was developed a few years after Echelon's founding, and the company then invested heavily in the creation of user communities, encouraging exchanges of information to stimulate the optimization of the technology's utilization and to encourage new uses. Commercialized products only took off several years after LonWorks was first developed.

The incentives associated with the [markets for] intellectual property drive innovators toward generalized technologies and implementers toward gaining expertise in specialization.

To summarize, the story of the development of technology licensing is representative of a larger phenomenon involving business-model innovation based on intellectual capital. The incentives associated with the sale of intellectual property through market mechanisms drive innovators toward generalized technologies, and drive implementers toward gaining specific expertise in the specialization processes. In the distant past, the problem-solving character of technological development meant that many products and services were developed to address pre-specified customer needs. Under this regime, fortuitously-successful spillovers in the applicability of a technology were mainly unplanned (with 3M's 'invention' of Post-It Notes perhaps the most famous example). Today, by contrast, products and services are often driven from scientific and technological breakthroughs that are provoked by design- or simulation-based visions about possible applications rather than by customer-defined problems. Ideas hinge on more basic scientific and technological knowledge that make the underlying technologies more general and abstract with respect to specific applications. Thus security software and new, simulation-generated drug compounds are based more on theories about applicability than on customer-defined problems, and so the underlying technologies are not only inherently more general in nature because the initial spark of technological insight is theoretical, but also less clearly associated with specific individual applications. This allows innovators a broader market of potential opportunities for customization (and thus a broader set of opportunities to capture value).

Conclusions

The core of our argument is that business-model innovation from technology trends occurs concurrently across a sector's markets, its upstream and downstream industries and thus, eventually, its overall architecture.[15] This process is especially important when the business-model innovation involves trading on intellectual assets. Current markets for technology, focused principally on the licensing of patented property rights, are an early instance of processes that will continue to unfold in the future. Companies that innovate in their business models to take advantage of new markets have the potential to lead in developing new knowledge-exchange industries, and also enjoy unprecedented opportunities, simultaneously and dynamically, to develop underlying resources grounded in knowledge capital that can serve as the basis of sustainable competitive advantage for the long-term.

Enacting future business-model innovations will require the same enterprising insight, entrepreneurial energy and unyielding commitment to implementation that has characterized past breakthrough business models.

Enacting future business-model innovations will require the same enterprising insight, entrepreneurial energy and unyielding commitment to implementation that has characterized the breakthrough business models of the past. Yet several other major elements of business-model innovation also may emerge over the forthcoming five to ten years.

- First, a reconceptualization of the character and content of customer willingness-to-pay may be imminent. Breaking through the bottlenecks that limit the application of general technologies requires insights that connect them to the willingness-to-pay of ultimate customers. The prevalence of networks such as eBay's supplier rating system, Facebook and YouTube illustrates that customer assessments may be developing into a noteworthy social movement. The endogenization of such mechanisms may be a central element of business-model innovation over the forthcoming decade.
- Second, major business-model innovations have implications for the viability of both upstream and downstream industries. Many of the most successful business strategies for innovation have involved outsourcing or the deconstructing of essential services. Downstream firms can capitalize on the opportunities created by upstream innovation, and vice versa.
- Finally, the evidence on business-model innovation suggests that opportunities across an economic sector may be difficult — if not impossible — to anticipate entirely. Unexpected leaders may emerge as new industries develop. Business-model innovation is not programmatic, and new generations of modified business models will emerge eventually to solve problems and capitalize on opportunities created by original breakthroughs.

The evidence presented in the examples discussed here suggests that even innovators themselves will be affected by the opportunities that emerge as technologies are taken up across markets, partnering firms, and related industries. The widespread generalization of intellectual capital offered by markets for licensing suggests implications for the architecture of entire sectors of the economy. Over coming decades, the restructuring of industries and of the architecture that knits them together may defy predictability, but is an inevitable consequence of these processes.

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Biographies

Alfonso Gambardella is Professor of Corporate Management and the Dean of the PhD School at Bocconi University. He is editor of the European Management Review and serves on the editorial boards of the Academy of Management Review, Industrial and Corporate Change, Research Policy, and the Strategic Management Journal. He has published in many international journals. Markets for Technology (2001, MIT Press, with A. Arora and A. Fosfuri) is one of his best known books. His website is at http://www.alfonsogambardella.it. *Department of Management and KITeS, Università Bocconi, Via Roentgen 1, 20136, Milan, Italy. Tel: +390258363712 (or 3504); E-mail: alfonso.gambardella@unibocconi.it*

Anita M. McGahan is Professor, AIC Fellow for Corporate Citizenship, and Rotman Chair in Management at the Rotman School of Management at the University of Toronto, a Senior Associate at the Institute for Strategy and Competitiveness at Harvard University, the Senior Economist at the Massachusetts General Hospital Division for Global Health and Human Rights, and a past president of the Academy of Management's Business Policy & Strategy Division. Her credits include two books and over 100 articles, case studies, notes and other published material on strategic issues of competitive advantage, industry evolution, and financial performance. *Rotman School of Management, University of Toronto, 105 St. George Street, Toronto, ON, Canada M5S 3E6. Tel: (416) 978-6188; E-mail: Anita.McGahan@Rotman.Utoronto.Ca*