# What patents tell you about your competition

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# What patents tell you about your competition

*Patent citation techniques can characterize the key companies at the forefront of a technology area.*

**Francis Narin**
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**Michael B. Albert**

Scientific activity has doubled every 15 years for some three centuries (*1*). The number of publications emerging from the technological community is overwhelming. Every working day some 5000 new scientific papers are published and 1000 new patent documents are issued throughout the world.

The implications of this avalanche of technical knowledge are enormous and present at every level of research management. At the policy level it is clear that the ability of nations to retain a leading economic position is inextricably tied to their technical and scientific capability.

At the corporate strategic level the same is true. A technological company cannot hope to survive today without a strong base in science and technology.

Finally, at the tactical level, a research group or research program is at great risk unless it is scientifically and technologically competitive, and operating with full awareness of all the research surrounding it.

Fortunately, new computerized information banks have emerged. Quantitative, bibliometric analyses help to cope with the information avalanche. In particular, a series of technology and science indicator techniques has been evolving over the past two decades to allow a more quantitative approach to technological planning and managing. These techniques measure the magnitude, distribution, and impact of papers and patents; they provide a framework to help us understand, in a systematic way, how to incorporate this information into our planning.

For example, at the national level these technology indicator techniques were used to show that, in terms of technological strength, Japan is now equivalent to all of Western Europe combined (*2*). That policy-level analysis dealt with tens of thousands of patents.

At the strategic level these techniques were featured in the recent *Business Week Patent Scoreboard* (*3*). That strategic application used the technology indicators to rank 200 major companies across 13 different industries in terms of the number, citation impact, and technology cycle time of their patents. Technological profiles of more than 2000 different companies are now available on-line in our TECH-LINE database, available on LEXIS/NEXIS (*4*).

The use of these techniques is also growing at the tactical level. The papers listed in the bibliography will lead the reader, in particular, to technology indicators based on patent citation analysis, a specialty of CHI Research. Patent citation techniques provide a systematic way to identify the key companies, inventors, patents, and clusters that characterize technological activity at the forefront of any area of technology.

## Memory-enhancing agents

Much of the tactical technology indicator's work is proprietary. It is done on a confidential basis in response to a specific planning problem, and is, therefore, not available in the open literature. However, to provide a specific example of this work, we have performed an informal demonstration study of memory-enhancing agents (MEA).

As interesting as it turned out to be, we had chosen the MEA area arbitrarily, with no advance knowledge of either the magnitude or shape of the research in that area. We had only a general awareness of memory deficits in aging, of the growing importance of Alzheimer's disease, of the fact that this was an active research area, and of the proportion of gray on the heads around the table.

One of the approaches that CHI Research has developed for putting technological developments into a systematic framework is the "three-plane" model of technological development (Figure 1). The evolution of technology is viewed as occurring in three planes: the technology plane itself, where the activity under scrutiny is occurring; a precursor or base plane where earlier, cited research has

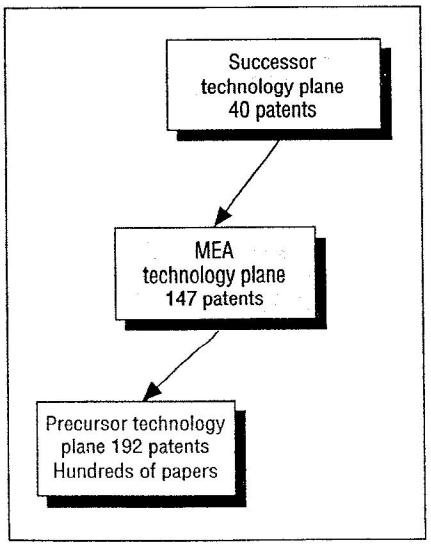


***Figure 1.*** **Evolution of memory-enhancing agent (MEA) technology.**



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occurred; and a successor citing plane, encompassing new applications or variations of the central technology. Of course, in the real world, the boundaries between the planes are fuzzy. The decision on whether a citing patent is different enough to be in the successor plane or belongs in the technology plane is sometimes arbitrary. One must decide whether some of the base plane technology or science is really different earlier technology or merely an earlier development in the current technology. Nevertheless, we have found the model to be useful in that it provides a systematic way of looking at the relationship between a current technological development, possible successor developments, and earlier base developments.

Having chosen the subject, we made a quick search to identify U.S. patents related to MEA. The search was conducted, as is usually the case, using a combination of patent classifications, key words, and citation analysis. The object of this initial search was to identify patents that belong to the technology plane, patents in the area of MEA itself, from 1986 to 1990.

The technology plane, MEA itself, is the central plane shown in Figure 1. Relationships in that plane will be used to develop the structure of the technology.

The other two planes, the successor plane above and the base plane below, refer to technology that is not MEA per se, but rather is closely related.

In the successor plane we have patents that cite the MEA patents. These represent other, generally related technologies that are building on the technology plane and might be areas of interest for expansion or acquisition around the MEA area, but are not MEA per se.

Similarly, the precursor or base plane contains the underlying technology and the underlying science upon which MEA patenting is based, and is identified as patents and papers cited by the patents in the technology plane itself, but not themselves in that plane.

From a technological intelligence viewpoint, the precursor and successor planes are every bit as important as the technology plane. They represent closely related areas that might be of interest for merger/acquisition or diversification. They also may represent, particularly in the successor plane, leading indicators of future activity.

## Linkages of the technology plane

After we identified patents in the MEA technology plane, we ran a series of programs to disaggregate those patents into clusters. Each cluster contains patents that cite or are cited by other patents in the plane.

*A research program is at great risk unless it is scientifically and technologically competitive, and operating with full awareness of all the research surrounding it.*

Of the 147 U.S. patents issued in this area between 1986 and 1990, 44 were cited one or more times through 1990. Because of the rapid growth rate of the area (Figure 2), almost 100 of the patents were issued in 1989 and 1990. Patents usually don't accumulate citations until a year or two after they are issued, so most of the 1989 and 1990 patents will not be cited until 1991 or 1992.

One of CHI's fundamental indicators of patent impact is how frequently a patent is cited. The basic idea of patent citation analysis is that when a patent is highly cited, that is, cited in at least five later patents, that earlier patent is likely to contain an important technical advance. When a U.S. patent is issued it contains, on average, five or six "references cited U.S. patents." These references are the earlier patents ("prior art") whose technology and claims were built on by the issued patent. When a patent is prior art to a large number of subsequent patents, then that highly cited patent more often than not contains an important invention or advance.

Figure 3 shows the main citation cluster and two smaller citation clusters within the MEA technology plane. The MEA patents are indicated by small black squares; the lines between the squares represent the individual citations. Thus, in the main cluster, the 1986 patent toward the lower left, with so many lines to it, is one of the two highly cited Hoechst–Roussel patents held by Shutske and Pierrat. That 1986 patent is cited 13 times within the cluster, and the related 1987 patent 12 times.

Table 1 lists the individual patents. It clearly shows how the main cluster is a Hoechst–Roussel cluster. It also

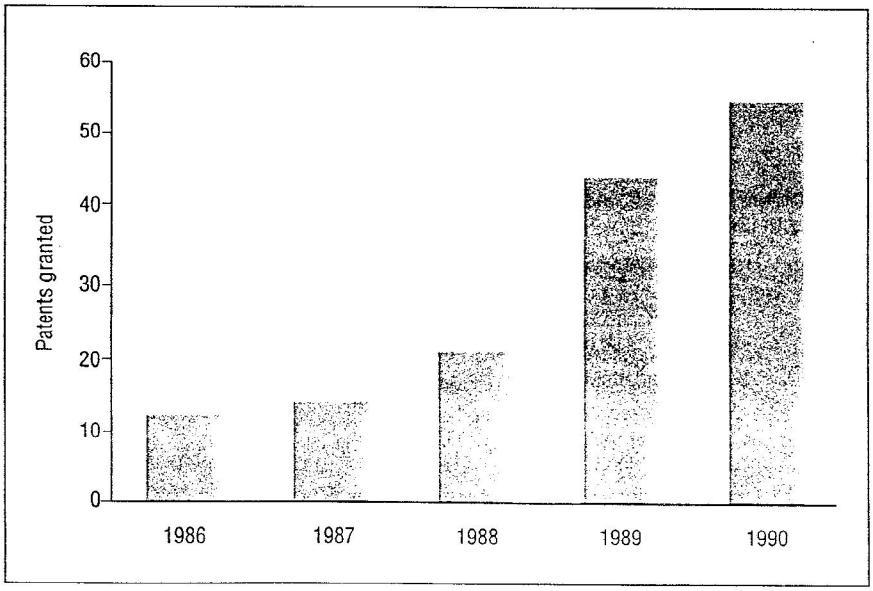


***Figure 2.*** **Growth of memory-enhancing agent patenting in the United States.**

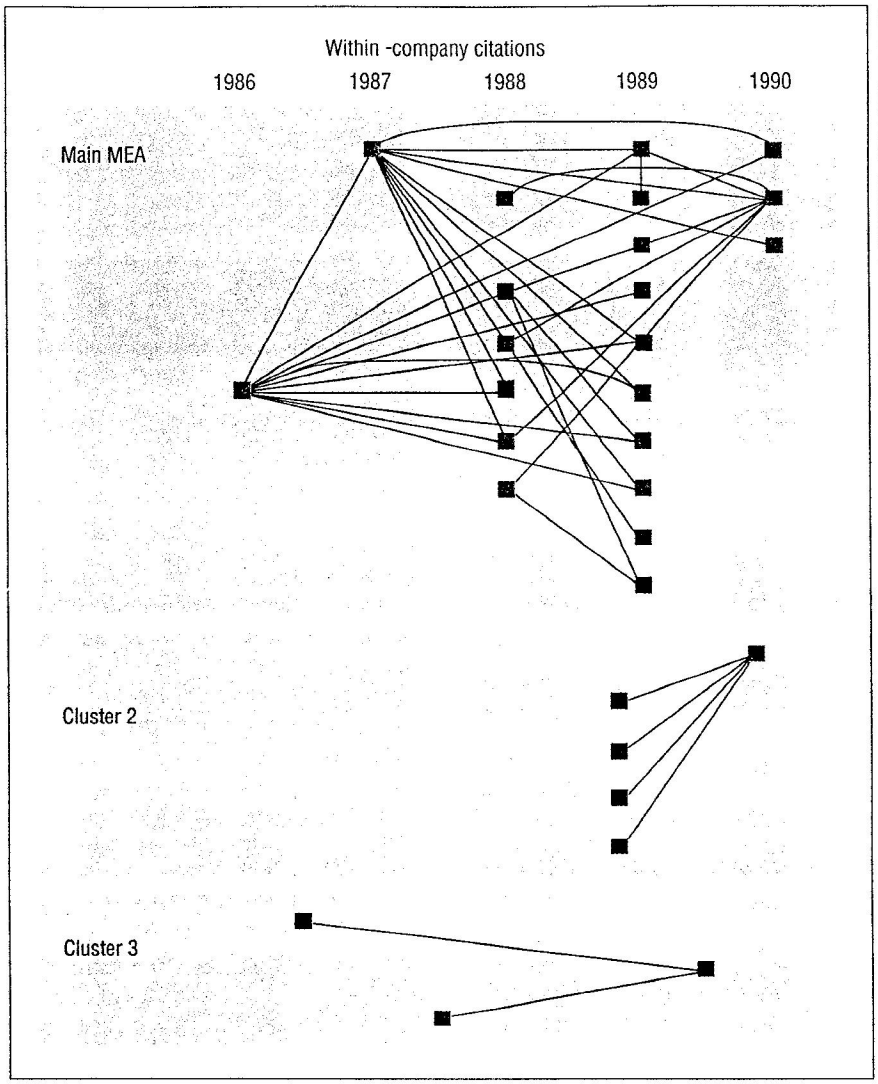


***Figure 3.*** **(a) Citation map using citations received through 1991; (b) listing of patents.**

shows that the others are separate clusters directly related to Alzheimer's disease.

Table 2 lists in more detail the six patents in the MEA technology plane cited three or more times from within and outside of MEA. Three are from Hoechst–Roussel, but these are not the only highly cited patents. Patents from Johns Hopkins and Bristol–Myers are cited five times, and the Delalande patent three times.

Figure 4 shows, by company, all MEA patents cited more than once. The height of the bar reflects the number of citations of the company's patents through 1990. Note the dominance of Hoechst–Roussel.

## The three planes

The general relationship among the three planes, and the key companies on them, are illustrated in Figure 5. The central MEA technology plane contains 147 patents; 48 of these are assigned to Hoechst–Roussel. The next largest companies are Sandoz and Lilly with nine patents each, and SmithKline Beckman, City of Hope, Novo Nordisk, and American Home Products with three each, followed by 68 companies or individual inventors with one or two patents in the area.

Interestingly, Hoechst–Roussel has a number of "hidden" patents. On the list of unassigned MEA patents, that is, patents that are not listed as assigned to a company, a number

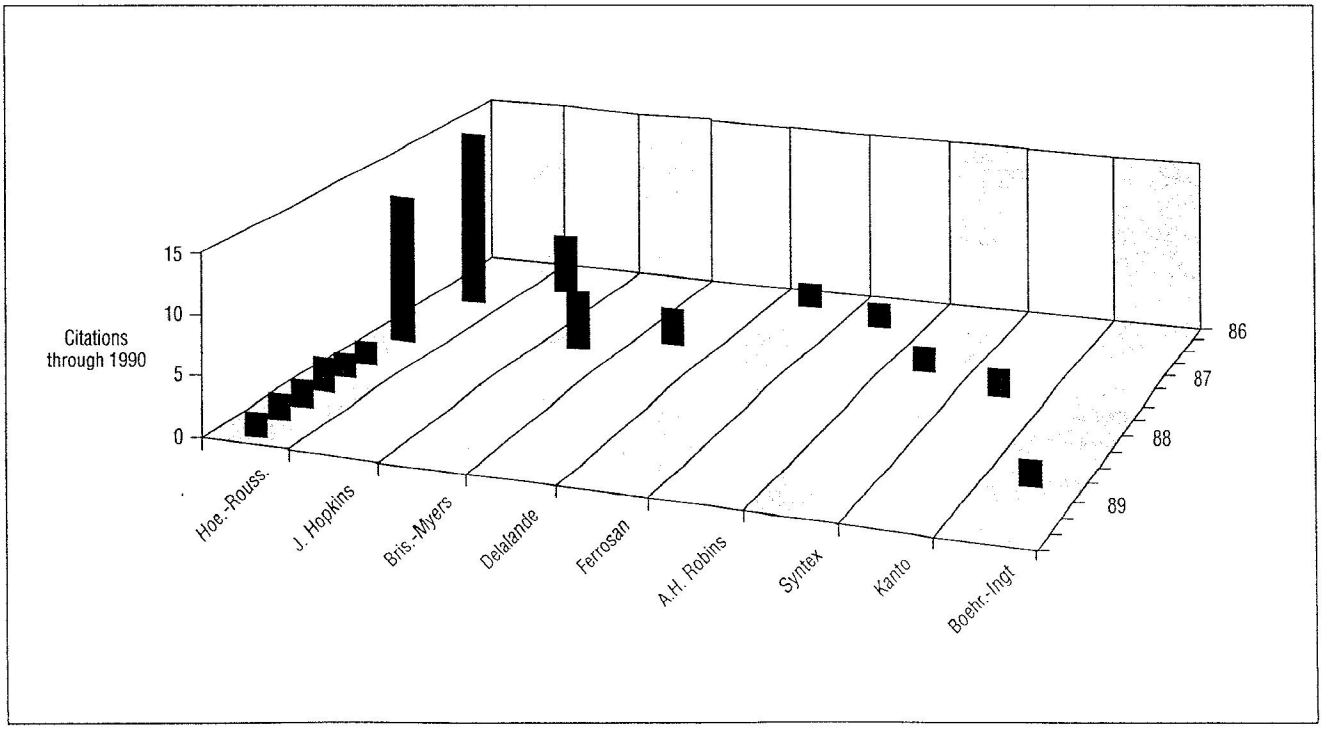


***Figure 4.*** **All MEA technology-plane patents cited more than once through 1990.**

*Table 1.* **Listing of patents in main cluster of Figure 3**

| Patent | Year | Assignee | Title |
|---|---|---|---|
| 4,695,573 | (1987) | Hoechst-Roussel Pharmaceuticals Inc. | 9-amino-1,2,3,4,-tetrahydroacridin-1-ol And Related Compounds |
| 4,800,203 | (1989) | Hoechst-Roussel Pharmaceuticals Inc. | Pyrrolo(1,2-b)cinnolines |
| 4,897,400 | (1990) | Hoechst-Roussel Pharmaceuticals Inc. | 9-amino-1,4-ethano-1,2,3,4-tetrahydroacridine And Relate . . . |
| 4,743,601 | (1988) | Hoechst-Roussel Pharmaceuticals Inc. | Dihydro-1,4-oxazino(2,3-c)quinolines |
| 4,883,794 | (1989) | Hoechst-Roussel Pharmaceuticals Inc. | Pyrrolo(1,2-b)cinnolines |
| 4,916,135 | (1990) | Hoechst-Roussel Pharmaceuticals Inc. | N-heteroaryl-4-quinolinamines |
| 4,806,646 | (1989) | Hoechst-Roussel Pharmaceuticals Inc. | Substituted 9-amino-spiro+8 Cycloalkyl+8 B+9 Quinoline-2 . . . |
| 4,927,820 | (1990) | Hoechst-Roussel Pharmaceuticals Inc. | Fused Heterocyclic Derivatives Of 1,2,3,4-tetrahydroacridine |
| 4,752,610 | (1988) | Hoechst-Roussel Pharmaceuticals Inc. | N-(pyrrol-1-yl)pyridinamines Having Memory Enhancing Pro . . . |
| 4,816,456 | (1989) | **Unassigned** | Administration Of Monoamine Acridines In Cholinergic Neu . . . |
| 4,753,950 | (1988) | Hoechst-Roussel Pharmaceuticals Inc. | Fused Heterocyclic Tetrahydroaminoquinolinols And Relate . . . |
| 4,839,364 | (1989) | Hoechst-Roussel Pharmaceuticals Inc. | 9-amino-3,4-dihydroacridines And Related Compounds Usefu . . . |
| 4,631,286 | (1986) | Hoechst-Roussel Pharmaceuticals Inc. | 9-amino-1,2,3,4-tetrahydroacridin-1-ol And Related Compounds |
| 4,762,841 | (1988) | Hoechst-Roussel Pharmaceuticals Inc. | Substituted 9-amino-spiro(cycloalkyl[b]quinoline)-2,1+40 . . . |
| 4,840,972 | (1989) | Hoechst-Roussel Pharmaceuticals Inc. | Relief From Memory Dysfunction With +60 -alkyl-4-amino-3 . . . |
| 4,789,678 | (1988) | Hoechst-Roussel Pharmaceuticals Inc. | Memory Enhancing +60 -alkyl-4-amino-3-quinolinemethanols . . . |
| 4,843,079 | (1989) | Hoechst-Roussel Pharmaceuticals Inc. | Fused Heteroalkylene Quinolinamines |
| 4,792,562 | (1988) | Hoechst-Roussel Pharmaceuticals Inc. | N-(pyrrol-1-yl)pyridinamines Having Memory Enhancing Act . . . |
| 4,855,479 | (1989) | **Unassigned** | Substituted 9-amino-spiro(cycloalkyl[b]quinoline)-2,1+40 . . . |
| 4,868,177 | (1989) | Hoechst-Roussel Pharmaceuticals Inc. | 1,2,3,4-tetrahydro-1,9-acridinediamines, Pharmaceutical . . . |
| 4,868,190 | (1989) | Hoechst-Roussel Pharmaceuticals Inc. | N-pyridinyl-9h-carbazol-9-amines |
| | | **Patents in Cluster 2** | |
| 4,966,893 | (1990) | **Unassigned** | Method For Treatment Of Senile Dementia |
| 4,814,339 | (1989) | Advanced Biologics, Inc. | Treatment For Alzheimer's Disease |
| 4,837,219 | (1989) | **Unassigned** | Medication For Alzheimer's Disease |
| 4,847,082 | (1989) | Sabin, Robert | Method Of Treatment Of Alzheimer's Disease Using Phytic Acid |
| 4,851,414 | (1989) | Kyowa Hakko Kogyo Co., Ltd. | Anti-dementia Agent |
| | | **Patents in Cluster 3** | |
| 4,663,318 | (1987) | **Unassigned** | Method Of Treating Alzheimer's Disease |
| 4,897,388 | (1990) | Geriatric Research Institute, Inc. | Method Of Treating Alzheimer's Disease |
| 4,758,430 | (1988) | **Unassigned** | Method Of Treatment Of Alzheimer's Disease Using Phytic Acid |

*Table 2.* **MEA patents with most patent citations through 1990**

| Patent | Patent date | Cites rec. | Assignee name | Inventor name |
|---|---|---|---|---|
| 4,631,286 | 12/23/86 | 15 | Hoechst–Roussel Pharmaceuticals Inc. | Shutske, Gregory<br>Pierrat, Frank A. |
| 4,695,573 | 9/22/87 | 13 | Hoechst–Roussel Pharmaceuticals Inc. | Shutske, Gregory<br>Pierrat, Frank A. |
| 4,593,095 | 6/3/86 | 5 | Johns Hopkins Univ, The | Snyder, Solomon H.<br>Daly, John W.<br>Bruns, Robert F. |
| 4,668,687 | 5/26/87 | 5 | Bristol–Myers Co. | Yevich, Joseph P.<br>Mattson, Ronald J. |
| 4,657,911 | 4/14/87 | 3 | Delalande S.A. | Imbert, Thierry F.<br>Dorme, Nicole A. M.<br>Langlois, Michel |
| 4,791,107 | 12/13/88 | 3 | Hoechst–Roussel Pharmaceuticals Inc. | Hamer, R. Richard L.<br>Helsley, Grover C.<br>Glamkowski, Edwar<br>Chiang, Yulin |

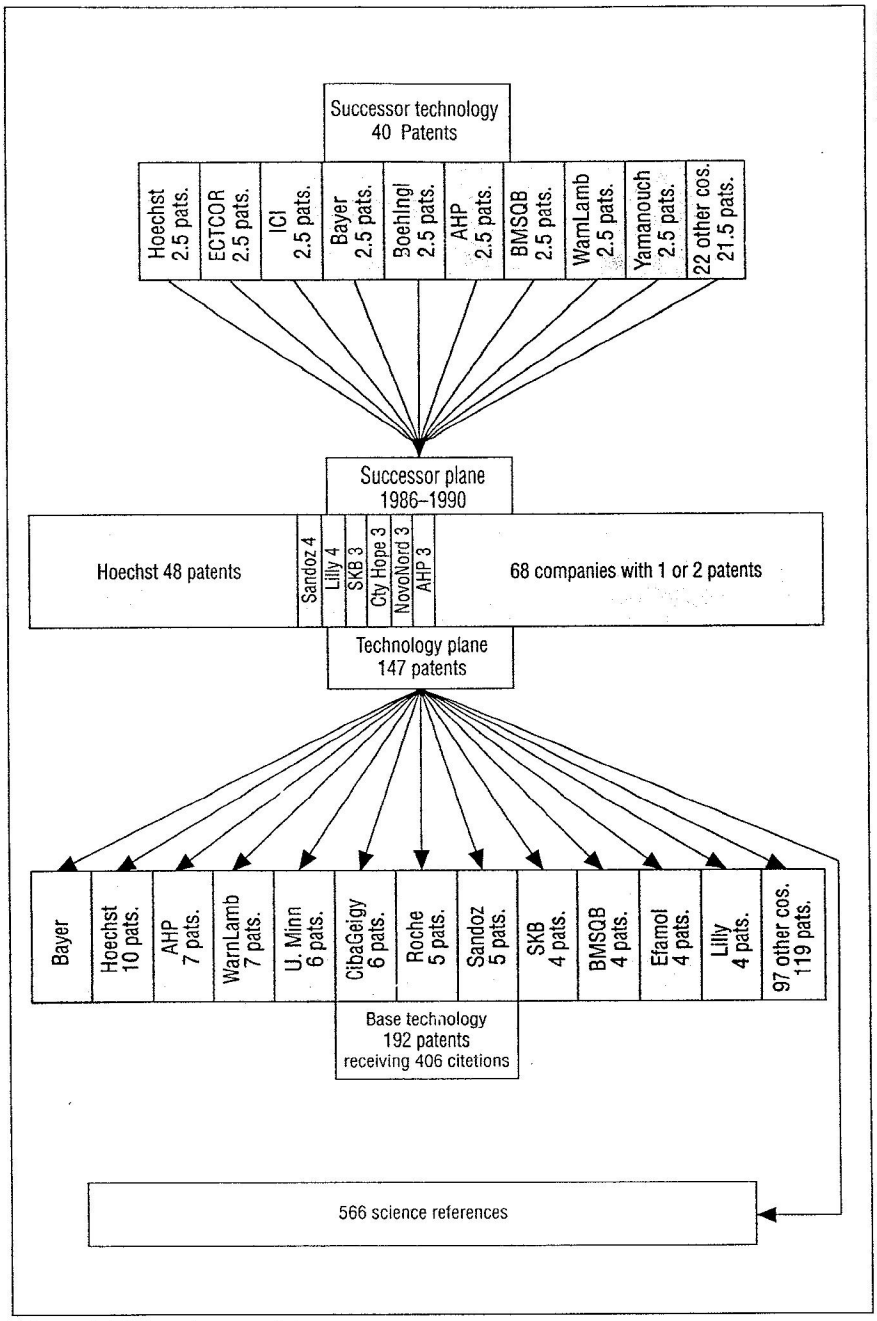


***Figure 5.*** **Three-plane model.**

are held by Hoechst–Roussel inventors, and one even belongs within the main Hoechst–Roussel cluster. The most likely explanation of this seems to be clerical error at the patent office; the assignee was not entered into the tapes. Nevertheless, these are, in a sense, hidden Hoechst–Roussel patents, which would only be discovered by means of this analysis.

The successor technology plane shown in Figure 5 is more dispersed. It contains 40 patents, only a few of which are from Hoechst–Roussel; these patents stem from a much wider swath of companies.

Although one would not expect those citing patents to be highly cited themselves, simply because they are too recent, one way of finding interesting new patents is to look for patents with many references to science. One of the advanced indicators used in CHI's patent citation analysis is whether a patent has a relatively large number of references to nonpatent literature, such as papers, books, meetings, and other publications, most of which are scientific.

Table 3 lists six of the successor patents with large numbers of science references. Remember that the lines among the successor, technology, and base planes are very thin; it is one of classification and judgment, and it is entirely possible that, on closer scrutiny, some of these successor patents might belong within the technology plane itself. The point here is not to worry about that fine line, but rather to illustrate the process of identifying interesting technology opportunities in the vicinity of the MEA technology plane.

Returning to the MEA plane, one of the most interesting aspects of this

***Table 3.*** **Successor technology patents with many science references**

| Patent | Patent date | # SCI refs. | Assignee name | Title |
|---|---|---|---|---|
| 4,977,152 | 12/11/90 | 35 | SANOFI | Novel tricyclic derivatives which are agonists of cholinergic receptors, and drugs in which they are present |
| 4,803,199 | 2/7/89 | 25 | **Unassigned** | Pharmaceutically useful heterocyclic and carbocyclic acid esters and amides of alkylene bridged piperidines |
| 4,910,207 | 3/20/90 | 25 | **Unassigned** | Method of treating psychosis with N-quinuclidinyl-benzamides |
| 4,851,536 | 7/25/89 | 14 | American Home Products Corp. | Cyclohexylquinolines as inhibitors of interleukin 1 |
| 4,879,296 | 11/7/89 | 10 | Burroughs Wellcome Co. | Xanthine derivatives |
| 4,774,326 | 9/27/88 | 8 | MECT Corp. | Process for preparing N-glycolylneuraminic acid derivatives |

**Table 4. Precursor technology patents with many patent citations**

| Patent | Patent date | Cites rec. | Assignee name | Title |
|---|---|---|---|---|
| 3,916,899 | 11/4/75 | 77 | Alza Corp. | Osmotic dispensing device with maximum and minimum sizes for the passageway |
| 4,118,396 | 10/3/78 | 25 | I.S.F. S.P.A. | Pyrrolidine derivatives |
| 4,398,029 | 8/9/83 | 22 | Kyorin Seiyaku Kabushiki Kaisha | Quinoline carboxylic acid derivatives and process for the preparation |
| 4,124,594 | 11/7/78 | 20 | I.S.F. S.P.A. | 4-Hydroxy pyrrolidin-2-onyl-amides |
| 4,138,562 | 2/6/79 | 20 | Univ. Minnesota Regents | Adenosine deaminase resistant antiviral purine nucleosides and method of preparation |
| 4,448,962 | 5/15/84 | 19 | Kyorin Seiyaku Kabushiki Kaisha | Substituted quinoline carboxylic acid derivatives |
| 4,185,090 | 1/22/80 | 18 | Abbott Laboratories | Chemically modified endotoxin immunizing agent |
| 3,962,416 | 6/8/76 | 17 | **Unassigned** | Preserved nutrients and products |
| 4,524,206 | 6/18/85 | 16 | Mead Johnson & Company | 1-Heteroary 4-(2,5-pyrrolininedion-1-yl)alkyl)piperazine derivatives |

**Table 5. Precursor technology patents with many science references**

| Patent | Patent date | SCI Refs | Assignee name | Title |
|---|---|---|---|---|
| 4,727,041 | 2/23/88 | 19 | **Unassigned** | Method of diagnosing Alzheimer's disease |
| 4,746,674 | 5/24/88 | 17 | Cellena (Cell Engineering) AG | Melatonin compositions and uses thereof |
| 4,247,549 | 1/27/81 | 14 | ICI America, Inc. | Piperazine-1-carboxylic acid esters possessing antidepressant or analgesic activity |
| 4,806,554 | 2/21/89 | 14 | Hoechst–Roussel Pharmaceuticals Inc. | Pyrazol and indazolpyridinamines |
| 4,419,365 | 12/6/83 | 13 | CIBA GEIGY Corp. | Method of treating Alzheimer's disease |
| 4,166,182 | 8/28/79 | 12 | Lilly, Eli & Co. | 6-N-Propyl-8-Methoxymethyl or methylmercapto-methylergolines and related compounds |
| 4,157,894 | 6/12/79 | 10 | Inverni Della Beffa S.P.A. | Production and analysis of ginseng root extract |
| 3,959,248 | 5/25/76 | 9 | Merck & Co., Inc. | Analogues of thyrotropin-releasing hormone |
| 4,727,064 | 2/23/88 | 9 | USA, Dept. of Health & Human Services | Pharmaceutical preparations containing cyclodextrin derivatives |

**Table 6. Sample of the types of science references cited**

| | |
|---|---|
| 4,808,582 | HOKURIKU, CHEMICAL ABSTRACTS 99: 122498H (1983). |
| 4,808,582 | KOWA, DERWENT ABSTRACT 25240 E/13 (2/20/82). |
| 4,808,582 | BURGER, "MEDICINAL CHEMISTRY" 2ND ED., P. 497, (1960). |
| 4,816,456 | DAVIS ET AL, "SELECTIVE LOSS OF CENTRAL CHOLINERGIC NEURONS IN ALZHEIMER'S DISEASE", LANCET (1980), VOL. 2 |
| 4,816,456 | HARBAUGH, M. D. ET AL, "PRELIMINARY REPORT: INTRACRANIAL CHOLINERGIC DRUG INFUSION IN PATIENTS WITH ALZHEIMER |
| 4,816,456 | SUMMERS, W. K. ET AL, "THA—A REVIEW OF THE LITERATURE AND ITS USE IN TREATMENT OF FIVE OVERDOSE PATIENTS", CL |
| 4,816,456 | SUMMERS, W. K. ET AL, "USE OF THA IN TREATMENT OF ALZHEIMER-LIKE DEMENTIA: PILOT STUDY IN TWELVE PATIENTS", B |
| 4,816,456 | KAYE, W. H. ET AL, "MODEST FACILITATION OF MEMORY IN DEMENTIA WITH COMBINED LECITHIN AND ANTI-CHOLINERESTASE |
| 4,816,456 | THAL, L. J. ET AL, "ORAL PHYSOSTIGNINE AND LECITHIN IMPROVE MEMORY IN ALZHEIMER'S DISEASE", ANNALS OF NEUROLO |
| 4,816,456 | SONI, N. ET AL., "4-AMINOPYRIDINE—A REVIEW", ANESTHESIA AND INTENSIVE CARE (1982), VOL. 10, PP. 120–126. |
| 4,824,861 | CARDINAUX, ET AL, HELV. CHIM. ACTA., 56, 339–347 (1973). |
| 4,824,861 | KLIXBULL, ET AL, INT'L J. OF PHARM., 20, 273–284 (1984). |
| 4,824,861 | LONGONI ET AL., NEUROPHARMACOLOGY, 15, 283 (1976). |
| 4,824,861 | SPIGNOTI ET AL., EUR. J. PHARMACOL., 126, 253 (1986). |
| 4,824,861 | DJOKIC, ET AL, CROATICA CHEMICA ACTA, 57, 271–280 (1984). |
| 4,831,155 | MARCH, ADVANCED ORGANIC CHEM., 2ND EDITION, PP. 349–352. |
| 4,831,155 | THE MERCK INDEX, 9TH EDITION. P. 961. |

analysis was the heavy dependence of the technology plane patents upon the scientific literature (Figure 5). The 147 technology plane patents cite 192 other U.S. patents a total of 406 times, but they cite nonpatent references 566 times. That means that patented Memory Enhancing Agent technology depends more heavily on science as prior art than on earlier technology.

As a comparison, for the U.S. patent system as a whole, the average patent has one nonpatent reference on its front page; in drugs and medicine, the most science-linked area, the average patent has about 2.5. On average these MEA patents have almost four front-page nonpatent references, clearly indicating that this is an area derived from science. In extremely hot areas of technology, such as genetic engineering, we sometimes find sets of patents with 10 or more science references per patent.

Because the precursor patents are earlier than the technology plane patents, many of them are old enough to have received many citations. Table 4 lists the precursor plane patents with the most patent citations. Most of these are, of course, outside the area of MEA and are cited by many other patents. Nevertheless, by analyzing the citations of these patents one would have another way of technologically browsing from the MEA area to its base or precursor technologies, and through those patents to the other technological areas that may have been built upon that base plane.

## *Patent scoreboard*

### Glossary

**Number of patents:** The number of patents granted by the U.S. Patent Office. The number excludes design patents and other special cases.

**Current impact index:** A measure of how important a company's patents are based on how often they're cited in other patents, which shows how frequently they're used as the foundation for other inventions. For example, a company's 1991 index is computed by first calculating the average number of times the patents it was granted in each of the previous five years were cited in new patents granted in 1991. Those figures are divided by the average number of 1991 citations for all U.S. patents in each of the previous five years. That yields a citation ratio for each year. A ratio of 1.0 means that the company's patents were cited as often as the overall average. A ratio of 1.2 means that the company's patents were cited 20% more often than average. Finally, the citation ratio for each of the five years is averaged to get the 1991 rating.

**Technological strength:** The number of patents times the current impact index.

**Technology cycle time:** The median age of the U.S. patent references cited in the company's new patents. The lower the number, the more quickly the company is replacing one generation of inventions with another.

Data: Chi Research, Inc.

| Company | Number of patents | | | Current impact index | | | Technological strength | | | Technology cycle time | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1991 | Avg. 1987–91 | % change 1987–91 | 1991 | Avg. 1987–91 | % change 1987–91 | 1991 | Avg. 1987–91 | % change 1987–91 | 1991 | Avg. 1987–91 | % change 1987–91 |
| **Group composite** | **6299** | **5792** | **6** | **0.82** | **0.83** | **1** | **5167** | **4809** | **7** | **10.0** | **10.0** | **0** |
| 1 Du Pont | 631 | 523 | 9 | 1.06 | 1.03 | 3 | 669 | 539 | 11 | 9.7 | 9.7 | 0 |
| 2 Minnesota Mining & Mfg. | 374 | 333 | 9 | 1.39 | 1.33 | 2 | 519 | 442 | 11 | 10.9 | 10.3 | –3 |
| 3 Hoechst | 575 | 536 | 7 | 0.88 | 0.78 | 8 | 507 | 422 | 15 | 8.6 | 9.4 | 4 |
| 4 Bayer | 706 | 657 | 7 | 0.66 | 0.72 | 0 | 463 | 474 | 8 | 9.5 | 9.1 | –1 |
| 5 Dow Chemical | 439 | 480 | –3 | 0.80 | 0.83 | –3 | 353 | 397 | –6 | 10.6 | 10.6 | –2 |
| 6 Ciba-Geigy | 430 | 384 | 7 | 0.79 | 0.78 | 3 | 342 | 300 | 10 | 9.2 | 9.5 | 1 |
| 7 BASF | 464 | 406 | 10 | 0.66 | 0.68 | –2 | 308 | 275 | 8 | 9.6 | 9.7 | 2 |
| 8 Monsanto | 196 | 148 | 10 | 0.90 | 0.73 | 7 | 176 | 110 | 20 | 11.6 | 10.9 | –1 |
| 9 Imperial Chemical Industries | 278 | 239 | 13 | 0.63 | 0.84 | –10 | 176 | 196 | 2 | 10.0 | 9.5 | –4 |
| 10 Olin | 121 | 87 | 18 | 1.44 | 1.17 | 32 | 174 | 105 | 54 | 9.5 | 10.2 | 3 |
| 11 Air Products & Chemicals | 123 | 102 | 14 | 1.27 | 1.13 | 10 | 156 | 115 | 16 | 8.7 | 9.7 | 5 |
| 12 W. R. Grace | 135 | 111 | 17 | 1.07 | 1.15 | –1 | 145 | 127 | 17 | 10.5 | 10.6 | 3 |
| 13 Shin-Etsu Chemical | 143 | 85 | 30 | 0.99 | 1.09 | –5 | 141 | 91 | 28 | 7.2 | 8.2 | 2 |
| 14 Union Carbide | 152 | 151 | –1 | 0.89 | 1.06 | –4 | 135 | 160 | –6 | 9.5 | 10.2 | 2 |
| 15 Rhône-Poulenc | 210 | 231 | –5 | 0.59 | 0.57 | 2 | 123 | 132 | –3 | 9.1 | 10.0 | 4 |
| 16 Sumitomo Chemical | 161 | 144 | 12 | 0.62 | 0.80 | –4 | 100 | 116 | 9 | 10.3 | 8.6 | –8 |
| 17 American Cyanamid | 114 | 119 | 2 | 0.79 | 0.71 | 11 | 90 | 85 | 14 | 8.6 | 9.5 | 3 |
| 18 PPG Industries | 108 | 119 | –3 | 0.82 | 0.84 | 1 | 89 | 100 | –2 | 11.6 | 11.3 | –3 |
| 19 Akzo | 104 | 90 | 8 | 0.76 | 0.79 | –2 | 79 | 71 | 8 | 10.9 | 10.9 | –3 |
| 20 Ethyl | 133 | 97 | 28 | 0.58 | 0.72 | 8 | 77 | 71 | 43 | 11.2 | 10.6 | 0 |

As was the case in the successor and technology planes, some of the patents in the precursor plane are highly science-linked; Table 5 lists those with the largest numbers of nonpatent references.

Also of great interest are the directly cited science references in the base plane, because they represent the underlying science upon which much of the MEA technology is based. Table 6 is a sample of the list of nonpatent references cited by the MEA patents. There were nine pages of these. Note that these might provide leads to people whose basic scientific research could be of importance in this area. This is a group of closely related activities that are only apparent from patent citation analysis.

It should be noted that the references listed are not unified; we have not taken the time to put the cited references into a unified format or to identify the specific cited papers. Unification is rather tedious; you see here the raw form to illustrate the many different and wondrous ways references exist in the U.S. patent system.

## Final observations

In this demonstration we arbitrarily focused on memory-enhancing agents, and discovered an area with:

- Rapid growth rate,
- Highly cited, high-impact patents,
- A clearly defined central cluster,
- A clearly defined central company, and
- High science linkage.

We also showed that patent citation techniques can identify potentially important activity surrounding an area, including technically and scientifically related researchers and organizations. The three-plane model is a convenient framework for tracing research progress.

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## Further information on patent citation analysis


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### WE MUST STOP MEETING LIKE THIS

**Too many meetings? Meetings too long? Here's what some firms do:**

**• No-chair, stand-up project review meetings at Merck seldom run more than 20 minutes.**

**• If you must have chairs be sure there's always one less chair than there are invitees. That way people show up on time.**

**• Declare one day each week "No Meeting Day." It's Wednesday at G.E.**

**• Use a cow bell to end run-on presentations. Any one at Manco can ring it.**

**Source unknown**

### SO TRUE

**"The educational system has been run with a lot of accountability for the educational process but not for the results."**

**John Chubb**
**The Brookings Institution**