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Chemicals – an Industry in a State of Transition

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Introduction

The global chemical industry is in transition from a structure that has existed since the beginning of the postwar era, a structure that was characterized by the dominance of large integrated petrochemical companies and large mixed-product 'classical' chemical companies. The new structure will be dominated by large life science companies and smaller R&D-driven companies besides the often state-owned petrochemical complexes.

This transition is shown schematically in *Fig. 1*. R&D will be a significant factor for the prosperity of most of the organizations competing in this new environment. R&D has been an important factor for chemical companies since the creation of the first chemical companies in the 19th century. The qualitative difference in this new phase that the chemical industry is entering is the prevalence of interdisciplinary, team-based research. It is this change in the nature of R&D in the chemical industry that I would like to discuss.

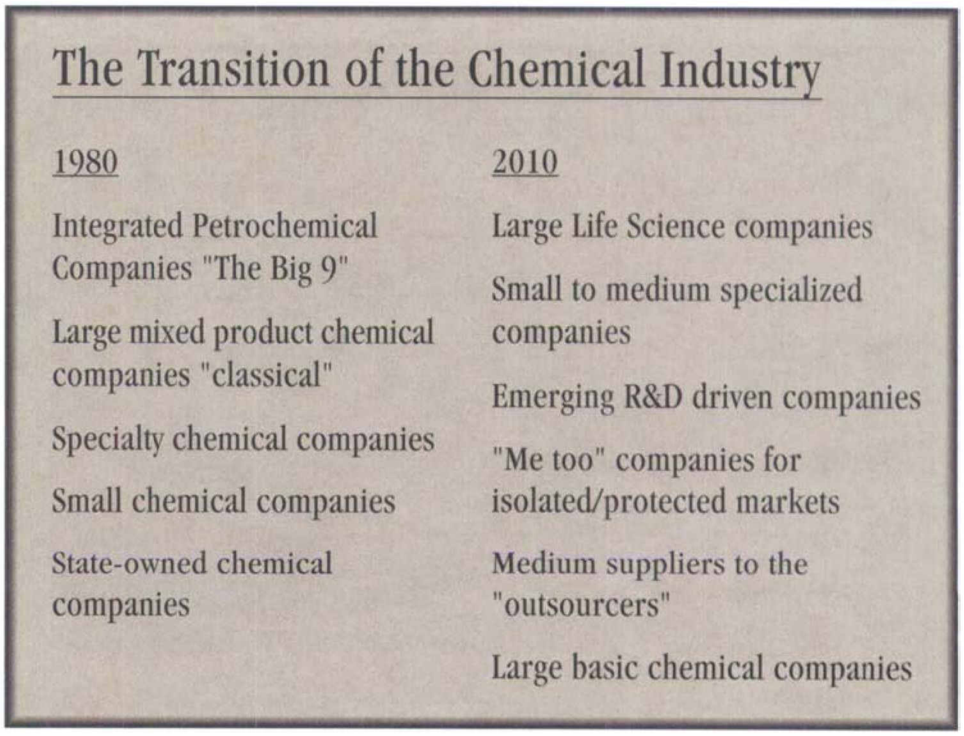

Figure 1

The Dominant Role of Innovation

So allow me to show you an, of course, oversimplified model of any public economy or any private industrial corporation (*Fig. 2*).

Our enterprise is symbolized by a house standing in a lake. The water level represents the costs. It is rising from year to year but at different speeds, vC. Whenever a storey of this building is flooded, it is generally irreversible. The only thing you can do is to slow down the speed of the rise of the water, and, in this respect many did a great job in the last few years. But during restructuring, we lost quite a few inhabit-

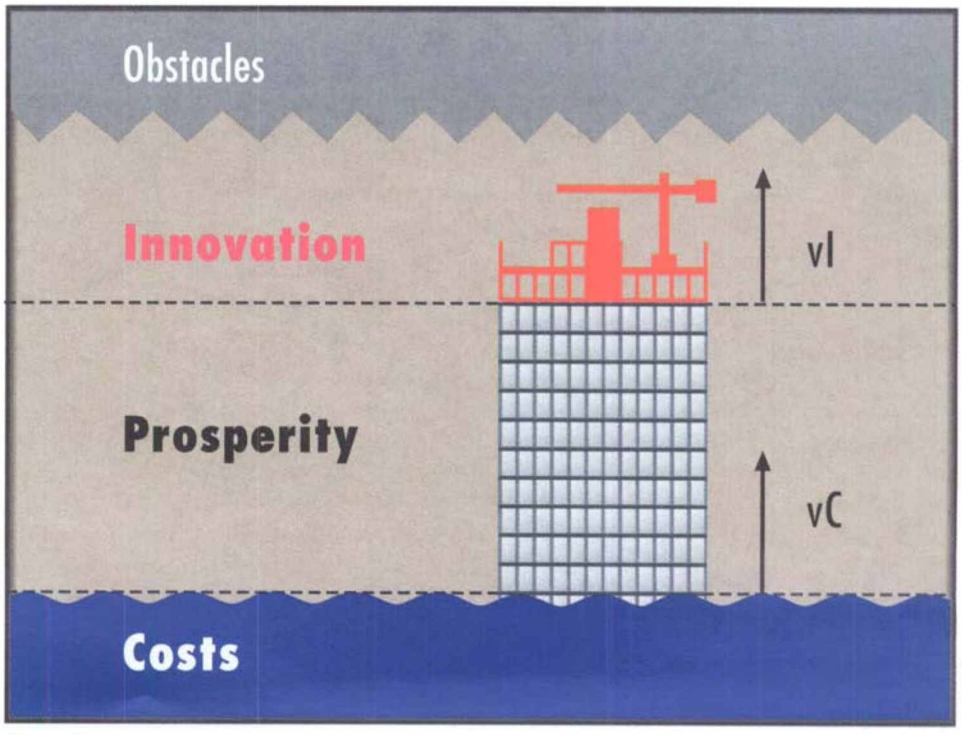

Figure 2

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able storeys of our building, of course. On the other hand, innovation is adding new floors at the speed of vI, and, obviously, the prosperity is proportional to the height, to the number of inhabitable storeys our house has. So whenever vC is greater than vI, our system is in danger. Whenever vI is greater than vC, the company shows a prosperous growth, and that is our aim. With reasonable effort, we can no longer get costs down further (although this is a permanent task), but we have to speed up innovation.

This leads to a substantial turnover in product mix. By way of example: *Lonza*, the chemical division of the *Alusuisse Lonza Group*, represents an example of a typical high-tech medium-size chemical corporation. Nearly 100% of the sales volume is the result of R&D. The chart (*Fig. 3*) shows that *Lonza* generates a remarkable fraction of its earnings from results of R&D, 30% or more of which were not known 10 years ago.

The same point can be made in a different way by considering the diagram shown in *Fig. 4*. The nature of the technology employed by *Lonza* has changed from the origins of the company in basic chemicals to its evolution into a fine chemicals company to its expected future as a company based on biotransformations and gene technology. This change implies a 'demographic' change in employment. The percentage of university-degree chemists has risen from 2 to 8% in *ca.* 15 years.

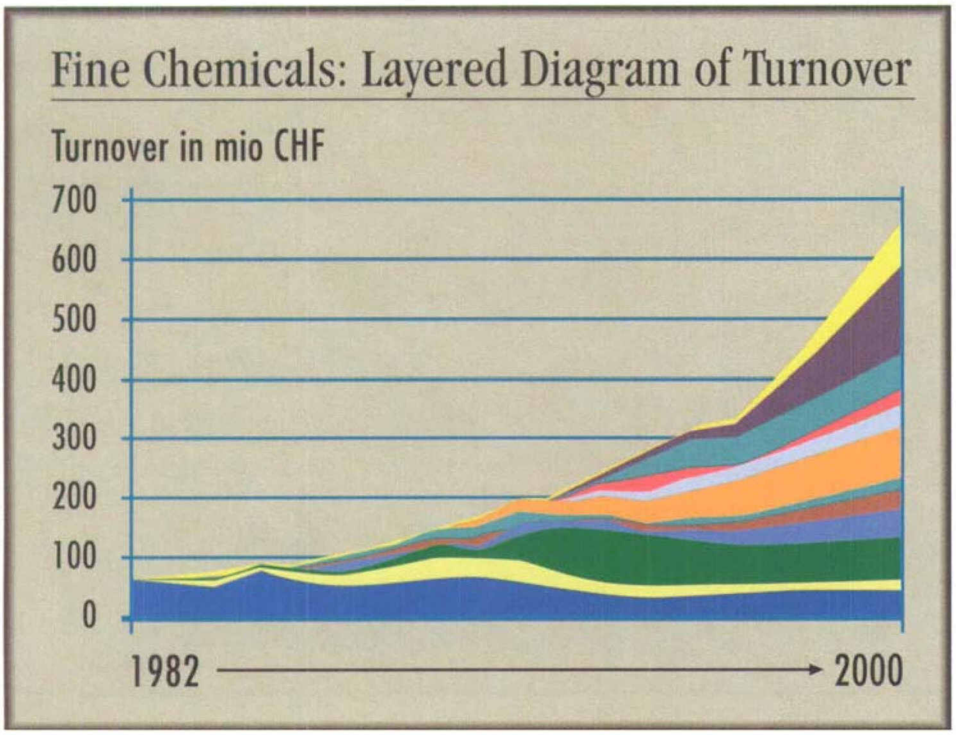

Figure 3

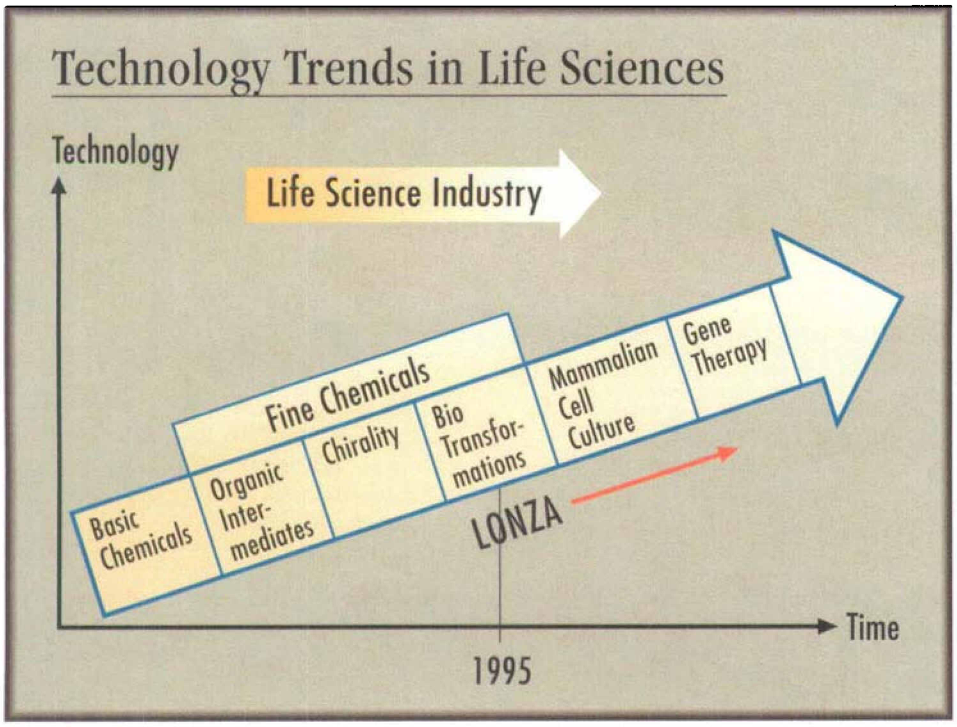

Figure 4

The Innovation Process

Since I believe we are entering a period where innovation will be a key success factor for the chemical industry, I would like to discuss the innovation process. This is a process that has many myths associated with it. *Fig. 5* is a diagram illustrating one of those myths, the myth of the linear progression from problem generation to result.

The obvious focus is solving a problem, and more and more I would propose (even to government-financed R&D): it would do good to look more at how to *find the problem.* In our times, techniques to solve a defined problem have been developed to the extreme and are today state-of-the-art. There are without doubt certain difficulties too to solve even a well-defined problem, we will describe them later. A substantial fraction of innovation is to find, isolate, and clearly describe a problem. Otherwise we run very often into the question: given are the laboratories and R&D people, missing is just one answer: what should we work on?

There is a well-known bad joke:

'It is easier to make research from money than money from research.'

How to find the problem?

As discussed above, before solving a problem, we have to define it. So let us first discuss the important phases of finding the real question: the problem!

In a consumer-goods corporation, very often discussions with clients, market research, or the sales people bring this question home, at least, you would expect them to. Generally, the results are disappointing.

In a more technologically oriented company, like ours, it can be even worse. There might be a certain exception – our classical sales talk of R&D chemists from *Lonza* with our major clients very often leads directly to useful questions. But it is worthwhile to study the morphology or methodology of problem finding (*Fig. 6*).

There is a possibly complete list of questions and comparisons shown in this diamond-like graph, and if you are really able to fill in all these interrelations, the problem will be very often directly visible. But it is not easy to feed this system because it needs an enormous market research and a real intelligence service. It is incredible how much money is spent on research, production and distribution without really knowing what competitors do and what clients want.

Project Evaluation

This leads to an oversimplified formula for project evaluation:

$Q = M \cdot F \cdot L\,(a + b + c\,...)$

M: Market 'Why does customer x order quantity q at price y?'
F: Financial 'Can we afford it?'
L: Legal 'Will it be allowed?'

The quality of project Q is again an equation with dominant factors and the usual qualifications we attribute to a project. The dominant factors (again, if one of the factors is zero, the whole equation or Q is zero) are the market, but with a precise answer to the tricky question: 'why does customer x order quantity q at price y?', the crucial financial question: 'can we afford it?', and more and more, is it allowed, is it legal?

Most of the factors we can artificially influence. An example: We can even discuss putting some pressure on a ban for chlorinated solvents in chemistry and for lacquers, if we have reasonable replacement by effective, but harmless solvents.

Timing and the Strategic Horizon

Let's start with two provoking statements:

a) Most industrial corporations (even consumer good-oriented ones) die, if they have only short-term goals (including profit optimization).
b) Most well-established and wealthy corporations, who generally foster and subsidize only long-term projects, die as well.

So it is not easy to find a reasonable and affordable mix for an industrial corporation. Obviously, we should have many projects with a horizon of 1–3 years, we should have nearly as many of 3–6 years, we urgently need – but only a few – of 7–10 years, and we have to afford even one or two going beyond 10 years. The latter two are for bridging the gap to science development including universities and to keep a standard of excellence.

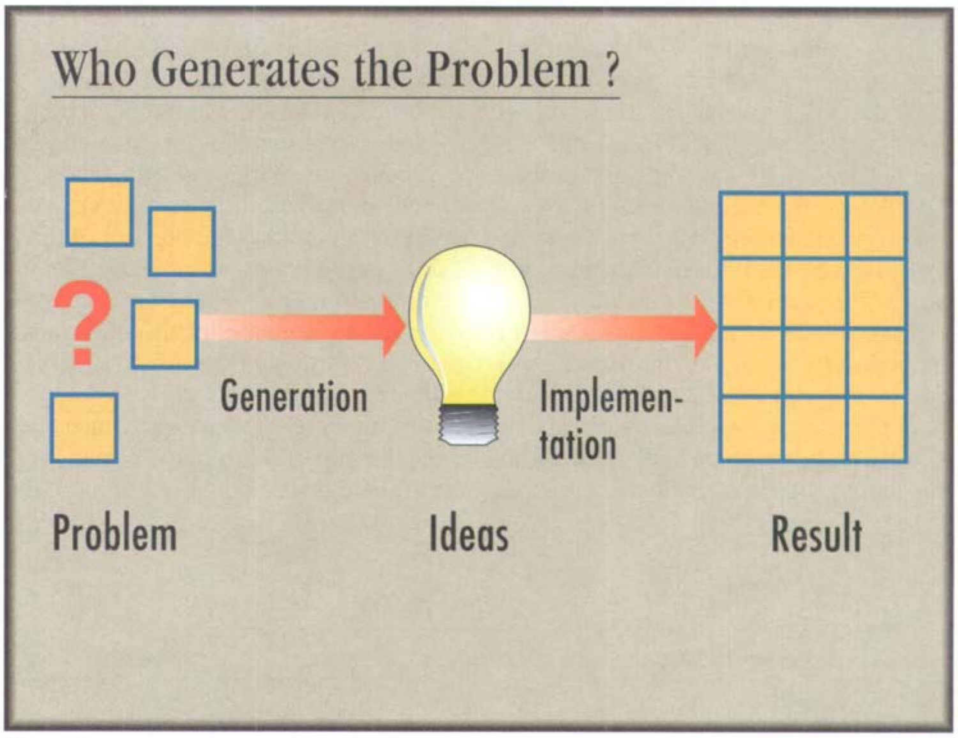

Figure 5

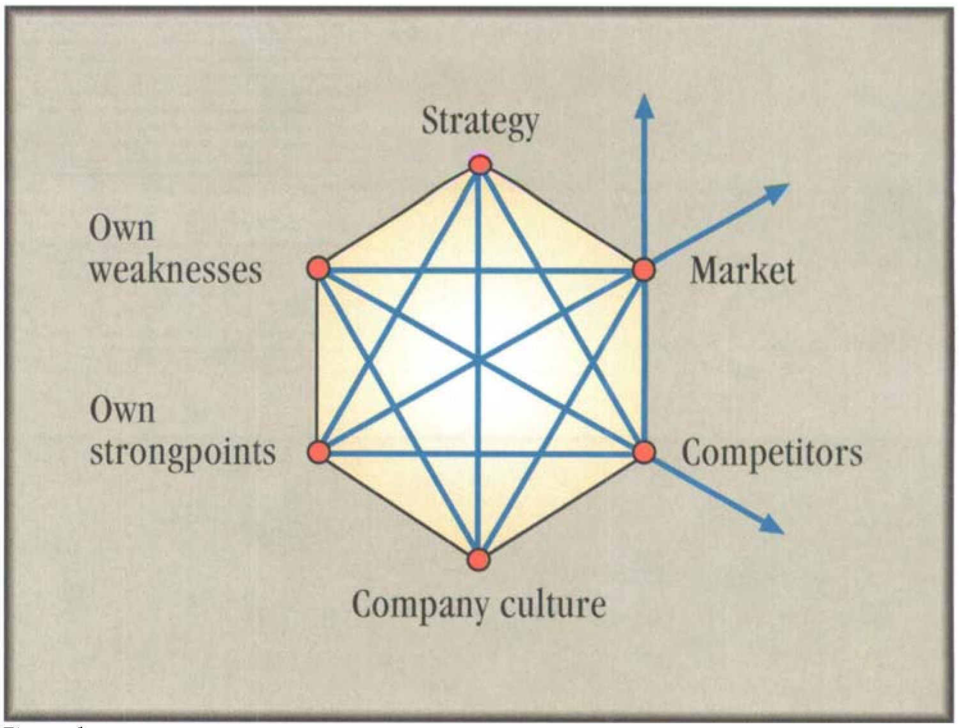

Figure 6

If we review a few projects from the past, we will again learn another lesson. Many of the cash cows of our company today, *e.g.*, ALUCOBOND, Niacine, and Steralcon have been projects with a horizon of probably 5 years, which lasted 10 and more, and should have been dropped because all classical judgements and calculations of textbooks would have proven that they are no good. Again: No equation, no calculation completely replaces a certain gut feeling. Of course, we need instruments to judge the quality of projects, both R&D and investments. Generally, the modern modes of calculation are quite good..., if the relevant factors are really treated as *factors*.

How to Solve Problems

How does one go about finding a solution?

Although I dared to grade down the questions compared to the now more dominant 'defining a problem', it is still the classical question of R&D, of Innovation

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Methodology. The Innovative Climate is difficult to initiate and often more difficult to maintain.

Today, nearly all industrial innovations occur on the borderline of the classic faculties. The state of knowledge is substantially lower, but the interdisciplinary approach is much more difficult to organize.

But mixed teams (even with outsiders) are a very successful instrument.

May I refer to the great teachers of methodology like the mathematicians *George Polya* or *Fritz Zwicky*, the inventor of morphology. *George Polya*, author of many useful practical books besides his (for us not readable) publications about modern maths, published 'How to solve problems'. From this book, I extracted the famous question scheme (see *Scheme*).

Fritz Zwicky, the astronomer with his Mt. Palomar observatory, discovered, *e.g.*, many fundamental laws of the nature of the universe. To bring some order to the multidimensional, huge number of difficult to interpret harvest of results, he invented morphology. The systematic, complex, generally three-dimensional order of possible solutions very often generates new ideas.

In an orderly process, ideas, questions and problems coming from 'somewhere' are filtered and selected in a funnel like system (*Fig. 7*).

Scheme

How does one go about finding a solution?

First of all You have to understand the problem	**Understand the problem**
Secondly Look for the correlation between the data and the unknown Perhaps you will have to take a look at a simplified version of the task if a direct correlation cannot be found Finally you must have a plan of the solution	**Think out a plan**
Thirdly Carry out your plan	**Carry out the plan**
Fourthly Verify the solution obtained	**Review**

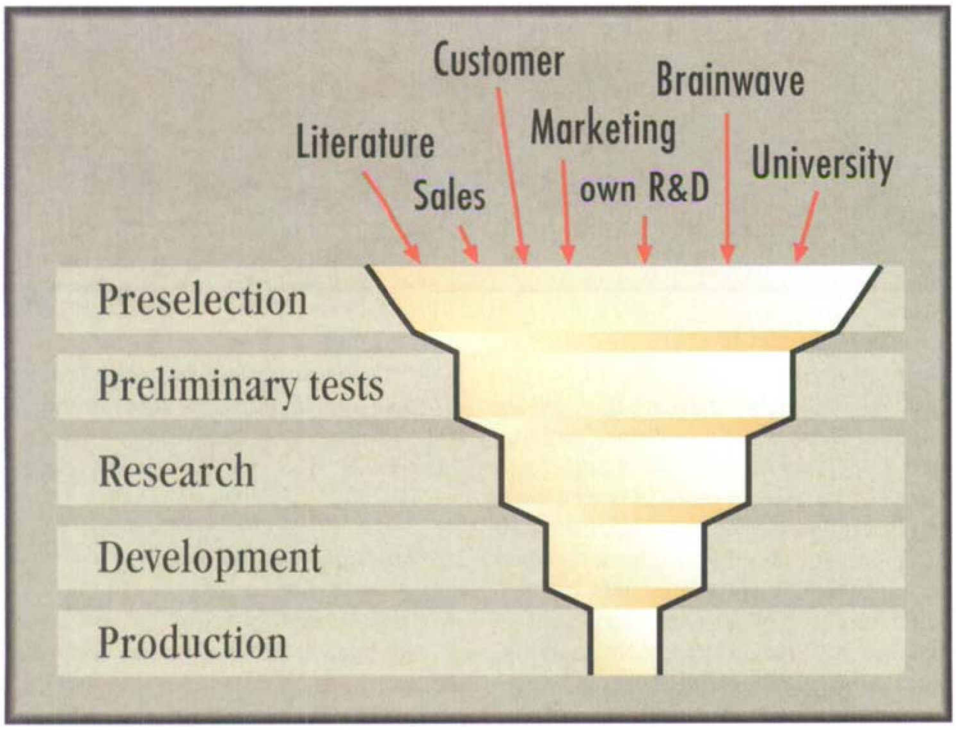

Figure 7

A continuous and large flow of good ideas from in- and outside our corporation can be preselected, tested, go through R&D, and, finally, 5 or 10% reach the states of production and sales.

But in many R&D and other organizations, especially of course government projects, there is somewhat an inversed funnel (*Fig. 8*).

How do people feel in this system? They are generally very busy – most even medium happy. Except the real innovators: they quit. But the rest organizes, structurizes, administrates, writes reports, and – asks for higher salaries.

Not many brilliant ideas reach the relatively large laboratories. Too many risky, too long-term, or even silly ideas have to be pursued and spoil even the reputation of excellent R&D. The major and most difficult question. What should we invent?' remains unanswered, the how to invent is now a widespread art in most of our facilities. So the methodology of idea generation will be an important topic for the next months and years.

Creating an Innovative Climate

But other dangers await the well-organized R&D machinery. The management at all levels is proud to show competent researchers, wonderful laboratories, and an excellent organization hungrily waiting for problems. Let's look to our funnel system again (*Fig. 9*).

Guests, politicians, students are shown round through the laboratories and consume time of all levels (eating and drinking). More and more controllers ask for facts and figures, written reports, project costs, costs per employee, useless RONOAs, and so on. More and more elderly researchers work in administration and produce paper. Even R&D people love to be sent to plants as a fire brigade, because they can really see success. Psychologically, it is easier to justify their monthly salary with small problems solved everywhere. By definition, R&D centers are excellent service centers because they are well equipped and well organized. This leads to meetings to justify the expenses to set programmes and so on. Customer claims are generally well treated and answered by R&D people. Altogether, the wonderful capacity of our R&D organization is eaten up by paper production, red tape, controlling, and a lot of other nonsense. Instead of new products and new production processes, we get paper, brochures, and presentations. The real yield drifts to nearly zero.

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From this we may learn that the best people, the best laboratories, and the best organization alone does not yet mean a creative and productive atmosphere.

Let us look again to the elements of a well-organized and orderly R&D system:

- Motivated coworkers
- An expedient organization
- A clearly structured project procedure
- Interdisciplinary teams
- A functioning infrastructure
- Permanent education
- Project leaders

As we have seen before, this is wonderful, but it just doesn't work. An organization always has to be challenged, shaken up. I would like to call this interference centers:

- 'Project Champions'
- Emergency situations, stress
- Lack of work, boredom
- Contacts over sector boundaries
- Coffee-table conversations
- 'Play corners' for researchers
- Customer contacts

Very often, chaos has been proposed as the real type of organization, but all the experiments show that it does not work either. We need clean laboratories, we need precise analysis, inventing products for later GMP production, so there must be an element of precise structure of glass-clear analysis and precise recording. This leads to the conclusion that only the interference of a dual system, well-organized and orderly R&D and interference centers (chaos), leads to results. If I personally claim to have invented or discovered any law of nature, it would be this one:

'Ideas for innovation and inventions are conceived at the centers of interference in a well-organized and -structured research and development apparatus.'

Let us now assume that we really have created an innovative atmosphere and that we have a good balance of a well-organized system and interference centers.

We have done our homework to find a good project. The evaluation gave a good result including especially the dominant factors so the project starts relatively well, is generally even above schedule after the first phase T1 (*Fig. 10*).

Practically in all projects, nearly a law of nature, again, a lot of difficulties occur. The crew gets frustrated. There is a real breakdown. I would call it the disillusionment phase leading to T2. There, we either give up or reorganize our project, motivate our crew again, and then it will need

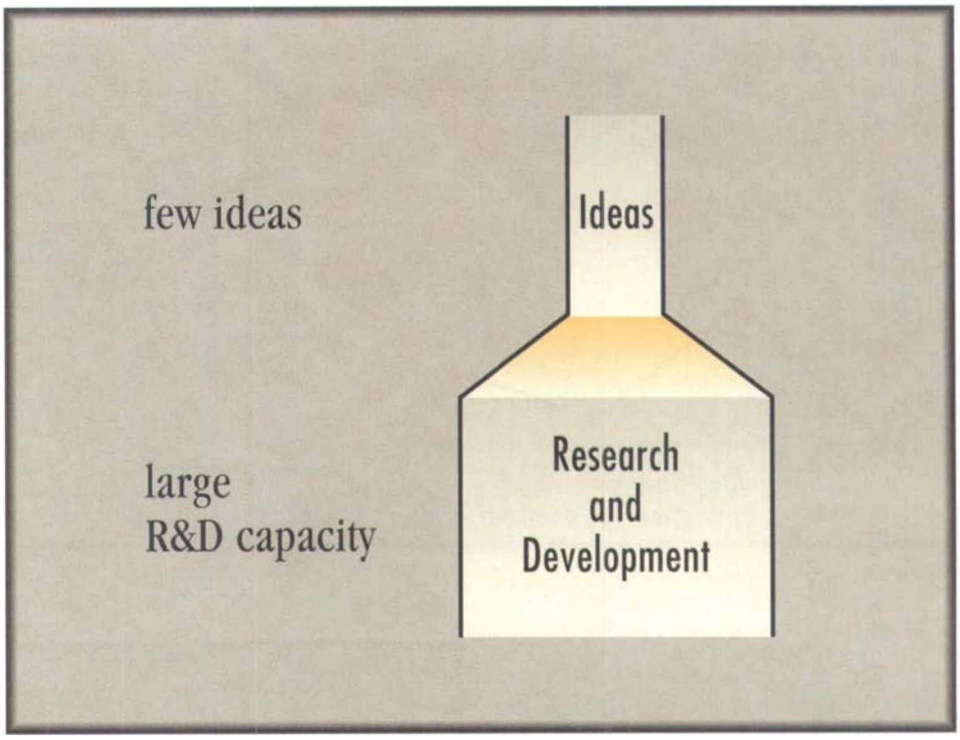

Figure 8

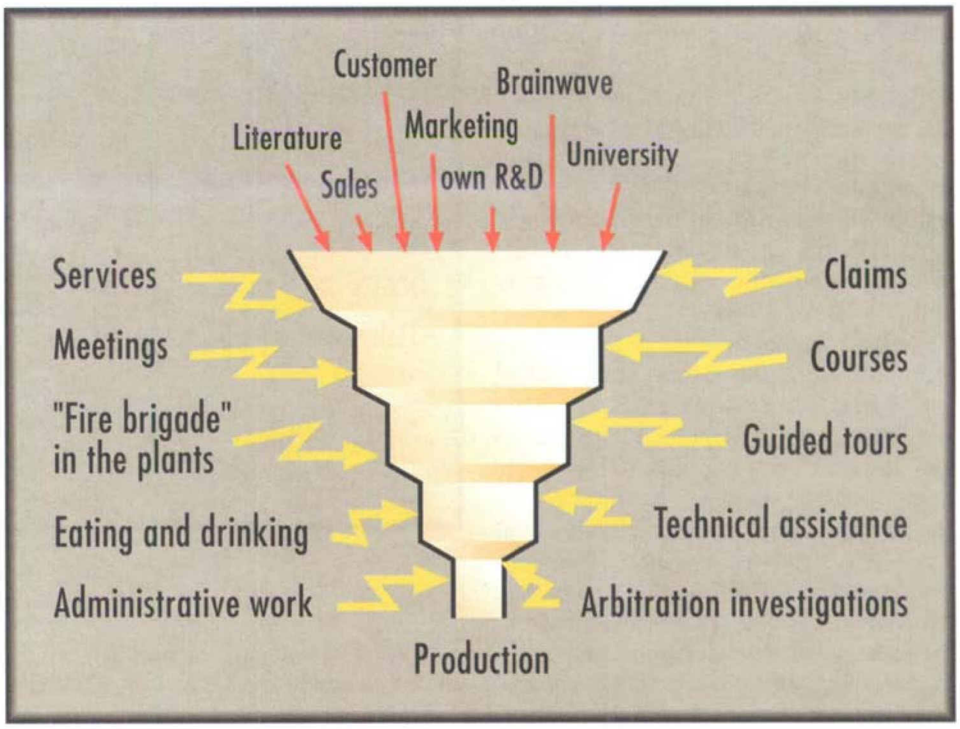

Figure 9

hard work even to get to the level of T1 again. Let's assume we reach T3. If we survive this phase, it generally leads in a reasonable time to T4 or a 100% success.

Psychologically it is not easy to survive these ups and downs. A project has to withstand a real bombardment of nasty questions. Many of the initiators feel frustrated or even insulted. But even if we have solved all the technical problems, the most crucial one in our days is even harsher than the trickiest internally. Will the customer order? And this in regard to today's economic situation.

Research and Legality

Another important ingredient for fruitful R&D is a certain degree of freedom. Given this free playground we discussed earlier, the most rewarding discoveries

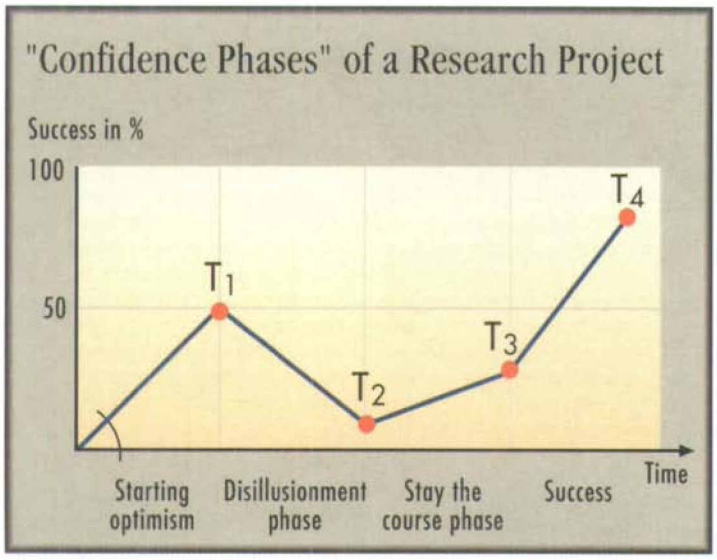

Figure 10

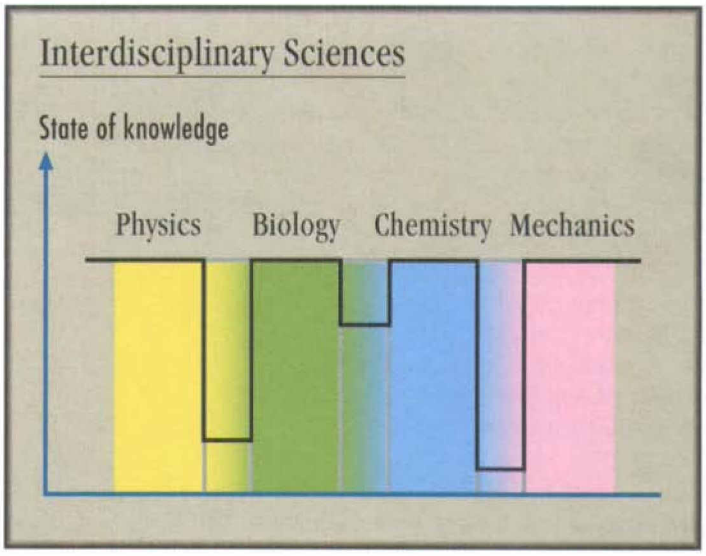

Figure 11

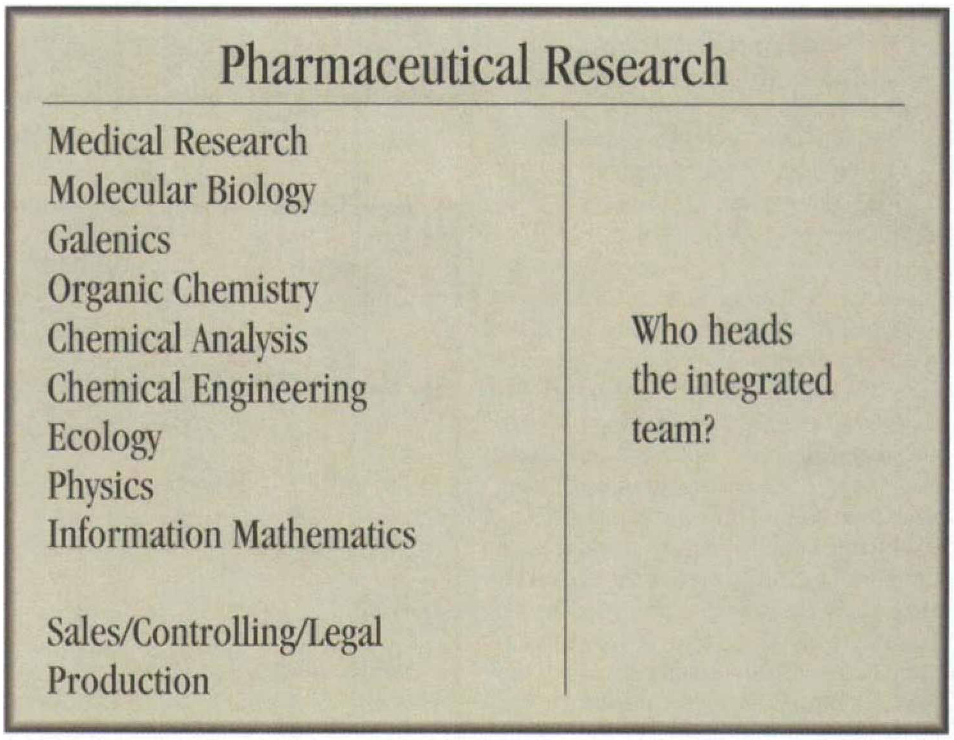

Figure 12

very often occur on side-arms of a well-organized project or as a fall-out. And anyway even with orders and control, you cannot stop innovators.

Three centuries ago, *Galileo Galilei* discovered the major principles of our planetary system. State and Church forbade the theory and banned *Galilei*. But just five years ago (1993), the church court in Rome revised the verdict: our planetary system is now indeed allowed to be heliocentric. *Albert Einstein*'s theory of relativity was accepted more quickly. Shortly before the explosion of the first Russian atomic bomb, the Soviets officially approved the equation $E = mc^2$ as correct and, therefore, allowed.

Popular understanding, political or religious intention, desirability and so-called usefulness are old problems; there is no general formula. In the past the local princes and the church determined what was to be researched and what not. In spite of constraints and narrow-thinking, there was at times still a forward-looking, often concealed liberty. Today research has become expensive; in democracies the people in the broader sense decide and finance it.

Does the public always decide wisely? Does the treatment of the 'borderline' biochemicals/gene technology differ so strongly from the *Galilei* trial? Can a local ban prevent unwanted knowledge being discovered and disclosed?

Out of fear and uncertainty about the unknown in our democratic countries, people would like to lock up new technologies like genetic engineering, in prisons like cages. But there are no such cages. We have only two options. Either to be relatively liberal in our Western countries, or illegal and less orderly in the rest of the world. But genes, bacteria and knowledge don't give (a damn!) about national borders. R&D and the best researchers would leave for more liberal reasons. The handling of science and research is a question of education, not of legislation.

Interdisciplinary Sciences

Future developments will more and more take place at the interfaces of traditional disciplines. *Fig. 11* shows, in a schematic way, the state of knowledge about these interfaces. The interface of biology and chemistry is well developed, while the interfaces between physics and biology and chemistry and mechanics are relatively underdeveloped. As a practical example of the reality of interdisciplinary research, we can look at the disciplines needed to conduct pharmaceutical research. *Fig. 12* is a list, probably incomplete, of the members of the ideal pharmaceutical research team. One essential question, who heads the integrated team? Hopefully, it will be the chemist (as it was between 1850 and 1970) but only if we manage to upgrade university studies in this respect.

Shareholder Value

I would like to return to the question implicitly raised at the beginning of this discussion. What constitutes shareholder value. This is a topic that can generate more heat than light. I would like to pose it in a slightly different way. How does a company generate shareholder value? Most business leaders would talk about providing a good (excellent) return on investment. This is in my view again the product of a multiplication.

$$\text{Shareholder Value} = \text{Customer Satisfaction} \times \text{Employee Motivation} \times \text{Service to the Community}$$

It is another conceptual equation to show what I propose are the necessary components for the creation of shareholder value. If these three factors can be optimized, shareholder value will be optimized. You will note that return on investment does not appear in this equation. Economic results are derived from customer satisfaction, which can only be achieved through employee motivation and service to the community.

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Summary of Afternoon Discussion

A. Rusanov (President Mendeleev Russian Chemical Society) informs about the 16th Mendeleev Congress, May 1998, in St. Petersburg, Russia. It is a Ceremonial Congress; 250 years since the first opening of the scientific laboratory. First circulars will soon be distributed.

A.J. Nuñez Sellés (President Cuban Chemical Society)
is excited about the idea of having a Presidents Meeting, and proposes to organize it regularly during IUPAC congresses. He raises the question, if and how societies of developed countries could help societies of less developed countries.

A. Fischli (President IUPAC)
informs that Presidents Meetings at IUPAC congresses had been realized previously, but it is entirely up to the local organizing society to decide on having one. Important is to have an attractive topic.

P. Walter (President-Elect, American Chemical Society)
expresses his concern about the lack of public understanding of what chemists do and of the importance of chemistry: What can be done to improve the situation? The American Chemical Society is organizing national chemical weeks to demonstrate the good aspects of chemistry. In 1999, a world chemical day will be organized. These are all long-term solutions, but what we need are short-term solutions. We have to improve the communication skills, so that the general public will understand. He asks what other societies are doing in this field.

M.J. Vernengo (President Asociacion Quimica Argentina)
recommends to exchange information among societies continuously, *e.g.* by e-mail.

E. Winterfeldt (President Gesellschaft Deutscher Chemiker)
National open-door days are organized in Germany, primarily in cities which have chemical plants and chemical operations. People from all the villages in those regions are invited to attend. He thinks that the attitude of teachers in schools has to be changed.

J.-C. Brunie (General Secretary, Société Française de Chimie) recommends to improve communication also within the chemical community.

A. Shani (President Israel Chemical Society)
stresses the importance of communicating already with high schools and primary schools. Make a bottom-up approach!

E. Breet (President South African Chemical Institute)
informs about their successful and good experiences with ties showing the periodic table of events.

H. Ohtaki (President Federation of Asian Chemical Societies) informs about the Federation (24 societies from 24 countries), advocates mutual help, *e.g. via* IUPAC, proposes a new organization 'Promoting Chemistry'.

A. Kalman (President Hungarian Chemical Society)
is excited about the idea with the ties (*E. Breet*), believes that small things will sometimes have more success, supports also the idea of organizing open-door events, and recommends to maintain the Presidents Meetings and also to use an e-mail network.

L. Niinistö (President Federation of European Chemical Societies)
informs about the Federation of European Chemical Societies (41 member societies from 32 countries) and its working parties and divisions, hands out the annual report 1996 of the federation.

K.-N. Chen (Chairman of the Committee on International Affairs, Chinese Chemical Society located in Taipeh)
informs about the publication of an educational video tape (public education), received grants for that, and is open for suggestions from other societies.

A. Shani (President Israel Chemical Society)
thanks the New Swiss Chemical Society in the name of all participants for the organization of the International Meeting of the Society Presidents and for its hospitality.