The transition of the chemical industry

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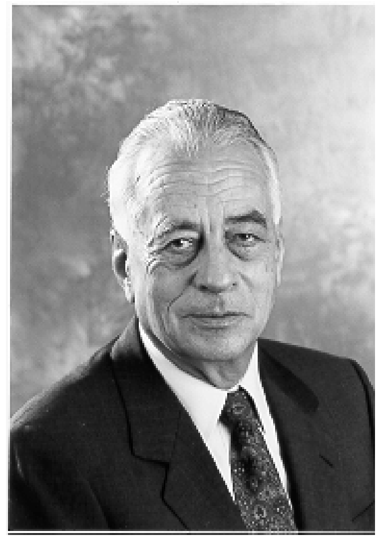
Presented to the Meeting of Chemical Society Presidents held in conjunction with the IUPAC Congress and General Assembly, Geneva Switzerland, 21 August 1997



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Introduction

The global Chemical Industry is in transition from a structure that has existed since the beginning of the post-war era. This structure 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 in 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.

The transition of the chemical industry

1980	2010
Integrated Petrochemical companies 'the big 9'	Large Life Science companies
Large mixed product chemical companies 'classical'	Small to medium specialized companies
Specialty chemical companies	Emerging R&D driven companies
Small chemcial companies	'Me too' companies for isolated/protected markets
Sate owned chemical companies	Medium suppliers to the 'outsourceers'
	Large basic chemical companies

Fig. 1 The transition of the chemical industry

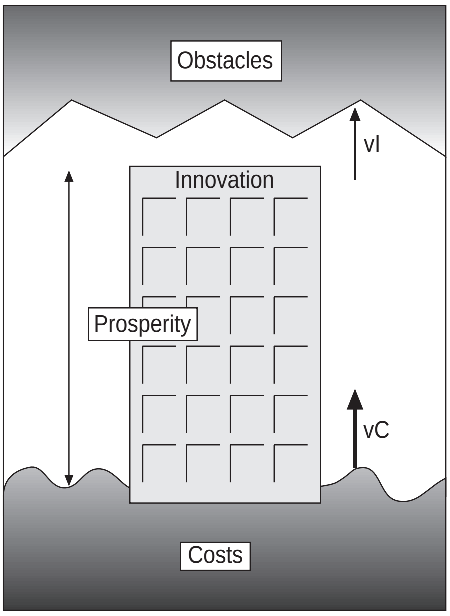

Fig. 2

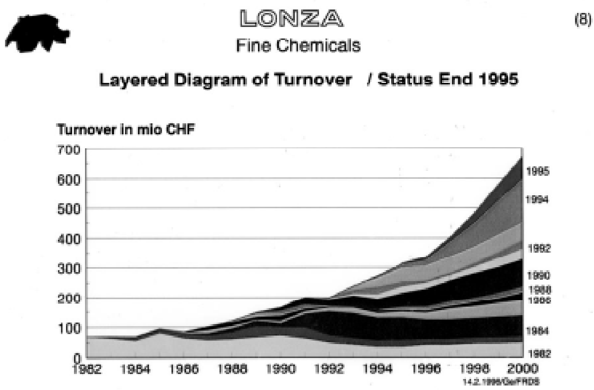

Fig. 3

The role of innovation

Figure 2 shows a building which represents a chemical company, or for that matter, any other enterprise in a modern economy. The building is slowly being flooded from below. The inhabitants must build new floors on top to maintain or increase the number of habitable floors. The number of habitable floors is a measure of the prosperity of the organization or society. The rising water level represents the increase in costs of the firm's activities. The rate of increase of costs is represented as v_c, while v_i represents the rate of innovation. It is by innovation that new floors are added to the building. Much of the activity of the past decade has been focussed on reducing v_c. The sustainability equation for the system therefore being $v_i > v_c$. Figure 3 shows the proportion of the current turnover of a member of the Alusuisse-Lonza Group from products developed since 1982. LONZA is a typical example of a high-tech, medium sized chemical corporation.

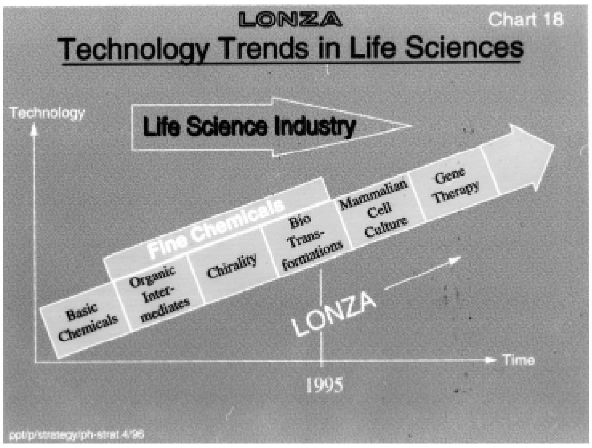

Fig. 4

The same point can be made in a different way by considering 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 therapy. Let us take as an example the LONZA plant in Visp (in the Valaisan alps, not far from Geneva) In this connection, we can note that the number of LONZA employees with technical degrees has increased from less than 200 in 1980 to over 300 in 1997, while the number of other employees has changed very little. Increasing from slightly more than 2200 to slightly less than 2400.

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. Figure 5 is a diagram illustrating one of those myths, the myth of the linear progression from problem generation to result. The mythological nature of this linear process

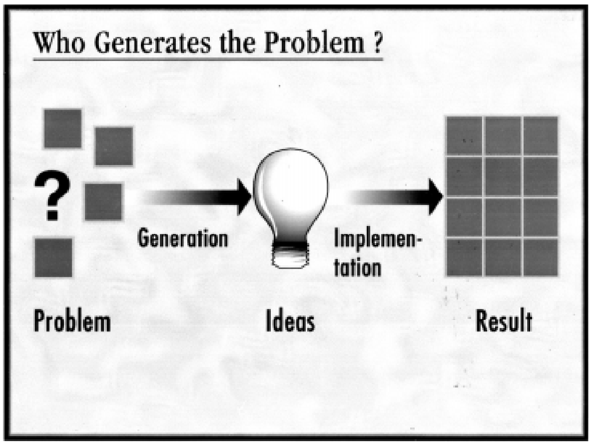

Fig. 5 Who generates the problem?

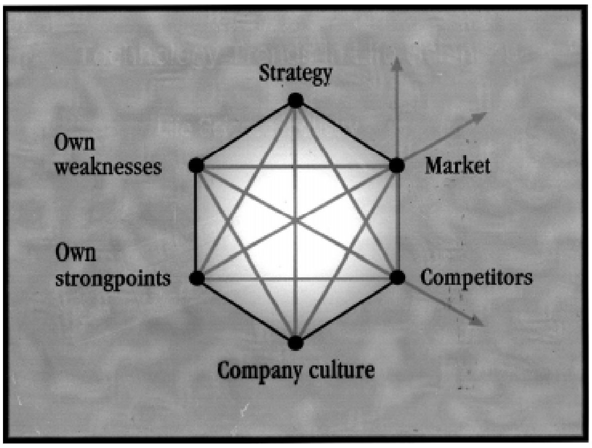

Fig. 6

lies not only in the lack of feedback loops and its neglect of what could be called the cultural aspects of innovation, but chiefly in the assumption that the problems are all around us. I would like to make the case that we have a highly advanced problem-solving system in our research laboratories, but a primitive problem selection process. The mindless application of this problem solving ability to problems of low value leads to the situation summarized in the following bit of folk wisdom: 'It is easier to make research from money than money from research.'

Figure 6 is a depiction of the morphology of the problem finding process. The complexity of the diagram reminds us that this process is still one of judgement rather than a mechanical one that can be applied by formula.

Project evaluation

The quality of a project can be represented by the following equation:

$Q = M{\cdot}F{\cdot}L{\cdot}[a + b + c\ldots]$

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

If any of the dominant factors, *M*, *F* or *L*, is zero the whole equation is zero. Each of these factors can be influenced, as can the qualifications *a*, *b*, *c*. The latter are factors such as: can we produce it?, is our R&D competitive?, is there a patent problem?, etc. This is, of course, not simple mathematics. Most of the problems of life do not follow classic mechanics, but rather the mathematics of fractals. The issue of the time horizon of projects is an important one. Two statements can be made on this subject:

*In a life science chemical company more probably 0.1 to 0.01%.

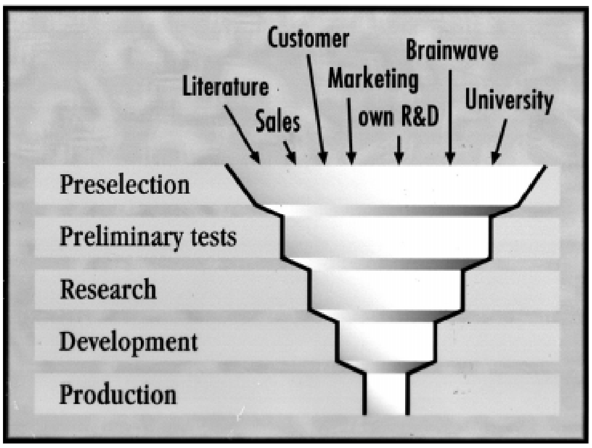

Fig. 7

- Most industrial corporations die, if they have only short-term goals
- Most well established and wealthy corporations, who generally foster and subsidize only long-term projects, die as well.

It is not easy to find a reasonable and affordable mix of long and short-term projects.

I have emphasized the importance of finding new project ideas. Figure 7 depicts the classic notion of product development. A continuous and large flow of new ideas from within and without the corporation is pre-selected, tested, gone through R&D and finally 1 or 5% reach the stages of production and sales.* Figure 8 shows an all too common actual inverted funnel. Because of a permanent demand for funds, the R&D capacity has expanded—but there are no really good project ideas (especially for government-funded research). How do people feel in this system? They are generally very busy—most even medium-happy. Except the real innovators, who quit. However, the rest organize, structurize, administrate, write reports—and ask for higher salaries. Not many brilliant ideas reach the relatively large laboratories. Too many risky, too

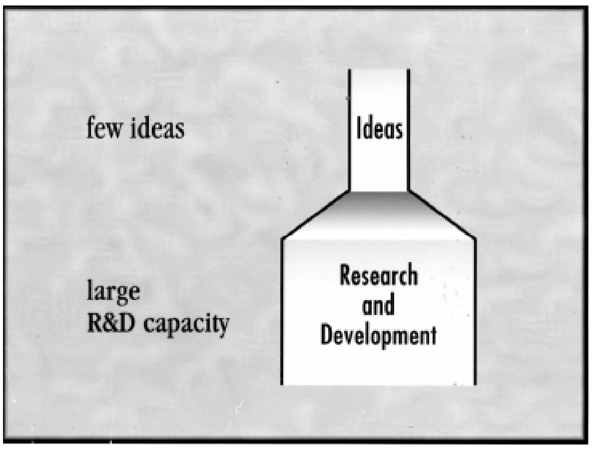

Fig. 8

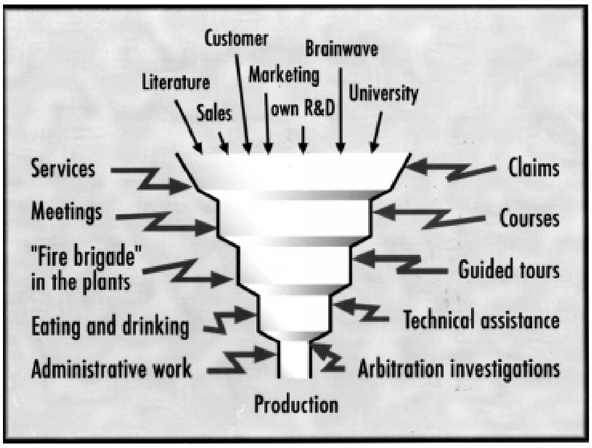

Fig. 9

Elements of a well-organized and orderly R&D System

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

Fig. 10 Elements of a well-organized and orderly R&D system.

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 laboratories. The methodology of idea generation remains the important question.

Interference Centers

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

Fig. 11 Inference Centers.

Creating an innovative climate

Another funnel, shown in Figure 9, describes the activities of many large laboratories. The wonderful capacity of an 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 almost zero. From this we may conclude that the best people, the best laboratories and the best organization alone do not mean a creative and productive atmosphere. Figure 10 shows the elements of a well-organized R&D system. This is a wonderful system, but it doesn't work. An organization always has to be challenged, shaken up. I would like to call this interference centers (Fig. 11).

Chaos has been proposed as the real type of organization, but all experiments show that it does not work either. We need clean laboratories, precise analysis, 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) lead to results.

What does Industry need from the State?

1. **A good high school education**
2. **University education**
3. **Permanent education**
4. **University Research**
5. **Research, development, education at the 'infrastructural boundaries'**
6. **Top level research in selected crucial sectors**
7. **Applied research and evelopment at engineering schools**
8. **Providing a helping hand with regard to technology transfer to smaller and medium-sized enterprises**
9. **An innovative climate**

Fig. 12 What does industry need from the state?

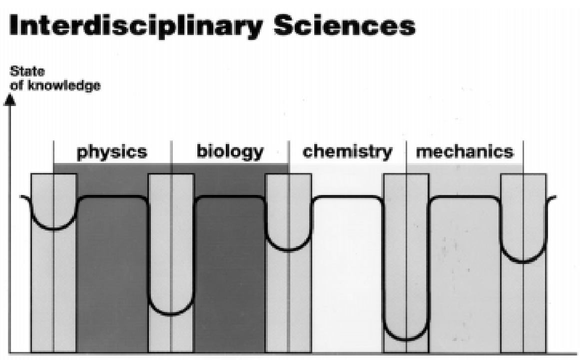

Fig. 13 Interdisciplinary Sciences.

PHARMACEUTICAL RESEARCH	
Medical Research **Molecular Biology** **Galenics** **Organic Chemistry** **Chemical Analysis** **Chemical Engineering** **Ecology** **Physics** **Information** **Mathematics** **Sales/Controlling/Legal** **Production**	**Who heads the integrated Team?**

Fig. 14 Pharmaceutical research.

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

What does industry need from the state?

Figure 12 lists those things that the state can do to support industry. As you can see, these are not direct support, but rather the development of human capital and the facilitation certain kinds of technology development and technology transfer.

Interdisciplinary Sciences

Future developments will more often take place at the interfaces of traditional disciplines. Figure 13 shows, in a schematic way, the state of knowledge about those 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. Figure 14 is a list, which is probably incomplete, of the members of the ideal Pharmaceutical Research team. One essential question, *who* heads the integrated team?

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. That is, in my view, a result. How does the company accomplish this? Figure 15 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 a return on investment does not appear in this equation. Economical results are derived from customer satisfaction, which can only be achieved through employee motivation and service to the community.

Shareholder Value = **Customer Satisfaction** × **Employee Motivation** × **Service to the Community**

Fig. 15