CHEMISTRY AND ENVIRONMENT: A FIELD OF INTERDISCIPLINARITY*

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Chemistry and, more so, Environment are both very broad concepts. Each covers a field of interdisciplinarity. Consequently, relationships between Chemistry and the Environment constitutes a dense network of interdisciplinarity. This remark has several positive or negative implications which will be ilustrated by examples in various domains: publishing, education, research, economics, legislation. Ignorance of it has been the source of difficulties, misunderstandings and mistakes. This is a major cause of the divorce between the "irrational" beliefs of radical ecologist groups and the "rational" arguments of industry. The approach of environmental matters must be synthetic, global and "integrated", they are not always accessible by experimental methods. This opposes the analytical cartesian practice of separating knowledge into numerous disciplines and subdisciplines, frequently based on specific experimental methodologies, as is the case in Chemistry. An interdisciplinary approach is mandatory for dealing with environmental matters. Reality is a very complex system. Treating parts of it, such as air or water pollution, waste disposal soil contamination, stratopheric or tropospheric ozone, the greenhouse effect, security or public acceptance is necessary for accumulating scientifically proved data, but this is insufficient. These different parts are too strongly related. Let us limit the discussion to the chemical community, although it could easily be extended to others. All divisions of Chemistry, including chemical engineering and all industrial companies are jointly concerned with all types of environmental disturbances. They might take a share of responsibility for these problems. However, altogether, they may play a major role in their detection, their study, their reversal. Solidarity is the human translation of the academic interdisciplinarity. There is an interesting analogy between environment and life. When a living being is dissected into is components life disappears. Anatomy is not medicine. Real world cut into slices is not reality anymore. Chemistry might be for the environment what medicine is for life.

Keywords: chemistry; environment; interdisciplinarity.

I. CHEMISTRY AND ENVIRONMENT

Environment and Chemistry

The relationship between chemistry and the environment is a long story, a very long story, beginning far back in the ancient times.

Before going ahead, let me be clear on the meaning of the words I am using.

I can "environment" the environment of man on Earth. With such a definition, this concept includes all forms of matter: gases, liquids and solids (formerly designated by the three "elements" air, water and earth) and all kinds of living beings: plants, animals, including humans. Briefly speaking: everything.

Ecology is the science dealing with the environmental questions: of course it is divided into a range of disciplines and subdisciplines. You may, or not, consider political ecology as one of them. I do not intend to argue on this multidisciplinarity.

Conversely, I feel it worthwhile to spend some time on the definition of the word "chemistry", even if this is somewhat paradoxical in front of an audience of qualified chemists.

As you know, the word "chemistry" has a variety of meanings. We are used to living with, but this variety can be a source of ambiguity, or worse, of confusion.

Chemistry is - in the order of historical appearance - an ensemble of techniques, a science and a sector of the Economy.

We celebrate this month the bicentennial of the beheading of LAVOISIER by the French revolutionaries. He is generally considered as the initiator of chemistry as a modern science for some solid reasons which are abundantly detailed in the current literature. In fact, he was not alone in founding this new science (SCHEELE and PRIESTLEY, for instance) and this science was in any case not exactly new[1]. Even if the theory of phlogiston of G.E. STAHL has been proven as false by LAVOISIER, it was a scientific approach of real chemical questions. Before STAHL, we may remember J. B. VAN HELMONT (1577-1644), Robert BOYLE (1627-1691), the "Cours de Chymie" of Nicolas LEMERY (1675) and some others. As a science, chemistry is not more than 350 years old, in the modern cartesian definition of the concept "science". That means that we refuse to admit as scientific the hermetic discourses of the alchemists. Nevertheless, a large part of the techniques used by chemists have been developed for the unfruitful and vain researches of alchemy.

Chemistry as an "industry", i.e. a sector of the Economy, is still more recent. It was born during the 19th century but became truly a factor of national importance at the beginning of the present century. I suggest a date: 1913, for the first high-pressure synthesis of ammonia by HABER in Germany. Obviously, the chemical industry exploits the possibilities of the chemical techniques and ideas of the relatively recent chemical science. But industry has its own specificities, for instance, the amplitude of its social implications.

Consequently, the word "chemistry" covers at least three "disciplines", different but not independent.

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For millennia, chemistry was only a technical activity before becoming a science and, later on, a recognized economical sector.

A Few Prehistorical Considerations

Man, this "nude monkey", is a puny and awkward animal. Fortunately, his insufficiencies are more than compensated by the flexibility of his mind which appears in his creativity and his aptitude to turn an individual discovery into a community practice. As any other animal, more than most other animals because of his physical insufficiencies, he cannot survive without aggressing his environment. His basic needs - food, clothing, shelter, security - cannot be satisfied without consumption, exploitation, destruction of natural resources.

For millennia, these resources were truly natural, I would say. Food was obtained by gathering wild fruits and plants, then, more and more during the Ice Ages, by killing wild animals; clothing was provided by animal furs; security was helped by solid wooden sticks, and so on. I do not see any trace of chemistry in that vision of the living conditions of our remote ancestors.

Apart from the living world - plants or animals - environment is (fortunately) chemically stable, at least approximately. Air, water and soil do not react with each other. To transform matter by means of a chemical reaction one needs something else: energy (i.e. the fourth aristotelian "element": fire). No chemical reaction, no chemistry could have been possible without mastery of fire, without Prometheus. That was a necessary condition, but not a sufficient one.

What was the first chemical process developed by man? Who was the inventor of the chemical industry? I propose the following answers: the first chemical process, the first chemical reaction intentionally performed for satisfying a social need was the reduction of iron oxides by charcoal (fig. 1). The inventor's name? Hephaestos for the Greeks, Vulcan for the Romans, Tubalcain according to the Bible*.

Fire control and metal extraction by chemical means have been two major breakthroughs in civilization. When and where have these discoveries taken place? The first traces of fire next to human settlements have been dated around 400000 B.C. in China. Prometheus could have been a cousin of the "Peking man". The first man-made iron appeared at a much later date, probably around 5000 years ago in Egypt. Vulcan could have been Egyptian, like another personage: Hermes Trismegistus, the mythic founder of alchemy, possibly during the same period.

Why such a long time between these two major discoveries? The first one was a necessary condition, but another condition was also mandatory: a chemical development could not be envisaged by a nomadic group. Sedentariness began with the domestication of wild wheat about 9000 years ago, somewhere in the Middle East[2].

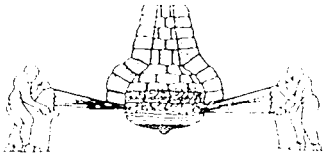

Figure 1. An early furnace (roman period) from "Ferrous Production Metallurgy", John L. Bray, J. Wiley, N. Y., 1950.

* People have always been conscious of the importance for mankind of the discoveries of Prometheus and Hephaestos. They have been distinguished by a high ranking in Greek mythology. Prometheus was said to be the initiator of humanity (with his brother Epimetheus and the help of Pandora, we frequently forget them, cf. Infra). We could say now that he has been the father of all types of civilization. I find in those myths some anology with the modern practice of the Nobel prizes.

Nomadic tribes were moving out of a place when they could not survive there, having exhausted the resources of the local environment. They became sedentary when they succeeded in developing a "sustainable" agriculture - to use a fashionable word - providing them with renewable resources. Then, and only then, could they establish some permanent "industrial" activities which need furnaces, such as pottery, bronze or iron production.

At the same time, the relationship between man and his environment had changed. Agriculture was modifying landscapes, cities were built, soils were dug for exploiting ore deposits. Waste disposal was appearing as a collective problem.

The Environmental System

The scene represented on fig. 1 is not only of historical interest, it is also a good schematic representation of any industrial process, particularly any chemical process (fig. 2). The two workers are symboles of the permanent human intervention which starts at the conception of the process, continues for its development and is active all along its industrial exploitation, including the social diffusion and utilization of the product. The product can be an object (iron ingot, tool, armament, ...) or a service (transportation, communication, protection...).

These two workers cannot have any concrete activity without the help of the environment, the only source of all types of materials transformed during the process, of course within the limits imposed by the natural laws. That is where chemistry appears.

From the stack of the furnace gases are polluting the atmosphere: sulfur dioxide, greenhouse gases, dioxin among others. Solid wastes have to be disposed of. Since Vulcan, there has been nothing really new in the relationship between chemistry and the environment. Nothing new in the physical reality, but there had been a significant evolution in the understanding of this relationship.

Until, let's say, 300 years ago, fig. 2 would have been insignificant. Natural resources were supposed to be unlimited.

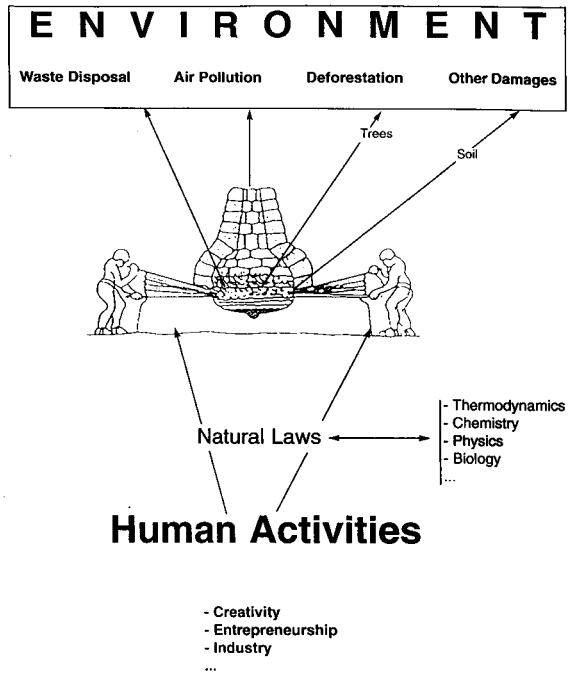

Figure 2. Process/environment interaction.

Pollution and wastes were considered unavoidable. Most of all: technology, per se, was treated as a secondary matter. Alchemy was triumphant with its mistrust of reason. The "great masters", on the basis of inherited ideas, were looking for the reproduction of the primordial matter which was at the origin of the universe in God's hands. Research at that time was looking backward.

Remember: for realizing the "philosopher's stone", the alchemist had to adopt all forms of intellectual means - physical, chemical, but also musical, aesthetic, theological, etc... He was concerned only with qualitative aspects (order or appearance of colors, ...), never with the quantities. At that time, technology, even if it was useful for the hermetic experiments and occasionally for social uses, was receiving limited interest from academy. Newton, Leibnitz (who were practicing alchemy), Galileo, Descartes and some others imposed the triumph of reason which spurred scientific advance and let to the industrial revolution. The concept of "progress", either material or social, became dominant and Prometheus a star symbol of mankind, mankind liberated by science. Thanks to the apparently unlimited capabilities of the natural riches and laws, the 19th century and the first half of the 20th century saw the triumph of a promethean perspective (fig. 3).

The "scientistic" approach has been, and is still largely, the background of our scientific and technical education: man has many needs, vital or not, thanks to his intelligence, he will satisfy them, finding everything necessary in the environment. The promethean perspective is univoque and fundamentally optimistic. All technical information coming out of a public-relation service of any industrial company is delivered in a promethean style.

Over the past two or three decades we have observed the development of another perspective which is in total opposition. A growing antiscience and antitechnology feeling in the population of the developed countries and, consequently, among politicians. Technology has become a convenient target for people seeking a scapegoat for societal issues[3]. According to this approach most of the human needs are futile, artificially created, without sound significance. Satisfying them is a waste of (rare) resources, a fruitless effort accumulating dangers for mankind, much more important than the illusions of "progress" which, in fact, precipitates it towards calamities: permanent risks, cancers, nuclear war... I call this perspective epimethean (fig. 4) to remind that, in Greek mythology, Prometheus had a twin-brother Epimetheus who was stupid enough to commit all possible errors. His worst error was probably his affair with Pandora, whose jar has been the source of all mankind's troubles.

The epimethean perspective is fundamentally pessimistic. According to it, an industrial process is inherently bad in damaging the environment, but its industrial exploitation is also creating various dangers to humans. The same thing is true of the products: cars are dangerous and polluting the atmosphere, pesticides have bad effects on our health, CFC in our refrigerator will ultimately destroy the stratospheric ozone and cause UV-induced cancers, and so on.

Invoking as references Prometheus and Epimetheus is a logical consequence of my prehistorical introduction and I find a serious support in the sages of the ancient Greeks for presenting now the environment system by a diagram (fig. 5) which is a synthesis of the promethean and epimethean perspectives*.

In Nature man is not alone to have vital needs. Environment itself has needs to be protected against man's stupidity or against its own natural failings. The comprehensive satisfaction of all these needs is a large part of what we call "civilization". Whether an action is progress or not is just a matter of appreciation.

Nature - including man - has its laws. The purpose of science is to discover and study them. Consciously or not, humans must take these laws in account in these activity. Chemistry appears then in the first rank, historically because it was at the very beginning of all civilizations, but also relatively to its importance, today, because of its relationship with the environment.

In the preceding sentence, the word "chemistry" has the ambiguity already mentioned: technology, science or economic sector? Which is considered here? The answer is: all three.

In the environmental system there is not necessity, nor any reason, to distinguish between disciplines - a fortiori between subdisciplines like organic or inorganic chemistry, air or water

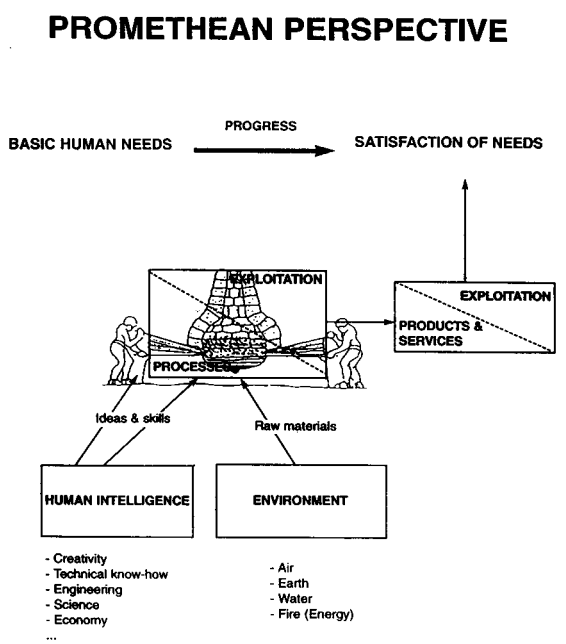

Figure 3. Promethean perspective.

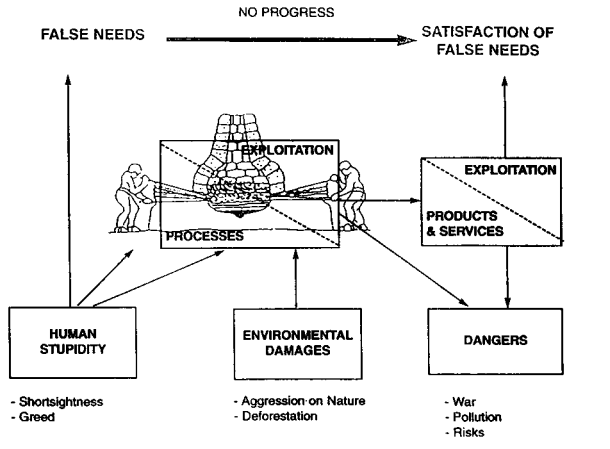

Figure 4. Epimethean perspective.

* The fact that Prometheus and Epimetheus were twins is obviously significant. Any technique undoubtedly useful for man has always, necessarily, a negative effect either by itself or by accident (a stupid or vicious operator, see Bhopal for instance). Like a coin, a technique has always two faces, one is promethean, the other epimethean).

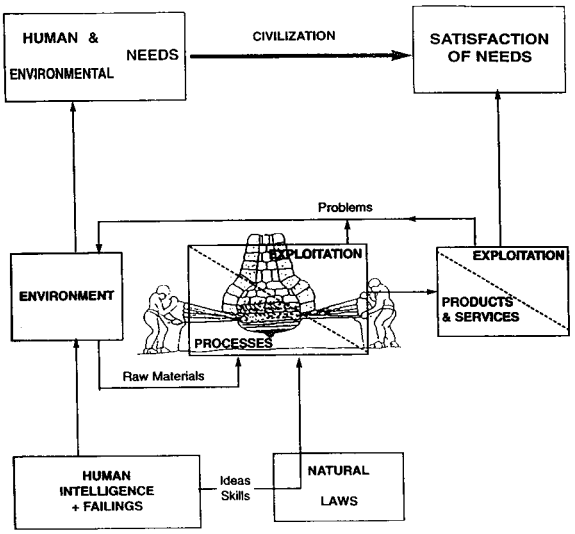

Figure 5. Environment system.

pollution. That is what I call a field of interdisciplinarity*. A part of the environment is not the environment anymore. Similarly, when a living being is dissected into its components life disappears. Anatomy is not medicine.

Definition:
A field of interdisciplinarity is a domain of knowledge which cannot be included in a limited number of scientific disciplines and, has a relationship with some if not all of them (Examples: environment, health, safety, ...). The relationship between a field of interdisciplinarity and a scientific discipline (chemistry, for instance) is a field of interdisciplinarity.

Environment, life, health, safety, ... must be considered globally, in an "integrated manner", they are open systems.

On the contrary, chemistry may be considered as one discipline, or an ensemble of three disciplines, themselves divided in a certain number of subdisciplines. Each of them is still chemistry. We could say that chemistry is a "field of multidisciplinarity". It is a closed system. The above definition does not apply to it.

II. A FIELD OF INTERDISCIPLINARITY

After these considerations, very general indeed, I would like to apply them, briefly, to a series of problems.

1 - Industry

Industry is the domain where interdisciplinarity is easily understood and practised - for Academia, it is the reverse. This is a source of discussion: Industry considers that universities do not provide them with newly trained chemists well adapted to the diversity of its problems. In France, the higher is the level of the diplomas, the more bitter is this discussion.

Let us consider the arrows of fig. 6. It is a good example of an epimethean approach. This drawing has been found, not on a radical ecologist leaflet but in a recent informative paper of Chemical & Engineering News[4] on the E.P.A rule requiring chemical manufacturers to cut their toxic air emissions nearly 90% from 1990 levels within 3 years.

The Chemical Manufacturers Association (CMA) cannot be enthousiastic, given the high capital and operating costs generated by this rule, but has declared to be ready to comply with it. A director of CMA is quoted to have said: "EPA deserves a lot of credit for issuing this major rule". The environmental groups applaud EPA even if they criticize some details of the rule.

Under those conditions, fig. 6, represents a good ilustration of the balanced environmental system proposed above.

Admittance of this system suppose from one part (industry) to give up a pure promethean approach, from others (environmentalists) their systematic epimethean vision.

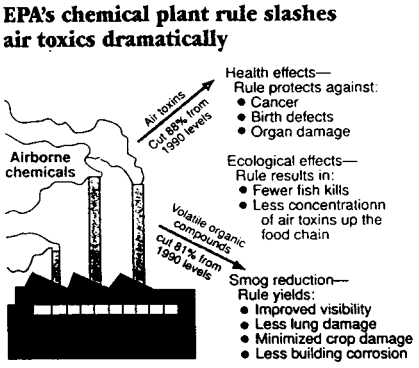

Figure 6. From 4.

2 - Education

Academia is organized on a disciplinar,* even a subdisciplinar basis. A multidisciplinar (or transdisciplinar) action is possible, often with difficulties of various types: administrative, psychological, geographical, (distances between university buildings), etc...

The field of interdisciplinarity chemistry - environment induces a large number of difficulties of that sort when it is envisaged by an university. That is rarely the case on a broad basis. Anyway, only a part of the field can be treated as elements of courses in analytical chemistry, atmospheric chemistry, oceanography, physical chemistry, water chemistry, etc...

Having had the responsability of an Institute of Technology** where more than 600 engineers are trained at the M. A. level, every year, in all fields of engineering, I have been particularly concerned about three questions:

1- *How to introduce environmental matters in the curriculum of all students?* By means of special courses or through an

* There are other examples of "fields of interdisciplinarity", for instance: health care. Because of the complexity of the phenomenon called "life", the relationship between a seriously sick person and medicine could not be restricted to one medical speciality, may be even to medicine itself. No general practioner can pretend to understand everything essential for his patient's survival. This is not an insult to say that a specialist is concerned with a sickness or a limited group of sicknesses, not so much with the patient himself. When a patient consults several M.D. of different specialities, it is multidisciplinarity. Consulting one or several general practitioners is a tentative of interdisciplinarity.

* The three disciplines constituting chemistry are usually taught in different structures: science in university departments of chemistry, technology in departments of chemical engineering, industry in business schools or in "generalist" schools, such as in France: Ecole Nationale d'Administration, Ecole Polytechnique, Ecole Centrale de Paris, ... They are considered as the most prestigious establishments in the French Academia.

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evolution of the existing ones? The answer can be somewhat different according to the field of engineering, but evidence appeared that no specific courses could satisfactorily cover all aspects of environmental problems in a relatively short time compatible with the constraints imposed by the other necessary matters. Except for a limited number of specialized lectures, environment had to be considered as an important factor in all technical courses.

2 - *Then, why not open a new department of "Environmental Engineering"?* The answer has been negative for two main reasons:

- Industry would have been reluctant to recruit these non-traditional engineers,
- The faculty was not cooperative.

These two reasons were clearly consequences of the interdisciplinarity of the environmental problems:

- Industrialists prefer to give responsibility in the domain of environment to experienced professionals, having a broad competence in industrial practice, rather than to new graduates.
- Faculty members were not desirous to invest large efforts that would not be recognized by their peers as pertaining to their usually narrow academic speciality.

3 - *Then how to train specialists in environmental problems?* My answer has been and still is: in preparing a doctor's degree, i.e. through a research activity. A Ph. D. assures a sound competence in a specific area, not a broad competence in Environment.

My conclusion is clear: because of its subdisciplinarity structure Academia cannot deliver a competence adapted to the interdisciplinary nature of environmental problems.

By this remark, I am not suggesting to modify the organization of the academic establishments. I just say that we must take this evidence in consideration. It is the unavoidable consequence of the state of "field of interdisciplinarity"*.

What are the wishes of the students? The answer is probably multiple. But we may admit what was said by James S. TREFIL at the Pittsburgh Conference, last March[5]:

"To a student, science is problem-oriented (...), science is transdisciplinary. The division of university science among traditional departments doesn't make sense to a student and the student approach is appreciation rather than performance".

I find remarkable to compare this statement with characteristics of alchemy that I mentioned earlier: involvement of all types of disciplines and priority given to the qualitative aspects. Schematically the students would prefer the alchemist's approach to the scientific cartesian way of dealing with real problems, cartesian approach which led the universities to be structured in departments.

James S. TREFIL adds: "the emphasis should be on what the student needs to know, not what the faculty wants to teach". Such a statement, isolated from its context is somewhat ambiguous. If it means that students, supposed to be aware of their needs, must construct the curriculum, I will parly disagree: the faculty must, in any cases, keep the total responsibility of assessing the possibilities of the "working market" in defining the curricula. On the other hand, we cannot efficiently teach someone who is not interested. Are students interested in science? in chemistry? in the relationship chemistry-environment? This is seriously doubtful.

H. E. SIMMONS in his PRIESTLEY Medal address[3] insists on this question: "We are concerned with education of the great majority of students rather than the small percentage who will end up doing science (...). The chemical enterprise will find it increasingly difficult to operate effectively in a society that does not understand more than ours science and the scientific process. (...) Science, and especially the central science of chemistry, must be identified as something that is part of life and done by real people".

It might be a question of democracy's survival*.

3 - Edition

Being presently the editor-in-chief of the French chemical magazine "L'Actualité Chimique", I have a permanent problem with the abundant flux of news and articles related to environmental questions: do I group them in a specific "Environment" section? or do I follow the advice of several members of the editorial board who rightly consider that environment is not a part of chemistry and ask these papers to be published in the regular sections "Teaching", "Research" or "Industry"?** The current practice is marked by a persistant hesitation: in some issues there is an environmental section, not in the others.

There is a clear analogy between this debate and what we have observed about education. Environmental problems concern specialists, some are chemists. They must be taught, studied, published by and for specialists, as for any other scientific domain. But AT THE SAME TIME these problems ALSO concern non-specialists who ask to be and must be informed, made vigilant, cooperative, ...

When a chemist is working on specific environmental problems, for instance "solid wastes characterization", it is not easy for him to publish research papers: on one side the major international journals refuse them because the topic is not noble enough, on the other side, magazines and professional journals are eager to publish them but only if they are limited in size and in scientific level.

We are lucky to have several excellent interdisciplinary journals or magazines*** where good original or review papers on environmental matters are published, but a small number of them are especially dealing with the relationship between chemistry and environment.

In preparing this text, I received the announcement of a new journal called ESPR**** which could bring a solution to this insufficiency. It is interesting to quote the accompanying leaflet: "ESPR reports from an interdisciplinary outlook (with emphasis on natural sciences, but including legislation, regulation and economy). ESPR is chemical compound oriented but also covers all of Environmental Science (...)"

The difficulty to adapt a journal to a field of interdisciplinarity is quite apparent here: either ESPR will specialize on a well-defined area (chemical compounds and the environment),

* Let's consider again the similarity with medicine. We know how to train specialists. They are knowledgeable in a limited field, but usually ready for contributing to a multidisciplinary treatment of a patient even if cooperation between specialists is made difficult by problems of vocabulary, tradition, prejudice, ... The training of a general practioner to keep him in touch with new treatments are much more difficult (as it would be for a M. A. in "Environment Engineering"), this remark can be extended to all fields of interdisciplinarity. Another example: chemistry and safety.

* In several developped countries we may observe a real alarm on this question, aggravated by the fear that the political deciders are unconscious of it, being themselves rarely scientifically educated. Example: "Canadians' lack of understanding and appreciation of science is a serious matter in a democracy where decisions at all levels of government increasingly involve science and technology"[6].

** The same question is regularly put about papers on chemical safety. Another similarity between two fields of interdisciplinarity.

*** Nature, Science, La Recherche, Scientific American, La Vie des Sciences, etc...

**** ESPR = Experimental Science and Pollution Research Ecomed Publishers, R. Diesel Str. 3, D-86899 Landsberg/Germany.

or it "covers all of environmental science". The announced policy of doing both is ambitious. It is worthwhile to follow this attempt and to encourage it.

4 - Research

Even more than in education, research in academia is discipline-driven, for many strong reasons which need not to be repeated here. Of course this is not so true in industrial or governmental laboratories where most researches are problem-oriented.

That means that academia is particularly handicapped to cope with the chemistry-environment relationship. Industry also, for different and obvious reasons.

A tentative conclusion is that research in a field of interdisciplinarity has to be programmed and largely carried out in government laboratories or, better, in international centers.

Partial environmental research remains feasible in any laboratory. There are very good monodisciplinar research on environment, in many places, in analytical chemistry for example.

More often muldisciplinar programs are established and carried out with the same difficulties already mentioned for education.

Interdisciplinarity makes Environment an ideal central topic for scientific meetings. They constitute the best, if not the only way to adjust the vocabularies of the different disciplines associated in a common search.

An excellent example is given by the series of yearly meetings (called "Global Change Institutes") organized by the Center for Energy and Environmental Studies of Princeton University*.

After the 5th Institute, R. H. SOCOLOW, director of the Center wrote[8] "We became more aware of the profound incompletness of environmental science when posed in the framework of societal problem-solving. In tracking a long-lived organic molecular or metal atom through the enviroment (...) there are islands of well developped science in a sea of partial understanding. Gas exchange at the earth's surface, crucial to the nitrogen cycle and ecosystem function, is determined by processes involving soil bacteria that are poorly understood. An understanding of the impacts of chemicals on the health of almost all organisms other than humans scarcely exists. Moreover, every ignorance is transient, and no area of certainty is safe from reappraisal (...)".

The foregoing clearly implies a new awareness of the field of interdisciplinarity chemistry-environment. This is far from a promethean perspective, without being an epimethean approach.

III. CONCLUSION

I like to cite the strong sentence of Derek J. de SOLLA PRICE[9]: "We are all prisoners of the petty compartmentalizations of knowledge that blight our educational arrangements"*.

More and more division and subdivision of science are in question outside the scientific world, not inside of it. The scientific method is itself under suspicion.

For centuries scientists have adopted without any restriction the promethean approach. This is not possible anymore.

Some significant questions: everybody knows the name of Prometheus and what he did. Who knows Epimetheus'name? Many people knows the name of Pandora and her jar. Who knows the connection between Pandora and the control of fire, source of all civilizations?

In contesting the scientific method there is unconsciously a temptation to approach complex problems by global methods with preeminence of affective** arguments. That was a major characteristic of the way of thinking of the alchemists: association of all disciplines (interdisciplinarity!) and exclusivity of qualitative considerations. Even if, today, the alchemists are disqualified, their way of thinking has ALWAYS been adopted outside the scientific world.

We discover that our societies are insufficiently open to the scientific spirit. However they have never been more informed, more educated. But, now, another attitude is growing. I call it epimethean. Because this attitude is affective and is concerned with very complex (interdisciplinar) domains (environment, safety, health) the alchemist's way of thinking is remarkly adapted to it.

To conclude I will again invoke Greek mythology. If the approach to environment problems has to be a balanced mixture of the optimistic promethean and the pessimistic epimethean perspectives, how could we qualify this mixture? The old books say that, after all troubles had been poured off Pandora's jar, somenthing was still at the bottom of the jar. Something precious, the true motor of all human activity: hope.

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* This center has organized in July 1992 at Snowmass (Colorado) the 5th Global Change Institute with 50 participants, either natural scientists or ecologists, elegantly designated as "human dimensions community". They discussed on "Industrial Ecology and Global Change". The papers presented there are to be published as a book later this year[7].

* During this 17th Annual Meeting of SBQ, Prof. Th. L. BROWN cited a pleasant version of the same opinion by Jonh A. AMSTRONG, former Director of Research of IBM: "We're beginning to realize that God did not create the Universe according to the departmental structure of our research universities".

**Many colleagues would have said "irrational" cf. the Heidelberg Appeal.