

## Some Reflections on Science, Industry and Education\*

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### I. THE MAJOR REVOLUTIONS OF OUR CENTURY

A hundred years ago, a major French writer, Anatole France, was asked to give his feelings about the future. He managed to escape through a clever sentence: “My dream”, said he, “would be to read the books of young schoolboys, as they shall be in the year 2000”.

We are now reaching this time, and we can ask to ourselves: what could we show, and what should we show, to Anatole France ?

The 20<sup>th</sup> century has had its technical revolutions – such as television, air transport, and all the commodities of life in the western world – with a much lower impact elsewhere.

At a deeper level, we may say that two conceptual revolutions have occurred: the first is our perception of the physical world, from atoms to stars: we have reached a precise, operative picture of nearly all scales. The only (major) gap in our knowledge concerns the origin of the universe.

The second conceptual revolution was started by molecular biology. We now have a precise, operative picture of life processes, ranging from bacteria to humans. The only (major) gap is again about the origins: the classical description of a “primordial soup” in the oceans – where nucleotides and peptides manage to self organise, (and decide upon one chirality) – is not yet very convincing.

Thus we have had two major scientific revolutions in this century. But we also had a historic revolution: ten years ago, we have seen the first example of a major conflict (East/West) which ends up without a global war. Of course, this leaves us with a hundred of unsolved problems; nevertheless, the fall of the Berlin wall is a historic landmark.

To a certain extent, we can look with pride at the contents of our school books. Some things have advanced. But, as we all know, this is not the whole story. In the school books, the global uncertainty of our future is hidden.

This uncertainty takes many forms: birth rates, material resources, North/South conflicts, old ideologies and new-born ideologies. In this text, I shall concentrate on two aspects only, related to my own trade: industrial and scientific activities.

Anatole France lived in the days of the great inventors: Gustave Eiffel, Thomas Edison... He could already guess the industrial explosion of the 20<sup>th</sup> century, where a few major companies installed electricity, chemistry, transport, communications, and computers in our everyday life. These groups have sculptured the 20<sup>th</sup> century. But they are now facing a major mutation: quitting long term research, and retaining only short term perspectives. This is due to economic factors – essentially to the pressure of shareholders in our current system. Shareholders are interested in short term benefits only.

This leads to very major changes. For instance,

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the oil companies have the means – intellectual and material – to prepare the energy plans of the next century. But they have abandoned this reflection.

## II. GOOD AND BAD FEATURES FROM THE US

In these issues, examples from the United States are especially useful: examples of success, but also examples of failure.

A very brilliant countermeasure, set up in the US, against the scientific weakening of the large industrial groups, has been the creation of *small high tech companies* which do provide the required long term reflection. Unfortunately, we, Europeans, are much less efficient on this. And we loose some of our best young people, who migrate to Route 128 or to Silicon Valley. In the last five years, France has lost more than fifty thousand computer scientists by this process.

On the other hand, we find some disastrous features in the American system of science and technology. One of the most obvious is related to *legal impediments*. At my small place (the Ecole de Physique et Chimie in Paris) we suffered from a recent example. One of our teams invented a clever system monitoring the heart beat of a new-born baby, without any instrument attached on the baby: this was based on a special bed sheet, which sends electrical signals under mechanical pressures. This set up was of major interest for families who suffered previously from one case of sudden death of a new-born. The production was ready to start in the US, but it was blocked, because of legal dangers. If one child would die on this sheet, whatever the cause of his death, the producing company would be sued, and would be considered as responsible by the American courts. Thus the sheet has not been produced: thousands of families which were anxiously waiting for it have been forced to keep the old, painful, monitoring systems, because of a legal impediment.

## III. DEMOBILISATION OF THE YOUNG

There is a certain disinterest for social activities in the young generation. And there is a certain disin-

terest for science. We see it in the US, where a large fraction of the new science students do not stem from the local schools, but are recent immigrants. We see it also in Europe. There are many reasons for this. The first is an American invention: the so called “politically correct” movement is very much opposed to Science, which is presented in these circles as “the rape of Nature”. And this propaganda diffuses from the non scientific departments of the universities to students, to high schools teachers, and ultimately to our children. In Europe, this trend is more limited, but still present.

Another obvious reason for the suspicions of the young people is based on the dangerous consequences of novel technologies: essentially weapons and pollution. To make, or not to make weapons is a state decision, not a scientific decision. To generate, or to suppress, pollution is an economic decision, but all progress against pollution requires large scientific investments. Let me quote an example which I have followed over the years: paints. Classically, to paint a wall, we used a liquid paint with suitable organic solvents, which evaporate when the paint is set, and leave a robust film of pigments plus additives. But these solvent vapors are toxic; we must use paints with a water-base, like the water colors of our schoolboys. However this water color must be able to resist rain! This is a difficult challenge, which has required a lot of research.

More generally, we must explain to our children that many pollution problems have to be solved by a patient scientific investment – and we must show this not only to them, but to their teachers.

Where will the scientific effort be focused in the 21<sup>st</sup> century? If we look back, we see that the first half of the 20<sup>th</sup> century saw a huge expansion of chemistry. This was followed later by the explosion growth of chips, computers, and communication systems. My guess is that the coming years will see a comparable explosion in bio engineering: new forms of drug deliveries, artificial organs, and so on. This will require a powerful education system, with students which have a mixed culture in

many fields. One of our major responsibilities is to prepare this culture. We should establish in France, and in Europe, a new educational channel, ranging from medicine to biology and physical chemistry.

More globally, I also dream of having more mature students. In the French system (leading to what we call “Grandes Ecoles”, two years after the end of high school) our students are extremely sheltered from the problems of real life – up to a late stage. In the American system, they must, in most cases, pay for their studies and they work for this – in the summers, or in the evenings: they mature faster. I envy the American system on this point.

On the whole, we hope to improve this maturing process *for* science and *through* science. I may quote here one of the major thinkers of our times, Primo Levi, a chemist, miraculously escaped from the death camps, who ultimately became writer. He wrote some moving stories about his life as a chemist and about “the strong and bitter flavor of our trade, which is nothing more than one special case, a more bold version, of the trade of life”.

Let us hope that Primo Levi’s spirit will illuminate the 21<sup>st</sup> century.

(extracted from a talk at Musée d’Orsay in the honor of G. Bush, November 1999)