FOR THE DEVELOPMENT OF A COMMON UNDERSTANDING FOR INNOVATION IN LIFE-NANOSCIENCES THROUGH INTERDISCIPLINARITY

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Abstract: Research is more and more divided up into scientific disciplines leading to difficulties to associate different specialized knowledge, inside projects of public usefulness.

Objectives: The object of this essay is to explore this topic by applying it to a domain supported by decision-makers, that of nanotechnologies and particularly their development as nano-drugs for medical applications. The choice of this selected topic corresponds to an ambivalent situation: rejection of new risks induced by the development of industrial production of nano-systems and need of new medical treatments leading to the improvement of the citizen health, including nano-medicine. The presentation is meant to be interrogative with open questions.

Methods: The author, consequently, wish to receive your opinions and some comments, you active readers who act in the joint domains of research and prevention of medical risks.

Results: Your answers will be the object of a synthesis which will be later published in “Prevention and Research” in a few months. The reader vision is of course of importance in a media system presently stimulated by active associations in which the scientists have a too little space of expression.

Conclusions: No final conclusion is proposed in this essay, only a Provisory closure called: For an operational proposal.

I-Background

Scientific Disciplines exist because the Man in his wish to understand the real cannot embrace complexity by a unique question which would cover the multiplicity of the possible disciplinary approaches. Research is subjected to numerous paradoxical injunctions linked to modes of social and financial regulations, which would probably need to be “re – visited” in order to take into account new “needs” of the Society (1, 2). The inter-disciplinarity or the cross-disciplinarity which are never well and deeply defined are nevertheless the object of a visible support on behalf of tutelage, but with a supervision still hard controlled by disciplines and the peers evaluation system (3, 4, 5, 6).

II-Objectives

The goal of this essay is to explore the missions of the scientific research in a society in profound mutation, and so to explore, without taboo, means to satisfy them “at the best way”by means of science. It is a question of finding ways of progress supporting responsible innovation as a motor of the dynamics of an existent research of the academic world to the advantage of the Society (7).

In this document, the author asks questions which seem to him necessary to hire a useful debate which should decrease the gap between decision makers, stakeholders, researchers and the citizens. From your answers to some of these questions, a synthesis will be accomplished constituting a form of collective expertise leading to recommendations linked to points of view concerning means to be implemented to reach targets of social usefulness, chosen in the joint domain of life sciences and nanotechnologies chosen as an example. All these comments and proposals should be the object of a synthesis serving to pro-active readers of “Prevention and Research” in the responsible development for inter-disciplinarity as a normal way of action for a high quality research associating social progress and mastering of risks (risk assessment and risk management).
II-1- Why such proposal?

The necessary cutting up of knowledge, its distribution in a disciplinary silo, is a thing which cannot be any more called into question (9). For complex systems, a unique knowledge doesn’t exists, but several options of knowledge have to be taken into consideration, a particular understanding of question through each cultural and knowledge spectra leading to specific answers. Conceptual walls were born separating disciplinary knowledge in more restrained units, or silos, allowing the deepening of researches and knowledge.

Every new research unit develops its own methods, its own procedures, refining them to answer questions very different from the historian to the biologist, by way of the musician and by the chemist or the engineer: first group of specialists search in texts recreating a past bit by bit, second dissects, experiment, makes out a will to understand the details of the mechanics of the living being, when in the third domain, it whets its practice by a methodology which would not know how to be essential in the two others, finally the chemist plays with a “partition” imposed by Mendeleyev… At the same time, as this specialization of tools and the Men who create knowledge, knowledge increases faster and faster, requiring new specialized paradigms, new disciplinary silos and new specific languages.

It is then the hatching of a new series of smaller entities, favoring the development of particular and more specific knowledge, with a vernacular specialized language in which will bloom other persons become specialists of the first specialty. This mechanism is particularly visible, for instance, in the scientific domains, where it is not rare to see researchers working on the single gene, on a single equation, leaving care others to attach their researches to more global concerns, integrating an ensemble of separated knowledge (8). This obvious situation has for consequence a real segregation of the different areas (and, in association, a certain linked implicit hierarchy, some being more equals than others…), transforming sciences into “a true Babel Tower” where each, in its own domain, pose and treats its tiny problems without caring too much about significations or consequences which these can have in other domains. The paradox is then put down.

Disciplines are the main actors there, conservative shelters were created to shelter our divided and specialized up knowledge. To keep one of the above-mentioned examples, musical training or the music theory such as they teach them, reveals the same symptoms as grammar.

What are the purposes followed by the practice of the reading of notes and rhythmic reading? Allow the reading of a code, which is at the root of the majority of musical practices in a context of western learned music! However the reading of note as such, is reserved for a pedagogic usage, there is not together reading, which would constitute a “musical reference practice”. We can draw similar conclusions if we wonder about dictations. This result means then that it is necessary to know how to use, to manipulate specialized knowledge, confined by the scientific disciplines with the aim of a specific use, and it is at this moment that interdisciplinary research intervenes, by the need, result of a specific intellectual constructs, a divergent way of thinking, finally disruptive of a system organized by the scientists themselves.

Numerous constraints exist and restrict the development of innovations for a progress induced by Science, and supported by the Society. For instance, numerous researchers suffer particularly from the “syndrome of the Kwai river” because formatted and discouraged by their own production (and the "h" factor for evaluation of the researchers which goes with it (9), they may lose the context view in which the research has to be used as well as the social world in which and for which they act. It therefore required there to remember the ethical missions of science, particularly those of support of progress for the Society (and for its sustainable survival) (10,11,12,13).

In this context, the development of interdisciplinary research can be not only useful in a society in doubt (exhaustion of mineral reservations, warming and climate change, pollution, epidemics, new risks, improvement of health and well-being, etc) but also to act as “laboratory” to optimize links between disciplines and for the accomplishment of social usefulness.

This consideration leads to work on the critical interfaces of interdisciplinary actions in research which correspond to organizational and cultural “knots” of coordination of researchers issued from different scientific disciplines, key instants of incorporation of research, within which near relations, of friendship, of deep motivation for the opening can be decisive for the orientation and sequence of interdisciplinary process.

The scientific mutation which they observe in numerous developed countries can be considered to be the result of the junction of “organized research” and societal needs, rather close to the socioeconomic needs or demands… In these conditions, the selection of the best “heads” in research is more and more performed on axes considered by scientific organizations as hard priorities because strongly interesting the decision-makers; amazingly, the present situation is translated, for a very broad part, by an accumulative and apparent random progress of knowledge without re-visit of the researcher responsibility, hardly protected (Galileo’s syndrome) and practically innocent of everything… Besides, the search of immediacy leads to a pressure of optimization on the main principal variables of an innovation, those considered as secondary being abandoned (remember that for basic researchers that risks are present in the second category, may be in a third one…).

And, for a decision-maker distant from any inventive process, specialization (or the legibility of a research unit) is translated in principle by:

1. A better clarity of modes of production of knowledge;
2. An optimize use of the specialized equipment and facilities;
3. An amplified productivity (linked often with disciplinary scientific papers);
4. A quicker training associated with the internal “culture” of specialized laboratory;
5. A “mass production” of scientific papers (allowing confrontation/quantitative competition through figures between States, etc.) with a risk of a research disconnected from the “true” needs;

6. Finally, a separation between creativity, comprehension and production of knowledge.

These elements are close to what was searched by Taylor and applied by Ford in the “chain” working activities (14), concept which made its proof broadly in the industries of production of consumer goods.

The transformation of scientific activity could be the result of a will of orientation of researches with the aim of certain goals (cf. supra). Then, what Science win in power of transformation of the real, Science risks to lose its critical rigor and a part of its freedom of thought disconnected from any ideology. By thinking to Albert Einstein (a scientific winner) and Giordano Bruno (a scientific looser relatively to the social/religious acceptance of scientific novelties), P. Nouvel in the Banquet (15) writes: “Glory to the one who provides the most distinguished face of the ideology of the instant, dead the one who would try to put it in danger”. But, do the scientific researchers think that the research is an ordinary good of consumption? Must they wait for existent creative investigations of other developed countries before knowledge production? It is possible to understand the interest for decision-makers to use a model easily applicable to the policy of research and to apply it to allow an annual budget founded on quantifiable indicators, often linked with mono-disciplines and “classical” scientific peers review evaluation. And then, in facts, the ambivalence of the scientist appears more than never in its relations with socio-economy, at the same time consenting and reticent, manipulated and manipulative. Hired in the complex of "technical delight" (remember Robert Oppenheimer), it represents at least two roles, two forms of commitment, two visions of the ethics of knowledge the swing of which between firm belief and responsibility concerns rather a contradictory and complex loyalty...

The act of creation has a descriptive aspect and a building aspect. (16). It is necessary that it breaks structures of the mental organization to rank a new synthesis. It is therefore a way of break of inertial intellectual processes, which let think that tomorrow will enter in a reassuring continuity with the past, what justifies the principles of optimization which have just been mentioned (17).

Stimulated interdisciplinary research, important contribution in the development of the sciences of action must be analyzed as a complex system and thought also with a fecundity of responsibilities and must allow thinking about cultural changes linked to a research of social usefulness. It is not therefore a “cosmetic”, fair “presentable” argument to apparently satisfy the society, it is an overhaul of the system and the frame of human interactions which must be envisaged responsibility is worth for complex system, to think of the incorporation of sciences into the social reality, it is to think of the social responsibility of research (and reciprocally). It is definitely on such important foundations that the researchers will be considered as legitimist actors in an interdisciplinary but also socially responsible research. And, as underlines it Hannah Arendt (18): “Finally, the powerless truth is not also miserable as the unconcerned power of the truth?”.

Should we able to re-examine, in a serene way, the elements of responsibility and opening of the researchers in the present complex social system? At the same time, Science would cease being a philosophical humanistic adventure to be only a “cold” implement supporting only the technological development? And, in spite of recurrent political discourses and significant financements, the present innovation issued from the Science remains difficult (at least in France in view of quantitative results).

We do not turn intentionally (or not) as held by a thong around an inscribed fixed axis, in a more or less indelible way, in the culture of the National research system? It is possible to settle the question of the defense of the existent paradigms by peers, anxious with being able them and of their role as “security guard” of a certain conservative coherence? However, it is possible to think that every researcher has, at various degrees, minimums of “still” aptitude in terms of creativity and ingenious resolution of perceptible problems. But cultural, social, external pressures, career, funding, etc. can be conjugated and heavily restrain this useful potential for an effective societal innovation.

The development of interdisciplinary research cannot probably be translated by a catalogue of “good” practices applied as a formal checklist. It needs to experiment (location of difficulties and problems to be solved) and to complete organizational methodologies (elaboration of action plans to be used as working hypotheses to get involved on spotted problems; towards learning organizations,…). It must move away from the “explosive” accumulation of the encysting models used by disciplines, while knowing how to work positively with and, contrariwise, try to promote a real exchange between disciplines, vector of cultural change, to get involved in fecundation and crossed studies of public utility (7). In fact, with complexity, it is the barriers between disciplines which have to disappear (without of course wanting therefore to abolish the disciplines of deepening which have their own usefulness).

At the same time, flexible organization and cooperation of points of view have to be implemented allowing the bet compromise between disciplinary competences and of behaviors for action (19). It is probably necessary to come back to reasoning of (20) Norbert Wiener (1992), that of the engineer whose look does not stop in the understanding of only material facts, but stretches up to human facts (actual and perceptible for tomorrow). But, simultaneously, must we accept that Science can work only by elaborating itself its own questions, sheltered from emergency and inherent distortion of economic contingencies? How then to act in confident relation with the Society? How to act together with researchers who do not know each other and who do not speak the same language?

II-2 - And, what about nano-drugs?

The concept of using nanotechnology in medical research and clinical practice holds great values and opens real perspectives for effective innovations in medical sciences (21). A broad spectrum of technologies can be used individually or in combination to make products and applications and to better understand science. One way of characterizing nanotechnology is by utilizing the following 4 segments: tools, materials, devices & intelligent materials and machines. The applications,
which pertain to both medical and surgical diagnosis and therapeutic techniques, are as diverse as the development of nano-particles for diagnostic and screening purposes, artificial receptors, DNA sequencing using nano-pores, manufacture of unique drug delivery systems, gene therapy, and enablement of tissue engineering, single-virus detection. Indeed, nanostructures, whether still under development or already in use, have the potential to play a critical role in the future of medicine, as they can be carriers for drugs, genes, and imaging agents as well as targeting units.

The need for the development of a new framework, including regulations, procedures and mechanisms, adapted specifically to govern research in nanotechnology, thus nano-medicine, is as salient in OECD Countries (22).

Heightened uncertainty regarding risks, fast-evolving science yielding complex and increasingly active materials, likelihood of research on vulnerable participants including patients, and potential risks to others beyond the research participant are identified as relevant confluent factors in support of the need for an exceptional oversight beyond the existing “Common Rules” supervised by either local or federal institutions.

Concern regarding potential risks does not involve only the volunteers and candidates recruited to participate to clinical trials, but also workers employed in the manufacturing industries, as well as, during the fundamental research stage, scientists conducting experiments in public or private Laboratories. In this last domain, the researcher’s culture is of great importance (23).

For nanotechnologies, not only used in the medical domain, more and more enthralled debates develop on the toxic potential of certain nano-materials; active groups offer interpretative schemes for industrial developments rejections or control (24). The carcinogenic effects of asbestos and time delay to take into account them often act as negative memory. In this respect, the analogy asbestos – nano-particles (case of carbon nano-tubes) is preeminent; it operates two modes of thought (25):

- Responsibility of the scientists in relation to the public, with health polemics which it would be necessary to anticipate;
- The existence of a "Pandora box" not to be opened because of unknown health and ethical effects in the long term.

Even if nobody stress on the possible progress which will be allowed thanks to nanotechnologies, deep and converging questionings manifest themselves; they seek confusion for medical innovations to treat, as an example, on certain cancers (as it already occurs, to a lesser degree, for the use of certain more classical chemical anti-cancers drugs which are dangerous for health services staff and for some extent for patients) (26).

To get legitimately involved in this ambivalent and new context, in the absence of toxicological robust knowledge, the exploration of the precautionary principle (27) in this research area is normally necessary. To reach this initial target, it is possible to lean on a charter of “Socially Responsible Research” published recently by certain Western Governments and National Research Organizations (7,28). In this frame of thinking, responsibility is not a disposition which prevents science from following its own search. It is necessary to favor the multiplicity of points of view, in other words to have an approach more planned by science, more controversial, to play all in all new forms of communicational rationalism because collective: learn to be able of constructing with other experts an object and a purpose, and, as much as possible, to be associated with all validated knowledge showing the “consistency” of hazard and risk (potentially supported, credible, hypothetical, potential, etc.) (31). Leaving with a vision shared by the participants in the research operation, the exchange with scientists of other domains (biologists, medical scientists, in association with jurists and of referents in hygiene and safety), it is possible in principle to define satisfactory technical criteria to nano-particles, dose effect relationships, test on animals, etc.

In this respect, several domains of actions, in an interdisciplinary research linked on the development of new nano-drugs can be proposed (21):

1. Scientific (mono-disciplinary) approach: synthesis of new chemical compounds, relationship between chemistry and therapeutics, chemical linkage of drugs to nano-particles, dose effect relationships, test on animals, etc.
2. Responsible and/or ethical approach: On the basis of actual knowledge, it is possible to define the more safe conditions of synthesis, without risk of exposure of the operators, of grafted nano-particles, their transport as well as their clinical use by taking into account hospital best practices and elimination of wastes in satisfactory conditions (29,30). By linking through an interdisciplinary approach specialists of complementary domains (engineering sciences, chemists, biologists, medical scientists, in association with jurists and of referents in hygiene and safety), it is possible in principle to define satisfactory technical criteria issued for “hard scientists”. However, if the insertion of disciplines involved in the scientific mastering of correlation between nano-particle used as a drug and medical treatment is satisfactory, it is possible to transfer the scientific knowledge into the technological world leading to potential medical applications. But, the central question of social agreement on the positive use of suspicious materials (coming from the nano-world…) is important and has to be solved. In situation of uncertainty, several criteria should be estimated on realization and impact of researches: “social acceptance”, easiness of observation, reducibility on one hand, irreversibility, strictness, plausibility on the other hand. These elements of oriented thinking have, as much as possible, to be associated with all validated knowledge showing the “consistency” of hazard and risk (potentially supported, credible, hypothetical, potential, etc.) (31). Leaving with a vision shared by the participants in the research operation, the exchange with scientists of other domains must be envisaged in order to test the robustness of the first one internal expertise. Approach should be then enlarged to “less informed” representatives (general population) allowing a first approach of the possible influence of militant members playing with the social control of decisions (militant associations for instance) to hire the development of researches in terms of application.

3. Toxico-toxicological approach: One of the credible means to reduce uncertainty on hazards consists on the development of research in toxicology in order to avoid the use of the precautionary principle, leading to come back in a more serene way on foundations of mastering of risks with stabilized methodologies of risk prevention. This third axis coupled with the two others constitutes therefore an essential element of facilitation of a social agreement on the use of new types of nano-particles medical probes.
III-For what kind of results?
The responsible development for research on nano-drugs leaning on interdisciplinary approaches must allow:

1. The mutual association of interests between specialists issued from different domains for a "true" interdisciplinarity; how to act in an efficient way?
2. The definition of the disciplinary research axis to be hired, place and nature of the expertise to allow them;
3. The learning for the researchers included in an interdisciplinary project for a better understanding of the correlation between science and society; the place of toxicology in the process of social stabilization of new and emerging techniques of medical treatment;
4. The development of methodology(ies) of building of an expertise in field of hazards and badly identified risks; how to reduce it by a better knowledge of hazards?
5. Etc.

In this understanding on ignorance and uncertainty, it must be possible to evaluate the level of the present uncertainties of scientific and technical knowledge, of approximations of knowledge, abuses of interpretation, limits of competence, to measure their perception, at least the expanse of undecided questions, and interrogation marks.

IV-Methodology
It is offered to use the competences of the readers of “Prevention and Research” to help the author to improve, modify this general vision about the entire question recalled above. On the basis of transmitted answers, it will be possible to translate the synthesis of comments as proposal for decision-makers to locate interdisciplinarity as means of redeployment of activities centered on new medical applications, domain where nano-drugs act here as focal object:

1. How to define the frame of interdisciplinarity in the field? Is it of existent spontaneous origin linked with the "hazardous" association of disciplines or contrariwise the result of top-down stimulation by getting involved via forecasting approaches? How to produce added values during the development of new (nano) drugs?
2. How to define again the place of interdisciplinarity for innovation in nano-medicine? For what type of innovation? How to create favorable conditions to the blossoming of new ideas and to their support for innovation and creativity in domain? How to settle "good questions"? What is to be done? How in processes of innovation associate freedom, initiatives and social and economic responsibilities? At the bottom, how to construct a collective intelligence leaning on interdisciplinary foundations?
3. How to go out of the disciplinary work division which can separate the scientific idea of its medical, social (societal) links? How to elaborate an interdisciplinary expertise for responsible action, mastering risks? What are the deontological foundations which support such action? How to links up Science-Innovation and Society?
4. How to assess/evaluate a scientific activity opened on / for the Society? How to define the interdisciplinary excellence in nano-medicine? How to evaluate researchers in case of a fiasco linked to the catch of risk? How to go out of a "vicious circle" of the evaluation of an innovation by using performance criteria linked to the pre-existing disciplinary system (32)? How to construct a methodology to help the researchers to ameliorate their own practices with the aim of the social usefulness of the projects?
5. How to include long temporalities in scientific activities (problem of the short term contracts in relation with the time scale for success and excellence in research)? How to satisfy the social needs through the incorporation of different disciplinary knowledge? How to manage irreversibility led by "strategically" choices coming from the top management?
6. How to develop a collective long-term forecasting in nano-medicine and a more individual activity in a context of economic competitiveness and of competition between researchers? How to plot actions open to the social needs? How to insert principles of organizational flexibility to reach objectives faster?
7. How to go out of the travesty of ideas induced by a possible control from certain stakeholders and/or decision-makers? How take out of (or know how to work with) protection on behalf of the "predominant"? How to raise central inflexibility by risk of disturbance of the status quo? How to go beyond the factors which stifle innovation? What do we hear by values?
8. How to optimize the dialogue of the "scientists" with the real, with all the concerned different bodies of the Society? How to generate trust in the activities of interdisciplinary research and innovation, while this concept starts with a reduction of medical and/or social complexity? How we can train a part of the research body for a better social responsibility (of the researcher in his entire environment)?
9. How to develop partnerships with other researchers and with the socioeconomic system? How to federate all energies? How to promote a shared research? How to support determination, firm belief and enthusiasm of the researchers in sciences of action acting for the service of the Society? How to "fabricate" interest for what we do?
10. How to explore "intelligently" the precautionary principle (27) on researches with potential and uncertain risks? How to manage through heuristic approaches a satisfactory prevention of possible risks for the operators and the citizens in the field of nanotechnologies and, in association, in nano-medicine? How to be sure of the respect of the present regulation? How to go out of "conspiracy" ideologies issued from militant groups? Can the biomedical research linked to topic be completely neutral?
V- Provisory closure: For an operational proposal

In France, the author tries to follow this search of information to deepen the present subject. He expects comments and suggestions from the active readers of "Prevention and Research" before 31-01-2012 (to be transmitted under free form to jean-claude.andre1@sfr.fr). On this deepening basis, the filled reservoir of knowledge will be able to serve for making useful proposals in form of scenarios (using SWOT analysis for instance).

In the complex domain of nano-biosciences or of nano-medicine, it will be necessary to think on how crossing ideas, how to link the scientific and medical actors positively to such project, how to bring added values in interdisciplinary research proposal in the field, how to build a network of experts to confer a theoretical substrate on approaches offered by experiments, counter-proposals to adjust reasoning and methodologies in disputations and in resistance of scientists (corresponding to the wish of a real common understanding).

Of course, this remark is related to the essential question in interdisciplinarity to positively gather heterogeneous talents between science, medicine and society, between innovation and prevention of risks, and to the development of existent expertise issued from different domains in order to try to resolve together problems linked to forms of "imprisonment" of Science.

It is therefore necessary to write together a "history" shared by those who make it and by those for whom it is intended. It is on this foundation that it will be possible to construct honestly forms of collective imagination allowing action (and valid proposals for some time). Conclusions of this work of synthesis will be the object of a publication in "Prevention and Research" in 2012.

Reference

For the development of a common understanding for innovation in lifenanosciences through interdisciplinarity


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