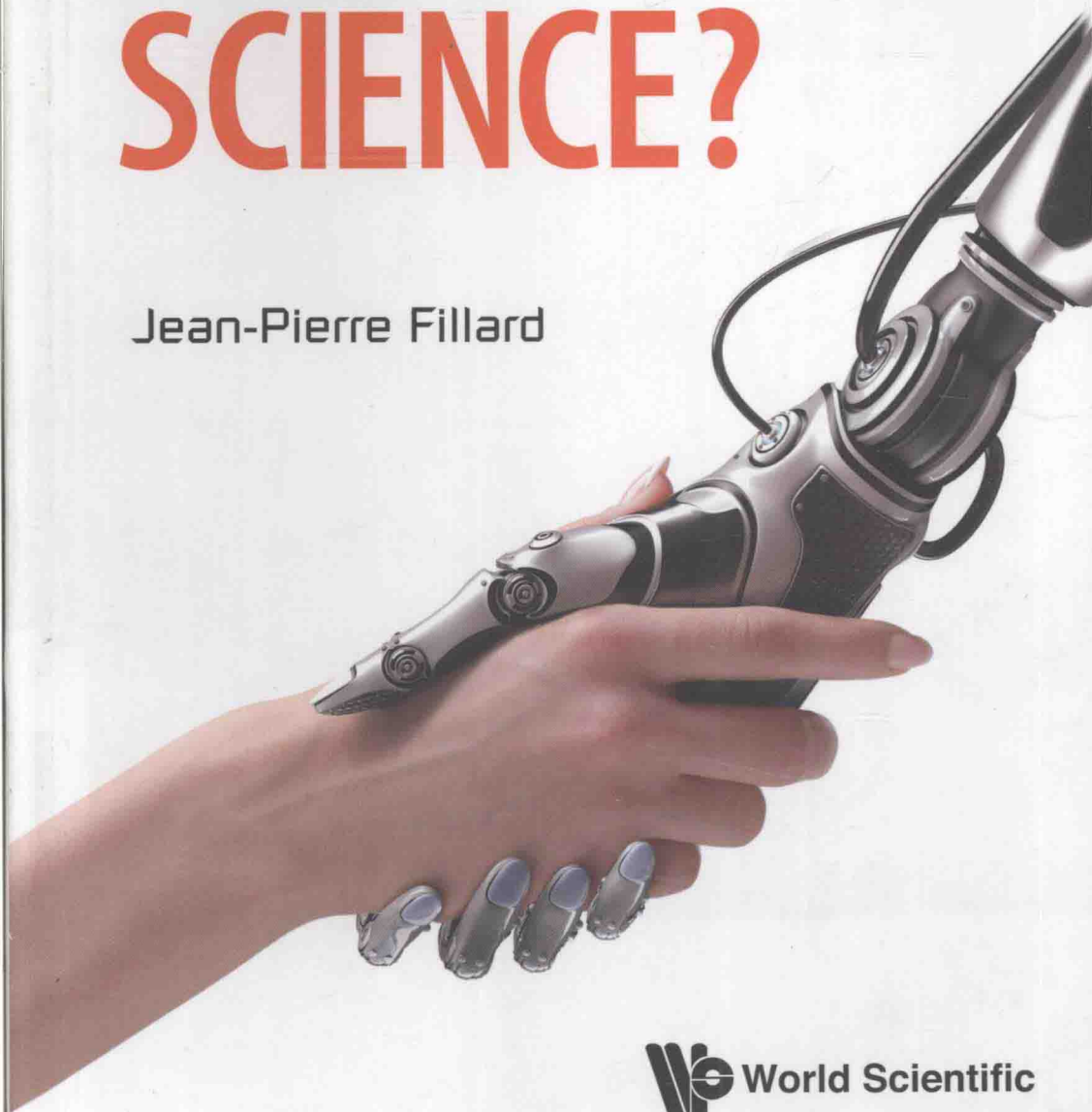
IS MAN TO SURVIVE SCIENCE?

Jean-Pierre Fillard



World Scientific

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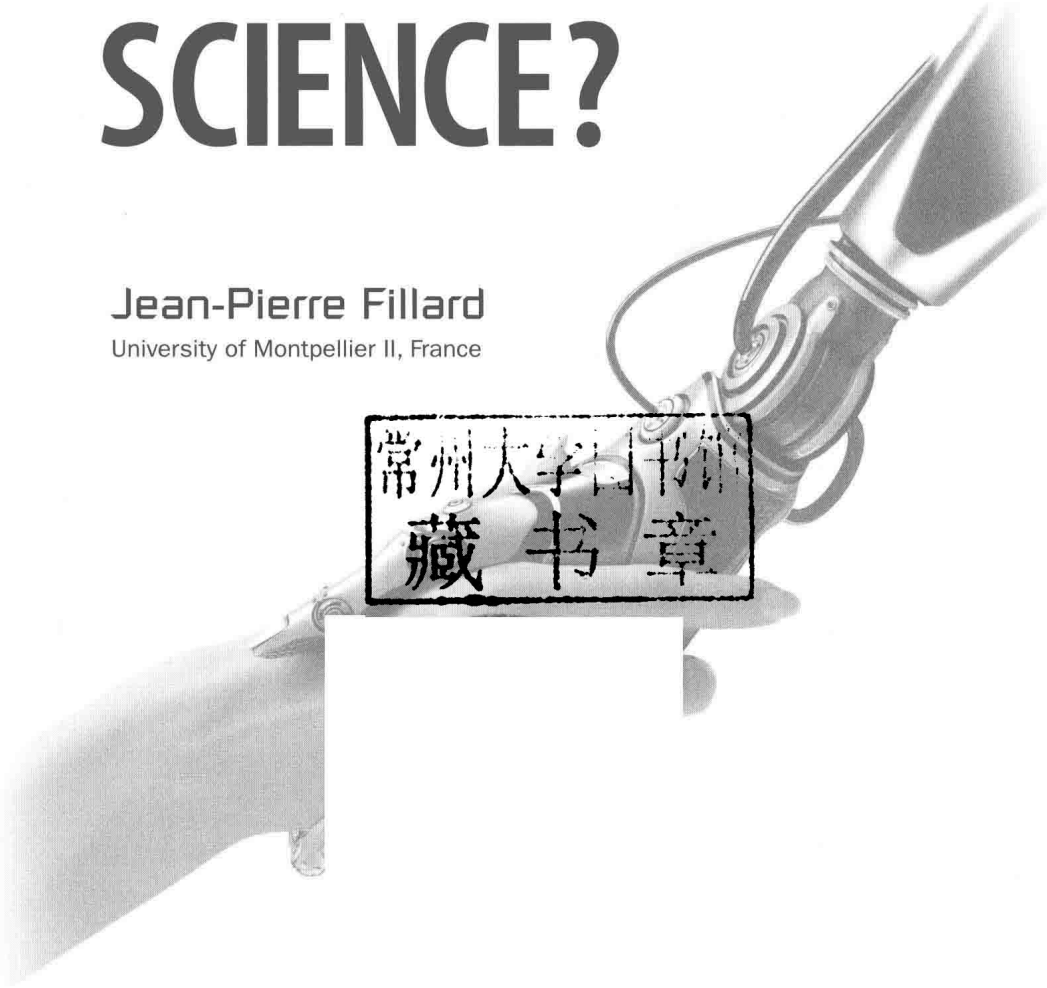

World Scientific
NEW JERSEY • LONDON • SINGAPORE • BEIJING • SHANGHAI • HONG KONG • TAIPEI • CHENNAI

Published by

World Scientific Publishing Co. Pte. Ltd.

5 Toh Tuck Link, Singapore 596224

USA office: 27 Warren Street, Suite 401-402, Hackensack, NJ 07601

UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

IS MAN TO SURVIVE SCIENCE?

ISBN 978-981-4644-40-2

ISBN 978-981-4644-41-9 (pbk)

In-house Editor: Song Yu

Typeset by Stallion Press

Email: enquiries@stallionpress.com

Printed in Singapore

IS MAN TO SURVIVE SCIENCE?

Foreword

Présenter le remarquable ouvrage du Professeur Jean-Pierre Fillard est pour moi un très grand plaisir. A cela participe bien sûr notre vieille amitié, qui remonte à la fin de nos études secondaires dans un lycée d'Alger, il y a près de 60 ans. Mais si l'amitié donne une tonalité particulière à un jugement, elle n'en exclut pas la lucidité et l'objectivité. Or le livre qui nous est proposé est remarquable à plusieurs égards, par le fond et par la forme.

Avec une maestria étonnante, Jean-Pierre Fillard dresse d'abord, dans «l'Homme survivra-t-il à la Science?», un état des lieux époustouflant sur les connaissances actuelles et sur l'évolution récente des «sciences dures», dont il est spécialiste comme physicien, mais également de la biologie et de la médecine, toutes deux qualifiées, parfois et curieusement, de «sciences molles», peut-être parce que leur sujet, la vie, est éminemment variable.

Les domaines abordés sont nombreux et variés puisqu'ils vont de la physique, à l'électronique, à la robotique, à l'informatique et aux nanotechnologies. Tous ces sujets sont traités avec une maîtrise reflétant une vaste compétence scientifique mais aussi une érudition étonnante dont témoigne une bibliographie faisant références aux plus récentes données. Chaque fois, l'auteur sait faire la part de la science et de la technologie, en soulignant combien elles sont indissociables, chacune d'entre elles permettant tour à tour les progrès les plus significatifs. Ces progrès scientifiques et techniques, le plus souvent très spectaculaires, vont d'ailleurs en s'accélérant puisque, par exemple, moins de 80 ans séparent l' «Eole» puis le «Zéphyr» de Clément Ader, plafonnant à quelques centimètres d'altitude, et le vol inaugural du Concorde à plus de 10.000 mètres d'altitude et à une vitesse de Mach 2. C'est précisément cette accélération fabuleuse des connaissances et des progrès techniques qui en découlent qui amènent à se poser la question de la place et de l'évolution de l'homme dans un monde aussi profondément changeant.

Les mêmes commentaires s'appliquent aux chapitres de l'ouvrage concernant la Biologie et la Médecine, mais dont la qualité est d'autant plus remarquable que l'auteur n'est plus directement ici dans son domaine de compétence. Il nous présente pourtant un remarquable panorama des progrès biologiques et médicaux, dans des voies aussi variées que la génétique, le clonage, les neurosciences, la pensée ou l'intelligence. Dans tous les cas, on voit se dégager la profonde convergence et l'évidente complémentarité des «sciences

dures», de la Biologie et de la Médecine. Cette complémentarité est pourtant trop fréquemment méconnue ou même ignorée — souvent en raison de l'esprit de chapelle de certains spécialistes — et je ne résiste pas à évoquer ici le souvenir d'un cercle dont mes parents, avant 1962, étaient membres à Alger, le Cercle Franco-Musulman, dont la devise était une phrase du philosophe Paul Valéry «enrichissons-nous de nos mutuelles différences»...

Face à cette montée brutale, à cette véritable explosion continue des connaissances, comment l'homme pourra-t-il évoluer et quelle sera sa place dans un monde en perpétuel changement? C'est la question majeure qu'aborde Jean-Pierre Fillard, avec d'autant plus de courage que cette question est éminemment difficile, notamment parce qu'elle touche aussi bien à la philosophie et à la morale qu'à la prospective. Certes, les schémas que l'on peut imaginer aujourd'hui ne se réaliseront peut-être jamais et nous feront sourire dans quelques années. Mais quelle qu'en soit la difficulté, il n'est pas moins essentiel de savoir prendre du recul, de réfléchir et d'imaginer ou de prévoir l'avenir. Aidés ou poussés par les progrès de la science, irons-nous vers l'apparition d' «hommes transhumains» ou d'«hommes zéro défaut» produits par des clonages ou des filtres génétiques, ce qui évoque bien sûr la perspective effrayante de l'eugénisme. Sans aller jusqu'à ces extrêmes, l'homme saura-t-il évoluer pour ne pas disparaître et sauver l'essentiel de son essence matérielle mais aussi intellectuelle et morale? Nul ne peut répondre à ces questions mais il est fondamental de savoir les poser et c'est

cette réflexion que nous apporte l'ouvrage de Jean-Pierre Fillard

Passionnant par le fond, ce livre est également remarquable par la forme. Les sujets les plus complexes sont présentés avec une parfaite simplicité qui donne au lecteur le sentiment — peut-être injustifié parfois... — d'avoir tout compris, mais cette volonté de « faire simple » n'altère en rien la rigueur de l'exposé. Celui-ci est conduit d'une manière naturelle, presque chaleureuse et, en le lisant, on a l'impression d'entendre Jean-Pierre Fillard dont les qualités de conférencier ne sont plus à vanter.

«L' Homme survivra-t-il à la Science?» est donc un livre passionnant, par les données scientifiques qu'il présente et par les pistes de réflexion qu'il ouvre. Mais c'est aussi, et c'est ce qui en fait également la valeur, un livre facile et agréable à lire.

Meylan 25 Janvier 2013

Professeur Pierre Ambroise-Thomas †
Président honoraire et membre de
l'Académie nationale de Médecine.
Membre de l'Académie nationale de Pharmacie.

This foreword was kept in French in respect of my old mate, Pierre, who passed away recently.

Jean-Pierre Fillard

Preliminaries

Before everything else, some words seem to be essential in order to get to know each other.

Where do I come from?

First of all, I do have to briefly introduce myself to the reader who has never heard of me. I was (scientifically) born in the late fifties and, at that moment, the old conceptions of our world were disappearing to give birth to modernity.

Physics was the cherished science and generated a bunch of new scientific topics which were strongly divergent, enthusiastic and futuristic. Each of them was developing from itself and in its own direction. In some ways, the times were at a real scientific "Far West", with the triumphant nuclear physics, but also emerging new promises.

Space was open, laser was just born, information was a theory, computer science "lay in a cradle", transmission and

television were in the starting blocks, whereas mathematics obviously turned "modern"; however, last but not least, the very revolution will arise from the transistor. What a rupture!

At that time also, a marked scientific priority was given to "hard" sciences. "Soft" ones (?), devoted to nature studies and observation, were in the background; biology, for instance, was considered (I surely overrate it) as a domain for "butterfly hunters"! The initial investigations on the DNA certainly did not occupy the headlines of the newspapers. Things will change and reverse later when "hard" sciences will get tired, giving birth to a strenuous baby, I mean: Instrumentation.

From there on, spectrometers, microscopes, analyzers, scanners, imaging systems, CATs, MRIs, and of course the unavoidable computer, will all become precise, powerful, adapted, and almost intelligent; they will provide the research with an unexpected dimension. Since then the move was such that diverging sciences will get closer and closer to the point that they tend to become now strongly associative.

Let us come back to the fifties; it was then, in this stimulating atmosphere, that I had the great opportunity to meet a prominent teacher, Professor A. Blanc-Lapierre[1] who later became president of the French National Academy of Science. It is a pleasure for me to greet him for allowing me to share his enthusiasm for Physics studies and providing me with a basic scientific culture in nuclear physics and quantum mechanics.

However, my preliminary works were orientated towards the field of solid-state physics which attempted to theoretically

[1] http://www.supelec.fr/actu/Blanc-Lapierre.PDF

strengthen the new experimental discovery of the transistor effect which just came to fruition. This initial work leads me to experimentally reveal the splitting of the "conduction band" in Copper Oxide crystals.

The following was more tragic because we were in 1962 and I had to leave my birth land to migrate towards a hostile homeland. This is mainly because of this hostility that I came back soon in Algiers and engaged in a new research with Ecole Normale Supérieure (Paris) in the field of organic semi-conductors. This was, then, rather unconventional and daredevil, but I got through successfully to the point that I defended a thesis later (*cum laude*) on the semi-conducting properties of Cu-Phtalocyanine thin films, in the new University of Montpellier (USTL[2]) which had just been created. Some 20 years later I was told that a young Japanese researcher was to extend my work to further conclusions!

Then I had to head my own laboratory with some young students eager to struggle with science. The following 30 years were devoted to understand the behavior of the electrons in semiconductor materials when they meet defects such as chemical impurities or structural disorders. Light, heat, electric fields interact to trap, free, recombine them, and emit light, thus perturbing the operations of electronic components.

At that time people were looking for a successor to King Silicium for more performances and the main challenger was Gallium Arsenide. During 10 to 15 years there has been an incredible worldwide activity to master this material.

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[2]Université des Sciences et Techniques du Languedoc.

Thousands of researchers were involved in new theories or experimental approaches and any issue of the prestigious *Physical Review* dedicated at least one paper to the subject. Then, step by step, improvement after improvement, the quality of the crystals became sharp enough to render possible to elaborate performing Integrated Circuits in the domain of the High Frequencies, thus giving rise to GPS, mobile phones, TV satellites, flat screens, intercontinental optical fibers ... and also Internet.

A recurring defect was named EL2 and during some 15 years, streams of ink flowed to give a satisfying explanation of the nature of this perturbing flaw. Was it a chemical interstitial atom? Was it a local vacancy or a combination of them? The answer never was clear. In spite of what, this difficulty has been empirically overcome by technology and (almost) nobody cared any longer of EL2. This story shows that if Science is in many cases required for the things to progress, nevertheless technology often finds its way (when shown) by itself.

During this term, we were among the first people to trust in digital imaging. With a Japanese colleague (Professor T. Ogawa since deceased) we imagined a Laser Scanning Tomography (LST) which made it possible, in the bulk material, to visualize particles as tiny as the nanometer scale and we invented a new word: "Nanoscopy".[3] These efforts were

[3]Near Field Optics and Nanoscopy, Jean-Pierre Fillard, World Scientific, Singapore, 1996.

comforted by the advent of the AFM[4] invented in Stanford by Calvin Quate who has been with our University as a visiting professor some years before.

This new kind of imaging takes place in the microscope's family which is called "Scanning Probe Microscopy". It works as the "pick-up" of my youth: a tiny and sharp needle is carried at the tip of a small silicon arm and is brought carefully close to the surface of the sample; when the contact is near to be reached some proximity forces arise which repels the needle thus bending the lever. This weak bending is optically detected. Scanning the sample with this equipment makes it possible for the computer to generate a quantitative image of the relief at a nanoscale.

Such instruments (as Scanning Tunnel Microscope) make up an extraordinary mean of investigation in the nanoworld not only for getting images but also to carry atoms, one after another one, from place to place, thus giving rise to individual molecular constructions the physical laws of which leads to a new chemistry. But, anyhow, the nanoworld remains as difficult to get access in as the outer space is.

It also soon appeared that such nanotools could be optical, the tip of the microscope being transformed into a nanorobot capable of directing light to and from a nanotarget. The experiment works well and it makes it feasible to use the silicon arm as a light guide[5]! From that time on, many other tentative explorations in the field have been carried out.

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[4] Atomic Force Microscopy.

[5] Ultra Microscopy, 61 85 (1995) to 71 231 (1998).

All of this gives, in a summary, what my prospects were during those 30 years. From this long period I remember that the "job" for a researcher is rather unusual, and it is for above average people. Science cannot be won without the researcher having explored, doubted, imagined, and checked. May be, this researcher could realize he was wrong and somebody else may re-study the problem with another mind. Success must be considered with a reservation taking into account that truth could be incomplete or temporary. A friend of mine told me once: "I appreciate when you say: I don't know!"

It stems from all the above that I am in no way a biologist, neither a robotician, nor a computer science specialist; however I still remain a simple, inquiring and objective physicist. But this restriction is not so dramatic at the moment, considering how drastically things have changed during the last decade. Since then information has become accessible, handy, profuse and swift and it turns out that even a non-specialist, as I am, can easily get a valuable idea of what is going on in a different field.

Many things which are today considered as impossible would likely be commonplace tomorrow. Claude Allègre did say incautiously but with due reason in his excellent book[6] in 2009: "One does not know how to synthesize life" but Craig Venter did it since at the cell scale and it is just a very beginning!

The evolution of the Science world can be sketched following three global and entangled trends:

Convergence — Acceleration — Applications.

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[6]Claude Allègre, "La Science est le défi du XXI^{e} siècle", Plon Ed., 2009.

Each of them provides means for the others to progress.

— Convergence: Biologists now need to deal with software. Chemists require quantum physics to understand individual atomic processes, and Roboticians are called for help by the doctor to artificially copy a knuckle, and so on.
— Acceleration: the speed of transfer of the knowledge gets faster giving tremendous efficiency in the scientific challenge.
— Applications: every result in the research advancement immediately leads to a serviceable conclusion in the form of an apparatus or an instrument which immediately gives rise to new performing investigations, and so on.

To give an illustration of the evolution, my own ancient lab, for a while, no longer cares about Gallium Arsenide crystals. My previous students, now in the business, collaborate in a team with doctors, chemists, software specialists to study biological cell luminescence properties under nano-MRI imaging! Quite a revolution!

Another epoch, another set of manners, another set of nanoscopies!

Then, as a conclusion, I feel perfectly authorized to give my careful opinion about stem cells, genomics or super computers as well! That I will do in this book.

Why such a Book?

Some time ago, a friend of mine gave me a short excerpt of a book he was reading. The title is "La Mort de la

Mort"[7] (The Death of the Death). It was produced by a doctor deeply involved in the business of genomics. This enticed me to get the book and read it too. The developed philosophy was that the progresses in the general scientific knowledge have become so fast that fantastic conclusions are to be soon reached which will overturn our ways of living with very short delays. More especially genomics, stem cell studies, computers could make it possible to largely improve the medicine to that point that living 150 years or much longer could become soon a common reality, thus leading to questions humanity will have to face without any possible escape. It seemed to me that the arguments were absolutely serious and were worth being considered to the point that writing a book would be an exciting challenge.

One can find today many publications dealing, under different angles, with the subject we are busy with. It can be observed in many cases that authors often use thoughtlessly mathematical expressions or the word "exponential" or the prefix "nano" which sound convenient in a scientific context, but are often in any way not justified.[8] Such enthusiastic outbreaks are prejudicial to the credibility of the purpose, however, we have not to dwell on the matter but rather look forward.

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[7] Laurent Alexandre, La mort de la mort, JC Lattès Ed., 2011.

[8] Even Ray Kurzweil had this sentence which could horrify a beginner in mathematics: "exponential trends do reach an asymptote!"