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Commentary

# Physics for the humanistic education of the doctor

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## Abstract

We discuss why and how physics is an essential component of the human figure and the education of the doctor and surgeon, as a practitioner and as a man of science. An adequate general culture, and attention to historical and methodological dimensions, are the essential resources.

**Keywords:** Physics, Medical-surgical sciences, Scientific culture, Profession, Humanity

## The problem: The Initial Education of the Physician Doctor (and) Surgeon

After a close and complex debate, the teaching of physics was reconfirmed as compulsory and fundamental for the first steps in the education of the doctor, specifically of the doctor (and) surgeon, in the Italian university. Physics is indispensable for the initial training of health professionals, and it is so first of all for educational and Bildung reasons.

Taking into account this debate, some reflections on Physics as a fundamental Medical Humanity have been expressed in a volume on the history of physics [1]. The history of science, as well as the history of the technique or technology, can really contribute to our goals. The discussion might need links to the present-day practice, but these connections are clear on the basis of an adequate scientific and technical culture [2].

We can reason about the fundamental importance of Physics, for example, for the fact that most of the objective evidence in medicine is properly physical or chemical or chemical-physical quantities. We may reflect on the fundamentally physical character of the study of Physiology, Ophthalmology or Audiology (including the inner ear), and of other branches of medical science. Or again, attention can be paid to the enormous and increasingly complex and varied availability of diagnostic and therapeutic tools for the doctor that require Physics skills, with the clear awareness that these are not just aids, they are essential innovations to be integrated with that specific professionalism.

To this purpose, it is not necessary to absolutize or generalize the aphorism attributed to Ernest Rutherford according to which «*All science is either physics or stamp collecting*», an aphorism powerfully expressive of the evolution of science in the twentieth century, and evidently organic to the evolution of Physics at the beginning of that century to which the physicist and chemic from New Zealand actively contributed, deserving the Nobel Prize in Chemistry 1908. It is necessary to understand and make one's own the paradigmatic character of Physics as a subject methodologically rigorous, and empirically controlled science; and first of all, if anything, to ask ourselves how and how much even in

medicine and surgery it is necessary to integrate what Galileo called «*sensate esperienze*» [sensible or meaning experiments] and «*necessarie dimostrazioni*» [necessary demonstrations] [3]. A component of medical science refers to an idiographic (or descriptive) methodology: a way of development is, therefore, to enhance that different essential component that refers to nomothetic sciences such as Physics.

The basic argument of that debate, in fact, was that Physics is fundamental for the formation of the doctor as a scientific mentality, with regard to the methodology and the foundational character of human creation of both Physics and Medicine, analogous to any natural science with reference to man; and man must be understood both as a subject and as a scholar and professional applicator.

In this summary note, extension or commentary, we will summarize some broad lines about the character of Physics as Medical Humanity, partly further examples with respect to the above-mentioned writing, which will constitute as many probative testimonies of the reconfirmed role of physics in the training of the doctor, which if anything allows us to glimpse the opportunity not to limit itself to a single university exam in the first year.

It will be appropriate to bring further historical examples, compared to Rutherford and Galileo, and for those who will intrude on a scientific note they will always be drops in the ocean. The teaching of Physics in this context of education should be practiced with an essential historical reference: Physics, like all sciences, is a process and not a sequence of states; let's not forget Kuhn's fundamental teaching. Not to confuse science in its historical development with the review of the current state operated by a textbook.

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## Medical Pedagogy

The concept of Medical Pedagogy is also consequently reformulated in more general terms, as research and as didactics relating to the human component in the training and professionalism of the doctor analogous to that of the physicist and the related professional practices.

In particular, a good training of the doctor or any health professional cannot be a curriculum that does not include adequate bases for the future performance of the profession, a development that is obviously unpredictable.

A snapshot of the state of medical culture at any given time is destined to quickly become obsolete, well before the basic degree course for this profession is also completed. This is an unavoidable topic that concerns any scientifically based intellectual profession: the evolution of knowledge is unpredictable, but it must be expected that it will be there, it will be challenging and it will not be possible to face it positively without adequate foundations, starting with solid foundations in Physics.

The education of the doctor as a human scientist and professional necessarily passes through the recognition of the humanistic character of physics and other basic sciences for Medicine and Surgery, similarly to what happens for any other professional operating in society and culture.

## Scientific Method Issues

The powerful and frenetic advancement of Physics, at least in the last two or three centuries, has formed the background for a close epistemological debate on the philosophy and methodology of scientific research. It should also be of maximum benefit in the context of medical sciences.

Since the nineteenth century, the philosophy of Positivism has had particular evidence, bringing an inductivist methodology, according to which the transition from the particular to the universal is accomplished on the basis of the premise of a number of recurrences considered sufficiently high and without exception. Among philosophers, Positivism was opposed to Idealism, the philosophical creation of general ideas and the consequent deduction from them of what is particular. Among the positivists there were also physicists, not of the first rank, and in this current of thinking there were scholars of the human sciences, particularly several distinguished sociologists.

A naïve vision of medical and surgical practice and in particular of medical evidence refers to a superficial and crude inductivism. A professional practice of verbose and a priori but completely uncontrolled medicine, which does not take the right account of the factual consequences, refers to an idealistic vision that is equally superficial and crude.

In Italian Positivism, however, there were talented methodologists of the medical clinic such as Salvatore Tommasi (1813–1888) and Augusto Murri (1841–1932), who moreover brought a more articulated and rational message than the principle of induction. The analogue can be said for other Italo-positivists with similarly applicative interests, as well as for numerous pedagogists and didactic teachers, for historians, jurists, and anthropologists.

The most empiricist positivist ideas, and in particular inductivism, had a revival at the beginning of the 20$^{th}$ century in Central Europe (Logical Neopositivism), in particular at the Wiener Kreis, the Berlin School and the Polish school. But it was a discourse that had already ended in the 30s of that century, even if some logical neopositivists who took refuge in the USA during Nazism such as Rudolf Carnap (1891–1970) or Herbert Feigl (1902–1988) made some further contributions to this way of understanding scientific research. By now it can be considered established that empirical induction does not exist, due to the convergence of Pragmatism [5] and Critical Rationalism [6] theorizing.

We could start by observing how the so-called "clinical eye" is not a particular passive detection tool, as complex as one want: rather, it is an eye that reasons, active and interactive, a tool that processes. In particular, it is not an observer according to classical Mechanics, but it is a quantum observer, subject to Heisenberg's (1901–1976) uncertainty principle. and with the fundamental inseparability between observer and observed.

It is hardly necessary to recall the importance of the critique of determinism in medicine, provoking a more elastic way of approach to diagnosis and therapy.

Only the placement of evidence and phenomena within the culture of the physician and surgeon allows us to speak, consistently with the essential scientific nature, of «*sensate*» experiences, as with Galileo, or *sinnvoll*.

## Pure Facts don't Exist

One of the most remarkable achievements of twentieth-century epistemology has been the overcoming of the last neo-positivistic inductivism, with the assertion that no induction from pure facts is possible, particularly because pure facts don't exist [7].

It may seem, at first and immediate impression, that this statement contradicts classical empirical views on medicine and science. But this is not the case, it is a nineteenth-and twentieth century evolution, a consequence of the awareness of the role of the doctor as well as the scientist in the acquisition of these facts. It is no coincidence that it is affirmed that pure facts "don't exist" and not that there are no pure facts.

The last serious attempts to propose a methodology inductivist of science were made in continental Europe in the first decades of the twentieth century and soon came to an end, it has been observed.

From the Physics of the XX century we can learn to the end and make our own the concept that in particular medical evidence is not a pure fact, it is not present in reality so the doctor should limit himself to detecting passively and impersonally its presence, absences and quantitative data, but are human constructions operated on reality, in such a way as to be able to know it and interact with it with adequate scientific and professional competence, also for diagnostic and therapeutic purposes.

This focus on the role of constructed medical evidence is undoubtedly challenging, but it throws lux on the human, relational and cultural context in which the doctor practices. Facts, and not "data", are products (latine loquendo *pro - ducere*, to carry ahead) in the interaction between the doctor and the health situation; Obviously, they are not made arbitrarily, as anyone with a scientific mindset understands.

Not even the detection of body temperature or heartbeat are pure facts, in this sense, but products of the operator with a certain competence, obviously produced in a non-arbitrary way, but conditioned by reality, as in any science. The degree Celsius or Fahrenheit does not exist in nature, it was devised by man, who also established the usual but not legal character of both units of measurement.

What we observe and interact with quantumly is not nature or for the doctor the human body, in themselves, but nature and the human body in interaction with our tools and methods.

Introducing Quantum Mechanics into the field of medicine can stimulate more sophisticated perception of diagnostics. Here we can only mention a few general ideas, which will recall the need for conceptual in-depth analysis: the inseparability between the observer and the observed is essential, which poses the problem of determinism and facts in new terms, and these are ideas that are recognized as profoundly consistent with the doctor, his culture and his professional practice.

Sigmund Freud himself (1856–1939) [8] encountered understandable aversions in the positivistic climate of his time because he had proposed too many conceptualities considered non-experienceable, for example the unconscious (*Unbewusstsein*) could not be seen, could not be palpable and weighed, it would not have been possible to say where it was. But it was not Idealism: the profoundly scientific spirit of his research and his psychoanalytic proposal were soon evident in the prediction of remission of symptoms through therapies that could also be non-material such as talk therapy. A similar function would have had the transposition of the conceptualities of Psychoanalysis into the Jurisprudence.

All this would have made it possible to corroborate the proposal and to perpetuate the subsequent evolution of medical and therapeutic knowledge and practice.

The existence of very precise and *sine materia* nervous diseases was very clear to Hippocrates (460–377 B.C.) and classical Greek medicine. This is the case of hysteria, traced back to the uterus (ὑστέρα) and considered until the nineteenth century a sexual disease; it is no coincidence that it has long since changed its name, Or, it is the case of melancholy, in classical Greek μελαγχολία, traced back to the excess of a black organic liquid (μέλαινα χολή).

From simple measurements of body temperature, heartbeat or blood pressure, to the most complex digital processing, for example by NMR or PET, the doctor perfectly understands that these are facts produced by a very specific culture, but not arbitrarily produced: which makes the sense of interaction with the patient and his symptomatology in Heisenberg's conception; and these are data that acquire *Sinn und Bedeutung* (sense and meaning) only in the light of a culture. It is precisely the progressive systematic advancement of contemporary physics in the context of the conceptual and operational tools of the physician that allows us to better understand and fully how essential it is to build an adequately solid basis of culture in the field of Physics for future professionals in the medical art.

## About the Clinical Method

The methodology of research by problems, solution hypotheses, control and asymmetric feedback can be considered common to the entire scientific domain, natural sciences and sciences of human culture, as well as to the numerous and diversified professions that have their basis in scientific culture.

We owe to the medical tradition, rooted in the West in its 2500 and more years of history, the testimony of a methodological approach called «*clinical method*» with rigorous etymological descent (κλίνω, κλίνη), application of a particular procedure called "abduction" or "retroduction".

It also becomes applicable to other professions, in particular that of pedagogist and those of various social and health professionals.

It could be discussed in principle whether the methodology of Medicine is fundamentally the same as that of Pedagogy, which can be considered and treated as a science and a profession, or not. Here, however, we emphasize the common traits, which are of fundamental importance.

The passage from the particular to the universal must be mediated by the professional with his competence and culture, in the sense that he finds in the particular case a series of evidences that refer to a universal general case without exception, the clinical diagnosis that can be medical as well as pedagogical, psychological, social.

Schematically:

**RULE, LAW, PRINCIPLE, …**

The general case A presents (or can present) the B phenomenology.

**DATA, FACTS, SYMPTOMS, EVIDENCES, …**

The evidence of the particular case reports aspects that I, a professional, due to my professional experience and competence, consider to be pertinent to phenomenology B of general case A, and no other reasonable hypothesis explains in a similar way what has been found.

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**CLINICAL DIAGNOSIS**

The case we are studying, the B data or evidences, constitutes a particular case of the general case A

It should be noted that this is a method whose logical basis is not built on tautologies, as in the case of inferences from the general to the particular, in the modus ponens «if A, and A implies B, then B».

This is better suited to the always hypothetical and research-based nature of medical professional practice which, like any scientifically based profession, has no certainties that are not absolutely provisional and contingent.

All this is more consistent with the idea of the so-called "clinical eye" as a quantum instrument subject to Heisenberg indeterminacy. The observer is inseparable from the observed. and conducts (l, l. *cum - ducere*) the appropriate clinical facts with his irreplaceable interaction. It may seem a difficult idea, or even a problem, a provocative assertion: but instead it is an effective testimony of how and to what extent Quantum Mechanics has represented an advance in man's knowledge of nature, with consequences on scientific culture as a whole.

The clinical eye is applied from man to man; there is no practice of the real clinical eye in the virtual field or in AI; if anything, it can be an imitation.

Among other things, a rigidly deterministic reading of Newton's Classical Mechanics had historically prevailed, for which the famous quote by Laplace applies: (Pierre-Simon de, 1749–1827).

"*Nous devons donc envisager l'état présent de l'Univers comme l'effet de son état antérieur et comme la cause de celui qui va suivre. Une intelligence qui, pour un instant donné, connaîtrait toutes les forces dont la nature est animée, et la situation respective des êtres qui la composent, si d'ailleurs elle était assez vaste pour soumettre ces données à l'Analyse, embrasserait dans la même formule les mouvements des plus grands corps de l'univers et ceux du plus léger atome : rien ne serait incertain pour elle et l'avenir, comme le passé serait présent à ses yeux* [9].»

On the other hand, for Quantum Mechanics, an indeterministic reading prevailed, for which Heisenberg's principle is paradigmatic.

"*There exists a body of exact mathematical laws, but these cannot be interpreted as expressing simple relationships between objects existing in space and time. The observable predictions of this theory can be approximately described in such terms, but not uniquely – the wave and the corpuscular pictures both possess the same approximate validity. This indeterminateness of the picture of the process is a direct result of the indeterminateness of the concept "observation" – it is not possible to decide, other than arbitrarily, what objects are to be considered as part of the observed system and what as part of the observer's apparatus* [10]."

Quantum theory does not lead to deterministic views of events.

## Maxwell's Equations, the Cultural Turning Point ...

The theory of the electromagnetic field was formulated in 1865 [11] by Maxwell (James Clerck 1831–1879). It was a system of four partial differential equations, a notable aspect of which was its incompatibility with Classical Mechanics developed from Newton's theoretical core. This contradiction was soon overcome with the foundation of Quantum Physics from 1897 and with Einstein's two theories of relativity (1905 and 1919) [12].

The history of science offers innumerable examples of such an alternating prevalence between great theories, in this case, it is remarkable that the overcoming of a general theory, and of a general theory that had had the enormous importance of Classical Mechanics, came primarily for theoretical reasons and coherence between theories rather than for empirical falsifications. which, moreover, had existed in the second half of the nineteenth century but had been valiantly worked to try to overcome them, and had long been considered not decisive. In short, a general theory of Classical Mechanics had been irreparably undermined by «*necessarie dimostrazioni*» rather than by «*sensate esperienze*».

The teaching is valid for the medical art and more generally: Even the best accredited theories are falsifiable, and through this falsification the evolution of culture and science for man is pursued.

It is therefore necessary, and easily corroborated, that the young future doctor fully understands how the doctor who kills the patient to save a diagnosis is not rational, and instead how and how rational is the doctor who "kills" all the diagnoses that must be killed to save the patient.

## … and the Electromagnetic Waves

Maxwell's theory made it possible to predict the existence of electromagnetic waves, and it is still remarkable that when this hypothesis was formulated, and when these waves were then produced in the laboratory, it seemed to everyone that we were faced with a scientific discovery of undoubtedly enormous cognitive value, but which was absolutely useless.

We all know that the enormous spectrum of electromagnetic waves has been of essential importance in technology since the 1900s, and that it directly affects both doctors and health professionals as well as physicists and health physicists. Note that X-rays had already been introduced in 1895 by Röntgen (Wilhelm C, 1845–1923), These rays, like all ionizing electromagnetic radiations, require special attention because they leave permanent consequences on the irradiated tissues.

We know well, today and for some time, that the use of x-rays has made very important contributions to medicine, but it took decades before irradiation of unnecessarily disproportionate dose

was avoided, and due attention was paid to the safety of patients and the health of doctors and operators who were seriously affected. Examples like this, and there are many, show how a doctor who began to be trained a few years earlier would still have to possess the basics of physical culture adequate to deal positively and decisively with such a problem. The cultural bases, of physics in particular, must be such as to allow a fully participatory use of the technical tools that will be proposed for the future.

All this, on the other hand, does not mean that there are no other reasons for consideration for the other various components of that spectrum, from radio waves to ultraviolet rays and beyond. These are phenomena and tools whose functionality has spread in the twentieth century, as is perfectly evident, in telecommunications, in the use of radars, and so on. It is clear that the culture of the doctor had to be adequate even to the basis for understanding electromagnetic theory and electromagnetic waves in their entire spectrum, and this even before the very first electromagnetic waves were artificially produced in the laboratory for exclusive initial research reasons.

## … in Nuclear Physics, and the Training of the Future Doctor

A similar lesson about the relationship between scientific research and technological applications would be offered to us a few decades later, from the research of nuclear physics and in particular from those of Enrico Fermi (1901–1954).

The scientific curriculum of the roman scientist is a great teaching in itself. He was first a theoretical physicist, then an experimental physicist and finally a professional definable as a nuclear engineer, and this last role he played first as a civil engineer with the construction of the atomic pile, then in other contexts of dramatic state of war.

The application of Enrico Fermithenthe two empirical phases he exposed himself to doses of radioactivity that would lead him to an early death from neoplasia at the age of only fifty-three. In short, he faced the same cause of death that the first radiology doctors had faced for decades.

But this was been the same fate, for example, as Maria Skłodowska-Curie (1867–1934), who had suffered a painful death probably from radiological causes, she who had also engaged in the medical application of radiation; or her daughter Irène Joliot-Curie (1897–1956).

In the case of X-rays, the diagnostic utility appeared almost immediately, due to the evident and well-known opportunity to see the bones in their possible infractions or in other pathological sufferings. Instead, the usability of nuclear physics continued to be put in serious and insurmountable doubt until the 40s. Again, there is an aphorism that is probably apocryphal, attributed to Robert Millikan or even to Ernest Rutherford, but which deserves every attention because it clearly reflected the mentality of the time among top scientists, and which in fact has been widely taken up.

As is well known, a turning point came when it was possible to reproduce in the laboratory nuclear fission that made it possible to convert matter into energy according to Einstein's well-known (relativistic) formula $E = mc^2$.

The aphorism is from those same years:

"*Yet, he doubted that atomic physics would produce a practical source of power, and he referred to such speculations as "talking moonshine", i.e., talking foolishly.*"

The statement is attributed to one or the other and could even be apocryphal, but it realistically reflects the widespread belief in the late 30s among top physicists.

## The Evolution of Scientific Culture in a Few Decades

Teaching is important as a contribution to the rigorously scientific and open mentality that the doctor must have, like any professional operator in the health and social domains, but even more so for the need for adequately solid and comprehensive cultural bases for those who place themselves in the perspective of 40–50 years of professional practice in the context of a frenetic and unpredictable becoming of scientific knowledge and technical applications. Doctors, as well as all the higher intellectual professionals who have fifty years of their knowledge behind them, or even much less, should reflect on what has been the technical and technological evolution of reference in recent decades, as a culture and not only as a practical instrumentality, and make themselves available to imagine how such an evolution for future decades can only be even more important and even more frenetic.

In other words, how could one ever think of facing half a century of continuous education in medicine and health, similarly to any scientific and professional domain, without the adequate foundations, that is, first of all sufficiently healthy and comprehensive bases of Physics, understood both as a research method and as contents?

In essence, the young beginner university student must be clear and aware of the need to build adequate foundations, first of all in physics, to face scientific, technical, and professional practice knowledge that can only make all the reference knowledge evolve powerfully, and therefore have to rely even decades later on adequately solid and organic initial foundations. And it is well understood that it is not just an instrumental propaedeutic, it is precisely a matter of forming a mentality open to continuous evolution. which is the only one compatible with the reality of the medical art, as of the rest of any higher professional art and of any profession.

## A Role for Ethics in Scientific Research

At the end, we observe that several ethical considerations may arise in this contest. Physics, like Medicine, offers the answers of that science which contains in itself and in its method an ethics: the ethics of coherence, of empirical control, of continuous research, of systematic doubt, of the absence of definitiveness, and so on, listing ideas known and familiar to physicists as well as to physicians and to anyone who is a man of science.

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