A C T A  U N I V E R S I T A T I S  L O D Z I E N S I S
FOLIA OECONOMICA 255, 2011

*Janusz Kupczun*[*]

# THE ROLE OF PROBABILITY THEORY AND STATISTICS IN METHODOLOGY OF THE EXACT SCIENCES

**Abstract.** At present, there are two types of exact sciences distinguished: (1) experimental sciences and (2) deductive sciences. This distinction corresponds to the ancient division of all "theoretical sciences" into: (1) physics (in most general sense of the world; natural science) on one side and (2) mathematics (with "metaphysics") on the other side.

In both types of sciences we strive to achieve certitude or at least we tend to achieve something what we call certitude. Respectively, this is so called "physical certitude" (for which exceptions from the proven statements are allowed) and so called "absolute certitude" (for which exceptions are not allowed).

In the face of the tremendous development of human knowledge there appeared an urgent need to think over the foundations and methodology of the exact sciences. Particularly important here are investigations concerning the role of various concepts of "probability" and "certitude", associated with probability theory. Those investigations are principally important not only for foundations of exact sciences, but also for accurate defining of and distinction between methods of the experimental and deductive sciences.

The present part (Part 1) of this work is an introduction to such investigations, from the positions of ancient, though updated and modernized realism.

**Key words:** stages of judgement; human convictions, their certitude versus probability; certi-tude in absolute sense and certitude in relative sense (physical or moral); analytic and empirical knowledge; science as a habit (or even "intellectual virtue"); final results of sciences in case of empirical descriptions.

## PART 1. THE RUDIMENTS

### I. INTRODUCTION

Rapid development of the exact sciences, especially their growth in the XVIII, XIX and XX centuries, requires a comprehensive and lucid exposition of their methodology, which might be of some help for the real, "concrete"

[*] Ph.D. in Math., Department of Statistical Methods, Łódź University (Poland).

research in these sciences and be employed in their didactics`. However, methodological "generalities", propagated by some university philosophers, are far from being satisfactory for these requirements in the major exact sciences. Moreover, some of the methodologists` conceptions are not acceptable for any realistically thinking scientists; for an example let us recall illusions propagated by "logistics circles", that the real existence of things in Nature is properly defined by "existential" logical quantifiers, applied to some kind of general formulas (see Ajdukiewicz (1951), p. 12).

Any intelligent person might even suspect, that contemporary methodologists by working mainly "on the surface of the problems" or producing extremely "logicized" materials, are really unable to provide our scientific communities with any useful and not controversial definitions, even of such general terms as "science" or "exact science".

Quite the opposite situation has happened in antiquity, at the very beginnings of our scientific inquiry, when the discoveries (or results pretending to be discoveries) were not so numerous as today. At this distant past the research in general philosophy and those in particular sciences inspired each other and illuminated each other, and all objections were finally reasonably answered.

The author is perfectly aware of innumerable discussions of methodological ideas, either at the interdisciplinary university seminars, or in many papers written every year on such subjects. However fashionable, these endless discussions do not offer any real solutions of the old problems, and even cause further stagnation and confusion.

Roughly speaking, the aim of this paper is to contribute toward "reanimation" of our present day methodology, on the grounds of the same conceptual tradition of realism as in antiquity. This, however, should be explained more plainly.

In every exact science, there are convictions qualified as "certain" and exposed by names created for this purpose, such as: "theorem" (in mathematics), "law of a given science" (in natural sciences), or simply "thesis". So, for a given science, problems of achieving certitude with respect to an analyzed assertion (and not only its "high probability), are of primary importance in the methodology of this science. Consequently, in general methodology (and epistemology), there appear two important problems:

(1)problem of comparison between "certitudes" in various sciences;

(2)problem of mutual dependence between their concepts and the concepts related to probability theory and statistics.

For lack of space, I have divided my intended work into three separate parts: part 1 (this present paper) contains my interpretation of the classical three kinds of certitudes; part 2 leads discussions about certitude and realism in modern physics; part 3 contains broader and more advanced relevant materials.

Parts 1 and 2 deal only with the rudiments for elaboration of the problem indicated in the title and are published simultaneously as two separate papers. Part 3 though will be published as a sequel in the near future.

In this work I present the idea that "physical certitude" does not secure (immediately) veracity of our statements. As far as I know, this conception is completely new in realistic epistemology, and might end many obscure and "abstract" quarrels. Here I assume full responsibility for this idea, as well as responsibility for the details of my paper.

The contents of all three parts of this work, as well as my intention (by presenting this paper) to evoke "concrete" discussions on the problem with the experts in particular sciences, sufficiently justifies the title. It is worth to mention, some of my remarks about the old realistic conceptions (including remarks about human cognition) may be helpful for the reader in his future investigations. It is as a proper "background" for methodology which I would like to "reanimate".

Since the quotes from various sources are properly understood only from their contexts, I have suggested the proper meanings of the words used in them by italicized phrases written in square brackets in a manner common among translators.

Hopefully in the not very distant future, as a final effect of many "concrete" works in the same conceptual direction and broad discussions among competent persons, there should emerge more complete, precise and reliable expositions of all methodological ideas in a realistic "frame". My personal hope is that after some further careful studies, I will be able to participate with others in preparation of such a complete work, written in a more unabridged fashion.

## II. COLLOQUY CONCEPTIONS OF EXACT SCIENCES AND A FEW DISTINCTIONS IN TERMINOLOGY

According to linguists, the English term "science" was created from the Latin word "scientia", whose original meaning was "knowledge" (or "news", "information", etc.). However, in both English and Latin, as well as in many other languages of the world, including my native Polish language, the word has acquired some derivative meanings, more important and more sophisticated than the original one.

The Polish equivalent of the term "science" is "nauka". This word presently designates the activity of learning and teaching, and by a metaphor means "this, what is learned and taught, mainly at school". The other meanings of this term probably were derived from these two. This is the reason why, presently in the Polish language, "science" usually means **"(unquestioned by reasonable people) any descriptions of some parts of reality, created by the effort of gen-**

**erations, which have been taught at school"**. More precisely there are three meanings of "science": (1) "knowledge (or a set of statements) about selected objects"; (2) "a set of statements referring to these objects and ordered by the rules of investigation"; (3) "a special order among such statements".

In the English tradition, the ordinary meaning of the term "science" is almost the same as the aforementioned.

Among the "sciences" (in a sense which is not very precisely stated), the important "exact sciences" are distinguished. These are **sciences with clear rules of investigation, not allowing any subtle changes in meanings. This excludes confusions** which require authorities for choosing among competing opinions.

It is emphasized, sometimes, that the universal means for "exactitude" of knowledge is to ground its terminology, mainly on numerical conceptions**.** Leonardo da Vinci has mentioned even [*fittingly or not quite fittingly – it depends on what is meant by "mathematics"*], that "there is no credibility in the sciences about such matters, where mathematical sciences are not applicable, and [*there is no credibility in anything*] not related to mathematics".

Some mathematicians proclaim slightly different, but stronger theses. They maintain that "mathematics is universal; there is no subject entirely foreign to it" (H. Steinhaus) and that "there is no science not related to mathematics; mathematics is a base of, and a key to, all human knowledge" (L. Euler).

Other well-known mathematicians and logicians add: "People usually search for proofs only for [their statements about] numbers and lines [*or other figures*], and look for things represented by them. The reason for this is clear: beyond numbers [*and lines*] there are no convenient things, corresponding to [*our*] conceptions" (G.W. Leibniz), and "in the nature of mathematics there is no necessity to discuss [*only*] ideas of numbers and quantities" (G. Boole).

On the other side, some intellectuals compromise by saying "without mathematics you will not reach the depths of philosophy; without philosophy – that of mathematics. Without both, you will not reach the depths of anything" (philosopher J.B. Bordas-Demulin). Others, with a dose of criticism and humor warn us: "mathematicians are like Frenchmen. Whatever one says to them, they translate this into their own language. Then, this becomes something completely different [*than originally intended*]" (famous poet J.W. Goethe).

The classical examples of the exact sciences are: mathematics and natural sciences. Obviously, also statistics is an exact science and a lot of other disciplines.

The classical examples of the sciences in the wider sense, which are not exact until now, or which are not even able to be exact at all, are: history (not only of states and nations, but also of mathematics and physics), social sciences, philology, various versions of aesthetics, and (very controversial(!)) "futurology".

In the domain of history, the major source of information is human testimony. But this testimony is often false and then we only have very few other means of verification. Nobody is able to repeat the events from the past and there are limited experimental sources of knowledge about archeological excavations. So, one is highly satisfied if one reaches "reasonable" opinions about such events. In case of "futurology", one even does not have such a chance, because the future, often, partly depends on unpredictable human free will, as maintain many religious thinkers and philosophers.

We should add: in the English tradition "science" often designates only the exact sciences (without this "collection of opinions on various subjects", which is today called "philosophy"). The other sciences are numbered among "humanities".

At the present time, the average person trained at school, is able to accept the above division and qualifications of all our particular sciences.

At the universities, however, one could find a large variety of opinions in strong opposition to common views. As a perfect example we could quote a "meta-opinion" of one of our contemporary methodologists expressed in an authoritative manner that "mathematics, which is [*traditionally*] considered a pattern of exactitude, [*presently*] is not counted among the exact sciences at all" (see Nowaczyk (1985), p.26).

One may suspect that such opinions are effects of some misuse of our language, or they are purposely iconoclastic and astounding.

However, the quoted opinion about opinions (evidently opinion unmotivated and false), was probably affected by views of the physicist R. Feynman. This famous teacher of physics, under the name of "science" understood only the natural sciences and often expressed his highly controversial view that physics will be finally free from mathematics.

It is not known, what kind of concepts or branches of mathematics Feynman considered as "mathematics" and attempted to eliminate from modern physics. Also, we may suspect, nobody ever tried to interview world leading physicists on such difficult subjects as above, and to analyze their answers in a proper, objective way (even without any appropriate statistical procedures).

The ordinarily utilized methodological ideas are not always clarified in all their details, and for this reason, extreme opinions of university intellectuals gain their audience.

As a matter of fact, even now the authors of university handbooks avoid any methodological questions by vague "explanation" that: "physics is a science which physicists create" (e.g. Jeżewski (1970), p. 15). The same is (sometimes) said about geometry or generally about mathematics.

Being more ambitious, I will try to explain and specify the terminology which is still present in our culture, and has been developed mainly by the traditional school of Aristotelian realism, often called "perennial philosophy".

Modern literature on the tradition of realism exists in a "state of confusion", being a cause of long lasting quarrels among otherwise well educated scholars. So, for any specialists in the exact sciences, there is no sufficiently lucid introductory and modern book on this subject. On the other hand, in the past the original works of great philosophers have been excellent and lucid expositions of their ideas. For centuries, however, languages of these works have slowly changed their original meanings, and for the vast majority of us today, these works are also almost unintelligible. Therefore, (with a few exceptions) we will not send anybody to such misleading or puzzling sources. Instead, from the very beginning, we will explain even quite simple conceptions.

First of all, very briefly, one should distinguish a few important notions, often confused. Among others, these are:

**(1) convictions** ("analytically" or "physically") **certain** from unmotivated (to the end) **opinions**;

**(2) certitude** from **probability** in the old sense (often expressed in our ordinary language);

**(3) "absolute" certitude** (in other words – "not relative", but not in a sense of "strong" or "lasting") from **"relative" certitude (**including so-called **"physical" certitude** and **"moral" certitude)**. Also one should specify, which of these certitudes shall be required in particular sciences;

**(4) probability in the old sense** and **in the present sense;**

**(5)** so-called **"principles"** from **"derivative"** (or justified) **convictions** (Fortunately, in deductive sciences, this distinction is already very well known. Therefore, it is not difficult).

Next, one should distinguish very clearly: **knowledge** (as Aristotle has been saying, **"knowledge through causes"** or "knowledge acquired by consideration of causes"), from **science** and **the present state of science**. Finally, everything should be ready for the detailed classification of sciences.

## III. THE OLD CONCEPTION OF SCIENCE AS AN INTELLECTUAL VIRTUE. APPROPRIATE ELUCIDATIONS

### 3.1. Habit i.e. permanent disposition

In order to make clear distinctions indicated above, the well known from philosophy and psychology, conception of **"habit"** or **"permanent disposition"** is of primary importance.

The English term “habit” is related to the Latin name “habitus”, a derivative from “habere”, which means “to have”, “to possess”. It might be said, this term originally means “possession of the very possibility for the transition from potency to act”; in other words, “improvement towards acting”, “proficiency”. Also the word “custom” (by a metaphor) means almost the same.

The term “habit”, however, is employed here, not in its full general meaning, but in applications with respect to the activity of human intellect and will.

More clearly: our acquired concepts, while used, leave “traces” in our mind, as kind of a preparation for the better use “in act” of these concepts. By means of these “traces” we easily utilize these concepts “in act”, when it is necessary (“easily and with pleasure”). In particular, when we understand a proof of some new theorem, for instance Pythagoras’ theorem, by such “traces” from this very moment we are able to utilize this theorem in action. We might say, this theorem (being a very specific concept) remains in our mind and not only in our sensory memory (as one could expect), but as a **habitual** (not completely actual) **state of mind**.

Not always do we actually have a “habit”. When we have a “habit”, we are able to utilize it, and we work in a more efficient way, differently than before.

At first such explanatory remarks seem to be very “philosophical”, too difficult for any normal intelligent person. However, the exact understanding of the above distinctions (immediate and in details) is at this moment of secondary importance. More important is the intuitive understanding in what way these distinctions could be done. Equally important is to create traces of conceptual “paths” for ourselves (for now and the future). In spite of apparent difficulties, this does not require too much effort from anybody, even from persons without any philosophical background.

Many of the notions described here are not based on our external experience, but they are acquired mostly from introspection and self-knowledge. Hence, they belong to the domain of “rational psychology”.

### 3.2. “Strata” of language. Judgment. Conviction and its certitude

Our everyday language, all our words and expressions, have two related “strata of language”:

(1) stratum of **external speech** (of sounds and inscriptions);

(2) stratum of so-called **internal speech** (which consists of concrete, “singular” phantasms and “general” concepts).

Hence we could talk about the names and sentences, found in both “strata” of language and related to each other, not introducing for these “strata” distinct terminology.

When we judge, at the last stage of this action, we pronounce a **statement**, modulating our voice and ending our inscription with a dot (a dot being also a sign of full stop in pronunciation). At the first stage, we create some kind of **mental "synthesis"** – our mental "description" or **"name" of some fact**. Then, at once, at the second (and last) stage we mentally create a **"name" of our attitude towards this "synthesis"** (precisely, a "name" of the "relative". This "relative" is a subject consisting of us and our attitude (relation) towards this "synthesis"). The results of both stages of judgment are called **"sentences"**, without any diversification. However, for the sake of clarity, the sentence of the last stage of judgment, and only this sentence, we call a "**statement"** (sometimes**: "enunciation" or "proposition"**).

There is no necessity to show, that (very often) such an attitude (towards our mental synthesis) exists in us; this we know merely by self-observation. However, from time to time, our judgment may end at his first stage, when (by the action of our will) we pronounce a sentence without its proper intonation; then this judgment is called **"suspended"**.

In some situations we only pretend that we have the aforementioned attitude. Then, either we express sounds that are not a statement at all, or (if possible) we still have the second stage of our judgment, but there is not any mental attitude in us and we express an empty concept.

If our statement designates something (i.e. designates our attitude towards the "synthesis" (!)), we call this statement briefly our **conviction**. Whereas, our determination towards our attitude (and by this, some determination towards forming the statement), we call our **certainty** or **certitude**.

Some contemporary authors, and (in very rare cases) some old logicians and philosophers, are of opinion that the statement (also called assertion) is a kind of "meta-sentence", in other words, that it is a "sentence about sentences". However, as far as our comprehension is concerned, we do not form any new sentence by the next judgment. Actually, by the same process (at the second stage of judgment) we do create a new concept (i.e. a "name" of our attitude) that is not a sentence of the first stage of judgment at all.

Moreover, usually, we do not use any "meta-language", i.e. we do not speak about our language. Hence, in particular, in many cases we never formulate any "meta-sentences". The aforementioned opinions (even if correct, that something new is formed in us (!)) should be considered as evidently mistaken.

It is necessary here to clearly point this out: our conviction is a state of our intellect but not a state of our will. Sometimes, however, our certitude is caused by our will or even by our will with our sensitive emotions. Such a voluntary certitude, caused by the current act of our will, does not occur in cases of scientific knowledge, but rather in cases of religious or human beliefs (including more or less justified opinions). So, we shall not analyze such cases here.

On the other hand in natural sciences and in our moral life, so-called habitual intention of our will (not necessarily intention in act (!)) plays some part in achieving certitude. So, in such cases, strictly the same requirements for certitude as in mathematics would cause a real stagnation. We describe this particular case of certitude better, in following pages.

In the sequel, we often talk at first about very subjective expressions, which are constructed with the application of at least one singular concept, usually given in somebody's sensory perceptions. However, for obvious reasons, we pay more attention to the other expressions called **"general"**, **constructed solely from general concepts**.

### 3.3. Analytic knowledge and analytic certitude

It might happen that the certitude of our statement is solely affected by understanding our "mental synthesis", being independent from our sensory perception at this very moment and independent from our previous convictions. Then, we call our statement a **"principle in an absolute sense", "statement analytically self-evident", or simply "analytic principle"** (also: "**axiom"** or "**postulate")**.

From **"analytic principles"**, we obtain purely deductively all **derived analytic statements**; however, there is no need for the full formalization of the process. Together with analytic principles, they form our so-called **"analytic knowledge"**.

The certitude of analytic knowledge one may call **"certitude in an absolute sense"**, **certitude caused by "analysis of the concepts"**, or briefly "**analytic certitude"**.

Here are a few examples of analytic principles:

(1)convictions of Andrew: "This is warm.", "I feel warmth." are Andrew's (subjective) analytic principles (when Andrew touches something, and he really feels warmth). However, he could change the meaning of the name "warmth" (usually given by his earlier observations, which were immediately generalized) and then his new convictions of the same external form, might be erroneous and not analytic principles at all;

(2)conviction of Andrew: **"{not[(this is not warm) and (this is warm)]}."** is his (objective) analytic principle, a very special case of the famous general law of not contradiction. We may call this conviction "objective" in some broad sense; the general law of not contradiction **"For every x {not[(not x) and x]}." we** may call called "objective" in the narrow, strict sense.[*]

[*] Here we have perfect examples how modern logic (though in a very few cases only (!)) introduces precision and new structures in our ordinary language. Instead of the form "(not p)." one might obviously consider the more sophisticated sentence " 'p' is not true.", but there is no reason for such a change. The constant care for precision in the use of dots is specific for this work.

Examples of derived analytic convictions one could easily find among well known tautologies.

### 3.4. Relative knowledge and relative certitude

From our birth we habitually (by a habitual intention of our will (!)) rely on the data of our senses, performing various operations; however in some exceptional cases we correct our sensory interpretations. The convictions obtained in this way one may call **"common sense' convictions** or **"perceptional" convictions**.

We say that a statement is a **physical** (or empirical) **principle in a broad sense**, if it is our perceptional or our analytic conviction. Here we implicitly assume that our certitude of the statement is caused by our certitude, that we worked in proper conditions, i.e. as far as we could notice that our senses and instruments worked according to their purpose. The last additional certitude may be achieved for example, after observations or experiments, by reflection on the conditions that we remember and by reflection on fact that we had the intention to work properly.

We say that a statement "s." is an analytic conclusion from a statement "p.", if implication of the form "(p implies s)." is our analytic conviction.

Next we introduce **physical** (or empirical) **derivative convictions** as analytic conclusions from physical principles, similarly as in the case of analytic convictions.

Further, by an analogy we introduce the other terms, including "physical knowledge".

Since we assumed that all analytic convictions belong to the class of physical principles, we must admit that **always analytic certitude is physical. However, sometimes the opposite (that physical certitude is analytic) is not true**.

For obvious reasons, physical certitude in the described sense is very subjective and may lead to convictions that are contradictory. If such a case occurs, we are not forced to have any "revolution in natural sciences". Simply, we have to reflect, analyze all data, and add some of the previous physically certain convictions to the new perceptional convictions calling them a **new physical principle.** These will be principles of a new stage of physics where one should build the whole physical knowledge again (with better instruments and greater precision). Therefore, this kind of certitude one might also describe as **relative (or conditional)**.

In order to avoid subjectivity in our physical knowledge, we should always look for new general physical principles. We may call them **"physical proper principles"**, allowing some additional assumptions about them. We may require that they describe causes of material things, in some sense similar to that required by Aristotle. This however, would be too difficult a task to fulfill at the

present time, taking under consideration all controversies accumulated throughout the ages on the subject of "causes".

The detailed descriptions of the underlying certitude (about senses and instruments) depend on the "World View" (or rather "Reality View") of particular groups of scientists. However, even within those groups of scientists the "World View" varies. Objective discussions of the detailed requirements presupposed for experiments belong to some kind of "meta-physics". This "meta-physics" is implicit even in thoughts of materialistic or skeptical thinkers. In a similar way as above we may also describe **"moral certitude"**, weaker than the two certitudes described already. This certitude may play some preparatory role for achieving other certitudes: either analytic or physical.

Our judgments about human affairs often depend on trust in people. **For moral certitude it should be required here that the persons involved are trustworthy** (in other words, they act according to their destination as people). The new certitude (based on another one) **might be called moral** and (additionally) **relative**, similarly as in cases of physical certitude.

A better understanding of "objective finality" in human affairs one may develop by analyzing discussions in "moral philosophy" (e.g. discussions in Cathrein (1904), pp. 203, 212, 213). Obviously, materialism most often rejects any "objective purposes". Therefore, on its grounds, morality of human action seems to be only a very specific effect of the animal instincts in us, similar as in wild gees (biologist K. Lorenz (!)), effect of socially useful training or simply a mistake.

We do not discuss here in detail any problems specific to moral certitude. This certitude is of great importance mainly in our practical, everyday life. For instance, it is important as a precondition for Christian faith (as well as faiths of many other religions). Similarly this moral certitude is important in cases when we give full confidence to our friends, up to the moment of realization that they (friends) are taking advantage of us, have been cheating or lying.

Now, we add a few more remarks about physical certitude.

It is worth noting, that physical certitude (differently than analytic certitude) does not guarantee the truth of our statements. At most, **we could expect that in the process of constant corrections in our experimental knowledge, we finally reach the truth on some subjects. Even though in all particular cases we are unable to be certain that we already reached the truth.** As good examples of such cases one could probably give general (already popular) convictions about: (1) the causes of high and low tides in the oceans; (2) the presence of three massive particles (quarks) in atomic nuclei (i.e. protons and neutrons); (3) the presence of a double spiral in biological cells responsible for mechanisms of heredity; (4) the concrete estimate (from the top and from the bottom) of the age of our material World.

Some modern physicists are of the (implicit) opinion that the **efficacy of their methods (in aspect of reaching the truth) is justifiable by some kind of philosophical argumentation or by religious beliefs**. A brief analysis of their opinion shows that they think about justification by objective "finality" of the World (so often criticized by materialists). On the other hand one can easily admit that this (controversial for other physicists) conception could really serve their purpose.

Indeed, let us assume for a moment, that **our World has been created** (i.e. caused in its whole reality) **by a Perfect Intelligent Being (God) according to His creative conceptions or ideas.** Also, that **God has created the World for us – people, in order that we could start and develop our knowledge in constant evolution towards our (and the World's) final state. This final state includes knowing in some way God and the whole Reality.** One may easily obtain, a very reasonable conclusion, that **God** is **not deceiving us, and He ordered everything in the material World in such a way that we are able to gain our experimental knowledge.** The details of this traditional approach should be elaborated in modern "natural theology".

To reinforce such arguments as above (arguments still possible in our European culture), leading physicists of the Copenhagen School quote the views of the famous Kepler. For this great physicist, physical knowledge is some kind of very specific God's service: **"As a spiritual creature, man is an image of God. As such, man is able to meditate on the creative thoughts of God and recognize them in material creatures. This recognition, this 'God's service', is precisely natural science** [***i.e. physics***]**"** (e.g. Weizsäcker (1980), p. 134).

In a purely materialistic or agnostic World View, any justification of the evolution of the whole World (exactly such an evolution as it is, in the three dimensions with these parameters, not the other) would be extremely difficult, if possible at all. Our optimistic expectations of such "positive" evolution resulting in a completely correct final state in some areas of our physical knowledge is also extremely difficult to achieve, if not impossible.

One might consider the very abstract hypothesis of "parallel Worlds" existing independently, and in which all mathematical possibilities are realized. For these "Worlds" one might also examine possible evolutions and efficacy of experimental knowledge in them. However, any justification of "positive" evolutions in these "parallel Wordls", as well as any justification of efficacy of experimental knowledge in these "parallel Wordls" (valid for all of them (!)), seems to be impossible.

Without some kind of "meta-physics", the physicist M. Planck, frankly admits that "the scientific picture of the World ... [*never*] is ... something final". He goes on to say "Absolutely certain is [*only*] this, what we experience by mediation of our own body [*so, purely subjective knowledge about singular objects*]..." and "the purpose of exact sciences is [*however*] gaining knowledge.... that has

a general meaning [*not a singular one*]..."(Planck (1970), pp. 210, 207, 208). Without some kind of "meta-physics" (theistic or materialistic in its results), one has to admit finally that there are no such natural sciences which could be "justified".

The success of physical inquiry is not of necessity dependent on the (theistic or atheistic) "World View" of the scientists. We do not have two physics: one created by theists and the second by atheists. However, this is true under one condition – the researchers should act according to the rules of empirical science, described by many present day and old "naturalists'. It is easier to accept (and follow) these rules for anyone who not only has guessed them or has taken them from others, but also is optimistic on the grounds of his World View (which includes metaphysical justifications and religion). For Kepler as well as for many other Christians, essential stimulus to human activity, including scientific activity, has been given by Christ wha revealed: "seek, and you shall find... For every one ... that seeks finds" (see e.g. New Testament, Gospel according to St. Luke, IX, sect. 9 and Kepler (1981), p. 98).

Even for theistic thinkers there still remains an interesting, important and not easy to answer question in metaphysics (or philosophy of Nature): how has God organized evolution of the World in order to safeguard all final successes of empirical inquiries. Here is no place for such an inquiry.

Let us return to the main subject.

Our knowledge might be accumulated in time, both in our books and in our intellect, in a rather accidental way. However this knowledge does not need to be accidental at all.

It might happen that we **habitually** raise new hypotheses, reducing them to principles.

If, in the range of physical certitude, one justifies his convictions about material things, reducing them to (general) physical principles about the same subject, he develops a related habit with relation called **physics** (for the old meaning of "relation" or "reference" see Aristotle (1984): Categories, Book VII; Metaphysics, Book V, Sect. 15). Whereas, all convictions gained in this way, up to a given moment (and present in him as habits) are called **actual states of physics** in him at this moment.

Let us note that any habit belongs to Aristotle's category of qualities (or is something that plays this role in a particular case). However, a habit may also have a natural "relation" or "order" towards something. In this way, physics is an order "present generally" in many physical habitual convictions. Sometimes it is expressed by saying that "science is a habit of conclusions" (St. Thomas) or even "a disposition for proving" (Aristotle).

"Virtue" is a habit of the will, leading to moral good (as it is described in ethics). Hence, by analogy, scientific convictions (and science) considered as a habit leading to the truth (which is goodness of the intellect), might also be called an intellectual virtue.

Obviously, it would be more in conformity with tradition to understand **"physics"** in a "collective" objective sense. I.e. the same **order as a "species" in many persons at the same time** (such a presence of a species in many individuals is often considered in the traditional ontology (!)). Then, "the present state of physics" should be understood in a similar manner.

To secure any transition of our scientific convictions by teaching to other people, one should additionally assume that these convictions are about "general" situations and not about any individual facts.

In an analogous manner, we may speak about **"mathematics"**, as being an order in habitual convictions for the purpose of reducing them to analytic principles about quantities.

The concept of science as an order in statements for reducing them to principles (for the purpose of achieving certitude) is implicit in the works of Aristotle (see Aristotle (1984), Nicomachean Ethics, book VI: 1139b/15 p. 209 and 1141a/5 p. 215, where five genera of intellectual habit are described). In a more detailed manner this habit is discussed by St. Thomas (see for example St. Thomas (1996), Q. 53–54). Also, in his works there are other related explanations. For instance, there is elaboration on which one of the human faculties (intellect, will, senses etc.) needs habits for its better acting and what is the reason for this need (see St. Thomas (1996), Q. 50, art. 5 and Q. 51, art. 2).

The concept of science as an order in habits, allows us to talk about the same science at present time and also in antiquity, even if the sets of scientific convictions in both cases might be mutually contradictory and different. Similarly, we may talk about one and the same science acquired by a young pupil and already established scientist.

In a similar way one may conclude that a contradiction between a natural science and some other science is possible, but when it emerges, it should be "conquered".

In a similar manner the Pope JP-II in his famous encyclical was able to maintain, that we never have any "real" [*in the sense of "final", "insurmountable"*] contradiction between [Christian] faith and science.

The Pope JP-II has been conscious of limitations on both sides, and as a very important representative of all Catholics expressed his apologies for the process of Galileo. So, in the ordinary sense of the word, JP-II should admit that some contradictions between poorly developed (Catholic, Lutheran, etc.) theology and physics have occurred, but they slowly vanished; and that similar situations might happen in the future.

Let us note that almost the same conceptions of science as held in antiquity (but in an "embryonic state") are present in some of the eminent contemporary scientists. At least, they move towards the same conceptual tradition.

For instance, well known mathematicians: H. Rademacher and O. Toepliz in their popular book expressed views that mathematics (or at least a slight breeze

of mathematics) appears only momentarily, when one solves a problem by means of an idea, and not by examination of all options. They added that contemporary mathematics refers to the problems and methods of the Greeks in its important chapters. (see Rademacher and Toepliz (1994)).

In the same spirit, Prof. A. Mostowski, specializing in modern algebra and advanced modern logic, tells us "a proof [*in mathematics or logic*] is not understood yet, if there is only a precision of its components, verified step by step; but one has not cared for a clear insight into idea of the proof".

Similarly, contemporary physicists (among them R. Feynman) lay emphasis on the role of organizing ideas in the development of modern physics. Although, Feynman does not care for ideas organizing our deductions, he still stresses the role of such ideas during observations and proper transformations of all raw data carefully obtained from them. As a perfect example of such work, he again mentions Kepler's discovery of his three famous laws of planetary movements (see Feynman (1965), p. 11).

Contemporary physicists pay attention to empirical interpretations of all the parameters which appear in hypotheses of physics. If there is a parameter without evident empirical sense, it is very likely that there is not any empirical interpretation of the hypothesis, and the formula under consideration is not any general law of physics.

Such formulas really have appeared in ancient astronomy, in the theory of epicycles. In order to describe the movement of a planet, ancient theory required a sufficiently large number of centers of the epicycles given a priori – without any reason. In cases of other heavenly bodies, for the formula to work, this number should be increased, otherwise the formula fails. The freely chosen, "accidental" formulas are not proper for science and had to be replaced by the laws of Kepler, which were not "accidental" at all.

The great physicists of the Copenhagen School insist, that the discovery of a [*general*] law of physics, [*usually*] **is not any** ordinary improvement of the old descriptions, as often happens in the work of an engineer. Also, [*they insist that*] the form of a finally acquired law is a matter of importance: "When .... Nature leads us to mathematical forms of great simplicity and beauty..., and not invented by anybody up to the present, then it is impossible to abstain from conviction, that they represent its [i.e. Nature's] true property" (see Heisenberg (2001), pp. 130 and 96).

## REFERENCES

I. ON MODERN CONCEPTIONS

Feynman R. (1965), The Character of Physical Law, Cox & Wyman UTD, London (Russian ed. 1968).

Heisenberg W. (2001), The Part and the Whole. Talks about Atomic Physics (in German), R. Piper, München (Polish ed.1987).

Kepler J. (1981), Mysterium Cosmographicum. The Secret of the Universe, Abaris Books, New York (Polish ed. 1972).
Planck M. (1909), The Unity of Physical World View, Physicalische Zeitschrift (1909), 10, 62–75 (As a book – Polish ed.1970).
Rademacher H., Toepliz O. (1994), The Enjoyment of Mathematics, Princeton Univ. Press, Princeton, New Jersey (On Numbers and Figures – Polish ed.1956).
Weizsäcker C. F. (1980), The Unity of Nature, Farrah Strauss Giroux, New York (Polish ed.1978).
II. ON TRADITIONAL REALIZM†
Aristotle (1984), The Complete Works of Aristotle, The Revised Oxford Translation (ed. J. Barnes), Princeton Univ. Press, Princeton (for a free copy see Internet page:
The San Antonio College LitWeb **Aristotle**… ).
Cathrein W., S.J. (1911), Moral Philosophy, Part1, General Philosophy of Morality (in German), Herder & Herder Books, Freiburg in Breslau, St. Louis, vol.1 (Polish ed. 1904).
St. Thomas Aquinas (1996), Summa Theologica (part.1 of 2, Q.49–70, Treatise On Habits) – Encyclopedia Britannica, The Great Books of the Western World, Inc, Chicago, vol. 18 (for a free copy of the 1947 ed., see Internet page: Thomas Aquinas in English A Bibliography).
III. WORKS LOOSELY RELATED TO THE CONTENTS
Ajdukiewicz K., (1951), On the notion of Existence, Studia Philosophica, Posen, Vol. IV, p. 7–22.
Jeżewski M. (1970), Physics (in Polish), PWN, Warsaw.
Nowaczyk A. (1985), Logical Foundations of the Exact Sciences (in Polish), PAN IFiS, Warsaw.

*Janusz Kupczun*

**ROLA RACHUNKU PRAWDOPODOBIEŃSTWA I STATYSTYKI W METODOLOGII NAUK ŚCISŁYCH. Część 1**

Współcześnie odróżnia się dwa typy nauk ścisłych: (1) nauki doświadczalne oraz (2) nauki dedukcyjne. Odpowiada to starożytnemu podziałowi wszystkich nauk "teoretycznych" na: (1) fizykę (w sensie najogólniejszym, czyli tzw. przyrodoznawstwo) – z jednej strony oraz (2) matematykę (i „metafizykę") – z drugiej strony.

W obu typach nauk osiągamy pewność lub co najmniej dążymy do osiągnięcia pewności (w jakimś sensie tego słowa). Odpowiednio – tzw. „pewności fizycznej" (dla której co do udowodnionych stwierdzeń dopuszcza się wyjątki) oraz tzw. „pewności absolutnej", inaczej „nierelatywnej" (dla której wyjątków już się nie dopuszcza).

Wobec ogromnego rozwoju wiedzy pojawiła się obecnie dość pilna potrzeba przemyślenia na nowo podstaw i metodologii nauk ścisłych. Szczególnie ważne wydają się być badania roli rozmaitych pojęć prawdopodobieństwa i pewności, związanych z rachunkiem prawdopodobieństwa. Badania te są szczególnie ważne nie tylko dla tworzenia podstaw, ale również dla sprecyzowania i odróżnienia od siebie metod nauk doświadczalnych i metod nauk dedukcyjnych.

Obecna, część 1 pracy stanowi wprowadzenie do takich badań z punktu widzenia starożytnego, nieco uwspółcześnionego realizmu. Autor sygnalizuje treści zasadniczych pojęć, starając się przygotować przyszłą, konkretną dyskusję dotyczącą tego tematu.

Część 2 pracy uzupełnia fragmenty części 1 oraz nieco dokładniej precyzuje rolę pewności w naukach przyrodniczych.

† There exist many English and Polish editions of classical works of Aristotle and St. Thomas. In recent editions original realistic terminology has been often modernized and might be a cause of confusion for inquiring readers. Reading of word for word translations (as well as comparison betwen modern editions) is usually preferable for our purpose.