JAN SUCH
(Poznań)

UNIVERSALITY OF SCIENTIFIC LAWS

1. INTRODUCTION

The opinion that "...perceptive suntences as such are not scientific statements and as such do not belong to science"[1] is becoming common in present day methodology of science. This is so because scientific statements must be substanciated in an intersubjective manner which is as a rule subject to control on the part of any adequately prepared scientist who has adequate means of cognition at his disposal and the intention to doit. Perceptive sentences as such do not fulfil this condition of intersubjectivity since — as direct results of observation, tests and experiments — they are always singular and concern singular unique phenomena. Thus they always require an indirect (intersubjective) substanciation. Thus perceptive sentences cannot be considered scientific statements until they have been substanciated in an intersubjectively attainable and reproducible way, i.e. through methods other than direct experiment. This is due to subjectivity and uniqueness of the direct experiment method[2].

This is one of the reasons why general staements formulated in science play such a significant role. They serve for deducing and substanciating (through reasoning) singular statements, e.g. for predicting singular facts.

Popper says in connection with this: "Kant was perhaps the first to realize that the objectivity of scientific statements is closely connected with the construction of theories with the use of hypotheses and universal statements. Only when certain events recur in

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[1] K. Ajdukiewicz, *Logika pragmatyczna.* Warsaw 1965, p. 225.

[2] Ibid. p. 224 - 225; also K. R. Popper, *The Logic of Scientific Discovery*, Basic Books INC, New York 1959, p. 64 - 70.

accordance with rules or regularities, such as in the case of repeatable experiments, can our observations be tested — in principle — by anyone. We do not take even our own observations quite seriously, or accept them as scientific observations until we have repeated and tested them. Only by such repetitions can we convince ourselves that we are not dealing with a mere isolated 'conincicence', but events which, on account of their regularity and reproducibility, are in principle inter-subjectively testable. Kant realized that from the required objectivity of scientific statements it follows that they must be at any time inter-subjectively testable, and that they must therefore have the form of universal laws or theories"[3].

Among general statements encountered in sciences the greatest role is attributed to those which are given the status of scientific laws. The value of a scientific law depends in turn to a considerable extent on the degree of its generality — it is generally considered the more important the more it is general. In this respect the viewpoint of present day authors is identical with that of former methodologists. J. St. Mill, for instance when discussing the chief problem of science, says: "What are the fewest assumptions, which being granted, the order of nature as it exists would be the result? What are the fewest general propositions from which all the information existing in nature could be deduced?"[4] Albert Einstein expresses the same idea when he says that the chief task of the physicist is „to search for those highly ... universal laws from which the image of the world can be received by means of pure deduction"[5]. In this context, the problem of conditions to be fulfilled by a statement which could serve as a formulation of a scientific law becomes important.

To start with, it is worth noting that for some basic reasons it seems impossible in practice to give a precise reporting definition of a scientific law. One of the reasons is that in different fields of science sentences of a different type are considered laws, moreover, even among specialists in a given discipline full agreement does not

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[3] K. R. Popper, op. cit. p. 45.

[4] J. St. Mill, *A System of Logic Ratiocinative and Inductive*, Longmans, Greens and Co., London—New York—Toronto, 1947. p. 311.

[5] A. Einstein, *Mein Weltbild*, 1934, p. 162.

prevail as to what conditions must be fulfilled by general statements to consider them scientific laws. For example, there have been long disputes as to whether statements such as "All planets move on the same plane and in the same direction", "All ravens are black", Kepler's laws etc., ought to be considered 'real' scientific laws or not. On the other hand, an analysis of the very synthetic structure of the general sentence proves evidently insufficient in ruling whether it does or does not represent a law of nature. In this case, a 'functional analysis, i. e. a review of functions of the given sentence in the system of knowledge seems also essential, as well as an 'epistemological analysis' to establish whether the given sentence fulfils the cognitive conditions attributed to laws. For both these and other reasons, the question of conditions which one imposes or would like to impose on statements which we grant the very honorable, but in fact disputable status of a scientific law — is at least to a considerable degree — not a question of proof, but of decision (Popper). In this sense, it is not possible to discover what is a scintific law, it is only possible to attempt formulation of the most serviceable explanation of the notion of a scientific law, one that would be as much as possible in agreement with the intuition of specialists in various fields of science. Consequently, any explanation assuming a definite demarcation line between the statements suitable for formulation of a law, i.e. lawlike statements, and statements not suitable for this purpose, i. e. nonlawlike statements, is to a certain extent at least, according to Nagel, "bound to be arbitrary"[6]. However, Nagel does not consider the situation hopeless. It is not impossible to establish reasons for a numerous class of statements to be granted the special status of laws of nature. The 'objective' situation and the function of a certain class of statements predestine them, according to most scintists at least, to be called laws of nature[7]. The present paper is limited to a discussion of the intuitions connected with the notion a law which concern the question of universality of scientific laws alone. This concerns those requirements of universality which, according to the majority of competent scientists ought to be applied to statements considered by them to be

[6] E. Nagel, *The Structure of Science*, London 1961, p. 49.
[7] Ibid., p. 49 - 50.

scientific laws. In short, what type of universality is represented by a scientific law? Naturally, it is essential to refer to views and intuitions on this subject most common in science in order to avoid too much arbitrariness in solving the question. With this in mind we shall describe various types of general statements in science distinguished by present day methodologists and discuss their suitability in the process of formulating scientific laws.

2. STRICT AND NUMERICAL UNIVERSALITY

A discussion on the generality of laws usually begins with deliberations concerning the difference between sentences which are strictly general and those which are numerically general. Those deliberations can be brought down to an analogical difference between terms occuring in the subject of general sentences. The terms can be strictly general, or numerically (enumerationally) general. According to A. Ajdukiewicz, "a term is called enumerationally general, if its content gives us a method to enumerate all the designates of the term in a definite time and to assertain that they have all been enumerated[8]". This is possible, for example, when the term contains a limitation of its designates to "some space-time region" which is in turn closely connected with the occurence in the sentence of proper names or supplementary descriptions (e. g. individual descriptions or space-time co-ordinates) which cannot be defined without the aid of proper names[9]. Thus "Lack of proper names or expressions which it is impossible to define without the aid of proper names proves a strictly general character of the statement[10]". This is connected with the fact that the content of a term in the subject of a strictly general statement cannot provide us with a method for an exhaustive enumeration of its designates. For example, such descriptive terms as "apples which ripened in this orchard last summer", or "letters sent from Poland in the year 1966" are numerically general terms, whereas pharases "ripening apples", or "gravitating bodies" ave strictly general terms.

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[8] K. Ajdukiewicz, op. cit. p. 145 (gloss).

[9] Ibid.

[10] J. Giedymin, *Problemy, założenia, rozstrzygnięcia*, Poznań 1964. p. 151.

Among contemporary methodologists K. R. Popper introduces an analogical division. He emphasises that it is not a matter of proof but of convention whether laws of nature are strictly or numerically general. However, he does not refrain from considering this difference between strict and numerical generality a fundamental one. According to Popper its significance results from a basically different role played in science by general statements on one hand and individual ones on the other[11]. Similarly to Mill, Popper considers it useful to attribute the term general statements only to strictly general statements and to attribute the status of scientific laws to those alone, if they fulfil some further conditions. "The other kind, the numerically universal, are in fact equivalent to certain singular statements, or to conjunctions of singular statements, and they will be classed as singular statements here[12]". As to the former, they can be put in the form: 'Of all points in space and time (or in all regions of space and time) it is true that'... By contrast, the statements which relate only to certain finite regions of space and time can be provided with what is clalled a historical quantifier: "within the given space-time co-ordinates it is true that..." These are called singular statements[13].

Popper also points out to the fact that although the difference between general and singular statements is closely connected with the difference between general and singular notions and terms, it is not sufficint to characterize general sentences as statements in which proper names or their equivalents do not occur[14]. This is because in many statements there occur only general names (e. g. in the sentences: "some ravens are black", "there are black crows"), and yet these statements are not general. If, however, the logical form of the statement is general (the statement contains a general quantifier given at the beginning), it does not contain singular names or space-time co-ordinates (Popper mentions that singular names which are proper names or could be defined only with the aid of proper names often occur 'in disguise' of space-time co-ordi-

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[11] K. R. Popper, op. cit. p. 62 - 64.

[12] Ibid., p. 62.

[13] Ibid., p. 63.

[14] Ibid., pp. 64, 68.

nates or vice-versa) the statement is universal, i. e. strictly general. Thus, according to Popper, not every statement which is general in the logical sense of the word (i. e. not every statement which contains at least one general quantifier) can serve to formulate a scientific law. Such a statement is only a lawlike statement, i. e. a strictly general statement. He believes that only a synthetic strictly general statement which is falsified has been subjected to a sufficient amount of testing (confirmed) and has definite informative functions (e. g. prognostic ones) can be considered a scientific law.

J. St. Mill represents a similar viewpoint on the universality of laws. He distinguishes strictly general and numerically general statements and points out to the difference in methods of obtaining and substanciating each of the types of sentences, as well as to the fact that a numerically general sentence, which he calls 'apparently general', is equivalent to a definite number of singular sentences. Mill says: "A general proposition is one in which the predicate is affirmed or denied of an unlimited number of individuals; namely, all, whether few or many, existing or capable of existing, which possess the properties connoted by the subject of the proposition (...). When the signification of the term is limited so as to render it a name not for any and every individual falling under a certain general description, but only for each of a number of individuals designated as such, and as it were counted off individually, the proposition, though it may be general in its language, is no general proposition, but merely that number of singular propositions, written in an abridged character[15]". Mill definitely rejects as inadequate the concept of a general sentence as a conjunction of a finite class of singular sentences. He emphasises that "...generals are but collections of particulars, definite in kind but indefinite in number[16]". Thus Mill calls a general sentence one which we call here a strictly general sentence.

According to Mill, of all argumentations called inductive only induction proper (enumerative or eliminative) leads to statements which are really, i.e. strictly general. The argumentation called complete induction, which is in fact only "an abridged recording of

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[15] J. St. Mill, op. cit. Vol. I. p. 169.

[16] Ibid., p. 186.

known facts and does not consist in concluding from known facts about unknown facts" is not real inductive argumentation since it does not lead to actual generalizations, i. e. to general propositions[17]. Induction proper occurs only when we conclude "about a general sentence from individual cases[18]".

Thus undoubtedly, when identifying scientific laws with well substanciated general sentences Mill is speaking of strictly general sentences and not numerically general ones equivalent to a number of singular sentences such as, for example, historical generalizations concerning past events from a given period of time. His concept of scientific laws as strictly general sentences undoubtedly played a positive part in the times when extremely nominalist and early positivist trends propagated contrary views, the concept of laws-conjunctions of a finite number of singular sentences. E. Mach, L. Wittgenstein, M. Schlick, F. Kaufmann, and others are among the authors who do not recognize laws as strictly general statements but consider them pseudostatements.

The view that laws ought to formulate a type of universality higher than purely numericall (generality, i. e. a strict generality) or "illimitable generality" (which will be discussed in paragraph four) is at present practically generally accepted both in methodology and in individual sciences. The problem of the character of the openness of class which designates the scope of application of the law, i. e. of its non-empty fulfilment is more disputable.

3. THE PROBLEM OF OPENNESS OF A CLASS DESIGNATING THE RANGE OF A LAW. ONTOLOGICAL AND EPISTEMOLOGICAL OPENNESS

By discussing laws as strictly general statements we assume a certain incompleteness of our knowledge of the number of cases covered by the class designating the range of applicability of the law, we do not, however, further postulate that the number of cases be unlimited. Some authors do lay that further condition and require the number of cases within the validity of the law to be not only undefinable to us, but also undefinable in the ontological

[17] Ibid., pp. 188 - 200.
[18] Ibid., p. 188.

sense of the word. This is because our intuition does not accept as a law a statement whose scope of non-empty fulfilment is identical with the scope of empirical evidence at our disposal. This occurs when the examined cases are all the cases embraced by the validity of the given statement, i.e. all the cases for which the law can be applied. The condition that the scope of the law's present applicability and cases examined up to the present moment should not be indentical with the law's validity in general is connected with functions generally attributed to laws. In this case they are the functions of predicting and explaining.

According to a widespread view, shared — among others- also by Mill, a genuine proof of every general truth (i.e. of a true strictly general sentence, that is of a scientific law) lies in its containing power of prediction. Such a truth always applies also to further facts, so far not implemented[19]. "The sentence: 'all men are mortal' does not mean all now living but all men present, and to come"[20]. Hence it can form a basis for predicting future facts. Thus the law applies not only to past reality, but also to reality which has not been realized yet, i.e. to the future because it covers cases which can be predicted by applying the law and some additional data called initial conditions. In this case a law applies always to a class which can be called ontologically open for the future since part of the range of the law projects beyond the frame of the present and past and covers future facts not yet realized. Many present day authors are of a similar opinion. According to J. Pelc, for example, a scientific law ceases to be a law when its scope is completely fulfilled, i.e. when it is ontologically, though not necessarily perceptively, exhausted by the cases which have occured so far. The law loses then all direct power of prediction (prognosis) as it cannot be applied to any phenomenon in the future. Such a law becomes a historical generalization (a historical sentence) concerning only cases realized at a given period of time[21] and serving only for the purpose of retrodiction (postgnosis).

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[19] Ibid., p. 192.

[20] Ibid., p. 189.

[21] J. Pelc, M. Przełęcki, K. Szaniawski, *Prawa nauki*. Warsaw 1957, p. 22 - 32.

There is, however, no unanimity in this problem[22]. Some authors when speaking of the openness of a class designating the scope of validity of a law, mean another type of openness which can be called epistemological openness. A class is open in this sense when the range of p r o v e d cases which are its elements is not identical with the whole class, thus with the full scope designated by this law, but from its typical sub-set. In this case, too, it is assumed that one of the basic and essential foundations of a law is its previdistic power (the law occurs as one of the substancial data in the deductive process of prediction). The term prediction is taken to embrace both prognosis and postgnosis (retrodiction)[23]. Thus a law is expected to allow deduction "about unknown cases on the basis of known ones" which fall under its scope. It is, however, not required for this deduction to form a way from "post cases to future ones". According to this view, a law need not be characterized by both the previdistic functions: serve both for prognosis and postgnosis. It is sufficient if it performs one of them and forms one of the data of a widely interpreted process of prediction. (Naturally, it becomes evident eventually that in many cases postgnosis is not possible without prognosis in that the process of verifying postgnosis usually necessitates reference to prognosis, predicting results of future observations. This, however, means only that s o m e scientific laws must also perform the prognostic function but does not mean that a l l laws need perform this function.) From this point of view it is inessential for the law whether a class which is epistemologically open is also ontologically open. Naturally, ontological openness results in epistemological openness of a law, but not vice versa.

Evidently, ascribing epistemological openness to a law suffices for the statement that the law as a strictly general sentence is not verifiable in an exhaustive way: at the moment of its ultimate verification, i.e. verification of all its cases it would ex definitione cease to be a law since the class designating its scope would be epistemologically closed. It would not then be able to perform

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[22] see e. g. A. Malewski and J. Topolski, *Studia z metodologii historii*, Ch. I. *Metodologiczny charakter historii — zagadnienia idiografizmu.* Warsaw—Wrocław 1960.

[23] Comp. e. g. K. R. Popper, op. cit., p. 60.

functions so important for a law as the explanatory function or that of predicting unknown phenomena.

It seems doubtless that in sciences called theoretical (e.g. in physics) we ought to require from laws that they be ontologically open, and in fact it is generally so. In historical sciences, however, epistemological openness seems in many cases sufficient since postgnosis is perhaps the chief previdistic function which they are expected to perform.

The question arises, however, whether historical generalizations (or more generally speaking — historical sentences) could not also perform previdistic functions including prognostic functions, i.e. concern future cases on the condition that they occur in a given in advance strictly defined (limited) space-time area. Naturally, the answer depends on the explication of the term historical sentence. If we assume that a numerically general sentence containing spacetime determination is a historical sentence independent of whether it refers only to historical, i.e. past reality or not, the answer will naturally be positive. For a statement refering to all Poles living in the 20th century will, on the basis of this explication, not to be a law, but a historical generalization which could not perform direct prognostic functions, i.e. serve as a datum in predicting future cases within the range of that generalization. Those who object to the above explication on the assumption that a historical statement is one that concerns only past historical reality, will naturally also reject the proposition that historical sentences can be applied not only for postgnosis but also for predicting future facts. Thus the question may be considered open. The problem of type of openness of a class which designates the validity of a law is, however, not the one that arouses most controversies in the current dispute on the demand for strict generality of laws. The main controversy concerns the occurence in the definition of a law of proper nouns and is closely connected with the difference between strict universality and what is called unlimited universality.

4. STRICT GENERALITY OR UNLIMITED GENERALITY?

Although it is a general belief nowadays that a numerically general statement does not represent the type of generality (the degree of universality) required from a law of nature, the demand of strict generality seems to many authors too exacting. It is pointed out that the condition that the definition of a law should not contain proper nouns or individual names, singular descriptions or space-time co-ordinates which could not be eliminating, is too restrictive since it automatically excludes from the family of laws a large class of statements considered to be scientific laws both curently and by the majority of specialists. This concerns such statements as the laws of Kepler, Galileo's law of free fall of bodies in the vicinity of the Earth (according to which a falling body covers the distance $= s = \frac{981t^2}{2}$), etc.

In this way many statements, such as the ones refering to phenomena occuring in the vicinity of the Sun ("heliocentric laws") or the Earth ("geocentric laws") whose definitions include excplicite or implicite proper nouns ("in the vicinity of the Earth"), ("round the Sun") would not be counted among scientific laws though they are granted this status by the overwhelming majority. Two of the proposed solutions require particular attention. We shall present them after E. Nagel[24].

The first one is based on classifying predicates which can be used in formulating laws into two categories: purely qualitative predicates and the rest which are often not qualitative. A purely qualitative predicate occurs when the definition of its meaning does not require reference to any particular object or space-time area. Its content can be explained without reference to proper nouns or space-time co-ordinates (or supplementary phrases). In this proposition laws are not required unconditionally to contain purely qualitative predicates (although some sciences, such as theoretical physics, tend to formulate their fundamental statements with purely qualitative predicates alone). It is sufficient if they fulfil one of the following conditions which do not exclude each other:

1. contain only purely qualitative predicates, or
2. are derivative statements which can be deduced from

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[24] E. Nagel, op. cit., pp. 57 - 60.

fundamental statements alone, without reference to statements of another kind. Moreover, a statement is considered fundamental if it does not contain proper nouns or individual constants and all its predicates are purely qualitative.

It is now possible to answer the question concerning the conditions which must be fulfilled by a statement suitable for formulation of a law. The answer is as follows: a statement is suitable for formulation of a law, i.e. it is lawlike, it is a fundamental or a derivative statement.

However, the authors of the above concept seem to forget that the second condition is in fact of no importance, if it is not in turn supplemented by some additional restrictions. Evidently, it is always easy — through a purely formal manipulation — to find for each given statement such a fundamental statement, or even a number of such statements which contain only purely qualitative predicates and from which the given statement can logically be deduced. Thus a fundamental statement can be transformed into its derivative. In order to exclude this purely formal evasion, the admissible fundamental statements ought to be supplemented by some limitations concerning their veracity or degree of substanciation, e.g. the condition that they should be selected only from among statements considered in their time to be scientific laws. The last restriction, however, seems too exacting since a derivative statement can — when deduced from some law — be considered not only a formal lawlike statement, but a law proper and that substanciated to a degree no lesser than the fundamental law. It is now evident that formulation of adequate conditions to be fulfilled by the fundamental statement for another statement that can be logically derived from it to fulfil the requirements for a lawlike statement is not an easy task. But let us return to the proposal under discussion.

The occurance in a statement (e.g. in a Kepler's Law) of proper nouns is not — according to the concept under analysis — contrary to qualifying it as a scientific law, if only it can be proved that it is a derivative law which can be derived (explained) on this basis from fundamental statements which contain only purely qualitative predicates. Does it follow that, for example, Kepler's Laws could be qualified as scientific laws before Newton's days, or at least nowadays?

The answer is no, because, firstly, fundamental laws (Newton's Laws) from which Kepler's Laws could be derived did not exist; secondly, it is practically certain that also today it would be impossible to derive Kepler's Laws from Newton's Laws alone, or any other fundamental laws[25], without refering to what is called statements concerning "collocation of causes[26]".

It is natural then that assumptions concerning collocation of causes (in the case of Kepler's Laws they are statements designating the value and direction of gravitation and inertion of planets) cannot be formulated, at least generally, without the use of proper nouns (which occur in definitions of the mass of the Sun, the mass and velocity of particular planets). Hence, is not possible to derive Kepler's Laws from data (fundamental laws) containing only purely qualitative predicates. Thus, if we wish to consider Kepler's Laws (and other statements such as "the orbits of all planets are situated on one plain which coincides with that of rotation of the Sun", "all bodies in the proximity of the Earth fall with a velocity proportional to 981 t^2") scientific laws, the explanation of the law under discussion which refers to purely qualitative predicates and to the classification of laws into "fundamental" and derivative, is too restrictive. This is why another proposal is put forward. Nagel considers it satisfactory. It is based on a classifica-

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[25] Nagel says at this point that "it is far from certain whether such statements as Kepler's are in fact logically derivable even today from fundamental laws alone (...)" E. Nagel, op. cit. p. 58.

[26] This fact has long been under discussion. E. g. Mill, when discussing the derivation of Kepler's First Law from Newton's Laws, says: "... in this resolution of the law of a complex effect, the laws of which it is compounded are not the only elements. It is resolved into the laws of the separate causes, together with the fact of their co-existence. The one is as essential an ingredient as the other". J. St. Mill, op. cit. Vo. I. p. 340. Mill believes moreover that "... the element which is not a law of causation, but a collocation of causes, cannot itself be reduced to any law". Ibid. p. 340. With regard to Kepler's First Law, the assumption concerning the "collocation of causes" would maintain that planets are subject to both gravitiation and inertia taken in appropriate proportions.

tion of general statements different from those hitherto discussed, i.e. on differenciation between unrestricted universals and restricted universals. Nagel quotes the first of Kepler's Laws: "All planets move on eliptic orbits with the Sun at one focus of each elipse" (...) as an example for an unrestricted universal; the statement: "all the screws in Smith's car are rusty" as an example for restricted one. He continues to say: "Both statements contain names of individuals and predicates that are not purely qualitative. Nevertheless, there is a difference between them. In the accidental universal, the object of which the predicate 'rusty during the time period *a*' is affirmed (let us call the class of such objects the "scope of predication" of the universal) are severely restricted to things that fall into a specific spatio-temporal region. In the lawlike statement, the scope of predication of the somewhat complex predicate 'moving on an eliptic orbit during the time interval *t* and the Sun is at one focus of the elipse' is not restricted in this way: the planets and then orbits are not required to be located in a fixed volume of space or a given interval of time" [27]. A general statement whose scope of predication is not restricted to objects present in a given period of time is called by Nagel an unrestricted universal even if it contains proper nouns. He postulates that lawlike statements, i.e. formal candidates to the status of laws which fulfil the conditions of universality layed on laws be unrestricted universals, but he does not postulate that they be strictly general.

All basic difficulties in classifying such statements as Kepler's Laws and other statements commonly considered to be scientific laws disappear when this general requirement has been satisfied. What, then, is the difference between Nagel's unrestricted universal and Ajdukiewicz and Popper's (their definitions coincide) strictly general statement? The answer is not simple, since Nagel's explanation of the term unrestricted generallity is far from clear. One, however, is doubtless: when introducing the notion, Nagel and the others wished to lay on laws a condition less restricting than the condition of strict generality, one in which the occurence of proper names should not be fatal for the

[27] E. Nagel, op. cit. pp. 58 - 59.

law and which would save a large class of statements (e.g. in physics or astronomy), commonly classified as scientific laws from being denied the status of a law.

It is worth noting that Popper who lays the condition of strict generality on laws, believes also that lack of proper nouns or their equivalents is an essential condition, but not a sufficient condition of strict generality. Sentences containing only general names are called by him strict or pure sentences and he ephasises that strictly general sentences form the most important, but not the only kind of statements containing no proper nouns. He says further: "But in many other statements, such as 'many ravens are black' or perhaps 'some ravens are black' or 'there are black ravens', etc., there also occur only universal names; yet we should certainly not describe such statements as universal. Statements in which only universal and no individual names occur will here be called 'strict or pure'." Undoubtedly, it is a question of a terminological decision and not of deduction or fact whether we adopt Popper's or Nagel's position in this matter[28]. Nevertheless, it seems that Nagel's proposal to classify as scientific laws some statements containing proper names, if they fulfil certain additional conditions, is more in line with a physicist's or astronomer's intuition and language habits and terminological formulations more or less openly accepted in physics (including astronomy). This is probably even more true with regard to other disciplins of science and humanities. This is due to the fact that in physics we can observe a tendency stronger than in the remaining exact sciences for formulation of fundamental statements on the basis of general names only.

5. LAW AND NECESSITY. NOMOLOGICAL AND ACCIDENTAL UNIVERSALITY

Apart from the classification of general sentences into 1) strictly general and numerically general sentences and 2) into unrestricted and restricted universals, methodological literature knows a dychotomous classification of general sentences (or strictly general sentences) into 3) nomologically general and accidentally general

[28] K. R. Popper, op. cit. p. 68.

sentences. J. St. Mill, K. R. Popper and E. Nagel all apply it in their works, though J. St. Mill uses a different terminology[29]. An analysis of Mill's numerous declarations concerning the classification of laws of time sequence into causative and non-causative laws shows that he was not satisfied with classifying general sentences into strictly general ones (he called them "really" general) and numerically general ("seemingly" general), but was to some extent aware of the above mentioned more subtle difference between two types of strictly general sentences: those expressing nomological universality and those representing accidental universality[30]. The difference between the opinion of Mill and Popper and that of Nagel consists in this case in Nagel's classifying nomologically general sentences and accidentally general sentences within the general framework of general sentences, whereas Mill and Popper — within the framework of strictly general sentences.

We shall restrict our explanation of the notions of accidental and nomological universality to true sentences. Moreover, like Mill and Popper, we shal assume that the classification refers to strictly general sentences only and does not include numerically general sentences. True strictly general sentences which express accidental universality, i.e. true accidentally universal sentences will be called accidentally true, whereas true strictly general sentences expressing nomological universality, i.e. true nomologically universal sentences — necessarily true sentences (laws). An accidentally true general sentence is one for which there are no counter cases. This means that if we express this type of sentence in form of a conditional period, there is realized in this world, either now, or at any time, such a state which would fulfill the conditions formulated in the antecedent, but not the conditions formulated in the consequent of this conditional period. Thus if we establish that a scientific law can also be formulated as an accidentally universal sentence (not only as a nomological sentence), such an

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[29] J. St. Mill, op. cit. Vol. I. p. 221 - 223; Vol. II p. 53 - 54; K. R. Popper, op. cit. p. 420 - 422; E. Nagel, op. cit. p. 49 - 69.

[30] See J. Such, *Johna Stuarta Milla koncepcja uniwersalności praw* In: Pojęcie prawa nauki w XIX wieku. Warsaw 1967, p. 32 - 41.

accidentally universal law will be considered true, if there has not existed and will not exist a state which would fulfil the antecedent of the law but not its consequent. For example, the sentence: no man lives longer than three hundred years will be considered an accidentally true statement if no man has so far or will in future live for over three hundred years. Hence, lack of cases contrary to it is sufficient and necessary proof for an accidentally true sentence.

Is it also necessarily true? In order to answer this it is essential to establish *whether laws of nature admit* the existence of circumstances in which man could live for more than three hundred years. If such conditions exist or are possible, even if man has never experienced them and so has not lived for over three hundred years, the above statement is not necessarily true because an ("accidental") appearance of a man in such circumstances would invalidate the statement. Hence, a necessarily true sentence is a *law for which no counter cases exist, moreover, their existence would be impossible (out of question) because of existing regularities of nature.* In other words, a necessarily true law is one in which the antecedent supplies *conditions* which are from the point of view of existing regularities of nature *sufficient* for the phenomena expressed in the consequent to take place, i.e. conditions after which — according to the very definition of the notion "nomologically sufficient condition" — the consequent is (non-emptily) fulfilled regardless of any other circumstances. An accidentally true law is one which does not formulate the conditions sufficient for the occurence of the phenomena specified in the consequent; and its being true in spite of this is due to an accident, due to the fact that certain conditions which could have been fulfilled as far as existing regularities of nature are concerned, have not been fulfilled. It could be said that necessarily true laws are fulfilled not only in the scope of reality (which embraces all states actually realized), but also in the scope of possibility, i.e. in all the worlds governed by the same regularities as this world, or in all the worlds differing from ours only in the initial conditions, but not in the laws. It is obvious that lack of counter cases alone in our world does not necessarily guarantee that this kind of law is true. Analogically to Leibniz's concept of logically true worlds, i.e. worlds whose logical structure is identical with the logical structure of our world, i.e. where all the laws of logics (of our world) are fulfilled, we could introduce a concept of nomologically possible worlds with a nomological structure identical with that of our worlds, worlds in which all the laws valid for our (empirical) world are fulfilled.

The terms nomological universality and accidental universality may suggest that — as is believed to be true by many — nomologically universal sentences are suitable for formulating laws, whereas accidentally universal laws — as the very terms seem to suggest — are not. This need not be discussed here, but it is worth noting that laws actually formulated in science do not always aspire to be necessarily true in the meaning discussed above, i.e. to express nomological universality (or necessity). Yet it seems to be the ideal, or ultimate end of science to formulate nomologically universal laws, i.e. laws of sui generis necessities of nature and thus supplying in the antecedent a complete set of nomologically sufficient conditions, i.e. sufficient from the point of view of existing regularities of nature for the consequent to take place. As has been said before, it is expected from such laws not only that there be no counter cases for them, but, further more, a confirmation e.g. through enumerational induction (of agreement with our empirical worlds); i.e. it is expected from them that there be no counter cases for them also in the scope of possibility (agreement with each of the nomologically possible worlds), that is the very possibility of their existence is excluded as contrary to the nomological type of laws of nature. This permits us to interpret necessarily true laws as some prohibitions or limitations imposed on the realization of laws of nature, limitations which express what is called nomological necessity of the world.

Hence, we do not share the view, common in present day methodology of science, that only nomological statements are suitable for formulation of scientific laws while universally accidental statements are not, even if they express strict universality. We are inclined to share Mill's opinion that if some laws of nature, e.g. clauses of reason express an unchangable and unconditional relationship, i.e. a necessary relationship between the reason and the result and are — according to our terminology — nomologically universal, then the remaining laws of sequence in time (concerning, for example, the sequence of seasons of the year, the sequence of day and night, etc.) express only unchangable sequences, i.e. they can prove to be accidentally universal. To avoid misunderstandings, I should like to point out that some present day methodologists use the terms nomic universality and accidental universality in a slightly different meaning. For example, among accidentally general statements Nagel classifies also one which, after Popper, Ajdukiewicz and others, we call here numerically general statements. When discussing the difference between the two kinds of strictly general statements, we usually refer to possibility. What is understood by the term possible when we say that the relationship in the law must refer not only to all past and present cases, but also to all possible cases? Does it refer only to cases which, though not yet realized, will be realized some time in future (possible would then mean something that will actually take place in future), or also cases which- though not eliminated by the existing regularities designating the nomological structure of reality, will never take place because of lack of conditions essential for their realization? The latter would refer to cases which are eliminated, i.e. impossible not because of existing regularities of nature, but because of conditions valid now and in future. This problem can be formulated in the question: does a law refer to phenomena embraced by an appropriate counter fact conditional (whose formulation contains the functor: if ... then... or an analogical one) which states that if the conditions formulated in the anticedent and not eliminated by existing regularities were fulfilled, then given consequences formulated in the consequent would be realized? If the answer is positive, a law refers to all cases (of a given class) possible from the point of view of regularities of nature, regardless of whether the cases are ever realized. If the answer is negative, the scope of the law should be restricted to cases which actually take place (at any time). The difference between the scope of possibility (determined by laws of nature) and the scope of reality (designated by laws and fundamental laws) forms the ontological corelate of the difference between nomological universality and accidental universality. The foundation for differenciating two types of strict universality (and hence two types of laws: necessarily true and accidentally true) lies in the dychotomy of laws and conditions. The dychotomy consists in the distribution of fundamental conditions being — partly at least — independent of laws (nomologically universal) and vice versa, laws (nomologically universal) — partly at least — being independent of fundamental conditions realized in the world. If the assumption proved false, the classification of statements presented above would have to be subjected to far reaching modifications.

To return to the above question, it must be said that if (similarly to Mill's causal laws) laws express a natural necessity in the sense that they are not only accidentally true (i.e. there are no counter facts for them in existence), but true in a necessary manner, i.e. true in all possible conditions or worlds — from the point of view of regularities of nature — (we could also call them nomologically true), they will always take the form of a nomological conditional containing in its scope the scope of the appropriate counter fact conditional and true in all fundamental conditions possible from the point of view of regularities of nature[31]. On the other hand, laws whose scope is restricted to fields of reality embracing only cases actually realized cannot be formulated in this way since they are only accidentally true, true on account of existing circumstances, i.e. due to coincidence. These circumstances render impossible the realization of other cases equally possible from the point of view of regularities of nature which could prove fatal for the accidental cases under discussion (as their counter cases). Since the validity of some type of laws can be influenced by coincidence, it is also to a certain degree dependent on man, on his action, i.e. in cases where through production or experiment we are able to bring about such situations which would prove fatal for these laws by being their counter cases but which would never have occured without man's assistance, or vice versa: would occur without fail. This is impossible with regard to necessar-

[31] It is assumed in this concept that regularities of nature can be adequately described only in nomological laws, and that accidental laws describe only some "accidental conincidents" which cannot aspire to the status of laws (regularities) of nature.

ily true laws since it is impossible to bring about or prevent their counter cases on account of regularities of nature. On the other hand, to prove that there are no counter cases for a law of this category and that in this sense it is in accordance with reality, it is not in itself sufficient to prove its nomological validity, although it is sufficient to state that it is accidentally true. Accordance with reality must also refer to the scope of possibility embracing cases which may never be realized. It follows then, that enumerational induction is not sufficient to prove nomological truth of a law, even if it were possible (which it is not, on account of the openness of the class designating the scope of any law) to apply full induction to the whole scope of the law, i.e. to all the cases it embraces.Mill was fully aware of this when he emphasised many a time that the enumerational method of induction based on observation is insufficient; it is essential to employ the more perfect enumeration methods of induction based on experiment, i.e. on artificial production of facts which might never occur without our interference.

The dispute connected with classification of statements into nomologically general and accidentally general in the sense discussed above refers to three important questions: firstly, is this classification at all sensible some question its practicability by arguing that it requires reference to the concept of worlds nomologically possible which is indefensible, and that it assumes our knowledge of all the regularities of nature, secondly, should scientific laws always be required to express nomological universality, or could they sometimes be accidentally universal statements; thirdly, can the concept of nomological universality be explained in extentional language and without reference to such intuitive and unclear modal notions as necessity of nature or physical impossibility whose adequate explanation still seems too difficult?

The problem of the nature of necessity of nomologically universal statements has interested thinkers since Hume, if not before. Those of the opinion that the concept of nomological universality can be explained without the use of non-reducible modal concepts are considered to be followers of Hume. Those who believe that the use of some modal concepts concerning regularities of nature is unavoidable in any adequate analysis of nomological universality are considered to be his opponents (in this matter). The difficulty in solving this matter lies in the fact that a nomologically universal statement ought to justify the appropriate counter factual conditional and be formulated as a nomological implication true not only in all actually occuring conditions (at any time and place), but also in all nomologically possible conditions, also in those which are never realized. Thus a nomological implication cannot apply only to phenomena which actually occur; on the other hand, it cannot apply to such situations as: what would happen if the laws of gravitation were not fulfilled, or if there were in its place some law of "antigravitation", etc. It can embrace only the cases (the worlds) which assume at the most non-fulfilment of existing conditions, but fulfilment of existing regularities. The assumption of inviolability of nomological laws differenciates the nomological conditional and the contrary to fact conditionals which do not have to fulfil this condition.

The difficulty of transforming a nomological conditional into the terminology of categorical and ordinary (real) conditionals consists in the formulation of some conditions which must be fulfilled by these categorical statements or real periods in order to become equivalent with the nomological conditional, i.e. for the transformation to be correct. So far formulation of such conditions has not been possible without reference to some unreal conditionals. The difficulty appears to be shifted, but not overcome[32].

CONCLUSION

To end with, we shall revise the problems discussed in this paper concerning universality of laws which seem to be uncontroversial, and then the ones which are still to a greater or lesser degree subject to controversy.

With regard to laws, the demand for a higher degree of generality than that represented by numerical generality seems

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[32] An interesting attempt to explain the contrary to fact conditional was undertaken by J. Kmita in his paper: *Potoczny okres warunkowy*. Studia Metodologiczne, No. 3, 1967

undisputable. Hence, it seems reasonable to assume epistemological openness of the class designating the scope of the law, i.e. that it is never possible to verify effectively the full scope of a law; the scope of a law's applicability cannot be identical with the scope within which its exemplification has been applied and verified so far.

This results in the number of cases embraced by the scope of applicability of a given law always remaining to a certain extent indefinite since the cases established so far, do not, ex definitione, cover the whole scope of the law.

Which of the discussed problems can be considered controversial (apart from certain suggestions which have been put forward in the discussion above)?

1. With regard to the occurence of proper nouns in many statements commonly considered to be laws, there is the open question whether the condition of strict generality is not too restrictive and whether we should not limit ourselves to a more liberal condition in classifying statements as laws, e.g. the condition of unlimited universality (which, however, ought to be defined in greater detail):

2. With regard to the condition of strict generality (or unlimited generality) of laws, the problem of the character of the openness of the class designating the scope of the law (epistemological or ontological openess?):

3. The following problems seem controversial with regard to classification of general statements into nomological and accidental:

a) is this classification at all theoretically substanciated and useful in practice?

b) Ought it to be perfomred within the framework of strictly general statements, or of all general statements?

c) Ought scientific laws to express nomological universality alone, or can accidentally universal laws also occur (and to they)?

d) Hume's problem: is it possible to explain the notion of nomological universality in extentional language and without refering to unreal conditional periods and can the notion of natural (nomological) necessity be reduced to non-modal notions with a clearer content which would be easier to perceive (such as the notion of strict universality, exceptionalessness, constant sequences, unchangable reoccurrence, etc.)?

The above problems are related; a solution of one may imply a definite attitude with regard to the rest.

Translated by Hanna Grabińska