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Alfred Tarski - the man who defined truth

There is the time of life, the time of death, and the time of human memory.

Alfred Tarski, a genius of logic and mathematics of the twentieth century, was a great Polish scientist. The mission of every great scientist is contained not only in the present, but also in the future. The greatness of a scientist is measured by his or her creative accomplishments, his or her presence in the memory of future generations, and the long lasting character of this memory. Alfred Tarski's contribution to logic and mathematics was recognized in the 1980s; his works and thoughts will remain in the memory of generations of ascendants.

Many people, not just the circle of logicians and mathematicians, remember the legend that surrounded Alfred Tarski. This legend was built not only on his scientific accomplishments, but also on the "exotic" character of his life and the "exotic" nature of his accomplishments.

Tarski and Milosz – Two Great Individualities

Tarski was connected with Berkeley and University of California from 1942, that is, for 41 years, half his life; the University of California is the same university in which somewhat later, Czeslaw Milosz became a professor.

Thus, Berkeley, the center of the University of California, became a harbor for two Polish creative individualities:

Alfred Tarski, considered to be one of the four greatest logicians in history (next to Aristotle, Gottlob Frege and Kurt Gödel), and one of the most famous mathematicians of our century

and

Czeslaw Milosz, a famous humanist and poet and laureate of Noble Prize for literature in 1980.

It seems impossible to compare these two personalities, since there are so many differences between them. The mere fact of describing these two personalities next to each other may seem to be highly unjustifiable. Even the fact that Tarski and Miłosz were thrown by destiny into the same part of California, at the San Francisco Bay, is due to different causes. What similarities can we possibly find between the creativeness of a mathematician and a poet?

Despite professional differences separating these people and, perhaps, their different beliefs, they were both tied to each other by means of political freedom, freedom of speech, thought, and, indeed, the creativeness, a link on a chain about which Jan Lukasiewicz, one of the two teachers of Alfred Tarski (the other was Stanislaw Lesniewski) wrote many years ago in a well-known essay in the original Polish:

> Twórczosc poetycka nie rózni sie od naukowej wiekszym polotem fantazji. Kto, jak Kopernik, Ziemię ruszył z posad i pchnął ją na tory w krąg Słońca, lub, jak Darwin, ujrzał w mgle dziejów genezyjskie przemiany gatunków, godzien stanąć obok największych poetów.

Now in my translation:

> The poetic creativeness does not differ from that of a scientist by the greater role of creative imagination. So anybody that, like Copernicus, moved the Earth from its foundations, and pushed it onto track around the Sun, or, that like Darwin, detected in the fog of the history genetical changes of the species, deserves to stand on a pedestal next to the greatest poets[1].

Unlike Copernicus or Darwin, who were involved in empirical research, Tarski was involved in deductive sciences and their theory, i.e. metamathematics; however, he revolutionized not only this theory but also linguistics and philosophy. He pushed semantics of language – the science dealing with the relations and objects which these expressions denote – onto a new track. Miłosz impressed us with the uniqueness of the truth of written word; Tarski, quite a bit earlier, moved the world by defining the truth.

Problematic of the Truth

The problematic of the truth belongs to the general theory (methodology) of sciences and theory of cognition. Tarski had worked out, in a precise mathematical way, a conception of truth in the precise symbolic languages of the deductive sciences; this was a first in the history of philosophy. Tarski built a formal, semantic theory of truth, in the framework of which he formulated the concept of the *true sentence* according to the classical definition of truth deriving from Aristotle.

The truth, as defined within this conception, should not be confused with the ontological truth, the moral truth, or the utilitarian truth. According to this classical definition *truth* and *falsity*, the so-called *logical values*, are semantic properties of sentences since they are ascribed to these sentences by the virtue of their relationship with the state of affairs described by these sentences. According to the classical definition of truth, a sentence is true if, and only if, the state of affairs exists which existence the sentence states, and it is false if such state does not exist.

The concept of a sentence used in this intuitive manner causes certain difficulties which might be a source of *antinomies*, the so-called *semantic antinomies*. Antinomies arise as a result of a particular conflict between two contradictory sentences, each of which seems to be justified. The oldest and most known semantic antinomy is the *antinomy of the liar*[2].There are many versions of this antinomy, but the simplest one can be represented in the following humorist way.

Let us say, that a diplomat by the name John, known among the politicians, quite frequently "misses the truth", but, being aware of the reputation of the liar that burdens him, once in a while perversely utters a statement:

(*) I lie.

It then turns out that John, in saying that he lies, enters into a conflict with himself: he lies and he doesn't lie (tells the truth) at the same time. Indeed, if the sentence (*) uttered by John is true, that is John tells the truth and does not lie, then he lies; if nonetheless, he lies (does not tell the truth), the sentence (*) is false, so John does not lie; thus, lying, he does not lie.

A formal correct scientific theory must, of course, be free from paradoxes and antinomies. Such a theory of truth was awaited for centuries. Tarski presented such a theory in 1933 in his monumental work – *Pojecie prawdy w językach nauk dedukcyjnych (The Concept of Truth in the Languages of Deductive Sciences)*[3], which was subsequently translated in several languages: first in German[4], then in English in *Logic, Semantics, Metamathematics*[5], and next in Italian[6] and French[7].

Tarski defines the goal of his conception in the introduction to his book:

> The present article is almost wholly devoted to a single problem - *the definition of truth*. Its task is to construct – with reference to given language – *a materially adequate and formally correct definition of the term 'true sentence'*. This problem, which belongs to classical questions of philosophy, raises considerable difficulties. For, although the meaning of the term 'true sentence' in colloqial language seems to be quite clear and intelligible, all attempts to define this meaning more precisely have hitherto been fruitless, and many investigations in which this term has been used and which started with apparently evident premisses have often led to paradoxes and antinomies (for which, however, a more or less satisfactory solution has been found). The concept of truth shares in this respect the fate of other analogous concepts in the domain of the semantics of language[8].

Tarski showed precisely why a definition of truth cannot be formulated for colloquial language. The source of the semantic antinomies, for example, the antinomy of a liar, lies in the inability to distinguish between two levels of the language, sentences belonging to the *object language*, and, at the same time, sentences of the higher level, the so called *metalanguage*, in other words, the sentence concerning the expressions of the object language or expressions containing semantic terms referring to the expressions of such language. Let us notice that sentence (*)[9] is, at the same time, the expression of the object language and metalanguage. The presence in a language of expressions belonging to two different levels – the object language and the metalanguage – in a language is the source of paradoxes. Such

expressions are, indeed, present in the universal colloquial language, in which, next to usual expressions, for example, sentences or names, there are expressions of metalanguage concerning these expressions, in particular, the expression 'true sentence'. Defining the concepts of the true sentence on the grounds of the colloquial language, or, in a more general sense, a universal language, may lead to creating contradictions. It follows that such definitions should be formulated only for formalized languages of deductive sciences, and, on the grounds of the appropriate metalanguage, the language which is richer than the language of a given deductive system.

Tarski provided formal conditions for an adequate definition of truth, which are recorded in history as the convention Tarski T[10]. provided a general method of defining semantic terms concerning expressions of language J in the stronger language MJ, which satisfies the following conditions:

1) for each expression of language J there is an expression in MJ which is its translation, and which is synonymous with it,

2) for each expression in language J there exists its name in the language MJ.

Tarski precisely formulates a definition of a true sentence as exemplified by the language of a certain known deductive theory – the calculus of classes. At the same time he provides general conditions indicating how the method of defining the concept of true sentence can be applied to other deductive systems. The outline of this method is presented in a simple way by Jan Wolenski[11]. The basic means of defining the concept of truth is an ancillary concept of semantic *satisfaction*. The framework of this present work does not allow for engaging in more specific outlining of Tarski's adequate conception of truth. The substantial validity of this conception contains the appropriate indicative argumentation, that the definition provided by Tarski specifies the sense "true sentence" according to the classical definition of truth. The substantial correctness of this definition is supported with a series of metamathematical formulas confirming intuitions connected with the conception of truth. Tarski's definition of truth makes it possible for him to prove:

a) the principle of two-valuedness of truth: each sentence is either true or false;

b) the metalogical law of the excluded middle: one of the two contradictory sentences is true;

c) the metalogical law of contradiction: one of the two contradictory sentences is false.

Tarski proves, in particular, that the general set of true sentences of a given language supplies a *consistent* and *complete* deductive system[12].

The concept of truth is a basic notion of the theory of models, one of the most important branches of mathematical logic[13].Tarski's semantic theory of truth had a significant influence on the development of this theory after World War II, and this constituted its significance in logic. The possibility of defining semantic concepts in logic, including the concept of a true sentence in the sense of a classical definition of truth and with the exclusion of semantic antinomies has, however, at

the same time extremely crucial philosophical significance. Indeed, this concept, as it has been previously mentioned, belongs to the basic concepts of the theory of cognition[14].

The Warsaw Period

The results of Tarski's work relating to the concept of truth fall in the period of the years from 1928 to 1931. This is included in the first period of Tarski's scientific path, which I will call the *Warsaw period*.

Tarski was born in Warsaw, on January 14, 1901. He was educated in Warsaw where, in 1924, he received his Ph. D. at the Uniwersity of Warsaw at the age of 23. His Ph. D. dissertation was entitled: *O wyrazie pierwotnym logistyki* (*On the Primitive Term of Logistic*)[15]. Stanislaw Lesniewski, who, next to Jan Lukasiewicz, belongs to the founders of the so-called *Warsaw Logic School*, was Tarski's supervisor. The school started its activity in the independent Poland which followed World War I, and conducted its active work at the university until World War II. The school conducted new original research in the fields of mathematical logic, the foundations of mathematics, and the methodology of the sciences. Although its founders were philosophers, they were appointed to be the heads of the department of mathematics and natural sciences. From the beginning of its existence the Warsaw school was connected with the circle of mathematicians, who not only supported its activity, but also cooperated with it. In this way, the members of the school cooperated with both the group of great mathematicians, such as Waclaw Sierpiński and Stefan Mazurkiewicz, and with philosophers, in particular with Tadeusz Kotarbinski. This can, perhaps, explain the fact that Tarski, who by profession was a mathematician, considered himself to be Kotarbinski's disciple[16], and his scientific achievements, like the achievements of other representatives of this school, can be characterized by philosophical "commitment".

It is not a goal of this essay to attempt to describe Tarski's achievements of that period[17]. However, I would like to emphasize the multiple character and remarkable significance of these achievements, which mainly concerned the methodology of deductive sciences (metamathematics) and semantics (the definition and formulation of concepts: satisfaction, truth, and logical consequence). His accomplishments in the fields of mathematics are related to formalization of the deductive sciences. What Tarski accomplished from 1925 to 1929 is summarized in two works published in 1930 which present, in detail, general and richer theories of the deductive systems, which are well-known and more developed today. His famous work on the truth concept of 1933 also contains fundamental ideas of syntax, presents the first axiomatic theory of metalanguage of any science, and formally defines recursive grammars, outlining the main research direction of contemporary linguistics. It should be noted that the man who defined truth attached a lot of significance to the study of definition itself and the study of the notion of *definability*. Two concepts of definibility: *semantic* and *syntactic*, play important roles in Tarski's articles of the Warsaw period (1930–1935).

The Warsaw period is also marked by studies in some branches of mathematics such as set theory, measure theory, abstract algebra, or elementary geometry. In the field of elementary geometry Tarski designed an algorithm to decide the truth or falsity of any of its sentence, thus becoming a pioneer of the research on decision problems and contributing, in this way, to the development of theoretical computer science.

In this very creative period of Alfred Tarski's activity, a logical bestseller of the twentieth century, *O logice matematycznej i metodzie dedukcyjnej* (*On Mathematical Logic and Deductive Method*)[18] was published in 1936 and translated into eleven languages (!), first in German in 1937. This still up-to-date textbook was published several times in the U.S.A. and is still used as an academic textbook on logic[19].

Despite all these outstanding achievements, Tarski did not received adequate recognition, since he never became the head of the department in the period between WWI and WWII. The Warsaw Logic School, however, gained an international reputation largely due to the achievements of Alfred Tarski.

The California Period

Tarski came to the U.S.A. in 1939 to attend the Unity of Science Congress at Harvard. It was at that time that Germany's invasion of Poland made it impossible for him to return home. Tarski looked for an academic position in the U.S.A. compatible with his accomplishments (at Harvard University, the City College of New York, and the Institute for Advanced Study in Princeton) and, in 1942, became a lecturer in the Department of Mathematics at the University of California at Berkeley. He was promoted to full professor in 1946 and remained at Berkeley until his retirement in 1968, after which he still continued to teach courses and to conduct his scientific research almost till the time of his death, which took place on October 27, 1983.

The second period of Tarski's scientific path, the California period, remained under the clear influence of interests shaped mostly, but not only, in Poland. His interests concentrated mainly on model theory, general algebra, algebraic logic, undecidable theories, and set theory. The last of these theories, which belongs to the foundations of mathematics, consituted the subject of Tarski's life-long interest and resulted in the writing of a book co-authored with Steven Givant. The collaboration on the book was finished by Tarski shortly before his death; the book appeared in print in 1987.

The results of the research of Tarski, his disciples, and his co-workers had an impact on the development of logic as well as mathematics in the post-war period.

Tarski's world fame, highest among the representatives of the *Warsaw Logic School*, was not only the result of his scientific accomplishments, but also due to the fact that he created the *California Logic School*, the world center for research in logic and the foundations of mathematics. The school, which was similar in its "philosophical component" of logic to the *Warsaw Logic School*, became not only

a lode of talents, but also a rich source of ideas and scientific exchange of ideas. Berkeley became a center, hosting postdoctoral visitors and students from all over the world who came to either work with Tarski or study logic.

Logic studies at Berkeley were made possible thanks to Tarski's initiative in the estabilishment of a pioneering interdisciplinary *Group in Logic and Methodology of Science* at Berkeley in 1958.

The Group administers the special graduate program leading to the degree of Ph. D. for students who wish to study both the mathematical and philosophical aspects of logic. The Group is an interdepartmental agency which cooperates closely with both the Department of Mathematics and the Department of Philosophy. The Group maintain a logic library and conduct a *Logic Colloquium* which is intended to serve as a unifying common core of experience for group students and faculty. The lectures and reports on current research and scholarly work are given by members of the faculty, visitors, and graduate students.

Tarski had more than twenty Ph. D. graduates in Berkeley. He raised generations of students, whom he attracted with the deepness of his philosophical thoughts, his pioneering ideas, his ability to perceive and approach scientific problems, and the exactness with which he applied formal-logical means to his research[20].

Memorials

The world takes pride in people who popularized the name of Poland in the second half of the twentieth century. John Paul II, Czesław Miłosz, and Lech Wałęsa all represents Polish values, each of them slightly different ones; each of them also represents universal values.

Regardless of the considerations on how universal these values brought by Alfred Tarski to Polish logic – the most universal of science – are, it can be stated with certainty that both Poland and the world of the twentieth century can be proud of Tarski, whose fame also represents Poland, although there are many aspects of being Polish.

As a logician visiting Berkeley I was aware of the fact that Alfred Tarski had selected Berkeley as his hometown after WWII, and that the Berkeley campus was the place where he achieved his well deserved recognition. During my visit I could not help reflecting on Tarski, a man who had passed away leaving such a rich heritage for Polish and world science.

It is an amazing fact that „The Alfred Tarski Room" was officially dedicated at the University at Berkeley in 1981, while Tarski was still alive. This is the room in which the members of the *Group in Logic and Methodology of Science*, the Group estabilished by Tarski, gathered for discussions. The room is located in Evans Hall and is still a meeting place for the Group. Scholars and students meet there for coffee and informal discussions after *Logic Colloquium*. The room is very cozy and well equipped; texts, monographs, and magazines from the library of logic can be found there; one can conduct lectures at the blackboard, or relax and watch a sun-set through the window, which offers a beautiful view of the San Francisco

Bay. There are two more things attracting the eye of a newcomer: Tarski's portrait and a inscribed bronze plaque on the wall which describes Tarski as a "Great Logician and Inspiring Teacher". Prof. J.W. Addison, chairman of the *Group in Logic and Methodology of Science* for many years, wrote in an obituary devoted to the late Tarski: „Future generations of logic students may well add to this inscription the epitaph: 'He Sought Truth and Found it'." This may mean seeking a definition of truth and finding it. But it can also mean more: it can mean looking for a sense of life and finding it. Tarski seems to have found both.

Scientific research and pedagogical work, which has served as a model for new generations of logicians (and not only logicians), filled Tarski's life.

The University and Evans Hall were Tarski's official home and office at Berkeley. However, Tarski was particularly attached to his residence at 462 Michigan Avenue, where he spent most of his "Californian" life. Here he contemplated new ideas and scientific programs, did his research, prepared his lectures and hosted his present and former students. The house has white siding and a green roof. Both the front and the rear, southern part of the house appear cheerful and free from the seriousness which one may associate with a scientist of Tarski's greatness. The southern part of the house is adjacent to an extended exotic garden, of which Tarski used to be so foud.. One may unexpectedly encounter a deer looking out from bushes. The south-western part of the house overlooks the San Francisco Bay. Tarski's office is an isolated room on the bottom floor.

The present owner, Dr. Jan Tarski, Alfred's son, presently takes care of the house. One may notice quite a few Polish accents in the interior. These are, first of all, numerous Polish books by Miłosz, Tuwim, Boy-Żeleński and others, and paintings by Polish artists including one by Stanisław Witkiewicz. One painting is especially intriguing; it is a portrait of a thirty-five-year old, already famous, Alfred Tarski painted by Witkacy in December 1936. Tarski's focused face is surrounded with blue and white panache; his deep, expressive eyes appear somewhat sad (in my opinion perhaps a little worried or looking into the near future). He has the tall forehead of a thinker, and a bright green halo, symbolizing the radiation of creative ideas and concepts.

Tarski's house, situated as it is – in the architectually diversified neighborhood of Berkeley – represents Californian beauty and charm and makes it possible to contemplate the beauty of nature and all its phenomena. Perhaps by observing this beauty as he wandered the paths of his thoughts, Tarski was able to create a different type of beauty: the beauty of logical and mathematical truth – clear and precise, dressed with most magnificant formulas and symbols.

The truths formulated by Tarski are contained in the four volumes of his work, entitled *Collected Papers*[21]. These four voluminous books are "homes" to Tarski's thoughts and ideas. Anyone who can open the gates marked by his creative explorations can enter. These are the "homes" of rest of Tarski's thoughts. These constitute the whole scientific achievement of Tarski. They end the path of Tar-

ski's intellectual existence on the Earth, which, however, can still be followed and recreated and recalled in human memory, as an incentive for new scientific ideas.

There is another resting spot: an urn containing his ashes (along with ashes of his wife Maria) which is shaped like a book. The book is placed in a unique memorial: The Chapel of the Chimes, not far away from Berkeley, in Oakland. The interior of the building is very impressive. The real chapels – one on the first and the other on the second floor – are designed for visitors; the remaining part of the building is like a library in which „catalogues of past lives" are enclosed in huge marble drawers, and books on the shelves are the „books of earthly lives." These books do not contain the immaterial thoughts of men, but their cremated bodies. The wing in which the book-urn with Alfred Tarski's ashes is stored is inscribed in its upper part with the words: HOW SWEET THEIR MEMORY STILL.

The Chapel of the Chimes, unique and so distinct from Christian cemeteries, the home of eternal rest for Alfred Tarski, is filled with a subtle silence of pensiveness and reflectiveness, barely disturbed by the melancholic sounds of music and the quiet splashing of fountains – symbols of the springs of life. Visiting this place stimulates reflection of a philosophical nature.

Final Reflections

There is something very particular about Berkeley, the city that may provide so many impressions. It is here that Czesław Miłosz was creating. It is also here that wrote the poem entitled „Sroczość" ("Snoopiness")[22]. The following fragments of wich brins about philosophical reflectoins referring in particular to Tarski:

Jezeli jednak sroczość nie istnieje,
To nie istnieje i moja natura.
Kto by pomyslał, ze tak po stuleciach,
Wynajdę spór o uniwersalia.

The following is my free translation of this fragment:

But, if there is no snoopiness,
There is no my nature.
Who would think, that after centuries,
I will invent a controversy on universals.

It is hard to say what Tarski's position was in the *controversy on universals*, a controversy which already estabilished in ancient times and which concerned the objective existence of abstract entities. Although Tarski avoided accepting any of definite attitudes, it appears from the accounts of his disciples Andrzej Mostowski, who was the oldest one, and Steven Givent, who was the youngest, that Tarski supported *nominalism*, and in particular, *reism*, which was promoted by his mentor, Tadeusz Kotarbinski.

On the other hand, in his research in metamathematics and his conception of truth, Tarski continued to use abstract notions, which a nominalist tries to avoid. In particular, in his definition of true sentence, Tarski assumes that the so-called sentences-types are classes of equiform expression-tokens (physical objects, concrete

objects) – in other words, that they are abstract objects. Tarski's scientific practice somehow interferes with his accepting the nominalistic position in the controversy on universals.

A set of expressions used by a human being is always a finite set, since a human being can only produce a finite number of them. A finite, though huge, number of inscriptions is contained in the four volumes of Tarski's works, those peculiar „homes" to his written thoughts, the „certificate" of his life filled with hard work, his creative mind and his vision of truths. Tarski thoughts and truths, forever captured and materialized in his writing, will last, be rediscovered, and lead to new ideas and truths, as long human memory keeps bringing them to another existence and reaching for material shapes of his creative thoughts – copies of his own inscriptions, being their concrete representations and the creations of his eminent mind.

And there is a lot to reach for, since Tarski was an exceptionally prolific scientist as a logician and mathematician. The complete list of his works includes seven books and over three hundred publications. Tarski is alive and will live by being recalled in lecturing halls and in references made to his works, not only in the field of logic and mathematics, but also in philosophy, linguistics, computer science and other disciplines. His creative thoughts surpassed the bounds of death, the truth, which closes the book of material existence of human beings.

„Go through life in such a way that your footprints may outlast you"[23] – this thought was fully applied by Alfred Tarski in his scientific mission, which will be a model for many generations of scientists.

Footnotes

1. Jan Lukasiewicz, *O twórczosci w nauce, Księga pamiątkowa ku uczczeniu 250 rocznicy założenia Uniwersytetu Lwowskiego* (Lwów: 1922), pp. 1-15. This essay has been re-printed, among others, in: Jan Łukasiewicz, *Z zagadnien logiki i filozofii*, w: *Pisma wybrane* (Warsaw: 1961, ed. J. Słupecki), pp. 61–75.
2. It derives from a famous representative of eristic school (eristics – the art of leading controversy) Eubulides from Milet and had already been known to Aristotle, recognized the father of formal-logic (the fourth century B.C.).
3. Warsaw: Prace Towarzystwa Naukowego Warszawskiego, Wydzial III Nauk Matematyczno-Fizycznych, no 34, 1933, vii+116 pp.
4. „Der Warheitsbegriff in den formalisierten Sprachen", Studia Philosophica, vol. 1, 1935, pp. 261–405.
5. Papers from 1923 to 1938; first edition was published by Oxford University Press, (Oxford: 1956) and translated by J.H. Woodger (English title: *The Concept of Truth in Formalized Languages*); second, revised edition by Hackett Publishing Company, (Indianapolis, Indiana: 1983).
6. „Il concetto di verit nei linguaggi formalizati" (translated by Francesca Rivetti-Barb , published as a part of the book of Francesca Barb *L'antinomia del*

mentitore nel pensiero contemporaneo, Da Peirce a Tarski (Milano: Societ editrice Vita e Pensiero, 1961), pp. 391-677.

7. In: *Logique, Sémantique, Métamathématique*, 1923-1944 (Paris: Librairie Armand Colin,1972).
8. see footnote 5, second edition, p. 152.
9. The distinction between object language and metalanguage for the purpose of solving the issue of semantic antinomies is attributed to Stanisław Leśniewski, Alfred Tarski's mentor.
10. See: Jan Woleński, *Logic and Philosophy in Lvov-Warsaw School* (Dordrecht-Boston-London: Kluwer Academic Publishers, Synthese Library, vol. 198, 1989), chapter VIII.
11. Woleński, chapter VIII.
12. It should be noted here that the semantic definition of truth does not apply not only natural languages, but also to some formalized ones, which, of course, does not diminish the overall significance of Tarski's conception of truth. A system is said to be *consistent* if of any contradictory sentences at least one cannot be proved in this system and a system is called *complete* if of any two contradictory sentences at least one can be proved in this system.
13. In a free formulation, a model of deductive system is an ordered system consisting of the universe and the relations between its objects, such, that each theorem of this deductive system is true in this system. The conceptual apparatus of the model theory made it possible to investigate a number of fundamental problems of mathematical logic, such as consistency of a theory, definability of notions, etc.
14. The discussion concerning Tarski's influence on the twentieth-century logic and philosophy is provided by Woleński, chapter VIII (see: footnote 10).
15. „Przegląd Filozoficzny" („Revue Philosophique"), vol. 26, 1923, pp. 68–89.
16. Tarski dedicated to him the selection of the interwar period papers, *Logic, Semantics, Mathematics*; see footnote 5.
17. The most important papers of the Warsaw Period were collected in *Logic, Semantics, Mathematics*; see footnote 5. They are discussed in Editor's Introduction to the revised edition of 1983 by John Corcoran.
18. Lvov and Warsaw: Biblioteczka Matematyczna, vol. 3-5, 1936, p 167.
19. Second Polish edition (ed. Witold Marciszewski, „Philomath", Warszawa 1995), a translation of already fourth American extended publication, entitled „*Introduction to Logic and to the Methodology of Deductive Sciences*", with editor's foreword Dr. Jan Tarski (Alfred Tarski's son), who edited this edition (Oxford and New York: Oxford University Press, 1994).
20. Alfred Tarski's scientific and private portrait is drawn in details, in a very interesting, and expressive way by his disciple, Steven R. Givant in: „A Portrait of Alfred Tarski", *The Mathematical Intelligencer*, vol. 13, no 3, 1991, pp. 16–32.

21. Alfred Tarski, *Collected Papers*, edited by Steven R. Givant and Ralph N. McKenzie, (Basel-Boston-Stuttgart: Birkhaüser, 1986), vol. 1: 1921–1934, vol. 2: 1935–1944, vol. 3: 1945–1957, vol. 4: 1958–1979.
22. Czesław Miłosz: *Gdzie wschodzi słońce i kędy zapada* (Kraków: Znak, 1980), p. 12.
23. This citation was taken from Foreword, by Jan Trznadlowski, editor of the volume *Uczeni Wrocławscy*, 1945–1979 (Wrocław Scientist), (Wrocław: Ossolineum, 1980).