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The essence of scientific enquiry, determined by the aim that is to know the world and arrive at its true knowledge, delimits the scope of interest for philosophy of science, and especially for one of its domains – methodology of science. It provides not only ready-to-use methods and research procedures but also applies to their products: hypotheses, concepts, laws, assertions and theories. In particular, contemporary methodologies try to resolve the problem of building and applying proper rules to evaluate full-fledged and publicly presented theories that aspire to the label of „scientific" ones as well as rules to select best of them. These rules are also used as criteria of demarcation (separating what is scientific from what is metaphysical; cf. Kołakowski 2004: 192) and as „theories of scientific rationality" (serving to establish general norms of rational conduct of researchers and scientific communities) (Lakatos 1995: 171–172). The most known XX century „logics of scientific discovery" were created by: Karl Raimund Popper, Thomas Samuel Kuhn and Imre Lakatos.

Popperian methodological falsificationism (put forward in his *Logik der Forschung* in 1934) is a kind of conventionalism that was conceptualised in face of criticism and collapse of not only inductionism but also of dogmatic falsificationism. His point of departure was to question development of science as based on the principle of induction or to reject – related to it – the commonsensical theory of knowledge. Called by Popper *the bucket theory of mind* (Popper 1992: 11, 87), it posits that the mind passively collects and arranges empirical observations that are treated as an exclusive source of information about the world and subsequently, basing on the reiterative nature of such experiences, it forms expectations as for the incidence of certain regularities in the future. In Popper's opinion, this strategy of conduct, relying on confirmation, does not constitute a method of science but of pseudoscience since one is not able to indicate any grounds to justify validity of one's inferences regarding the future on the basis of incidences experienced in the past. In this respect, Popper favoured a traditional solution to the problem of induction that had been proposed by David Hume (and re-confirmed by Bertrand Russell in his *A History of Western Philosophy*), assuming that induction by repetition does not exist (Popper 1992: 16; cf. Grobler 2006: 60–61).

Not stopping at depriving inferences based on induction of the status of cognitive inferences, Popper re-formulated Hume's logical problem, posing not only the question regarding legitimacy of inductive reasoning but also asking whether we may admit an evaluation of a theory's truthfullness relying on individual empirical statements that are taken to be true. Answering in the negative – no number of empiricallly true statements can justify truthfulness of a universal explanatory theory (referring to past incidences) – he stated in turn that in some situations it is possible, by means of empirical assertions, to prove that a given theory is false.

Taking – as a logical consequence of the above assumption – that all theories are only conjectures, suppositions or hypotheses that are only tentatively approved (Popper 1992: 24), Popper further posed a question concerning a method to select and evaluate some of theories as better than competing conjectures. The theory of preferences that he formulated for this purpose has it that one should choose those out of a set of theories presenting solutions to the same problem whose falsity has not been as yet proven, provided that they explain not only successes but also failures of the rejected (disproven) theories. Those should be hypotheses that may be best tested, meaning the ones that yield most information and have the most explanatary power (Popper 1992: 28).

However, not taking them to be true on just this basis but only as possibly verifiable (Popper 1992: 69) at a given time *t*, Popper proposed that they should be subjected to a rigorous testing procedure that aims at identifying a counter-example and disproving (rejecting) the tested hypothesis. His anti-inductionist position made him thus clearly emphasize negative arguments, indicating that anything that may be assumed as positive in our scientific knowledge, is positive only as long as some theories are at a certain time preferred to others owing to their critical discussion that consists of their attempted disprovals, including empirical tests. Hence, even if something could be assumed to be *positive*, it could be so only because of negative methods (Popper 1992: 34).

Popper's conception, alongside the above discussed critique of inductionism, contains also a positive research programme that outlines a proper model of scientific conduct (*postępowania naukowego*) together with a presentation of a scientific procedure that has been deemed correct (Krauz-Mozer 2004: 633). This procedure, which was called the hypothetical-deductive method or falsificationism, begins with adopting a purposeful and systematic approach by a critical researcher regarding fully-fledged, articulated theories. Popper encouraged making bold conjectures (hypotheses that are rich in contents) and then undertaking rigorous and incisive attempts at falsifying them by means of observation and experimentation. Thus, he did not concentrate on the manner and circumstances of the theory's gestation (known as the context of discovery) but on their incisive justification that aimed at verifying the correspondence between conclusions deducted from the given theory and empirical evidence.

Hypotheses that will not survive such rigorous tests are to be rejected and replaced with new, competing theories that strive to overcome problems inherent in their predecessors (Popper 1977: 317–318). Owing to this, according to Popper, progress in science takes place: not through repetition or accumulation but by way of elimination of existing errors (Popper 1992: 199 and ff.), which forces scientists to create next, ever better – but always temporary – conjectures. Knowledge is never certain or impossible to undermine but rather it constantly develops by admitting new theories and including them into scientific discourse when they satisfy the requirement of falsificability that constitutes the Popperian criterion of demarcation determining that only those hypotheses are scientific for which there exist empirical statements (falsifiers) that are logically possible but incongruent with those theories. If these were to turn out to be true, they could disprove the theory (Chalmers 1993: 64). This view ascribes a new role to experience in science: scientific theories are not formed on the basis of facts and they are not secondary to facts or proven by them; they always precede observation that may eliminate them (Popper 1992: 434 and ff, cf. Lakatos 1995: 238). Popper called this insight the theory of spotlight.

In the Popperian methodology, scientific rationality is unequivocally related to such a way to develop science that is seen to rely on adopting a critical stance regarding nascent theories. In accordance with this methodology, the researcher should direct all his/her efforts at preparing merciless tests whose aim is to falsify predictions and not strive to carry out ever next verifications thereof. Only incessant questioning and critiquing of the existing knowledge may lead to a gradual emergence of ever more perfect theories since at times we see that we have been mistaken; we can learn from our mistakes, we can draw conclusions upon being aware that we have made a mistake (Popper 1992: 52).

Even though it has dominated the philosophy of science, the above position has not been appreciated by all methodologists. Thomas Kuhn, among others, criticised it, who in his famous *The Structure of Scientific Revolutions*, published in 1962, demonstrated that the Popperian logic of scientific discovery constitutes a purely normative approach that has nothing to do with the reality of research practice (Dunbar 1996: 35). His depiction of the way in which scientists work concentrated primarily on demonstrating – contrary to Popper – a „discontinuity" (Losee 2001: 245) of progress in science, an anti-accumulative nature of knowledge, while stressing integrity and coherence of science within particular periods of its development (Kuhn 2001: 22).

In Kuhn's opinion, development of science has a revolutionary character and is basing upon the existence of mutually independent and incommensurable theoretical structures that remain rooted in diverse ways to perceive the world and to make science in the world (Kuhn 2003: 36 and ff). Their change, at the same time meaning progress in science, is effected according to the following model: normal science – crisis – scientific revolution – new normal science.

The bulk of this model, called *normal science*, constitues scientists' activity proper, basing on their conviction that they know what the world is like. On the basis of this certainty, that stems from previous scientific achievements that have been accepted by the given research community, specific shared procedures of scientific practice are formed that create a model (paradigm) for conducting further research. Broadly understood, the paradigm consitutes a *sui generis* disciplinary matrix that consists of: laws and theoretical assumptions, ways of their applying, technical equipment enabling to project the laws derived from the paradigm on the real world as well as of quasi-metaphysical convictions that influence scientific work (Kuhn 2001: 34, 81-84; cf. Chalmers 1993: 123). The formation of a paradigm and its acceptance by a given group of scientists are indispensable conditions of organising specialized research within the framework of normal science that aims at solving problems called puzzles through applications of the paradigm and its rules to new situations.

Scientific work involves then elaborating details of the paradigm, extending the scope of its applicability and resolving specific problems generated by the paradigm in a manner that is analogous to the one that has led to some key discovery. The paradigm encompasses three classes of issues: rules of analyzing relevant facts, rules of confronting the facts with the paradigm theories and rules of solving some of the ambiguities within the theories (Kuhn 2001: 57). In this mode of operation, the Popperian „critical discourse" (Jodkowski 1993: 74) is lost that questions scientific claims, replaced by defending merits of the given paradigm. Kuhn maintains that scientists are ready to ignore apparent anomalies and innovations when those undermine suppositions that are fundamental in their paradigm (Kuhn 2001: 26). As such, they do not aim at all at identifying counterfactuals that falsify their hypotheses but – as long as possible – they stick to findings derived from the existing paradigm. While – for Popper – science is a *permanent revolution* and criticism constitutes the essence of the enterprise called science, according to Kuhn – revolutions are exceptional and as a matter of fact external to science whereas criticism is – in *normal times* – banned (Lakatos 1995: 5).

Normal research is a way to discover changes within a paradigm that result from appearing new facts and theories. They are the effect of becoming aware of anomalies and so of recognising that reality disproves to a certain degree predictions generated by the paradigm. Nevertheless, as long as research in the area in which these anomalies appear allows for such an adjustment of theories to facts that the anomalies become something predictable, the normal science lasts. In Kuhn's opinion one not only cannot falsify a theory but should even defend it against falsifying by introducing specifications and multiple *ad hoc* modifications to the hypotheses that aim at eliminating discrepancies that appear. According to him, this is the only way for science to develop, the one that guarantees time needed for a new theory to emerge that would be capable of taking over functions performed by the so far existing paradigm. To reject one paradigm without its simultaneous replacement by another is tantamount to abandoning science itself (Kuhn 2001: 146). His position is therefore completely different to the one articulated by Popper, who in his *Logika odkrycia naukowego* unequivocally criticised that type of scientists' behaviour, urging them to reject it or at least limit it considerably (Popper 1977: 70–72; more about it in: Sady 1994: XVII–XVIII).

However, if it had been Kuhn who had formulated an adequate model of research procedure, then it turns out that progress is made owing to the fact that scientists are not rational or that scientific rationality has little to do with Popperian criteria (Sady 1994: XIX). Only when the amount of unexplained puzzles begins to rise that strike at the foundations of the paradigm, consistently escaping continuous attempts at their explaining, does a crisis start and sceptical attitudes regarding the existing paradigm are admitted. Until that moment, normal science, contrary to Popper's claims, is decidedly anti-critical.

The Kuhnian crisis, revealing fallibility of the existing paradigmatic rules, constitutes a „state of exception" during which multiple hypotheses appear that compete with one another in a struggle to win the status of a new paradigm. In order for one of them to win, scientists debate fighting an irrational battle in order to have their respective theories recognised. Each side hopes that it will succeed in persuading the other to its perception of science and of its problems, while none is able to prove its rightness (Kuhn 2001: 258) since it has to be based solely on faith in the future success of the given paradigm. Ultimately, in Kuhn's opinion, the transition to a new paradigm is far from a logical decision basing on neutral experience; rather it resembles *conversion* (Kuhn 2001: 262–263) that consitutes a proof that a *scientific revolution* has been made. It is by no means animated by the Popperian type of rationality as part of the logic of scientific discovery, but rather by something that was called by Imre Lakatos a „psychology of discovery" (Lakatos 1995: 5).

In 1968, in a paper *Criticism and the Methodology of Scientific Research Programmes* Lakatos put forward a methodology of scientific research programmes as an attempt to resolve problems that the above mentioned methodologies could not handle. It was meant mainly as a response to Kuhn's views, albeit it was partially also a polemics with Popper. It should, however, be remembered, that Lakatos approved of many ideas of the latter, judging them to be a most important event in the XX century philosophy (Lakatos 1995: 235).

The basic thrust of his methodology was focussed on demonstrating that scientists in their research practice act both according to rules proposed by Popper and those formulated by Kuhn. He was able to merge the two seemingly contradictory positions owing to an insight that each refers to a different kind of theory (Dunbar 1996: 36).

As claimed by Lakatos, scholars pay their attention to solving problems within frameworks of scientific research programmes (Lakatos 1995: 71 and ff) that are constituted by series of hypotheses (and not single theories) related to one another in such a way that a perception of continuity is created. They share a common problematic and methodological rules defining what research steps are to be avoided (negative heuristics) and what are to be followed (positive heuristics).

Negative heuristics defines primarily the so called *hard core*, meaning a set of assumptions and statements that constitute basic theses of a programme – they are assumed to be impossible to disprove on the basis of a methodological decision by a research group that has accepted them. The abandoning of such a core is tantamount to giving up the given research programme in exchange for another. This is a clear analogy to the situation that takes place in the period of Kuhnian normal science that is concentrated on the defense of the paradigm and then on its replacement during a scientific revolution.

Positive heuristics in Lakatos's conception is, in turn, congruent with conditions stipulated by Popper since it consists of a set of rules specifying what is the way to develop secondary hypotheses (that single out details of the given programme) – they form a falsifiable and modifiable *protective belt* around the hard core (Lakatos 1995: 72–76). Their falsification may lead to transformation and even a thorough change of the protective belt that – in spite of this – remains untouched.

The programme theory, similarly to the paradigm as conceptualised by Kuhn, continues to function as long as it anticipates new facts with the help of secondary hypotheses. What takes place then involves some progressive advancement of problems that is decisive in the development of science regardless of attempted disprovals. However, if the programme reaches a point in which its heuristic power is exhausted, anomalies and hypotheses ad hoc multiply that cannot be replaced with explanations further enriching the programme's contents and then the programme enters the phase of degeneration. In Popper's terms, it starts to lose its „empirical character" (Lakatos 1995: 109) and is soon replaced by a competing programme.

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