Archives Italiennes de Biologie, 142: 353-357, 2004.

MICHEL JOUVET: THE ENIGMA OF SCIENTIFIC CREATIVITY

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I would like to try to answer the question of this round-table discussion, "forty years of progress?" in a philosophical, epistemological way. Philosophically speaking, the enigma of scientific creativity is more fascinating than ever. There is a particular reason for that. Michel Jouvet mentioned Claude Bernard. Claude Bernard wrote once that in experimental science logic alone is never sufficient. There is something else than pure logic which is responsible for creativity in experimental science. The work of Michel Jouvet is a fascinating example of this "something else" which is true scientific creativity and is so difficult to capture.

Let us now turn to the particular question, "forty years of progress?" This question is an excellent starting point for an enquiry about the notion of scientific progress as well as about the recent developments of sleep research. Indeed, sleep research is a wonderful example to discuss what we mean really by scientific progress, due to the fact that, as mentioned in the title of this symposium, we are dealing with an unfinished story, at least in some respects. Under these circumstances, we can see mainstream lines of investigation and reflection, we can observe more or less rapid advances, but regarding unsolved problems, an outside observer would be definitely unable to grasp which line of research is the most fruitful, since we have learned from past experience how misleading such judgements frequently are.

Now, let us try to consider this question of what we mean really by scientific progress under such circumstances, from slightly different viewpoints. A cumulative and quantitative view of progress (for instance in terms of the number of discoveries made, of new data disclosed, or of new technologies being introduced), is surely very unsatisfactory but also unavoidable in a way as a measurement. A more qualitative, sophisticated, and philosophical view of scientific research has been proposed by the American philosopher Nicolas Rescher (1). It is based on the idea of a varying ratio between the known (perceived as such by scientists) and the unknown (perceived as such). This ratio may change quite significantly during the course of history, according to the feeling of the scientists who tend to think either that most of the knowable is already known, or that most of the knowable remains to be investigated. In other words, the perception of solved versus unsolved problems is an important parameter in the view of scientific progress. Scientists may have different views regarding the situation of their respective fields of research in this oscillating ratio between the known and the unknown. In a way, optimism may be linked to the idea that what has been recently discovered, far from being closer to a complete theory, just leads us to conclude that important facts remain to be discovered and that

what is already known is just the beginning of a scientific revolution being underway.

During forty or fifty years of sleep research, many problems have been solved, but as we heard some minutes ago the deepest questions, which are the functional ones, remain to be solved. At this point, one may ask a new question: how can we define progress in the treatment of unsolved problems? How can we distinguish it from regression – perhaps thanks to the Popperian test of refutation? My own suggestion here would be that we can define progress in terms of the renewal in the ways scientists ask new, different questions and are able to reformulate or rephrase them. This reformulation process is surely an important part of scientific progress. I am thus going to concentrate on the formulation and reformulation process which has been performed by Michel Jouvet and his colleagues and students. To make a comparison with another field of biomedical research, haematology and blood cells pathology, I was once struck by two colleagues and friends of Michel Jouvet, Jean Bernard and Marcel Bessis, who devoted a whole symposium of their Blood Cells Club to the topics: "Leukemic cells: What are the right questions to ask?" (2) In order to proceed in their investigation, they decided to examine the choice of questions they considered important and to decide whether they were formulated clearly enough to allow precise answers. Some of these questions dealt with facts and others with concepts and theories. In the forthcoming discussion, I will mainly deal with questions of concepts and theories.

Questions are conjectures, interpretations or hypotheses, put under an interrogative form. Forty years ago, at the time of the Lyon symposium in 1963, which means ten years after the Aserinsky-Kleitman discovery in 1953, theoretical hypotheses were much discussed and formulated by William Dement and by Michel Jouvet. Deep ideas or insights were formulated. These insights took sometimes the form of functional, physiological, but also phylogenetical and ontogenetical questions, with the prospect, that all these different types of evidence could be one day or the other put together in a single unified theoretical framework. All these questions which were asked in these early days were totally unexpected some years before. Some of them remain still unanswered. Unexpected and still unanswered questions are the clear sign, not merely of progress, but also of a scientific revolution being underway.

This phrase, "scientific revolution" has been perhaps overused. However, in this particular case, it is entirely justified because prior to the discoveries pertaining to paradoxical sleep, the very idea of a neurobiology of dreaming including all of its implications was hardly conceived at all. Furthermore, the theoretical framework which has been worked out by Michel Jouvet and his colleagues was extremely innovative, for that reason, that it put together: first, ideas borrowed from computer science, the notion of programming and reprogramming; second, the recognition of the relevance of genetics for the workings of the nervous system; third, personal discoveries on the behavioural component of dreaming. As early as 1965, Michel Jouvet discovered the oneiric behaviour by destroying bilaterally the locus coeruleus nuclei in the cat. This discovery, together with the notion of paradoxical sleep as the third state of sleep and wakefulness, are perhaps his biggest philosophical contribu-

tions, and are the main nucleus of his further theoretical interpretations and conjectures. As early as 1963, forty years ago, his student Marc Jeannerod proposed the idea that the rapid eye movements which occur during dreaming may be conceived as sketches ("ébauches") of behaviour. This idea was formulated in the context of the discussions about the meaning of psychophysical parallelism, which is an old philosophical doctrine whose relevance for contemporary neuroscience is perhaps less important than what was believed some decades ago (which is perhaps also a sign of progress). Michel Jouvet's discovery of the oneiric behaviour is something very different in its spirit and in its background, which is really the study of the neurobiological mechanisms of animal behaviour including conditioning (the subject of his PhD thesis), attention, and sleep and wakefulness. The context of the discovery of oneiric behaviour is physiological. Being physiological, it is likely to induce functional questions, since the neurobiologist might expect to be able to go naturally from mechanisms to functions. So, starting from his discovery of the oneiric behaviour during the course of his experiments on paradoxical sleep mechanisms, he asks new, unexpected questions and is able to reach quite striking formulations. One of these formulations was written in 1972 in a review about neurotransmitters in sleep. He proposed to consider paradoxical sleep as a genotypic arousal (3). This a very unexpected, striking and innovative formulation, which is partly based on new pieces of evidence regarding sleep ontogenesis. As already mentioned, Danièle Jouvet-Mounier, expanding the scope of previous studies by Jean-Louis Valatx in 1963 and by Howard Roffwarg, introduced in her PhD thesis in 1968 a comparative dimension in the study of sleep ontogenesis, which brought new evidence to formulate and improve conjectures. According to these conjectures, paradoxical sleep should play a major role in the maturation of the central nervous system. The idea of genotypic arousal meant that repetitive stimulation could help establishing specific synaptic connections at the level of late connecting interneurons. It meant a form of central nervous system arousal which is directed towards the expression of genotypic features. Together with the idea of genotypic arousal, came the idea of genotypic coding, which had a more behavioural content since paradoxical sleep was supposed to help to establish the circuitry of basic instincts and behaviours. This creative idea was further developed and extended to a similar reprogramming function of paradoxical sleep in the adult – and a more systematic study of oneiric behaviour was performed in 1978-79 in order to answer a question based on other physiological and anatomical data: are the cat's oneiric behaviours closely related to PGO waves, and is it possible to imagine that PGO waves are coding for these basic innate behaviours? Asking these new questions is surely a progress. However, what is even more surely a progress (this time in a more Popperian way) is that not all these questions could be answered in a positive way, since suppressing paradoxical sleep in the rat does not impair basic behaviours. This lack of confirmation lead Michel Jouvet to speculate that paradoxical sleep, instead of programming or reprogramming basic instinctive behaviours, was responsible for maintaining more idiosyncratic, individual properties, which could correspond to the phenotypic variance between individuals, as suggested in 1986. In other words, he devised the following reformulation

of the previous question: does paradoxical sleep maintain phenotypic individual variations? This question is still not answered, but one of the striking features of dream research is that the real fact of formulating or reformulating this kind of questions stimulated greatly various analogous speculations by other well-known biologists who proposed their own variations and interpretation on this basic theme, including sleep, memory, learning and unlearning. As a matter of fact, Michel Jouvet's hypotheses play a most important role in contemporary thinking about this subject, as everybody knows. Now, if we measure progress by two different quantitative parameters, the number of hypotheses which are abandoned, and the number of hypotheses which are proposed, we can observe that both of these numbers were growing very fast during the last forty years, so that the answer is rather obvious, which does not mean that the question of progress is artificial, because many researchers had sometimes the feeling that things were not moving fast enough, at least according to their wishes. My own comment would be that this feeling has surely very good reasons but that it has to be put under a more philosophical form.

There are several possible forecasts about the future. It could be said as a conclusion that there is plenty of room for researchers eager to illustrate and substantiate Michel Jouvet's insights during the twenty-first century. In this way, I would stress the fact that these insights are very far reaching ones, so that the answers are surely not easy to get. Indeed, if one considers recent research in dream cognitive psychology compared with recent research in dream neurobiology, the prospect of seeing these different fields of research merging into each other remains very far away. This situation is not that different from what happens in other fields of cognitive neuroscience. However, as happens frequently in the history of science, there may be an acceleration due to progress made in other fields. At this point, I would like to take an example from the field of genetic engineering. In 1970, a Conference was organised in London by the British Society for Social Responsibility in Science (4). In this Conference, forecasts were made about the future realisations in biotechnology, like recombining DNA, synthesis of human proteins by Escherichia Coli, reproductive cloning, and human gene therapy. The synthesis of human proteins like insulin by Escherichia Coli appeared at that time as a mid-term, twenty years project. As a matter of fact, it took only seven years to get the synthesis of human somatostatin by Escherichia Coli using a synthetic gene, and eight years to get the synthesis of human insulin, with enormous medical consequences regarding the availability of treatment for diabetes. The key observation at that time was acceleration of progress. It may happen that a similar acceleration occurs in the field of sleep research, so that Michel Jouvet's insights would be further illustrated and substantiated. This would be, obviously, a great satisfaction.

SUMMARY

In this paper, Michel Jouvet's major achievements are put in a more philosophical perspective regarding scientific progress as measured by the varying ratio

between the known and the unknown. The process of reformulating questions and hypotheses is considered as a measure of progress. The boldness of these speculations is seen as an attempt to grasp the unknown and to open a path towards the future. Sometime ago, the sleep research was considered as decelerating. It is argued that there well may be a renewal and an acceleration in this field.

Acknowledgements. - I am grateful to Michel Jouvet who allowed a philosopher to stay in his laboratory for several years and to get a real and fascinating experience of sleep neurobiology.

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