

## Tribute to Moruzzi

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We have gathered at this Symposium to honour our friend and colleague Giuseppe Moruzzi. In adding to the tributes from other sources, I am using the privilege of age to welcome him into the brotherhood of retired physiologists. I can assure him that he is entering a gathering of tolerant and benevolent people who respect the idiosyncrasies and mannerisms of one another and neither get irritated nor depressed when they see themselves and their past achievements gradually falling into oblivion. Chastened by age and experience, they sit back and enjoy from the outside, or perhaps from above, what they previously enjoyed from the inside.

It is said that those who have had many pupils and co-workers will be kindly treated by posterity. I believe this is true, and you, Moruzzi, are indeed, by this criterion, on the safe side and can retire peacefully. Klüver once told me that his friend Stephen Polyak held to the view that large books loaded with detail are the best guarantee for a safe corner in the history of one's science and, as we know, he also acted on this notion. I am not so certain that he was right. Techniques alter so rapidly nowadays that the emphasis on what once seemed frightfully important is soon forgotten and replaced by a quite different chunk of emphasis.

Oblivion does not mean that the individual effort has been exerted in vain. The advancing frontier of knowledge is based on fleeting moments of actuality. By helping to create such moments and living with them vividly and personally in experimentation and thinking, the individual scientist will have contributed his share to the growth of insight within a given period.

When I see the present avalanche of papers, books and symposia within any conceivable field, I realize that Moruzzi, like myself, was born into a better time than the present. Those of us born between 1900 and, say, 1920 were lucky to enter active experimentation at the beginning of the electronic era of neurophysiology. We were not too many and all of us were carried away by the new possibilities opened up in electrical recording and stimulation. Our papers met an audience of reading and listening friends and so we did not experience the frustration that must be a common lot of the many who feel themselves unjustly neglected in the neurosciences of today. All of us also got into the same unprinted *Who's Who* of early

neurophysiology; partly no doubt a consequence of the good positions that so easily fell into our laps. The modern catchword "alienation" did not exist in our vocabulary. We believed that our lives as scientists were pregnant with meaning.

Moruzzi entered physiology of the nervous system in the Italian tradition of Luciani. His theme was the cerebellum, so difficult to understand, despite a uniformity of organization that goes on tempting interpreters. Since those days we have advanced a bit in the elucidation of vermal inhibitions and excitations, and we know why these inhibitions do not respond to strychnine in the expected way. To the analysis of postural and cortical effects from the cerebellum, Moruzzi added discoveries of vermal influences on circulation and respiration neglected by those who today write and theorize about cerebellar functions. What is, for instance, the relevance of the hypotensive effect on the arterial blood pressure that is obtained only during a centrally determined pressure rise?

There was a common denominator in these experiments on vermal inhibitions: hyperpnea was necessary for cerebellar inhibition of respiration; the effect on sinus caroticus reflexes likewise required that their centers were in the state of raised excitability caused by release from tonic baroreceptor inhibitions. I have ready at hand a very general answer regarding my own pet notion that the cerebellum is the main central compensator of deviations from a desirable homeostatic mean, but my main reason for taking up these particular experiments is to point out how well prepared Moruzzi was to enter the hypothalamic area when he cooperated with Magoun on that important paper of 1949.

Moruzzi and Magoun showed that fastigial stimulation yielded a generalized EEG arousal in animals with intact cerebrum and studied arousal from the medial bulbo-reticular formation. This paper was responsible for providing a physiological version of "arousal" and for establishing this phenomenon as something dependent on a hitherto much neglected part of the brain.

With Brookhart and Snider, Moruzzi entered the growing field of microrecording from single neurons and they discovered the high spontaneous discharge rates by which Purkinje cells differ from their motor partners in the cortex cerebri. Adrian and Moruzzi had already studied the latter in 1940 and made the observation that there was a permanent activity in the pyramidal path that had no detectable effect on the muscles it innervates.

After returning to Italy in the 1950s, Moruzzi and his students concentrated on the cerebello-reticular link and on cortical effects on the reticular discharges. Two leading techniques were the microrecording of single spikes and anodal polarization of the cerebellum. This work expanded to the nucleus of Deiters and the fastigial nucleus. Postural asymmetries, rigidity, and atonia continued high on the list of the activities of the Pisa Institute, likewise the general problem of "activation." Luciani's atonia was one of the difficult problems which Moruzzi and Pompeiano attacked in a study of ipsi- and contralateral fastigial atonia, the latter dependent upon a crossed effect from the caudal pole of the fastigial nucleus.

However, this is neither the place nor the time for a review of the many significant contributions of the Pisa Institute as directed by Moruzzi. Nor do I feel it urgent

to enumerate the names of his many prominent pupils, several of whom contributed to this occasion. A host of foreign guest workers look back with gratitude to their Pisan visits and works. A large number of contemporary physiologists have been influenced by the ideas, experiments, and results emanating from this important school of continental Europe. Its contributions to physiology are formative elements of the structured knowledge we possess today.

Cerebellum alone suffices to illustrate the broad range of knowledge and interests of the Pisa Institute. After having exhaustively analyzed every single cerebellar function and in particular the regulation of postural tone Moruzzi wrote: "Markedly different as all these functions are in their mechanism, and above all in the extent and continuity of control exerted by the cerebellum, they appear to share at least one feature, namely that none of the nervous centres involved appears to be exclusively related to the cerebellum. . . . (they) may ultimately work independently." This quotation is from the monumental work with Dow in which the theoretical section was written by Moruzzi (1958). This statement contains in fact a definition of control, a hierarchic function in the sense that it regulates by accelerating, retarding, or inhibiting otherwise autonomic events at different hierarchic levels. But every pathway of regulation presents its own anatomical and physiological problems, as does the biological situation that should disclose the purpose of the cerebellar interference.

Although the Pisa school of physiology reflects so many of Moruzzi's original interests, it has not been in the least regimented. The laboratory has stood for freedom of the individual members to develop their own ideas. We often find a young man, after having done something with Moruzzi, soon being let loose to develop his own interests. Generosity with the young has been one of the great attractions of the Pisa Institute in which Moruzzi's wide knowledge, experience, and critical mind have been available assets whenever required.

The high reputation of the Institute has made it possible for Moruzzi to mobilize support for his special creation, the research institute of the *Consiglio Nazionale delle Ricerche*. This adjacent laboratory has attracted a number of first rate capacities, internationally known for excellent contributions to vision—retinal, cortical, psychophysical—and to interhemispheric communication. Since my own retirement, I have had the pleasure of following the experimental progress at the Moruzzi laboratories with annual visits and thus I can speak with some authority of the unassuming, quiet wisdom of Moruzzi's leadership and of the goodwill and respect he has enjoyed from the authorities of the State responsible for basic support of science.