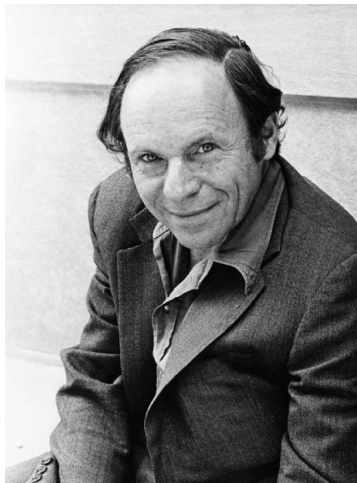


## Fermi Questions

THE thoughtful recommendations of the Second Arbor Conference are bound to have a strong effect on the training of physics majors for years to come.<sup>1</sup> For this reason, I think it important to bring out that the authors of the report themselves remind us that there are pitfalls in the way of designing a curriculum solely from any list of texts and topics, valuable as that list can be. The key paragraph occurs in Sec. II of the Recommendations, immediately before the subheading "Curriculum R." I should like to echo, indeed, to amplify, their paragraph. For that purpose, I append a paragraph or two of my own which I hope may aid in realizing the intent of this part of their helpful Recommendations.

It is by no means possible to specify the training and readiness of a prospective graduate student by a mere list of topics. There is a kind of power over the theoretical and



Моррисон, Филип (Philip Morrison) (1915-2005)  
[https://ru.wikipedia.org/wiki/Моррисон,\\_Филип](https://ru.wikipedia.org/wiki/Моррисон,_Филип)  
[https://en.wikipedia.org/wiki/Philip\\_Morrison](https://en.wikipedia.org/wiki/Philip_Morrison)  
<https://history.nasa.gov/EP-125/part3.htm>  
 Фильм "Степень десятки".

experimental studies in which he has engaged which is difficult to define, but whose presence is perhaps more important than much knowledge which is more formal and complete. There is one test for such power which is at the same time a remarkably apt method for its development. That is the estimation of rough but quantitative answers to unexpected questions about many aspects of the natural world. The method was the common and frequently amusing practice of Enrico Fermi, perhaps the most widely creative physicist of our times. Fermi delighted to think up and at once to discuss and to answer questions which drew upon deep understanding of the world, upon everyday experience, and upon the ability to make rough approximations, inspired guesses, and statistical estimates from very little data. A few samples are indispensable:

How much does a *watch* gain or lose when carried up a mountain?

How many piano tuners are there in the city of Chicago? (These are authentic Fermi questions from the source.)

A few more of Fermi type:

What is the photon flux at the eye from a faint visible star?

How far can a crow fly?

How many atoms could be reasonably claimed to belong to the jurisdiction of the United States?

What is the output power of a firefly, a French horn, an earthquake?

Such questions can of course be found for nearly any level of education. It should go without saying that no such question fulfills its purpose unless it is being heard for the first time. The accumulation of confidence and skill which such answers bring is a very good apprenticeship to research. Indeed, the conception of experiments and the formation of theoretical hypotheses are activities which are well simulated by asking and answering good Fermi questions.

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<sup>1</sup> Am. J. Phys. 31, 328 (1963).