of this requires careful planning and cooperative exchanges of ideas.

Faculty are obviously a key factor in any progressive program. Without good faculty pursuing established teaching and research goals, no amount of money or pressure will yield an outstanding department. Faculty members must be able to interact with one another on both research and teaching matters, thus providing mutual stimulation and critical insight. As mentioned previously, this means that in a physics department of 25 faculty members, two or at most three areas of physics can be attacked in depth. It is also important to remember that not *all* faculty members can have their expertise and training in the rather narrow areas chosen to be emphasized in the mission. The department must equip undergraduates to compete in technical occupations, in medical school or at any major graduate school and must invest in some faculty members whose training and research lie in fields other than those that form the major emphasis of a small department. Special consideration must be given to these people, because their need for outside communication is greater than those of faculty members in the areas of specialization of the department. Innovative teaching must also play an important part in any department.

Just as it is important to have a mission and able faculty, interested and capable graduate students are a prime ingredient of a good program. The departmental program must be responsive to graduate student needs in terms of education and personal development. Faculty members must spend personal time as individuals with the graduate students. One of the strengths of a small department is the opportunity for emphasis on interpersonal communication. There is no reason or excuse for a small department, despite the familiarity that exists between the faculty and graduate students, to graduate mediocre physicists.

The majority of the funding in most physics departments comes from state funds allocated for the purpose of teaching. Thus, the teaching base of any department must be considered in formulating the size and mission of a department. In physics, teaching and research are so intertwined that disentanglement is impossible, but it is important for the various publics of universities to understand that the emphasis of physics departments is on creative ideas, teaching and training. "Program budgeting" and "cost per student credit hour" are common terms in this day of cost accountability. When a physics department shows an exorbitant cost per student credit hour, there is pressure to reduce the budget. It is important in the planning phase of building a department to understand what the teaching base for the department should be. As a rule of thumb, a solid teaching base would consist of a teaching load of 14 000 student credit hours per year for a full-time faculty of 20.

A major source of funds for the summer program, for travel and for equipment is federal grants. Federal funds are usually granted to scientists who do excellent research. This should be uppermost in the mind of the person in a small department responsible for planning departmental goals and emphasis. Only competent people capable of doing outstanding research will "win" grants. Competition for these monies has become greater each year and cooperative efforts by capable and energetic faculty members are required, under today's funding conditions, to build and maintain a well-balanced small physics department. Another source of research support is local industry. Departmental research programs should be coordinated with the needs of local industry. There must be a *quid pro quo* if industry is to invest in university programs.

In conclusion: I feel it is important to reiterate that for the next few years regional planning by physics departments should be of high priority and that the accomplishment of a major research effort and adequate graduate program involves a "road map," excellent faculty, and capable graduate students. If these elements are present, even in the face of modest resources, a viable, vigorous and valuable program can be developed.

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W. A. SIBLEY
Oklahoma State University
Stillwater, Oklahoma

Nebula error?

I suppose that anyone can call anything by any name, but if communication and transfer of information are the aims it is surely best to use names that others will understand. Rudolph Minkowski once despaired of giving an absolutely com-

plete and correct definition of a planetary nebula, and ended up by saying that a planetary nebula is an object listed in a catalogue of planetary nebulae, but most definitions of them stress their morphology and origin. In any case, the Crab Nebula is not included in any modern catalogue of planetary nebulae, and so far as I know no serious astronomer or astrophysicist has considered it a planetary nebula since the work of Mayall, Baade and Oort in the years around 1940. Surely Steven Weinberg can't have written that caption for figure 1 of his article in the June issue (page 33).

DONALD E. OSTERBROCK
Lick Observatory
Santa Cruz, California

EDITOR'S COMMENT: Reader Osterbrock is certainly right when he says that Weinberg could not have written the erroneous caption. It was written by a member of the PHYSICS TODAY staff on the basis of information given in the *Catalogue of Photographs and Slides* of Hale Observatories, which supplied the photo.

Measuring loudness

Although Edgar Shaw has given an overview (January, page 46) of the problem of quantitatively evaluating noise pollution, this reader wishes to dispel any impression that the problem is solved by any of the completely empirical numerical measures discussed in the article. Even the fundamentals are debatable. For example, according to current orthodoxy, a 10-dB reduction in sound-pressure level corresponds to halving the loudness. This result was derived from subjective loudness judgment, or psychoacoustic, tests.[1] However, the most recent, extensive (1320 subjects) and unbiased psychoacoustic tests indicate that a 6-dB (not 10) reduction corresponds to half loudness.[2] This result receives strong support from mathematical analysis of neurophysiological data.[3]

Shaw has used A-weighted, sound-pressure level (dBA) as his basic subjective measure of noise. Of the available measures of loudness, this one is probably the best.[4] Noisiness and other subjective quantities are too complex to be evaluated at present.[5] In any event, for a subject in a given emotional state, loudness may serve as a satisfactory indicator of relative noisiness. Unfortunately dBA is not a very good measure of loudness. For example, the loudness level of a steady sound at constant dBA may vary up to 15 phons (decibels) depending on the bandwidth of the sound. The broader the bandwidth, the louder the sound. This is certainly a significant effect. A new measure of loudness is called for.

Basic studies of human response to sound as related to noise pollution seem to have been dominated by psychologists. However,an understanding of the connection between sound and loudness requires knowledge of intermediate operations of the auditory system, that is, of human physiology, especially neurophysiology. Ultimately the data collected by psychologists and physiologists can best be correlated into mathematical theories of the sensations by physicists, since the system must obey physical principles. For this reason the still unsolved problem of quantitative evaluation of noise pollution offers a fertile field for the physicist.

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WALTON L. HOWES
Middleburg Heights, Ohio

THE AUTHOR COMMENTS: To cover the entire field of noise pollution in a single article was no easy task. The point mainly at issue was touched on in the single clause "a 10-dB increase in sound level (more properly, loudness level) is perceived as a doubling of 'loudness'" (page 46 of my article). This, I am assured, correctly reflects a well-established scientific consensus in an area of psychophysics fraught with difficulty. The subject of loudness is of course, like all scientific questions, open to further enquiry. I am indebted to Howes for drawing attention to noise pollution as a fertile field for the physicist. It is a point I intended to make.

EDGAR A. G. SHAW
National Research Council
Ottawa, Canada

The 20-micron window

In my review on "The Past and Future of American Astronomy" (December, page 23) I refer to the work of H. Rubens and E. Aschkinass,[1] in the course of which I stated that "in essence they also found the 10- and 20-micron windows in the Earth's atmosphere." The phrase "in essence" is—at least for the 20-micron window—too strong. Ru-