Letters

Healthier Frogs

The letters from Papermaster and Gralla (6 Apr., p. 10), Emmons (15 June, p. 1118), and Amborski and Glorioso (10 Aug., p. 495) follow a curving course which, in a manner of speaking, takes us full circle and puts us back at the beginning—back where we know little about the health of the frog and where hope for healthier frogs seems uncertain. Papermaster and Gralla wrote that they found oral tetracycline, which I recommended for the treatment of *Aeromonas hydrophila* infections in frogs, to be of great help in obtaining healthy frogs. They also commented that the treatment was somewhat time-consuming and that frog suppliers might be encouraged to provide healthier frogs if investigators refused to accept shipments containing sick frogs. As a representative of the frog supply system, Emmons then wrote to say that "most of the time you get what you pay for" and that the present acceptable price for a frog was simply not enough to cover the costs of providing the quality of frog which should be used by scientists. Finally, Amborski and Glorioso wrote to say that "successful antibiotic therapy is not only difficult but incomplete" if one does not have full knowledge of the bacterial pathogens and their antibiotic sensitivities. They further suggested that many pathogens having different antibiotic sensitivities may be involved in frog diseases. In a sense, this is where I started more than 10 years ago.

I have written or helped to write many articles dealing with frog health. The complex issues, arguments, and data have all been presented where sufficient space permitted thoughtful discussion (*1*). However, the main thread of the frog health problem can be summarized as follows: (i) every year countless research dollars are spent on experiments which begin with wild, caught frogs of poor health, undetermined origin, and with undetermined environmental requirements; (ii) the frog is a valuable research animal that cannot be replaced, and it is essential to the accuracy of research that the scientific community awaken to the need for developing healthy, defined strains or populations of laboratory frogs; (iii) until healthy, defined laboratory frogs are available, researchers should not fail to establish the significance of genetic, health, and age variables in their experiments. Every attempt should be made to control and understand these variables. Our most up-to-date experience with the frog as a laboratory animal will be reviewed in *Standards and Guidelines for the Breeding, Care, and Management of Laboratory Animals; Amphibians* (*2*).

I would like to take issue with a number of very important details in the letter from Amborski and Glorioso. First, they imply that my colleagues and I "assumed" that *Aeromonas hydrophila* was the major frog pathogen. This was not an assumption. Based on the populations of frogs which we studied and on historical evidence, this was fact. We also reported on several other lesser pathogens and have repeatedly warned of the need for continued bacterial and viral screening in frog disease. Great care should be taken not to confuse organisms present naturally in the frog's environment or intestines with pathogens.

Amborski and Glorioso isolated *Corynebacterium* and *Flavobacterium* from frogs that died during tetracycline treatment. It is to be expected that the strains they isolated would be resistant to tetracycline, as they reported. Moreover, the fact that the organisms were present (in what tissues is not detailed) does not prove they were truly pathogenic. Frogs and other amphibians can suffer incredible tissue destruction before actually dying. Many organisms can invade a seriously debilitated frog without actually being pathogens. Therefore, care should be taken to isolate organisms aseptically from frogs which are not too close to death. And the organisms isolated should be reinjected into healthy frogs at reasonable concentrations to determine if they actually do cause disease. Since healthy frogs may have a considerable ability to defend themselves against common pathogens, "reasonable concentrations" may be hard to calculate. Obviously, injecting test organisms into frogs already sick from undefined causes is not very conclusive. Amborski and Glorioso report having tested the pathogenicity of their organisms by injecting them into a single frog of undefined health.

Amborski and Glorioso also indicate that frogs apparently infected with *Corynebacterium* and *Flavobacterium* did not show "observable clinical symptoms, as in the case of redleg disease." On numerous occasions I have pleaded the case for dropping the term "redleg" from the terminology of frog medicine. Many frogs infected with *A. hydrophila* do not develop the symptoms of redleg. On the other hand, simple malnutrition and irritation can produce many of the symptoms of redleg. Redleg is not a discrete disease.

Oral and intratheral tetracycline were apparently used interchangeably by Amborski and Glorioso. I have had success only with the oral route. In my experience, tetracycline injections are very irritating to the frog, and tetracycline placed in cage water is not absorbed, but will damage the frog's skin.

It is important to take a hopeful approach to the treatment of frog disease. We have only scratched the surface, and a great deal can be done with simple procedures. However, our zeal should not be allowed to interfere with logical methodology. We should test each hypothesis by asking what experimental facts would result if the hypothesis were *wrong*, as well as right.

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References

1. E. L. Gibbs, *Lab. Anim. Care* **13**, 781 (1963); ———, T. J. Gibbs, P. C. Van Dyke, *ibid.* **16**, 142 (1966); E. L. Gibbs, G. W. Nace, M. B. Emmons, *BioScience* **21**, 1027 (1971); E. L. Gibbs, *Amer. Zool.* **13**, 93 (1973).
2. G. W. Nace, D. D. Culley, M. B. Emmons, E. L. Gibbs, V. H. Hutchison, R. G. McKinnell, *Standards and Guidelines for the Breeding, Care, and Management of Laboratory Animals; Amphibians* (Subcommittee on Amphibian Standards, Institute of Laboratory Animal Resources, National Academy of Sciences–National Research Council, Washington, D.C., in press).

Thinking Metric

Don DeVault (Letters, 3 Aug., p. 392) suggests we delude the public into adopting the metric system by renaming metric units "new inches," "new feet," "new pounds," "new quarts," and so forth. At this, I balk.

I agree with DeVault that the difficulty of selling the metric system to nontechnical people is semantic rather than technical, but I disagree with his approach.

We can sell the metric system by pointing out its advantages in computation (addition, subtraction, multiplication, and division for nontechnical persons) and resulting standardization [to both nontechnical and technical persons; for example, the garage mechanic must now sort out different sizes—SAE (Society of Automotive Engineers), English, and metric].

Yet, we cannot teach the metric system simply by teaching equivalents (for example, DeVault's new inch). Experienced teachers of foreign languages know that students learn a language by using it, not simply by learning vocabulary. By analogy, we can best learn the metric system by using it. Many readers of *Science*, including myself, teach; I suggest *we* (not the amorphous they) use the metric system exclusively in our courses. Quickly we would learn to think metric and live metric.

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Pollution Taxation

Richard Wilson's suggestion of a tax based on the product of air pollution concentration and the affected population density would appear to have limitations not covered in his report (13 Oct. 1972, p. 182). With his scheme in effect, areas of low population concentration would suddenly become economically desirable locations for heavily polluting industries. Wilderness areas would then suffer; the rights of minorities (homeowners, scientific investigators, and appreciative visitors) in these areas would then be subject to gross abuse ("I moved to the city because I couldn't stand the pollution in the country").

There is more to the pollution problem than just its effect upon the health of the people. We must be concerned with our paucity of knowledge of perhaps irreversible trip points in nature (just what are the factors initiating an ice age?). From a worldwide viewpoint, any advantages accrued by limiting pollution in heavily populated areas would be speedily nullified by the relatively uncontrolled emissions in remote areas.

Wilson's final statements, ". . . the tax should be related to people because smog where there are no people is unimportant" and "there are mountain valleys filled with smog from natural NO_x, but no one is worried about this natural smog," at best indicate an unnecessary pessimism concerning the interests of the environmental community.

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I believe my proposed tax will safeguard the rights of those in the countryside much better than current procedures. Present air quality standards specify a definite limit below which air quality is considered adequate (although there is some litigation in progress on this).

A common way of meeting such standards is to disperse the pollutant. Great Britain, for example, already has many tall stacks from power stations located in the countryside. Complaints have been reported from Sweden and Norway.

My proposed tax would continue to encourage this dispersal, but a simple computation of the tax based on the numbers I propose shows that there are very few areas in the world where there would not be an economic incentive to install good air pollution control equipment. At the moment there is almost no incentive.

Of course, there are limitations in any simple formula, and it is possible that my formula will not suffice to keep global, man-made sulfur dioxide and nitrogen oxide emissions to a small fraction of natural emissions (the present U.S. figure is about 20 percent). If so, I agree that other measures will be necessary.

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Artifacts or Geofacts?

Charles Dawson, presumed architect of one of the greatest scientific hoaxes—Piltdown man—devised in the early part of this century a simple experiment that now could be used to support one facet of the argument Vance Haynes advances (27 July, p. 305) about the ori-