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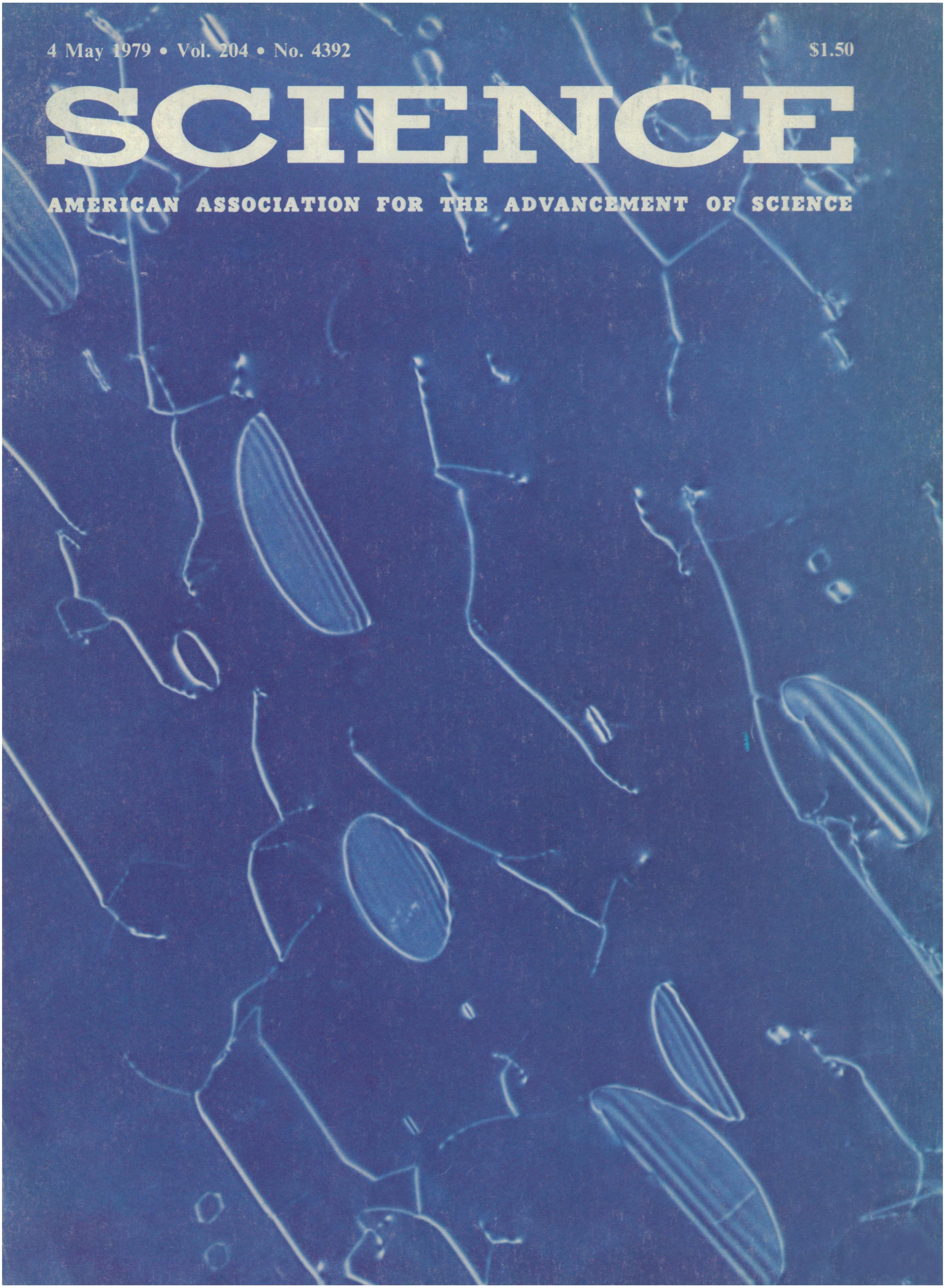
SCIENCE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE



1979 AAAS/ Westinghouse Science Writing Awards

Top: The Golden Gate, tallest bridge in the world. Bottom: an excerpt by Leonardo daVinci describing a proposed bridge which would have been the world's largest at the time.

RULES

1) The aim of this competition is to encourage and recognize outstanding writing on the sciences and their engineering and technological application in newspapers and general circulation magazines. The following categories are not eligible: articles on the field of medicine, articles published originally in AAAS publications, articles by employees of the AAAS or Westinghouse Electric Corporation.

2) Each entrant in a newspaper award competition and each entrant in the magazine award competition may submit three entries.

3) An entry for a newspaper competition may be any of the following: a single story; a series of articles; or a group of three unrelated stories, articles, editorials, or columns published during the contest year. A magazine entry may be a single story or series published during the contest year.

4) A completed entry blank must be submitted together with six copies of each entry in the form of tear sheets, clippings, reprints, or syndicate copy (not over 8½" x 11"), showing name and date of the publication. ENTRIES MUST NOT BE ELABORATE.

5) Each entry must have been published in a newspaper or general circulation magazine within the United States during the contest year — 1 October 1978 through 30 September 1979. (In the case of a series, more than half of the articles comprising it must have been published during the contest year.) Date on the issue in which an article appeared will be considered as the date of publication. All entries must be postmarked on or before midnight, 15 October 1979.

6) Persons other than the author may submit entries in accordance with these rules. Entries will not be returned.

7) Winners of the 1978 awards are not eligible for the 1979 awards. Persons winning three times are no longer eligible.

8) The Judging Committee, whose decisions are final, will choose the winners. There are three awards of $1000: for the winning entry in the over-100,000 daily circulation newspapers competition, for the winning entry in the under 100,000 circulation newspapers competition; and for the winning entry in the general circulation magazine competition. For award purposes, newspaper circulation will be sworn ABC daily circulation as of 30 September 1979. The Judging Committee may cite other entries for honorable mention.

9) The awards will be presented at the dinner meeting of the National Association of Science Writers, during the 1980 meeting of the American Association for the Advancement of Science in January, 1980. Travel and hotel expenses of the award winners will be paid. Entrants agree that, if they win, they will be present to receive their awards, unless prevented by circumstances beyond their control.

Grayce A. Finger

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

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COVER

Defects in boron-implanted silicon after conventional thermal annealing as seen in a false color transmission electron micrograph. Defects in the form of dislocations, loops, and stacking faults are observed by the electron microscope at a magnification of about ×60,000 in the implanted, thermally annealed (at 1100°C for 30 minutes) specimens whereas no defects were observed after high-powered laser annealing of the ion-implanted specimens. The black-and-white negative of the micrograph was exposed through an amber filter to produce this color. See page 461. [J. Narayan, C. W. White, and R. T. Young, Solid State Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830]

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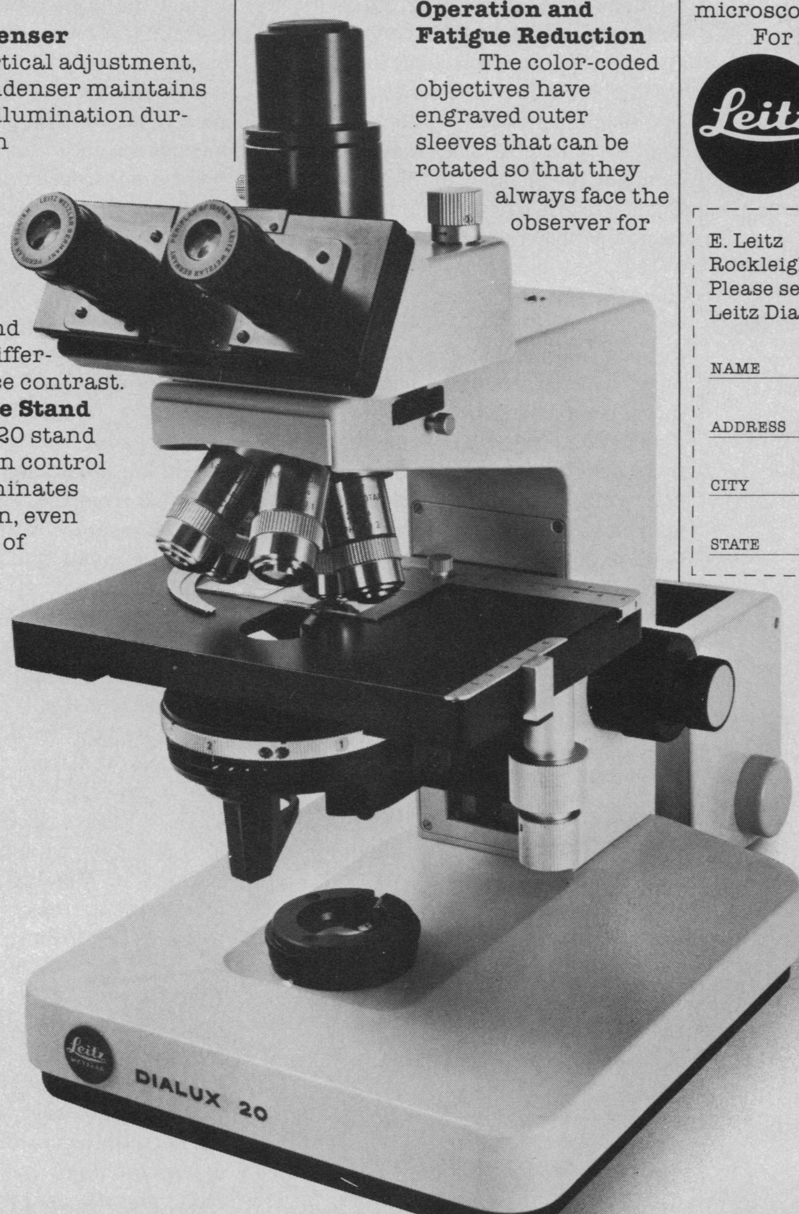

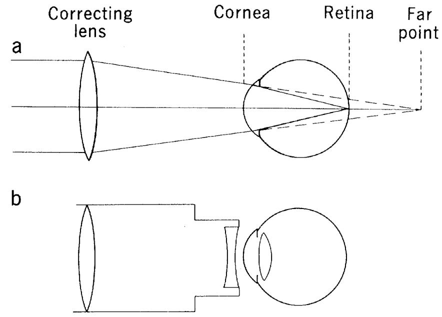

Fig. 1. (a) The aphakic eye corrected by a converging lens. Any lens that would, in the absence of the eye, form an image at the far point will serve to correct aphakia. (b) A Galilean telescope and a normal eye. With an appropriate choice of lenses, this system is the optical equivalent of the one shown in (a) (not drawn to scale).

close enough to resolve its detail. Purely fortuitously, Davenport, having forgotten to put the contact lens in his lensless (aphakic) eye, discovered that with the detachable lens from a monocular bird glass, he could get excellent resolution of small objects 50 to 100 centimeters away at a magnification of ×2 to ×3. He was also surprised to find that simply by changing the distance of this lens relative to his lensless eye, he could obtain clear focus for objects at all distances beyond a few centimeters. In addition, ever since the surgery he has been struck by a second phenomenon. The world seen through his aphakic eye is brighter and more vividly colored than that seen through his normal eye. The blues in particular stand out. Oddly enough, none of these phenomena had been mentioned to him by his ophthalmologists nor by other aphakics, so he brought them to the attention of the other of us (J.M.F.), a specialist in visual perception.

Actually, these phenomena have relatively simple optical explanations, which, although well known to visual scientists, deserve to be more widely known. In the normal eye, light rays are bent inward so as to form a sharp image on the retina. Most of this bending is done by the front surface of the eye (cornea). The rest is done by the lens, which before middle age varies in shape so as to focus objects at different distances (accommodation). An eye without a lens does not bend light enough to bring any object into focus. A sharp retinal image may be restored by placing an artificial converging lens in front of the aphakic eye. There is a wide range of lens powers (power is the reciprocal of the focal length in meters) that will do this, provided that each is held at an appropriate distance in front of the eye.

Table 1. Correction of aphakia. Approximate relation between correcting lens distance, focal length, and magnification (compared to the normal eye) for a distant object and for one at 72 cm.

Distance lens to cornea (cm)	Distant object		Object at 72 cm	
	Focal length required (cm)	Magnification	Focal length required (cm)	Magnification
2	10	1.4	8.8	1.4
4	12	1.6	10.2	1.8
8	16	2.2	12.8	2.5
16	24	3.3	16.8	4.3
32	40	5.5	20.0	10.0
48	56	7.7	16.8	23.0
56	64	8.8	12.8	40.0
60	68	9.3	10.2	57.0
62	70	9.6	8.8	70.0

To understand why a single lens can be so useful in aphakia, one must understand the relation between the lens power and the lens distance required for its correction. There is a point behind the aphakic eye (its *far point*) such that rays converged toward this point by a correcting lens will be focused by the aphakic eye on its retina (Fig. 1a). (The far point is not to be confused with the focal point of the eye, also behind the eye in aphakia, which is the point at which rays parallel to the axis will be focused.) The far point is about 8 cm behind the cornea of the aphakic eye. Any lens which would, in the absence of the eye, form an image of the object at the far point will, together with that eye, bring the image into focus on the retina. The relation between the focal length of the lens, f, the distance from the lens to the object, d_o, and the distance from the lens to the image, d_i, is given by the well-known Gaussian lens formula $1/f = 1/d_o + 1/d_i$. Here the image distance is the distance from the correcting lens to the far point. Table 1 gives some solutions to this equation both for a distant object and one at 72 cm. Note that the distances in the table are measured from the cornea (that is, $d_i - 8$ cm).

These lenses not only bring the image into focus in the aphakic eye, they also magnify it. Magnification is the ratio of image size to object size, which is equal to the ratio of image distance to object distance, both distances being measured from the lens. What is of interest here is not the magnification per se, but relative magnification, that is, the ratio of magnification in the corrected aphakic eye to that in the normal eye. To determine this we need only consider the image formed at the far point by the correcting lens alone and the image formed at the same point by a lens located at the position of the normal lens, about 7.3 cm in front of the far point (*1*). Values of magnification for a distant object and one at 72 cm are given in Table 1.

It is clear that for a distant object the farther the lens is held from the eye, the greater the required focal length and the greater the magnification. For an object at 72 cm the required focal length at first increases and then decreases as the lens is held farther in front of the eye. Since magnification increases with lens distance, one might think the farther the better. However, in addition to the awkwardness of holding a lens far from the eye, there is also the disadvantage that the field of view decreases with lens distance. A more practical solution for many purposes is a lens with a focal length of about 16 cm (power, +6.25 diopters). With such a lens an aphakic eye can (i) focus far objects with a magnification of ×2; (ii) when moved farther out from the eye, focus near objects with a magnification of ×4; and (iii) when moved out still farther, focus near objects with a magnification of more than ×20. The range of distances that this lens can focus is infinity to 59 cm. What a remarkably useful optical instrument a simple lens becomes when combined with an aphakic eye! Of course, magnification is not always desired. To minimize it, a high-power lens must be close to the eye. This is one reason why contact lenses are often used to correct aphakia; they magnify only about 10 percent.

In practice a simple lens will produce aberrations which reduce image quality. Quality can be improved by using a lens system consisting of two or more elements designed to reduce aberration. Davenport gets excellent image quality by use of an achromatic projector lens system (50 millimeters in diameter) with a focal length of 15 cm. The metal tube which holds the lenses also serves to reduce stray light. These advantages are obtained at the cost of more bulk and a slightly higher price ($10 secondhand at a photography shop).

Why cannot the normal eye get the same advantage from a comparable system? Put simply, any lens that produces appreciable magnification also changes the vergence of the rays. This tends to put objects out of focus for the normal eye, but in focus for the aphakic eye. The normal eye needs at least two lenses to achieve the same result. The simplest system that does this is the Galilean telescope (Fig. 1b). This consists of a converging lens (objective) and a diverging lens (eyepiece) usually mounted in a variable length tube. The Galilean system has essentially the same optical properties as the converging lens–aphakic eye system. The reason for this similarity is that removing the lens of the eye is optically equivalent to adding a diverging lens. In effect, cataract surgery provides the aphakic person with a built-in eyepiece.

Finally there is the second fringe benefit of cataract surgery, the enhancement of color and brightness. The normal lens absorbs light of all wavelengths but particularly in the blue, and this absorption increases with age (*2*). When the lens is removed this light reaches the receptors, producing larger responses particularly in the short-wavelength cones. In addition ultraviolet light, normally almost completely absorbed by the lens, now reaches the retina (*3*). This has two effects. It is absorbed directly by the short-wavelength cones producing a violet sensation, and it causes the retina to fluoresce, producing visible light of a wide range of wavelengths up to 600 nanometers. This light appears greenish blue. One is reminded, however, that high-intensity ultraviolet may be damaging to the unshielded aphakic eye.

In summary, the aphakic eye both transmits more light than the normal eye and, aided by a simple converging lens, can produce sharp retinal images with a wide range of magnification. These properties add greatly to esthetic enjoyment, particularly for the flower lover (*4*), collector of small insects, jewel fancier, or "museum-watcher." Davenport may be one of the few persons in the world who, when he went to the Tutankhamon exhibit, *took out* his contact lens.

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References and Notes

1. Relative magnification is $d_i d'_o / d_o d'_i$, where d_i, d_o refer to the image distance for the correcting lens and d'_i, d'_o to these same distances for a lens 7.3 cm in front of the far point (that is, d'_o = 7.3 cm). When the object is very far away, $d_o \approx d'_o$ and relative magnification is d_i / d'_i.
2. Y. Le Grand, *Light, Color and Vision* (Chapman & Hall, London, 1968).
3. G. Wald, *Science* **101**, 653 (1945).
4. In a recent brief experiment, in which with his aphakic eye and contact lens Davenport observed through a filter with an upper cutoff at 360 nanometers a sunbathed flower of the Carolina jasmine *(Gelsemium sempervirens)*, he could clearly discern the pattern of the ultraviolet-reflecting ("honey-guide") tissue of the petals. "*One side*, bees!"

Erratum: A report described in the 27 April issue (News and Comment, p. 389) was incorrectly identified. It was coauthored by Rosemary Chalk and Frank von Hippel for the Committee on Scientific Freedom and Responsibility of the AAAS and will be published in a forthcoming issue of *Technology Review*.

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SCIENCE

Public Policy and Health Manpower

Health, Education, and Welfare Secretary Joseph Califano recently acknowledged before the annual meeting of the Association of American Medical Colleges that the nation may face an oversupply of physicians. He indicated that HEW will seek ways to encourage medical schools to reduce enrollments.

This dramatic policy shift was made less than 2 months after the beginning of an academic year in which there was a federally mandated (one-time) enrollment increase. Even now, a number of medical schools across the country, old and new, are expecting state budgetary support for the 1979–1980 academic year to meet enrollment increases. In many instances, the federal government is obligated to assist in meeting construction or operations costs. The paradox of continued expansion in the face of a threatening surplus, with the associated costs to society, is poignant in a time of public fiscal constraint.

How did we get into this position? The first health manpower legislation (1963) was passed on the background of the Bane report, which contained concrete goals in terms of aggregate physician numbers and a plan for how to achieve them. Federal funds were provided for operational support, construction, and student aid. The possibilities were not lost on aggressive institutions, chambers of commerce, professional and academic entrepreneurs, political aspirants, and state legislatures. Community developers could envision the economic benefits of a publicly supported academic medical center. State legislatures had the statutory authority and the tax base to launch expensive new educational and service enterprises. In status and dollars, a medical school represents an especially attractive political spoil.

By 1968, the legislative goal had shifted from a reasonably concrete number to "meeting the demand," and a serious shortage of physicians was still envisioned. Barely noted in the congressional hearings was evidence of a decline in the rate of population growth. Although it was originally estimated that about 20 new medical schools would be needed by the middle 1970's, twice that number have been started. And programs in other health professions have been expanding at similar rates.

It is clear that decision-making in national health manpower legislation has been characterized by vacillating goals and increasing frustration. There is some evidence that aggregate numbers will not solve the problems of access to medical services, but may enhance the problem of increasing medical costs.

Although the answers are not yet in, even the questions point to a serious dilemma in health policy and in public policy. There has been no clear plan for the expansion of medical education, no continuity in setting and revising goals, and insufficient collaboration between state and federal agencies. A manpower shortage was perceived, and we raced pell-mell to correct it, incorporating a variety of agendas (other than the care of patients).

As we approach an era of probable retrenchment in health professional education, it is profoundly to be hoped that more rational, collaborative long-term planning and implementation can obtain. Administrative agencies, Congress, and the academic and professional communities should work together to achieve these ends. Prospects for such an approach have been compromised by the proposal of the Administration, made within months of the undertaking of new obligations by the schools, to reduce institutional funding as of 1 October 1979.

It is time for the establishment of a national commission, made up of leaders from the public and private sectors, to undertake the development of intermediate and long-range plans for health manpower and assist policy-makers in serving the public interest.—CHRISTOPHER C. FORDHAM, III, *Dean, School of Medicine, University of North Carolina, Chapel Hill 27514*