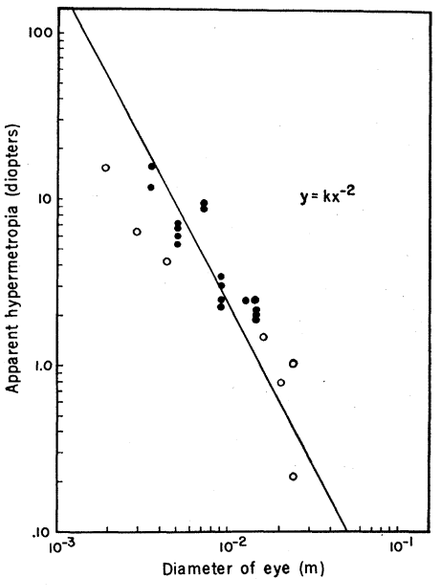

Fig. 2. Data from Fig. 1 plotted in log-log coordinates. Line is fitted by eye with a preset slope of −2 and eye diameter in meters.

times that of the eye of a small bat and yet the retinas of these two animals are about equally thick. Indeed, the retinas of 15 different mammalian species examined in our laboratory vary by a ratio of about 2 to 1 from thickest to thinnest. Insofar as the distance between retinal layers is constant, the dioptric error in retinoscopy should be inversely proportional to the square of the focal length of the eye.

We performed retinoscopy on representative subjects from seven species of mammals whose corneo-retinal length ranged from about 3 to 14 mm. Two independent workers carried out the observations on anesthetized animals, usually with a cycloplegic. As a control procedure, measurements were repeated on several animals without anesthesia or cycloplegia in some cases with a 3-mm artificial pupil. Measurements of refractive error did not differ significantly under these various conditions of testing.

All of the subjects examined appeared to be hypermetropic. We plotted the observed refractive error in these animals along with values from six other species (*5*) as a function of corneo-retinal length of the eye (Fig. 1). The same data are transformed and replotted on log-log coordinates in Fig. 2; the data are well fitted by an equation of the form $y = kx^{-2}$ where y is refractive error in diopters, x is the corneo-retinal length of the eye, and k is a constant. Corneo-retinal length was assumed to be a relatively constant multiple of the focal length. If our interpretation of the data is correct, k would be dependent on distance from receptors to reflective layer and on the refractive index of the eye.

If we assume that the posterior focal length equals 9/10 the corneo-retinal length and that the refractive index is 4/3, then the approximate distance from the plane of the receptors to the reflective layer can be determined by solving Eq. 2 with the data in Figs. 1 and 2. This calculation gives an estimated average distance from the outer segments to the reflective layer of about 135 μm. Moreover, the apparent hypermetropia suggests that the retinoscope light is reflecting from some plane on the vitreous side of the receptors. An average distance of 135 μm between the plane of the receptors and of the reflective layer would be consistent with reflection of retinoscope light from the boundary between vitreous and retina.

The vitreous differs in refractive index from the retina (*6*). Our data suggest that the interface between the vitreous and retina can reflect light. This interpretation would account for differences between objective and subjective refraction in man (*4*), and may correct some earlier ideas about refractive error in animals. These earlier observations paradoxically suggested that small animals were farsighted. Rather than true farsightedness we suggest that the apparent refractive error may be due to the inherent error in retinoscopic technique. It may be inferred that the eyes of most animals are free of refractive error.

Although light may be reflected from the boundary between vitreous and retina, there must also be other reflective surfaces with the eye. For example, the differential absorption that follows bleaching seen in retinal densitometry demands that some component of the reflected light come from behind the outer segments. A similar consideration applies to the colored reflections from the eyes of animals that have a tapetum lucidum and to the red reflex.

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Quicklime: Effects on Soft-Bodied Marine Organisms

North and Pearse (*1*) suggest the possible use of quicklime to control the coral-eating sea star *Acanthaster planci*. This method of control has serious implications for other soft-bodied reef organisms. Quicklime has been used, since the mid-1930's, to eradicate sea stars in oyster beds (*2*) and, more recently, sea urchins in kelp beds (*3*). The particulate lime spread over the surface waters falls upon and destroys the soft tissues of the body wall, causing eventual death. Quicklime is detrimental to numerous other marine organisms (*2–4*).

I have studied the effects of lime on the soft-shelled clam *Mya arenaria* and the sea cucumber *Cucumaria frondosa*. At concentrations used to eradicate sea stars (*5*), all ten lime-treated clams considerably reduced their filtering activity for a few hours after liming. The irritating lime particles, taken in through the inhalant siphon, interrupted "normal" feeding ability. However, the clams enveloped the particles in mucus and discharged the fouled mucus periodically via the siphons. The clams resumed "normal" filtering activity within 1 day.

Although the sea cucumbers secreted abundant mucus after liming, they developed wounds in the body wall, through which viscera protruded within 12 hours. Within 11 days, 20 of the 24 lime-treated *C. frondosa* died, and the remaining four were extremely deteriorated. Unlike *Mya*, the sea cucumbers were unable to dispose of the fouled mucus.

The use of quicklime for controlling *Acanthaster* must depend on the ability of coral polyps and other soft-bodied reef organisms to remove quicklime effectively from their bodies by mucus secretion or other mechanisms. I agree with North and Pearse that preliminary experiments need to be undertaken to determine the effects of quicklime on inhabitants of coral reefs. Quicklime may prove more serious to the ecosystem than the predacious *Acanthaster*.

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5. Experimentally, 313 and 940 kg per hectare have been used (*2*). I used 313 and 626 kg per hectare on *Mya* (five specimens at each concentration), and 447 and 895 kg per hectare on *C. frondosa* (12 specimens each). Particle size has also varied from powdered lime to coarse grades of particle diameter 0.5 to 5.0 cm (*2*). I used powdered reagent-grade lime.

2 February 1970

Initiation of the Breakdown to Turbulence

The review paper on clear air turbulence by Dutton and Panofsky (*1*) makes me wonder if I have been looking at another part of the same "elephant" (*2*). This part comprises the temporal course of winds, temperatures, and their vertical gradients as measured on towers, mostly in elevated layers near the ground, and especially during the hours following sunrise. On some fair mornings when the wind is not too strong, the transition to turbulence can be quite abrupt, as is seen in the record of wind-direction fluctuations. From the sequence of changes in gradients preceding these abrupt onsets, a process is hypothesized, termed "local shear destabilization," to explain the initiation of the breakdown to turbulence, in which relatively rapid enhancement of stability is a significant early event.

It might be useful to give more attention in studies of clear air turbulence to relative temporal sequences of flow parameters during internal frontogenesis. While the necessary measurements are difficult (but should be attempted) in the atmosphere at altitudes at which clear air turbulence occurs, they are not so difficult near the ground, where flow patterns can also be made visible at selected times and heights.

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9 March 1970

Birth Control for Economic Development?

Enke (*1*) proposes one "economic-demographic method of assessing what reduced human fertility might contribute to increased economic development." His proposal is based on a function that relates national output (V) to employed workers (N), capital stock (K), and improving technology (t). This function, when applied to an imaginary nation called Developa with a population of 10 million and an income per head of $150 in 1970, yields two tables in which certain economic indices —the income per head, unemployment rate, savings from income and others— for the years 1985, 1989, and 2000 in situations of high fertility and low fertility are compared.

In the text certain assumptions are made; it is stated, "These various estimates are only suggestive. Their exact magnitudes are unimportant. What is significant is that combinations of alternative parameters indicate that declining fertility rates do contribute to economic welfare. . . . Twice as much labor and capital will not double output if there is a scarcity of equally useful land. . . . Conversely, a slowing rate of population growth accords more economic benefits than a slow growth rate. . . . Fewer children per family give each family member more potential consumption from the same family income. But actual consumption should rise less than the potential consumption. The difference is 'released' for investment."

From these statements and an economic-demographic model the author leapfrogs to a general conclusion that "Enough is known about the main parameters that a demographic-economic computer model can be used to assess the effects of declining fertility rates on various indices of economic welfare in a typical less-developed country." He finally concludes that "the benefit to cost ratio [of] 80 to 1" is possible when a birth-control program is adopted for a less-developed country, inducing the reader to believe that governments should encourage contraception.

It is misleading to take a somewhat simple function of economic indices of developed countries and apply it to underdeveloped countries with very low income, as if the indices and ratios could be used without any further consideration.

1) The function considers only employed workers (N); it is a well-known fact in underdeveloped countries that employed workers are a fraction of the total labor force and that the major part of the workers in rural areas are not included in labor-force statistics. This might be overlooked in a hypothetical model but leads to another gap in the economic consideration of per capita income. A large part of the family income in underdeveloped countries is obtained as food provided directly from the land and consumed by the family. Thus it is not registered as cash economy, and the more the country is underdeveloped, the more highly distorted are the statistics.

2) The distortion of economic statistics adopted in the model becomes clear when one considers that in South America there is no country with a $150 per capita income (the lowest is Bolivia with $165). If there were such a country, there would be no family savings; it is unbelievable that this low an income has any significance as a means for a person to feed, clothe, and shelter himself, if he had to pay for it. In other words, it is meaningless to speak of $150 per capita income or of $75 as a poverty index, and of saving income in such conditions.

3) Certain indices of development may only be obtained within a satisfactory population concentration. For instance, there is no return on investment on highways, communications systems, community electric systems, or services for water and sewage in a country where population density is below, say, five inhabitants per square kilometer and where no urban concentrations of a sufficient size allow economic concentration. Also, it is impossible to compare the trade of commodities representing economic activity