(*7*). In such states, lens changes are accompanied by a wide variety of other manifestations such as loss of weight, inactivity, and inability to reproduce. Rats on yogurt, however, showed no such signs or symptoms of dietary deficiency. Thus, their cataracts must have some other origin.

Yogurt is made from whole milk. The carbohydrate of milk is lactose which breaks down into equal parts of glucose and galactose. Attention is immediately centered on galactose, in view of the findings that a diet with a galactose caloric percentage of 22 percent was sufficient to produce cataracts in rats (*8*). However, in caloric content, galactose comprises only 14.4 percent of whole milk and only 14.2 percent of yogurt made from whole milk (*9*). Both of these values are well below the cataractogenic level.

Analysis of the commercially produced yogurt used in our study revealed a much higher content of galactose—from 22 to 24 percent, a value definitely within the cataractogenic range. This striking difference between the galactose content of the commercial yogurt we were using and that of the standard analysis of yogurt prompted us to discuss this discrepancy with the manufacturers of the yogurt.

We learned that yogurt made in this country is no longer simply the product of fermentative action of the *Lactobacillus bulgaricus* and *Streptococcus thermophilus* upon whole milk. Most of the butterfat in the milk is removed before its conversion to yogurt. Removal of butterfat produces a milk which has, relatively speaking, more carbohydrate—and thus more galactose. However, yogurt made from such milk is thin and watery. To improve the consistency, manufacturers add skim milk powder, thus further increasing the caloric percentage of galactose. These procedures account for the elevation of the caloric percentage of galactose in the commercially produced yogurt to cataractogenic level for rats.

As evidence that cataracts produced by the yogurt diet result from its high content of galactose is the fact that cataracts produced by yogurt and galactose are clinically indistinguishable.

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References and Notes

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2. Certain Mediterranean people (Armenians, Jews, and Arabs) have a high rate of benign paroxysmal peritonitis [S. Siegel, *Ann. Inter. Med.* **23**, 1 (1945); H. A. Reiman, *J. Amer. Med. Assoc.* **136**, 239 (1948)]. The search for factors common to the lives of these peoples—especially a factor common to practices observed during pregnancy and nursing since the symptoms of paroxysmal peritonitis often occur so early in life—centered eventually upon the widespread use of fermented milks, and in particular, yogurt. We felt that this factor warranted study because a number of patients had symptoms of gastrointestinal allergy and because, in some instances, elimination of milk from the diet had eliminated symptoms of paroxysmal peritonitis [A. H. Rowe, *Ann. Allerg.* **6**, 252 (1948)]. We decided to determine whether symptoms of the illness and periodic recurrences of the symptoms could be produced experimentally in rats. We had reproduced in rats various aspects of other types of periodic illnesses of man—for example, the periodicity characteristic of relapses in catatonic schizophrenia by prolonged feeding of antithyroid drugs [C. P. Richter, in *Endocrinology and Human Behaviour*, R. P. Michael, Ed. (Oxford, London, 1968), p. 284].
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5. Records of body weight, food intake, and water intake of these rats were carefully inspected for presence of any periodic changes. In no instance were any signs of periodicity manifest; also, the rats never, at any time, showed symptoms of paroxysmal pain. This suggested that yogurt probably plays no role in the etiology of benign paroxysmal peritonitis.
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14 April 1970

Phycomyces: Habituation of the Light Growth Response

Abstract. Phycomyces *sporangiophores respond to four distinct physical stimuli: gravity, light, stretch, and an avoidance stimulus. Saturating the organism with a light stimulus so that it does not respond to any additional light program does not decrease its ability to respond to an avoidance stimulus. This demonstrates that the organism has the potential to respond after a saturating light stimulus and that the avoidance stimulus acts at some point past or parallel to the light-receiving mechanism.*

The stage IV sporangiophore of the fungus *Phycomyces* has been the object of intense study in numerous laboratories over the past decade. It responds quantitatively to several distinct stimuli: light, stretch, and gravity, and in addition has the ability to grow away from solid objects (*1*). This last property has been termed avoidance, and it has been the least studied and the most poorly understood of the properties.

We now present further experiments on the mechanism of the light growth response. Several papers describe in detail the response of *Phycomyces* to light (*1, 2*). The light growth response occurs when the intensity of stimulating light is greater than that to which the organism has become adapted. After several minutes at the higher intensity, an increase in growth occurs which sometimes leads to a doubling of the initial growth rate. But, after approximately 5 minutes, the rate begins to decrease again to the initial basal growth rate of about 3 mm/hour. Now the organism must adapt to the new light intensity before it will respond to a further increase in light. After the initial increase in light intensity, there is a period during which additional light stimuli will not cause a full increase in growth. This return to a state of sensitivity has been described in an equation that is similar to one describing the charging of a capacitor (*3*). In 1966 Castle (*4*) proposed a model in which an increase in growth depleted a pool of substrate to a point below which further increase in growth could not be evoked. This model makes possible a very simple prediction. If the organism were unable to respond to a second light stimulus because of depletion of substrate, it should also be unable to respond to any of the other stimuli.

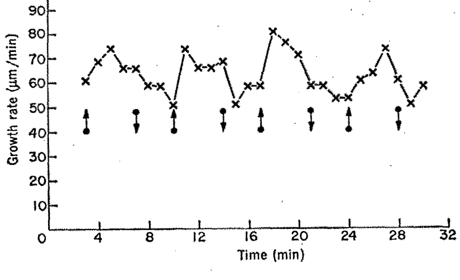

Fig. 1. A fully dark-adapted, stage IV sporangiophore stimulated by a double barrier at the times indicated with an upward arrow ↑. Removal of the double barrier is indicated by a downward arrow ↓.

To test this prediction, we used the avoidance response because it is the easiest of the three nonlight responses to measure. Because it is necessary to obtain a net increase in growth to test a substrate-limitation model, a simple bending response is not adequate. This arises from the fact that a decrease in growth on one side would also cause an increase in bending with no increase in net growth. A way around this dilemma is to place a double barrier around the sporangiophore and observe the growth response when both sides of the sporangiophore are trying to grow away from their respective barriers. A transient growth response (referred to as an avoidance growth response) occurs when a steadily growing sporangiophore is either inserted into a capillary or between glass cover slips 2 mm apart (*5*). This growth response is very similar to the light growth response except that the initiation of the response often occurs in less than 1 minute. This is quite unlike the light growth response which never begins before 2.5 minutes and often as late as 3 minutes after the stimulus.

We were first interested in whether a series of double-barrier stimuli would give a series of avoidance growth responses (Fig. 1). The apparatus for observing the change in growth rate was an optical comparator (*6*). A double barrier consisting of two glass cover slips 2 mm apart was placed around the sporangiophore by a trolley-like device, and changes in growth rate were recorded with the comparator. The placement of the barrier was from the side and normal to the direction of observation. There is a transient growth response with essentially no significant latent period. Removal and reinsertion of the double barrier causes a second similar response as does the third removal and insertion.

We were then interested in whether the avoidance growth response occurred during a period when a light stimulus gave no light growth response (Fig. 2). The stage IV sporangiophore was given a large increment (step-up) from 0 to 82 mw/cm^2 by means of an argon laser (488 nm). After 10 minutes the light was shut off for 2 minutes and then a second stimulus of 30 seconds was given. There was no response. None was expected since the sporangiophore was still light-adapted, and, at these very high intensities, the light-receiving mechanism was fully saturated (*7*). If the second stimulus was an avoidance stimulus resulting from a double barrier, there was an avoidance growth response (Fig. 2).

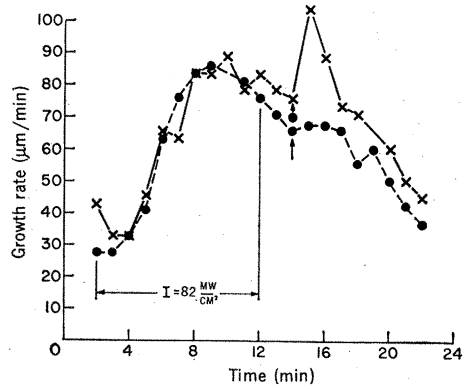

Fig. 2. The dotted line represents the control with a 10-minute stimulus given at an intensity of 82 mw/cm^2 followed by 2 minutes in the dark and then by a 30-second light stimulus at the same intensity indicated by the upward arrow ↑. The solid line represents results of the same experiment except that after 2 minutes in the dark a double barrier is inserted around the sporangiophore.

Thus, even after a light stimulus, saturating in intensity, the organism still has the ability to grow faster. Additionally, the avoidance stimulus acts either at some point between the light-receiving mechanism and the final response or on an independent parallel branch.

The technique of saturating one sensory pathway of an organism to a point where it no longer responds to that stimulus but does respond to another type of stimulus is a classic test for habituation. Accordingly, a saturating light stimulus habituates *Phycomyces* to a light stimulus but not to an avoidance stimulus.

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7. It is well known (*1*) that sporangiophores that have been adapted to light intensities greater than 0.5 mw/cm^2 yield no light growth response observations. We are operating at intensities two orders of magnitude higher in order to insure full saturation of the photomechanism. Lower light intensities and larger step-ups in light intensities would, of course, give a light growth response, but we specifically chose a light program that would not give a light growth response in order to be able to test the avoidance growth response.
8. We thank F. Barnes for fruitful discussions and for the use of his laser. We thank the Mechanical Engineering Department for lending us their optical comparator and L. Massie for help in calibrating the laser.

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Chemical Individuality of Lunar, Meteoritic, and Terrestrial Silicate Rocks

Turner and Ulbrich (*1*) recently suggested a basis for the chemical comparison of nonterrestrial with terrestrial rocks. Particular emphasis was placed upon atomic ratios such as Ca/Na, (Ca + K)/Na, Fe/Mg, and Al/Ti, which in terrestrial igneous rocks conform to sharply limited general patterns reflecting genesis and fractional crystallization of magmas under conditions prevailing in the outer mantle and crust of the earth (*2*).

In this note I illustrate the potentiality of this same suggestion by presenting some composition fields plotted respectively for appropriate igneous rocks, eucrite meteorites, and surface lunar materials sampled by Surveyor 5 and 6 (*3*) and the Apollo 11 mission (table 1 in *4*; *5*, *6*). Analyses of 140 igneous rocks were selected at random from the recent literature to cover the SiO_2 range from 39 to 55 percent [excluding analyses of monomineralic rocks such as anorthosites and analyses in which the individual value for any of the three oxides CaO, MgO, or ($FeO + Fe_2O_3$) falls below 2 percent]. The selected data include extreme and rare as well as common rock types (such as basalt). Individual points are not plotted in the accompanying diagrams, since their clustering might convey an impression of statistical significance in no way warranted by and quite outside the scope of this study.

In Fig. 1 terrestrial and extraterrestrial rocks are seen to fall in two mu-