A second breakdown of the data is shown in Fig. 1. This figure presents the mean percentage of correct responses on each trial for each of the four groups, averaged in blocks of five trials. The striking finding illustrated here is that little or no learning to go to food occurred in the group reared in sensory deprivation that received food in the simple-stimulus goal. In fact, the first four points for this group are either at or below the 50-percent performance level expected on the basis of chance. To further illustrate the nature of this finding, on 21 out of the 25 trials a majority of the subjects in this group chose the checkerboard goal rather than the half-black, half-white goal containing food ($P < .01$). All curves for the other groups show the typical increasing function characteristic of learning data. It is also instructive to note that on the first block of trials even the normally reared animals tested with food on the simple-stimulus side exhibit a tendency to choose the more complex, checkerboard stimulus.

These results reveal one major empirical fact. Under the conditions of this experiment, food is not a uniformly reinforcing substance serving to increase the probability of responses associated with it. If the rat has been reared in visual sensory deprivation, even though he has not been subjected to sensory deprivation during his adult life, he does not prefer a response alternative leading to food. Instead, he tends to choose a response alternative leading to a more perceptually complex, stimulating situation. Further, these data hint, although they do not show as clearly, that, for an animal subjected to sensory deprivation, the probability of going to food is higher than that for a normally reared animal if food is found in a complex visual-stimulus situation.

One problem concerning effects of sensory deprivation might be raised to question these results. The procedure used may have detrimentally affected the vision of the visually deprived animals. This problem is answered indirectly by the fact that the animals subjected to sensory deprivation and receiving food in the checkerboard goal *did* discriminate between the two goal stimuli. Thus, although retinal damage may have occurred, it was not sufficient to eliminate the subjects' ability to make a pattern discrimination.

If they can be replicated, results such as were found in this study must motivate a change in some of the current thinking concerning the necessary and sufficient conditions for choice behavior and for reinforcement. In the light of these data, the so-called "primary" biological needs, as such, do not appear to be the uniformly sufficient, let alone the necessary, conditions for motivation that have been assumed in the past. And, substances satisfying these "primary" biological needs do not appear to be the generally sufficient conditions thought to reinforce behavior and lead to learning.

The findings of this study are consistent with a number of investigations and formulations, such as the work of Harlow, Dember, and Levin and Forgays (*2*). Their reports, concerned with the so-called curiosity, exploratory, and/or manipulatory motives, illustrate the importance of temporal changes in stimulation, and the complexity of environmental stimulation as determinants of the activation and persistence of approach responses. The present study expands on this earlier work, indicating that (i) need for perceptual experience, like need for food, may involve biological processes just as basic as the classical "primary" biological needs; and (ii) the effects of early perceptual deprivation on later behavior may persist, in the form of an extremely strong motive to respond to complex stimulation, throughout the life of the organism (*3*).

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Nutritional Relationships among Certain Filamentous Fungi and a Marine Nematode

Abstract. *A marine form of nematode,* Aphelenchoides *sp., can develop and reproduce effectively on viable mycelia of various filamentous fungi including certain widespread marine species. The efficiency of utilization of fungal mycelium by the animal, based on the ratio of the number of nematodes to the dry weight of fungal mycelium, varies greatly among fungi, from less than 100 to as much as 5000 for several of the marine species studied.*

The various reported associations between thalassiomycetes (*1*) and metazoans in the marine environment (*2*) suggest the diversity of biological activity of this mycota. The major portion of this work has involved studies of parasitic or pathogenic fungi, mostly Phycomycetes, except for a series of publications dealing with possible interrelationships between lignicolous fungi and wood-boring animals (*2*). The significance of these interrelationships has been subject to considerable speculation, although there are few detailed quantitative studies evaluating the activity of filamentous fungi in the growth and reproduction of marine animals. During a survey for the possible occurrence of marine predacious (nematode-capturing) fungi, observed activity within a fungus-nematode complex suggested the need for further examination of the beneficial effect of the fungal mycelia on the associated animal population.

Fungi were isolated from portions of various substrates, including submerged wood panels and pieces of sponges (both used as specific fungal baits), vascular plant and algal tissue, encrusted shells, coral pieces, rocks, and sediments, and were transferred to sea water agar supplemented with 100 mg chloroamphenicol per liter to inhibit bacterial growth. A diverse population of deuteromycetous fungi rapidly colonized the medium. Often, the development of these fungi was associated with active growth of species of marine nematodes. One plate exhibiting growth of a fungus, identified (*3*) as *Dendryphiella arenaria* Nicot, a salt-tolerant species originally isolated from intertidal sand (*4*), also showed a stylet-

bearing nematode actively feeding on the fungal hyphae (Fig. 1). The nematode, identified as a species of *Aphelenchoides* (*5*), developed excellently on the sea water agar medium in association with the fungus. The animal was transferred to liquid sea water media containing corn-meal extract and inoculated with the fungus, *D. arenaria*. Further tests permitted mass growth of the animal in liquid culture devoid of all nutrients except the fungal mycelium itself.

Stock cultures of *D. arenaria* and the other fungi were maintained on a medium consisting of 0.1 percent Difco yeast extract, 1.0 percent glucose, and 1.5 percent agar in sea water.

The fungi for experiments were grown in shaken culture in 125-ml erlenmeyer flasks, each containing 25 ml of the foregoing medium without the agar. Inocula, at a final suspension containing 2 mg of fungus (dry weight) per flask (*6*), were obtained from stock cultures. Before inoculation, a sterile glass disk (*7*) was weighed and added aseptically to each flask (*8*). These disks supported uniform development of the fungus on the surfaces and provided an excellent habitat for nematode colonization during the growth period of 14 days. After growth of the fungus on the disk, which occurred usually within 3 to 7 days after inoculation, the fungal mat (glass disk with fungal mycelium) was transferred to a sterile filtering apparatus (*9*), washed thoroughly with sterile sea water, and then aseptically resuspended in fresh flasks containing 25 ml of sterile sea water. Thus the fungal mycelium was washed free from metabolic substances produced in the original medium of yeast extract and glucose during growth. Furthermore, changes in *p*H or possible overgrowth by chance bacterial contamination were reduced considerably by this method wherein no supplemental nutrients were present in the final sea water medium.

Known numbers of nematodes, usually 400 to 700 animals, obtained from stock cultures, were inoculated into each flask containing sea water and an appropriate fungal mat. Fungal mats also were placed in flasks of sea water without nematodes to check changes in weight of the fungi during the total incubation time of from 10 to 14 days. The dry weight of the control mat was taken at the beginning and end of the test.

The control flasks were designated by the symbol "SW," plus the required number of days, such as SW + 10, whereas nematode-inoculated flasks were indicated by the symbol "N" with the same time indication (Table 1).

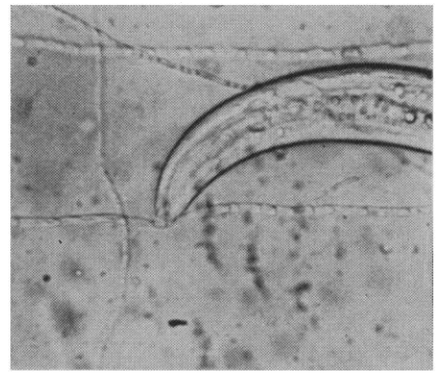

Fig. 1. Nematode feeding on fungal hypha. Pictured are hyphae which have been drained of their cytoplasmic content. Round bodies shown in the lower right-hand portion of the nematode are the contents of the hypha passing through the metacorpus of the animal to the gut (about × 400).

After tabulation of numbers of animals, the fungal mat supporting animal development was washed with distilled water to remove extraneous salts, and dried to constant weight. In the counting, two calculations were made to obtain total numbers, that is, number of animals in the liquid portion, and number of nematodes within the mycelial mat itself. The latter counts were taken after incubation of the mat for 24 to 72 hours in a Baermann funnel (*10*). Counts were based on duplicate 0.1-ml samples containing a maximum of 200 animals. Concentrated samples were diluted with sea water to obtain this approximate number of nematodes. Separate tabulations were made of both young and mature animals at appropriate magnifications under a dissecting microscope. Excellent agreement among different samples, and between separate flasks of the same test, demonstrated the accuracy of the counting method.

Table 1. Growth and reproduction of *Aphelenchoides* sp. on mycelia of *D. arenaria*. Control flasks: SW plus the number of days. Inoculated flasks: N plus the number of days. All mats originally contained 47 mg of mycelium.

	Weight of mycelium (mg)	Total number of animals	Animals in mat * (%)	Utilization factor†
	Test A, 4-day-old mats			
46	(SW + 10)			
35	(N + 10)	38,780	72	843
42	(SW + 12)			
39	(N + 12)	104,300	65	2483
36	(SW + 14)			
34	(N + 14)	86,180	71	2393
	Test B, 2-day-old mats			
20	(SW + 14)			
21	(N + 14)	43,692	57	2184
	Test B, 4-day-old mats			
37	(SW + 14)			
34	(N + 14)	100,466	21	2715

* Based on a 48-hr Baermann funnel incubation.
† SW flask used as mycelial weight standard.

The development of the nematode on *D. arenaria* is shown in Table 1. The efficiency of utilization of fungal mycelium by the nematode, expressed in terms of total number of animals produced per weight of dry (control) fungal mat, in milligrams, has been termed the "utilization factor." All of the comparative determinations are based on this value.

The difference in weight between the SW and N flasks is within the recorded statistical variation observed in replicate flasks and, at this time, cannot be attributed to the actual feeding of the nematode population. With the exception of the 10-day collection of test A, the utilization factor in the remaining tests was between 2000 and 3000. This was true even in the 2-day-old fungal mats, weighing approximately 50 percent less than at 4 days. The effectiveness of the disks for nematode colonization is apparent where, in all but one collection, over 50 percent of the animals were isolated from the fungal mat during the 48-hour incubation process. The percentage of adult animals in the different collections varied from 13 to 60 percent.

Mycelium of *D. arenaria*, killed by immersion in sea water for 5 minutes at 100°C, failed to support reproduction of the nematodes, although viable nematodes were present in the medium at the termination of the test. Comparable controls of viable mycelium of the fungus actively supported animal growth and reproduction.

To check the specificity of the observed fungus-nematode association, 15 different filamentous fungi, representing 12 deuteromycetous and three ascomycetous species, were examined. Included were such widespread thalassiomycete species as *Halosphaeria mediosetigera, Lulworthia floridiana, Zalerion xylestrix*, and *Culcitalna achraspora*. Results of these tests showed noticeable differences in nematode growth. In general, the fungi could be separated on the basis of four general

utilization factor groups, namely, less than 100, 100 to 1000, 1000 to 3000, and more than 3000. Eight of the fungi, including species of *Fusarium, Syncephalastrum, Pestalotia, Stachybotrys,* and *Nigrospora,* fell within the first two groups, while the remaining species had utilization factors above 1000. Of the various fungi tested, two widespread marine species, *Z. xylestrix* and *H. mediosetigera,* showed the highest utilization factor, occasionally as great as 5000.

Nematodes represent (*11*) the most diversified and most abundant group of metazoans living at the bottom of the sea. While the rearing of terrestrial representatives of *Aphelenchoides* on fungal cultures has been reported (*12*), this relationship has not been noted in the marine environment. Other workers (*13*), observing an association between a terrestrial species of nematode, *Ditylenchus destructor,* and various species of fungi, postulated that a wide variety of fungi may play an important role in the survival of this nematode in nature. A similar pattern may exist between the marine-occurring *Aphelenchoides* sp. and representatives of the marine mycota (*14*).

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Palynological Investigation of a Core from the Biscay Abyssal Plain

Abstract. *An investigation of Quaternary, Tertiary, Mesozoic, and Paleozoic pollen and spores found in sediments of the Biscay Abyssal Plain provides data leading to the interpretation of the provenance of the lutite in which reworked plant microfossils occur. Owing to the difficulty of distinguishing between Quaternary and reworked Tertiary pollen grains belonging to extant genera, caution is necessary in interpreting the pollen record in terms of Quaternary climatic changes.*

Pollen analysis of bog and other continental deposits has been perhaps the most potent method in studying climatic changes during the Quaternary, but one difficulty is inherent in such work: the records that such deposits can furnish are always discontinuous in time.

A beginning was made with a palynological investigation of the sediments of the continental shelf off the east coast of North America, and, later, with a few cores from the deeper parts of the Atlantic Ocean. The lutites occurring on the shelf are usually quite fossiliferous, but in some areas long cores are necessary to reach Wisconsin or older deposits. In other shelf areas deposition may be interrupted due to lowered sea level during glacial stages, resulting in a discontinuous pollen record.

In the deeper parts of the ocean, farther away from the continents, sediment accumulation is likely to be continuous and relatively slow as compared with that on the shelf, and, consequently, climatic fluctuations might be represented in the pollen spectrum even in rather short cores. In order to test this hypothesis, cores from three locations were processed; most of the samples proved to be fossiliferous. This report is concerned with core SP 3-33, located in the Biscay Abyssal Plain, 47°10.8′N and 11°25.5′W, at a depth of 4610 m.

The core consists of brown-gray lutite to a depth of 400 cm; at this depth a change occurs to a gray sandy lutite to 417 cm. Between 417 and 477 cm a gray lutite is found, and below this depth occurs brown-gray lutite, similar to that of the upper part of the core. The carbonate content is about 25 percent in the upper 50 cm, and between 400 and 417 cm; in the remainder of the core it is 10 to 15 percent.

A preliminary examination of the material revealed that, although many Cenozoic pollen grains and spores are present, a significant number of reworked Mesozoic and Paleozoic forms occur in all samples. The Cenozoic pollen forms an assemblage which may well have been produced during the last several thousand years, except for a few grains of *Anacolosidites* and *Pterocarya,* which were reworked from Tertiary desposits. It is, however, difficult, if not impossible, to differentiate between, for instance, modern and Tertiary *Pinus* grains, and the same can be stated for pollen and spores of many other extant genera. Therefore, the Cenozoic pollen assemblage can be used only with great caution in the study of climatic fluctuations during the Quaternary Period, unless supporting data can be obtained from the study of foraminifera, or from oxygen isotope investigations.

In addition to pollen and spores, a few dinoflagellates, hystrichosphaerids, and other acid-insoluble microfossils were found. The latter are probably planktonic organisms, but I could not identify them.

In most of the samples, less than half of the Cenozoic grains are winged conifer pollen, nearly all belonging to the genus *Pinus,* except in the samples from 297 to 302 cm, 352 to 358 cm, and 413 to 417 cm. These samples, and particularly the last mentioned, contain some *Picea* and *Abies* (?) pollen, suggesting, if they are not reworked from older deposits, a slight cooling of the climate at the time of their deposition. The occurrence of *Picea* and *Abies* (?) is accompanied by rather high percentages of *Pinus* and lower than average percentages of angiosperm pollen. It is interesting to note that Ericson (*1*) also suspects some climatic deterioration on the basis of his study of foraminifera in a sample from 350 cm. However, since the number of *Picea* and *Abies* (?) pollen grains is small, and the foraminiferal data indicate a minor rather than a drastic climatic change, it would be unwise to conclude that the sediments between 297 and 417 cm were deposited during the last glacial period. Rather, it appears probable that both the foraminifera and the plant microfossils present at this depth reflect a minor change during post-glacial time.

Among the Cenozoic angiosperm pollen, that of *Alnus* and the Ericaceae are most common. Cenozoic spores are