an average of 57 epsilon amino groups of lysine (56 and 59, respectively) per molecule of human serum albumin, molecular weight 69,000. There was no apparent freeing of additional alpha amino groups of human serum albumin detectable by this method.

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Importance of Proteases as Factors Involved in the Exsheathing Mechanism of Infective Nematode Larvae of Sheep

The importance of pepsin as a factor influencing the exsheathment of third-stage infective nematode larvae in the host has been raised by Crofton (*1*). Working with *Trichostrongylus retortaeformis* from the rabbit, he obtained a high rate of exsheathment by using solutions of pepsin in hydrochloric acid. Solutions of hydrochloric acid alone and of distilled water gave no exsheathment, and boiling the pepsin solutions rendered them inactive.

The researches of Poynter (*2*), however, on infective nematode larvae of parasites of the horse indicate that enzymes do not have a role in the exsheathing mechanism. Sommerville (*3*) recently obtained rapid exsheathment *in vivo* with several species of infective larvae of sheep by using cellophane dialysis membranes in fistulas of the rumen and abomasum. Exsheathment has similarly been obtained in this laboratory at a slower rate and using an abomasal fistula only.

Further evidence that enzymes do not play a part in the exsheathing mechanism of infective larvae of sheep has been obtained by studying the action of pepsin and trypsin on the cast cuticle of *Haemonchus contortus*. Separation of the cuticle was obtained as previously described (*4*). Pepsin was made up in the manner described by Hollaender *et al.* (*5*), and trypsin was made according to the method of Moscona (*6*). The potency of these solutions was tested by using controls containing muscle fibers. Experiments were carried out at 38°C over a period of 3 days, and in no case did hydrolysis of the cuticles occur.

It has been shown that proteins that have a very low aromatic amino acid content, such as gelatin, have a correspondingly slow peptic hydrolysis, and that proteins that contain many aromatic amino acids are hydrolyzed rapidly by pepsin. Recent investigations by Baker (*7*) have shown that dipeptides containing two residues of the *l* form of the aromatic amino acids phenylalanine, tyrosine, and diiodotyrosine are hydrolyzed more rapidly than any previously known synthetic peptide, indicating that the specificity of pepsin is related to the hydrolysis of peptide linkages involving aromatic amino acids. The studies of Hofmann and Bergmann (*8*) on the specificity of trypsin indicate that this is directed to the hydrolysis of peptide bonds involving arginine and lysine.

It has recently been shown that the cuticle of infective larvae of *H. contortus* is composed of proteins, which, however, lack the aromatic amino acids lysine and arginine (*4*). The failure of the proteases to attack the cuticle of the larvae can, therefore, be attributed to the chemical composition of the constituent proteins. It is of further interest to note that more rapid exsheathing rates were obtained in distilled water in which the cuticle had been shown to be soluble at higher temperatures than in solutions of pepsin similar to those used by Crofton (*9*).

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Earthworm Breeding Farms

I have read with interest the news item on earthworm breeding farms [*Science* **120**, 825 (1954)]. It seems necessary that a note of caution be introduced in evaluating the ability of worms to enhance the chemical and physical properties of soil. For example, Chadwick and Bradley [*Proc. Am. Soc. Hort. Sci.* **51**, 552 (1948)] concluded after an extensive series of experiments that although castings are beneficial when added directly to potted plants, the presence of large numbers of worms in the soil had no beneficial results upon plant production. Different species of worms have a strong selectivity for various types of soil.

With regard to this fact it is interesting to note that *Eisenia foetida* is one species that is commonly supplied by worm farms. While easy to culture, the worm is restricted to a habitat of manure or compost, and will die when placed in the loamy soil of the field or garden. Hence any increase in yield from soils to which this species has been added is of a transient nature, being the result of the worms' decomposition

and not their activity. The statement that the farm worms contribute significantly to flood relief in the Netherlands is open to question, for it is well known that earthworms have a low tolerance to carbon dioxide and will perish in most water-logged soils. The Darwin estimates of yearly soil turnover by worms at 400 lb/acre would more properly read from 7 to 18 tons per acre, per yr.

In general it can be said that worms are abundant in well-aerated soils of high organic content, but it is doubtful whether they actually improve poor soil conditions because their action is most likely effective only in the maintenance of good soil properties already present. The organic gardener should look with some skepticism on the claims for the benefits derived from the introduction of worms into soil and at least should be certain that worms supplied by the earthworm farmers are of a species known to inhabit the type of soil into which they are to be introduced.

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A Scattering Layer Observation

The deep-scattering layer has been shown to be present over most of the oceans with the possible exception of the polar areas. It is generally believed to consist of marine organisms, and one of its remarkable features is the constancy with which it shows on an echo sounding record as a ship moves along. This constancy is surprising in view of the relative patchiness of plankton indicated by the towing of continuous plankton samplers (*1*).

At the depth of the scattering layer an echo sounder indicates only the presence or absence of a scatterer within a large area. In an effort to obtain better resolution in recording the layer a transducer was lowered to various depths. With the echo sounder set on its shortest range, only a small volume of sea was returning echoes at any one time. The drifting of the ship moved the transducer through the water and resulted in scanning. Figure 1 shows the type of record obtained under these conditions. Two conclusions can immediately be drawn. First, the scattering is patchy as though it was caused by individuals or small schools. Second, the size of the "individuals" is small relative to 25 ft. This is indicated by the concave underside of the patches on the record even at ranges as short as 50 ft. As the scatterer passes through the beam its distance from the transducer varies. It is initially further away, reaches a point of closest approach directly beneath the transducer and then again recedes as it passes out of the conic sound beam. If the scatterer were longer than the beam width it would return sound from a greater range when part of it was at a minimum range. Since this is not the case even at a range of 50 ft, where the sound beam is 25 ft wide, the second conclusion seems justified.

The velocity of the scatterers relative to the transducer can be computed from the curvature of the upper sides of the patches. Nearly the same value is obtained for all patches; therefore it would seem that the scatterers are not affected by the sound and are not moving about randomly. For this reason it is straightforward to count the number of patches in a known volume of water scanned and calculate their density.

So far it has been possible to do this only outside the scattering layer. The scatterers occur on the average of one for every 3×10^5 ft^3 of sea. This is in agreement with the frequency of large individual echoes found by Raitt (*2*) outside the scattering layer in the Pacific Ocean. It is also in substantial agreement with the numbers of fish caught by a mid-water trawl of efficient design described in some unpublished work of Backus. Backus' investigation was made in the same area of the Atlantic as ours.

The scattering layer in the North Atlantic is usually best developed during the day at a depth of about 250 fathoms. Consider that some transducers are sensitive over an angle of about 30 deg. Then from the surface the sound beam is sampling a circular section of the layer 750 ft in diameter. Echoes are returned from a thickness of half a pulse length, which for the records here is 20 ft. The volume of sea returning sound at any instant is then about 10^7 ft^3.

Unfortunately the only figures here are for outside the main region of scattering. Even in this sparsely populated area there are 30 individuals in the sound beam at one time. Backus (personal communication) reports a density of fish in the layer that would place at least 500 in the beam at one time. Marshall (*1*) has presented plausible evidence that bathypelagic fish are widespread and nonschooling in behavior. It is not surprising then that the scattering layer record appears continuous. Such a large average number would only rarely be expected to fluctuate to a low value and thus give no echo.

Work will be done to narrow the cone angle and

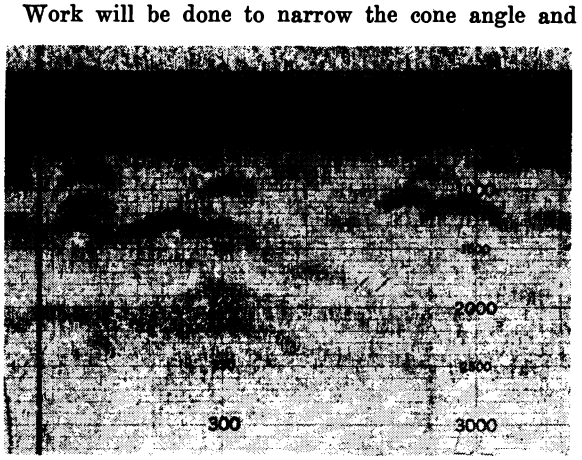

Fig. 1. Section of recording tape with the transducer at a depth of 200 m. The vertical scale is 0 to 500 ft. This represents depths below the transducer. The frequency of the sound was 12 kcy/sec.