and therefore only a small amount of intact coat protein would be produced. We also note a hyperproduction of polymerase. The presence of this excess enzyme further depresses phage yield by converting newly synthesized single-stranded phage RNA to double-stranded RNA, thereby preventing its entering finished phage particles. From such data Lodish and Zinder (11) concluded that the coat protein plays a role as a "repressor" substance in modulating the frequency of translation of the different genes on the phage RNA molecule, a hypothesis for which there is some direct evidence (13).

The events occurring after infection of Su-III are not unlike those after infection of Su-II, but the same explanation is not applicable because suppression by Su-III has been at least as efficient as that by Su-I (6, 7, 14). We infer that the tyrosine residues inserted by Su-III are incompatible with the normal functioning of the coat protein. The tyrosine-containing proteins can neither form phage particles nor "repress" polymerase production, if these are indeed separate phenomena. Hence the overproduction of polymerase with all of its consequences.

Thus in our experiments the bacteria lysed when the kind of coat protein produced was capable of forming phage particles (S6 or S70 in Su-I) even though the amount of coat protein was lower than normal (S6 and S70 in Su-II), although lysis seems to be somewhat delayed in this latter case (Fig. 1C). When no coat protein is made or when protein incapable of forming phage particles is made (S6 and S70 in Su⁻ or Su-III), the cells do not lyse. We explain those instances where cell growth ceases (S70 in Su⁻, S6 and S70 in Su-III) as being a result of the continued synthesis of large amounts of phage RNA, ultimately depleting the cells' own necessary synthetic capacities.

The data presented above support the hypothesis that the coat protein of the RNA phage is required for the lysis of the host bacteria. We do not know whether it performs this lytic function directly or indirectly, nor do we know whether the ultimate target of its action is cell membrane or cell wall. So far, we have not been able to show in vitro any effect of coat protein on a variety of substrates.

Genes are known to specify the structures of proteins which have enzymatic, structural, and regulatory roles in cel-

lular economy. Surprisingly, the single polypeptide chain specified by the "coat protein" gene of the phage f2 appears to have all three kinds of function.

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Sulfate Reduction in Soil: Effects of Redox Potential and pH

Abstract. *Reduction of sulfate to sulfide in waterlogged soils was dependent on soil redox potential and pH. Little or no sulfide accumulated with a redox potential above −150 millivolts, or with a pH outside the range 6.5 to 8.5.*

Low oxidation-reduction (redox) potentials are necessary for bacterial reduction of sulfate. As pointed out by Postgate (1), the *Desulfovibrio* organisms largely responsible for dissimilatory reduction of sulfate are more exacting in their requirement of anaerobic conditions than are most anaerobes; he noted that a potential in the medium of about −200 mv was required for the initiation of sulfate reduction. Harter and McLean (2)

Fig. 1. Reduction of sulfate to sulfide during 30-day incubation at controlled redox potentials in Crowley (●——●) and in Hockley soil (○——○).

found sulfide formation from sulfate in a soil to be very active with a redox potential below −75 mv. Takai and Kamura (3) reported that sulfate reduction in waterlogged soil takes place with a redox potential ranging from 0 to −190 mv. In all reported studies of sulfate reduction in waterlogged soils, the redox potential was not controlled during the course of the experiments. In our study, reduction of sulfate to sulfide was examined in two soils under conditions of closely controlled redox potential.

The procedure used for control of redox potential in waterlogged soils [reported (4)] consists in automatically supplying oxygen to saturated soil cultures when the redox potential falls below the selected value. We used two soils commonly used for rice: a Crowley silt loam from Louisiana and a Hockley very fine sandy loam from Texas. Samples (75-g) of soil containing 0.5 percent of finely chopped rice straw and sulfate sulfur at 100 parts per million (ppm) were incubated for 3 weeks with equal weights of water at controlled redox potentials. After incubation the amount of sulfate that had been reduced to sulfide was determined. The potentials selected ranged from +100 to −250 mv.

The results (Fig. 1) show that redox potential was a controlling factor in the reduction of sulfate to sulfide. In
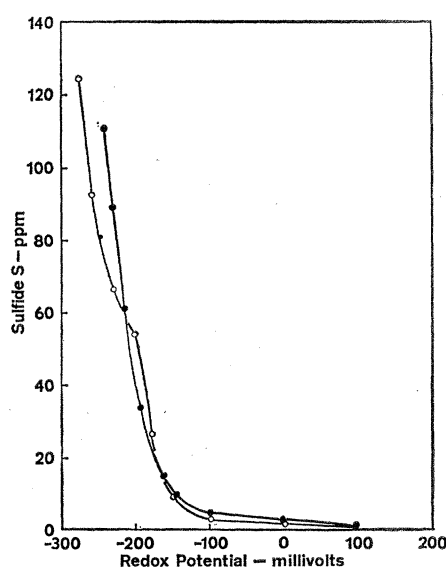
both soils, sulfate became unstable at a potential of about -150 mv; the more negative the potential below this value, the more complete was the reduction of sulfate to sulfide during the 3-week incubation. The curves relating sulfide concentration to redox potential in the two soils were almost identical. The pH of the two soils were about the same and changed from approximately 6.8 to 7.1 as the potential changed from $+100$ to -250 mv.

An interesting consequence of the reduction of sulfate to sulfide at such a low potential is that accumulation of H_2S is prevented in soils containing reducible iron, because of the precipitation of sulfide as insoluble FeS. Ferric iron is reduced to ferrous iron in the soil at a considerable higher redox potential than that at which sulfate is reduced (5); consequently ferrous iron is always present before sulfide is formed. Harter and McLean (2) recorded the production of 2000 ppm of sulfide, under waterlogged conditions, without the release of H_2S from the soil. In our study, all the sulfide was in the combined form; none was present as H_2S.

In addition to its dependence on redox potential, reduction of sulfate to sulfide in a soil or other media depends on pH also. Zobell (6) reported sulfate reduction occurring between pH 6.4 and pH 9.5 in marine bottom deposits and between pH 4.2 and pH 10.4 in poorly drained soils. Starkey and Wright (7) found the range of active sulfate reduction in the soil to be
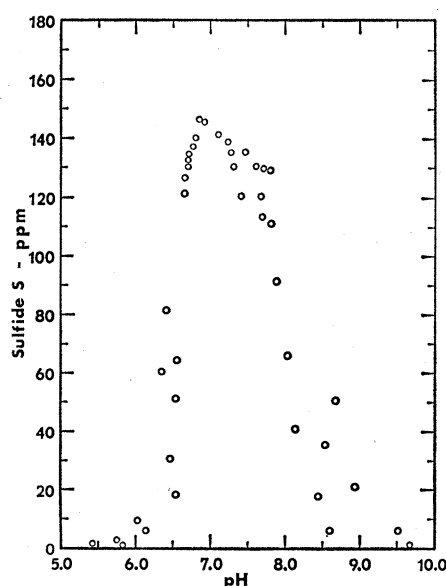

Fig. 2. Reduction of sulfate to sulfide in Crowley soil, during 28-day incubation, as affected by soil pH.

between pH 5.5 and pH 8.5, with the greatest accumulation occurring near pH 7.

The effect of pH on reduction of sulfate to sulfide was studied with 50-g samples of a Crowley silt loam soil, initially of pH 5.8, which had been adjusted to a wide range of pH values with either HCl or NaOH. The acid-treated or alkali-treated soil, 50 ml of distilled water, 0.5 percent of finely chopped rice straw, and sulfate S at 100 ppm were placed in serum bottles and incubated for 28 days under an atmosphere of argon; the samples were then analyzed for total sulfide content. The redox potential of the highly reduced soil was approximately -250 mv. The pH values that we report are those measured at the end of the incubation period. The original soil contained approximately 40 ppm of sulfate sulfur.

A pronounced effect of pH on sulfate reduction was recorded in this experiment. The data of Fig. 2 show little reduction of sulfate to sulfide at pH outside the range 6.5 to 8.5. The sulfide-pH gradient on the acid side was especially steep, with a marked decrease in sulfide production between pH 6.7 and pH 6.2.

The restriction of sulfate reduction to the pH range 6.5 to 8.5 does not necessarily mean that soils with normal pH values, outside this range, do not support sulfate reducers. After waterlogging, the pH of both acid and alkaline soils tends to shift toward the neutral point as a result of chemical reactions, involving iron and manganese, that bring most waterlogged soils, regardless of original pH, into the pH range of sulfate reduction (8). In our study, sufficient acid or alkali was added to counteract the shift in pH that normally occurs.

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Oxygen Consumption of Red and White Muscles from Tuna Fishes

Abstract. Metabolic rates of unstimulated, minced preparations of red and white muscles from two species of Pacific tuna fishes (Katsuwonus pelamis and Thunnus obesus) were determined from respirometric measurements of oxygen consumption. Ratios of mean metabolic rates for red muscles to those of white muscles averaged 6.2 at five temperatures over the range of 5° to 35°C. Temperature coefficients (Q_{10}'s) for mean metabolic rates for both types of muscle were between 1.0 and 1.2 over the entire temperature range. Metabolic rates of tuna red muscles were equal to those of preparations of mixed red and white muscle from the white rat at 25° and 35°C, and were higher than the mammalian rates at lower temperatures.

The large size of tuna fishes and their extreme sensitivity to capture and handling have made physiological studies on these fishes difficult. Only recently has adequate evidence been obtained for even such basic phenomena as the long-suspected physiological regulation of body temperature (endothermy) of several species (1). This paper contributes to the understanding of the metabolic basis for and the significance of this endothermy, also of the spectacularly high levels of continuous activity of these fishes. I have measured the oxygen consumption of fresh, minced, unstimulated samples of red and white muscles taken from two common species of Pacific tunas, the skipjack (Katsuwonus pelamis) and the bigeye tuna (Thunnus obesus). Similar data for mammalian (white rat, Rattus rattus) skeletal muscles containing both red and white fibers are included for comparison.

Adult skipjack (550 to 1200 g) and bigeye tuna (2000 to 3900 g) adapted to water at 25°C were killed by a blow on the head immediately after removal from the water. Within 2 to 3 minutes, 2- to 3-g samples of white muscle from the dorsal musculature and red muscle from the deep masses of that tissue were excised from about midway along the fishes' bodies [see both (1) and (2) for anatomical descriptions of the distributions of the muscle types]. The samples were transferred to ice-cold, covered petri dishes containing filter-paper disks moistened with Ringer solution. The tissues were