carboxyl group, COOH, when this group breaks up into fragments after having been severed from the original acid molecule by R–COOH bond rupture. The balance of these fragments, *i.e.* the OH groups and H atoms, may contribute to the formation of H_2O and H_2. Simple computations show, however, that this takes care only of part of the large amounts of H_2 formed. Thus, most of the H_2 must derive from H atoms produced by C–H bond rupture. The formation of the light paraffins, CH_4 to C_4H_{10}, is most readily explained by C–C bond ruptures near the

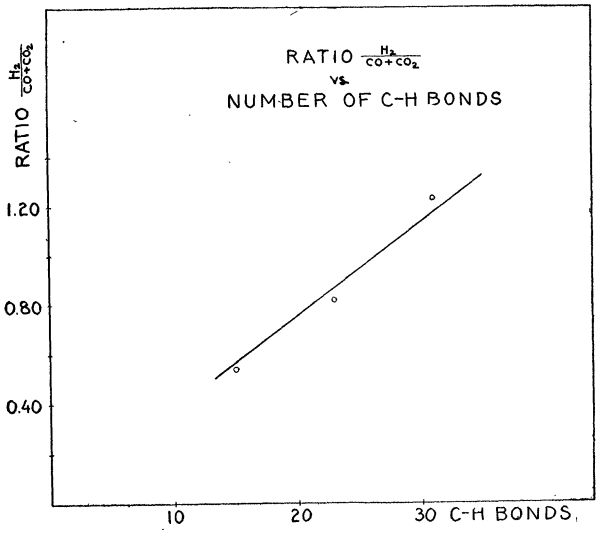

FIG. 1. Abundance of hydrogen relative to carbon monoxide plus carbon dioxide as a function of the number of C–H bonds in the molecule.

"left" end of the molecules, yielding methyl to butyl radicals. Free H atoms can combine with these radicals and produce the corresponding paraffins. These simplified considerations do not include the possibility that part of the gases found in the analysis may derive from reconverted primary gases.

In the case of palmitic acid, for which the available data are most complete, it is possible to perform computations which give a rough idea of the statistical probability of the rupture of different bonds in this molecule under alpha-particle or deuteron bombardment. Thus, it is found that, for every 100 C–H bonds broken, about 45 C–C bond are ruptured at the junction of the long chain and the COOH group, while probably not more than 5 C–C bonds are broken anywhere else along the chain. These ratios are of interest because they give an indication of bond strengths. Since at least 90 per cent of all the C–C bond ruptures seem to occur at the terminal COOH group, the strength of this particular bond must be considerably lower than that of the paraffinic C–C bonds (about 80 kcal./mole). This conclusion is confirmed by considering the ratio of R–COOH and C–H bond ruptures, which is far in excess of estimates just based on the relative number of these bonds available.

A comparison of the actual gas yields from the three acids cannot be carried out, since some of the data necessary are not sufficiently accurate. However, if for the three acids investigated the abundance of H_2 relative to CO plus CO_2 is plotted *vs.* the number of C–H bonds in the molecule, a straight line is obtained (Fig. 1). Thus, the assumption seems justified that in long-chain molecules the probability of breaking C–H bonds is directly proportional to their number.

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Surface Phagocytosis—Its Relation to the Mechanism of Recovery in Pneumococcal Pneumonia[1]

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During the course of a systematic study of the effect of chemotherapy upon the pulmonary lesion of pneumococcal pneumonia it has been shown that pneumococci are destroyed in the lung by phagocytosis (*8, 9*) and that the phagocytic process takes place in the absence of demonstrable circulating antibody (*11*). All existing experimental evidence indicates that virulent pneumococci are protected, by virtue of their capsules, against the attacks of phagocytic cells (*2*). Both polymorphonuclear leucocytes and macrophages have been found to ingest fully encapsulated pneumococci only in the presence of type-specific opsonins (*6*). Thus, the phagocytic reaction which takes place in the lung during chemotherapy remains unexplained.

Three possible explanations may be offered for the occurrence of phagocytosis in the absence of demonstrable circulating antibody: (1) The reaction may be brought about by the local accumulation of specific antibody in the pneumonic lesion; (2) it may result from injury to the pneumococcus capsule; or (3) it may be due to a hitherto undescribed mechanism which is related neither to opsonins nor to capsular injury. Although all attempts to substantiate the first and second of these hypotheses were uniformly unsuccessful (*11*), the third explanation was conclusively confirmed by direct observation (*12, 13*).

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Suspensions of thrice-washed phagocytic cells[3] in gelatin-Locke's solution were mixed with washed pneumococci (Type I, Strain A5), and the mixtures were kept on ice until used for phagocytic tests. In successive experiments the phagocyte-pneumococcus mixtures were injected intrabronchially into (a) the lungs of normal rats, (b) lungs removed from rats and perfused with gelatin-Locke's solution, and (c) rat lungs fixed for 24 hours in 10 per cent formalin and washed for several days to remove the fixative. Each experiment was carried out at body temperature. Sections cut from all three types of preparations and stained by the Gram-Wiegert technique showed clearly that both polymorphonuclear leucocytes and macrophages phagocytized pneumococci in the alveoli within less than an hour. In the experiments with the formalin-fixed lungs, there was no possible source of intermediary opsonin.

Further examination of the formalin-fixed lungs revealed that pneumococci were engulfed by the phagocytic cells in the large bronchi as well as by those in the alveoli. Phagocytosis failed to occur, however, when the same leucocyte-pneumococcus mixtures were tested in rotating glass tubes, hanging-drop preparations, and even in capillary tubes of the same diameter as the bronchi. This last finding suggested that the crucial factor in the phagocytic process was related in some way to the character of the bronchial surface.

Other tissue surfaces were therefore tested. Small pieces of selected tissues taken from freshly killed rats were placed in the bottom of Petri dishes lined with moistened filter paper to prevent drying during incubation. A small drop of the leucocyte-pneumococcus mixture was spread over each tissue surface, and the Petri dishes were then closed, sealed with Scotch tape, and incubated for one hour. At the end of incubation, impression smears were made of the tissue surfaces and stained with methylene blue. Bronchial and tracheal epithelium, esophageal epithelium, the intima of both aorta and vena cava, lung, pleura, pericardium, endocardium, peritoneum, liver, spleen, kidney, mesentery, retina, muscle, and clotted plasma all were found to support phagocytosis. When the tissues had been boiled previously for 30 minutes the phagocytic reaction still took place. Finally, a variety of inert surfaces were tested, and although phagocytosis failed to occur on glass, ground glass, paraffin, albumen, and cellophane, phagocytes brought into contact with filter paper, blotting paper, lens paper, cloth, and fiber glass were found to be highly active.

From these observations it may be concluded (1) that both polymorphonuclear leucocytes and macrophages, when given access to a suitable surface, will phagocytize virulent pneumococci without the aid of an intermediary antibody or any other tissue factor, and (2) that most body tissues afford surfaces suitable for the efficient operation of phagocytic cells in this nonantibody reaction.

Due largely to the profound influence upon immunological thought of the now-classic investigations of Avery and his collaborators (*7*), most of the previous studies of the mechanism of recovery in pneumococcal pneumonia have centered about the role of specific antibodies. The methods of classical immunology, however, have failed to reveal why untreated patients sometimes recover from pneumococcal pneumonia before specific antibody is demonstrable in their blood sera (*3, 5*), why sulfonamide chemotherapy usually causes a crisis several days before immune bodies appear in the blood (*1, 10*), and why phagocytes destroy pneumococci in the lungs of patients dying of pneumonia even when the pneumonic lesion contains large quantities of unbound antiphagocytic polysaccharide (*4*). The phenomenon of surface phagocytosis described in this report offers an adequate answer to each of these previously unsolved questions. It also explains the phagocytosis of fully encapsulated pneumococci in experimental pneumonic lesions in the absence of specific opsonins and in the presence of excessive amounts of polysaccharide. In view of the tremendous surface area afforded by the alveolar architecture of pulmonary tissue it seems logical that surface phagocytosis should constitute an important defense against bacterial invasion of the lungs. Preliminary experiments already indicate that this nonantibody phagocytic mechanism operates in other body tissues and is responsible for the destruction of other species of encapsulated microorganisms.

[3] The phagocytes were obtained from peritoneal exudate of rats inoculated 24 hours previously with an aleuronat-broth mixture. Approximately 90 per cent of the cells were polymorphonuclear leucocytes, and 10 per cent, macrophages.

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