numbers will be identical when a strong magnetic field is applied.

The Pauli exclusion principle is essentially a statement of the rugged individuality of electrons and the impossibility of promoting a merger between them.

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GEOLOGY—BACTERIOLOGY

Bacteria and Petroleum

Bacteria may have played many important roles in the formation of deposits as well as have had something to do with the relative scarcity today.

➤ BACTERIA may have had a number of important roles in the formation and development of the earth's petroleum deposits, Dr. Claude E. ZoBell of the Scripps Institution of Oceanography stated in a lecture before a Washington scientific audience. They may also have had something to do with the relative scarcity of petroleum today, he added, for it seems likely that much more oil has been formed in the long course of geologic history than is now present in the rocks, and it is known that some species of bacteria can feed on petroleum and related compounds, unlikely though they may seem as food materials.

There is little direct evidence that bacteria helped to make oil, Dr. ZoBell admitted. However, laboratory experiments have given a number of very interesting clues, some of which are being followed intensively in the hope of throwing more light on this most difficult and baffling geologic riddle.

If bacteria did aid in producing oil, it was probably a highly complex process as well as a very long one. As many as 40 or 50 different kinds of bacteria may have been involved.

Most geologists now believe that petroleum formation started with the dead plant or animal materials. These, of course, are always subject to bacterial action. One of the things that happens to such organic remains is the bacterial removal of elements other than carbon and hydrogen, especially sulfur, phosphorus and nitrogen. The nearer organic remains come to consist of carbon and hydrogen alone, of course, the nearer they are to being hydrocarbons, which are the constituents of petroleum and natural gas. This general observation receives some backing from the known fact that bacteria can convert dead organic remains into the simplest of hydrocarbons (methane), and also some of the most complex of hydrocarbons (bacterial pigments), as well as a few other compounds of intermediate complexity.

Another thing that certain bacteria may have done toward oil formation is hinted at in the activity of some species in releasing quantities of hydrogen from organic compounds. Addition of hydrogen to carbon under heat and pressure (hydrogenation) is a standard method for manufacturing synthetic oil out of coal or lignite. Bacteria-freed hydrogen, under the heat and pressure conditions in the earth's crust, may have been added to buried carbonaceous deposits in a similar manner, Dr. ZoBell suggested.

The role of bacteria was not necessarily limited to the formation of oil, Dr. ZoBell continued. Other bacteria may have had a good deal to do with the loosening of oil from films coating soil and rock particles and its accumulation into pools. If the particles are of limestone, acid-forming bacteria can dissolve them altogether, leaving pores and channels through which the released oil can flow. Production of carbon dioxide, both through the dissolving of limestone and as a result of the microorganisms' own life processes can do several things: it makes the oil less viscous, so that it will flow more freely; it directly pries the oil films loose from the particles to which they cling; it can form pressure-bubbles in dead-end pockets and drive out the oil that has accumulated in them.

Bacteria are known to be able to feed on various kinds of hydrocarbons, ranging from the simple methane to the highly complex paraffin waxes, and including all varieties of petroleum products. They require water and certain mineral salts, but use the hydrocarbons as their sole energy foods. It is for this reason that Dr. ZoBell suggested that bacteria may have in the course of geologic ages destroyed vast oil pools that other bacteria had vital parts in forming.

Present-day bacterial appetites for oil and related compounds work both beneficially and harmfully, from the human point of view. Oil pollutions of the soil, near oil wells and where oil has spilled from broken pipe lines or wrecked tanks, do not last long, Dr. ZoBell pointed out. Bacteria clean them up, and as a rule leave the soil more fertile than it was before the pollution occurred. Similarly, but more slowly, bacteria clear up oil pollution on bodies of water.

Bacteria have been known to attack kerosene, releasing explosive gas mixtures. Deterioration of high-octane gasoline during the North African campaign was traced to bacteria present in the water at the bottoms of the tanks. Bacteria also made a lot of trouble, for a time, in non-leak gasoline tanks of airplanes by attacking the synthetic rubber linings, which are made from hydrocarbons derived from petroleum or natural gas.

Finally, bacterial fondness for petroleum constituents has been used as a sure-nosed means in oil prospecting. Several of the lighter, more volatile petroleum constituents, especially ethane, propane and butane, diffuse upward toward the earth's surface, and where they do, the special kinds of bacteria that feed on them will accumulate in the soil. By hunting for them, and especially by hunting for fossil evidences of their long-continued presence, new oil pools may be found.

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CHEMISTRY

Insoluble Soap Useful as Lubricant

➤ A MIXTURE of three kinds of soap which most people would never recognize as soaps at all is the basis for patent 2,389,523, issued to Dr. Frank A. Leyda of Berkeley, Calif. The ordinary sudsy soaps of bathroom and kitchen are compounds of either potassium or sodium with fatty acids, usually stearic or palmitic acids. When used with too-hard water, a flocculent precipitate, slippery but insoluble, sometimes comes out. This also is a soap—a calcium stearate.

To the housekeeper, such an insoluble soap is a plain nuisance, making troublesome rings in the bathtub or washbowl, but to the mechanical engineer metallic soaps of this kind are often very valuable greases. The grease on which Dr. Leyda has obtained his patent is a mixture: barium, calcium and magnesium compounded with stearic and palmitic acids.

Patent rights have been assigned to the California Research Corporation.

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