disciplines of embryology and anatomy demand. The way is long and tedious, but the scientific footing is solid.

ARNOLD GESELL,
Director

THE YALE CLINIC OF
CHILD DEVELOPMENT

THE ORIGIN OF NATURAL OIL

THE writer of this article is compelled to adhere to his view expressed in SCIENCE of September 7, and questioned by Professor J. M. Macfarlane in the issue for November 23. The reasons are to be found in chemical and geochemical considerations. The specialist in the field of bituminous coal, natural asphalt and oil is struck with the relation of these substances. They consist of aliphatic, semi-aromatic and aromatic compounds. The presence of bituminous coal and oil in the same localities, but in different strata, for instance, near Pittsburgh, forces one to the point of view that both substances were formed from the same original material. If this point of view *and* the fish theory are correct, the origin of bituminous coal and oil would have to be traced back to dead fish. Probably few adherents will be found for such a theory.

The chemical world to-day rejects almost entirely the fish theory. Investigations by P. D. Trask and C. C. Wu[1] have shown that on distillation of samples of sea and lake water muds, which probably contain the remainder of dead fish, oil-like substances can scarcely be obtained. The quantity of oil received therefrom was exceedingly small.

Investigations have shown that under geochemical conditions the teeth and bones of fish remain almost intact. In rocks containing oil fewer inorganic relics of fish are found than undamaged parts of cellulose and wood.

The so-called catastrophe theory has been invented to save the fish theory. The entrance of fresh water into sea water or sea water into fresh water is supposed to have led to the death of enormous quantities of fish. Professor Macfarlane believes volcanic and seismic causes are responsible for this. It is difficult to explain from such a point of view the presence of oil in different strata above each other. Such would mean that catastrophes occurred at the same place at several different times.

Carbohydrates are produced by nature in the greatest degree; probably even more so in earlier periods. The quantity of fish compared to this is small. The presence of enormous quantities of oil in the interior of the earth is therefore contrary to the fish theory. It is more than probable that the savings buried by nature in the form of coal and oil in the earth originate principally in the enormous quantities of carbohydrates and carbohydrate-humic acids transformed therefrom (not lignin-humic acids) and very little, if any at all from fish.

The question of the origin of oil and bituminous coal may be clarified only by experiments and observation of thermo-dynamic, geological and geochemical conditions. The carrying out of experiments should take place under geochemical conditions. In this respect, the writer of this article has to criticize the otherwise valuable experiments carried out by Warren and Storer.[2] Warren and Storer decomposed at "red hot heat" the lime soap which was produced on saponification of fish oil with strong excess of lime. All those who have been engaged with research work on the origin of oil know that neither the action of strong hydrate of lime nor such high temperatures were possible during the formation of oil. At the low temperatures which must be considered here, the lime soap would have to be stable. In any case, it would not lead to the formation of aromatics, such as has been observed in crude oil. From a thermodynamic view-point, the transformation of aliphatic hydrocarbons formed from aliphatic acids into ring hydrocarbons is not possible at lower temperatures. The temperatures required for such transformation are above the temperature for the formation of crude oil, which certainly has not gone beyond 300° C. One can find derivatives of chlorophyll in all crude oils and asphalts. These substances are completely destroyed at temperatures above 300°.

For the formation of aromatic compounds, therefore, other reactions must be responsible. Carbohydrates may be transformed at comparatively low temperatures into semi-aromatics and aromatics (phenols and phenolcarboxylic acids). By such reactions the presence of aromatics and naphthenes in crude oil is not difficult to explain.

On the basis of his own experiments and because of thermodynamic, geological and geochemical facts, which are contrary to the fish theory, the writer of this article can not adhere to the truth of the aphorism that "fish is the source of petroleum." His experimental work and that of his collaborators in this regard will be published elsewhere.

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[1] *Bull. Am. Ass. Petrol. Geol.*, No. 11, 1928, and 1451, 1930.

LUNAR RINGS

ON the evening of November 22, 1934, San Franciscans were treated to a display of spectral rings about the moon. It was first noticed by us from the steps of the Academy of Sciences at 10 P. M.,

[2] "Amer. Acad. Arts and Sc. Memoirs," S2, 9, page 177, 1867.