Reports

"Atom Bomb Effect"—Recent Increase of Carbon-14 Content of the Atmosphere and Biosphere

In a study of C^{14} variations in nature (*1*), collection of atmospheric carbon dioxide for the measurement of its C^{14} activity commenced in New Zealand on 24 Nov. 1954. The first three results were reported (*1*) in 1955, and the mean value + 3.73 percent with respect to the New Zealand wood standard apparently agreed well with Craig's predicted value of + 3.68 percent (*2*). There was, however, in these results an indication that the C^{14} content of the atmosphere was increasing; hence, the sampling program was continued to check whether or not there was a seasonal variation or a C^{14} enrichment of the atmosphere by atomic explosions. Nine samples of air have been assayed since 3 June 1955. The results indicate a steady increase in the C^{14} content of the atmosphere. Duplicate samples collected over the period 12 Dec. 1956 to 23 Mar. 1957 have assayed + 7.60 ± 0.03 percent and 8.05 ± 0.30 percent with respect to the New Zealand wood standard. Taking the average value + 7.83 percent for the C^{14} enrichment of air for the first 3 months of 1957, these results show that the C^{14} content of the atmosphere of the Southern Hemisphere has increased by 4.10 ± 0.5 percent since February 1955.

Because of the recently reported depletion of the C^{14} specific activity of the atmosphere (*3*) owing to the combustion of fossil fuels (the so-called "industrial effect"), before the total increase in C^{14} content of the atmosphere can be deduced from the foregoing figures, allowance must be made for this effect in (i) the atmosphere at the present time; (ii) the atmosphere prior to high-power atom-bomb tests (1953); and (iii) the New Zealand wood standard used in these comparisons.

It has recently been shown in this laboratory (*4*) that, up to 1953, a worldwide depletion of 2.0 percent in the C^{14} specific activity of the atmosphere has occurred. The New Zealand wood standard is depleted by only 1.5 percent. Thus, 1953 air with respect to 1953 wood should show a + 3.7 percent enrichment factor, but when assayed with respect to the New Zealand wood standard, it should show only a + 3.2 percent enrichment factor. Furthermore, depletion of atmospheric C^{14} specific activity is still occurring at a rate of approximately 0.05 percent per year; hence, 1957 air should assay + 3.0 percent with respect to the New Zealand wood standard.

Since the average value in early 1957 is + 7.8 percent with respect to the New Zealand wood standard, the increase in C^{14} content of the atmosphere of the Southern Hemisphere since 1953 is (7.8–3.0) percent—that is 4.8 ± 0.5 percent of the C^{14} normally present.

Since these results must be of considerable value in the calculation of atmospheric and ocean circulation times, an attempt has been made to verify these data by other methods of sample collection. To obtain sufficient carbon dioxide to achieve the maximum accuracy from equipment currently in use (*5*), the carbon dioxide has to be completely removed from 2500 to 3000 ft^3 of air. This has been done by the method previously described (*1*), but an alternative and quicker method is simply to expose trays of barium hydroxide solution to the atmosphere. In 7 to 10 days, 20 to 30 lit of carbon dioxide can be recovered. Samples collected by this method show an increase in C^{14} specific activity of 4.90 ± 0.60 percent between May 1955 and May 1957.

If such an increase has really taken place, it should be detectable in the wood and leaves of trees, grass, and so forth. To test this conclusion, the youngest leaves were taken, in May 1957, from a tree growing in a locality from which wood and leaf samples had previously been assayed. The results of these measurements indicated an enrichment of 4.25 ± 0.5 percent with respect to 1953 wood. The good correlation of the C^{14} enrichment of the atmosphere with that of the contemporary portion of the biosphere is in agreement with the expected rapid exchange between these carbon reservoirs.

The exchange rate of carbon dioxide between the atmosphere and the ocean is also a quantity of considerable importance. Since measurements on sea-water samples had been made (*1*) in November and December 1954 (when the increase of C^{14} in the atmosphere was very small), further 80-gal samples of sea water were collected from the same location, to establish whether or not an increase could be detected in surface ocean water. A steady increase has been apparent, especially since late 1956, and samples collected in May 1957 show a C^{14} enrichment of 2.0 ± 0.5 percent with respect to samples collected in late 1954.

Current estimates of the exchange rate of a CO_2 molecule from the atmosphere to the ocean range from 7 to 10 years (*6*), while the measurements reported here indicate a value of approximately 18 months. However, since the sea water has been collected from a rocky seacoast, it may not be representative of surface ocean water. Surface ocean waters from the South Pacific are therefore being investigated to check for any coastal effect.

It is appreciated that these results are too few and should be checked in other parts of the world before any generalization about atmospheric circulation or atmosphere-ocean exchange times can be formulated. It is, however, interesting to use the data given by Libby (*7*) to estimate, from the C^{14} increase, the total power of atomic weapons to date. Libby states that, when a reasonable escape figure for neutrons from an atomic explosion of 15 percent is used, nearly 1000 megatons of TNT equivalent of fission would be necessary just to double the C^{14} content of the atmosphere on a short-term basis (before mixing with the sea occurs). The 4.8-percent increase for the atmosphere reported here would account, on this basis, for 48 megatons of TNT equivalent of fission. The actual value must be greater than 48 megatons, first, because the increase of C^{14} in the Northern Hemisphere must be greater than that observed in the Southern Hemisphere, and second, because it has been shown here that the biosphere and surface ocean waters have already absorbed some of the artificially produced C^{14} from atomic explosions.

Since all the atomic weapons tests to date have taken place in the Northern Hemisphere, it would be expected that the increase in C^{14} specific activity in the Northern Hemisphere would be greater than that observed in the Southern Hemisphere. A knowledge of the

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present value in the Northern Hemisphere would thus yield important meteorologic data on the mixing rate of the atmospheres of the two hemispheres. If information on the power of all the weapons exploded to date were available, the rate of C^{14} increase in the Northern Hemisphere with time could be calculated fairly accurately. From a comparison of the atmospheric C^{14} specific activity with time in the two hemispheres, it should be possible to elucidate the mechanism and rate of the main mixing processes.

Should atomic weapons testing cease, the C^{14} specific activity of the atmosphere would begin to return to the preatomic bomb level as the result of exchange of CO$_2$ between the atmosphere and the oceans. The observation of this decrease and also of the change in C^{14} specific activity of surface water of the oceans would provide a valuable check on the exchange constants currently assumed for these reservoirs (*8*).

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8. A fuller discussion of these results will be published in the *New Zealand Journal of Science and Technology.*

27 June 1957

Effect of Rat Intrinsic Factor on Vitamin B$_{12}$ Absorption in Pernicious Anemia

Castle's intrinsic factor greatly improves the intestinal absorption of vitamin B$_{12}$. In pernicious anemia, both normal human gastric juice and hog-stomach preparations are sources of the intrinsic factor.

Rats in which the glandular part of the stomach has been resected do not absorb radioactive vitamin B$_{12}$, unless rat gastric juice or homogenized rat stomach is administered simultaneously (*1*). Normal human gastric juice and different preparations derived from hog stomach are ineffective in the gastrectomized rat. On the contrary, some of these intrinsic factor preparations were found to decrease the absorption of vitamin B$_{12}$ in the normal rat (*2*). These studies suggested the species specificity of rat intrinsic factor.

It was decided to supplement these data by a study of the effect of rat intrinsic factor on the absorption of radioactive vitamin B$_{12}$ in patients with pernicious anemia. For this purpose, a modification of the urinary excretion technique described by Schilling (*3*) was used. Human gastric juice collected from normal donors after the injection of histamine was neutralized after filtration through gauze. It was pooled and kept frozen.

Rat gastric juice was obtained from animals in which the pylorus had been ligated after an overnight fast. Eight hours after the ligation the animals were sacrificed, and the gastric juice was collected. After filtration through gauze, it was neutralized. The nearly clear, slightly yellow, and tasteless fluid was kept frozen.

The excretion of radioactive vitamin B$_{12}$ in the urine, collected over 48 hours after a test dose of 1 µg of CO^{56}-B$_{12}$, varied from 14.2 to 46.4 percent, average 29.1 percent, in 30 control subjects. In 14 patients with pernicious anemia, 0.05 to 4.35 percent, average 1.68 percent, of the test dose was recovered in the urine. After simultaneous administration of 25 ml of human gastric juice, the urinary excretion increased to 12.9 to 35.9 percent, average 22.3 percent, in 13 of the patients with pernicious anemia.

Data about the clinical activity of rat intrinsic factor are given in Table 1. The intrinsic factor activity of 25 ml of rat gastric juice was less than that of the same quantity of human gastric juice. In dialysis experiments performed by us, 1 ml of rat gastric juice was able to bind 0.029 µg of vitamin B$_{12}$, while human gastric juice bound 0.077 µg of vitamin B$_{12}$. If the amount of rat gastric juice given, together with the test dose of vitamin B$_{12}$, was increased to provide the same binding power as 25 ml of human gastric juice, rat intrinsic factor appeared to be about as active as human intrinsic factor in patients with pernicious anemia, at least in this short-term experiment.

Table 1. Urinary radioactivity expressed as a percentage of the test dose of 1 µg CO^{56}-B$_{12}$.

Treatment	Case number					Average
	1	2	3	4	5	
B$_{12}$ only	2.71	4.35	0.84	0.44	0.82	1.83
B$_{12}$ + 25 ml of human gastric juice	25.1	25.8	12.9	21.2	27.3	22.5
B$_{12}$ + 25 ml of rat gastric juice	11.6	11.3	7.76	5.56	3.47	7.9
B$_{12}$ + 70 ml of rat gastric juice	19.1	23.4	22.8	20.6		21.5

These findings in human beings, who are able to utilize intrinsic factor derived from human, hog, or rat sources, are in striking contrast to the results previously obtained in the rat (*4*).

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4. This study was made possible by a gift of radioactive vitamin B$_{12}$ from the N. V. Philips-Roxane Co., Weesp, the Netherlands. Technical assistance was given by J. H. Jans and A. O. de Vries.

18 June 1957

Distribution of Lysogenic Streptomyces

Temperate bacteriophage might be responsible for outbreaks of *Streptomyces*-phage during antibiotic fermentation. However, few examples of lysogeny among the *Streptomyces* have been reported (*1, 2*). Recently, three strains of *Streptomyces* which had been maintained in the laboratory for more than 2 years, with frequent colonial isolation, were found to be lysogenic. This prompted a survey of other laboratory strains and of some strains newly isolated from soil samples collected in Minnesota (*3*).

All strains were purified by at least 15 serial replatings from well-isolated colonies on AMC agar (*4*). Temperate phages were isolated from peptone-yeast extract broth cultures inoculated with fragmented aerial hyphae and incubated at 30°C on a reciprocal shaker. Although the cultures were sampled frequently, no free phage was detected until autolysis became evident. Phage-enriched autolysate was made by adding germinated spores of other strains of *Streptomyces* to an autolyzing culture. This frequently increased the numbers of free phage considerably but in no case led to the detection of a new lysogenic strain. In a few instances the addition of spores masked the phage already present in the autolysate.