The B_2O_3 and B were mixed in various ratios, ball milled and pressed into pellets. The pellets were thoroughly baked out in the system by preheating at 900° until a pressure of less than 10^{-3} mm. was obtained. When the temperature was increased to above 1050° and the pressure had dropped to 10^{-4} mm. or less, an amber glassy deposit began to form on the wall of the glass heating chamber and on the metal cold finger above the heated crucible.

The most favorable ratio of boron to oxygen in the mixture was found to lie between 3:1 and 4:1. In this range a yield of 65% (based on available oxygen) was obtained in two hours at 1350° with an average yield of 0.5 g. per run. The purity of the product, expressed as the ratio B:O, fell within the limits of 1:1.00 and 1:1.014. The material which condensed on the cold finger was found to be pyrophoric in a few instances in more than 100 production runs and ignited spontaneously in the course of its removal.

Boron monoxide obtained by this method is a polymorphic glass which gave an X-ray diffraction pattern showing only amorphous rings. Attempts to develop a crystalline pattern by heating the polymer at temperatures below 400° were unsuccessful. At temperatures above 450° its color changed as it disproportionated to boric oxide and a black amorphous insoluble non-reducing solid which was probably boron. The rate of disproportionation increased with temperature. The density of the polymer, determined by the flotation method, is 1.765 ± 0.001 g./cm.^{3}. No solvent has been found for the polymer. It reacts vigorously with water and alcohols with the evolution of hydrogen which contains traces of boranes. The rate of reaction with alcohols decreases with increasing molecular weight of the alcohol. The resulting solutions in water and alcohol have reducing character which decreases with aging. The rate of decrease in reducing ability is a function of *p*H and is affected by the presence of dissolved oxygen in the solutions.

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INTERCONVERSION OF PURINES IN THE BIOSYNTHESIS OF NUCLEIC ACID ADENINE AND GUANINE AND OF HISTIDINE[1]

Sir:

Cell free extracts of *Aerobacter aerogenes* and of *Escherichia coli* were found to convert IMP[2] to GMP by the following reactions:

$$\text{IMP} + \text{DPN}^+ \longrightarrow \text{XMP} + \text{DPNH} + \text{H}^+ \quad (1)^3$$

$$\text{XMP} + \text{ATP} + \text{NH}_4 \longrightarrow \text{GMP} + \text{AMP} + \text{PP} \quad (2)$$

The enzymes catalyzing these reactions have been purified 30 and 50 fold, respectively. The crude extracts are also capable of converting IMP to an adenine derivative. Extracts of *A. aerogenes* strain P-14, a guanine requiring mutant which excretes xanthosine,[4] are unable to aminate XMP (reaction 2). Consequently, it appears that reactions 1 and 2 are essential steps in the biosynthesis of nucleic acid guanine. They are also essential in the conversion of exogenous adenine to nucleic acid guanine, since mutant P-14 incorporates adenine into xanthosine, but not into nucleic acid guanine.[5]

The following observations indicate that the conversion of exogenous guanine to nucleic acid adenine does not proceed through a reversal of these steps: (a) Reactions (1) and (2) are not reversible; (b) xanthine, which is converted to both nucleic acid adenine and guanine in mutant PD-1 blocked at an early stage of purine biosynthesis[6] (Table I, Exp. 2), cannot be converted to either of the nucleic acid purines in P-14, but is excreted exclusively as xanthosine (Table I, Exp. 8); (c) exogenous guanine is a precursor of nucleic acid adenine in P-14[5] (Table I, Exp. 7).

TABLE I

INCORPORATION OF VARIOUS PRECURSORS INTO NUCLEIC ACID PURINES AND HISTIDINE

Exp.	Strain	Supplement added	Relative specific activity—Guanine	Adenine	Histidine
1[a]	PD-1[b]	Guanine-8-C^{14}	100	100	
2	PD-1	Xanthine-8-C^{14}[c]	103	103	0
3	PD-1	Guanine-2-C^{14}[c]	100	40	38
4	PD-1	$C^{14}O_2$[d]	0.3	0.4	2.5
5	PD-1	$HC^{14}OOH$[d]	0.1	0.1	1.7
6	PD-1	Glycine-2-C^{14}[d]	0.7	7.4	6.4
7[a]	P-14[e]	Guanine-8-C^{14}	97	38	
8	P-14	Xanthine-8-C^{14}[c]	0	0	
9	P-14	Guanine-2-C^{14}[c]	96	24	19
10	HP-1[f]	Xanthine-8-C^{14}[c]	107	94	0
11	HP-1	Guanine-2-C^{14}[c]	110	106	99[g]
12	HP-1	Histidine-2-C^{14}[d]	0	2	65[g]

[a] See reference 5. [b] *A. aerogenes* mutant requiring guanine, adenine, hypoxanthine, xanthine or 4-amino-5-imidazole carboxamide. [c] Kindly supplied by Drs. G. B. Brown and M. E. Balis, Sloan-Kettering Institute, New York. [d] Unlabeled guanine added. [e] *A. aerogenes* mutant requiring guanine or 2,6-diaminopurine. [f] *E. coli* mutant requiring guanine or xanthine; spared by histidine. [g] Label located in position 2 of the imidazole ring.

The pathway of the conversion of guanine to adenine was explored by experiments with C^{14} labeled compounds (Table I). In strain PD-1 carbon 8 of exogenous guanine or xanthine is transferred to nucleic acid adenine without dilution (Expt. 1, 2), while carbon 2 of guanine contributes only 40% (Exp. 3). The methylene carbon of glycine, but not formate or CO_2, is incorporated into nucleic acid adenine when guanine is the purine source (Exp. 4, 6). Similar results are obtained in strain P-14, except that here some of the nucleic acid adenine is formed by synthesis *de novo*[5] (Exp. 7–9).

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(2) Abbreviations: IMP, inosine-5'-phosphate; DPN^+ and DPNH, oxidized and reduced diphosphopyridine nucleotide; XMP, xanthosine-5'-phosphate; ATP, adenosine triphosphate; GMP, guanosine-5'-phosphate; AMP, adenosine-5'-phosphate; PP, pyrophosphate.

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Carbon 2 of guanine and the methylene carbon of glycine are incorporated equally into nucleic acid adenine and into histidine (Exp. 3, 6, 9), suggesting that they enter a pool from which 1-carbon units are drawn for the biosynthesis of the precursors of purines and of histidine.[7]

This assumption gains support from the results obtained in mutant HP-1, a strain with an unusually high guanine requirement which is spared by histidine. Here carbon 2 of guanine is incorporated into adenine and into the amidine carbon of histidine without dilution (Exp. 10–12), indicating that it is the only available source of the 1-carbon units required for the formation of these compounds; it would seem that in this mutant the guanine requirement reflects a genetic block which prevents the production of these 1-carbon units from other sources.

The experiments presented here suggest that the conversion of guanine to adenine occurs through the replacement of the amino-substituted carbon 2 of guanine by a single carbon unit. An alternative possibility, the reduction of carbon 2 of guanine by a pathway not involving reactions (1) and (2) followed by interchange with single carbon units, is not rigorously excluded but appears less likely because it would not account for the equal incorporation of carbon 2 of guanine into adenine and histidine.

(7) The transfer of carbon 2 of guanine to the amidine carbon of histidine has recently been observed in *Lactobacillus casei;* C. Mitoma and E. E. Snell, *Proc. Nat. Acad. Sci.*, **41**, 891 (1955).

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AN INVESTIGATION OF THE CHLOROCARBON, $C_{10}C_{12}$, M.P. 485° AND THE KETONE, $C_{10}Cl_{10}O$, M.P. 349°

Sir:

A chlorocarbon, $C_{10}Cl_{12}$ (I), m.p. 485°, has been obtained from the reaction of 1,1,2,3,3,4,5,5-octachloropentene and aluminum chloride[1] and directly from hexachlorocyclopentadiene (II) by reaction with aluminum chloride in boiling methylene chloride or carbon tetrachloride.[1,2,3] When II was treated with sulfur trioxide, and the product hydrolyzed, a ketonic material, $C_{10}Cl_{10}O$ (III), m.p. 349°,[3] resulted. Compound III was originally thought to be perchloro-3a,4,7,7a-tetrahydro-4,7-methanoindene. When compound III was treated with phosphorus pentachloride, compound I was obtained.[3] It was initially thought that compound I was perchloro-3a,4,7,7a-tetrahydro-4,7-methanoindene (IV), the "Diels–Alder" dimer of compound II. Recently however, the Diels–Alder dimer (IV) of II has been prepared[4]; thus the compound described as compound I, m.p. 485°, is not the Diels–Alder dimer. The high m.p. of I contrasts sharply with that of IV, m.p. 221° and with 1,2,3,-3a,4,5,6,7,7a,8-decachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene (V), m.p. 215°, both of which give good yields of their respective monomers on thermal degradation. In contrast, the chlorocarbon (I) undergoes pyrolysis only at very high temperatures (500° or above) giving largely carbonaceous material and chlorine with only a small amount of II. Compound IV can be isomerized to I by aluminum chloride. Neither I nor III contain a carbon–carbon double bond. No addition of chlorine, bromine, or other reactive species has been noted. The infrared spectra of I and III, in contrast to the spectra of IV and V, showed no absorption in the 6–7 μ region where the carbon–carbon double bond is known to absorb unless a selection rule is in operation because of the presence of certain elements of symmetry in the molecule.[5] Ultraviolet absorption spectra are not subject to such selection rules. The ultraviolet spectrum of I contrasts sharply with the spectra of IV, 1,2,3,-4,5,6,7,7-octachlorobicyclo[2.2.1]hept-2-ene and octachlorocyclopentene which absorb in the region above 210 mμ, a characteristic of highly chlorinated cyclic monoenes and dienes.[6] The ketone III shows a maximum of 307 mμ which is ascribed to an unconjugated carbonyl group,[7] but no maxima in the "double bond" region. This is in contrast to the spectrum of octachloro-3a,4,7,7a-tetrahydro-7,7-methanoindene-1,8-dione, the structure of which has been established.[7]

Compound I is unaffected by the following: zinc dust and hydrochloric acid, acetic acid, or methanol; silver nitrate and ethanol for long periods; alkaline reagents such as potassium hydroxide in methanol or lithium aluminum hydride in ether; oxidizing agents such as ozone, potassium permanganate, chromic acid, sulfur trioxide, sulfuric acid, nitric acid or nitric acid with selenium. Compound III does not undergo the haloform reaction which would be expected for a dichloromethylene group adjacent to a carbonyl group. The presence of a bridged carbonyl is excluded by the fact that III does not lose carbon monoxide on heating to 200°. Compound III fails to exhibit olefinic properties. The presence of a reactive carbonyl group is demonstrated by the preparation of several hemi-ketals, thiohemiketals, and amine adducts. However, III fails to react with Caro's acid or hydrazoic acid. To meet the requirements of the formula $C_{10}Cl_{12}$ and, excluding the carbonyl double bond, $C_{10}Cl_{10}O$, the structures must contain six rings and/or double bond. Preliminary X-ray diffraction studies on I indicate a highly symmetrical molecule crystallizing in the cubic system or in an arrangement closely approximating the cubic system.

From the preceding evidence, aromatic systems, aliphatic olefins and acetylenes and alicylic olefins seem to be excluded. The only remaining possibility is a "caged" structure possessing a total of six saturated rings. On the basis of the informa-

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