prepared in this way from calf thymus DNA(I).[3] Light scattering, intrinsic viscosity and sedimentation data are contained in the table. When the

TABLE I

LIGHT-SCATTERING, VISCOSITY AND SEDIMENTATION DATA[a]

Sample	$M_w \times 10^{-6}$	$(\overline{r^2})^{1/2}$ Å.	$[\eta]$, 100 ml./g.	$S_{20,w}$
I (original DNA)	3.3	1420	40	26
III[b]	1.2	1000	8	11

[a] Determinations carried out in 0.2 M salt, 23°. Rotating cylinder viscometer used to determine $[\eta]$. A Spinco Model E ultracentrifuge equipped with ultraviolet optics was used for sedimentation data. [b] Obtained by passing DNA through atomizer eight times: rate of flow of solution, 0.2 cc./sec. (diameter of capillary, 0.015"); air pressure, 16 cm. (width of annular space, 0.013").

data for III are substituted into the equation for a flexible coil[4]

$$\frac{s[\eta]^{1/3}}{M^{2/3}} = 2.5 \times 10^6 \frac{(1 - \bar{v}\rho)}{\eta_0 N}$$

(where $\bar{v}$ is the partial specific volume of the solute, ρ the density of the solution, η_0 the viscosity of the medium and N Avogadro's number), the calculated value of the left side is 1.95×10^{-17}, which is in excellent agreement with the theoretical value (right side) of 1.99×10^{-17}. Since the DNA is nearly monodisperse (Sample III), application of the Peterlin theory[5] for non-Gaussian chains is justified. The persistence length is 620 Å., radius of gyration, $(\overline{r^2})^{1/2}$, is 980 Å. (compare 1000 Å. in the table), and the contour length is 6300 Å., which is nearly identical with the value calculated from the molecular weight and a spacing of 3.4 Å. between nucleotide pairs.

The stiffness of the molecule, the 40% hyperchromic effect and the retention of transforming activity[6] by similarly-treated pneumococcal DNA all show that these DNA samples are not "denatured"[7]; *i.e.*, the H-bonds are intact. It is probable that the low molecular weights result from covalent bond cleavage.

Sedimentation distributions similar to those in the figure have been obtained with pneumococcal DNA containing biological markers. There is partial loss of transforming activity incurred by the spraying procedure. Theoretical calculations (to be published soon) show that the loss can be correlated with the molecular weight change to give the size of the particular genetic marker. Such results, unlike those obtained from X-ray inactivation data, are unequivocal because of the near monodispersity of the product. Further, the size of the specific determinant can be distinguished from that of the non-specific matrix in which it resides. It should be emphasized that the mechanism of transformation may require a relatively large matrix, while the various genetic functions may be carried out by smaller units of varying size within the matrices.

SLOAN-KETTERING DIVISION
CORNELL UNIVERSITY MEDICAL COLLEGE
NEW YORK, NEW YORK LIEBE F. CAVALIERI

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THE PROTECTIVE ACTION OF CRUDE PETROLEUM FOR METAL-PORPHYRIN COMPLEXES EXPOSED TO GAMMA IRRADIATION

Sir:

In the course of a systematic study of the properties of porphyrin compounds, several samples of porphyrins and metal–porphyrin complexes in benzene solutions, and crude oils containing metal–porphyrin complexes were subjected to high dosages of gamma irradiation. An unexpectedly high "protective" action of crude petroleum was observed. Series of tests were made in which duplicate samples, sealed in glass ampoules, were exposed to dosages of 5×10^7 r. in 18.4 hours and 7×10^7 r. in 28.2 hours in the MTR Gamma Facility of the Phillips Petroleum Co. The results are summarized in Table I.

TABLE I

DECOMPOSITION OF PORPHYRIN MATERIALS BY GAMMA IRRADIATION

Material	Concentration (micromolal) Orig.	Final	Decomposition, %
Irradiation: 5×10^7 r.[a]			
Mesoetioporphyrin	124	~0	~100
Mesoporphyrin IX dimethyl ester	91.5	~0	~100
Copper–porphyrin complex (syn.)	26.3	3.1	88
Nickel–porphyrin complex (nat.)	17.3	3.9	77
Vanadium–porphyrin complex (nat.)	27.0	6.2	77
Petroleum, Okla.	345	330	4
Petroleum, Calif.	815	790	3
Asphalt, Okla. petroleum	1430	1380	3
Asphalt, Calif. petroleum	1560	1490	4
Irradiation: 7×10^7 r.[a]			
Vanadium–porphyrin complex (nat.)	16.3	<0.1	>99
Nickel–porphyrin complex (syn.)	29.8	<0.1	>99
Vanadium–porphyrin complex (syn.)	39.5	1.2	97
Vanadium–porphyrin complex (syn.)[b]	39.5	2.7	93
Vanadium–porphyrin complex (syn.)[c]	14.5	1.1	92
Vanadium–porphyrin complex (syn.)[c,d]	24.1	6.9	71
Petroleum, Okla.	345	305	12
Petroleum, Okla. (enriched with synthetic vanadium complex)	420	360	14

[a] Sealed under atmosphere of air unless otherwise indicated. [b] Ampoule sealed inside petroleum-containing ampoule. [c] Dehydrated, deaerated, sealed under vacuum or atmosphere of nitrogen. [d] Contained 5% propane-deasphalted Oklahoma petroleum.

No appreciable differences were observed among the stabilities of the synthetic vanadium– and nickel–porphyrin complexes and those actually isolated from petroleum. In view of the sensibly

complete destruction of the metal–porphyrin complexes, the durability of the porphyrin components of the crude oils and asphalts was unexpected. The data (footnote *b*) indicate that simple shielding by the petroleum is an insignificant factor as expected from the energy range of gamma radiation from spent fission products.[1] Crude petroleum may afford some protection against radiation-induced oxidation. However, the data (footnote *c*) indicate that the metal–porphyrin complexes are extensively decomposed even under anaerobic conditions. The metal–porphyrin complexes were separated from the petroleum by mild physical methods.[2] The possibility remained that the complexes in the petroleum were chemically different from those isolated. However, the enriched petroleum samples suffered essentially the same degree of decomposition as did the natural samples.

These data are interpreted as indicating that crude petroleum acts as a "protective" solvent for the metal–porphyrin complexes. Such action has been the subject of considerable research[3] but is only incompletely understood.[4] However, it appears that petroleum may be a natural protective agent against gamma irradiation by either of the commonly accepted mechanisms[5-6] in which it scavenges free radicals or provides an effective medium for internal energy transfer. The protective action of petroleum may have considerable practical importance in the development of nuclear engineering processes.

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U. S. DEPARTMENT OF THE INTERIOR
BUREAU OF MINES H. N. DUNNING
BARTLESVILLE, OKLAHOMA

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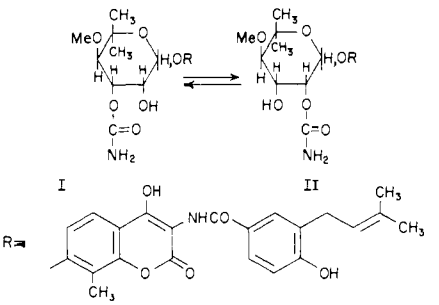
NOVOBIOCIN.[1] V. CARBAMYL MIGRATION AND ISONOVOBIOCIN

Sir:

The studies reported here show that novobiocin (I) isomerizes to isonovobiocin (II) in dilute alkali and establish the structure of II as 4-hydroxy-3-[4-hydroxy-3-(3-methyl-2-butenyl)-benzamido]-8-methyl-2-oxo-2*H*-1-benzopyran-7-yl 2-*O*-carbamyl-4-*O*-methyl-5,5-dimethyl-L-lyxoside.

When a solution of novobiocin was held at *p*H 10 for 2 hours at 25°, statistically significant bioassays indicated a loss of 30–35% of its antibiotic activity. The amorphous acid which was isolated was indistinguishable from *amorphous* I by ultraviolet measurements, elemental analyses and specific rotation. The amorphous nature of the material impaired infrared comparison, but no interpretable differences were detected. This ap-



parently homogeneous material was partially resolved, however, by countercurrent distribution into 2 main components after 2000 transfers using a solvent system comprising water, acetone, methyl ethyl ketone, and Skellysolve B (3:9:2:6 by volume). Analysis of the distribution data[2] showed the mixture contained *ca.* 67% of I and *ca.* 33% of a new material. This inactive component, very similar in physical properties to I, was named isonovobiocin.

When pure II was subjected to the original isomerization conditions, it was converted back to I in 55–60% yields. An equilibrium was thus indicated. Since no spectral changes were detected, it seemed most likely that the sugar moiety was involved.

The material used for the structure determination of II was obtained as follows: With the knowledge gained from the initial countercurrent distribution experiment a fractional crystallization procedure was developed to remove most of I from the equilibrium mixture. The remaining mixture was separated by countercurrent distribution (2000 transfers) and found to contain about 65% II, 22% I, and 13% sodium chloride and unidentified materials.

The purified isonovobiocin was heated under reflux in methanol containing a slight excess of one equivalent of acetyl chloride,[3] cleaving the molecule selectively to crystalline novobiocic acid (IV) in 98% yield and the methyl glycoside (III). The novobiocic acid was identical with that obtained from I by infrared, ultraviolet and melting point comparisons.

Compound III, crystallized from acetone and Skellysolve B, was found to be isomeric with methyl 3-*O*-carbamyl novioside[Ia,3] (calcd. for $C_{10}H_{19}NO_6$: C, 48.19; H, 7.68; N, 5.62. Found: C, 48.46; H, 7.59; N, 5.54). It was different on the basis of infrared absorption. Barium hydroxide at 25° converted III to methyl novioside (V)[Ic,3] in 96% yield, showing that III differed from methyl 3-*O*-carbamylnovioside only in the position of the carbamyl group. Acid hydrolysis of III yielded an

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