B_{12} in promoting growth of *Lactobacillus lactis* and *Lactobacillus leichmanni;* however, these desoxyribosides do not replace this vitamin in reversing the toxicity of sulfanilamide for *Escherichia coli* under conditions such that methionine synthesis is the limiting factor for growth.[3] In the present investigation the phosphorylated derivatives of the desoxyribosides have been found to be approximately as effective as the desoxyribosides for the Lactobacilli. Also, the desoxynucleotides (100 γ per 10 cc.) are inactive for *Escherichia coli* under the conditions for assay of vitamin B_{12}.[3] Desoxycytidylic acid frequently stimulated greater early growth of the lactobacilli than did the other desoxynucleotides. This suggests the possibility that desoxycytidylic acid is more closely related to the immediate product of the functioning of vitamin B_{12} in the biosynthesis of desoxyribosides than are the other desoxynucleotides; however, the delay in obtaining a maximal response with certain desoxynucleotides, particularly desoxyadenylic acid and thymidylic acid, may be the result of the inhibitory activity of these compounds on related systems.

Although vitamin B_{12} is approximately 10,000 to 30,000 times as effective as the desoxynucleotides in stimulating growth of the lactobacilli in test-tubes, the effect of the desoxynucleotides cannot be accounted for on the basis of contamination with vitamin B_{12}, because the desoxynucleotides are inactive in the *Escherichia coli* assay, are, relative to vitamin B_{12}, more effective in plate assays than in tube assays with the lactobacilli, and migrate differently on paper chromatograms.

On paper chromatograms in several different solvents the desoxynucleotides were found to move much more slowly than the corresponding desoxyribosides. Since the R_f values for these phosphorylated compounds fall within the range of those for vitamin B_{12}, these substances may give abnormally high values when the vitamin B_{12} content of natural materials is determined by paper chromatographic methods.

The results of the studies are indicated in Table I.

TABLE I

REPLACEMENT OF VITAMIN B_{12} BY DESOXYNUCLEOTIDES

Supplements	Quantity γ per 10 cc.	Ri[a] Value	Galvanometer readings[b] *Lactobacillus leichmanni*	Galvanometer readings[b] *Lactobacillus lactis*	Plate method[c] *Lactobacillus lactis*
None			4	3.5	13.2
Vitamin B_{12}	0.0001	0.17–0.29	27	28	
	.0002		41	41	
	.0005		55	60	
	.001		62	70	
	.002				15.8
	.005				17.6
	.01				20.3
	.02				22.7
	.05				25.2
Desoxycytidylic acid	.3	.14–0.16	11	8	
	1		22	22	19.7
	3		44	52	23.4
	10		56	73	27.8
Desoxythymidylic acid	0.3	.21–0.29	7.5	7	
	1		17	12	18.7
	3		33	29	22.6
	10		53	39	26.8
Desoxyguanylic acid	0.3	.12–0.16	12	9	
	1		22	30	20.2
	3		43	47	24.5
	10		56	73	28.5
Desoxyadenylic acid	0.3	.16–0.23	10	6	
	1		23	19	20.4
	3		38.5	41	24.0
	10		52	61	27.9
5-Methyldesoxycytidylic acid	0.3	.10–0.18	10	11	
	1		21	24	
	3		35	44	
	10		50	60	
Thymidine	0.3	.73–0.88	14	9	
	1		26	19	19.4
	3		45	40	24.6
	10		54	65	28.5

[a] Paper chromatographs with 2,6-lutidine. [b] A measure of culture turbidity; distilled water reads 0, an opaque object, 100. [c] Diameter of zones of growth in mm. Paper disc is 13.1 mm. in diameter.

Experimental

The desoxynucleotides used in this work were kindly supplied by Drs. Waldo E. Cohn[7] and C. E. Carter.

The organisms used in this work were *Lactobacillus leichmanni* 313 and *Lactobacillus lactis* Dorner 8000.

The tube assays were carried out on either the medium described by Shive, *et al.*,[2a] and Wright, *et al.*,[2b] or a modification of the medium described by Caswell, Koditschek and Hendlin.[8] In the latter case, two grams of Tween 80 per liter of final medium was added, and the phosphate content was increased. The organisms responded equally well on either medium, but that of Caswell, *et al.*,[8] was used preferentially because of its definite chemical composition.

For the plate assays, 10-cc. portions of the above sterilized medium containing 2% agar and inoculated with *Lactobacillus lactis* were poured into sterile Petri dishes and allowed to harden. A 13.1 mm. disc of filter paper was laid with forceps on the hardened medium, and an aliquot (an amount just sufficient to moisten the entire disc) of the proper dilution of each substance to be tested was delivered to the paper disc from a special pipet delivering a constant volume of 0.1 cc. Four different dilutions were usually assayed on each plate. After the plates were incubated for 16 hours at 37°, diameters of zones of growth were determined.

The capillary ascent method of Williams and Kirby[9] was employed for the paper chromatograms, 65% 2,6-lutidine being the solvent used. The resulting filter paper strips were dried and placed on a hardened agar medium identical with that used for the plate assays. After 15 to 30 minutes the paper strips were removed and the plates were incubated for 16 hours at 37°. The R_f values were calculated from the position of the zones of growth.

(7) Volkin, Khym and Cohn, unpublished work, Oak Ridge National Laboratory.

(8) Caswell, Koditschek and Hendlin, *J. Biol. Chem.*, **180**, 126 (1949); Shorb, *Science*, **107**, 397 (1948).

(9) Williams and Kirby, *Science*, **107**, 481 (1948).

THE BIOCHEMICAL INSTITUTE AND THE
DEPARTMENT OF CHEMISTRY
THE UNIVERSITY OF TEXAS, AND THE
CLAYTON FOUNDATION FOR RESEARCH
AUSTIN, TEXAS

RECEIVED AUGUST 8, 1950

The Mutual Solubility of Mercury and Gallium

BY WILLIAM M. SPICER AND HENRY W. BARTHOLOMAY

Little is known about the mutual solubility of gallium and mercury. Ramsay[1] in a study of the

(1) W. Ramsay, *J. Chem. Soc.*, **55**, 521 (1889).

molecular weights of metals dissolved gallium in boiling mercury to the extent of 0.7855%. However, he did not attempt to determine the solubility. Puschin, Stepanovic and Stajic[2] investigated the mutual solubilities by means of freezing point lowering and concluded that the metals are at their freezing points either insoluble or very slightly soluble in one another. Davies and Keeping,[3] in a study of the magnetic susceptibility of some amalgams, made an amalgam containing 0.2436% gallium at 18.9°. Gilfillan and Bent,[4] on the basis of freezing point lowering, concluded that at the freezing points the solubility of gallium in mercury is about 0.13%, while that of mercury in gallium is immeasurably small.

In view of the uncertainty in these data, it was decided to determine the mutual solubilities at 35° and at 100° by the following direct method: The liquids were mixed and allowed to equilibrate. Weighed samples were removed from each layer and the gallium dissolved out by hydrochloric acid. The remaining mercury was weighed. Our results indicate that the solubilities are considerably greater than had been thought.

Experimental.—The gallium was obtained from the Aluminum Co. of America and was said to be better than 99.95% gallium. This high purity was confirmed by qualitative spectrographic analysis. The mercury was purified by washing with nitric acid and water, drying and distilling.

Gallium wets glass and oxidizes rapidly when exposed to air. It was found, however, that when it is placed under a weakly acidic (with HCl) solution of gallium chloride its surface apparently remains free of oxide and it no longer wets glass. It was felt that the presence of this film of oxide may have caused previous investigators to obtain low results for the solubility. Therefore, the gallium was always kept under such a solution.

Weighed portions of the metals (approximately 3.5 g. Ga and 7.0 g. Hg) were placed in a glass tube under the gallium chloride solution and allowed to equilibrate, with frequent shaking, in a bath maintained at constant temperature.

The interface between the two phases could not be seen. In order to locate it, a steel shot of somewhat smaller diameter than the tube was added and forced to the bottom of the mixture of metals by means of a small glass rod. When released the shot rose to what was assumed to be the interface. That the shot would stop at the interface is reasonable in view of the densities which are: Hg = 13.6, Fe = 7.5 and Ga = 5.9.

Several small samples were taken from each layer and weighed. (Samples were removed from the lower mercury-rich layer through a stopcock on the lower end of the tube, and from the upper layer by means of a pipet.) To these, concentrated HCl was added to dissolve the gallium. As soon as all of the gallium had dissolved as indicated by the discontinuance of gas evolution, the solution was decanted from the mercury, which was quickly dried with filter paper and reweighed. Gallium reacts only slowly with hydrochloric acid and the gallium-rich samples required several days for complete reaction even when heated on a water-bath. In spite of this long time, that no mercury dissolved was proved by spectrographic analysis of the acid solution.

Furthermore, the validity of the method of analysis was demonstrated by applying it to a mercury–gallium mixture of known composition.

The results are given in Table I. In order to eliminate the possibility that the metals were simply dispersed in one another, two of the determinations were made after the metals had stood in contact for approximately two months. These are indicated in the table by an asterisk.

(2) N. A. Puschin, S. Stepanovic and V. Stajic, *Z. anorg. Chem.*, **209**, 329 (1932).

(3) W. G. Davies and E. S. Keeping, *Phil. Mag.*, [7] **7**, 145 (1929).

(4) E. S. Gilfillan, Jr., and H. E. Bent, THIS JOURNAL, **56**, 1661 (1934).

TABLE I

LIQUID–LIQUID EQUILIBRIA DATA FOR THE SYSTEM GALLIUM MERCURY

Run no.	Layer rich in	Wt. of sample, g.	Wt. of mercury, g.	Hg, %	Ga, %
		At 35°			
1	Hg	0.4671	0.4615	98.8	1.2
2	Hg	.4659	.4594	98.6	1.4
3	Hg	.4083	.4036	98.8	1.2*
4	Hg	.7873	.7774	98.7	1.3*
5	Ga	.3138	.0189	6.0	94.0
6	Ga	.2022	.0135	6.7	93.3
7	Ga	.3687	.0241	6.6	93.4*
8	Ga	.1007	.0067	6.7	93.3*

Average: mercury-rich layer, 98.7% Hg; gallium-rich layer, 6.5% Hg. In terms of atom per cent.: solubility of gallium in mercury is 3.6% and solubility of mercury in gallium is 2.0%.

		At 100°			
1	Hg	0.8370	0.8258	98.6	1.4
2	Hg	.8200	.8090	98.6	1.4
3	Hg	.8518	.8400	98.6	1.4
4	Ga	.2133	.0183	8.5	91.5
5	Ga	.2944	.0250	8.5	91.5
6	Ga	.5042	.0443	8.8	91.2

Average: mercury-rich layer, 98.6% Hg; gallium-rich layer, 8.6% Hg. In terms of atom per cent.: solubility of gallium in mercury is 3.9% and solubility of mercury in gallium is 3.2%.

In view of the small increase in solubility with temperature, it is doubtful that a critical solution temperature exists in this system at one atmosphere pressure.

The low mutual solubilities of these metals are not surprising in view of the large difference in their internal pressures. Taking the boiling point of gallium as 2300°K. as given by Harteck[5] and using the Hildebrand rule[6] for estimating internal pressures one computes 38,800 atm. for mercury and 196,000 atm. for gallium.

(5) P. Harteck, *Z. physik. Chem.*, **134**, 1 (1928).

(6) J. H. Hildebrand, "Solubility of Non-Electrolytes," second edition, Reinhold Publishing Corp., New York, N. Y., 1936, p. 103.

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA RECEIVED SEPTEMBER 5, 1950

Some Fluorine Containing Isosteres of Sulfa Drugs

BY AUGUST SVEINBJORNSSON AND CALVIN A. VANDERWERF

Investigation of the effect on the chemotherapeutic properties of various medicinals produced by the substitution of fluorine atoms for other groups in the molecule has been extended by the herein reported study of the synthesis and bacteriostatic action of a number of analogs of familiar sulfa drugs in which the amino group is replaced by the isosteric fluorine atom. Several *p*-fluorobenzamides have also been synthesized, as compounds of considerable interest from a bacteriological standpoint because of their relationship to *p*-aminobenzoic acid.

Experimental

***p*-Fluorobenzenesulfonamide.**—This compound, m.p. 123.1–124.0°, was prepared in 92% yield from *p*-fluorobenzenesulfonyl chloride and ammonia.

2-(*p*-Fluorobenzenesulfonamido)-pyrimidine.—To a 125-ml. conically shaped flask, equipped with a mechanical