water. The dichloromethane extract was dried over sodium sulfate, filtered, and evaporated to dryness. The residue was purified by chromatography on silica gel using benzene–ethyl acetate (1:1) as eluent. The main zone was crystallized from hexane: mp 131–132°; $[\alpha]^{22}D$ +8.8° (*c* 2.2, chloroform); τ^{CDCl_3} 4.28 (d, H-1, $J_{1,2}$ = 4.0 Hz), 5.5 (two d, H-2, $J_{1,2}$ = 4.0 Hz, $J_{2,3}$ = 1.5 Hz), 6.5 (2 H, CH_2N), 7.5 (m, H-3).

Anal. Calcd for $C_{15}H_{22}NO_6F_3$: C, 48.78; H, 5.97; N, 3.79. Found: C, 48.65; H, 6.09; N, 3.84.

Attempted Reduction of 3-*C*-Carbamoyl-3-deoxy-1,2:5,6-di-*O*-isopropylidene-α-D-glucofuranose (2).—The amide **2** was subjected to lithium aluminum hydride reduction and the product was treated with trifluoroacetic anhydride and pyridine according to the same procedure as described above. Chromatographic (tlc) examination of the product showed a complex mixture of products which could not be separated. Pmr of the impure main fractions indicated that the sugar moiety had changed.

Photohydroxyalkylation of 3-Deoxy-1,2:5,6-di-*O*-isopropylidene-α-D-erythro-hex-3-enose (1) to Yield Compounds 4 and 6.—A solution of **1** (4.0 g) in isopropyl alcohol (200 ml) and acetone (100 ml) was irradiated for 26 hr through a Pyrex filter. The product was worked up as described previously and then chromatographed on a silica gel comumn (1000 g) using benzene–ethyl acetate (1:3 to 2:1) as developer. The fastest moving zone **6** (0.500 g, 8%) was followed by a zone consisting of a mixture of compound **4** (1.59 g, 31%) and pinacol (1.0 g). The latter two compounds were separated by distillation at 0.1 mm and 100°. The pinacol was compared with an authentic sample of pinacol and shown to be identical (ir spectrum).

3-Deoxy-3,4-*C*-bis(1-hydroxy-1-methylethyl)-1,2:5,6-di-*O*-isopropylidene-α-D-gulofuranose (6).—Product **6** was recrystallized from benzene–hexane (1:9): mp 174–175° (crystal form changes at 147–149° from prisms to needles); $[\alpha]^{22}D$ +73° (*c* 1, chloroform); mass spectrum *m/e* 360 and 345 (M − CH_3) (calcd *m/e* 360); ir (0.005 and 0.001 *M* in CCl_4) 3623 (sharp intense peak due to free OH), 3458 cm^{-1} (intense broad peak); τ^{CDCl_3} 4.09 (d, H-1, $J_{1,2}$ = 4.5 Hz), 5.01 (two d, H-2, $J_{2,1}$ = 4.5 Hz, $J_{2,3}$ = 7.0 Hz), 5.62–6.1 (H-5 and H-6), 6.3–6.85 (broad OH peaks, disappear on addition of D_2O), 7.05 (d, H-3, $J_{3,2}$ = 7.0 Hz), 8.38, 8.46, and 8.50 (3-Me), 8.60 and 8.63 (4-Me), 8.86 (1-Me) (irradiation at τ 5.0 collapsed the doublets at 4.09 and 7.05 to singlets).

Anal. Calcd for $C_{18}H_{32}O_7$: C, 59.98; H, 8.95. Found: C, 59.68; H, 9.30.

Registry No.—**1**, 10368-85-1; **2**, 34289-95-7; **3**, 34289-96-8; **4**, 34297-59-1; **6**, 34289-97-9; **7**, 34289 98-0.

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Nucleosides. XIII.[1] Synthesis and Interconversions of *C*-Methyl-Branched 1-(3-Amino-3-deoxy-β-D-hexopyranosyl)uracils. An Empirical Method for Configurational Assignments at the Branch Point by Nuclear Magnetic Resonance[2]

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C-Methyl-branched 3′-nitrohexosyl uracils of gluco, galacto, manno, and allo configuration (**4–7**) were prepared from uridine by treatment with metaperiodate and subsequent base-catalyzed cyclization with nitroethane. Hydrogenation afforded the title compounds **12–15** which were further characterized as the *N*-acetyl (**20–22**) and the fully acetylated derivatives (**16–19**). While coupling patterns of the ring protons readily provided configurational proof for the arrangement of the hydroxyl groups at C-2′ and C-4′, the stereochemistry at the branch point was established chemically by conversion of the *gluco*-*N*-acetate **20** into derivatives of manno (**22**) and galacto configuration (**33**) in a series of reactions which involved as decisive steps a displacement *via* oxazolines of mesyl functions, introduced at C-2′ and C-4′, respectively. In the gluco → manno conversion, both intermediates possible, the O²,2′ cyclonucleoside **28** and the 2′,3′-oxazoline **29**, were isolated and their structures established by chemical and spectroscopical means. Tertiary acetoxy and acetamido resonances at a *C*-methyl branch, as compared to their secondary counterparts, are shifted toward higher field by about 0.1 ppm in $CDCl_3$ or in DMSO-d_6. This provides a facile and surprisingly accurate means for determining configurations at the tertiary center of *C*-methyl-branched cyclitol and pyranose peracetates.

Branched-chain sugar nucleosides, which were virtually unknown prior to 1966, have since attained considerable chemical interest,[3–10] no doubt mainly evoked by the cytotoxic and antiviral activities of some compounds of this type.[3] The prevailing synthetic route[3–10] consisted in linking nucleobase and branched-chain sugar *via* standard procedures of nucleoside synthesis, an approach which is encumbered by the still limited availability of branched-chain sugars and by certain unsuccessful attempts[11] to convert them into nucleosides. As an alternate approach toward the synthesis of branched-chain sugar nucleosides, we exploited the applicability of the dialdehyde–nitroalkane

(1) (a) For paper XII see J. Černá, F. W. Lichtenthaler, and I. Rychlík, *FEBS (Fed. Eur. Biochem. Soc.) Lett.*, **14**, 45 (1971). (b) Simultaneously taken as paper XVIII of the series "Nitromethane Condensations with Dialdehydes." Part XVII: F. W. Lichtenthaler and N. Majer, *Tetrahedron Lett.*, 411 (1969).

(2) Taken in part from the Doctoral Dissertation of H.Z., Technische Hochschule Darmstadt, June 1969. (b) Financial support of this work by the Deutsche Forschungsgemeinschaft and the Fonds der Chemischen Industrie is gratefully acknowledged. (c) A preliminary account of this work has appeared: F. W. Lichtenthaler and H. Zinke, *Angew. Chem.*, **78**, 774 (1966); *Angew. Chem., Int. Ed. Engl.*, **5**, 737 (1966).

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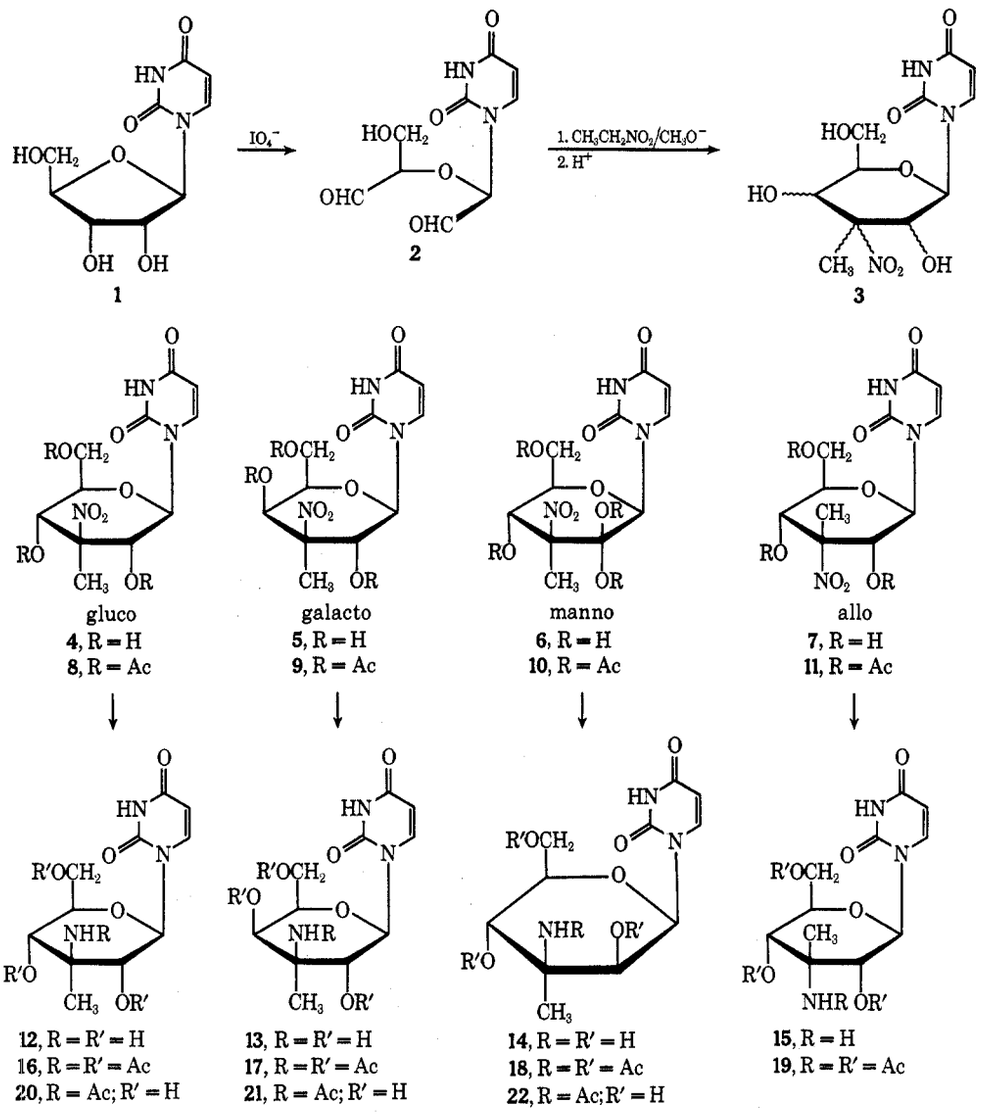
(10) H. Yanagisawa, M. Kinoshita, S. Nakada, and S. Umezawa, *Bull. Chem. Soc. Jap.*, **43**, 246 (1970).

(11) A. Rosenthal, K. S. Ong, and D. Baker, *Carbohyd. Res.*, **13**, 113 (1970); A. Rosenthal and M. Sprinzl, *Can. J. Chem.*, **48**, 3253 (1970).



cyclization[12] to "nucleoside dialdehydes." If feasible, this would allow one to start from readily available ribo nucleosides and would simultaneously introduce a nitro (and thus amino) group and an alkyl branch into the sugar portion of the molecule. In this paper, we report the details[2c] of the reaction of 2-*O*-[(*R*)-formyl-(1-uracilyl)methyl]-(*R*)-glyceraldehyde (**2**) ("uridine dialdehyde") with nitroethane and of entailing studies which were required to unequivocally establish the configurations at the branch point of the products formed.

When **2**, obtained by oxidation of uridine (**1**) with sodium metaperiodate, is allowed to react with nitroethane–sodium methoxide in methanol (6 hr, 25°) followed by deionization of the reaction mixture with an acidic resin, a crystalline mixture of cyclization products **3** is obtained in a yield of 80%.[13] Thin layer chromatography revealed the presence of one major and three minor compounds, together with traces of two other substances. By combination of fractional recrystallizations from several solvents and column chromatography separation was achieved. The main product, 1-(3-deoxy-3-*C*-methyl-3-nitro-β-D-glucopyranosyl)uracil (**4**), is obtained in 40% yield, whereas the minor components, having galacto (**5**), manno (**6**), and allo configuration (**7**), are isolated in yields of 5, 5, and 1%,[13] respectively. Though these yields are preparative, they rather concisely reflect the composition of the cyclization mixture **3**.

The nitro sugar nucleosides **4**–**7** were readily converted into 2′,4′,6′-tri-*O*-acetates **8**–**11** by acid-catalyzed acetylation; their hydrogenation over Raney nickel in aqueous methanol afforded the corresponding 1-(3-amino-3-deoxy-3-*C*-methyl-β-D-hexopyranosyl)uracils **12**–**15** in yields of 70–90%, which were further characterized by their tetraacetyl derivatives **16**–**19** and, except for the allo compound, by their *N*-acetyl compounds **20**–**22**.

The stereochemistry at C-2′ and C-4′ of each of these nucleosides was deduced from the coupling patterns of the ring protons which are best resolved in the nitrotri-*O*-acetates **8**–**11** and in the corresponding tetraacetyl derivatives of the amino compounds **16**–**19** (*cf.* Table I).

In the gluco series (**8** and **16**) large couplings of 9–10 Hz are exhibited by each of the doublets obtained for H-1′, H-2′, and H-4′, and clearly indicate their axial orientation. In the galacto derivatives **9** and **17**, H-4′ gives rise to a 2-Hz doublet as expected from a 4′e,5′a

(12) For a recent review, see F. W. Lichtenthaler, *Fortschr. Chem. Forsch.*, **14**, 556 (1970).

(13) Yields given are based on uridine (**1**).

TABLE 1
NMR ASSIGNMENTS[a,b]

Series	Compd	Solvent	Uracil NH	H-6[c]	H-5[c]	3′-NH	H-1′ ($J_{1',2'}$)	H-2′	H-4′ ($J_{4',5'}$)	OAc	NHAc	3′-CH_3
gluco	8	$CDCl_3$	0.51	2.56	*d*		*d*	*d*	*d*	7.93, (2), 8.02		8.11
	16	$CDCl_3$	0.50	2.49	4.21	4.51	3.75 (9)	4.12	3.99 (10)	7.90, 7.93, 7.99	8.15	8.53
		DMSO-d_6	−1.36	2.58	4.26	2.62	3.78 (9)	4.16	4.05 (10)	7.96, 8.00, 8.06	8.33	8.66
galacto	9	$CDCl_3$	0.49	2.64	*e*		*e*	*e*	4.41 (2)	7.86, 7.96 (2)		8.05
	17	$CDCl_3$	0.53	2.73	4.19	?	4.00 (9)	4.92	?	7.83, 7.91, 7.96	8.16	8.22
		DMSO-d_6	−1.26	2.63	4.35	2.59	4.15 (9)	4.98	4.49 (2)	7.89, 8.02, 8.05	8.29	8.32
manno	10	$CDCl_3$	0.47	2.75	4.36		4.09 (2)	4.18	4.40 (10)	7.87, 7.91, 8.02		8.05
	18	$CDCl_3$	0.56	2.73	4.40	4.05	3.81 (2)	4.17	5.00 (10)	7.82, 7.91, 7.96	8.19	8.25
		DMSO-d_6	−1.30	2.70	4.50	2.90	4.06 (2)	4.41	5.05 (10)	7.91, 7.98 (2)	8.29	8.31
allo	11	$CDCl_3$	0.99	2.62	4.18		3.30 (9)	4.77	4.65 (10)	7.90, 7.92, 7.96		8.40
	19	$CDCl_3$	0.07	2.59	4.20	3.85	3.73 (9)	5.01	4.98 (10)	7.90, 7.93 (2)	7.95	8.36
		DMSO-d_6	?	2.09	4.34	2.71	3.81 (9)	4.80	4.93 (10)	7.94, 7.99, 8.02	8.06	8.51

[a] Chemical shifts are expressed in parts per million (τ scale) from tetramethylsilane as an internal standard. [b] H-5′ and C-6′ CH_2, not listed in Table I, generally appear as complex 3 H multiplets in the region of τ 5.6–6.1. [c] Obtained as doublets with $J_{5,6}$ = 7–8 Hz. [d] 4 H multiplet at τ 4.1–4.4. [e] 3 H multiplet centered around τ 4.08.

arrangement, whereas the 1′a,2′e orientation in the manno compounds **10** and **18** gives rise to doublets with small couplings ($J_{1',2'}$ = 2 Hz) for H-1′ and H-2′. The allo derivatives **11** and **19**, being C-3′ epimers of the corresponding gluco compounds, expectedly exhibit the same coupling features as **8** and **16** ($J_{1',2'}$ = 9 and $J_{4',5'}$ = 10 Hz); yet there are characteristic differences in the chemical shifts of the ring protons at C-2′ and C-4′. For example, when going from the gluco compound **16** to its C-3′ epimer **19** of allo configuration, the chemical shift of H-1′ remains virtually constant in the two solvents measured, whereas considerable upfield shifts are observed for H-2′ (by 0.89 ppm in $CDCl_3$ and 0.64 ppm in DMSO-d_6) and H-4′ (0.99 and 0.75 ppm, respectively). This effect must be entirely due to the different steric arrangement at C-3′, *i.e.*, the anisotropy of the nitro group, which in an equatorial arrangement (gluco configuration) will exert a quite different shielding on vicinal axial protons than when oriented axially as in the allo derivatives.

The configurational assignments at C-2′ and C-4′ are supported by the chemical shifts of the acetoxy resonances (*cf.* Table I), which nicely comply with the empirical principles laid down in the "acetyl resonance rule" for cyclitols,[14] carbohydrates,[15] and hexopyranosyl nucleosides.[15] Thus, the gluco and allo derivatives show no acetyl resonances below τ 7.90, whereas in the galacto compounds **9** and **17** one of the *O*-acetyl signals appears at lower field (τ 7.83 and 7.86 in $CDCl_3$; τ 7.89 in DMSO-d_6) clearly falling into the range for axial acetoxy groups, in accord with all other polyacetyl galactopyranosyl nucleosides known.[16,17] Similarly, the manno derivatives show one acetoxy resonance at lower field, which can be attributed to the *O*-acetyl group at C-2′.

Configurational Assignments at the *C*-Methyl Branch by Chemical Means.—At present, all of the cyclic compounds bearing a *C*-methyl branch and an amino function at the same ring carbon atom, have been prepared *via* dialdehyde–nitroethane cyclization followed by hydrogenation.[19–22] It might be surmised from the steric course of the cyclizing additions of nitromethane onto dialdehydes[21] that, here too, the nitro group will preferentially adopt the equatorial orientation in the cyclization step rather than the less bulky methyl substituent. However, no rigorous chemical proof has been advanced concerning the configuration at the branch point. Since hydroxyl functions, when situated trans to an adjacent acetamido group, can be inverted stereospecifically *via* oxazoline intermediates, a procedure which has found extensive use in the field of aminocyclitols,[23] amino sugars,[24] and amino sugar nucleosides,[25,26] it seemed appropriate to utilize this method for firmly establishing the stereochemical relationships between the *C*-methyl branch and its vicinal OH functions.

Inversion at C-2′.—For the synthesis of the 2′-*O*-mesylate **24** required for displacement reactions at C-2′, the *N*-acetate **20** was converted to the 4′,6′-*O*-benzylidene derivative **23** by treatment with benzaldehyde–zinc chloride, in which the remaining hydroxyl group is subsequently mesylated to give **24**. When allowed to react with sodium acetate in refluxing 2-methoxyethanol–water (9:1) for 3 days, **24** yields an approximate 1:1 mixture of the 4′,6′-*O*-benzylidene-*manno*-*N*-acetate (**26**) and its de-N-acetylated derivative **25** separable by fractional crystallization in moderate yields (15 and 23%, respectively). The structure and configuration of **25** were ascertained by N-acetylation to **26** with acetic anhydride in methanol. Compound **26** was proved to be of manno configuration by its non-

(14) F. W. Lichtenthaler and P. Emig, *Carbohyd. Res.*, **7**, 121 (1968).
(15) F. W. Lichtenthaler, G. Bambach, and P. Emig, *Chem. Ber.*, **102**, 994 (1969).
(16) F. W. Lichtenthaler, G. Bambach, and U. Scheidegger, *ibid.*, **102**, 986 (1969).
(17) Findings by Cushley, *et al.*,[18] that the axial C-4′-acetoxy resonance of 1-(3-acetamido-3-deoxy-2,4,6-tri-*O*-acetyl-β-D-galactopyranosyl)uracil and its 5,6-dihydrouracil derivative appear in the equatorial range (τ 8.03 and 8.11, respectively), have been shown[16] to be incorrect.
(18) R. J. Cushley, K. A. Watanabe, and J. J. Fox, *J. Amer. Chem. Soc.*, **89**, 394 (1967).
(19) H. H. Baer and G. V. Rao, *Justus Liebigs Ann. Chem.*, **686**, 210 (1965).
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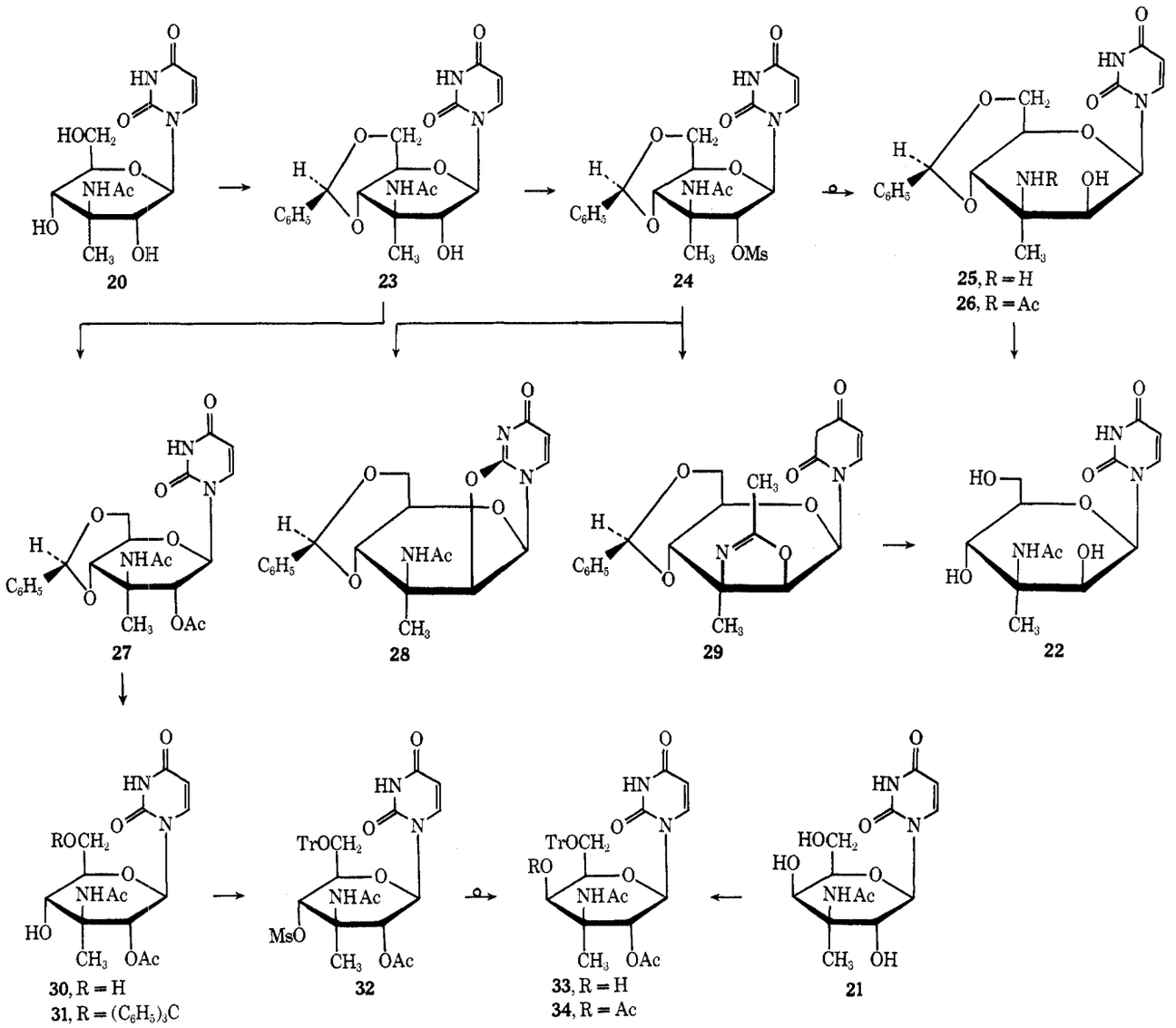
(23) F. W. Lichtenthaler, *Chem. Ber.*, **94**, 3071 (1961); **96**, 2047 (1963).
(24) (a) B. R. Baker, *Methods Carbohyd. Chem.*, **2**, 444 (1963); A. C. Richardson and H. O. L. Fischer, *J. Amer. Chem. Soc.*, **83**, 1132 (1961). (b) D. H. Buss, L. Hough, and A. C. Richardson, *J. Chem. Soc.*, 5295 (1963); W. Meyer zu Reckendorf, *Chem. Ber.*, **97**, 325 (1964).
(25) B. R. Baker and R. E. Schaub, *J. Amer. Chem. Soc.*, **77**, 2396, 5900 (1955); F. J. McEvoy, M. J. Weiss, and B. R. Baker, *ibid.*, **82**, 205 (1960); F. W. Lichtenthaler, T. Nakagawa, and J. Yoshimura, *Chem. Ber.*, **100**, 1833 (1967); F. W. Lichtenthaler, P. Emig, and D. Bommer, *ibid.*, **102**, 971 (1969).
(26) K. A. Watanabe and J. J. Fox, *J. Org. Chem.*, **31**, 211 (1966).



identity with **23**, by its nmr data, exhibiting the anomeric proton at τ 4.36 as a 3-Hz doublet, and by its conversion on acidic de-O-benzylidenation to a product, identical in all respects with compound **22**, obtained from the manno derivative **14** on N-acetylation. However, since displacement of the sulfonyloxy group in **24** can occur either with participation of the nucleobase *via* the cyclonucleoside **28**, or with participation of the acetamido group through the oxazoline **29**, the origination of **25** and **26**, and hence the steric relationship between C-2′ and the branch point, cannot be deduced unequivocally from these results. Yet, when modifying the de-O-mesylation conditions to sodium ethoxide–95% 2-methoxyethanol (80 hr, 130°),[27] a mixture of four products is obtained, from which, aside from **25** and **26** (15 and 38%), both of the intermediates **28** and **29** can be isolated in yields of 11 and 15%, respectively.

The structure of the O²,2′ cyclonucleoside **28** was shown by its conversion, on hydrolysis, to the *manno-N*-acetate **26**, and by spectral data. The ultraviolet spectrum of **28** in methanol displayed two maxima (227 and 242 nm) as required for a cyclonucleoside of this type;[28] in the nmr spectrum of **28** in DMSO-d_6, which except for the 3′-*C*-methyl group is highly reminiscent of the one observed for the unbranched analog of **28**,[26] the anomeric proton and H-2′ are easily identified as 3-Hz doublets at τ 3.96 and 4.53, respectively, whereas the amide hydrogen is obtained as a singlet at τ 1.86.

The structure of **29**, which represents the first example of an oxazoline in the hexosyl nucleoside area, was based on the distinct absence of NH stretching and amide II absorption at 3300–3100 and 1540 cm^{-1}, respectively, on a uv maximum at 260 nm, convincingly corresponding to an intact uracil moiety, and on the nmr spectrum in DMSO-d_6, exhibiting the expected features, *e.g.*, a singlet for the uracil NH at τ −1.49. As **28**, the methyl oxazoline is converted to *manno-N*-acetate **26** on hydrolysis.

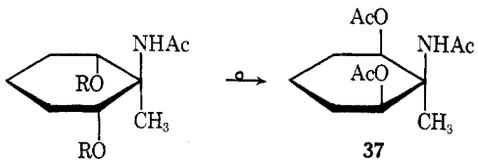
These results clearly demonstrate the trans arrangement of C-2′ OH and C-3′ NH_2 groups in **12** and its ensuing products and firmly establish that **14** and its derivatives are C-2′ epimers thereof.

(27) Under milder conditions, *i.e.*, hot ethanolic sodium ethoxide[24b] or sodium ethoxide in ethanol–pyridine,[26] only unchanged starting material was recovered.

(28) J. F. Codington, I. L. Doerr, and J. J. Fox, *J. Org. Chem.*, **30**, 476 (1965), and earlier papers referred to therein.

Inversion at C-4′.—The 4′-mesyloxy group in the gluco derivative **32**, obtained from **23** in four steps, using standard procedures for acetylation (to **27**), de-O-benzylidenation (to **30**), tritylation (to **31**), and mesylation, can only be displaced with participation of the vicinal acetamido group *via* an oxazoline derivative similar to **29**. The fact that on de-O-sulfonylation with sodium acetate in refluxing 2-methoxyethanol–water (9:1) only one uniform product is isolated in 90% yield, identical in all respects with **33** obtained from the *galacto-N*-acetate on tritylation, clearly establishes the stereochemical relationship between the C-4′ OH group and the amino function at the *C*-methyl branch.

Similarly, the configuration at the branch point of 1-acetamido-1-methylcyclohexane-2,6-diol (**35**), obtained on cyclization of glutaraldehyde with nitroethane, followed by hydrogenation and N-acetylation,[21] can be established chemically. On treatment of its di-*O*-mesylate **36** with sodium acetate in 90% 2-methoxyethanol (17 hr, 130°), both sulfonyloxy groups are displaced with inversion, to give, after acetylation, 1-acetamido-2*t*,6*t*-diacetoxy-1*c*-methylcyclohexane (**37**) in 60% yield, as evidenced by the nmr data (*cf.* Table III).



35, R = H
36, R = Ms
37

Assignment of Configuration at the *C*-Methyl Branch by Nmr.—At the tertiary center of branched-chain sugars and cyclanols, nmr analysis of coupling patterns will not provide any information concerning the stereochemistry at the branch point. In view of the "acetyl resonance rule" for secondary acetoxy and acetamido groups,[14,15] it is to be surmised that similar relationships between chemical shift and steric arrangement exist for $C(CH_3)OAc$ and $C(CH_3)NHAc$ groups on cyclohexane or pyranoside rings, where the influence of the *C*-methyl group, as compared with that of a hydrogen atom, must be taken into account.

On the basis of eight *C*-methyl-branched cyclanol acetates it was found that replacement of a ring hydrogen by a methyl group causes an upward shift of the acetoxy resonance by about 0.1 ppm.[29] These findings have been supported[30] and are further substantiated by the data presented in Table II, in which the substituent resonances of four *C*-methyl-branched cyclanol acetates, tri-*O*-acetyl-1*c*-methylcyclohexane-1,2*t*,6*t*-triol (**39**), and the hexa-*O*-acetyl derivatives of mytilitol (**41**), laminitol (**43**), and 2-*C*-methyl-*epi*-inositol (**45**), are compared with those of their unbranched counterparts. As expected,[29] no stereochemical information is provided by the chemical shift of the *C*-methyl protons, apparently being under the influence of too many shielding effects to show distinct differences between axial (*e.g.*, **43**) and equatorial orientation (*e.g.*, **45**). However, when comparing the acetoxy resonances of the compound pairs

(29) F. W. Lichtenthaler and P. Emig, *Tetrahedron Lett.*, 577 (1967).

(30) A. Hasegawa and H. Z. Sable, *J. Org. Chem.*, **33**, 1608 (1968); G. B. Howarth, W. A. Szarek, and J. K. N. Jones, *Carbohyd. Res.*, **7**, 284 (1968).

TABLE II

CHEMICAL SHIFTS OF SUBSTITUENT RESONANCES IN FULLY ACETYLATED CYCLANOLS, IN $CDCl_3$ AND DMSO-d_6.[a]

Compd	τ ($CDCl_3$)[b] OAc	τ ($CDCl_3$)[b] CCH_3	τ (DMSO-d_6)[b] OAc	τ (DMSO-d_6)[b] CCH_3
38	7.96 (2), 7.99		8.04 (2), 8.07	
39	7.97 (2), 8.12	8.58	8.02 (2), 8.19	8.67
40	8.02 (6)		8.10 (6)	
41	8.00 (2), 8.04 (3), 8.14	8.50	8.06 (2), 8.10 (3), 8.20	8.58
42	7.80, 8.00 (5)		7.85, 8.04 (3), 8.06 (2)	
43	7.85, 7.94 (2), 7.99, 8.03, 8.10	8.42	7.87, 7.99 (2), 8.04, 8.07, 8.17	8.53
44	7.85 (2), 7.98, 8.02 (3)		7.88 (2), 8.00 (2), 8.04, 8.07	
45	7.88, 7.93 (3), 8.02, 8.04	8.43	7.91, 7.98 (3), 8.05, 8.09	8.51

[a] The nmr data of the unbranched polyacetates are from ref 14; compound **39** was prepared *via* addition of methylmagnesium iodide to 1,3-diacetoxycyclohexan-2-one and subsequent acetylation (*cf.* Experimental Section); the other branched polyacetates, **41**, **43**, and **45**, were prepared according to known procedures (*cf.* T. Posternak, "The Cyclitols," Holden-Day, San Francisco, Calif., 1965, pp 252–259). [b] Ciphers in parantheses refer to the number of coincident $COCH_3$ signals.

38/39, **40/41**, and **42/43**, in each of the *C*-methyl-branched derivatives one of the signals appears at higher field (τ 8.10–8.14 in $CDCl_3$, 8.17–8.20 in DMSO-d_6), attributable to an equatorically oriented tertiary acetoxy group. As revealed from the substituent resonances obtained for **44** and **45** (*cf.* Table II), axial acetoxy groups at the *C*-methyl branch show a similar upfield shift by about 0.1 ppm (τ 7.85 → 7.93 and 7.88 → 7.98, respectively). On the basis of these results, the configuration at the branch point of cyclohexane or pyranoside derivatives can be deduced from the chemical shift of a $C(CH_3)$-acetoxy group, provided that substituents next to the branch do not exert any extraordinary shielding. Thus, while this method may safely be applied to compounds having acetoxy, acetamido, or methoxy groups next to the tertiary center, aryl substituents are apt to considerably change the position of a vicinal acetoxy signal, owing to the anisotropy of the aromatic ring. This effect has been demonstrated with *O*-benzyl,[31] *O*- and *N*-benzoyl,[31,32] *O*-tosyl, *O*-trityl, *N*-benzyloxycarbonyl, and *N*-(2,4-dinitrophenyl) groups;[33] hence it seems questionable to assign the allo configuration to compounds **46**[34] and **47**[35] on the basis of their acetoxy resonance at τ 7.89 and 8.03, respectively, without recourse to adequate supporting evidence.

For acetamido resonances, a similar upward shift of about 0.1 ppm is observed, when going from CHNHAc to $C(CH_3)NHAc$ derivatives, as is demonstrated by the data summarized in Table III. The CCH_3 resonances of the branched compounds listed vary considerably within a rather broad range of τ 8.22–8.68

(31) T. D. Inch and H. G. Fletcher, Jr., *J. Org. Chem.*, **31**, 1810, 1815, 1821 (1966).

(32) T. D. Inch, J. R. Plimmer and H. G. Fletcher, Jr., *ibid.*, **31**, 1827 (1966).

(33) D. Horton, J. B. Hughes, J. S. Jewell, K. D. Philips, and W. N. Turner, *ibid.*, **32**, 1073 (1967).

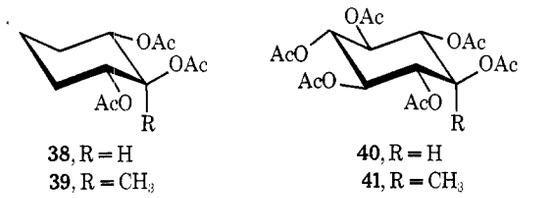
(34) B. R. Baker and D. H. Buss, *ibid.*, **31**, 217 (1966).

(35) G. B. Howarth, W. A. Szarek, and J. K. N. Jones, *Can. J. Chem.*, **46**, 3376 (1968).

TABLE III
CHEMICAL SHIFTS OF SUBSTITUENT RESONANCES OF FULLY ACETYLATED AMINO SUGAR DERIVATIVES AND THEIR C-METHYL-BRANCHED COUNTERPARTS

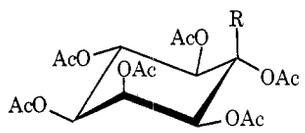
Compd	τ (CDCl3)[a] OAc	NHAc	CCH3	τ (DMSO-d6)[a] OAc	NHAc	CCH3	Ref
48	7.95 (2)	8.07		8.07 (2)	8.26		14
49	7.97 (2)	8.17	8.68	8.04 (2)	8.34	8.86	21
50	7.94 (2), 7.97 (3)	8.08		8.10 (5)	8.29		14
51	7.99 (2), 8.04 (3)	8.20	8.57	8.03 (2), 8.07 (3)	8.37	8.75	20
52	7.91, 7.93	8.10					b
53	7.88 (2)	8.15	?				22
54	7.92 (2)	8.16	8.54				19
55	7.88, 7.92	8.17	8.45				19
56	7.92, 7.96 (2)	8.08		8.00, 8.01, 8.03	8.25		15
57	7.92 (3)	8.17	8.53				19
58	7.92, 7.95 (2)	8.09		8.00 (2), 8.04	8.26		15
59	7.88, 7.91 (2)	8.17	8.46				19
60	7.93, 7.95, 7.99	8.08		7.99, 8.02, 8.11	8.23		15
16	7.90, 7.93, 7.99	8.15	8.53	7.96, 8.00, 8.06	8.33	8.66	
61	7.81, 7.97, 8.00	8.08		7.84, 8.02, 8.09	8.23		16, 17
17	7.83, 7.91, 7.89	8.16	8.22	7.89, 8.02, 8.05	8.29	8.32	
62				7.92, 7.97 (2)	8.21		18
18	7.82, 7.91, 7.96	8.19	8.25	7.91, 7.98 (2)	8.29	8.31	
19	7.90, 7.93 (2)	7.95	8.36	7.94, 7.99, 8.02	8.06	8.51	
37	7.92 (2)	8.09	8.55	7.97 (2)	8.14	8.55	

[a] Ciphers in parentheses refer to the number of coincident $COCH_3$ signals. [b] A. C. Richardson and K. A. McLauchlan, *J. Chem. Soc.*, 2499 (1962).

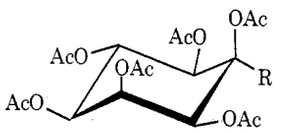


38, R = H
39, R = CH_3

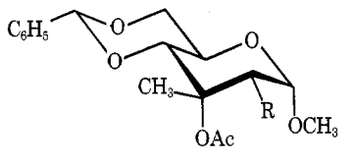
40, R = H
41, R = CH_3



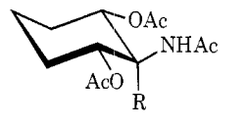
42, R = H
43, R = CH_3



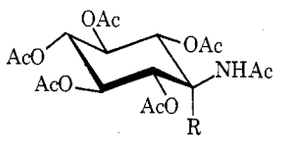
44, R = H
45, R = CH_3



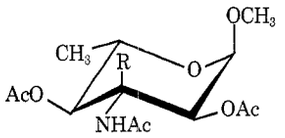
46, R = C_6H_5CONH—
47, R = $CH_3C_6H_4SO_3$—



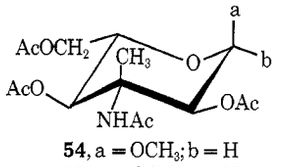
48, R = H
49, R = CH_3



50, R = H
51, R = CH_3

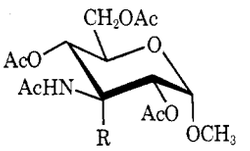


52, R = H
53, R = CH_3

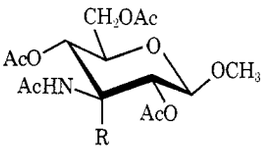


54, a = OCH_3; b = H
55, b = OCH_3; a = H

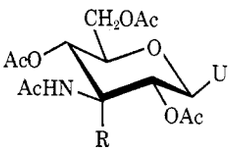
(CDCl3) and 8.31–8.86 (DMSO-d_6), hence excluding any stereochemical deductions from their chemical shift differences. However, the tertiary acetamido resonances of the nucleosides **16–18**, and of compounds



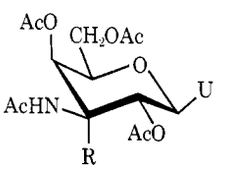
56, R = H
57, R = CH_3



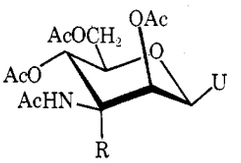
58, R = H
59, R = CH_3



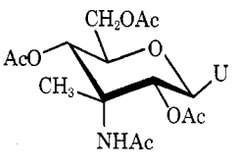
60, R = H
16, R = CH_3



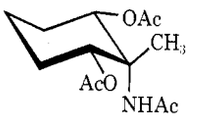
61, R = H
17, R = CH_3



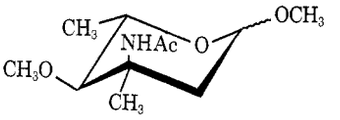
62, R = H
18, R = CH_3



19



37



63

49, **51**, **53–55**, **57**, and **59**, which were similarly prepared *via* dialdehyde–nitroethane cyclizations,[19–22] appear within a very narrow range (τ 8.15–8.20 in $CDCl_3$, 8.29–8.37 in DMSO-d_6), clearly separated from the other acetyl resonances. This strongly indicates an identical steric orientation. When comparing these acetamido resonances with those of their equatorial CHNHAc counterparts (compounds **48**, **50**, **52**, **56**, **58**, and **60–62** in Table III), the expected upward shift of about 0.1 ppm is clearly revealed, suggesting an equa-

torial orientation in each case. Convincing support for this deduction is given by the fact that in four of these *C*-methyl-branched derivatives, namely **49** and **16–18**, the configuration at the tertiary center has been established by chemical means (*cf.* above).

Additional proof of these conclusions is obtained from the chemical shifts of the tertiary acetamido resonances in compounds **19** and **37**, of which the configuration of the latter has also been established chemically (*cf.* above). They appear at τ 7.95 and 8.09 ($CDCl_3$, *cf.* Table III) and τ 8.06 and 8.14 (DMSO-d_6), respectively, clearly indicating an axial orientation. On the basis of these results, it seems very likely that compound **63**, obtained on reduction and acetylation of evernitrose, a component of the everninomycin antibiotics B and D, has the L-ribo rather than the alternate L-xylo configuration owing to its acetamido resonance, in $CDCl_3$, at τ 8.05.[36]

Experimental Section

Thin layer chromatography (tlc) on Kieselgel PF_{254} (E. Merck AG, Darmstadt) was used to monitor the reactions and to ascertain the purity of the reaction products; developers employed (A) butyl acetate–acetic acid–water (55:16:5); (B) butyl acetate–acetic acid (100:1); (C) ethanol–concentrated ammonia (4:1); (D) ethyl acetate–ethanol–water (15:2:1). Dectection was by uv or in iodine vapor (free amines with ninhydrin).

Melting points were determined on a Bock Monoskop and were not corrected. Spectra were recorded on Perkin-Elmer 125 (ir), Perkin-Elmer 137 (uv), and Varian A-60A (nmr) instruments.

Nitroethane Cyclization of "Uridinedialdehyde" to Mixture 3.—To a magnetically stirred ice-cooled solution of 32.1 g (0.15 mol) of sodium metaperiodate in 450 ml of water was added 36.6 g (0.15 mol) of uridine (**1**) in small portions during 15 min. Stirring was continued for 6 hr at room temperature, and the solution was concentrated *in vacuo* at 35° to about 100 ml. Addition of methanol (300 ml) precipitated most of the sodium iodate formed; this was removed by filtration and washed with methanol (100 ml). The filtrate and washings were combined and evaporated to dryness under diminished pressure below 40°. The residue was dissolved in 200 ml of methanol, and a small amount of inorganic material was removed by filtration. The resulting solution of the dialdehyde **2** was diluted with 400 ml of methanol, and nitroethane (10.7 ml, 0.15 mol) was added, followed by dropwise addition, with vigorous stirring and ice-cooling, of 0.1 *M* sodium methoxide in methanol (100 ml). The mixture was allowed to warm to room temperature, and was kept for 24 hr. Following deionization of the solution with a strongly acidic ion-exchange resin (Merck) which was filtered off and washed with 600 ml of methanol, the filtrate and washings were combined and concentrated under diminished pressure at 35° to about 200 ml. The product, which separated after standing for 2 days at room temperature,[37] was filtered off and washed with a little methanol to give "fraction F_1" (14.6 g), representing an approximate 10:1 mixture of **4** and **5** (tlc in A). By concentrating the filtrate to about half of its original volume and subsequent standing, three further fractions (F_2, F_3, and F_4, together 11.5 g) were obtained, containing **4** and **5** in an approximate 1:1 ratio. The remaining mother liquor was taken to dryness *in vacuo*. The residue was dissolved in 200 ml of water, treated with charcoal, and set aside for 1–2 days to give fraction F_5 and, upon reducing the volume of the filtrate to about 100 ml, fraction F_6 ($F_5 + F_6$, 7.2 g), consisting mainly of **5** and **6** aside from traces of **4** and **7**. The mother liquor remaining (filtrate M) contained (tlc in A) the allo isomer **7** with **4**, **5**, and **6** as minor components. Total yield was 33.3 g (70%).

(36) A. K. Ganguly, O. Z. Sarre, and H. Reimann, *J. Amer. Chem. Soc.*, **90**, 7129 (1968).

(37) Crystallization of the various fractions of mixture **3** proceeds rather slowly, requiring 1–2 days in each case for completion. Tlc in solvent system A to follow the separation of the individual isomers is indispensable; the nitro nucleosides appear in the order allo (**7**), galacto (**5**), manno (**6**), and gluco (**4**), from the starting point.

1-(3-Deoxy-3-*C*-methyl-3-nitro-β-D-glucopyranosyl)uracil (4).[38]—Fraction F_1 (see above) was dissolved in methanol (45 ml/g) and the solution was evaporated *in vacuo* to about one-tenth of its initial volume. The crystals that separated after 2 days were collected (filtrate M_1) and recrystallized from methanol by the same procedure (filtrate M_2) to give 7.5 g of pure **4** (tlc in A). In similar fashion, the combined fractions F_2, F_3, and F_4 were recrystallized from methanol (filtrates M_3 and M_4, respectively), yielding another 7.1 g of **4**. From the combined mother liquors M_1–M_4, when concentrated to about 50 ml, a further crop of crystals was obtained to give, after three recrystallizations (filtrates M_6, M_7, and M_8), 4.2 g. Total yield of chromatographically pure **4** was 18.8 g (40%, based on uridine) as colorless prisms, mp 226–240° dec, $[\alpha]^{20}D$ +25.5° (*c* 1, water).

Anal. Calcd for $C_{11}H_{15}N_3O_8$: C, 41.64; H, 4.77; N, 13.25. Found: C, 41.61; H, 4.69; N, 13.25.

1-(3-Deoxy-3-*C*-methyl-3-nitro-β-D-galactopyranosyl)uracil (5).—The combined filtrates M_5–M_8 were concentrated to a volume of about 40 ml, and the crystals precipitating after standing for 2 days were collected (filtrate M_9) to give 1.7 g of **5**. An analogous work-up of filtrate M_{11} (see below) afforded another 0.6 g (filtrate M_{13}). Total yield was 2.3 g (5% based on **1**) of **5** as colorless needles, mp 232–235° (after drying at 50° and 0.1 mm for 6 hr[39]), $[\alpha]^{20}D$ +52° (*c* 1, MeOH).

Anal. Calcd for $C_{11}H_{15}N_3O_8$: C, 41.64; H, 4.77; N, 13.25. Found: C, 41.78; H, 5.09; N, 13.12.

1-(3-Deoxy-3-*C*-methyl-3-nitro-β-D-mannopyranosyl)uracil (6).—The crystal fractions F_5 and F_6 (7.2 g, see above) were dissolved in the minimum amount of hot water and kept for 2 days at room temperature. The precipitate was filtered off (filtrate M_{11}) and recrystallized from water (filtrate M_{12}) to give 2.61 g (5%, based on **1**) of **6** monohydrate as colorless rhombs, mp 186–190°, $[\alpha]^{20}D$ +121° (*c* 1, MeOH).

Anal. Calcd for $C_{11}H_{15}N_3O_8 \cdot H_2O$: C, 39.38; H, 5.11; N, 12.54. Found: C, 39.66; H, 5.23; N, 12.55.

1-(3-Deoxy-3-*C*-methyl-3-nitro-β-D-allopyranosyl)uracil (7).—The filtrates M, M_{10}, M_{12}, and M_{13}, containing **7** as the major component (tlc in A), were combined and taken to dryness *in vacuo*. The residue was subjected to a silica gel column (130 × 4 cm) and eluted with ethyl acetate–methanol–water (40:2:1). A distinct separation was achieved between the nitro nucleosides **4**, **5**, and **6**, eluted first, and the allo compound **7**. The fraction containing **7** was evaporated to dryness to give, after recrystallization from a small amount of methanol, 620 mg (1.2%, based on **1**) of **7** as colorless crystals, mp 225–227° dec, $[\alpha]^{20}D$ +44° (*c* 1, water).

Anal. Calcd for $C_{11}H_{15}N_3O_8$: C, 41.64; H, 4.77; N, 13.25. Found: C, 41.64; H, 4.95; N, 12.98.

1-(3-Deoxy-3-*C*-methyl-3-nitro-2,4,6-tri-*O*-acetyl-β-D-glucopyranosyl)uracil (8).—To 3.0 g (9.5 mmol) of **4**, in acetic anhydride (10 ml), was added, with cooling, 2 drops of concentrated H_2SO_4. After 4 hr at room temperature the mixture was stirred into ice–water and the precipitate was removed by filtration. Recrystallization from ethyl acetate afforded 2.6 g (62%) of **8** as prisms, mp 228°, $[\alpha]^{20}D$ −8° (*c* 1, $CHCl_3$).

Anal. Calcd for $C_{17}H_{21}N_3O_{11}$: C, 46.05; H, 4.77; N, 9.48. Found: C, 46.04; H, 5.10; N, 9.37.

1-(3-Deoxy-3-*C*-methyl-3-nitro-2,4,6-tri-*O*-acetyl-β-D-galactopyranosyl)uracil (9).—To 5 ml of acetic anhydride containing 2 drops of concentrated H_2SO_4 was added 600 mg of **5** and the mixture was stirred. After 4 hr the clear solution was poured into ice–water, which was subsequently extracted with chloroform (3 × 40 ml). The extracts were washed with $NaHCO_3$ solution, dried (Na_2SO_4), and evaporated to dryness. On trituration of the sirupy residue with cold benzene, **9** slowly crystallized to afford 513 mg (61%) of colorless, chromatographically (B) pure crystals, mp 107–110°, $[\alpha]^{20}D$ +24° (*c* 1, $CHCl_3$)

Anal. Calcd for $C_{17}H_{21}N_3O_{11}$: C, 46.05; H, 4.77; N, 9.48. Found: C, 46.03; H, 4.96; N, 9.39.

1-(3-Deoxy-3-*C*-methyl-3-nitro-2,4,6-tri-*O*-acetyl-β-D-mannopyranosyl)uracil (10).—Acetylation of **6** (400 mg, 1.2 mmol), in a manner identical with that described for **9**, afforded 340 mg (55%) of **10** as colorless needles, mp 106–109°, crystallizing with 1 mol of benzene, $[\alpha]^{20}D$ +124° (*c* 1, $CHCl_3$).

(38) A more simplified procedure, concentrating only on the isolation of **4**, has been described: F. W. Lichtenthaler and H. Zinke, *Syn. Proc. Nucleic Acid Chem.*, **1**, 366 (1968).

(39) Air-dried preparations of **5** contain varying amounts of methanol, melting considerably lower (~160°).

Anal. Calcd for $C_{17}H_{21}N_3O_{11}\cdot C_6H_6$: C, 52.95; H, 5.22; N, 8.06. Found: C, 52.94; H, 5.34; N, 8.14.

1-(3-Deoxy-3-*C*-methyl-3-nitro-2,4,6-tri-*O*-acetyl-β-D-allopyranosyl)uracil (11).—To a suspension of 150 mg (0.45 mmol) of **7** in acetic anhydride (4 ml) was added 5 drops of BF_3 etherate, resulting in a clear solution on stirring. After 2 days at room temperature, the reaction mixture was evaporated to dryness *in vacuo* (0.1 mm) and the residue was triturated with ice–water (20 ml). The crystals separating were collected and recrystallized from water–ethanol (10:1) to give 97 mg (49%) of **11** as colorless prisms, mp 203–204° dec, $[\alpha]^{20}D$ +12° (*c* 1, $CHCl_3$).

Anal. Calcd for $C_{17}H_{21}N_3O_{11}$: C, 46.05; H, 4.77; N, 9.48. Found: C, 46.14; H, 4.64; N, 9.36.

Catalytic Hydrogenation of the Nitrohexosyluracils.—The nitro compounds **4**, **5**, **6**, or **7** (5 mmol) were dissolved in a sufficient quantity of methanol–water (1:1) (*ca.* 25 ml/mmol), added to a prehydrogenated suspension of 1 ml of freshly prepared Raney nickel T4 catalyst[40] in 15 ml of water, and the hydrogenation was continued. After uptake of the calculated amount of H_2 (6–15 hr) the catalyst was filtered off and washed with hot methanol–water (1:1) and the combined filtrate and washings were evaporated to a small volume. For isolation of **12** and **14** the solution was kept overnight at room temperature to effect crystallization. To isolate **13** and **15**, the solution was evaporated to dryness and the residue was precipitated by addition of ether to an ethanolic solution. The compounds were obtained in chromatographically pure form (tlc in C).

1-(3-Amino-3-deoxy-3-*C*-methyl-β-D-glucopyranosyl)uracil (12).—Recrystallization from water afforded **12** as the monohydrate in 69% yield in the form of colorless crystals, mp 146–148°, $[\alpha]^{20}D$ +39° (*c* 1, water).

Anal. Calcd for $C_{11}H_{17}N_3O_6\cdot H_2O$: C, 43.29; H, 6.28; N, 13.77. Found: C, 43.22; H, 6.41; N, 13.75.

1-(3-Amino-3-deoxy-3-*C*-methyl-β-D-galactopyranosyl)uracil (13) was obtained as a solid, amorphous product, $[\alpha]^{20}D$ +63° (*c* 1, water), yield 92%.

1-(3-Amino-3-deoxy-3-*C*-methyl-β-D-mannopyranosyl)uracil (14) was obtained as colorless crystals, mp 154–155°, $[\alpha]^{20}D$ +93° (*c* 1, Me_2NCHO), yield 75%.

Anal. Calcd for $C_{11}H_{17}N_3O_6$: C, 45.99; H, 5.97; N, 14.63. Found: C, 45.73; H, 6.12; N, 14.47.

1-(3-Amino-3-deoxy-3-*C*-methyl-β-D-allopyranosyl)uracil (15) was obtained as a solid, amorphous product, $[\alpha]^{20}D$ +25° (*c* 1, MeOH).

N-Acetylation of the Aminohexosyluracils.—To a solution of 5 mmol of amine **12**, **13**, or **14** in methanol (150 ml) was added 2 ml of acetic anhydride. The mixture was kept at room temperature for 48 hr and subsequently evaporated to dryness *in vacuo* with repeated addition of ethanol. The residue was crystallized by trituration with ethanol to give a first crop of product, the second being obtained after concentration of the mother liquors. The compounds **10–22** are homogeneous by tlc in solvent system D.

1-(3-Acetamido-3-deoxy-3-*C*-methyl-β-D-glucopyranosyl)uracil (20) was obtained as prisms, mp 248°, $[\alpha]^{20}D$ +72° (*c* 1, water), yield 87%.

Anal. Calcd for $C_{13}H_{19}N_3O_7$: C, 47.41; H, 5.82; N, 12.76. Found: C, 47.14; H, 5.83; N, 12.72.

1-(3-Acetamido-3-deoxy-3-*C*-methyl-β-D-galactopyranosyl (21) was obtained as crystals, mp 213–125°, $[\alpha]^{20}D$ +104° (*c* 1, water) after recrystallization from ethanol, yield 52%.

Anal. Calcd for $C_{13}H_{19}N_3O_7$: C, 47.41; H, 5.82; N, 12.76. Found: C, 47.58; H, 6.05; N, 12.52.

1-(3-Acetamido-3-deoxy-3-*C*-methyl-β-D-mannopyranosyl)uracil (22).—Crystallization occurring rather sluggishly, the product was precipitated from an ethanolic solution by addition of ether to give an amorphous solid, $[\alpha]^{20}D$ +86° (*c* 1, water).

Anal. Calcd for $C_{13}H_{19}N_3O_7$: C, 47.41; H, 5.82; N, 12.76. Found: C, 47.41; H, 6.02; N, 12.65.

Peracetylation of Acetamidohexosyluracils.[41]—A solution of 1 mmol of the *N*-acetates **20**, **21**, or **22** in 5 ml of acetic anhydride containing 1 drop of concentrated H_2SO_4 was kept at room temperature for 24 hr followed by stirring the reaction mixture into ice–water. Extraction with chloroform (3 × 40 ml), washing of the extracts with $NaHCO_3$ solution and water, and subsequent evaporation to dryness yielded the tetraacetyl derivatives **16–18** as amorphous, chromatographically (tlc in C) pure products, which resisted crystallization from the usual organic solvents. For nmr data *cf.* Table I.

1-(3-Acetamido-3-deoxy-3-*C*-methyl-2,4,6-tri-*O*-acetyl-β-D-glucopyranosyl)uracil (16) was obtained in 38% yield, $[\alpha]^{20}D$ +21° (*c* 2, $CHCl_3$).

Anal. Calcd for $C_{19}H_{25}N_3O_{10}$: C, 50.11; H, 5.53; N, 9.23. Found: C, 49.97; H, 5.69; N, 9.20.

1-(3-Acetamido-3-deoxy-3-*C*-methyl-2,4,6-tri-*O*-acetyl-β-D-galactopyranosyl)uracil (17) was obtained in 63% yield, $[\alpha]^{20}D$ +93° (*c* 1, $CHCl_3$).

Anal. Calcd for $C_{19}H_{25}N_3O_{10}$: C, 50.11; H, 5.53; N, 9.23. Found: C, 50.07; H, 5.50; N, 8.99.

1-(3-Acetamido-3-deoxy-3-*C*-methyl-2,4,6-tri-*O*-acetyl-β-D-mannopyranosyl)uracil (18) was obtained in 60% yield, $[\alpha]^{20}D$ +41° (*c* 1, $CHCl_3$).

Anal. Calcd for $C_{19}H_{25}N_3O_{10}$: C, 50.11; H, 5.53; N, 9.23. Found: C, 49.92; H, 5.63; N, 9.01.

1-(3-Acetamido-3-deoxy-3-*C*-methyl-2,4,6-tri-*O*-acetyl-β-D-allopyranosyl)uracil (19).—A solution of 250 mg (0.8 mmol) of **15** in a mixture of 25 ml of methanol and 0.5 ml of acetic anhydride was allowed to stand at room temperature for 40 hr and evaporated to dryness *in vacuo*. The residue was dissolved in acetic anhydride (5 ml) containing 2 drops of concentrated H_2SO_4 and the mixture was kept for 24 hr at 60°. Addition of ice–water, extraction with chloroform (3 × 30 ml), and evaporation of the extracts afforded a brownish sirup, which was applied to a silica gel column (75 × 4 cm) and eluted with ethyl acetate–methanol–water (40:2:1). The fraction containing **19** was taken to dryness and reevaporated twice with ethanol to yield 143 mg (38%) of an amorphous product, $[\alpha]^{20}D$ +9° (*c* 1, $CHCl_3$).

Anal. Calcd for $C_{19}H_{25}N_3O_{10}$: C, 50.11; H, 5.53; N, 9.23. Found: C, 49.81; H, 5.65; N, 9.12.

1-(3-Acetamido-4,6-*O*-benzylidene-3-deoxy-3-*C*-methyl-β-D-glucopyranosyl)uracil (23).—Anhydrous zinc chloride (9.0 g) and 5.80 g (17.6 mmol) of **20** in 60 ml of benzaldehyde were stirred at ambient temperature for 36 hr, after which the excessive benzaldehyde was removed by evaporation *in vacuo* (0.1 mm). The resulting sirup was triturated twice with water (100 ml), followed by decantation to give a semisolid mass, which was extracted with petroleum ether (2 × 50 ml) and subsequently suspended in 30 ml of benzene. Filtration, washing with cold benzene and ether, and recrystallization from water yields 6.51 g (85%) of **23** as a monohydrate in the form of colorless prisms, mp 294–296° dec, $[\alpha]^{20}D$ −12° (*c* 1, Me_2CO).

Anal. Calcd for $C_{20}H_{23}N_3O_7\cdot H_2O$: C, 55.17; H, 5.79; N, 9.65. Found: C, 55.12; H, 5.82; N, 9.53.

1-(3-Acetamido-4,6-*O*-benzylidene-3-deoxy-2-*O*-mesyl-3-*C*-methyl-β-D-glucopyranosyl)uracil (24).—To a cooled solution (0°) of 4.3 g (9.9 mmol) of **23** monohydrate in pyridine (80 ml), 2 ml of methanesulfonyl chloride was added slowly, followed by storage at ambient temperature for 24 hr. After removal of a precipitate by filtration, the mixture is taken to dryness *in vacuo* (0.1 mm). The crystals appearing on trituration of the residue with water were collected and recrystallized successively from methanol–water (1:1) and water to yield 3.1 g (60%) of **24** monohydrate as colorless needles, mp 179°, $[\alpha]^{20}D$ +13° (*c* 1, MeOH).

Anal. Calcd for $C_{21}H_{25}N_3O_9S\cdot H_2O$: C, 49.12; H, 5.30; N, 8.18. Found: C, 49.13; H, 5.31; N, 8.18.

1-(3-Amino-4,6-*O*-benzylidene-3-deoxy-3-*C*-methyl-β-D-mannopyranosyl)uracil (25) and Its *N*-acetate (26) by De-*O*-mesylation of 24.—A mixture of sodium acetate (2.5 g), **24** monohydrate (3.0 g, 5.9 mmol), and 20 ml of β-methoxyethanol–water (9:1) was refluxed (140° bath temperature) for 70 hr and evaporated to dryness *in vacuo* (0.1 mm). The residue was triturated with water to afford 2.3 g of an approximate 1:1 mixture of **25** and **26** (tlc in solvent system D). Two recrystallizations from methanol–water (1:1) (filtrates M_1 and M_2) and one from ethanol–water (1:1) yielded 360 mg (15%) of chromatographically pure (tlc in D) **26** as crystals, mp 268–272° dec, $[\alpha]^{20}D$ +17° (*c* 1, MeOH).

Anal. Calcd for $C_{20}H_{23}N_3O_7$: C, 57.55; H, 5.55; N, 10.07. Found: C, 57.36; H, 5.46; N, 10.08.

(40) S. Nishimura, *Bull. Chem. Soc. Jap.*, **32**, 61 (1959).

(41) Attempted peracetylation of the free aminohexosyluracils (**16–19**) with acetic anhydride in the presence of pyridine or acidic catalysts (BF_3, H_2SO_4) yields mixtures of the peracetate and two or three other products (tlc in C), seemingly resulting from incomplete acetylation under these conditions.

The mother liquors M_1 and M_2 were evaporated to a yellowish residue, which was dissolved in a little methanol, applied to a silica gel column, and eluted with 90:2:1 ethyl acetate–methanol–water. After elution of **26** and fractions consisting of mixtures of **25** and **26**, the final eluate contained only **25**. Evaporation gave 510 mg (23%) of **25** as colorless rhombs, mp 249–253° dec, $[\alpha]^{20}D$ +29° (*c* 1, MeOH) and +35° (*c* 1, Me_2NCHO).

Anal. Calcd for $C_{18}H_{21}N_3O_6$: C, 57.59; H, 5.64; N, 11.20. Found: C, 57.34; H, 5.64; N, 10.99.

De-*O*-mesylation of 24 in Sodium Ethoxide–2-Methoxyethanol.—To 1.22 g (2.4 mmol) of mesylate **24** in 2-methoxyethanol (20 ml) was added 2.45 ml (1.02 molar equiv) of 1 *N* sodium ethoxide in ethanol and the mixture was refluxed (140° bath temperature). As evidenced by tlc (solvent system D), 80 hr are required for complete reaction, the mixture then consisting of four components, the anhydro nucleoside **28** (R_f in D 0.15), the amine **25** (0.30), the *N*-acetate **26** (0.47), and the oxazoline **29** (0.62). After evaporation to dryness *in vacuo* at 0.1 mm, the residue was subjected to chromatography on silica gel (75 × 2.5 cm column) with ethyl acetate–methanol–water (90:2:1). Elution occurred in the order **29**, **26**, **25**, and **28** as monitored by a uv recording instrument. The appropriate fractions were then evaporated to afford compounds **25**, **26**, **29**, and **28**.

A. Amino nucleoside 25, yield 281 mg, had melting point, $[\alpha]D$, and ir spectrum identical with those of the product obtained by sodium acetate evoked de-*O*-mesylation.

B. 3-Acetamido nucleoside 26, yield 150 mg (15%), was identical (melting point, $[\alpha]D$, ir) with the compound described above. Treatment of **25** with acetic anhydride in methanol under conditions used for N-acetylation of the aminohexosyluracils afforded **26** in yields of 75–80%.

C. 1-[4,6-*O*-Benzylidene-2,3-dideoxy-3,2-(2-methyl-1-oxa-3-azaprop-2-eno)-β-D-mannopyranosyl]uracil (29).—After recrystallization from methanol, 140 mg (15%) of colorless rhombs was obtained: mp 310–320°; $[\alpha]^{20}D$ −51° (*c* 1, Me_2NCHO); λ_{max}^{MeOH} 256 mμ; nmr (DMSO-d_6) τ −1.49 (s, 1, uracil NH), 2.36 and 4.31 (two d, 1, J = 8 Hz, uracil H-6 and H-5), 3.81 (d, 1, $J_{1',2'}$ = 3 Hz, H-1'), 5.80 (d, 1, J = 3 Hz, H-2'), 8.06 (s, 3, oxazoline CH_3), 8.57 (s, 3,3'-CH_3).

Anal. Calcd for $C_{20}H_{21}N_3O_6$: C, 60.14; H, 5.30; N, 10.52. Found: C, 60.13; H, 5.23; N, 10.55.

Hydrolysis of **29** by refluxing with sodium acetate in 9:1 2-methoxyethanol–water for 16 hr, evaporation to dryness, and purification of the residue by chromatography on silca gel with ethyl acetate–methanol–water (40:2:1) afforded the *N*-acetate **26**, mp 268–270° dec, in 56% yield.

D. O^2,2'-Anhydro-1-(3-acetamido-4,6-*O*-benzylidene-3-deoxy-3-*C*-methyl-β-D-mannopyranosyl)uracil (28).—Recrystallization from methanol afforded 103 mg (11%) of colorless crystals: mp 330° dec; $[\alpha]^{20}D$ −15° (*c* 1, MeOH); λ_{max}^{MeOH} 227 nm (ε 9900) and 242 (8400); ir (KBr) 3300 (NH), 1640 (amide I), 1535 cm^{-1} (amide II); nmr (DMSO-d_6) τ 1.86 (s, 1,3'-NH), 2.13 and 4.13 (two d, 1, J = 8 Hz, H-6 and H-5), 2.56 (s, 5, C_6H_5), 3.96 (d, 1, J = 3 Hz, H-1'), 4.37 (s, 1, C_6H_5CH), 4.53 (d, 1, J = 3 Hz, H-2'), 5.76 (m, 1, H-4'), 8.10 (s, 3, $NHCOCH_3$), 8.38 (s, 3, 3'-CH_3).

Anal. Calcd for $C_{20}H_{21}N_3O_6$: C, 60.14; H, 5.30; N, 10.52. Found: C, 60.08; H, 4.94; N, 10.37.

Refluxing a mixture of **28** (30 mg) with sodium acetate in 9:1 methoxyethanol–water for 16 hr, followed by evaporation and purification on a silica gel column with ethyl acetate–methanol–water (40:2:1), gave the *N*-acetate **26** in 64% yield.

De-*O*-benzylidenation of 26.—A solution of 270 mg of **26** in 10 ml of acetic acid–water (1:1) was kept at 80° for 3 hr, followed by extraction with light petroleum ether (3 × 20 ml) to remove the benzaldehyde formed. The aqueous phase was evaporated to dryness and the residue, after three reevaporations from ethanol, was dissolved in a little ethanol. Addition of ether affords 170 mg (80%) of **22** as an amorphous solid, identical in R_f (tlc in D), $[\alpha]D$, and ir spectrum with the product obtained by N-acetylation of amino nucleoside **14**.

1-(3-Acetamido-2-*O*-acetyl-4,6-*O*-benzylidene-3-deoxy-3-*C*-methyl-β-D-glucopyranosyl)uracil (27).—A mixture of 1.50 g (3.5 mmol) of **23** monohydrate and 4 ml of acetic anhydride in pyridine (20 ml) was stored overnight at room temperature and subsequently evaporated to dryness. Trituration of the residue with ice–water afforded a crystalline solid which was recrystallized twice from methanol–water (1:1) to give 820 mg (52%) of **27**: mp 174–176°; $[\alpha]^{20}D$ 15° (*c* 1, $CHCl_3$); nmr (DMSO-d_6) τ 2.46 (s, 1, 3'-NH), 2.52 and 4.27 (d, 1, $J_{5,6}$ = 8 Hz, H-6 and H-5), 2.60 (s, 5, C_6H_5), 3.98 (d, 1, $J_{1',2'}$ = 9 Hz, H-1'), 4.11 (d, 1, J = 9 Hz, H-2'), 4.41 (s, 1, ArCH), 5.06 (d, 1, $J_{3',4'}$ = 9 Hz, H-4'), 5, 6–6.3 (m, 3, H-5' and C-6' CH_2), 8.03 and 8.23 (s, 3, 2'-OAc and 3'-NHAc), 8.61 (s, 3,3'-CH_3).

Anal. Calcd for $C_{22}H_{23}N_3O_8$: C, 57.51; H, 5.48; N, 9.15. Found: C, 57.34; H, 5.66; N, 9.15.

1-(3-Acetamido-2-*O*-acetyl-3-deoxy-3-*C*-methyl-β-D-glucopyranosyl)uracil (30).—A solution of 99 mg (2 mmol) of **27** in 1:1 acetic acid–water (10 ml) was kept at 80° for 3 hr, and subsequently extracted with light petroleum ether (3 × 25 ml) to remove the benzaldehyde formed. The aqueous layer was evaporated to dryness to give a residue, which crystallized on trituration with ethanol to give 460 mg of **30**. A further crop (120 mg) was obtained by evaporation of the mother liquor, followed by recrystallization from ethanol. Total yield was 580 mg (80%) of **30**, mp 232–234° after sintering around 170°, $[\alpha]^{20}D$ +103° (*c* 1, MeOH).

Anal. Calcd for $C_{15}H_{21}N_3O_8$: C, 48.51; H, 5.70; N, 11.32. Found: C, 48.48; H 5.92; N, 11.19.

1-(3-Acetamido-2-*O*-acetyl-3-deoxy-3-*C*-methyl-6-*O*-trityl-β-D-glucopyranosyl)uracil (31).—Triphenylchloromethane (2.3 g, 8.3 mmol) was added to 440 mg (1.2 mmol) of **30** in pyridine (10 ml) and kept at ambient temperature for 5 days. After removal of a precipitate by filtration, the mixture was evaporated to dryness and repeatedly reevaporated from dioxane. The residue was applied to a silica gel column (2.5 × 75 cm) and first eluted with ethyl acetate to remove excessive trityl chloride, subsequently with ethyl acetate–methanol–water (90:2:1). Evaporation of the appropriate fraction and recrystallization of the residue from 2:1 methanol–water afforded 254 mg (35%) of **31** as colorless crystals, mp 244–247°, $[\alpha]^{20}D$ +52° (*c* 1, MeOH),

Anal. Calcd for $C_{34}H_{35}N_3O_8$: C, 66.64; H, 5.75; N, 6.85. Found: C, 66.44; H, 5.83; N, 6.81.

1-(3-Acetamido-2-*O*-acetyl-3-deoxy-4-*O*-mesyl-3-*C*-methyl-6-*O*-trityl-β-D-glucopyranosyl)uracil (32).—The trityl derivative **31** (200 mg, 0.3 mmol) was suspended in pyridine (5 ml), and with cooling (0°) and stirring 0.25 ml of methanesulfonyl chloride was added. The mixture, after being kept for 3 days in the refrigerator, was evaporated to dryness *in vacuo* (1 mm), followed by trituration of the residue with ice–water, filtration, and purification by chromatography on silica gel with ethyl acetate–methanol–water (40:1:1). After evaporation of the appropriate fraction, 201 mg (89%) of **32** was obtained as a chromatographically uniform (tlc in D), amorphous product: $[\alpha]^{20}D$ +64° (*c* 1, MeOH); nmr ($CDCl_3$) τ 2.37 and 4.16 (d, 1, $J_{5,6}$ = 8 Hz, H-6 and H-5), 2.7 (m, 15, 3 C_6H_5), 3.52 (d, 1, $J_{1',2'}$ = 9.5 Hz, H-1'), 4.05 (d, 1, $J_{3',4'}$ = 10 Hz, H-4'), 4.12 (d, 1, J = 9.5 Hz, H-2'), 4.70 (s, 1,3'-NH), 6.2–6.8 (m, 3, H-5' and C-6' CH_2), 7.50 (s, 3, 4'-OMs), 7.99 and 8.07 (s, 2, 2'-OAc and 3'-NHAc), 8.60 (s, 3, 3'-CH_3).

Anal. Calcd for $C_{35}H_{37}N_3O_{10}S$: C, 60.77; H, 5.39; N, 6.07. Found: C, 60.51; H, 5.40; N, 5.91.

1-(3-Acetamido-3-deoxy-3-*C*-methyl-6-*O*-trityl-β-D-galactopyranosyl)uracil (33). A. Tritylation of *galacto*-*N*-Acetate 21.—A mixture of 560 mg (1.7 mmol) of **21** and 2.0 g (6.2 mmol) of triphenylchloromethane in pyridine are stored overnight at ambient temperature, followed by evaporation to dryness, trituration with ice–water (60 ml), filtration, and purification of the solid material by chromatography on silica gel in a manner identical with that described for **31**. Recrystallization from methanol gave 710 mg (73%) of **33** as colorless crystals, mp 223–225°, $[\alpha]^{20}D$ +1° (*c* 1, MeOH).

Anal. Calcd for $C_{32}H_{33}N_3O_7$: C, 67.23; H, 5.82; N, 7.35. Found: C, 67.09; H, 5.86; N, 7.34.

B. De-*O*-mesylation of 32 with Subsequent De-*O*-acetylation.—A mixture of sodium acetate (80 mg), **32** (132 mg, 0.19 mmol), and 9:1 2-methoxyethanol–water (15 ml) was refluxed for 20 hr and subsequently evaporated to dryness. The residue was purified by chromatography on silica gel with ethyl acetate–methanol–water (20:2:1). Evaporation of the appropriate fraction and recrystallization from methanol yielded 48 mg (43%) of colorless crystals, identical in melting point, $[\alpha]D$, tlc in solvent D, and ir spectrum with **33**, described under A.

1-(3-Acetamido-3-deoxy-2,4-di-*O*-acetyl-3-*C*-methyl-6-*O*-trityl-β-D-galactopyranosyl)uracil (34).—A solution of 295 mg of **33** and 0.5 ml of acetic anhydride in pyridine (8 ml) was kept at ambient temperature for 2 days and subsequently evaporated to dryness. Trituration of the residue with ice–water induced

crystallization to give, after recrystallization from methanol, 280 mg (84%) of **34**: mp 188–190°; $[\alpha]^{20}D$ −9°(*c* 1, MeOH); nmr ($CDCl_3$) τ 4.01 (d, 1, $J_{1',2'}$ = 9.5 Hz, H-1'), 7.93 and 8.04 (s, 3,2'- and 4'-OAc), 8.18 (s, 3, NHAc), 8.27 (s, 3,3'-CH_3).

Anal. Calcd for $C_{36}H_{37}N_3O_9$: C, 65.94; H, 5.69; N, 6.41. Found: C, 65.84; H, 5.49; N, 6.48.

***C*-Methyl-Branched Cyclanols. 1*r*-Methylcyclohexane-1,2*c*,6*c*-triol.**—To an ethereal solution of methylmagnesium iodide, prepared from 3.4 g of magnesium and methyl iodide (11.4 ml) in ether (80 ml), was added a solution of 4.3 g of 1,3-diacetoxycyclohexan-2-one[42] in chloroform (140 ml). The mixture was refluxed for 30 min and subsequently stirred into an excess of 2 *N* H_2SO_4. After evaporation of the organic solvents and addition of the calculated amount of silver carbonate, the mixture was neutralized with 1 *N* sodium hydroxide (pH 7), filtered to remove the silver iodide formed, and evaporated to dryness. The residue was extracted with ether overnight, to give, after evaporation and recrystallization from ethyl acetate, 900 mg (31%) of a product melting at 122–124°.

Anal. Calcd for $C_7H_{14}O_3$: C, 57.51; H, 9.65. Found: C, 57.43; H, 9.68.

Tri-*O*-acetyl-1*r*-methylcyclohexane-1,2*c*,6*c*-triol (39).—To a mixture of 5 ml of acetic anhydride and 3 drops of concentrated H_2SO_4 was added 300 mg of 1*r*-methylcyclohexane-1,2*c*,6*c*-triol. After 4 hr at ambient temperature, the solution was stirred into ice–water, which was repeatedly extracted with chloroform. The extracts were washed with $NaHCO_3$ solution, dried (Na_2SO_4), and evaporated to dryness. Recrystallization of the residue from ethyl acetate afforded 240 mg (45%) of **39** as colorless prisms, mp 102–103°; for nmr *cf.* Table II.

Anal. Calcd for $C_{13}H_{20}O_6$: C, 57.34; H, 7.40. Found: C, 57.22; H, 7.30.

1-Acetamido-2*c*,6*c*-dimethanesulfonyloxy-1*r*-methylcyclohexane (36).—To a cooled solution of 22.2 g (0.12 mol) of the *N*-acetate **35**[21] in pyridine (300 ml) was added gradually 40 ml (0.52 mol) of methanesulfonyl chloride with stirring. The mixture was stored at 0° for 20 hr, then concentrated to a crystalline solid *in vacuo* (finally 0.1 mm), and triturated with ice–water. The product was filtered off, thoroughly washed with acetone–methanol (2:1), and recrystallized from water–methanol (10:1) with the addition of activated carbon, to give 34.0 g (81%) of **36** as colorless crystals: mp 147°; nmr (DMSO-d_6) τ 2.30 (s, 1, NH), 4.52 (q, 2, $J_{a,a}$ = 10 and $J_{a,e}$ = 5 Hz, H-2 and H-6), 6.92 (s, 6, 2- and 6-OMs), 8.18 (s, 3, NHAc), 8.87 (s, 3, 1-CH_3).

Anal. Calcd for $C_{11}H_{21}NO_7S_2$: C, 38.47; H, 6.16; N, 4.08. Found: C, 38.35; H, 6.13; N, 4.05.

1-Acetamido-2*t*,6*t*-diacetoxy-1*r*-methylcyclohexane (37).—The dimesylate **36** (3.0 g) was refluxed for 17 hr with sodium acetate (3.6 g) in 150 ml of 2-methoxyethanol–water (9:1), and then concentrated. The resulting residue was extracted several times with hot acetone and the combined extracts were then evaporated to dryness to give a pale yellow sirup, which is acetylated by treatment with acetic anhydride (5 ml) and pyridine (30 ml) at room temperature overnight. The mixture was concentrated to a semicrystalline solid, which, after trituration with water, was filtered off and recrystallized twice from water to yield 1.42 g (60%) of **37** as colorless crystals: mp 156–158°; nmr ($CDCl_3$) τ 4.13 (s, 1, NH), 4.50 (m, 2, H-2 and H-6); nmr (DMSO-d_6) 2.67 (s, 1, NH), 4.70 (m, 2, H-2 and H-6); for other data *cf.* Table III.

Anal. Calcd for $C_{13}H_{21}NO_5$: C, 57.55; H, 7.80; N, 5.16. Found: C, 57.50; H, 7.71; N, 5.17.

Registry No.—**4**, 13184-57-1; **5**, 13184-60-6; **6**, 13184-59-3; **7**, 34280-68-7; **8**, 13184-58-2; **9**, 13184-65-1; **10**, 13184-64-0; **11**, 34280-72-3; **12**, 13184-61-7; **13**, 34280-74-5; **14**, 34280-75-6; **15**, 34280-76-7; **16**, 13184-63-9; **17**, 34280-78-9; **18**, 34297-61-5; **19**, 34280-79-0; **20**, 34297-62-6; **21**, 34280-80-3; **22**, 34280-81-4; **23**, 34280-82-5; **24**, 34280-83-6; **25**, 34280-84-7; **26**, 34280-85-8; **27**, 34280-86-9; **28**, 34280-87-0; **29**, 34280-88-1; **30**, 34280-89-2; **31**, 34297-63-7; **32**, 34280-90-5; **33**, 34280-91-6; **34**, 34280-92-7; **36**, 34280-93-8; **37**, 34280-94-9; **39**, 34280-95-0; 1*r*-methylcyclohexane-1,2*c*,6*c*-triol, 34280-96-1.

(42) G. W. Cavill and D. H. Solomon, *J. Chem. Soc.*, 4426 (1955).

C → O Migration of an Ethoxycarbonyl Group[1,2]

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The first example of a base-catalyzed C → O ethoxycarbonyl shift is described, occurring during the reaction of dialdehyde **1** (obtained from methyl α-D-glucopyranoside by periodation) with ethyl nitroacetate in the presence of base. The reaction products were proved to be methyl 3-deoxy-6-*O*-ethoxycarbonyl-3-nitro-α-D-hexosides of gluco (**8**) and manno configuration by preparation of a number of derivatives **9**–**12** by hydrolysis of the ethoxycarbonyl group in **9** and **12** to give known glucosides and by nmr and mass spectral data. Mechanistic aspects of this C → O migration are discussed.

While the occurrence of C → C migrations of alkoxycarbonyl groups is exceedingly well documented in the literature,[3] only one example each of an N → O[4] and of an O → O alkoxycarbonyl shift[5] has been disclosed. We now wish to report on yet another type, namely, on the first example of a C → O migration of an ethoxycarbonyl group. This rearrangement took place in a product formed from reaction of ethyl nitroacetate with a 1,5-dialdehyde.

The reaction of 2-*O*-(*S*-methoxyformyl)methyl-(*R*)-glyceraldehyde[6] (readily accessible from methyl α-D-glucoside by periodate oxidation) with ethyl nitroacetate in aqueous ethanol at pH 8.6 has been reported to give a substance to which the 1,4-dioxane structure **2** was assigned. Though structure **2** was further supported by derivatives **3**–**5**, and though some nmr data were cited as proof,[7] these findings neither explain why addition should preferentially occur at one aldehyde function nor why two pentose dialdehydes,[8] differing from **1** only in the absence of a hydroxymethyl sub-

(1) Nitromethane Condensation with Dialdehydes. XIX. Paper XVIII: F. W. Lichtenthaler and H. Zinke, *J. Org. Chem.*, **37**, 1612 (1972).

(2) (a) Taken in part from the doctoral dissertation of G. Bambach, submitted to the Technische Hochschule Darmstadt, Oct 1971. (b) Financial support of this work by the Deutsche Forschungsgemeinschaft and the Fonds der Chemischen Industrie is gratefully acknowledged.

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(4) J. H. Ransom, *Chem. Ber.*, **33**, 199 (1900).

(5) D. Trimnell, W. M. Doane, C. R. Russel, and C. E. Rist, *Carbohyd. Res.*, **13**, 301 (1970).

(6) In naming **5**, we prefer this designation derived from *R*-glyceraldehyde rather than the previous system of E. L. Jackson and C. S. Hudson, *J. Amer. Chem. Soc.*, **59**, 994 (1937), according to which **5** would be a "D-3-methoxy-D-hydroxymethyldiglycolaldehyde."

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(8) H. Yanagisawa, M. Kinoshita, and S. Umezawa, *Bull. Chem. Soc. Jap.*, **42**, 1719 (1969).