Synthesis of *ara*-3,7-Dideazaadenosine and Related Pyrrolo[3,2-*c*]pyridine D-Arabinofuranosides

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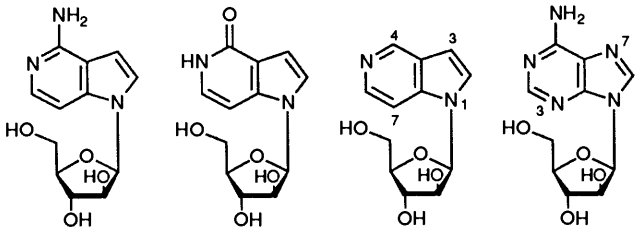
Pyrrolo[3,2-*c*]pyridine (3,7-dideazapurine) D-arabinonucleosides, including *ara*-3,7-dideazaadenosine **1**, *ara*-3,7-dideazainosine **2**, and *ara*-3,7-dideazanebularine **3** were synthesized from 1-(β-D-arabinofuranosyl)-4,6-dichloro-1*H*-pyrrolo[3,2-*c*]pyridine **10**. Compound **10** was obtained by glycosylation of the 4,6-dichloro-1*H*-pyrrolo[3,2-*c*]pyridine **5** anion (phase-transfer conditions) with the 2,3,5-tri-*O*-benzyl-D-arabinofuranosyl halides **6** or **7**. The ratio of glycosylation products (β:α) was 4:1 in the case of the bromide and 13:1 using the chloride. In contrast to *ara*-A, compound **1** is not deaminated by adenosine deaminase.

Arabinonucleosides are of importance as antiviral and antitumour agents. However, their medicinal application is limited since they are involved in normal cellular metabolism and/or they are destroyed by enzymatic deactivation. Thus, *ara*-A **4** is rapidly deaminated by adenosine deaminase, resulting in reduced activity.[1] In this regard the syntheses of *ara*-3,7-dideazapurine (pyrrolo[3,2-*c*]pyridine) nucleosides are presented, since they may show resistance towards this enzyme.

Stereoselective glycosylation during the synthesis of base-modified nucleosides using anions of nucleobases and appropriately protected halogeno sugars has been demonstrated for β-D-ribo-,[2] 2′-deoxy-β-D-ribo-[3] and β-D-arabino-furanosides.[4] Thus, *ara*-tubercidin (7-deaza-*ara*-adenosine) and its inosine congener were prepared using liquid–liquid phase-transfer conditions.[5] *ara*-Tubercidin was found to be deaminase resistant.[6] We now describe the synthesis of *ara*-3,7-dideaza-adenosine **1**, as well as that of congeners such as *ara*-3,7-dideazainosine **2** and *ara*-3,7-dideazanebularine **3**, which employs nucleobase anions generated under solid–liquid phase-transfer conditons (MeCN, KOH, TDA-1).[7]



1 **2** **3** **4**

Compound **5**[8] was used for glycosylation studies as it is a versatile intermediate, being subsequently converted into our target molecule **1** or **2**. First, the glycoslyation reaction of compound **5** with the halogenose **7**[9] was carried out. The two nucleosidic products, which were isolated after chromatographic purification, were identified as anomers (see compounds **10** and **11**, Table 1). The β-anomer **8** was obtained in 69% yield and the α-anomer **9** in 17% yield (Scheme 1). The β:α ratio was 4:1. Nevertheless, upon using the halogenose **6**[10] the β:α ratio was significantly better (**8** 78%, **9** 6%; β:α = 13:1) at almost the same total yield. The anomeric ratio (β:α) of the halide **6** was determined on the basis of the ^{1}H NMR signal intensities of the anomeric protons to be 1:12, pointing to inversion of configuration upon glycosylation.

In the case of pyrrolo[2,3-*d*]pyrimidines, glycosylation with the recently reported 2,3-*O*-isopropylidene-5-*O*-[(t-butyl)-dimethylsilyl]-α-D-ribofuranosyl chloride[11] was also stereoselective and gave anomerically pure β-D-ribofuranosides.[2] Surprisingly, this was not found for 4,6-dichloro-1*H*-pyrrolo[3,2-*c*]pyridine **5**. The reaction of compound **5** with this ribofuranosyl chloride in the presence of a three-fold excess of KOH and in the presence of tris-[2-(2-methoxyethoxy)ethyl]-amine (TDA-1) (MeCN) resulted in the formation of an anomeric mixture **13** 17% yield, **14** 18% yield).[12] Similar results were reported when employing the NaH-mediated glycosylation reaction **13** 13% yield; **14** 40% yield).[13] Apparently, anomerization of the α-D-ribohalogenose occurs before glycosylation.

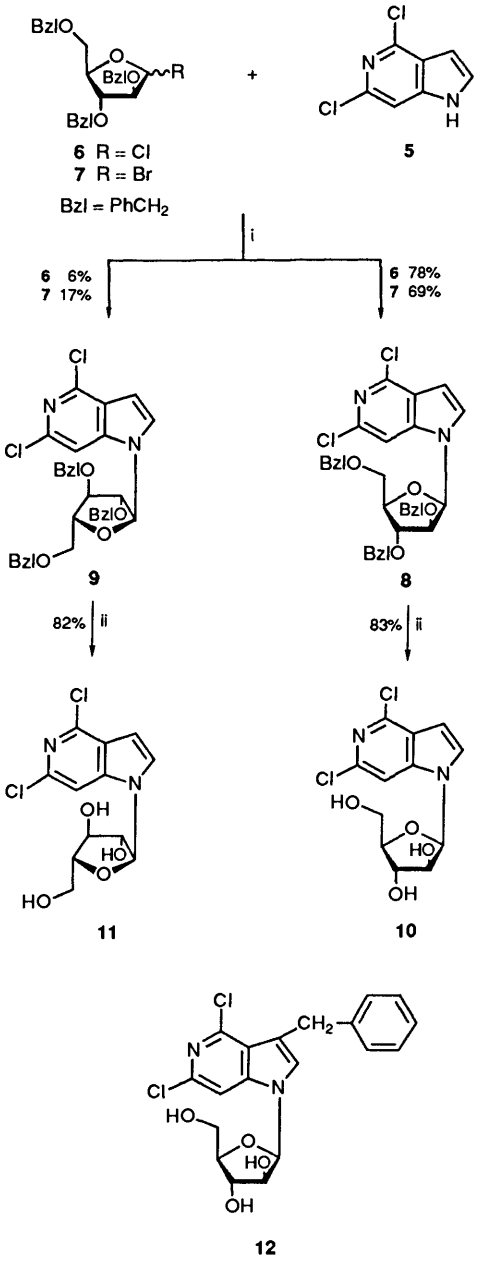
Table 1 1-D-NOE Difference data (%) of compounds **10** and **11** upon irradiation of 1′-H[a]

Compound	2′-Hα	2′-Hβ	3′-H	4′-H	2-H	7-H
10	12.1		0	2.5	4.6	17.8
11		2.3	3.5	0	5.2	14.1

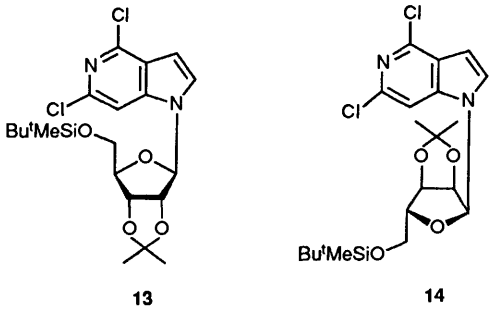
[a] Spectra measured in [$^2H_6$]Me_2SO.

Debenzylation of compounds **8** and **9**, respectively, with boron trichloride (dichloromethane at −78 °C) afforded the crystalline *ara*-nucleosides **10** and **11** in 83 and 82% yield, respectively. On carrying out the debenzylation of compound **8** at −15 °C, we observed a further UV-active zone, migrating somewhat faster than product **10**. From a comparison of the downfield shift of C-3 in the ^{13}C NMR spectrum,[14] compared with that of compound **10**, the structure was assigned to be the 3-benzyl derivative **12**.

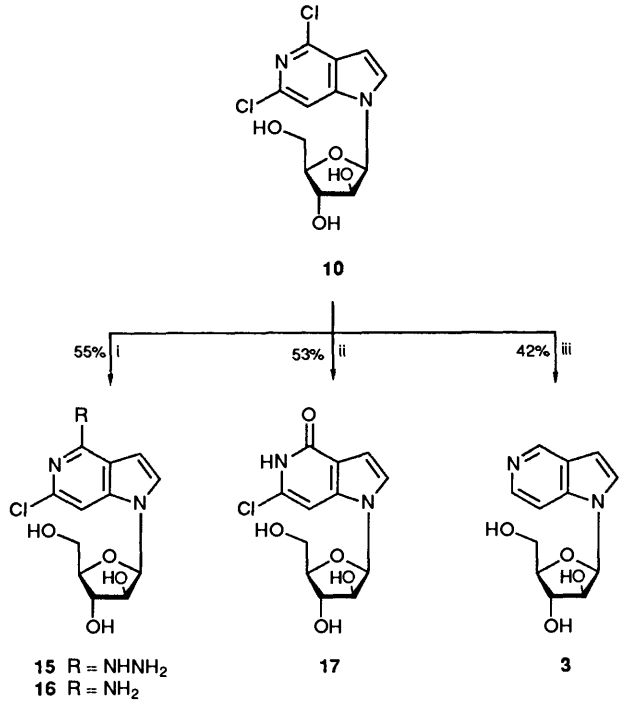
From a study of the NOE values of compounds **10** and **11** upon irradiation of the anomeric protons,[15] a β-configuration was deduced for product **10**. Consequently compound **11** was assigned as the α-anomer (Table 1). Moreover, the enhancements of 7-H and 2-H showed N-1 to be the glycosylation position. Within the series of anomers **10** and **11**, the sequence of glyconic OH signals changes. According to the ^{1}H NMR NOE data of Table 1 the following order was established. The 2′-OH group of the α-anomer **11** appears at higher field than the 3′-OH group, but *vice-versa* for the β-anomer **10**. Furthermore, the chemical shift difference between the signals for the 2′- and 3′-OH protons is significantly larger in the case of compound **11** (0.29 ppm) than in the case of **10** (0.05 ppm). All of the new compounds described herein were characterized by ^{13}C NMR spectra (Table 2). Chemical shift assignment was made on the basis of gated-decoupled spectra (Table 3) and [^{1}H, ^{13}C]-correlation spectra.



Scheme 1 *Reagents and conditions:* i, KOH, TDA-1, MeCN, room temp., 20 min; ii, BCl_3, CH_2Cl_2, −78 °C, 4 h



Within the series of pyrrolo[3,2-*c*]pyridine 2′-deoxyribo- and 2′,3′-dideoxyribo-nucleosides, displacement reactions at the 4-chloro group have been carried out selectively.[16] Thus, displacement of the 4-chloro substituent of **10** was carried out as depicted in Scheme 2. Reaction with hydrazine at 60 °C for 30 min followed by treatment with Raney nickel afforded crystalline amine **16** in 55% yield. The hydrazino intermediate **15** was also isolated. The UV maximum of compound **15** is bathochromically shifted compared with that of amine **16**. Removal of the chloro group in compound **16** was accomplished by catalytic hydrogenation (Pd/charcoal). Owing to the high (pK_{BH^+})-value (8.6 for the 2′-deoxy compound)[16] compound **1** had to be crystallized from water containing a trace of ammonia. Displacement of the 4-chloro substituent by a hydroxy group was achieved by heating of compound **10** under reflux (2 mol dm^{-3} NaOH) for 30 h. In contrast to the corresponding purines, the pyrrolo[3,2-*c*]pyridine ring (like that of pyrrolo[2,3-*d*]pyrimidines) is stable under these strongly alkaline conditions, whereas the 5-membered ring of purines is readily opened. Thus, compound **17** was able to be crystallized after desalting of the reaction mixture on an Amberlite XAD-2 resin (53% yield). Catalytic hydrogenation of compound **17** gave crystalline product **2**, isosteric with *ara*-inosine. Catalytic hydrogenation of compound **10** afforded the nebularine derivative **3** which is fluorescent, exhibiting an emission maximum at 405 nm upon irradiation at the excitation maximum (317 nm).



Scheme 2 *Reagents and conditions:* i, N_2H_4, 60 °C, 30 min; then Ra–Ni, EtOH, heat, 2 h; ii, 2 mol dm^{-3} NaOH, heat, 30 h; iii, Pd/C, H_2, EtOH, room temp., 2 h

The glycosydic bond of the pyrrolo[3,2-*c*]pyridine arabinofuranosides, unlike that of the purine counterparts, is stable to proton-catalysed hydrolysis. Moreover, compound **1** is not deaminated by adenosine deaminase. Data on the antiviral activity of pyrrolo[3,2-*c*]pyridine arabinofuranosides will be published elsewhere.

Experimental

Elemental analyses were performed by Mikroanalytisches Laboratorium Beller (Göttingen, Germany). ^1H NMR spectra were recorded at 250 MHz, and ^{13}C NMR spectra at 62.9 MHz, on a Bruker AC 250 spectrometer. Chemical shifts are relative to Me_4Si. UV spectra were measured on a 150-20-spectrophotometer (Hitachi, Japan). M.p.s were determined on a Linström apparatus (Wagner & Munz, Germany) and are not corrected.

Table 2 ^{13}C NMR data of *ara*-3,7-dideazapurine nucleosides in $[^2H_6]Me_2SO$[a,b]

Compound	C-2	C-3	C-3a	C-4	C-6	C-7	C-7a
1	124.9	100.3	110.4	153.5	139.2	97.0	140.2
2	124.1	103.3	115.4	159.5	127.0	94.1	138.9
3	129.0	100.6	125.2	142.9	140.1	106.0	139.5
5	129.4	100.2	122.5	140.2	138.9	106.3	142.2
8	131.2	100.9	122.9	140.3	139.6	106.6	142.4
9	130.2	101.7	123.2	140.7	140.0	106.0	141.9
10	131.2	100.3	122.8	140.1	139.2	106.4	142.4
11	130.2	101.2	123.2	140.6	139.7	105.9	142.0
12	130.2	113.6	120.8	140.1	139.1	106.1	143.5
15	125.5	100.3	108.3	153.8	140.6[c]	96.1	141.1[c]
16	125.6	100.4	109.3	152.7	140.5[c]	95.3	141.6[c]
17	125.1	103.0	113.6	158.7	128.5	95.4	139.4

Compound	C-1′	C-2′	C-3′	C-4′	C-5′	CH_2
1	85.0	76.3	75.4	83.4	61.2	
2	85.4	76.3	74.8	83.3	60.8	
3	85.1	76.5	75.0	83.4	60.9	
8	85.6[c]	81.4[c]	79.9[c]	82.2[c]	69.0	71.4/71.8/72.4
9	89.4[c]	82.9[c]	82.6[c]	86.4[c]	69.7	71.4/71.4/72.5
10	85.9	76.6	73.9	83.3	60.3	
11	90.2	80.3	75.1	85.3	61.2	
12	85.6	76.5	74.2	83.2	60.5	
15	85.1	76.4	74.7	83.1	60.8	
16	85.1	76.4	74.7	83.1	60.9	
17	85.6	76.5	74.4	83.2	60.6	

[a] Chemical shifts are given in δ-values relative to $SiMe_4$ as internal standard. [b] Superimposed by $[^2H_6]Me_2SO$. [c] Tentative assignment.

Table 3 *J*(C,H)-Coupling constants (Hz) of compounds **10a** and **11**[a]

		10	**11**		**10**	**11**
C(2),	H–C(2)	190.2	190.2	C(1′), H–C(1′)	163.8	161.9
	H–C(3)	8.5	8.8	C(2′), H–C(2′)	149.8	145.6
	H–C(1′)	4.4	4.8	C(3′), H–C(3′)	145.0	149.0
C(3),	H–C(3)	179.8	180.3	C(4′), H–C(4′)	145.1	148.8
	H–C(2)	7.9	7.6	C(5′), H–C(5′)	141.9	139.4
C(3a),	H–C(3)	9.0	9.0			
	H–C(2)	4.5	4.4			
	H–C(7)	4.5	4.4			
C(4)		*b*	*b*			
C(6),	H–C(7)	2.5	2.5			
C(7),	H–C(7)	174.5	173.5			
C(7a),	H–C(7)	6.8				
	H–C(2)	5.3				
	H–C(1′)	2.1				

[a] Spectra measured in $[^2H_6]Me_2SO$ relative to $SiMe_4$. [b] Singlet.

TLC was carried out on silica gel Sil G-25 UV_{254} plates (Macherey-Nagel & Co., Germany). Flash chromatography (0.5 bar) was carried out on silica gel 60 H (Merck, Germany). The columns were connected to a Uvicord S detector and an UltroRac II fraction collector (LKB-Instruments, Sweden). Acetonitrile (MeCN) was distilled from CaH_2. Solvent systems used were: A (CH_2Cl_2–EtOAc, 99:1), B ($CHCl_3$–MeOH, 8:2), C ($CHCl_3$–MeOH, 7:3), D ($CHCl_3$–MeOH, 9:1), E (CH_2Cl_2–MeOH, 95:5), F (CH_2Cl_2–MeOH, 8:2). Tris-[2-(2-methoxyethoxy)ethyl]amine (TDA-1) was a trade product of Aldrich Chemicals (USA).

Anomeric 4,6-*Dichloro*-1-(2,3,5-*tri*-O-*benzyl*-D-*arabinofuranosyl*)-1H-*pyrrolo*[3,2-*c*]*pyridines* **8** *and* **9**.—To a solution of 4,6-dichloro-1*H*-pyrrolo[3,2-*c*]pyridine[8] **5** (600 mg, 3.5 mmol) in MeCN (150 cm^3) were added powdered KOH (543 mg, 9.68 mmol) and TDA-1 (50 mm^3, 0.16 mmol) and the mixture was stirred at room temperature for 10 min. A solution of 2,3,5-tri-*O*-benzyl-D-arabinofuranosyl chloride **6**, which was prepared[9] from 2,3,5-tri-*O*-benzyl-1-*O*-(4-nitrobenzoyl)-D-arabinofuranose (2.2 g, 3.86 mmol), in MeCN (5 cm^3) was added and the mixture was stirred for a further 20 min (under N_2). Insoluble material was filtered off and the filtrate was evaporated to dryness. The oily residue was adsorbed on silica gel 60 and chromatographed on a silica gel column (35 × 5 cm). Solvent A eluted two main zones.

4,6-*Dichloro*-1-(2,3,5-*tri*-O-*benzyl*-α-D-*arabinofuranosyl*)-1H-*pyrrolo*[3,2-c]*pyridine* **9**. From the faster migrating zone an *oil* (114 mg, 6%) was isolated; R_f (solvent A) 0.45 (Found: C, 67.1; H, 5.3; N, 4.7; Cl, 11.8. $C_{33}H_{30}Cl_2N_2O_4$ requires C, 67.23; H, 5.13; N, 4.75; Cl, 12.03%); λ_{max}(MeOH)/nm 226 (ε/dm^3 mol^{-1} cm^{-1} 40 000), 277 (7100) and 290sh (5100); $\delta_H([^2H_6]Me_2SO)$ 3.66 (2 H, d, *J* 5.2 Hz, 5′-H_2), 4.26 (1 H, m, 4′-H), 4.47–4.65 (8 H, m, 3 × CH_2Ph, 2′-H and 3′-H), 6.39 (1 H, d, *J* 3.3 Hz, 1′-H), 6.69 (1 H, d, *J* 3.6 Hz, 3-H), 7.18–7.33 (15 H, m, ArH), 7.83 (1 H, d, *J* 3.6 Hz, 2-H) and 7.84 (1 H, s, 7-H).

4,6-*Dichloro*-1-(2,3,5-*tri*-O-*benzyl*-β-D-*arabinofuranosyl*)-1H-*pyrrolo*[3,2-c]*pyridine* **8**. From the slower migrating zone an *oil* (1.482 g, 78%) was obtained after evaporation of the solvent; R_f (solvent A) 0.40 (Found: C, 67.2; H, 5.2; N, 4.7; Cl, 12.2%); λ_{max}(MeOH)/nm 226 (37 200), 277 (6700) and 289sh (5000); $\delta_H([^2H_6]Me_2SO)$ 3.72 (2 H, m, 5′-H_2), 4.12 (1 H, m, 4′-H), 4.29 (1 H, m, 3′-H), 4.42 (1 H, m, 2′-H), 4.54–4.68 (6 H, m, 3 × CH_2Ph), 6.50 (1 H, d, *J* 5.3 Hz, 1′-H), 6.61 (1 H, d, *J* 3.5 Hz, 3-H), 7.14–7.35 (15 H, m, ArH), 7.70 (1 H, d, *J* 3.5 Hz, 2-H) and 7.91 (1 H, s, 7-H).

1-(β-D-*Arabinofuranosyl*)-4,6-*dichloro*-1H-*pyrrolo*[3,2-c]-*pyridine* **10**.—To a solution of compound **8** (1.0 g, 1.7 mmol) in CH_2Cl_2 (160 cm^3) at −78 °C solid CO_2–acetone was added a 1.2 mol dm^{-3} solution of boron trichloride in CH_2Cl_2 (16 cm^3, 19 mmol). The mixture was kept for 4 h at the same temperature and was then treated with MeOH–CH_2Cl_2 (160 cm^3, 1:1) and stored at room temperature for another 30 min. The solvent was evaporated off and the residue was chromatographed on a silica gel 60 H column (20 × 4 cm). Elution with solvent D and crystallization from aq. MeOH gave compound **10** as crystals (449 mg, 83%), m.p. 204–205 °C; R_f

(solvent **B**) 0.7 (Found: C, 45.1; H, 3.8; N, 8.7; Cl, 22.3. $C_{12}H_{12}Cl_2N_2O_4$ requires C, 45.16; H, 3.79; N, 8.78; Cl, 22.22%); λ_{max}(MeOH)/nm 278 (6700); δ_H([$^2H_6$]Me_2SO) 3.66 (1 H, m, 5′-H_b), 3.74 (2 H, m, 4′-H and 5′-H_a), 4.07 (1 H, q, *J* 5.5 Hz, 3′-H), 4.21 (1 H, q, *J* 5.8 Hz, 2′-H), 5.16 (1 H, t, *J* 4.7 Hz, 5′-OH), 5.45 (1 H, d, *J* 5.5 Hz, 2′-OH), 5.50 (1 H, d, *J* 5.2 Hz, 3′-OH), 6.30 (1 H, d, *J* 5.5 Hz, 1′-H), 6.63 (1 H, d, *J* 3.6 Hz, 3-H), 7.84 (1 H, s, 7-H) and 7.87 (1 H, d, *J* 3.6 Hz, 2-H).

1-(α-D-*Arabinofuranosyl*)-4,6-*dichloro*-1H-*pyrrolo*[3,2-c]-*pyridine* **11**.—In the same manner as described for the preparation of compound **10**, compound **9** (500 mg, 0.85 mmol) was treated with BCl_3 to afford the *title compound* as crystals (222 mg, 82%), m.p. 198–199 °C (from aq. MeOH); R_f (solvent D) 0.3 (Found: C, 45.3; H, 3.8; N, 8.8; Cl, 22.1%); λ_{max}(MeOH)/nm 226 (40 900), 277 (7100) and 291sh (5100); δ_H([$^2H_6$]Me_2SO) 3.45–3.57 (2 H, m, 5′-H_2), 3.98–4.34 (2 H, m, 3′- and 4′-H), 4.30 (1 H, q, *J* 5.2 Hz, 2′-H), 4.91 (1 H, dd, *J* 5.5, 6.0 Hz, 5′-OH), 5.54 (1 H, d, *J* 5.0 Hz, 3′-OH), 5.83 (1 H, d, *J* 5.2 Hz, 2′-OH), 5.94 (1 H, d, *J* 5.2 Hz, 1′-H), 6.70 (1 H, d, *J* 3.4 Hz, 3-H), 7.83 (1 H, s, 7-H) and 7.85 (1 H, d, *J* 3.4 Hz, 2-H).

1-(β-D-*Arabinofuranosyl*)-6-*chloro*-4-*hydrazino*-1H-*pyrrolo*-[3,2-c]*pyridine* **15** *and* 4-*Amino*-1-(β-D-*arabinofuranosyl*)-6-*chloro*-1H-*pyrrolo*[3,2-c]*pyridine* **16**.—Compound **10** (600 mg, 1.88 mmol) was dissolved in anhydrous N_2H_4 (7 cm^3) and the solution was heated at 60 °C for 30 min. Excess of hydrazine was evaporated off and the residue was coevaporated with EtOH (2 × 10 cm^3). For analytical data, *compound* **15** was crystallized from EtOH to afford crystals with m.p. 205 °C (decomp.); R_f (solvent **B**) 0.2 (Found: C, 45.9; H, 4.8; N, 17.9; Cl, 11.1. $C_{12}H_{15}ClN_4O_4$ requires C, 45.80; H, 4.80; N, 17.80; Cl, 11.26%); λ_{max}(MeOH)/nm 296 (13 900); δ_H([$^2H_6$]Me_2SO) 3.55–3.75 (3 H, m, 4′-H and 5′-H_2), 4.02 (1 H, m, 3′-H), 4.12 (1 H, m, 2′-H), 4.36 (br, NHNH_2), 5.04 (1 H, m, 5′-OH), 5.38 (2 H, m, 2′- and 3′-OH), 6.08 (1 H, d, *J* 5.4 Hz, 1′-H), 6.65 (1 H, d, *J* 3.3 Hz, 3-H), 6.86 (1 H, s, 7-H), 7.35 (1 H, d, *J* 3.3 Hz, 2-H) and 8.14 (1 H, s, N*H*NH_2).

The remaining hydrazide **15** was dissolved in aq. EtOH (60 cm^3; 1:1) and Raney nickel (1.5 g) was added. The mixture was heated to reflux for 2 h. The catalyst was filtered off and washed thoroughly with EtOH. The combined washings and filtrate were evaporated to dryness. The residue was dissolved in MeOH and adsorbed on silica gel 60 (1.0 g). Chromatographic purification (column 3 × 15 cm; solvent **B**) yielded the *amine* **16** as crystals (310 mg, 55% based on initial **10**), m.p. 205–206 °C (from aq. MeOH); R_f (solvent **B**) 0.5 (Found: C, 48.2; H, 4.7; N, 14.0; Cl, 11.7. $C_{12}H_{14}ClN_3O_4$ requires C, 48.09; H, 4.71; N, 14.02; Cl, 11.83%); λ_{max}(MeOH)/nm 277 (13 600) and 284sh (12 800); δ_H([$^2H_6$]Me_2SO) 3.50–3.75 (3 H, m, 4′-H and 5′-H_2), 4.01 (1 H, m, 3′-H), 4.12 (1 H, m, 2′-H), 5.02 (1 H, t, *J* 5.1 Hz, 5′-OH), 5.36 (1 H, d, *J* 5.4 Hz, 2′-OH), 5.42 (1 H, d, *J* 4.9 Hz, 3′-OH), 6.05 (1 H, d, *J* 5.2 Hz, 1′-H), 6.47 (2 H, s, NH_2), 6.59 (1 H, d, *J* 3.3 Hz, 3-H), 6.78 (1 H, s, 7-H) and 7.34 (1 H, d, *J* 3.3 Hz, 2-H).

4-*Amino*-1-(β-D-*arabinofuranosyl*)-1H-*pyrrolo*[3,2-c]*pyridine* (ara-3,7-*Dideazaadenosine*) **1**.—Compound **16** (200 mg, 0.67 mmol) was dissolved in MeOH (20 cm^3) and 25% aq. NH_3 (1 cm^3) was added. The solution was hydrogenated in the presence of Pd/charcoal (50 mg; 10% Pd) at room temperature for 30 h. The catalyst was filtered off and the filtrate was evaporated to dryness. The residue was applied to an Amberlite XAD-4 column (20 × 2 cm). The inorganic salt was eluted with aq. NH_3 (pH 12) and product **1** was eluted with Pr^iOH/H_2O (1:1). After evaporation of the solvent, *compound* **1** was obtained as crystals (106 mg, 60%), m.p. 236 °C (decomp.) (from MeOH); R_f (solvent C) 0.2 (Found: C, 54.4; H, 5.8; N, 15.7. $C_{12}H_{15}N_3O_4$ requires C, 54.33; H, 5.70; N, 15.84%); λ_{max}(MeOH)/nm 272 (12 800); δ_H([$^2H_6$]Me_2SO) 3.53–3.76 (2 H, m, 5′-H_2), 3.68 (1 H, m, 4′-H), 4.04 (1 H, m, 3′-H), 4.10 (1 H, m, 2′-H), 5.04 (1 H, m, 5′-OH), 5.39 and 5.48 (2 H, 2 m, 2′-and 3′-OH), 6.01 (2 H, s, NH_2), 6.08 (1 H, d, *J* 4.9 Hz, 1′-H), 6.59 (1 H, d, *J* 3.3 Hz, 3-H), 6.71 (1 H, d, *J* 6.1 Hz, 7-H), 7.33 (1 H, d, *J* 3.3 Hz, 2-H) and 7.53 (1 H, d, *J* 6.1 Hz, 6-H).

1-(β-D-*Arabinofuranosyl*)-1H-*pyrrolo*[3,2-c]*pyridine* (ara-3,7-*Dideazanebularine*) **3**.—A solution of compound **10** (300 mg, 0.94 mmol) in MeOH (25 cm^3) containing conc. aq. NH_3 (0.5 cm^3) was hydrogenated in the presence of Pd/charcoal (60 mg; 10% Pd) at room temperature for 2 h. The catalyst was filtered off and the filtrate was evaporated under reduced pressure. The solid residue was crystallized from water containing a trace of NH_3 to give *compound* **3** as needles (98 mg, 42%), m.p. 225–226 °C; R_f (solvent **B**) 0.15 (Found: C, 57.7; H, 5.7; N, 11.1. $C_{12}H_{14}N_2O_4$ requires C, 57.59; H, 5.64; N, 11.19%); λ_{max}(MeOH)/nm 270 (4500); δ_H([$^2H_6$]Me_2SO) 3.55–3.80 (3 H, m, 4′-H and 5′-H_2), 4.08 (1 H, m, 3′-H), 4.17 (1 H, m, 2′-H), 5.09 (1 H, m, 5′-OH), 5.44 (1 H, m, 3′-OH), 5.51 (1 H, m, 2′-OH), 6.28 (1 H, d, *J* 5.2 Hz, 1′-H), 6.61 (1 H, d, *J* 3.4 Hz, 3-H), 7.55 (1 H, d, *J* 5.8 Hz, 7-H), 7.65 (1 H, d, *J* 3.4 Hz, 2-H), 8.17 (1 H, d, *J* 5.8 Hz, 6-H) and 8.79 (1 H, s, 4-H).

1-(β-D-*Arabinofuranosyl*)-6-*chloro*-4-*oxo*-4,5-*dihydro*-1H-*pyrrolo*[3,2-c]*pyridine* **17**.—Compound **10** (400 mg, 1.25 mmol) was dissolved in 2 mol dm^{-3} NaOH (50 cm^3) and the solution was heated to reflux for 30 h. The mixture was then neutralized with 2 mol dm^{-3} aq. HCl, filtered, and applied to an Amberlite XAD-2 column (4.5 × 20 cm). Inorganic salt was eluted with water. Elution with aq. MeOH (1:1) afforded *compound* **17**, which was crystallized from aq. EtOH (~1:1) as needles, m.p. 238–240 °C (200 mg, 53%); R_f (solvent E) 0.25 (Found: C, 48.05; H, 4.3; N, 9.3; Cl, 11.7. $C_{12}H_{13}ClN_2O_5$ requires C, 47.93; H, 4.36; N, 9.32; Cl, 11.79%); λ_{max}(MeOH)/nm 213 (29 200), 270 (11 100), 293 (9800) and 304sh (6900); δ_H([$^2H_6$]Me_2SO) 3.66 (3 H, m, 4′-H and 5′-H_2), 4.02 (1 H, m, 3′-H), 4.12 (1 H, m, 2′-H), 5.07 (1 H, m, 5′-OH), 5.42 (2 H, m, 2′- and 3′-OH), 6.07 (1 H, d, *J* 5.4 Hz, 1′-H), 6.49 (1 H, d, *J* 3.3 Hz, 3-H), 6.85 (1 H, s, 7-H) and 7.37 (1 H, d, *J* 3.3 Hz, 2-H).

1-(β-D-*Arabinofuranosyl*)-4-*oxo*-4,5-*dihydro*-1H-*pyrrolo*[3,2-c]*pyridine* (ara-3,7-*Dideazainosine*) **2**.—Compound **17** (100 mg, 0.33 mmol) was dissolved in EtOH (50 cm^3) and hydrogenated in the presence of Pd–C (10% Pd, 20 mg) for 5 h (normal pressure; room temp.). The catalyst was filtered off and the filtrate was evaporated to dryness. The solid residue was crystallized from aq. MeOH to afford the *title compound* as crystals (50 mg, 56%), m.p. 241–243 °C (Found: C, 54.1; H, 5.3; N, 10.6. $C_{12}H_{14}N_2O_5$ requires C, 54.13; H, 5.30; N, 10.52%); R_f 0.3 (solvent F); λ_{max}(MeOH)/nm 212 (29 900), 265 (11 200), 283sh (8000) and 295sh (5300); δ_H([$^2H_6$]Me_2SO) 3.59–3.73 (3 H, m, 4′-H and 5′-H_2), 4.06 (1 H, m, 3′-H), 4.14 (1 H, m, 2′-H), 5.07 (1 H, t, *J* 5.0 Hz, 5′-OH), 5.44 (1 H, d, *J* 5.6 Hz, 2′-OH), 5.48 (1 H, d, *J* 4.8 Hz, 3′-OH), 6.09 (1 H, d, *J* 5.1 Hz, 1′-H), 6.52 (1 H, d, *J* 3.2 Hz, 3-H), 6.58 (1 H, d, *J* 7.2 Hz, 7-H), 7.01 (1 H, d, *J* 7.2 Hz, 6-H) and 7.33 (1 H, d, *J* 3.2 Hz, 2-H).

1-(β-D-*Arabinofuranosyl*)-3-*benzyl*-4,6-*dichloro*-1H-*pyrrolo*-[3,2-c]*pyridine* **12**.—Compound **8** (1.0 g, 1.7 mmol) was treated at −15 °C as described for the preparation of compound **10**. In addition to compound **10** (342 mg, 63%), the *title compound* was obtained as crystals (63 mg, 9%), m.p. 206–207 °C (from aq. MeOH) (Found: C, 55.8; H, 4.4; Cl, 17.2; N, 6.9. $C_{19}H_{18}Cl_2N_2O_4$ requires C, 55.76; H, 4.43; Cl, 17.32; N, 6.84%); R_f 0.68 (solvent **B**); δ_H([$^2H_6$]Me_2SO) 3.55–3.75 (3 H, m, 3′-H and 5′-H_2), 4.01 (1 H, m, 4′-H), 4.16–4.23 (3 H, m, 2′-H

and CH_2Ph), 5.03 (1 H, t, 5′-OH), 5.45 (1 H, d, *J* 5.5 Hz, 2′-OH), 5.48 (1 H, d, *J* 5.1 Hz, 3′-OH), 6.27 (1 H, d, *J* 5.5 Hz, 1′-H), 7.17–7.27 (5 H, m, Ph) and 7.62 and 7.81 (2 H, 2 s, 2- and 7-H).

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