110. Synthesis and Properties of 2′-Deoxy-1′,2′-seco-D-ribosyl (5′ → 3′)Oligonucleotides (= 1′,2′-Seco-DNA) Containing Adenine and Thymine[1])

by **Ling Peng**[2])* and **Hans-Jörg Roth**[3])

Laboratory of Organic Chemistry, Swiss Federal Institute of Technology, Universitätstrasse 16, CH-8092 Zürich

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Some 2′-deoxy-1′,2′-seco-D-ribosyl (5′ → 3′)oligonucleotides (= 1′,2′-seco-DNA), differing from natural DNA only by a bond scission between the centers C(1′) and C(2′), were synthesized and studied in order to compare their structure properties and pairing behavior with those of corresponding natural DNA and homo-DNA oligonucleotides (2′,3′-dideoxy-β-D-glucopyranosyl oligonucleotides). Starting from (−)-D-tartaric acid, 2′-deoxy-1′,2′-secoadenosine derivative **9a** and 1′,2′-secothymidine (**9b**) were obtained in pure crystalline form. Using the phosphoramidite variant of the phosphite-triester method, a dinucleotide monophosphate 1′,2′-seco-d(T_2) was synthesized in solution, while oligonucleotides 1′,2′-seco-d[$(AT)_6$], 1′,2′-seco-d(A_{10}) and 1′,2′-seco-d(T_{10}) were prepared on solid phase with either automated or manual techniques. Results of UV- and CD-spectroscopic as well as gel-electrophoretic studies indicated that neither adenine-thymine base pairing (as observed in natural DNA and homo-DNA), nor the adenine-adenine base pairing (as observed in homo-DNA) was effective in 1′,2′-seco-DNA. Furthermore, hybrid pairing was observed neither between 1′,2′-seco-DNA and natural DNA nor between 1′,2′-seco-DNA and homo-DNA.

Introduction. – Our studies on 2′-deoxy-1′,2′-seco-D-ribosyl (5′ → 3′)oligonucleotides (= 1′,2′-seco-DNA; *Fig. 1*), [10] were inspired by the stimulating results obtained from the investigation of 2′,3′-dideoxy-β-D-glucopyranosyl (6′ → 4′)oligonucleotides (homo-DNA; *Fig. 1*) [1–11] in the laboratory of *A. Eschenmoser*. According to a qualitative conformational analysis [1], the backbone of an idealized single-strand homo-DNA oligonucleotide is linear, while that of natural DNA oligonucleotide is helical. The linearity of the idealized homo-DNA backbone is a direct consequence of the endocyclic torsion angle δ in the six-membered hexopyranose chair being fixed to 60° [1]. The corresponding angle in a five-membered ribofuranose sugar, as a result of the intrinsic flattening of the ring, must be greater (δ = 80–140°), leading to the helical backbone of natural DNA [1]. The structure properties of homo-DNA resulted in a pairing behavior, which is, in part, similar to, but also, in part, strikingly different from that of natural DNA, namely, stronger *Watson-Crick* base pairings in homo-DNA than in natural DNA and surprisingly stable purine-purine base pairings in homo-DNA [3] [5] [12]. These uncovered divergences in pairing behavior between homo-DNA and natural DNA, due

[1]) This work was made possible by the support of Prof. *Albert Eschenmoser* and was carried out in his laboratory in the context of the studies on the chemistry of homo-DNA [1–11].

[2]) Part of the thesis of *L. Peng* [10]; present address: Laboratoire de Chimie Bio-Organique, URA 1386 CNRS, Faculté de Pharmacie, Université Louis Pasteur Strasbourg, BP 24, F-67401 Illkirch Cedex.

[3]) Present address: *Novartis Pharma AG*, CH-4002 Basel.

basically to the change of the endocyclic torsion angle δ from a flexible (80–140°) to a rigid value (60°), make us raise further questions such as, what would happen to the pairing behavior of oligonucleotides if the endocyclic torsion angle δ of the sugar component could be much more flexible or could even rotate freely ($\delta = 0-180°$). For example, a simple bond scission of the ribofuranose ring betwen C(1′) and C(2′) (*Fig. 1*) leads to a more flexible acyclic sugar component, where the endocyclic torsion angle δ is free of ring strain, and is thus theoretically free-rotating ($\delta = 0-180°$). We call oligonucleotides made of such sugar components 1′,2′-seco-DNA. Is there any pairing in 1′,2′-seco-DNA? Is the *Watson-Crick* pairing principle valid in 1′,2′-seco-DNA? Does stable purine-purine base pairing exist in 1′,2′-seco-DNA as in homo-DNA? If yes, we anticipate, according to the flexible acyclic sugar component, much weaker base pairings. Furthermore, does a 1′,2′-seco-DNA oligonucleotide also hybrid with its counterpart of natural DNA or homo-DNA?

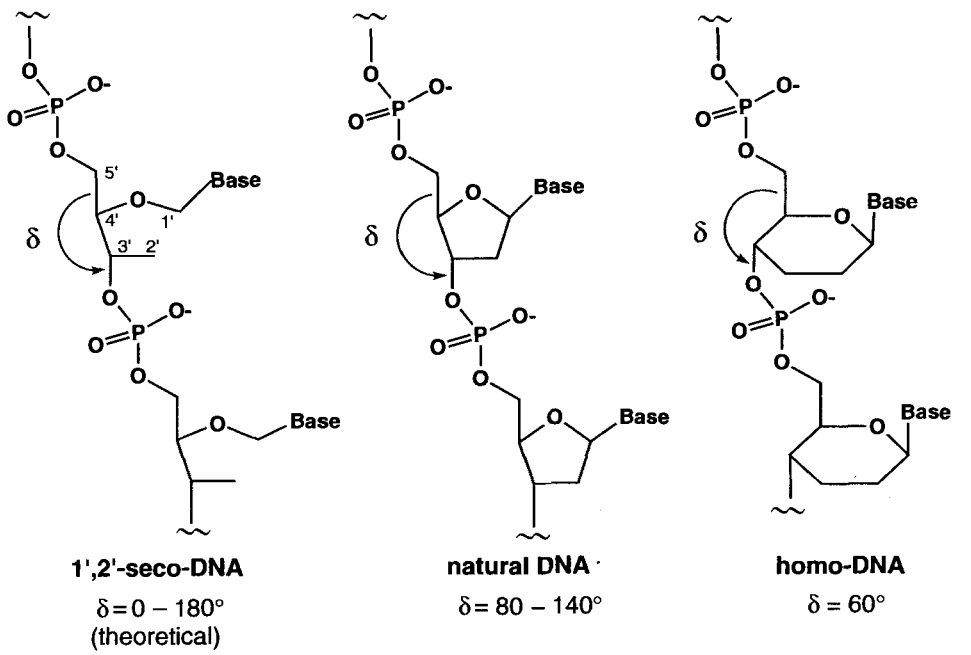
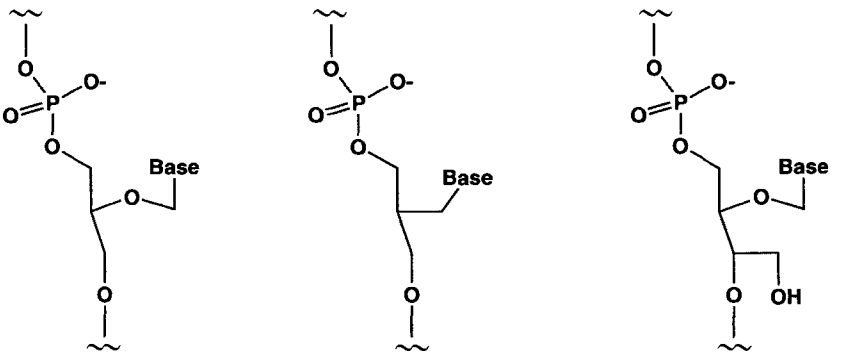


Fig. 1. *Constitution of a 1′,2′-seco-DNA oligonucleotide strand as compared to a DNA and a homo-DNA oligonucleotide strand*

Flexible, acyclic oligonucleotides have been proposed as prebiotic nucleic-acid analogues which might be potentially considered as ancestral genetic molecules [13–15]. Furthermore, acyclic DNA analogues might also be of pharmaceutical interest [15] [16] because they might serve as potential antiviral drugs or nuclease-resistant antisense probes. We were particularly interested in the 1′,2′-seco-DNA structure for the sake of comparison of its pairing behavior with those of the corresponding natural DNA and homo-DNA. Several research groups have investigated 'flexible' DNA analogs where the ribose component of RNA is replaced by an acyclic sugar component [13–16] (see **A**–**C**,

Fig. 2). However, the pairing properties of DNA oligonucleotides entirely constituted of acyclic sugar components has not been studied and reported. Here, we report the synthesis and properties of 2′-deoxy-1′,2′-seco-D-ribosyl (5′ → 3′)oligonucleotides containing adenine and thymine (1′,2′-seco-DNA in *Fig. 1*) which differs from the natural DNA only by a bond scission between C(1′) and C(2′) of the sugar component.



A [13-16] **B** [14] **C** [14]

Fig. 2. *Constitution of some selected acyclic RNA oligonucleotides* [13–16]

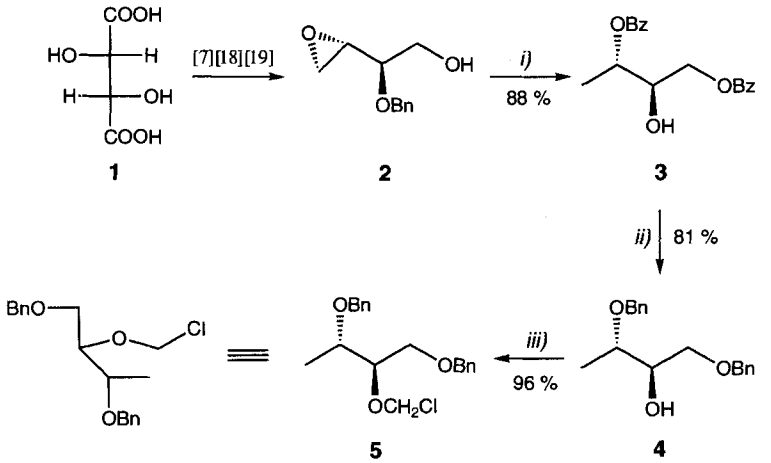
Synthesis. – *Scheme 1* illustrates the preparation of the precursor of the sugar constituent in 1′,2′-seco-DNA, 2,4-di-*O*-benzyl-1-deoxy-D-erythritol (**4**)[4]), starting from (−)-D-tartaric acid (**1**) [7] [18] [19]. Regiospecific opening of the epoxide ring in 1,2-anhydro-3-*O*-benzyl-D-erythritol (**2**) with $LiAlH_4$, followed by protection of the diol with benzoyl groups and subsequent removal of the benzyl function gave 2,4-di-*O*-benzoyl-1-deoxy-D-erythritol (**3**). The benzoyl protecting groups in **3** were changed to the benzyl protecting groups (→ **4**) for the sake of avoiding undesired transesterification in the subsequent chloromethylation. The conversion of **3** to **4** was straightforward with a transient protection of the free OH group in **3** by the tetrahydro-2*H*-pyran-2-yl group. Treatment of **4** with paraformaldehyde and HCl gas gave the corresponding chloromethyl ether **5** in quantitative yields.

Condensation of the chloromethyl ether **5** with persilylated thymine (*Scheme 2*) in the presence of a catalytic amount of $(Bu_4N)I$ [16] gave the corresponding benzyl-protected nucleoside **6**, which was then deprotected by catalytic transfer hydrogenation with *Pearlman*'s catalyst, $Pd(OH)_2/C$, to give 2′-deoxy-(1′,2′-seco-D-ribosyl)thymine (**9b**). The N^1 substitution of thymine nucleoside **9b** was assigned by ^{1}H-NMR difference NOE experiments (irradiation at the reasonance of 2 H−C(1′) → very strong positive NOE at the signal of H−C(6)).

Condensation of the chloromethyl ether **5** with 6-chloropurine (*Scheme 2*) in the presence of Et_3N [20] resulted in two nucleoside isomers, the N^9-isomer **7a** and the N^7-isomer **7b**, which could be separated by flash column chromatography. Treatment of **7a** and **7b** with methanolic ammonia solution gave the corresponding adenine nucleoside **8a** and **8b**, respectively. The N^7 substitution of adenine nucleoside **8b** was assigned by

[4]) The 2,4-di-*O*-benzyl-1-deoxy-D-erythritol (**4**) can be also prepared from D-isoascorbic acid [17].

Scheme 1. *Synthesis of the Precursor* **5** *of the Sugar Unit in 1′,2′-Seco-DNA from (−)-D-Tartaric Acid* (**1**)



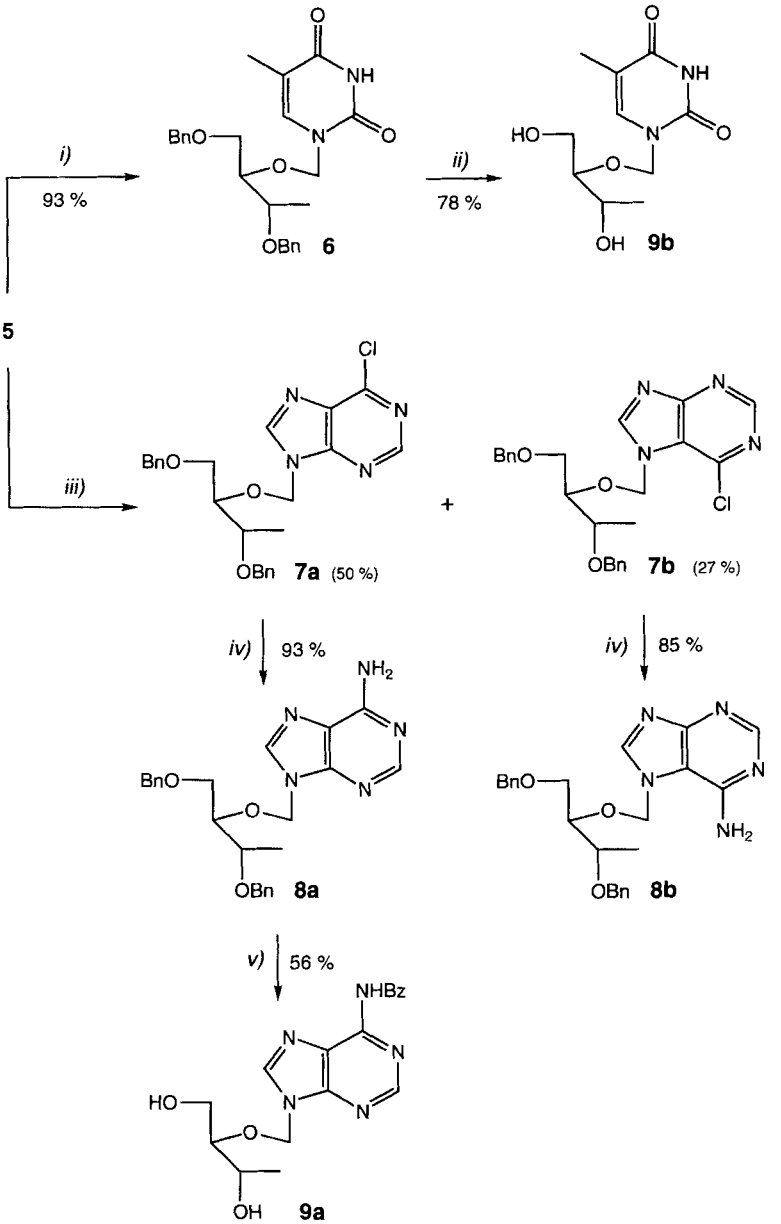
i) 1. $LiAlH_4$, Et_2O, $-70° \rightarrow$ r.t., 16 h (99%); 2. benzoyl chloride (BzCl), pyridine, r.t., 45 min (94%); 3. H_2, Pd/C, MeOH, r.t., 50 bar, 27 h (93%). *ii*) 1. 3,4-Dihydro-2*H*-pyran, pyridinium *p*-toluenesulfonate, r.t., 4.5 h (99%) 2. 0.2M NaOH, THF/MeOH/H_2O 5:4:1, 0°, 20 min (93%); 3. benzyl bromide (BnBr), NaH, $(Bu_4N)I$, r.t., 8 h (97%); 4. pyridinium *p*-toluenesulfonate, EtOH, 60°, 3 h (89%). *iii*) Paraformaldehyde, HCl (g), CH_2Cl_2, 0°, 45 min (96%).

^{1}H-NMR NOE experiments (irradiation at the signal of NH_2–C(6) → clear positive NOE at the signal of 2 H–C(1′)). Corresponding ^{1}H-NMR NOE experiments on **8a** were hampered by overlapping signals (NH_2–C(6) and arom. H). Nevertheless, the unambiguous assignment of the N^7 substitution to **8b** indirectly confirmed the N^9 substitution of **8a**. The *N*-benzoyl derivative **9a** was prepared from **8a** by subsequent deprotection of the benzyl groups by hydrogenation, and then one-pot treatment [21] including transient silylation of the two free OH groups of the sugar unit with trimethylsilyl chloride, benzoylation of the amine function at the adenine moiety with benzoyl chloride, and final desilylation with aqueous ammonia solution.

According to the phosphoramidite variant [22] of the phosphite-triester method [23] for nucleic-acid synthesis, the phosphoramidites **11a** and **11b** and the solid-support-linked derivatives **12a** and **12b** were prepared as described in [2] [24] (*Scheme 3*). Regioselective tritylation of the primary OH group in **9a,b** with 4,4′-dimethoxytrityl chloride gave **10a,b** in almost quantitative yield. Treatment of **10a,b** with chloro(2-cyanoethoxy)-(diisopropylamino)phosphine yielded phosphoramidites **11a,b** as mixtures of diastereoisomers (*ca.* 1:1 ratio as determined by ^{1}H- and ^{31}P-NMR). The solid-support-linked derivatives **12a,b** were prepared by conversion of **10a,b** to *p*-nitrophenyl-ester derivatives with heptanedioic acid bis(*p*-nitrophenyl)ester and subsequent coupling with long-chain-alkylamine-controlled pore glass (CGP-NH_2). Loading capacities were over 30 μmol of nucleoside per g of solid support (trityl assay).

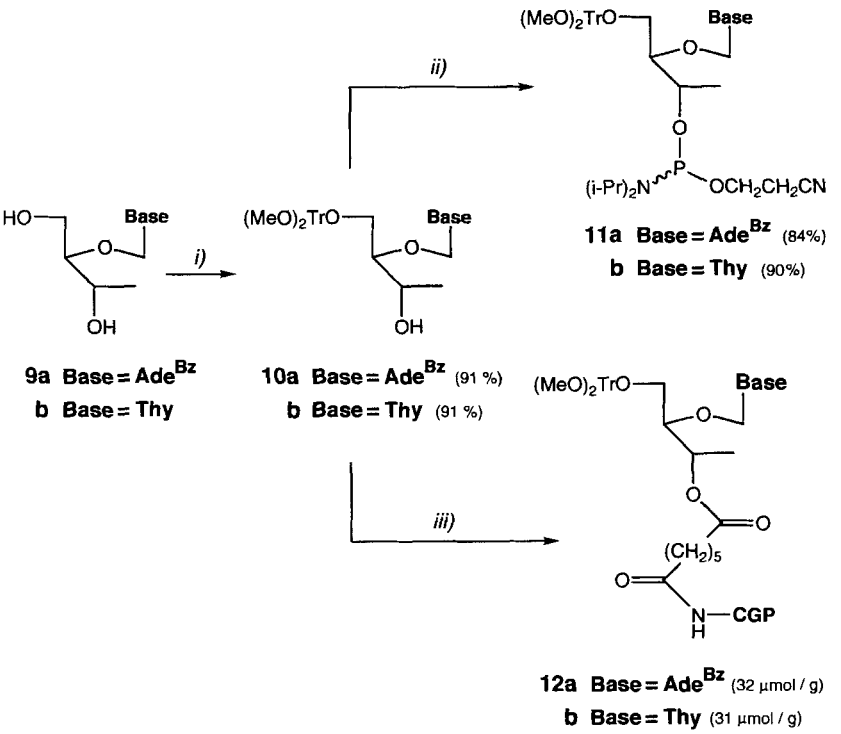
The oligonucleotides 1′,2′-seco-d(A_{10}), 1′,2′-seco-d(T_{10}), and 1′,2′-seco-d[$(AT)_6$] were prepared on a *ca.* 1–2 μmol scale on solid phase with automated or manual techniques as described in [2] [24], using the solid-support-linked starting units **12a,b** and the coupling units **11a,b**. The average coupling yield was over 95% (trityl assay). After chain assembly was complete (trityl-off mode), detachment from the solid support and removal of the

Scheme 2. *Synthesis of the 1',2'-Seconucleoside Derivatives* **9a** *and* **9b**, *Containing the Nucleobase Adenine and Thymine, Respectively*



i) Thymine, *N,O*-bis(trimethylsilyl)acetamide, $(Bu_4N)I$, CH_2Cl_2, 80°, 3 h (93%). *ii*) Cyclohexene, $Pd(OH)_2/C$, EtOH, 80°, 16 h (78%). *iii*) 6-Chloropurine, Et_3N, DMF, r.t., 18 h. *iv*) Sat. NH_3 in MeOH, 110°, 17 h. *v*) 1. Cyclohexene, $Pd(OH)_2/C$, EtOH, 80°, 17 h (69%); 2. Me_3SiCl, pyridine, r.t., 30 min; benzoyl chloride, r.t., 1.5 h; conc. NH_3, r.t., 30 min (81%).

Scheme 3. *Synthesis of the 1′,2′-Seconucleoside Phosphoramidites* **11a** *and* **11b**, *and Solid-support Derivatives* **12a** *and* **12b**, *Containing the Nucleobase Adenine and Thymine, Respectively*



i) $(MeO)_2TrCl$, $(Bu_4N)ClO_4$, pyridine, r.t., 1 h (91%). *ii*) $[(i\text{-}Pr)_2N]PCl(OCH_2CH_2CN)$, $(i\text{-}Pr)_2EtN$, CH_2Cl_2, r.t., 45 min (84–90%). *iii*) 1. $(p\text{-}NO_2)C_6H_4OCO(CH_2)_5COOC_6H_4(p\text{-}NO_2)$, 4-(dimethylamino)pyridine, pyridine, r.t., 16 h; 2. CPG-NH_2, Et_3N, DMF, r.t., 48 h; Ac_2O, pyridine, 4-(dimethylamino)pyridine, r.t.

base and phosphate protecting groups was effected in a standard manner by treatment with methanolic ammonia solution at 55° for 16 h. The crude oligonucleotides were purified by HPLC (*Table 1*) on an ion-exchange or reversed-phase column leading to > 95% purity, which was confirmed also by gel electrophoresis.

To check the synthetic procedure by spectroscopic product characterization, 1′,2′-seco-d(T_2) was prepared on a 100-μmol scale in solution by coupling **11b** with **13** (*Scheme 4*). The composition and structure of 1′,2′-seco-d(T_2) was verified by ^1H-, ^{13}C-, and ^{31}P-NMR spectroscopy (*Table 2*) as well as FAB mass spectrometry (*Table 1*).

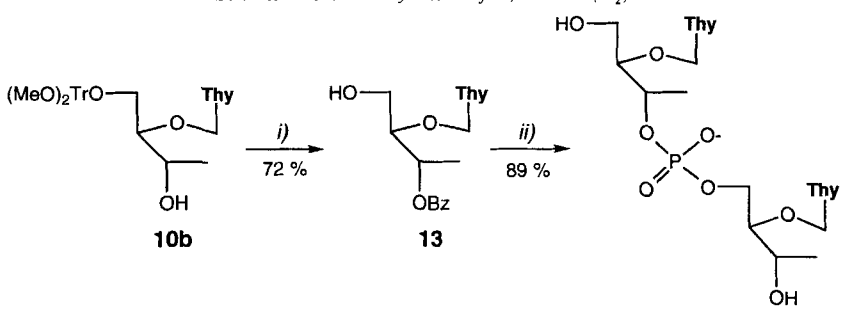
Properties. – Methods for the characterization of the pairing behavior of 1′,2′-seco-DNA oligonucleotides were the same as those used in the studies of natural and homo-DNA [3] [25], namely, temperature- and concentration-dependent UV spectroscopy, as well as temperature-dependent CD spectroscopy and gel electrophoresis in the concentration range of 4–50 μM oligonucleotide in 0.15M NaCl and 0.01M *Tris* · HCl buffer, pH 7.0. The results, obtained from 1′,2′-seco-DNA oligonucleotides containing adenine and thymine, were always compared to those obtained from corresponding natural DNA and homo-DNA oligonucleotides.

Table 1. *HPLC and MS Data of 2'-Deoxy-1',2'-seco-D-ribosyl Oligonucleotides*

Oligonucleotide	Anal. HPLC		FAB-MS[a])	
	DEAE[b]) t_R [min]	*Mono Q*[c]) t_R [min]	$[M-H]^-$ (obs.)	$[M-H]^-$ (calc.)
1',2'-seco-d(T_2)			549.0	549.0
1',2'-seco-d(T_{10})	20[d])			
1',2'-seco-d(A_{10})		24[e])		
1',2'-seco-d[$(AT)_6$]	17[f])			

[a]) Fast atom bombardment mass spectrometry; matrix: glycerol/thioglycerol. [b]) *Nucleogen DEAE 60-7*, 125 × 4.6 mm (*Macherey & Nagel*). [c]) *Mono Q HR 5/5*, 58 × 6.0 mm (*Pharmacia*). [d]) 20–60% *B* within 40 min; *A*: 20 mM K_2HPO_4/KH_2PO_4 in H_2O/MeCN 4:1, pH 6.0; *B*: *A* + 1M KCl; flow 1 ml/min; detection at 260 nm. [e]) 0–40% *B* within 30 min; *A*: 10 mM NaOH, pH 12; *B*: *A* + 1M NaCl; flow 1 ml/min; detection at 260 nm. [f]) 35–85% *B* in 30 min; *A*: 20 mM K_2HPO_4/KH_2PO_4 in H_2O/MeCN 4:1, pH 6.0; *B*: *A* + 1M KCl; flow 1 ml/min; detection at 260 nm.

Scheme 4. *Solution Synthesis of 1',2'-Seco-d(T_2)*



i) 1. Benzoyl chloride, pyridine, r.t., 1 h (95%); 2. 80% AcOH/H_2O, r.t., 1 h (76%). *ii*) 1. **11b**, 1*H*-tetrazole, MeCN, r.t., 3 h; 2. I_2, THF/2,6-dimethylpyridine/H_2O 2:2:1; 3. 80% AcOH/H_2O, r.t., 30 min; 4. conc. NH_3, 55°, 20 h (89%).

Under the experimental conditions employed, oligonucleotide dodecamer 1',2'-seco-d[$(AT)_6$] displays a steadily increasing hyperchromicity on measurement of the UV melting-point curve (*Fig. 3,a*), indicating pronounced intramolecular base stacking rather than cooperative intermolecular duplex formation. Under the same conditions, however, the natural DNA oligonucleotide d[$(AT)_6$] shows a typical sigmoid melting-point curve (*Fig. 3,b*) [3], resulting from a paired duplex with a melting point of 24°, as does the homo-DNA oligonucleotide ddGlc[$(AT)_6$] which forms an even more stable duplex with a melting point of 59° (*Fig. 3,c*) [3].

The 1',2'-seco-d(A_{10}) undergoes only intramolecular base stacking, as indicated by the results of UV and CD spectroscopy (*Fig. 4*). The steadily increasing hyperchromicity at 260 nm for 1',2'-seco-d(A_{10}) (*Fig. 4,a*) in the UV melting curves is similar to that observed for the natural DNA oligonucleotide d(A_{10}) [3] for which intramolecular stacking of the adenine bases is well known, but different from that for homo-DNA oligonucleotide ddGlc(A_{10}) [7] where unambiguous sigmoid melting curves indicate formation of intermolecular duplexes and the melting points of duplex display a strong

Table 2. *Chemical Shifts* (δ [ppm]) *of Non-exchangeable Protons*[a]) *and of the P- and C-Atoms*[b]) *of 1',2'-Seco-d(T_2) and Coupling Constants J(P,C)*[c]) [Hz]

	H–C(1')	H–C(1')	3 H–C(2')	H–C(3')	H–C(4')	H–C(5')	H–C(5')	Me–C(5)	H–C(6)	P
T^1	5.30	5.31	1.21	4.28[d])	3.75	3.56	3.68	1.87	7.55	
										−1.78
T^2	5.30	5.31	1.15	3.90	3.72	3.87	4.00[d])	1.87	7.55	

	C(1')	C(2')	C(3')	C(4')	C(5')	C(2)	C(4)	C(5)	*Me*C(5)	C(6)
T^1		18.95 $J = (2.0)$	74.72 $J = (5.7)$	84.70 $J = (8.1)$	63.26					
	80.18					169.58	155.00	113.80	14.2	144.87
	80.23					169.62	155.02	113.90	14.2	144.79
T^2		20.07	69.03	85.25 $J = (6.7)$	67.45 $J = (5.4)$					

[a]) Assignment based on ROESY and COSY. [b]) Assignment based on $^{13}C,^{1}H$ correlation. [c]) J(P,C) determined from the ^{1}H-broad-band-decoupled ^{13}C-NMR spectrom. [d]) Determined by comparison of ^{31}P-coupled and -decoupled spectra.

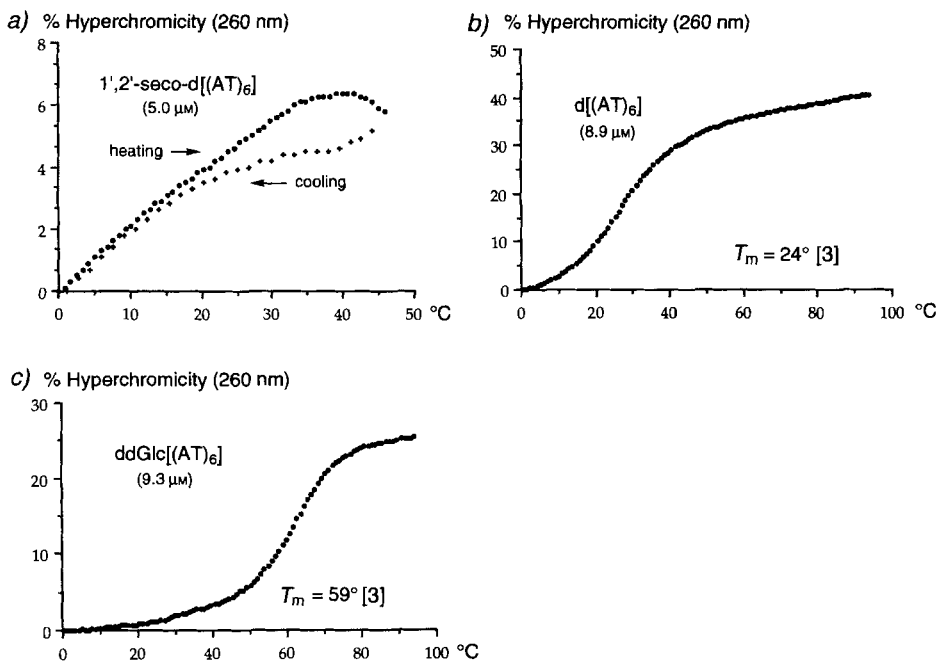


Fig. 3. *Temperature-dependent UV spectroscopic studies of* a) *1',2'-seco-DNA oligonucleotide 1',2'-seco-d[$(AT)_6$], in comparison with* b) *the corresponding natural DNA oligonucleotide d[$(AT)_6$]* [3] *and* c) *the homo-DNA oligonucleotides ddGlc[$(AT)_6$]* [3]

dependence on concentrations. Moreover, the temperature-dependant CD spectra of 1′,2′-seco-d(A_{10}) (*Fig. 4,b*) show one positive *Cotton* effect around 250 nm and two negative *Cotton* effects around 220 and 270 nm, different from those of d(A_6) and of ddGlc(A_6) [3] which exhibit two positive *Cotton* effects around 220 and 270 nm and a negative one around 250 nm. However, all CD spectra show diminishing of spectral structures with increasing temperature. Neither 1′,2′-seco-d(A_{10}) nor d(A_6) manifests a sigmoid melting curve derived from their CD spectra (*Fig. 4,c*), while ddGlc(A_6) displays a sigmoid curve with a turning point of *ca.* 40° [3]. These results are in good agreement with those obtained from UV spectroscopy, implying that 1′,2′-seco-d(A_{10}) undergoes intramolecular stacking of adenine bases as natural DNA oligonucleotide d(A_6), but does not form intermolecular duplexes as homo-DNA oligonucleotide ddGlc(A_6) under the experimental conditions employed.

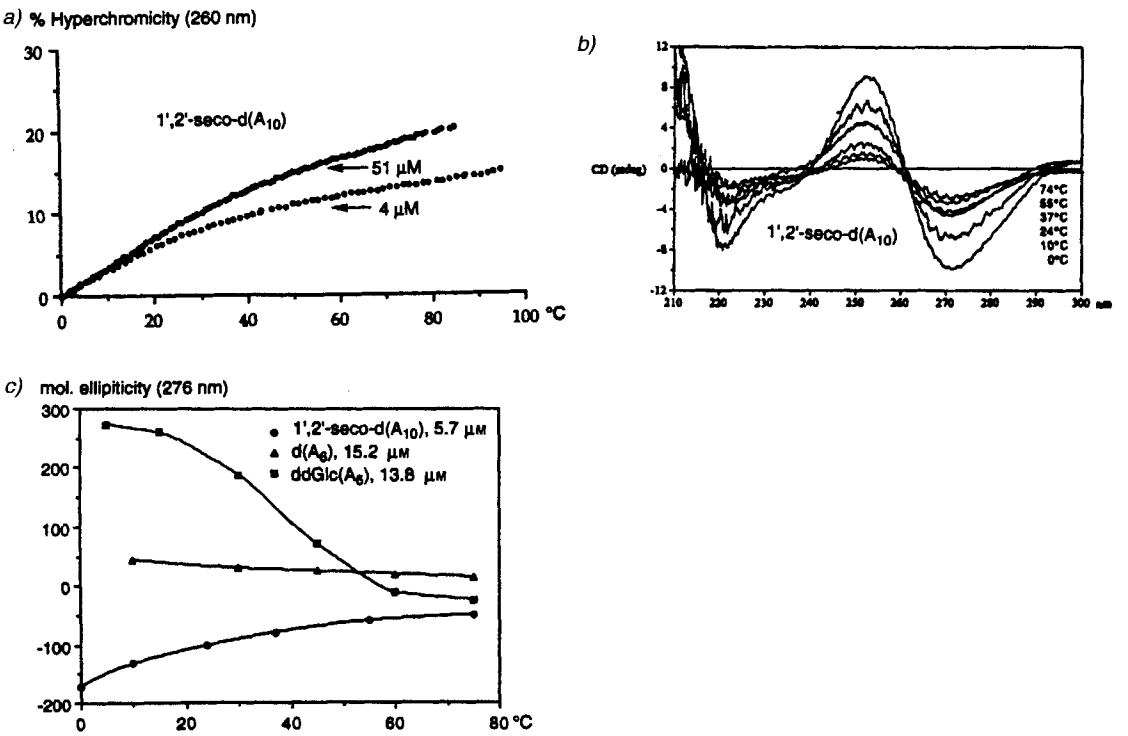


Fig. 4. *UV- and CD-spectroscopic studies of 1′,2′-seco-DNA oligonucleotide 1′,2′seco-d(A_{10})*

No duplex formation between 1′,2′-seco-d(A_{10}) and 1′,2′-seco-d(T_{10}) could be deduced from the results of temperature-dependent UV and CD spectroscopy as well as gel electrophoresis of a 1:1 mixture of 1′,2′-seco-d(A_{10}) and 1′,2′-seco-d(T_{10}) (*Fig. 5*). UV Spectroscopic measurement of 1:1 mixture of 1′,2′-seco-d(A_{10}) and 1′,2′-seco-d(T_{10}) (*Fig. 5,a*) display a steadily increasing hyperchromicity curve rather than a sigmoid curve, indicating intramolecular stacking of adenine bases of 1′,2′-seco-d(A_{10}) rather than cooperative intermolecular duplex formation between 1′,2′-seco-d(A_{10}) and 1′,2′-seco-

d(T_{10}). CD Spectroscopy of a 1:1 mixture of 1′,2′-seco-d(A_{10}) and 1′,2′-seco-d(T_{10}) (*Fig. 5, b*) shows a spectral structure which resembles very much that of the 1′,2′-seco-d(A_{10}) single strand and can be considered as a simple addition of the spectra of 1′,2′-seco-d(A_{10}) and 1′,2′-seco-d(T_{10}), implying also no duplex formation. Gel electrophoresis under non-denaturing conditions (*Fig. 5, c*) provides further corroboration: the 1:1 mixture of 1′,2′-seco-d(A_{10}) and 1′,2′-seco-d(T_{10}) runs as separated components of the single strands of 1′,2′-seco-d(A_{10}) and 1′,2′-seco-d(T_{10}), demonstrating unambiguously that there is no duplex formed between 1′,2′-seco-d(A_{10}) and 1′,2′-seco-d(T_{10}). This behavior is in sharp contrast with that of corresponding natural DNA and homo-DNA oligonucleotides, where d(A_{10}) pairs with d(T_{10}) as a *Watson-Crick* duplex in natural DNA, while ddGlc(A_{10}) pairs with itself, but not with ddGlc(T_{10}) in homo-DNA [3].

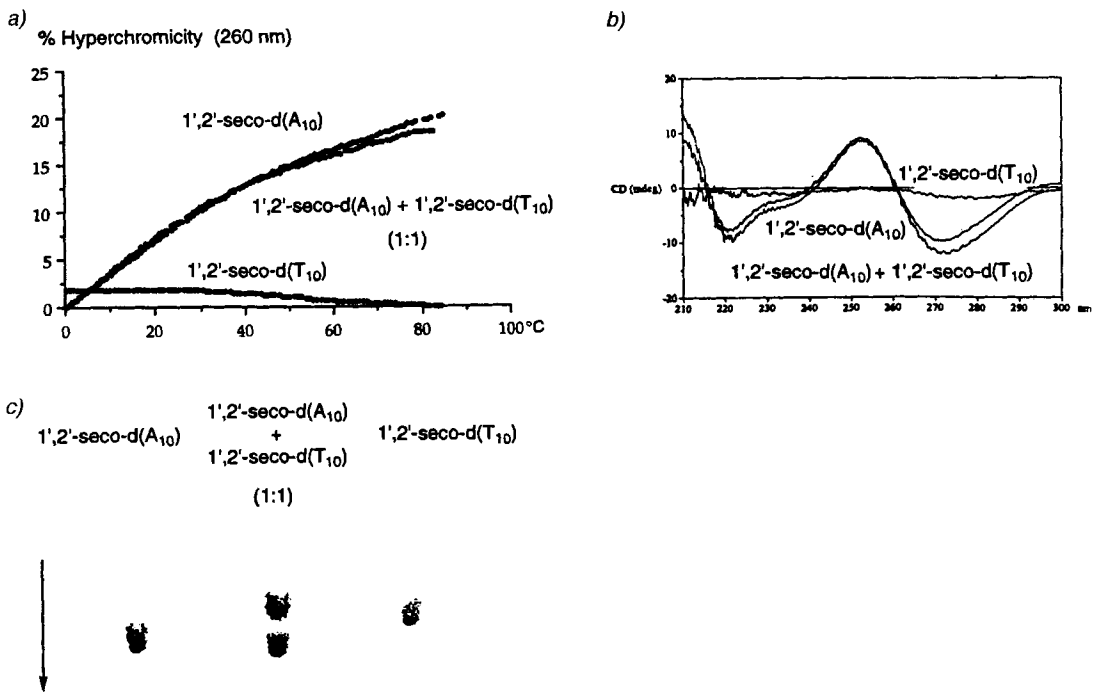


Fig. 5. *UV- and CD-spectroscopic and gel electrophoretic studies of a 1:1 mixture of 1′,2′-seco-d(A_{10}) and 1′,2′-seco-d(T_{10})*

Furthermore, hybrid pairing neither between 1′,2′-seco-DNA and natural DNA nor between 1′,2′-seco-DNA and homo-DNA could be established from the hybrid experiments using oligonucleotides 1′,2′-seco-d(A_{10}), d(T_{10}), and ddGlc(T_{10}) (*Fig. 6*). For the reason that neither d(T_{10}) nor ddGlc(T_{10}) undergoes intramolecular stacking of bases or forms an intermolecular duplex [3], we chose them intentionally as oligomers with complementary base sequence to pair with 1′,2′-seco-d(A_{10}) for testing whether hybrid pairings exist between 1′,2′-seco-DNA and natural DNA or between 1′,2′-seco-DNA and homo-DNA. The results of UV- and CD-spectroscopic and gel electrophoretic studies

(*Fig. 6*) on mixtures of 1′,2′-seco-d(A_{10}) and d(T_{10}) (*Fig. 6, a–c*), and of 1′,2′-seco-d(A_{10}) and ddGlc(T_{10}) (*Fig. 6, d–f*) demonstrated undoubtedly that there is hybrid pairing neither between 1′,2′-seco-d(A_{10}) and d(T_{10}) nor between 1′,2′-seco-d(A_{10}) and ddGlc(T_{10}).

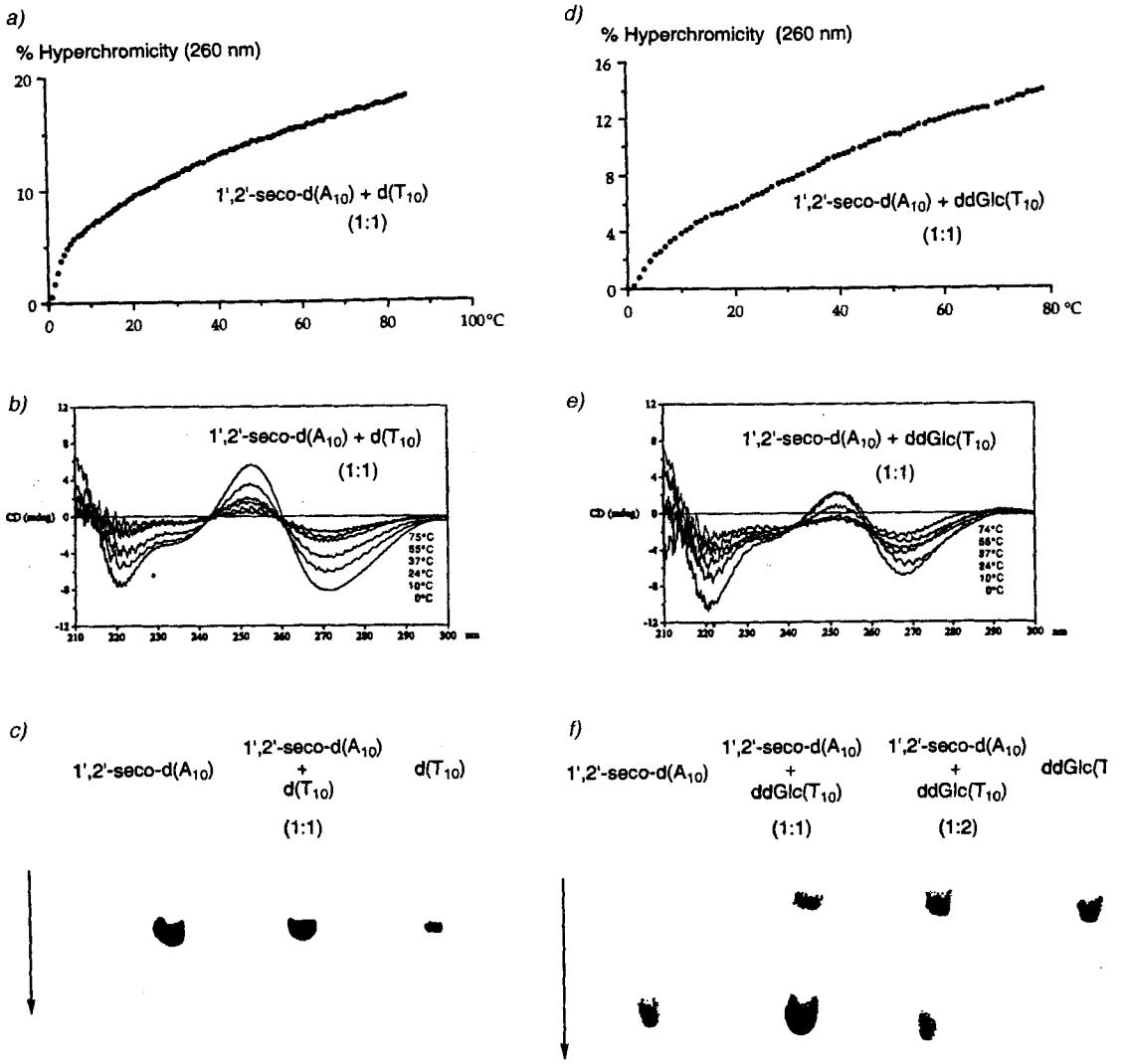


Fig. 6. *UV- and CD-spectroscopic and gel electrophoretic studies on possible hybrid pairing between 1′,2′-seco-(A_{10}) and d(T_{10}) or between 1′,2′-seco-d(A_{10}) and ddGlc(T_{10})*

Conclusion. – The 1′,2′-seco-DNA, having a highly flexible oligonucleotide backbone brought about by a bond scission between C(1′) and C(2′) of the ribofuranose ring in the nucleoside units, was chosen for the study of the structure-properties relationship in comparison with conformationally less flexible natural DNA as well as conformationally rigid homo-DNA (*Fig. 1*). The investigation of pairing properties showed that 1′,2′-seco-

DNA oligonucleotides, under the employed experimental conditions, did not form stable pairing neither with 1′,2′-seco-DNA oligomers possessing complementary base sequences or self-complementary base sequences nor with counterparts from natural DNA and homo-DNA strands.

The dramatic difference of the pairing properties of 1′,2′-seco-DNA as compared to natural DNA and homo-DNA can be interpreted as a direct consequence of the opening of the five-membered ribose ring, where the endocyclic torsion angle δ is free of ring strain. The acyclic sugar constituents in 1′,2′-seco-DNA are much more flexible in conformation than the five-membered pentofuranose rings in natural DNA as well as the six-membered hexopyranose rings in homo-DNA. As a consequence, the backbone of 1′,2′-seco-DNA oligonucleotides is multiconformational, leading to an entropic disadvantage for the pairing process of 1′,2′-seco-DNA. If the entropic disadvantage could be compensated by an enthalpic advantage, pairing would still be possible such as in the case of PNA (peptide nucleic acids) [26], where a neutral polyamide backbone replaces the deoxyribose phosphate backbone, suppressing the electrostatic repulsion between the negatively charged phosphate backbones, and thus allows stable PNA · DNA or PNA · RNA pairings.

Through the investigation of pairing properties of 1′,2′-seco-DNA, we get a better understanding of the significance of the flexibility of the sugar component in nucleic acids, which was first addressed by homo-DNA [1–5], and further by bicyclo-DNA [27–31] and ribopyranosyl DNA [32] [33]. The natural DNA with five-membered pentofuranose rings is between the strongly paired, autonomous homo-DNA system with rigid six-membered hexopyranose rings and the unpaired 1′,2′-seco-DNA, where sugar components are obviously too flexible for pairing. The behavior of 1′,2′-seco-DNA support furthermore the evidence, manifested first by the investigation of homo-DNA, that the *Watson-Crick* base-pairing rules [34] are a consequence not only of the intrinsic chemical properties of the bases, but of the specific structure of the natural DNA backbone as well [12].

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Experimental Part

General. Solvents for extraction: technical grade, distilled. Solvents for reactions: reagent grade, distilled over CaH_2 (MeCN, CH_2Cl_2, pyridine) or Na (Et_2O, THF). Reagents: if not otherwise stated, from *Fluka*, highest quality available. TLC: silica gel *60* F_{254} glass plates, *Merck*; visualization by dipping in a soln. of cerium(IV) sulfate (10.5 g), phosphomolybdic acid (21 g), sulfuric acid (60 ml), and H_2O (900 ml), followed by heating with a heating gun. Flash column chromatography (CC): silica gel *60* (220–440 mesh, ASTM, *Fluka*). HPLC: *Pharmacia-LKB* gradient pumps, mod. *2249*, *ABI-Kratos-Spectroflow-757* UV/VIS detector and *Tarkan-W + W* recorder *600* or *HP-3396-A* intergrator. Optical rotation: at 25°, $d = 10$ cm, c in g/100 ml. UV: λ_{max} (ε in nm. IR: $\tilde{\nu}$ in cm^{-1}. NMR: δ in ppm rel. to $SiMe_4$ as internal standard, (^1H, ^{13}C) in D_2O rel. to HDO (= 4.769) (^1H) and sodium 3-(trimethylsilyl)propane-1-sulfonate as external standard (^{13}C), resp., for ^{31}P rel. to 85% H_3PO_4 soln. as external standard, J in Hz; ^{13}C multiplicities from DEPT spectra. MS: m/z (intensities in %); EI, ionization energy 70 eV; FAB (positive mode), matrix solvent 3-nitrobenzyl alcohol; FAB (negative mode), matrix solvent glycerol/thioglycerol.

UV Melting Curves. Perkin-Elmer-Digital-Controller-570-071 UV/VIS spectrometer equipped with a temp.-controller unit and connected to a *Compaq-DeskPro-286e* computer and *Perkin-Elmer-PECSS* software (Vers. 4.0), temp. gradients of 0.5°/min, data points collected in intervals of *ca.* 0.5°; at temp. < 20°, the cell

compartment was flushed with N_2 to avoid condensation of H_2O on the UV cell; % hyperchromicity (wavelength) = $100 \times [D(T) - D_0]/D_0$ with $D(T)$ = absorption at temp. T and D_0 = lowest absorption in the temp. interval.

Gel Electrophoresis. The $365 \times 365 \times 0.8$ mm polyacrylamide gels (acrylamide/bisacrylamide 30:1, 20% in buffer) were prepared according to [35]. The buffer used was 0.1M *Tris*, 0.1M boric acid, 5 mM $MgCl_2$, pH 8.3. The sample was loaded in the same buffer with 10% sucrose, using bromophenol blue as migration indicator. The electrophoresis was run under a constant power of 10 W during 16 h at 4°, using a *Bethesda-Research-Laboratories* mod. *S2* (sequence gel) equipment with *Bio-Rad* power supply mod. *3000/300*. The oligonucleotides were visualized in a soln. of 100 mg stain all (*Fluka*, No. *85663*) in 800 ml of H_2O/$HCONH_2$ 1:1 [36].

*1,2-Anhydro-3-*O*-benzyl-*D*-erythritol* (**2**). TLC (hexane/AcOEt 4:6): R_f 0.40. $[\alpha]_D$ = + 13.6 (c = 1.32, $CHCl_3$). UV (EtOH): 207 (7300). IR (KBr): 3590*m* (br.), 3480*m* (br.), 3090*m*, 3060*m*, 3030*s*, 2920*m*, 2880*m*, 2460*w* (br.), 1950*w*, 1875*w*, 1810*w*, 1710*m*, 1605*w*, 1495*m*, 1480*m*, 1455*s*, 1395*m*, 1370*m*, 1350*m*, 1310*m*, 1285*m*, 1230*s*, 1160*m*, 1110*vs*, 1070*vs*, 1025*vs*, 970*m*, 960*m*, 930*m*, 918*m*, 860*m*, 855*m*, 840*m*, 820*m*, 700*vs*, 660*m*. ^{1}H-NMR (300 MHz, $CDCl_3$): 2.23–2.27 (*m*, OH–C(4)); 2.70 (*dd*, J = 5.2, 2.7, H–C(4)); 2.79 (*dd*, J = 5.2, 3.9, H–C(4)); 3.00 (*ddd*, J = 2.7, 2.7, 11.8, H–C(3)); 3.36 (*ddd*, J = 3.6, 5.7, 5.7, H–C(2)); 3.69 (*ddd*, J = 11.8, 5.9, 5.9, H–C(1)); 3.80 (*ddd*, J = 11.8, 3.8, 7.0, H–C(1)); 4.63 (*AB*, J_{AB} = 11.6, PhCH_2); 7.25–7.37 (*m*, 5 arom. H). ^{13}C-NMR (75 MHz, $CDCl_3$): 45.6 (*t*, C(1)); 51.0 (*d*, C(2)); 63.0 (*t*, C(4)); 72.5 (*t*, PhCH_2); 78.7 (*d*, C(3)); 127.81, 127.98, 128.12, 128.35, 128.53 (5*d*, arom. C); 137.9 (*s*, arom. C). EI-MS: 194.0 (M^+), 107.0 (30), 105.0 (11), 92.0 (28), 91.0 (100), 79.0 (12), 77.0 (11), 70.0 (19), 65.0 (19).

*2,4-Di-*O*-benzoyl-1-deoxy-*D*-erythritol* (**3**). To a soln. of **2** (15.1 g, 77.8 mmol) in Et_2O (1270 ml) was added dropwise at −70° under Ar a suspension of $LiAlH_4$ (10.0 g, 294 mmol) in Et_2O (260 ml). The mixture was brought to r.t. and stirred for further 16 h. A sat. NH_4Cl soln. (500 ml) was added carefully at 0°, the resulting mixture extracted with AcOEt (3000 ml), the org. phase dried ($MgSO_4$) and evaporated, and the residual oil dried *in vacuo* for 24 h; diol (15.2 g, 99%). To a soln. of this diol (5.09 g, 25.5 mmol) in pyridine (30 ml), benzoyl chloride (6.20 ml, 51.8 mmol) was added at 0°. After further stirring at r.t. for 45 min, the mixture was filtrated over *Celite* and the filtrate co-evaporated with toluene. The residue was dissolved in CH_2Cl_2 (150 ml) and the org. soln. washed with sat. $CuSO_4$ soln. (150 ml) and H_2O (150 ml), dried ($MgSO_4$), and evaporated: dibenzoyl product (9.85 g, 94%) as colorless oil. A soln. of this product (4.75 g, 11.7 mol) in MeOH (30 ml) was added dropwise under N_2 to Pd/C (1.2 g). After stirring at r.t. under 50 bar of H_2 for 27 h, the mixture was filtered over *Celite*. The filtrate was evaporated and the residual oil purified by CC (silica gel, hexane/AcOEt 3:1): **3** (3.41 g, 93%). Colorless oil. TLC (hexane/AcOEt 7:2): R_f 0.23. $[\alpha]_D$ = + 51.0 (c = 0.875, $CHCl_3$). UV (EtOH): 209 (24300). IR ($CHCl_3$): 3600*w*, 3450*w* (br.), 3090*w*, 3060*w*, 3015*m*, 2990*w*, 2950*w*, 1715*vs*, 1600*m*, 1575*m*, 1490*w*, 1450*s*, 1395*m*, 1375*m*, 1360*m*, 1315*s*, 1270*vs* (br.), 1178*s*, 1160*m*, 1115*vs*, 1098*s*, 1070*s*, 1055*m*, 1025*s*, 1000*m*, 970*w*, 935*w*, 708*s*, 688*m*, 660*m*. ^{1}H-NMR (300 MHz, $CDCl_3$): 1.48 (*d*, J = 6.5, 3 H–C(1)); 2.88 (br. *d*, J = 4.9, OH–C(3)); 4.19 (br. *m*, H–C(3)); 4.44 (*dd*, J = 6.5, 11.7, H–C(4)); 4.57 (*dd*, J = 3.7, 11.7, H–C(4)); 5.31 (*qd*, J = 6.5, 5.1, H–C(2)); 7.26–7.45, 7.53–7.59, 8.02–8.06 (3*m*, 10 arom. H). ^{13}C-NMR (75 MHz, $CDCl_3$): 15.9 (*q*, C(1)); 65.74 (*t*, C(4)); 72.0, 72.3 (2*d*, C(2), (3)); 128.4, 129.6, 133.2, 133.3 (4*d*, arom. C); 129.7 (*s*, arom. C); 166.0, 166.9 (2*s*, CO). FAB-MS (pos.): 315.2 (23, $[M + H]^+$), 193.2 (32), 155.1 (15), 154.1 (50), 139.1 (812), 138.1 (23), 137.1 (50), 136.1 (46), 132.9 (20), 107.0 (21), 106.0 (14), 105.0 (100), 91.0 (13), 90.0 (15), 89.0 (23), 70.0 (28), 78.0 (14), 76.9 (39).

*2,4-Di-*O*-benzyl-1-deoxy-*D*-erythritol* (**4**). To a soln. of **3** (1.11 g, 3.50 mmol) and 3,4-dihydro-2*H*-pyran (0.480 ml, 5.25 mmol) in $ClCH_2CH_2Cl$ (20 ml) was added under N_2 *pyridinium p-toluenesulfonate* (88.0 mg, 0.350 mol). After stirring at r.t. for 4.5 h, Et_2O (100 ml) was added, and the mixture was extracted with sat. $NaHCO_3$ soln. (100 ml) and sat. NaCl soln. (100 ml). The org. phase was dried ($MgSO_4$) and evaporated: viscous oil (quant.). To a soln. of this oil (25.3 g, 63.6 mmol) in THF/MeOH/H_2O 5:4:1 (1400 ml), 2N NaOH (140 ml) was added at 0°. After stirring at 0° for 25 min, NH_4Cl (18.0 g, 336 mmol) was added. The mixture was stirred at r.t. for further 30 min and then evaporated until a white precipitation appeared. To this mixture, MeOH (50 ml) was added and the resulting mixture adsorbed on silica gel (30 g) and purified by CC (silica gel, CH_2Cl_2/MeOH 13:1): diol (11.24 g, 93%) as a colorless oil. To a soln. of this diol (0.460 g, 2.40 mmol) in THF (5 ml) NaH (200 mg, 4.95 mmol) was added at 0° under N_2 (→ viscous suspension). After addition of $(Bu_4N)I$ (88.0 mg, 0.240 mmol) and benzyl bromide (0.600 ml, 5.04 mmol), the mixture was stirred at r.t. for 8 h. Then MeOH (1 ml) and NH_4Cl (500 mg) were added, and the mixture was diluted with Et_2O (100 ml). The org. phase was washed with sat. NaCl soln. (100 ml), dried ($MgSO_4$), and evaporated. Purification by CC (hexane/AcOEt 9:1) gave a colorless oil (0.89 g, 97%). A soln. of this oil (6.05 g, 16.3 mmol) and pyridinium *p*-toluenesulfonate (410 mg, 1.63 mmol) in EtOH (120 ml) was stirred at 60° for 3 h. After evaporation, the obtained residual oil was purified by CC (silica gel, hexane/AcOEt 4:1): **4** (4.14 g, 89%). Colorless oil. TLC (hexane/AcOEt 4:1): R_f 0.25. $[\alpha]_D$ = + 28.8 (c = 1.25, $CHCl_3$). IR ($CHCl_3$): 3660*w*, 3570*m*, 3466*w* (br.), 3095*m*, 3060*m*, 3030*m*, 3005*s*, 2970*m*,

2915*s*, 2870*s*, 1900*w*, 1875*w*, 1810*w*, 1710*m*, 1605*w*, 1585*w*, 1495*m*, 1450v*s*, 1375*s*, 1305*m*, 1235*s*, 1150*m*, 1080v*s* (br.), 1025v*s*, 1000*m*, 910*m*, 890*m*, 820*w*, 700v*s*, 660*m*. ^{1}H-NMR (400 MHz, $CDCl_3$): 1.22 (*d*, *J* = 6.3, 3 H–C(1)); 2.47 (*d*, *J* = 4.4, OH–C(3)); 3.53–3.63 (*m*, H–C(2), 2 H–C(4)); 3.80–3.86 (*m*, H–C(3)); 4.53 (*s*, PhCH_2); 4.53 (*AB*, J_{AB} = 10.5, PhCH_2); 7.27–7.36 (*m*, 10 arom. H). ^{13}C-NMR (100 MHz, $CDCl_3$): 15.3 (*q*, C(1)); 71.0, 71.1 (2*t*, PhCH_2); 73.0, (*d*, C(3)); 73.4 (*t*, C(4)); 75.5 (*d*, C(2)); 127.6, 127.7, 127.75, 127.8, 128.37, 128.43 (6*d*, arom. C); 138.0, 138.52 (2*s*, arom. C). EI-MS: 287.1 ([*M* + H]$^+$), 195.1 (21), 181.1 (35), 135.1 (10), 107.1 (21), 92.1 (27), 91.1 (100).

*2,4-Di-*O*-benzyl-3-*O*-(chloromethyl)-1-deoxy-*D*-erythritol* (**5**). HCl Gas (dried over conc. H_2SO_4 and $CaCl_2$) was bubbled at 0° through a suspension of **4** (4.12 g, 14.4 mmol) and paraformaldhyde (0.86 g, 28.8 mmol) in CH_2Cl_2 (28 ml) until a clear soln. was formed. After 45 min stirring at 0°, the mixture was dried ($CaCl_2$) and evaporated. The obtained viscous oil was dried *in vacuo* for 1 h and used for the further reaction without purification.

*1-(3′,5′-Di-*O*-benzyl-2′-deoxy-1′,2′-seco-*D*-ribosyl)thymine* (**6**). To a suspension of thymine (1.45 g, 11.6 mmol) in $ClCH_2CH_2Cl$ (10 ml) was added *N,O*-bis(trimethylsilyl)acetamide (5.9 ml, 23.1 mmol). The mixture was refluxed at 80° under Ar, until a clear soln. was formed. To this soln. were added (Bu_4N)I (350 mg, 0.948 mmol) and a soln. of **5** (9.6 mmol) in $ClCH_2CH_2Cl$ (10 ml). After 2.5 h reflux at 80°, H_2O (50 ml) was added and the mixture extracted with $ClCH_2CH_2Cl$ (100 ml). The org. phase was dried ($MgSO_4$) and evaporated and the residue purified by CC (silica gel, hexane/AcOEt 6:4): **6** (3.78 g, 93%). Colorless oil. TLC (hexane/AcOEt 6:4): R_f 0.15. ^{1}H-NMR (200 MHz, $CDCl_3$): 1.08 (*d*, *J* = 6.2, 3 H–C(2′)); 1.80 (*d*, *J* = 1.1, Me–C(5)); 3.50–3.70 (*m*, 3 H, H–C(3′), H–C(4′), H–C(5′)); 3.85–3.95 (*m*, 1 H, H–C(3′), H–C(4′), H–C(5)); 4.49 (*s*, PhCH_2); 4.51 (*AB*, J_{AB} = 11.5, PhCH_2); 5.28 (*s*, 2 H–C(1′)); 7.12 (*d*, *J* = 1.1, H–C(6)); 7.21–7.38 (*m*, 10 arom. H); 8.96 (br. *s*, H–N(3)).

*6-Chloro-9-(3′,5′-di-*O*-benzyl-2′-deoxy-1′,2′-seco-*D*-ribosyl)purine* (**7a**) *and 6-Chloro-7-(3′,5′-di-*O*-benzyl-2′-deoxy-1′,2′-seco-*D*-ribosyl)purine* (**7b**). To a suspension of 6-chloropurine (0.520 g, 3.36 mmol) in dry DMF (5 ml) was added Et_3N (0.45 ml) (→ clear yellow soln.). To this soln. was added dropwise at 0° a soln. of **5** (3.20 mmol) in DMF (4 ml) during 15 min (→ white solid). After 18 h stirring at r.t. CH_2Cl_2 (30 ml) was added and the mixture extracted with sat. NaCl soln. (30 ml). The org. phase was dried ($MgSO_4$) and evaporated and the residue purified by CC (silica gel, hexane/AcOEt 4:6): **7a** (0.720 g, 50%) and **7b** (0.380 g, 27%) as colorless oils.

Data of **7a**: TLC (hexane/AcOEt 6:4): R_f 0.40. $[\alpha]_D$ = + 3.5 (*c* = 0.97, $CHCl_3$). UV (EtOH): 202 (32800), 264 (7430). IR ($CHCl_3$): 3110*m*, 3090*m*, 3060*m*, 3030*m*, 3010v*s*, 2940*m*, 2910*m*, 2870*m*, 1950*w*, 1880*w*, 1810*w*, 1710*m*, 1595v*s*, 1565v*s*, 1560v*s* (sh), 1495*s*, 1455*s*, 1440*s*, 1430*m*, 1410*s*, 1400*s*, 1380*s*, 1365*m*, 1340v*s*, 1260*m*, 1235*m*, 1160*s*, 1145v*s*, 1100v*s* (br.), 1030*s*, 940v*s*, 910*m*, 880*m*, 860*m*, 820*w*, 700v*s*, 680*w*, 660*m*, 650*m*, 640*s*. ^{1}H-NMR (300 MHz, $CDCl_3$): 1.10 (*d*, *J* = 6.4, 3 H–C(2′)); 3.44–3.61 (*m*, H–C(4′), 2 H–C(5′)); 3.88–3.93 (*m*, H–C(3′)); 4.40 (*s*, PhCH_2); 4.41 (*AB*, J_{AB} = 11.7, PhCH_2); 5.85 (*s*, 2 H–C(1′)); 7.18–7.36 (*m*, 10 arom. H); 8.23, 8.75 (*s*, H–C(2), H–C(8)). ^{13}C-NMR (75 MHz, $CDCl_3$): 14.9, (*q*, C(3′)); 71.1 (*t*, PhCH_2); 72.4 (*t*, PhCH_2); 73.5 (*t*, C(5′)); 73.5 (*t*, C(1′)); 74.7 (*d*, C(3′)); 81.2 (*d*, C(4′)); 127.6, 127.7, 127.8, 128.4 (4*d*, arom. C); 137.6, 138.1 (2*s*, arom. C); 145.6 (*d*, C(8)); 151.1 (*s*, C(4)); 152.0 (*s*, C(5)); 152.3 (*d*, C(2)). FAB-MS (pos.): 453.0 (28, *M*$^+$), 245.0 (26), 181.1 (31), 167.0 (12), 155.0 (15), 147.0 (12), 92.0 (21), 91.0 (100), 72.9 (23).

Data of **7b**: TLC (hexane/AcOEt 1:1): R_f 0.29. ^{1}H-NMR (200 MHz, $CDCl_3$): 1.10 (*d*, *J* = 6.4, 3 H–C(2′)); 3.50–3.64 (*m*, 3 H, H–C(3′), H–C(4′), H–C(5′)); 3.68–3.76 (*m*, 1 H, H–C(3′), H–C(4′), H–C(5′)); 4.42 (*s*, PhCH_2); 4.42 (*AB*, J_{AB} = 11.1, PhCH_2); 5.99 (*s*, 2 H–C(1′)); 7.20–7.40 (*m*, 10 arom. H); 8.30 (*s*, H–C(8)); 8.87 (*s*, H–C(2)).

*9-(3′,5′-Di-*O*-benzyl-2′-deoxy-1′,2′-seco-*D*-ribosyl)adenine* (**8a**). A soln. of **7a** (1.24 g, 2.73 mmol) in sat. NH_3/MeOH soln. (50 ml) was stirred at 110° in an autoclave for 17 h. After cooling to r.t., the mixture was evaporated and purified by CC (silica gel, MeOH/CH_2Cl_2 1:18). Recrystallization from acetone/pentane gave **8a** (1.10 g, 93%). White crystals. TLC (MeOH/CH_2Cl_2 1:9): R_f 0.52. $[\alpha]_D$ = – 2.58 (*c* = 1.06, $CHCl_3$). UV (EtOH): 208 (28600), 258 (12300). IR (KBr): 3400*m* (br. sh), 3330*s*, 3260*m*, 3150*s*, 3090*m*, 3060*m*, 3030*m*, 2980*m*, 2930*m*, 2730*w*, 2670*w*, 1660v*s*, 1600*s* (sh), 1598v*s*, 1575*s*, 1505*w*, 1495*m*, 1485*m*, 1455*m*, 1425*m*, 1410*w*, 1405*w*, 1390*m*, 1375*m*, 1365*m*, 1325*s*, 1315*s*, 1285*m*, 1250*m*, 1220*m*, 1200*m*, 1170*m*, 1160*m*, 1130*m*, 1110*s* (sh), 1100v*s*, 1090v*s*, 1075*s*, 1050*m*, 1030*m*, 1015*m*, 950*w*, 900*w*, 865*w*, 850*w*, 835*w*, 800*m*, 762*s*. ^{1}H-NMR (300 MHz, $CDCl_3$): 1.08 (*d*, *J* = 6.4, 3 H–C(2′)); 3.49–3.63 (*m*, 3 H, H–C(3′), H–C(4′), H–C(5′)); 3.87–3.92 (*m*, 1 H, H–C(3′), H–C(4′, H–C(5′)); 4.45 (*s*, PhCH_2); 4.46 (*AB*, J_{AB} = 11.7, PhCH_2); 5.70 (br. *s*, NH_2–C(6)); 5.76 (*AB*, J_{AB} = 11.0, 2 H–C(1′)); 7.22–7.36 (*m*, 10 arom. H), 7.92 (*s*, H–C(8)); 8.39 (*s*, H–C(2)). ^{13}C-NMR (75 MHz, $CDCl_3$): 15.2 (*q*, C(2′)); 70.2 (*t*, C(5′)); 71.1, 72.7 (2*t*, PhCH_2); 73.4 (*t*, C(1′)); 74.7 (*d*, C(3′)); 80.3 (*d*, C(4′)); 119.5 (*s*, C(5)); 127.6 (*d*, arom. C); 128.4 (*d*, arom. C); 137.9, 138.2 (2*s*, arom. C); 141.0 (*d*, C(8)); 150.4 (*s*, C(4)); 153.4 (*d*, C(2)); 155.4 (*s*, C(6)). EI-MS: 434.0 (*M*$^+$), 165.9 (34), 164.9 (23), 163.9 (57), 138.9 (13), 147.9 (51), 134.9 (18), 91.9 (10), 90.0 (100). Anal. calc. for $C_{24}H_{27}N_5O_3$: C 66.50, H 6.28, N 16.16; found: C 66.50, H 6.19, N 16.31.

7-(3',5'-Di-O-benzyl-2'-deoxy-1',2'-seco-D-ribosyl)adenine (**8b**). From **7b** (0.370 g, 0.820 mmol) and sat. NH_3/MeOH soln. (15 ml) as described for **8a**. CC (silica gel, $MeOH/CH_2Cl_2$ 1:15) gave **8b** (0.301 g, 85%). Colorless oil. TLC ($MeOH/CH_2Cl_2$ 1:15): R_f 0.18. ^{1}H-NMR (300 MHz, (D_6)DMSO): 1.10 (*d*, J = 6.1, 3 H–C(2')); 3.44–3.60 (*m*, 3 H, H–C(3'), H–C(4'), H–C(5')); 3.56–3.63 (*m*, 1 H, H–C(3'), H–C(4')); 4.40 (*s*, PhCH_2); 4.40 (*AB*, J_{AB} = 11.4, PhCH_2); 5.82 (*AB*, J_{AB} = 10.8, 2 H–C(1')); 6.82 (br. *s*, NH_2–C(6)); 7.18–7.36 (*m*, 10 arom. H); 8.22 (*s*, H–C(2)); 8.38 (*s*, H–C(8)). Difference NOE: 6.82 (NH_2–C(6)) → 5.82 (H–C(1')), 8.22 (H–C(2)), 1.10 (H–C(2')).

N^6-*Benzoyl-9-(2'-deoxy-1',2'-seco-D-ribosyl)adenine* (**9a**). In a soln. of **8a** (1.00 g, 2.31 mmol) in cyclohexene/EtOH 1:2 (33.3 ml) was suspended $Pd(OH)_2$/C (670 mg). The mixture was stirred at 80° in an autoclave for 17 h. After cooling to r.t., the mixture was filtrated over *Celite*, the filtrate evaporated, and the residue purified by CC (silica gel, $MeOH/CH_2Cl_2$ 1:7). The obtained product was recrystallized from MeOH/pentane as white crystals (0.405 g, 70%). To a soln. of these crystals (185 mg, 0.730 mmol) in pyridine (4.3 ml) was added trimethylsilyl chloride (0.45 ml, 3.65 mmol). After 30 min stirring at r.t., benzoyl chloride (0.42 ml, 3.65 mmol) was added and the mixture stirred for 1.5 h. Then H_2O (0.5 ml) and conc. NH_3 soln. (1.75 ml) were added at 0°. After stirring for further 1.5 h, the mixture was co-evaporated with toluene. The residue was purified by CC (silica gel, $MeOH/CH_2Cl_2$ 1:10). Recrystallization from EtOH gave **9a** (0.210 g, 80%). White crystals. M.p. 139–141°. TLC ($MeOH/CH_2Cl_2$ 1:4): R_f 0.36. $[\alpha]_D$ = – 6.8 (*c* = 1.00, EtOH). UV (EtOH): 203 (24400), 279 (17200). IR (KBr): 3670*w*, 3400*s* (br. sh), 3460*s*, 3390*s*, 3090*m*, 2990*m*, 2970*m*, 2940*m*, 2920*m* (sh), 2840*m*, 2750*w*, 1775*w*, 1690*vs*, 1650*w*, 1600*s*, 1580*s*, 1525*vs*, 1505*m* (sh), 1490*s*, 1460*m*, 1430*m*, 1395*m*, 1380*w*, 1350*m*, 1330*s*, 1315*m*, 1305*m*, 1280*m*, 1260*s*, 1225*m*, 1200*m*, 1190*m* (sh), 1155*w*, 1125*vs*, 1110*m*, 1075*m*, 1050*w*, 1025*s*, 1000*w*, 950*w*, 940*w*, 930*w*, 900*w*, 890*w*, 860*w*, 835*w*, 800*m*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 0.85 (*d*, J = 6.1, 3 H–C(2')); 3.35–3.61 (*m*, H–C(3'), H–C(4'), 2 H–C(5')); 4.62–4.66 (br. *m*, OH–C(3'), OH–C(5')); 5.81 (*s*, 2 H–C(1')); 7.53–7.68 (*m*, 3 arom. H); 8.04–8.07 (*m*, 2 arom. H); 8.61 (*s*, H–C(2)); 8.78 (*s*, H–C(8)); 11.2 (br. *s*, NH–C(6)). ^{13}C-NMR (75 MHz, (D_6)DMSO): 18.7 (*q*, C(2')); 61.2 (*t*, C(5')); 65.6 (*d*, C(3')); 72.5 (*t*, C(1')); 83.9 (*d*, C(4')); 125.2 (*s*, C(5)); 128.4, 132.3 (2*d*, arom. C); 133.4 (*s*, arom. C); 144.9 (*d*, C(8)); 150.1 (*s*, C(4)); 151.6 (*d*, C(2)); 152.5 (*s*, C(6)); 165.6 (*s*, CO). FAB-MS (pos.): 359.1 (26, $[M + H]^+$), 358.1 (100, M^+), 307.0 (14), 240.0 (49), 155.0 (19), 154.0 (61), 138.0 (23), 137.0 (42), 136.0 (45), 107.0 (16), 104.9 (42).

1-(2'-Deoxy-1',2'seco-D-ribosyl)thymine (**9b**). To a soln. of **6** (3.78 g, 8.90 mmol) in cyclohexene/EtOH 1:2 (80 ml) was suspended $Pd(OH)_2$/C (2.34 g). The mixture was stirred at 80° in an autoclave for 17 h. After cooling at r.t., the mixture was filtrated over *Celite*, the filtrate evaporated and the residue purified by CC (silica gel, $MeOH/CH_2Cl_2$ 1:9). The obtained product was recrystallized from EtOH: **9b** (1.70 g, 78%). White crystals. M.p. 130–132°. TLC ($MeOH/CH_2Cl_2$ 1:9): R_f 0.17. $[\alpha]_D \approx -$ 2.0 (*c* = 1.28, EtOH). UV (EtOH): 208 (9100), 263 (8800). IR (KBr): 3400*m* (sh), 3360*m*, 3180*m*, 3100*w*, 3050*m*, 3000*w*, 2960*w*, 2940*w*, 2890*w*, 2820*w*, 1700*vs*, 1660*s* (sh), 1465*m*, 1455*m*, 1440*w*, 1430*w*, 1400*w*, 1380*w*, 1370*w*, 1350*w*, 1335*m*, 1320*w*, 1280*w*, 1260*m*, 1230*w*, 1180*w*, 1140*m*, 1120*m*, 1105*s*, 1095*s*, 1070*s*, 1050*w*, 1025*w*, 1015*m*, 980*w*, 950*w*, 920*w*, 910*w*, 885*w*, 865*m*, 825*w*. ^{1}H-NMR (300 MHz, $CDCl_3$): 0.99 (*d*, J = 6.3, 3 H–C(2')); 1.76 (*d*, J = 1.1, *Me*–C(5)); 3.34–3.40 (*m*, 2 H, H–C(3'), H–C(4'), H–C(5')); 3.51–3.61 (*m*, 2 H, H–C(3'), H–C(4'), H–C(5')); 4.55 (*t*, J = 5.2, OH–C(5')); 4.61 (br. *d*, OH–C(3')); 5.15 (*AB*, J_{AB} = 10.2, 2 H–C(1')); 7.56 (*d*, J = 1.2, H–C(6)); 11.3 (br. *s*, H–N(3)). Difference NOE: 5.15 (H–C(1')) → 7.56 (H–C(6)). ^{13}C-NMR (75 MHz, $CDCl_3$): 11.8 (*q*, *Me*–C(5)); 18.8 (*q*, C(2')); 61.1 (*t*, C(5')); 65.7 (*d*, C(3')); 76.3 (*t*, C(1')); 83.6 (*d*, C(4')); 108.7 (*s*, C(5)); 140.9 (*d*, C(6)); 151.0 (*s*, C(4)); 164.2 (*s*, C(2)). EI-MS: 245 ($[M + H]^+$), 140 (16), 139 (91), 127 (37), 126 (100), 96 (96). Anal. calc. for $C_{10}H_{16}N_2O_5$: C 49.18, H 6.60, N 11.47; found: C 49.01, H 6.31, N 11.17.

N^6-*Benzoyl-9-[2'-deoxy-5'-O-(4,4'-dimethoxytrityl)-1',2'-seco-D-ribosyl]adenine* (**10a**). To a soln. of **9a** (0.430 g, 1.20 mmol) in pyridine (12 ml) was added under Ar at r.t. $(Bu_4N)ClO_4$ (0.470 g, 1.38 mmol) and 4,4'-dimethoxytrityl chloride (0.468 g, 1.38 mmol). After 1 h stirring at r.t., the reaction was quenched by addition of MeOH (1 ml). The resulting mixture was co-evaporated with toluene. The residue was dissolved in CH_2Cl_2 (30 ml), the org. soln. washed with sat. NaCl soln. (30 ml), dried ($MgSO_4$), and evaporated, and the residue purified by CC (silica gel, acetone/CH_2Cl_2 4:6): **10a** (0.720 g, 91%). White foam. M.p. 92–94°. TLC (acetone/CH_2Cl_2 4:6): R_f 0.37. $[\alpha]_D$ = – 30.7 (*c* = 0.98, $CHCl_3$). UV (EtOH): 204 (79900), 234 (31200), 280 (21700). IR (KBr): 3420*m* (br.), 3300*m* (sh), 3060*w*, 3030*w*, 2997*w*, 2975*w*, 2930*w*, 2830*w*, 1703*m*, 1615*vs*, 1580*s*, 1510*vs*, 1485*m*, 1450*s*, 1410*w*, 1335*m*, 1315*m*, 1300*s*, 1290*m* (sh), 1250*vs*, 1220*s*, 1200*m*, 1275*s*, 1155*m*, 1090*s* (br.), 1030*s*, 1000*w*, 980*w*, 950*w*, 935*w*, 900*w*, 885*w*, 830*m*, 800*w*, 790*w*, 755*m*. ^{1}H-NMR (300 MHz, $CDCl_3$): 0.95 (*d*, J = 6.3, 3 H–C(2')); 3.18–3.29 (*m*, H–C(3'), 2 H–C(5')); 3.77 (*s*, 2 MeO); 3.82–3.85 (br. *m*, 2 H–C(4'), OH–C(3')); 5.85 (*s*, 2 H–C(1')); 6.79–6.84 (*m*, 4 arom. H); 7.17–7.30 (*m*, 7 arom. H); 7.37–7.41 (*m*, 2 arom. H); 7.47–7.61 (*m*, 3 arom. H); 8.02–8.04 (*m*, 2 arom. H); 8.09 (*s*, H–C(8)); 8.29 (*s*, H–C(2)); 9.28 (br. *s*, NH–C(6)). ^{13}C-NMR (75 MHz, $CDCl_3$): 17.8 (*q*, C(2')); 55.2 (*q*, MeO); 63.7 (*t*, C(5')); 68.1 (*d*, C(3')); 73.4 (*t*, C(1')); 82.4 (*d*, C(4')); 86.7

(*s*, arom. C); 113.2 (*d*, arom. C); 126.9, 127.9, 128.1, 128.8, 130.0, 132.8 (6*d*, arom. C); 133.7, 135.7 (2*s*, arom. C); 143.0 (*d*, C(8)); 144.2 (*s*, arom. C); 149.7 (*s*, C(4)); 152.2 (*d*, C(2)); 153.0 (*s*, C(6)); 158.6 (*s*, arom. C); 164.7 (*s*, CO). FAB-MS (pos.): 661.0 (14, $[M + H]^+$), 660.0 (30, M^+), 304.0 (30), 303.0 (100), 240.0 (17), 155.0 (12), 154.0 (38), 138.0 (14), 137.0 (26), 136.0 (28), 107.0 (10), 104.9 (31).

*1-[2'-Deoxy-5'-O-4,4'-(dimethoxytrityl)-1',2'-seco-*D*-ribosyl]thymine* (**10b**). From **9b** (1.60 g, 6.54 mmol), $(Bu_4N)ClO_4$ (2.57 g, 7.52 mmol), 4,4'-dimethoxytrityl chloride (2.55 g, 7.52 mmol), and pyridine (50 ml), as described for **10a**. CC (silica gel, acetone/CH_2Cl_2 1:4) gave **10b** (3.24 g, 91%). White foam. M.p. 79–80°. TLC (acetone/AcOEt 1:4): R_f 0.20. $[\alpha]_D = -8.5$ ($c = 1.32$, $CHCl_3$). UV (EtOH): 205 (50200), 233 (19400), 263 (8800). IR (KBr): 3440*m* (br.), 3200*w*, 3060*w*, 3040*w*, 3000*w*, 2970*w*, 2940*w*, 2840*w*, 1670*vs*, 1610*s*, 1580*w*, 1510*vs*, 1465*s*, 1450*m*, 1415*w*, 1385*w*, 1300*m*, 1250*vs*, 1230*m* (sh), 1180*s*, 1155*w*, 1115*w*, 1100*s*, 1075*s*, 1035*m*, 980*w*, 900*w*, 830*m*. ^{1}H-NMR (300 MHz, $CDCl_3$): 1.03 (*d*, $J = 6.4$, 3 H–C(2')); 1.87 (*d*, $J = 1.2$, Me–C(5)); 2.44 (*d*, $J = 5.7$, OH–C(3')); 3.23–3.25 (*m*, 2 H–C(5')); 3.71–3.76 (*m*, H–C(3')); 3.79 (*s*, 2 MeO); 3.86–3.90 (*m*, H–C(4')); 5.28 (*AB*, $J_{AB} = 10.2$, 2 H–C(1')); 6.80–6.85 (*m*, 4 arom. H); 7.14 (*d*, $J = 1.2$, H–C(6)); 7.21–7.33 (*m*, 7 arom. H); 7.39–7.42 (*m*, 2 arom. H); 8.70 (br. *s*, H–N(3)). ^{13}C-NMR (75 MHz, $CDCl_3$): 12.2 (*q*, *Me*–C(5)); 18.1 (*q*, C(2')); 55.2 (*q*, MeO); 63.5 (*t*, C(5')); 68.1 (*d*, C(3')); 77.2 (*t*, C(1')); 81.9 (*d*, C4')); 86.7 (*s*, arom. C); 111.5 (*s*, C(5)); 113.2 (*d*, arom. C); 126.9, 127.9, 128.1, 130.0 (4*d*, arom. C); 135.7 (*s*, arom. C); 139.5 (*d*, C(6)); 144.6 (*s*, arom. C); 151.1 (*s*, C(4)); 158.6 (*s*, arom. C); 163.8 (*s*, C(2)). FAB-MS (pos.): 546 (M^+), 307 (15), 304 (39), 303 (100), 289 (13), 242 (21), 155 (19), 154 (43), 139 (19), 138 (22), 137 (33), 136 (34), 135 (13), 107 (14).

N^6*-Benzoyl-9-[2'-deoxy-5'-O-(4,4'-dimethoxytrityl)-1',2'-seco-*D*-ribosyl]adenine 3'-(2-Cyanoethyl Diisopropylphosphoramidite)* (**11a**). To a soln. of **10a** (100 mg, 0.152 mmol) in THF (1 ml) were added (i-Pr)$_2$EtN (0.12 ml, 0.608 mmol) and chloro(2-cyanoethoxy)(diisopropylamino)phosphine (0.05 ml, 0.198 mmol). After 30 min stirring at r.t., the mixture was evaporated and the residue purified by CC (silica gel, acetone/CH_2Cl_2/Et_3N 4:6:0.01): **11a** (110 mg, 84%). White foam. TLC (AcOEt/CH_2Cl_2/Et_3N 4.5:4.5:1): R_f 0.61. ^{1}H-NMR (300 MHz, $CDCl_3$): 0.98–1.16 (*m*, 13.5 H, H–C(2'), *Me*$_2$CH); 1.26–1.29 (*m*, 1.5 H, H–C(2'), *Me*$_2$CH); 2.50–2.63 (*m*, OCH$_2$C*H*$_2$CN); 3.16–3.19 (*m*, 2 H, H–C(4'), H–C(5')); 3.42–3.62 (*m*, 2 H, H–C(4'), H–C(5'), Me$_2$C*H*); 3.64–3.75 (*m*, OC*H*$_2$CH$_2$CN, Me$_2$C*H*); 3.77 (*s*, 2 MeO); 3.90–4.02 (*m*, 2 H–C(3'), OC*H*$_2$CH$_2$CN); 5.85–5.94 (*m*, 2 H–C(1')); 6.76–6.82 (*m*, 4 arom. H); 7.16–7.29 (*m*, 8 arom. H); 7.32–7.36 (*m*, 2 arom. H); 7.51–7.65 (*m*, 3 arom. H); 8.02–8.05 (*m*, 2 arom. H); 8.17 (*s*, 0.5 H–C(8)); 8.22 (*s*, 0.5 H–C(8)); 8.860 (*s*, 0.5 H–C(2)); 8.864 (*s*, 0.5 H–C(2)); 9.00 (br. *s*, NH–C(6)). ^{13}C-NMR (75 MHz, $CDCl_3$): 16.98, 17.25, 17.32 (3*q*, C(2')); 20.26, 20.34, 20.43, (3*t*, OH$_2$C*H*$_2$CN); 24.29, 24.38, 24.60, 24.69 (4*q*, *Me*$_2$CH); 43.0 (*dd*, *J*(C, P) = 11.9, Me$_2$C*H*); 43.1 (*dd*, *J*(C, P) = 11.5, Me$_2$C*H*); 55.2 (*q*, MeO); 58.1 (*dt*, *J*(C, P) = 18.7, OC*H*$_2$CH$_2$CN); 58.2 (*dt*, *J*(C, P) = 18.7, OCH$_2$C*H*$_2$CN); 63.8 (*t*, C(5')); 70.4 (*dd*, *J*(C, P) = 19.5, C(3')); 70.6 (*dd*, *J*(C, P) = 19.5, C(3')); 73.2 (*t*, C(1')); 82.1, 82.2, 82.3 (3*t*, C(4')); 86.5, 86.6 (2*s*, PhAr$_2$*C*); 113.1 (*d*, arom. C); 117.7 (*s*, CN); 122.7 (*s*, C(5)); 126.8, 127.8, 128.1, 128.2, 128.9, 130.0, 132.8 (7*d*, arom. C); 133.8, 135.9 (2*s*, arom. C); 143.2 (*d*, C(8)); 144.6 (*s*, arom. C); 149.5 (*s*, C(4)); 152.2 (*s*, C(6)); 153.1 (*d*, C(2)); 158.5 (*s*, arom. C); 164.5 (*s*, CO). ^{31}P-NMR (162 MHz, $CDCl_3$): 147.7, 148.6.

*1-[2'-Deoxy-5'-O-(4,4'-dimethoxytrityl)-1',2'-seco-*D*-ribosyl]thymine 3'-(2-Cyanoethyl Diisopropylphosphoramidite)* (**11b**). From **10b** (200 mg, 0.366 mmol), THF (2 ml), (i-Pr)$_2$EtN (0.29 ml, 1.46 mmol), and chloro(2-cyanoethoxy)(diisopropylamino)phosphine (0.11 ml, 0.476 mmol), as described for **11a**. CC (silica gel, hexane/AcOEt 5:2) gave **11b** (0.246 g, 90%). White foam. TLC (hexane/AcOEt 2:1): R_f 0.50. ^{1}H-NMR (300 MHz, CD_3CN): 1.00–1.13 (*m*, 15 H, *Me*$_2$CH, H–C(2')); 1.76 (*d*, $J = 1.1$, Me–C(5)); 2.52 (*t*, $J = 5.9$, OCH$_2$C*H*$_2$CN); 2.59 (*t*, $J = 6.0$, OCH$_2$C*H*$_2$CN); 3.08–3.12 (*m*, 2 H–C(5')); 3.43–3.75 (*m*, 4 H, H–C(3'), Me$_2$C*H*, OC*H*$_2$CH$_2$CN); 3.760, 3.763 (2*s*, 2 MeO); 3.83–4.01 (*m*, 2 H, H–C(4'), OC*H*$_2$CH$_2$CN); 5.23–5.32 (*m*, 2 H–C(1')); 6.82–6.87 (*m*, 4 arom. H); 7.21–7.32 (*m*, 7 arom. H); 7.34–7.43 (*m*, 2 arom. H). ^{13}C-NMR (75 MHz, CD_3CN): 12.4 (*q*, *Me*–C(5)); 18.1, 18.2, 18.3 (3*q*, C(2')); 21.0 (*dt*, *J*(C, P) = 7.3, OCH$_2$CH$_2$CN); 24.7, 24.8, 24.9, 25.0 (4*q*, *Me*$_2$CH); 43.77, 43.86, 43.94, 44.02 (4*d*, Me$_2$C*H*); 55.9 (*q*, MeO); 59.1 (*dt*, *J*(C, P) = 19.5, OCH$_2$CH$_2$CN); 59.3 (*dt*, *J*(C, P) = 19.3, OCH$_2$CH$_2$CN); 64.9, 64.8 (2*t*, C(5')); 71.4 (*dd*, *J*(C, P) = 16.0, C(3')); 77.8, 77.9, (2*t*, C(1')); 82.7 (*dd*, *J*(C, P) = 15.7, C(4')); 82.8 (*dd*, *J*(C, P) = 14.9, C(4')); 87.1, 87.2 (2*s*, PhAr$_2$*C*); 111.2 (*s*, C(5)); 114.1 (*d*, arom. C); 119.6 (*s*, CN); 127.8, 128.9, 129.1, 130.97, 131.03 (5*d*, arom. C); 136.99, 137.08, 137.16 (3*s*, arom. C); 141.36, 141.43 (2*d*, C(6)); 146.2 (*s*, C(4)); 159.7 (*s*, arom. C); 165.1 (*s*, C(2)). ^{31}P-NMR (121 MHz, CD_3CN): 148.5, 148.4.

Nucleoside-Modified Solid Supports **12a** *and* **12b**: *General Procedure*. To a soln. of each nucleoside derivative **10a** or **10b** in pyridine (0.16–0.25M) were added heptanedioic acid bis-(*p*-nitrophenyl) ester (3.6 equiv.) and 4-(dimethylamino)pyridine (0.9 equiv.). The mixture was stirred at r.t. for 18 h and then co-evaporated with toluene. The crude active ester was purified by CC (silica gel, hexane/AcOEt 4:6). To a soln. of the purified active ester in dioxane/DMF/Et_3N 0.5:1:0.2 was added long-chain-alkylamine-CGP (0.3 g/0.12 mmol active ester) and

the resulting suspension slowly stirred for 48 h at r.t. After filtration and extensive washing with DMF, MeOH, and Et_2O, the solid support was dried *in vacuo*, and the loading capacity (*ca.* 30 μmol/g) was determined by the trityl assay. Unreacted amino groups on the solid support were capped by treatment with pyridine/Ac_2O 5:0.5 containing 4-(dimethylamino)pyridine (5 mol-% rel. to Ac_2O) (5.5 ml soln./0.5 g CPG).

*1-(3'-O-Benzoyl-2'-deoxy-1',2'-seco-*D*-ribosyl)thymine* (**13**). To a soln. of **10b** (306 mg, 0.560 mmol) in pyridine (4 ml), benzoyl chloride (0.078 ml, 0.672 mmol) was added at 0°. After 1 h stirring at r.t., the mixture was co-evaporated with toluene. The residue was purified by CC (silica gel, acetone/CH_2Cl_2 1:8), giving a white foam (344 g, 95%). A soln. of this foam (328 mg, 0.504 mmol) in 80% AcOH/H_2O (8 ml) was stirred at r.t. for 45 min. Then H_2O (10 ml) was added, and the mixture was extracted with Et_2O. The aq. phase was evaporated until there was no AcOH left and then subjeced to lyophilization. The crude product was purified by CC (silica gel, acetone/CH_2Cl_2 1:2); **13** (133 mg, 76%). White foam. TLC (acetone/CH_2Cl_2 1:2): R_f 0.20. UV (EtOH): 228 (12500), 264 (7770). IR (KBr): 3440*m* (br.), 3200*m* (br.), 3060*m*, 2980*m*, 2960*w*, 2900*w*, 2830*w*, 1710*vs*, 1685*vs*, 1600*m*, 1585*w*, 1520*w*, 1470*m*, 1450*m*, 1410*w*, 1385*m*, 1345*m*, 1315*m*, 1280*s*, 1200*m*, 1180*w*, 1150*m* (sh), 1120*m*, 1075*s*, 1050*m* (sh), 1025*m*, 1005*m*, 975*w*, 940*w*, 900*w*, 835*w*, 805*w*, 780*w*, 715*s*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 1.24 (*d*, *J* = 6.5, 3 H–C(2')); 1.70 (*d*, *J* = 1.1, Me–C(5)); 3.47–3.51 (*m*, 2 H–C(5')); 3.84–3.86 (*m*, H–C(4')); 4.92 (br. *s*, OH–C(3')); 5.14–5.19 (*m*, H–C(3')); 5.21 (*AB*, J_{AB} = 10.5, 2 H–C(1')); 7.48–7.53 (*m*, 2 arom. H); 7.59 (*d*, *J* = 1.2, H–C(6)); 7.62–7.68 (*m*, arom. H); 7.89–7.92 (*m*, 2 arom. H); 11.3 (br. *s*, H–N(3)). ^{13}C-NMR (75 MHz, (D_6)DMSO): 11.7 (*q*, *Me*–C(5)); 14.1 (*q*, C(2')); 60.2 (*t*, C(5')); 70.4 (*d*, C(3')); 75.9 (*t*, C(1')); 80.1 (*d*, C(4')); 109.1 (*s*, C(5)); 128.6, 129.0 (2*d*, arom. C); 129.7 (*s*, arom. C); 133.2 (*d*, arom. C); 140.5 (*d*, C(6)); 151.1 (*s*, C(4)); 164.1 (*s*, C(2)); 164.9 (*s*, CO).

*1',2'-Seco-3'-thymidylic Acid 3' → 5' Ester with 1-(2'-Deoxy-1',2'-seco-*D*-ribosyl)thymine* (1',2'-seco-d(T_2)). A soln. of **11b** (35.0 mg, 0.10 mmol), **13** (150 mg, 0.20 mmol), and 1*H*-tetrazole (56.0 mg, 0.8 mmol) in MeCN (2 ml) was stirred at r.t. for 3 h. To this soln. was added dropwise a soln. (2 ml) of 0.1M I_2 in THF/2,6-dimethylpyridine/H_2O 2:2:1, until the mixture became dark brown. Then, a sat. $Na_2S_2O_3$ soln. (15 ml) was added, until the mixture became light yellow. To this mixture, AcOEt (20 ml) was added, and the mixture was extracted with sat. NaCl soln. (30 ml) and with H_2O (30 ml). The org. phase was dried ($MgSO_4$) and evaporated. A soln. of the obtained residue in 80% AcOH/H_2O (3 ml) was stirred at r.t. for 30 min. Then H_2O (20 ml) was added, and the mixture extracted with Et_2O (30 ml). The aq. phase was evaporated and the residue redissolved in conc. NH_3 soln. After 20 h stirring at 55°, the mixture was evaporated and the residue purified by TLC (silica gel, i-PrOH/conc. NH_3 soln. 2:1). Lyophilization gave 1',2'-seco-d(T_2) (50.4 mg, 89%). White powder. TLC (i-PrOH/conc. NH_3 soln. 2:1): R_f 0.30. ^{1}H-NMR (400 MHz, D_2O, 0.1M NaCl, 0.05M Na_2HPO_4, 0.1% (*w*/*v*) NaN_3, H_3PO_4, pH 7.00): 1.15 (*d*, *J* = 6.5, 3 H–C(2'.2)); 1.21 (*d*, *J* = 6.5, 3 H–C(2'.1)); 1.87 (2*s*, Me–C(5.1), Me–C(5.2)); 3.56 (*dd*, *J* = 7.1, 12.4, 1 H–C(5'.1)); 3.68 (*dd*, *J* = 3.44, 12.4, 1 H–C(5'.1)); 3.72 (*ddd*, *J* = 3.1, 6.4, 6.5, H–C(4'.2)); 3.75 (*ddd*, *J* = 3.4, 4.1, 7.1, H–C(4'.1)); 3.87 (*ddd*, *J* = 5.5, 6.5, 11.3, H–C(5'.2))[5]; 3.90 (*dq*, *J* = 6.4, 6.5, H–C(3'.2)); 4.00 (*ddd*, *J* = 3.1, 5.4, 11.3, H–C(5'.2))[5]; 4.28 (*ddq*, *J* = 4.1, 6.5, 8.4, H–C(3'.1))[5]; 5.30 (*AB*, J_{AB} = 10.7, H–C(1'.1), H–C(1'.2)); 5.31 (*s*, H–C(1'.1), H–C(1'.2)); 7.55 (2*s*, H–C(6.1), H–C(6.2))[5]. ^{13}C-NMR (100 MHz, D_2O, 0.1M NaCl, 0.05M Na_2HPO_4, 0.1% (*w*/*v*) NaN_3, H_3PO_4, pH 7.00): 14.02 (*q*, *Me*–C(5.1), *Me*–C(5.2)); 18.95 (*dq*, *J*(C, P) = 2.02, Me(2'.1)); 20.07 (*q*, Me(2'.2)); 63.26 (*t*, C(5'.1)); 67.45 (*dt*, *J*(C, P) = 5.4, C(5'.2)); 69.03 (*d*,C(3'.2)); 74.72 (*dd*, *J*(C, P) = 5.7, C(3'.1)); 80.18 (*t*, C(1'.1), C(1'.2)); 80.23 (*t*, C(1'.1), C(1'.2)); 84.70 (*dd*, *J*(C, P) = 8.1, C(4'.1), C(4'.2)); 85.25 (*dd*, *J*(C, P) = 6.7, C(4'.1), C(4'.2)); 113.8, 113.9 (2*s*, C(5.1), C(5.2)); 144.87, 147.79 (2*d*, C(6.1), C(6.2)); 155.00, 155.02 (2*s*, C(4.1), C(4.2)); 169.58, 169.62 (2*s*, C(2.1), C(2.2)). ^{31}P-NMR (162 MHz, D_2O, 162 MHz, 30 mM 1',2'-seco-d(T_2), 0.1M NaCl, 0.05M Na_2HPO_4, 0.1% (*w*/*v*) NaN_3, H_3PO_4, pH 7.00, 25°): −1.78 (*ddd*, *J* = 5.6, 5.6, 8.4, P). FAB-MS (neg.): 549.0 (84, *M*), 386.8 (13), 323.7 (16), 281.0 (10), 266.3 (25), 199.9 (12), 171.7 (17), 168.6 (14), 154.4 (19), 153.4 (100), 152.4 (24), 151.4 (36), 138.2 (11), 137.2 (11), 126.9 (52), 125.0 (30), 122.1 (11), 121.1 (10), 107.1 (38), 103.1 (21).

Oligo(2'-deoxy-1',2'-seco-nucleotides). The synthesis of 1',2'-seco-d[$(AT)_6$] was performed on a DNA synthesizer (*Applied Biosystem, 380B*), while 1',2'-seco-d(A_{10}) and 1',2'-seco-d(T_{10}) were synthesized manually, following the protocols as described for the synthesis of homo-DNA oligonucleotides [2]. After synthesis, the solid support was suspended in conc. NH_3 soln. and left for 16 h at 55° to effect deprotection. Evaporation, redissolution in H_2O, followed by filtration yielded the crude oligonucleotide soln. that was subsequently used for HPLC purification (*Table 1*).

[5]) The signal was simplified in the ^{31}P-decompled spectrum.

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