Supplementary Material (ESI) for Chemical Communications

General. Reagents were purchased from Aldrich, Sigma, Fluka, and Acros chemical companies. Solvents were purchased from Fisher Scientific, and dried by standard techniques. All reactions were monitored with analytical TLC (Merck Kieselgel 60 F_{254}). All experiments involving air and/ or moisture sensitive were carried out under a nitrogen atmosphere. Column chromatography was carried out with silica gel particle size 40-63 μm. NMR spectra were recorded using a Varian Inova 400 or 300 or a Bruker Avance 600 spectrometer at ambient temperature. Exact mass spectra were obtained on a VG-ZAB-2FHF mass spectrometer using FAB ionization. MALDI-TOF mass spectra were recorded on a PerSeptive Biosystems Voyager-DE STR instrument. Ultraviolet spectra were obtained on a Hewlett Packard 8452A photodiode array spectrophotometer. DNA melts were obtained on a Varian Cary 500 equipped with a peltier temperature controller. Circular dichroism spectra were obtained on a JASCO Corp. J-810 spectrometer.

Experimental procedures.

3,5-*O*-((1,1,3,3-tetraisopropyl)disiloxanediyl)-2-deoxy-D-ribono-1,4-lactone (1)[i]

A solution of 2-deoxy-D-ribose (1.0 g, 7.46 mmol) and bromine (2 mL) in water (6 mL) was stirred for 5 days in a sealed flask. The mixture was neutralized by addition of Ag_2CO_3 until a pH of 7.0 was obtained. The mixture was filtered, washed with water, and the combined filtrate was concentrated *in vacuo*. The oily residue was coevaporated with pyridine (3 × 20 mL), dried under a high vacuum, and the residue was used for next step without a further purification.

To a mixture of the oily residue, imidazole (1.27 g, 18.6 mmol), and DMAP (46 mg, 5 mol %) in dry DMF was added 1,3-dichloro-1,1,3,3-tetraisopropyl disiloxane (3.58 mL, 11.19 mmol) dropwise over 20 min, and the resulting mixture was stirred overnight. The reaction mixture was poured into water (100 mL), and extracted with ether (3 × 40 mL). The combined organic layers were washed with saturated aqueous $NaHCO_3$ solution, water, and brine, successively, and dried over anhydrous Na_2SO_4. The concentrated residue was purified by column chromatography with CH_2Cl_2 to give colorless oil (2.30 g, 82 %).

^{1}H-NMR (400 MHz, $CDCl_3$) δ: 4.64 (dd, 1H, *J* = 16.4, 7.8 Hz, H3), 4.22 (dt, 1H, *J* = 10.1, 3.3 Hz, H4), 4.14 (dd, 1H, *J* = 12.5, 3.5 Hz, H5), 3.93 (dd, 1H, *J* = 12.5, 6.2 Hz, H5), 2.86 (dd, 1H, *J* = 17.2, 7.8 Hz, H2), 2.72 (dd, 1H, *J* = 17.2, 9.4 Hz), 1.10-1.01 (m, 28H); ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 173.0, 84.8, 69.6, 62.3, 37.8, 17.4, 17.25, 17.2, 17.0, 16.8, 13.2, 13.1, 12.8, 12.5; HRMS (FAB+) Calcd. $C_{17}H_{34}O_5NaSi_2$: 397.18425, Found: 397.18620.

(7R)-6-(2-hydroxy-2-(3-pyridyl)ethyl)-2,2,4,4-tetraisopropyl-1,3,5,2,4-trioxadisilocan-7-ol (2) [ii]

To a solution of n-BuLi (1.6 M in hexane; 1.25 mL, 2.0 mmol) was added 3-bromopyridine (0.19 mL, 2.0 mmol) dropwise over a 20 min period at -78°C. After 2 hours, a solution of **1** in 5mL of dry ether (0.5 g, 1.33 mmol) was added to the reaction mixture via cannula over 10 min at the same temperature, and the resulting mixture was stirred for 3 hours. The reaction was quenched by the addition of saturated aqueous NH_4Cl solution at -

78 °C, and extracted with ether (3 × 40 mL). The combined ether layers were washed with brine (2 × 30 mL), dried over anhydrous Na_2SO_4, and concentrated *in vacuo*. The residue was dried under a high vacuum overnight and used for next step without further purification.

To a solution of the intermediate in dry THF (6 mL) was added L-selectride (1.33 mmol) dropwise at -78°C, and the mixture was stirred for 1.5 hours. The reaction was quenched by the addition of sat. aq. $NaHCO_3$ sol. at -78°C and extracted with ethyl acetate (3 × 40 mL). The combined extracts were washed with brine, dried over anhydrous Na_2SO_4 and concentrated. The residue was purified by column chromatography with CH_2Cl_2:MeOH = 50:1 to 40:1, and afforded white solid (0.37 g, 61 %)

^{1}H-NMR (400 MHz, $CDCl_3$) δ: 8.63 (s, 1H), 8.51 (d, 1H, *J* = 3.9 Hz), 7.74 (d, 1H, *J* = 7.8 Hz), 7.31~7.27 (m, 1H), 5.13 (dd, 1H, *J* = 10.1, 2.3 Hz, H1'), 4.32 (s, 1H), 4.24 (d, 1H, *J* = 11.7 Hz, H5'), 4.09-4.04 (m, 1H, H3'), 3.90 (dd, 1H, *J* = 11.7, 1.6 Hz, H5'), 3.75 (s, 1H), 2.21 (s, 1H), 2.18-2.11 (m, 1H, H2'), 1.14-1.06 (m, 28H); ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 148.7, 147.7, 140.0, 133.3, 123.3, 76,4, 72.8, 70.4, 69.3, 62.4, 42.4, 17.4, 17.3, 17.2, 13.3, 12.6, 12.5; HRMS (FAB+) Calcd. $C_{22}H_{42}NO_5Si_2$: 456.26016, Found: 456.25960.

(7R)-6-(2-hydroxy-2-(4-pyridyl)ethyl)-2,2,4,4-tetraisopropyl-1,3,5,2,4-trioxadisilocan-7-ol (3)

To a solution of n-BuLi (1.6 M in hexane; 0.5 mL, 0.8 mmol) was added 4-bromopyridine (5.3 mL of 0.15 M in ether, 0.8 mmol) [iii] dropwise over a 20 min period at -78°C. After 2 hours, a solution of **1** (0.2 g, 0.53 mmol) in 1 mL of dry ether was added to the reaction mixture via cannula over 10 min at the same temperature, and the mixture was stirred for 3 hours. The reaction was quenched by the addition of saturated aqueous NH_4Cl solution at -78°C, and extracted with ether (3 × 40 mL). The combined ether layers were washed with brine (2 × 30 mL), dried over anhydrous Na_2SO_4, and concentrated *in vacuo*. The residue was dried under a high vacuum overnight and used for the next step without further purification.

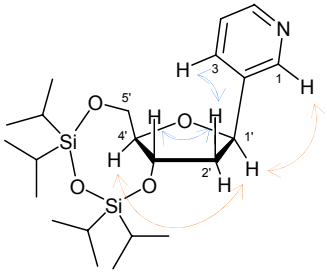
To a solution of the intermediate in dry THF (2 mL) was added L-selectride (0.53 mmol) dropwise at -78°C, and the resulting solution was stirred for 1.5 hours. The reaction was quenched by the addition of sat. aq. $NaHCO_3$ at -78°C and extracted with ethyl acetate (3 × 40 mL). The combined extracts were washed with brine, dried over anhydrous Na_2SO_4 and concentrated. The residue was purified by column chromatography with CH_2Cl_2:MeOH = 50:1 to 40:1 to afford a white solid (0.14 g, 60 %)

^{1}H-NMR (400 MHz, $CDCl_3$) δ: 8.56-8.54 (m, 2H), 7.33-7.26 (m, 2H), 5.07 (d, 1H, *J* = 10.2 Hz, H1'), 4.46 (s, 1H), 4.23 (d, 1H, *J* = 11.7 Hz, H5'), 4.09-4.05 (m, 1H, H3'), 3.90 (dd, 1H, *J* = 10.2, 1.6 Hz, H5'), 3.74 (d, 1H, *J* = 8.8 Hz, H4'), 2.53 (s, 1H), 2.22-2.18 (m, 1H, H2'), 2.07-1.99 (m, 1H, H2'); ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 153.7, 149.7, 120.6, 72.8, 70.4, 70.1, 62.4, 42.2, 17.4, 17.3, 17.2, 13.3, 12.6, 12.5; HRMS (FAB+) Calcd. $C_{22}H_{42}NO_5NaSi_2$: 456.26016, Found: 456.26230.

3,5-O-((1,1,3,3-tetraisopropyl)disiloxanediyl)-1,2-dideoxy-β-1-(3-pyridyl)-D-ribofuranose (4)

To a solution of **2** (0.35 g, 0.77 mmol) and triphenylphosphine (0.32 g, 1.16 mmol) in 15 mL of dry THF was added diisopropyl azodicarboxylate (0.23 mL, 1.16 mmol) dropwise at 0°C and allowed to warm to RT. After 20 hours stirring, the reaction mixture was treated with 0.5 M I_2 solution in CH_2Cl_2 until the iodine color persisted, and then concentrated *in vacuo*. The oily reside was partitioned between ethyl acetate and saturated aqueous sodium bicarbonate solution, and the separated aqueous layer was extracted with ethyl acetate (3 × 30 mL). The combined organic layers were washed with brine (2 × 30 mL), dried over anhydrous Na_2SO_4, and concentrated. The residue was purified by column chromatography with petroleum ether (bp 35~60 °C):EtOAc = 10:1 to 6:1 and afforded a colorless oil (0.30 g, 88 % d.e. >98 %)

^{1}H-NMR (600 MHz, $CDCl_3$) δ: 8.57 (s, 1H), 8.52 (d, 1H, *J* = 3.7 Hz), 7.70 (d, 1H, *J* = 7.8 Hz), 7.28-7.26 (m , 1H), 5.12 (t, 1H, *J* = 7.4 Hz, H1'), 4.55-4.52 (m, 1H, H3'), 4.13 (dd, 1H, *J* = 11.3, 2.9 Hz, H5'), 3.93-3.91 (m, 1H, H4'), 3.88 (dd, 1H, *J* = 11.3, 7.6 Hz, H5'), 2.44-2.40 (m, 1H, H2'α), 2.09-2.05 (m , 1H, H2'β), 1.10-1.03 (m, 18H); ^{13}C-NMR (150 MHz, $CDCl_3$) δ: 148.9, 147.7, 133.5, 86.5, 73.0, 63.4, 42.9, 17.6, 17.4, 17.2, 17.08, 17.05, 17.0, 13.5, 13.0, 12.5; HRMS (FAB+) Calcd. $C_{22}H_{40}NO_4Si_2$: 438.24959, Found: 438.25170.



Through space proton-proton interactions by gNOESY; In the gNOESY spectrum, H1' (α) interacts with H2' (α), H4' (α) and H1 or H3. H1 and H3 interact with H2' (β) and not with H2' (α), whereas H4' (α) interacts with H2' (α) and not with H2' (β).

3,5-O-((1,1,3,3-tetraisopropyl)disiloxanediyl)-1,2-dideoxy-β-1-(4-pyridyl)-D-ribofuranose (5)

To a solution of **3** (0.35 g, 0.77 mmol) and triphenylphosphine (0.32 g, 1.16 mmol) in 15 mL of dry THF was added diisopropyl azodicarboxylate (0.23 mL, 1.16 mmol) dropwise at 0°C. After stirring at RT overnight, the reaction mixture was treated with 0.5 M I_2 solution in CH_2Cl_2 until the iodine color persisted, and concentrated *in vacuo*. The oily reside was partitioned between ethyl acetate and saturated aqueous sodium bicarbonate solution, and the separated aqueous layer was extracted with ethyl acetate (3 × 30 mL). The combined organic layers were washed with brine (2 × 30 mL), dried over anhydrous Na_2SO_4, and concentrated. The residue was purified by column chromatography with petroleum ether (bp 35~60 °C):EtOAc = 10:1 to 6:1 and afforded a colorless oil (0.28 g, 82 % de>87 %).

^{1}H-NMR (600 MHz, $CDCl_3$) δ: 8.56 (d, 2H, *J* = 5.0 Hz), 7.29 (d, 2H, *J* = 5.4 Hz), 5.09 (t, 1H, *J* = 7.2 Hz, H1'), 4.48 (dd, 1H, *J* = 12.5, 5.4 Hz, H3'), 4.12 (dd, 1H, *J* = 10.8, 4.12 Hz), 3.94-3.89 (m, 2H), 2.45 (ddd, 1H, *J* = 12.4, 7.2, 5.6 Hz, H2'α), 2.01 (ddd, 1H, *J* = 12.7, 7.3, 5.9 Hz, H2'β); ^{13}C-NMR (150 MHz, $CDCl_3$) δ: 151.7, 149.6, 120.5, 86.2, 72.1, 63.0, 42.5, 17.5, 17.4, 17.3, 17.2, 17.02, 17.00, 16.9, 13.4, 13.3, 13.0, 12.5; gNOESY

spectrum was similar to comp **4**; HRMS (FAB+) Calcd. $C_{22}H_{40}NO_4Si_2$: 438.24959, Found: 438.24830.

1,2-Dideoxy-β-1-(3-pyridyl)-D-ribofuranose (6)[iv]

To a solution of **4** (0.30 g, 0.69 mmol) in 6 mL of dry THF was added triethylamine trihydrofluoride (0.51 mL, 3.1 mmol) dropwise at 0 °C. After 30 min, the reaction mixture was allowed to warm to RT. After stirring for 6 hours, the reaction mixture was concentrated *in vacuo*, and purified by chromatography with CH_2Cl_2:MeOH = 20:1 to 10:1 to give a colorless oil (0.13 g, 96 %).

^{1}H-NMR (400 MHz, $CDCl_3$) δ: 8.63 (d ,1H, *J* = 2.0 Hz), 8.53 (dd, 1H, *J* = 4.7, 1.5 Hz), 7.68 (dt, 1H, *J* = 8.0, 2.0 Hz), 7.29 (dd, 1H, *J* = 8.0, 5.0 Hz), 5.21 (dd, 1H, *J* = 10.2, 5.7 Hz, H1'), 4.50-4.48 (m, 1H, H3'), 4.06 (dt, 1H, *J* = 4.5, 2.9 Hz, H4'), 3.84 (dd, 1H, *J* = 11.7, 4.3 Hz, H5'), 3.77 (dd, 1H, *J* = 11.7, 4.9 Hz, H5'), 2.39 (br, 1H), 2.32 (ddd, 1H, *J* = 13.2, 5.7, 2.0 Hz, H2'), 2.04 (ddd, 1H, *J* = 13.2, 10.3, 6.2 Hz, H2'); ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 149.0, 147.8, 136.9, 133.8, 123.5, 87.5, 77.9, 73.6, 63.3, 44.0

^{1}H-NMR (400 MHz, CD_3OD) δ: 8.58 (d, 1H, *J* = 1.90 Hz), 8.44 (dd, 1H, *J* = 4.89, 1.49 Hz), 7.90 (td, 1H, *J* = 7.95, 1.72, 1.72 Hz), 7.42 (dd, 1JH, *J* = 7.91, 4.91 Hz), 5.18 (dd, 1H, *J* = 10.50, 5.47 Hz), 4.35 (td, 1H, *J* = 5.86, 1.85, 1.85 Hz), 3.97 (dt, 1H, *J* = 4.84, 4.82, 2.42 Hz), 3.69 (d, 2H, *J* = 4.84 Hz), 2.27 (ddd, 1H, *J* = 13.05, 5.50, 1.65 Hz), 1.96 (ddd, 1H, *J* = 13.06, 10.53, 5.89 Hz); ^{13}C-NMR (100 MHz, CD_3OD) δ: 149.18, 148.2, 139.98, 136.15, 125.16, 89.52, 79.16, 74.4, 63.94, 44.9; HRMS (FAB+) Calcd. $C_{10}H_{14}NO_3$: 196.09737, Found: 196.09724.

1,2-Dideoxy-β-1-(4-pyridyl)-D-ribofuranose (7)

To a solution of **5** (0.12 g, 0.27 mmol) in 3 mL of dry THF was added triethylamine trihydrofluoride (0.22 mL, 1.35 mmol) dropwise at 0°C. The reaction mixture was stirred for 30 min followed by warming to RT, and continued stirring for 6 hours. The reaction mixture was concentrated *in vacuo*, and purified by chromatography with CH_2Cl_2:MeOH = 20:1 to 10:1 to give a white solid (52 mg, 98 %).

^{1}H-NMR (400 MHz, $CDCl_3$) δ: 7.58-7.57 (m, 2H), 7.28-7.26 (m, 2H), 5.18 (dd, 1H, *J* = 10.2, 5.9 Hz, H1'), 4.48-4.45 (m , 1H, H3'), 4.07 (dt, 1H, *J* = 6.1, 2.9 Hz, H4'), 3.85 (dd, 1H, *J* = 11.5, 4.3 Hz, H5'), 3.78 (dd, 1H, *J* = 11.7, 4.8 Hz, H5'), 2.34 (ddd, 1H, *J* = 13.1, 5.8, 2.0 Hz, H2'), 1.98 (ddd, 1H, *J* = 13.4, 6.2, 2.9 Hz, H2'); ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 150.5, 149.9, 120.6, 87.5, 78.5, 73.6, 63.3, 43.8; ^{1}H-NMR (400 MHz, DMSO-d_6) δ: 8.50 (d, 2H, *J* = 4.9 Hz), 7.37 (d, 2H, *J* = 5.5 Hz), 5.12 (d, 1H, *J* = 3.9 Hz), 5.03 (dd, 1H, *J* = 10.2, 5.6 Hz), 4.79 (t, 1H, *J* = 5.6 Hz), 4.19 (d, 1H, *J* = 1.2 Hz), 3.83 (dt, 1H, *J* = 4.9, 1.8 Hz), 3.52-3.39 (m, 2H), 2.16 (ddd, 1H, *J* = 12.7, 5.7, 1.2 Hz), 1.73 (ddd, 1H, *J* = 12.7, 10.3, 5.5 Hz); ^{13}C-NMR (100 MHz, DMSO-d_6) δ: 151.8, 149.4, 120.8, 88.0, 77.8, 72.2, 62.3, 43.1; HRMS (FAB+) Calcd. $C_{10}H_{14}NO_3$: 196.09737, Found: 196.09765.

1,2-dideoxy-5-(4,4'-dimethoxytrityl)-β-1-(3-pyridyl)-D-ribofuranose (8)

Compound **6** (41 mg, 0.21 mmol) was coevaporated with dry pyridine (3 × 2 mL) and dried under a high vacuum overnight. To a solution of **6** in dry pyridine (1.5 mL) was added DMTCl (90 mg, 0.25 mmol) at one portion at RT, and the resulting mixture was

stirred for 7 hours. After cooling to 0°C, the reaction was quenched by addition of 1 mL MeOH, followed 10 min of stirring, and then concentration *in vacuo*. The residue was purified by column chromatography with CH_2Cl_2:MeOH = 50:1 with 1 % pyridine to afford a white foam (93 mg, 89 %).

^{1}H-NMR (400 MHz, $CDCl_3$) δ: 8.59 (d, 1H, *J* = 2.1 Hz), 8.52 (dd, 1H, *J* = 4.9, 1.7 Hz), 7.71 (dt, 1H, *J* = 8.0, 2.0 Hz), 7.46-7.43 (m, 2H), 7.35-7.09 (m, 8H), 6.84-6.80 (m, 4H), 5.20 (dd, 1H, *J* = 10.2, 5.6 Hz, H1'), 4.46-4.45 (m, 1H, H3'), 4.09 (dt, 1H, *J* = 7.2, 2.5 Hz, H4'), 3.79 (s, 6H), 3.36 (dd, 1H, *J* = 9.8, 4.6 Hz, H5'), 3.27 (dd, 1H, *J* = 9.8, 5.5 Hz, H5'), 2.29 (ddd, 1H, *J* = 13.1, 5.7, 2.0 Hz, H2'), 2.07-2.00 (m, 1H, H2'); ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 158.5, 149.0, 147.9, 144.7. 137.3, 135.9, 133.6, 130.1, 128.1, 127.9, 126.8, 123, 3, 113.1, 86.5, 86.3, 77.8, 74.6, 64.3, 55.2, 43.7; HRMS (FAB+) Calcd. $C_{31}H_{32}NO_5$: 498.22805, Found: 498.22720.

1,2-dideoxy-5-(4,4'-dimethoxytrityl)-β-1-(4-pyridyl)-D-ribofuranose (9)

Compound **7** (50 mg, 0.26 mmol) was coevaporated with dry pyridine (3 × 2 mL) and dried under a vacuum overnight. To a solution of **7** in dry pyridine (2mL) was added DMTCl (111 mg, 0.31 mmol) as one portion at RT, and the resulting reaction solution was stirred for 8 hours. After cooling to 0°C, the mixture was treated with 1 mL MeOH with 10 min stirring, and concentrated *in vacuo*. The residue was purified by column chromatography with CH_2Cl_2:MeOH = 50:1 with 1 % pyridine to afford a white foam (97 mg, 75 %).

^{1}H-NMR (400 MHz, $CDCl_3$) δ: 8.54 (s, 2H), 7.45-7.42 (m, 2H), 7.35-7.19 (m, 9H), 6.84-6.80 (m, 4H), 5.17 (dd, 1H, *J* = 10.0, 5.9 Hz, H1'), 4.43-4.40 (m, 1H, H3'), 4.10 (ddd, 1H, *J* = 7.0, 3.6, 2.5 Hz, H4'), 3.79 (s, 6H), 3.36 (dd, 1H, *J* = 10.0, 4.6 Hz, H5'), 3.28 (dd, 1H, *J* = 9.8, 5.3 Hz, H5'), 2.31 (ddd, 1H, *J* = 12.9, 5.9, 2.1 Hz, H2'), 2.18 (br, 1H), 1.98 (ddd, 1H, *J* = 13.1, 10.0, 6.0 Hz, H2'); ^{13}C-NMR (100 MHz, $CDCl_3$) δ: 158.5, 151.2, 149.7, 144.7, 135.9, 130.0, 128.1, 127.8, 126.9, 120.7, 113.1, 86.6, 86.3, 78.4, 74.2, 64.2, 55.2, 43.4; HRMS (FAB+) Calcd. $C_{31}H_{32}NO_5$: 498.22805, Found: 498.22620.

1,2-Dideoxy-5-(4,4'-dimethoxytrityl)-β-1-(3-pyridyl)-D-ribofurano-3-syl 2-cyanoethyl diisopropylphosphoramidite (10)

Compound **8** (90 mg, 0.18 mmol) was coevaporated with dry pyridine (3 × 2 mL) and dried under a high vacuum overnight. To a solution of **8** in dry CH_2Cl_2 (1 mL) were added diisopropylethyl amine (125 µl, 0.72 mmol) and 2-cyanoethyl diisopropylchloro phophoramidite (60 µl, 0.27 mmol), successively, dropwise at 0°C. After 2 hours stirring at the same temp, the reaction mixture was diluted with CH_2Cl_2 and concentrated. The residue was purified by column chromatography with Hexanes:EtOAc = 1:1 with 1 % pyridine to afford a white foam (114 mg, 91%).

^{1}H-NMR (400 MHz, $CDCl_3$) δ: 8.62 (dd 1H, *J* = 4.3, 2.1 Hz), 8.53 (ddd, 4.7, 3.1, 1.6 Hz), 7.77-7.73 (m, 1H), 7.47-7.44 (m, 2H), 7.36-7.18 (m, 8H), 6.83-6.79 (m, 4H), 5.18 (ddd, 1H, *J* = 10.5, 5.1, 1.6 Hz), 4.56-4.52 (m, 1H), 4.28-4.23 (m, 1H), 3.89-3.54 (m, 4H), 3.79 (s, 3H), 3.78 (s, 3H), 3.35-3.23 (m, 2H), 2.62 (t, 1H, *J* = 6.4 Hz), 2.46 (t, 1H, *J* = 6.4 Hz), 2.37 (dd, 1H, *J* = 12.5, 4.9 Hz), 2.07-1.99 (m, 1H), 1.19 (d, 3H, *J* = 6.8 Hz), 1.18 (d,

3H, *J* = 6.4 Hz), 1.16 (d, 3H, *J* = 6.6 Hz), 1.10 (d, 3H, *J* = 6.8 Hz); ^{31}P-NMR (160 MHz, $CDCl_3$) δ: 149.5, 149.3; HRMS (FAB+) Calcd. $C_{40}H_{49}N_3O_6P$: 698.3354, Found: 698.3366.

1,2-Dideoxy-5-(4,4'-dimethoxytrityl)-β-1-(4-pyridyl)-D-ribofurano-3-syl 2-cyanoethyl diisopropylphosphoramidite (11)

Compound **9** (96 mg, 0.19 mmol) was coevaporated with dry pyridine (3 × 2 mL). Diisopropylethyl amine (132 µl, 0.76 mmol) and 2-cyanoethyl diisopropylchloro phophoramidite (64 µl, 0.29 mmol) were added to a solution of **9** in 2 mL of dry CH_2Cl_2 at 0°C. After 2 hours stirring at the same temperature, the reaction mixture was diluted with CH_2Cl_2 and concentrated. The residue was purified by column chromatography with Hex:EtOAc = 1:1 with 1 % pyridine to afford a white foam (110 mg, 85 %).

^{1}H-NMR (400 MHz, $CDCl_3$) δ: 8.55-8.53 (m, 2H), 7.46-7.43 (m, 2H), 7.35-7.17 (m, 9H), 6.82-6.78 (m, 4H), 5.17-5.12 (m, 1H), 4.51-4.48 (m, 1H), 4.27-4.23 (m, 1H), 3.88-3.52 (m, 4H), 3.78 (s, 3H), 3.77 (s, 3H), 3.35-3.22 (m, 2H), 2.61 (t, 1H, *J* = 6.4 Hz), 2.49-2.35 (m, 1H), 2.45 (t, 1H, *J* = 6.4 Hz), 2.01-1.92 (m, 1H), 1.18 (d, 3H, *J* = 6.6 Hz), 1.17 (d, 3H, *J* = 6.3 Hz), 1.15 (d, 3H, *J* = 6.4 Hz), 1.08 (d, 3H, *J* = 6.8 Hz); ^{31}P-NMR (160 MHz, $CDCl_3$) δ: 149.4, 149.3; HRMS (FAB+) Calcd. $C_{40}H_{49}N_3O_6P$: 698.3354, Found: 698.3348.

3',5'-Diacetyl-2'-deoxyuridine (12)[v]

To a solution of 2'-deoxyuridine (0.10 g, 0.44 mmol), DMAP (cat.) and acetic anhydride (0.17 mL, 1.76 mmol) in dry CH_3CN (2mL) was added triethylamine (0.25 mL, 1.76 mmol). After 30 min stirring, the reaction mixture was quenched by addition of 1 mL MeOH stirring for 10 min, and concentrated in reduced pressure. The resulting oily residue was partitioned between CH_2Cl_2 (2 × 20 mL) and water. The separated and combined CH_2Cl_2 layers were dried over anhydrous Na_2SO_4, and concentrated *in vacuo*. The residue was purified by column chromatography with Hex:EtOAc:CH_2Cl_2 = 1:3:1 to afford a white foam (0.13 g, 93 %).

^{1}H-NMR (300 MHz, $CDCl_3$) δ: 9.73 (s, 1H), 7.50 (d, 1H, *J* = 8.1 Hz, H6), 6.29 (dd, 1H, *J* = 8.3, 5.9 Hz, H1'), 5.80 (d, 1H, *J* = 8.1 Hz, H5), 5.24-5.20 (m, 1H, H3'), 4.40-4.26 (m, 3H), 2.54 (ddd, 1H, *J* = 140.0, 5.6, 2.0 Hz, H2'), 2.22-2.11 (m, 7H).

3,5-Diacetoxy-1,2-dideoxy-β-1-(4-chloropyrimidinone)-D-ribofuranose[5]

To a solution of **12** (1.65 g 5.28 mmol) in dry $CHCl_3$ (45 mL) were added freshly double distilled thionyl chloride (3 mL, 41.1 mmol) and anhydrous DMF (0.3 mL) at RT, successively. The mixture was refluxed for 100 min. After cooling to RT, the reaction mixture was treated with saturated aqueous $NaHCO_3$ solution, which was carefully added until CO_2 gas production ceased. The separated organic layer was washed with 100 mL $NaHCO_3$ solution, water (3 × 50 mL), successively and dried over anhydrous sodium sulfate. The yellow oily reside was purified by column chromatography with CH_2Cl_2:MeOH = 99:1 to 50:1 to give a white solid (1.28 g, 74 %).

^{1}H-NMR (300 MHz, $CDCl_3$) δ: 8.01 (d, 1H, *J* = 7.1 Hz, H6), 6.44 (d, 1H, *J* = 7.1 Hz, H5), 6.16 (dd, 1H, *J* = 7.6, 5.6 Hz, H1'), 5.22 (ddd, 1H, *J* = 6.6, 2.6, 2.1 Hz, H3'), 4.42-

4.37 (m, 3H), 2.92 (ddd, 1H, *J* = 14.5, 5.7, 2.2 Hz, H2'), 2.13-2.03 (m, 1H), 2.12 (s, 3H), 2.07 (s, 3H).

3,5-Diacetoxy-1,2-dideoxy-β-1-(4-(2,2'-bipyridine)pyrimidinone)-D-ribofuranose (13)

A mixture of 3,5-diacetoxy-1,2-dideoxy-β-1-(4-chloropyrimidinone)-D-ribofuranose (73 mg, 0.22 mmol), 6-(tributylstannyl)-2,2'-bipyridine (for preparation, *vide infra*; 0.10 g, 0.22 mmol) and $Pd(PPh_3)_4$ (13 mg, 5 mol%) in 3 mL of dry toluene was refluxed for 4 hours. After cooling to RT, the reaction mixture was treated with 20 mL of saturated NH_4Cl solution, and extracted with EtOAc (4 × 20 mL). The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, and concentrated *in vacuo*. The yellowish residue was purified by column chromatography with Hexanes:EtOAc = 1:1 to 1:4 to afford a white foam (90 mg, 91 %).

^{1}H-NMR (300 MHz, $CDCl_3$) δ: 8.73-8.70 (m, 1H), 8.62-8.58 (m, 2H), 8.55-8.53 (m, 1H), 8.21 (d, 1H, *J* = 7.3 Hz), 8.00 (dd, 1H, *J* = 8.3, 7.8 Hz), 7.90-7.85 (m, 1H), 7.78 (d, 1H, *J* = 6.8 Hz), 7.39-7.34 (m, 1H), 6.35 (dd, 1H, *J* = 7.8, 5.4 Hz), 5.29-5.26 (m, 1H), 4.43-4.37 (m, 3H), 3.00 (ddd, 1H, *J* = 14.6, 5.7, 2.0 Hz), 2.20-2.00 (m, 1H), 2.14 (s, 3H), 2.11 (s, 3H) ; ^{13}C-NMR (75 MHz, $CDCl_3$) δ: 170.7, 170.4, 170.3, 155.6, 155.4, 151.9, 149.2, 142.2, 138.0, 136.9, 124.0, 123.5, 122.8, 121.0, 101.5, 87.9, 83.3, 74.3, 63.7, 39.1, 20.9, 20.8; HRMS (FAB+) Calcd. $C_{23}H_{23}N_4O_6$: 451.16176, Found: 451.16110.

2-(Tributylstannyl)pyridine. To a solution of 2-bromopyridine (2.4 mL, 25 mmol) in 10 mL of dry THF was added n-BuLi (15.7 mL of 1.6 M in hexane, 25 mmol) dropwise at -78°C, and the resulting mixture was stirred for 1 hour. Tributyltin chloride (6.8 mL, 25 mmol) was added quickly to the reaction mixture, and stirring was continued for 3 hours at -78°C. The reaction was quenched with sat. NH_4Cl solution, diluted with EtOAc, and extracted with EtOAc (2 × 70 mL). The combined organic layers were washed with brine (2 × 100 mL), dried over anhydrous Na_2SO_4, and concentrated. The resulting product was used in the next step without further purification (9.2 g, quant.).

^{1}H-NMR (300 MHz, $CDCl_3$) δ: 8.74-8.73 (m, 1H), 7.49-7.38 (m, 2H), 7.13-7.10 (m, 1H), 1.62-1.51 (m, 6H), 1.39-1.27 (m, 6H), 1.15-1.10 (m, 6H), 0.93-0.85 (m, 9H).

6-Bromo-2,2'-bipyridine. To a solution of 2,6-dibromopyridine (67 mg, 0.28 mmol) and $Pd(Ph_3P)_4$ (16 mg, 5 mol %) in 2 mL of dry toluene was added 2-(tributylstannyl)pyridine (0.10 g, 0.27 mmol) at RT. The mixture was refluxed overnight and then the resulting yellow solution was evaporated *in vacuo*. The oily residue was dissolved in CH_2Cl_2 and the solution was extracted with 6 M HCl (3 × 5 mL). The combined aqueous layers were transferred dropwise in aqueous ammonia (10 %, 30 mL) under cooling in an ice bath and the resulting solution was extracted with CH_2Cl_2 (3 × 20 mL). The extracts were washed with 10 % ammonia and water, successively, dried over anhydrous Na_2SO_4 and concentrated. The residue was purified by column chromatography with Hexanes:EtOAc = 8:1 to 4:1 to afford a white solid (50 mg, 79 %).

^{1}H-NMR (300 MHz, $CDCl_3$) δ: 8.67-8.65 (m, 1H), 8.42-8.36 (m, 2H), 7.84-7.78 (m, 1H), 7.66 (t, 1H, *J* = 7.8 Hz), 7.48 (dd, 1H, *J* = 7.8, 1.0 Hz), 7.34-7.27 (m, 1H); ^{13}C-NMR (75 MHz, $CDCl_3$) δ: 157.3, 154.4, 149.2, 141.5, 139.2, 137.0, 127.9, 124.2, 121.4, 119.7.

6-(Tributylstannyl)-2,2'-bipyridine. To a solution of 6-bromo-2,2'-bipyridine (2.20 g, 9.36 mmol) in 30 mL of dry THF was added n-BuLi (5.85 mL, 1.6 M in hexane, 9.36 mmol) dropwise at -78°C, and the mixture was stirred for 1 hour. Tributyltin chloride was quickly added to the solution at -78 °C, and stirring continued for 30 min at RT. The reaction was quenched with sat. NH_4Cl solution, and extracted with EtOAc (3 × 100 mL). The combined organic layers were washed with brine (2 × 100 mL), dried over anhydrous Na_2SO_4, and concentrated. The dark black solution was dried under a vacuum overnight and used for next step without further purification (4.1 g, quant.).
^{1}H-NMR (300 MHz, $CDCl_3$) δ: 8.66-8.64 (m, 1H), 8.55-8.51 (m, 1H), 8.26-8.23 (m, 1H), 7.83-7.77 (m, 1H), 7.65-7.59 (m, 1H), 7.41-7.38 (m, 1H), 7.30-7.27 (m, 1H), 1.68-1.57 (m, 6H), 1.43-1.30 (m, 6H), 1.18-1.13 (m, 6H), 0.89 (t, 9H, *J* = 7.3 Hz); HRMS (FAB+) Calcd. $C_{22}H_{35}N_2Sn$: 447.18223, Found: 447.18340.

1,2-Dideoxy-β-1-(4-(2,2'-bipyridine)pyrimidinone)-D-ribofuranose

A solution of **13** (86 mg, 0.19 mmol) in 15 mL of saturated methanolic ammonia was stirred for 16 hours in a pressure bottle at RT. The mixture was concentrated in vacuo. The residue was dissolved in MeOH and coated on silica gel by evaporation of the solvent. The coated silica gel was loaded onto a chromatography column and product purified with Hexanes:EtOAc = 1:3 to 1:4 to afford a white solid (57 mg, 81 %).

^{1}H-NMR (300 MHz, DMSO-d_6) δ: 8.74 (d, 1H, *J* = 4.4 Hz), 8.69 (d, 1H, *J* = 6.8 Hz), 8.62-8.56 (m, 2H), 8.39 (d, 1H, *J* = 7.8 Hz), 8.17 (t, 1H, *J* = 7.8 Hz), 8.01 (dt, 1H, *J* = 7.8, 2.0 Hz), 7.68 (d, 1H, *J* = 6.8 Hz), 7.54-7.50 (m, 1H), 6.20-6.16 (m, 1H), 5.32 (d, 1H, *J* = 4.4 Hz), 5.15 (t, 1H, *J* = 4.9 Hz), 4.30-4.27 (m, 1H), 3.98-3.94 (m, 1H), 3.71-3.64 (m, 2H), 2.49-2.41 (m, 1H), 2.19-2.10 (m, 1H); ^{13}C-NMR (75 MHz, DMSO-d_6) δ: 169.0, 155.1, 154.8, 154.6, 152.2, 149.4, 145.1, 138.8, 137.5, 124.6, 122.9, 122.1, 120.8, 100.4, 88.2, 87.1, 69.7, 60.8, 41.1; HRMS (FAB+) Calcd. $C_{19}H_{19}N_4O_4$: 367.14063, Found: 367.13980; ε_{max} (260 nm) 11272.

1,2-Dideoxy-5-dimethoxytrityl-β-1-(4-(2,2'-bipyridine)pyrimidinone)-D-ribofuranose

1,2-Dideoxy-β-1-(4-(2,2'-bipyridine)pyrimidinone)-D-ribofuranose (0.50 g, 1.36 mmol) was coevaporated with dry pyridine (3 × 3 mL), and dried under a vacuum overnight. To a suspension of 1,2-dideoxy-β-1-(4-(2,2'-bipyridine)pyrimidinone)-D-ribofuranose in 10 mL of dry pyridine was added DMTCl (0.53 g, 1.50 mmol) at RT, and the resulting solution was stirred for 5.5 hours. After cooling in an ice bath, the mixture was treated with 10 mL of MeOH with stirring. The mixture was concentrated *in vacuo*, and the resultant foam was purified by column chromatography with CH_2Cl_2:MeOH = 100:2 to 100:4 to give a pale yellowish foam (0.67 g, 74 %).

^{1}H-NMR (300 MHz, $CDCl_3$) δ: 8.70 (d, 1H, *J* = 4.9 Hz), 8.63-8.55 (m, 2H), 8.48 (d, 1H, *J* = 7.8 Hz), 7.97 (t, 1H, *J* = 8.0 Hz), 7.91-7.88 (m, 1H), 7.47-7.43 (m, 2H), 7.38-7.25 (m, 10H), 6.89-6.84 (m, 4H), 6.34 (dd, 1H, *J* = 6.3, 4.4 Hz), 4.61-4.55 (m, 1H), 4.15-4.11 (m, 1H), 3.74 (s, 3H), 3.73 (s, 3H), 3.64 (dd, 1H, *J* = 5.6, 3.2 Hz), 3.49 (dd, 1H, *J* = 10.7, 3.2 Hz), 2.81-2.77 (m, 1H), 2.45-2.37 (m, 2H); ^{13}C-NMR (75 MHz, $CDCl_3$) δ: 170.2, 158.7, 156.0, 155.5, 152.2, 149.2, 144.4, 143.9, 138.0, 136.9, 135.4, 135.3, 130.1, 128.2, 128.0,

127.0, 124.0, 123.4, 122.8, 121.1, 113.3, 101.6, 87.3, 87.0, 86.2, 69.9, 62.1, 55.2, 42.0; HRMS (FAB+) Calcd. $C_{40}H_{37}N_4O_6$: 669.27131, Found: 669.27500.

1,2-Dideoxy-5-dimethoxytrityl-β-1-(4-(2,2'-bipyridine)pyrimidinone)-D-ribofurano-3-syl 2-cyanoethyldiisopropylphosphoramidite (14)

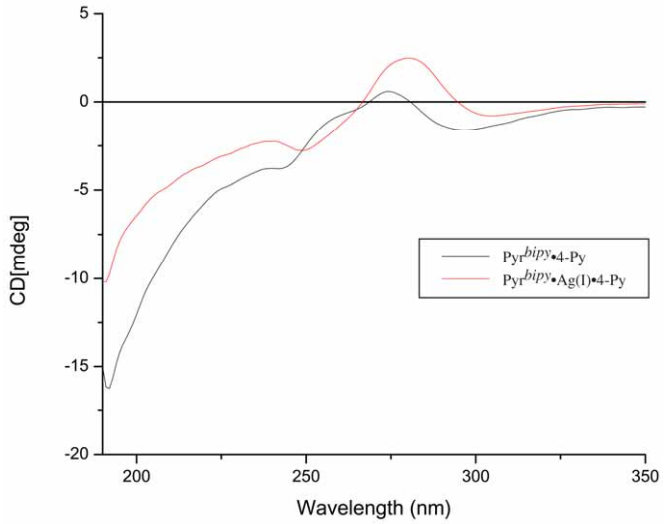
To a solution of 1,2-dideoxy-5-dimethoxytrityl-β-1-(4-(2,2'-bipyridine)pyrimidinone)-D-ribofuranose (0.42 g, 0.63 mmol) in 6 mL of dry CH_2Cl_2 were added diisopropylethyl amine (0.44 mL, 2.52 mmol), and 2-cyanoethyldiisopropylchloro phosphoramidite (0.17 mL, 0.76 mmol), successively, at 0°C. The reaction mixture was stirred for 4 hours. After cooling in an ice bath, the reaction was quenched by the addition of sat. aq. $NaHCO_3$, and the organic layer was washed with aq. $NaHCO_3$, brine, dried over anhydrous Na_2SO_4, and concentrated *in vacuo*. The residue was purified by column chromatography with CH_2Cl_2:MeOH = 100:1 with 1 % pyridine to give a white foam (0.38 g, 69 %).

^{1}H-NMR (300 MHz, $CDCl_3$) δ: 8.72-8.67 (m, 1H), 8.61-8.56 (m, 2H), 8.48-8.45 (m, 1H), 8.02-7.95 (m, 1H), 7.89 (dt, 1H, *J* = 7.8, 2.0 Hz), 7.48-7.43 (m, 2H), 7.38-7.25 (m, 10H), 6.89-6.83 (m, 4H), 6.38-6.35 (m, 1H), 4.74-4.66 (m, 1H), 4.23-4.21 (m, 1H), 3.92-3.71 (m, 8H), 3.67-3.41 (m, 4H), 2.87-2.74 (m, 1H), 2.64-2.59 (m, 1H), 2.47-2.38 (m, 2H), 1.19 (m, 9H), 1.06 (d, 3H, *J* = 6.8 Hz); ^{31}P-NMR (120 MHz, $CDCl_3$) δ: 150.3, 149.6, 14.9; HRMS (FAB+) Calcd. $C_{49}H_{53}N_6O_7NaP$: 891.36111, Found: 891.36180.

***DNA Synthesis*.** Solid-phase oligodeoxynucleotide synthesis was performed on an ABI 394 (for bipyridylpyrimidinone oligodeoxynucleotides) or Expedite 8909 (for pyridyl oligodeoxynucleotides) synthesizer using commercially available reagents and phosphoramidites (Glen Research). Modified phosphoramidites were chemically synthesized as described above and incorporated into oligonucleotides with coupling efficiencies comparable with the commercially available phosphoramidites. All oligodeoxynucleotides were synthesized trityl-off on a 500 Å CPG (1-μmol scale) solid support column derivatized with the appropriate nucleotide. Cleavage from the solid support and deprotection was accomplished in concentrated NH_4OH for 16 h at 55 °C. Oligonucleotides were purified by preparative acrylamide gel electrophoresis, quantified by UV absorbance at 260 nm at 70 °C and confirmed by MALDI-TOF mass spectrometry. Oligonucleotide concentration was then calculated using Beer's Law with the following extinction coefficients: dCMP, 7050; TMP, 8840; dGMP, 12010; dAMP, 15200; dPyMP, 2274; dPyr^{bipy}MP, 11272.

Oligonucleotide sequence	MW (calcd)	MW (found)
5'-CTTTCT3-PyTCCCT-3'	3464.6	3466.5
5'-CTTTCT4-PyTCCCT-3'	3464.6	3467.7
5'-CTTTCTPyr^{bipy}TCCCT-3'	3635.6	3639.0
5'-AGGGAPyr^{bipy}AGAAAG-3'	3889.7	3890.5

Circular Dichroism Spectra. Circular dichroism spectra were obtained at room temperature using the same conditions as the thermal denaturation experiments: 50 mM $NaNO_3$, 10 mM HEPES (pH 7.0), 2.5 µM of each DNA strand, and 0 or 5 µM $AgNO_3$. The red trace in the circular dichroism spectrum below corresponds to 5'-AGGGAPyr^{bipy}AGAAAG-3'/5'-CTTTCT4-PyTCCCT-3' in the presence of 5 µM $AgNO_3$; the black trace corresponds to 5'-AGGGAPyr^{bipy}AGAAAG-3'/5'-CTTTCT4-PyTCCCT-3' in the absence of $AgNO_3$.



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