Synthesis and Some Spectroscopic Properties of Porphyrin Derivatives Connected with Nucleobases (Adenine, Thymine, Guanine and Cytosine) by Alkanamide Chains

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Several kinds of porphyrin derivatives covalently connected with adenine, thymine, guanine, cytosine or adenine–thymine pair in a stacking mode between the porphyrin and nucleobase moiety have been synthesized *via* amide formation reaction of (2-aminophenyl)porphyrin derivatives with nucleobase–alkanoic acids, and characterized by spectroscopic methods. In the ^{1}H-NMR spectra of these nucleobase–porphyrins the proton signals of the nucleobase moieties appear at remarkably higher fields than those of the reference compounds (the corresponding nucleobase–alkanoates) which have no porphyrin moiety. The behaviors of the high field shifts, due to the diamagnetic ring current effect of the porphyrin ring, reflect the characteristic conformational features of these compounds in which the base moieties are located at the upper zone of the porphyrin ring. The Soret bands of the porphyrin in the electronic absorption spectra were markedly weaker in intensity compared with those of the reference compound which has no nucleobase moiety. Both the high-field shifts of the base protons and the hypochromic effects on the Soret band are larger in guanine and cytosine systems than those in adenine and thymine systems, respectively. Those results indicate greater affinity of guanine and cytosine for porphyrin in comparison with adenine and cytosine, respectively, and this conclusion is compatible with the reported electronic spectral properties of mixtures of polynucleotides and water-soluble porphyrin derivatives.

Key words nucleobase–porphyrin derivative; synthesis; stacking structure; ^{1}H-NMR spectroscopy; electronic absorption spectroscopy; nucleobase–porphyrin interaction

Porphyrin derivatives are used as sensitizers in photodynamic tumor diagnosis and therapy,[1,2] and may have intrinsic DNA cleavage activity.[3-8] It is considered that those characteristics derive from the affinity of porphyrin moiety for DNA; a number of spectroscopic or biochemical kinetic studies on the intercalation between porphyrin and DNA have been reported,[2,9-17] and several groups[10,12,13,17] have presented evidence for intercalation of porphyrin derivatives into DNA. For example, Pasternack *et al.*[17] reported that some water-soluble porphyrins bound with *Z*-form DNA and facilitated its conversion to the corresponding B-form DNA by rewinding, and Marzilli *et al.*[13] observed the shifts and hypochromicities in the Soret bands of "tentacle" porphyrins upon mixing them with DNA and concluded that the spectral changes were attributed to intercalation of the porphyrins into DNA.

The extent and selectivity of DNA intercalation should depend on the mode and strength of the interaction between the intercalant and nucleobase or nucleobase pair. Accordingly, investigation of the affinity of porphyrins for nucleobases would be useful for elucidation of the intercalation of porphyrins to DNA. Some groups[18-20] have discussed porphyrin complexation with nucleobase from the standpoint of molecular recognition; mixed systems of porphyrin and nucleobase in solvents were subjected to the spectroscopic examination in those studies.

We have synthesized several porphyrin derivatives (Chart 1), which are covalently bonded to a nucleobase or a nucleobase pair, as model systems for investigation of the interaction between porphyrins and nucleobases. Full details of the synthetic procedure and spectroscopic characterization of these model compounds are presented here. Some preliminary communications have appeared.[21-23]

The nucleobase–porphyrin derivatives were designed so that the two chromophores could stack in a face-to-face mode, as judged from molecular models; 5,15-bisphenylporphyrin was adopted as the porphyrin moiety and the side chains linking the nucleobase and the *o*-position of the phenyl group were chosen to consist of five atoms. Derivatives having a six atom side chain were also prepared and characterized in order to examine the correlation of nucleobase–porphyrin interaction with the distance between the two chromophores.

Results and Discussion

Synthesis Many kinds of synthetic porphyrins and a number of methods for preparation of porphyrin derivatives have been reported.[24,25] As a practical synthetic approach to connect porphyrin with nucleobase, we chose the amide formation method, in which aminophenylporphyrin and alkanoic acid bearing a nucleobase should be condensed by dehydration to afford the coupling product connecting the porphyrin moiety with the nucleobase side chain by an amide bond.

Nucleobase–alkanoates (**8**), the precursors of the free acids (**9**), were prepared by alkylation of the corresponding nucleobase with bromoalkanoate (Chart 2). Since the 9-position is preferentially alkylated by reaction of adenine with alkyl halide in the presence of a base,[26-30] adenine–butanoate and –pentanoate (**8a-A** and **8b-A**) were easily prepared by treatment of adenine with sodium

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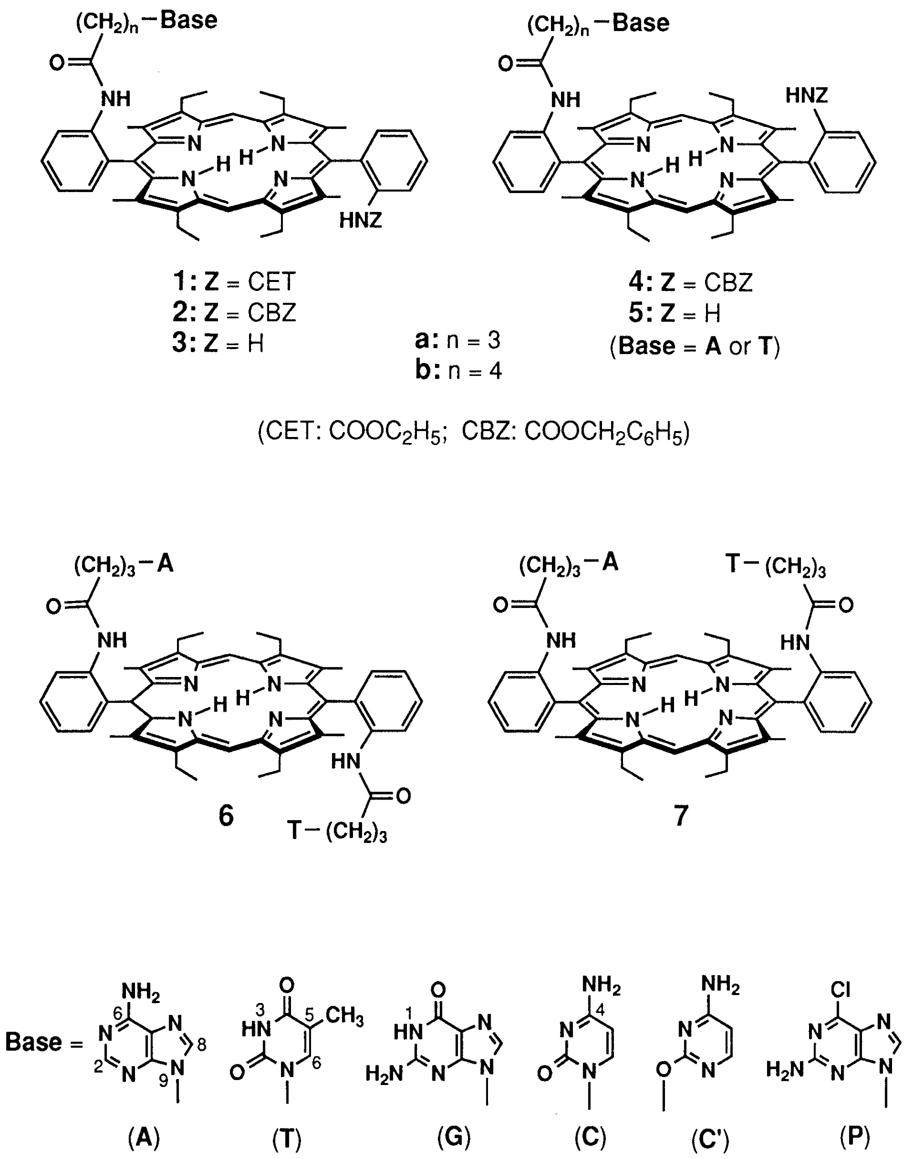

Chart 1

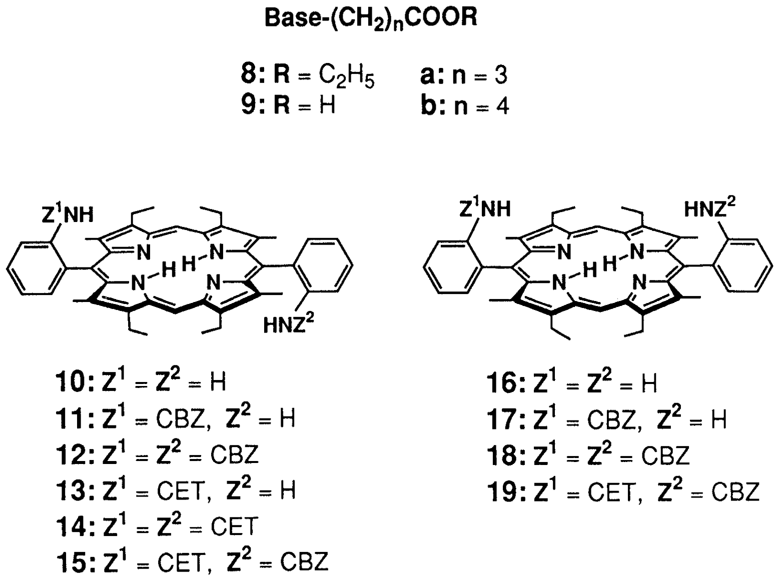

Chart 2

hydride in dimethylformamide (DMF) followed by addition of ethyl 4-bromobutanoate and 5-bromopentanoate, respectively.

Trimethylsilyl derivatives of pyrimidine base are employed for selective alkylation of the bases at the 1-position,[26b,27,31-34] because the bases have two or more reactive sites. On the other hand, 1-alkylated products of thymine and cytosine in direct alkylation of those bases are readily isolated from a mixture of positional isomers and dialkylated products by chromatography.[26b,35] Therefore, thymine– and cytosine–alkanoates were prepared by direct reaction of the corresponding pyrimidine base and bromoalkanoate with sodium hydride, in the same manner as in the synthesis of adenine–alkanoates. The main products in the reactions of thymine with 4-bromobutanoate and 5-bromopentanoate were monoalkylated thymines **8a-T** and **8b-T**, respectively. Their 1-alkyl structures were determined by nuclear Overhauser enhancement spectroscopy (NOESY) in two-dimensional ^{1}H-NMR; that is, the spectra of both compounds (**8a-T** and **8b-T**) showed the correlation peak between the olefinic 6-proton and the 1′-methylene protons of the alkanoate chain. Two positional isomers (**8a-C** and **8a-C′**) were isolated from the reaction products of cytosine and ethyl 4-bromobutanoate. The correlation peak of the 1′-methylene protons to the olefinic 6-proton was seen in a NOESY experiment. Therefore, the 1-alkyl structure of **8-C** was confirmed. The absence of a correlation peak of the 1′-methylene protons to both olefinic protons of the cytosine moiety in the NOESY spectrum of **8a-C′** and the appearance of the NH_2 proton signal (δ 4.88, 2H, b) in the one-dimensional ^{1}H-NMR spectrum indicated *O*-alkylation at the 2-position. Alkylated products other than 1-cytosine-pentanoate (**8b-C**) were also produced in the reaction of cytosine and 5-bromopentanoate, but those were not isolated or characterized. Adenine-, thymine- and cytosine-alkanoates were converted to the corresponding alkanoic acid by hydrolysis with aqueous NaOH or $Ba(OH)_2$.

9-Alkylguanines are conveniently prepared by alkylation of 2-amino-6-chloropurine followed by hydrolysis.[36-40] Reaction of chloropurine with 4-bromobutanoate using potassium carbonate in DMF gave two isomeric alkylated products in the yields of 72 and 17%. Since 9-alkylation of 2-amino-6-chloropurine occurs in preference to 7-alkylation,[36,39] the main product in the reaction is 9-alkylpurine **8a-P**. This assignment is supported by the facts that the 8-proton signal of **8a-P** (δ 8.08) appears at higher field than that of the minor product (δ 8.33) in the ^{1}H-NMR spectra in dimethylsulfoxide-d_6 (DMSO-d_6), because Kjellberg and Johansson[38] noted the same characteristic shift difference between 9- and 7-alkyl-2-amino-6-chloropurine as in the case of the present two products. Similarly, the pentanoate **8b-P** was obtained (68%) by the reaction of 2-amino-6-chloropurine and ethyl 5-bromopentanoate; the 8-proton of **8b-P** resonated at almost the same field (δ 8.10 in DMSO-d_6) as that of **8a-P**. Hydrolysis of **8a-P** and **8b-P** with aqueous hydrogen chloride gave the guanine-alkanoic acids **9a-G** and **9b-G**, respectively.

Preparation of ethyl 9-guaninebutanoate (**8a-G**) was required for the ^{1}H-NMR spectral examination of nucleobase–porphyrin derivatives, as mentioned later. The ester was prepared by application of the method described by Lee *et al.*[41] Treatment of **8a-P** with mercaptoethanol in the presence of sodium methoxide followed by hydrolysis gave the desired ester **8a-G**. The 8-proton signal of **8a-G** in the ^{1}H-NMR spectrum in DMSO-d_6 appeared at δ 7.83, and the resonance field is appropriate to that of the 8-proton signal in a 9-alkylguanine.[38]

Porphyrin moieties of the objective compounds, atropisomeric 5,15-bis(2-aminophenyl)porphyrins (**10**: *anti* form; **16**: *syn* form), were prepared according to the procedure reported by Young and Chang.[42] The activation energies of thermal interconversion of the two isomers were estimated to be 26.2 kcal/mol.[42] Therefore, it is not surprising that no detectable isomerization of **10**, **16** and their amides occurred through the reactions and work-up procedures described in this paper.

Several methods were examined to connect nucleobase–alkanoates to porphyrin through out amide bond. Coupling reaction of **10** with nucleobase–alkanoic acids **9** by using condensing agents [*N*,*N*′-dicyclohexylcarbodiimide (DCC); *N*,*N*′-carbonyldiimidazole (CDI)] under various conditions gave only small amounts of the expected amide or no product. The mixed anhydride method with ethoxycarbonyl chloride or benzyloxycarbonyl chloride was applied subsequently, and it was found that the desired coupling products were afforded in moderate yields only when the reaction was carried out in the presence of pyridinium chloride (5 molar eq to nucleobase–alkanoic acid) according to the procedure described by Wieland *et al.*[43] Pyridinium chloride is required to dissolve nucleobase–alkanoic acids in the reaction solvent [DMF/tetrahydrofuran (THF)], because the acids are scarcely soluble in the solvent.

Reaction of *anti* free base **10** with nucleobase–alkanoic acids (**9**, **B** = A and T; $n = 3$ and 4) using ethoxycarbonyl (carboethoxy: CET) chloride gave the corresponding nucleobase derivatives (**1**) of mono-CET-porphyrin (**13**), but no dinucleobase or mononucleobase derivatives (**3**). This fact indicates that protection of one of the two amino groups enhances the reactivity of the other amino group for acylation. Therefore, one of the amino groups in **10** was protected with a benzyloxycarbonyl (carbobenzyloxy: CBZ) group, which could be readily removed as required, to give mono-CBZ-porphyrin **11**. Coupling reaction of **11** with nucleobase–alkanoic acids (**9**) led to nine nucleobase–CBZ-porphyrin derivatives (**2**) made up of the combination of five nucleobases (**A**, **T**, **G**, **C** and **C′**) and two kinds of side chains ($n = 3$ and 4). Adenine–porphyrins **3a-A** and **3b-A** having a free amino group were prepared by removal of the CBZ group of **2a-A** and **2b-A**, respectively, with BBr_3. The chemical shifts of the base protons in the ^{1}H-NMR spectra in $CDCl_3$ were only slightly different among the three kinds of adenine–porphyrins (**1**, **2** and **3**) (see Table 1, ^{1}H-NMR spectral results are discussed later). Accordingly, not all the nucleobase–porphyrins (**1**—**3**) involving thymine, guanine and cytosine were prepared. The molecular ion peaks (M^+ or $[M+1]^+$) were observed in all compounds (**1**—**3**) by mass spectroscopy with the field-desorption ionization

Table 1. Chemical Shift Differences ($\Delta\delta$) of the Base Proton Signals of Nucleobase–Porphyrin Derivatives from Those of the Corresponding Reference Compound (Nucleobase–Butanoate **8a**) in the ^{1}H-NMR Spectra in $CDCl_3$[a)]

Compound			Purine moiety					Pyrimidine moiety					
No.	*n*	Z	1-NH	2-H	8-H	$6-NH_2$	$9-CH_2$	3-NH	$4-NH_2$	$5-CH_3$	5-H	6-H	$1-CH_2$
1a-A	3	CET		−1.37	−1.65	−1.35	−1.53						
1b-A	4	CET		−0.78	−0.41	−0.38	−0.97						
2a-A	3	CBZ		−1.37	−1.64	−1.33	−1.53						
2b-A	4	CBZ		−0.78	−0.40	−0.38	−0.97						
3a-A	3	H		−1.39	−1.63	−1.36	−1.53						
3b-A	4	H		−0.86	−0.40	−0.32	−1.05						
1a-T	3	CET						−1.72		−0.73		−0.97	−1.08
1b-T	4	CET						−1.05		−0.56		−1.21	−1.06
2a-T	3	CBZ						−1.72		−0.93		−1.19	−1.21
2b-T	4	CBZ						−0.99		−0.58		−1.27	−1.11
6a-AT	3	—		−1.35	−1.78	b)	−1.50	b)		−0.66		−0.90	−1.05
2a-G	3	CBZ	−1.30		−3.67	−0.22	b)						
2b-G	4	CBZ	−0.11		−1.22	−0.09	−1.27						
2a-C	3	CBZ							b)		−3.59	−2.17	−0.82
2b-C	4	CBZ							b)		−2.58	−2.27	−1.23
2a-C′	3	CBZ							−1.12		−0.81	−0.69	−0.66

a) The spectra were measured with solutions of *ca.* $0.9 \times 10^3\,mol \cdot m^{-3}$. *b)* The chemical shift of the signal in $CDCl_3$ has not been determined.

technique (FD-MS), and their chemical structures were confirmed by ^{1}H-NMR spectroscopy.

The *anti* adenine–thymine derivative **6** was obtained by coupling reaction of **3a-A** with thymine–butanoic acid (**9a-T**). The FD-MS of **6** showed the molecular ion peak at *m/z* 1057, and all proton signals corresponding to the structure of **6** were observed in the ^{1}H-NMR spectrum.

The *syn* derivative **7** having both adenine and thymine on the same side of the porphyrin ring is very interesting, because a base pair can be intramolecularly formed on the porphyrin ring in a face-to-face mode. Synthesis of **7** was achieved by stepwise condensation of the *syn*-porphyrin block with two base–butanoic acids in the same manner as in the preparation of the *anti* derivative **6**. The *syn* CBZ-porphyrin **17** was condensed with adenine–butanoic acid (**9a-A**) to give adenine–CBZ-porphyrin (**4a-A**), which was converted to **5a-A** by removal of the CBZ group with BBr_3. Condensation of **5a-A** with thymine–butanoic acid (**9a-T**) yielded the *syn* adenine–thymine–porphyrin **7**. The molecular ion peak in the FD-MS of **7** was observed at *m/z* 1057, and its ^{1}H-NMR spectrum in DMSO-d_6 showed all the proton signals expected for the structure **7**. Furthermore, in order to confirm the structure of **7** chemically, the same compound was prepared *via* an alternative route, in which coupling of porphyrin with thymine–butanoic acid (**9a-T**) was carried out prior to that with adenine (**9a-A**). The mass and ^{1}H-NMR spectra of the compound produced by this route completely coincided with those of **7** obtained by the original route. Therefore, the chemical structure of **7** was established.

The synthesis of *anti* and *syn* derivatives having both guanine and cytosine was also attempted according to the same procedure as that used for the adenine–thymine derivatives (**6** and **7**). However, isolation of the expected compounds in pure form has been unsuccessful in spite of repeated chromatographic purification. Recently, we succeeded in synthesis of a porphyrin system linked to a guanine–cytosine pair with side chains different from alkanamide.[44)] Accordingly, attempts at synthesis of guanine–cytosine derivatives in the amide system were discontinued.

^{1}H-NMR and Absorption Spectra The ^{1}H-NMR and absorption spectra of nucleobase–porphyrin derivatives were measured in order to examine the location of nucleobases to the porphyrin ring and the interaction between the two chromophores. Deuteriochloroform and dichloromethane were employed as solvents for measurement of ^{1}H-NMR and absorption spectra, respectively, because the use of low-polarity solvents should be helpful for revealing only the interaction of the two chromophores by exclusion of other interaction factors. Mixing nucleobase–alkanoate with *anti*-5,15-bis(2-aminophenyl)porphyrin (**10**) in those solvents brought about no change in the nucleobase proton signals or the Soret band of the porphyrin in the ^{1}H-NMR and absorption spectra. Therefore, the phenomena discussed below are caused by intramolecular, not intermolecular, interaction. Spectral data for the *syn* system are not discussed in this paper, since not all of *syn* system was obtained.

The ^{1}H-NMR spectral data of nucleobase–porphyrin derivatives are summarized in Table 1. The chemical shifts of the proton signals of nucleobase–butanoates are available as standard values for evaluation of the shift behaviors of the nucleobase protons in the derivatives. Since the chemical shifts of the proton signals of butanoates are similar to those of the corresponding pentanoates ($\Delta\delta = +0.06$ ppm), the shift data of butanoates are employed as standard chemical shifts. The values in Table 1 are the chemical shift differences ($-\Delta\delta$) of the nucleobase proton signals from nucleobase–butanoate. The negative sign indicates a high field shift in comparison with the base proton of the reference compound. Some proton signals of the NH_2, NH and methylene groups were not detected in the spectra in $CDCl_3$, possibly due to broadening or overlapping with other signals, though the corresponding signals were observed in DMSO-d_6.

All protons of the nucleobase moiety resonate at high fields owing to the diamagnetic ring current effect of the porphyrin ring. The high-field shifts demonstrate that the base moieties are located at the upper zone of the porphyrin ring plane; the shift values reflect degrees of proximity of the protons to the porphyrin plane. The shift behaviors of the nucleobase proton signals may be summarized as follows. (1) The chemical shifts are almost independent of variation of the amino group protection. (2) The high-field shifts of the 8-proton of guanine and the 6-proton of cytosine are larger than those of adenine and thymine, respectively. (3) Increase of methylene side-chain length results in a decrease of high-field shift in purine bases. (4) In pyrimidine base derivatives, the high-field shifts of the 6-proton signals in tetramethylene derivatives are slightly larger than those in trimethylene derivatives, although those of the 5-CH_3 and 5-H protons decrease with elongation of methylene side-chain in the same manner as purine derivatives. (5) The shielding effect on the protons of the *O*-alkylcytosine derivative (**2a-C′**) is significantly smaller than that in the *N*-alkyl compound (**2a-C**). (6) The base proton shifts of the adenine–thymine derivative (**6**) are similar to those of the mono-adenine and mono-thymine derivatives (**2a-A** and **2a-T**).

The following structural features of nucleobase–porphyrin derivatives are implied by the above results. A push–pull effect between the carbonyl and amino groups causes an increase in the basicity of the carbonyl group in guanine and cytosine; the resulting relatively strong hydrogen bonding of the carbonyl group with the inner NH group of the porphyrin would cause closer approach of the base to the porphyrin ring compared with adenine and thymine (item 2). The importance of the basic carbonyl group for access of the nucleobase to the porphyrin is supported by the observation of a remarkable decrease in high-field shifts of the proton signals in **2a-C′**, in which the carbonyl group is protected with an alkyl group (item 5). The finding in item 4 suggests a distinction between purine and pyrimidine bases in stacking mode with the porphyrin ring, but its nature cannot be determined from the NMR spectral data alone. Item 6 seems reasonable for the *anti* structure of **6**, because the spaces occupied by the two nucleobase moieties above and below the porphyrin ring plane are independent of each other. The ^{1}H-NMR spectrum of the *syn* isomer **7**, which is the most interesting compound in the present paper, showed an extremely broad and complicated spectrum in $CDCl_3$, while the measurement in DMSO-d_6 gave a sharp and completely assignable spectrum. The broad spectral pattern in $CDCl_3$ was unchanged even in measurement under a degassed condition. Since **7** was quantitatively recovered from the measured sample solution, decomposition of the compound in the solvent can be ruled out. The broadening is probably due to a slow equilibrium in conformational thermal motions and/or intramolecular association between the two nucleobases on the ^{1}H-NMR time scale at room temperature. Subsequently, the spectrum was measured at 60 °C, but more broadening was seen; work-up of the measured sample yielded only a complex mixture of decomposed compounds. Further spectral experiments have not been carried out. The origin of the broadening remains uncertain.

Table 2. Soret Band of the Porphyrin Ring in the Electronic Absorption Spectra of Nucleobase–Porphyrin Derivatives in CH_2Cl_2

Compound No.	*n*	Z	λ_{max} (nm)	ε (×10^5)	Hypochromism (%)
Reference compound					
10		H	408	2.12	100
Adenine derivatives					
1a-A	3	CET	410	1.75	83
1b-A	4	CET	410	1.86	87
Thymine derivatives					
1a-T	3	CET	408	1.73	81
1b-T	4	CET	408	1.87	88
Adenine–thymine derivatives					
6-AT (*anti*)	3	—	411	1.65	78
7-AT (*syn*)	3	—	416	1.27	60
Guanine derivatives					
2a-G	3	CBZ	408	1.18	56
2b-G	4	CBZ	408	1.31	62
Cytosine derivatives					
2a-C	3	CBZ	408	1.46	69
2b-C	4	CBZ	408	1.37	65
2a-C′	3	CBZ	408	1.63	77

In the electronic absorption spectra of nucleobase–porphyrin derivatives, the intensities of the Soret band of the porphyrin at near 410 nm are markedly dependent on the kind of nucleobase, though the wavelengths are similar to each other (407—410 nm) except for **7** (416 nm). The absorption spectral data are shown in Table 2. *anti*-5,15-Bis(2-aminophenyl)porphyrin (**10**) was employed as the reference compound to evaluate the degree of decrease in intensity; the hypochromicity of the porphyrin Soret band is given as a percentage of the intensity of the substrate on the basis of **10**. The features of the hypochromism are summarized as follows: (1) The hypochromicities in guanine and cytosine derivatives are greater than in adenine and thymine derivatives, respectively. (2) The hypochromicity of the trimethylene derivative is larger than that of the tetramethylene derivative for the same nucleobase, except for cytosine–porphyrins, in which the intensity of tetramethylene derivative (**2b-C**) is slightly larger than that of the trimethylene derivative (**2a-C**). (3) The hypochromicity of the *syn* derivative (**7**) is larger than that of the *anti* derivative (**6**). (4) The intensity of the *O*-alkylated cytosine derivative (**2a-C′**) is decreased compared with that of the *N*-alkylated compound (**2a-C**).

Since proximity of the nucleobase to a chromophore results in a hypochromic effect on the absorption of the chromophore,[45] the hypochromicities of the Soret band in the absorption spectra reflect the approach of the nucleobases to the porphyrin moiety. That is, those electronic spectral results substantially support the conclusions based on the ^{1}H-NMR spectral examination mentioned above. Unusual behavior of cytosine derivatives in relation to variation of the length of the side chain may be related to their stacking mode to the porphyrin ring, as indicated by the ^{1}H-NMR spectral results.

The large hypochromic effects of guanine and cytosine compared with adenine and thymine in the Soret band are of interest in connection with Pasternack's finding that mixing of a porphyrin derivative with poly(dG–dC) leads to a larger hypochromicity of the Soret band than that with poly(dA–dT), and with Marzilli's conclusion that porphyrin intercalation occurs in **GC**-rich regions in DNA.

Some variations in intensity and wavelength with the kind of nucleobase were also observed in the Q band of the porphyrin at 500—650 nm. However, no correlation of the change in the band with the nature of the base has been found, in contrast to the Soret band.

Experimental

All melting points were measured with a Yanaco hot-stage micro melting point apparatus and are uncorrected. Porphyrin derivatives in this paper did not melt below 300 °C, so their melting points were not measured. IR spectra were obtained with a Hitachi model 215 grating infrared spectrometer. ^{1}H-NMR spectra were measured on a JEOL JNM-GSX500, a JEOL JNM-FX100, or a Hitachi model R-24 spectrometer at 500, 100, and 60 MHz, respectively. Unless otherwise stated, the ^{1}H-NMR spectral data at 500 MHz are described. Chloroform-*d* ($CDCl_3$) used as a solvent in the ^{1}H-NMR spectral measurement was treated with neutral alumina immediately before usage. Commercial available deuterium oxide (D_2O) and hexadeuteriodimethylsulfoxide (DMSO-d_6) were employed without purification. All ^{1}H-NMR spectral data are given in ppm relative to tetramethylsilane (TMS, $\delta = 0.00$). The assignments of the proton signals were confirmed by the two-dimensional H–H COSY technique. The NH and NH_2 proton signals were assigned on the basis of disappearance of the signals when D_2O was added to the sample solution in $CDCl_3$. When proton signals in the spectrum in $CDCl_3$ could not be completely assigned, the spectral datum in DMSO-d_6 is given here. The following abbreviations are used for the constituent moieties of compounds and for signal patterns: Por = porphyrin, Ad = adenine, Th = thymine, Gu = guanine, Cy = cytosine, Pu = 2-amino-6-purine, CBZ = carbobenzyloxy (benzyloxycarbonyl), and CET = carboethoxy (ethoxycarbonyl); s = singlet, d = doublet, t = triplet, q = quartet, qu = quintet, m = multiplet, and br s = broad singlet. Mass spectra were recorded on a Hitachi M-80 double-focusing mass spectrometer by electron impact (EI) ionization using a direct inlet system unless otherwise stated. All mass spectra of porphyrin derivatives were measured by the field desorption ionization technique (FD-MS) employing a carbon or silicon emitter. High-resolution mass spectra were analyzed on a Hitachi M-003 data processing system. The electronic absorption spectra in freshly distilled dichloromethane were recorded on a Hitachi model 323 spectrophotometer.

General Procedure for Preparation of Nucleobase–Alkanoate (8) by Reaction of Bromoalkanoate with Nucleobase (1) Method A: A suspension of nucleobase in distilled DMF was treated with 60% NaH in mineral oil under an argon atmosphere, with stirring at room temperature. Ethyl bromoalkanoate was added to the resulting solution of nucleobase anion, and the reaction mixture was stirred at room temperature for 2 d. Toluene was added to the mixture, and DMF was removed as the toluene azeotrope under reduced pressure. The residue was column-chromatographed on silica gel with an appropriate chloroform/methanol (C/M) mixture to obtain the products.

(2) Method B: Ethyl bromoalkanoate was added to suspension of nucleobase and anhydrous K_2CO_3 in freshly distilled DMF. The mixture was stirred under an argon atmosphere at room temperature for 2 h. The DMF was removed as the toluene azeotrope under reduced pressure, and the resulting residue was column-chromatographed on silica gel.

Ethyl 9-Adeninebutanoate (8a-A) Method A: Adenine, 2.00 g (14.8 mmol); DMF, 200 ml; 60% NaH, 600 mg (15.0 mmol); ethyl 4-bromobutanoate, 3.20 ml (22.4 mmol). Eluent: C/M = 10/1, **8a-A** (3.60 g, 98%), colorless needles, mp 108—109 °C (from ethanol). IR (KBr) cm^{-1}: 3330, 3150 (NH_2), 1730 (C=O), 1670, 1600 (Ad). ^{1}H-NMR ($CDCl_3$) δ: 1.25 (3H, t, $J = 7.2$ Hz, $OCH_2C\underline{H}_3$), 2.23 (2H, qu, $J = 7.0$ Hz, Ad–$CH_2C\underline{H}_2$), 2.35 (2H, t, $J = 7.0$ Hz, CH_2CO), 4.13 (2H, q, $J = 7.2$ Hz, $OC\underline{H}_2CH_3$), 4.29 (2H, t, $J = 7.0$ Hz, Ad–CH_2), 5.75 (2H, br s, 6-NH_2 of Ad), 7.81 (1H, s, 8-H of Ad), 8.36 (1H, s, 2-H of Ad). MS *m/z* (rel. int., %): 249 (M^+, 10), 235 (21), 204 (33), 176 (45), 159 (22), 149 ($[AdCH_3]^+$, 100), 148 (88), 135 (40), 108 (24). *Anal.* Calcd for $C_{11}H_{15}N_5O_2$: C, 53.00; H, 6.07; N, 18.10. Found: C, 52.88; H, 6.00; N, 28.15.

Ethyl 9-Adeninepentanoate (8b-A) Method A: Adenine, 1.00 g (7.41 mmol); ethyl 5-bromopentanoate, 1.60 g (10.1 mmol); 60% NaH, 356 mg (8.90 mmol); DMF 100 ml. Eluent: C/M = 10/1, **8b-A** (1.80 g, 92%), colorless needles, mp 110—112 °C (from ethanol). IR (KBr) cm^{-1}: 3400, 3150 (NH_2), 1700 (C=O), 1660, 1600 (Ad). ^{1}H-NMR ($CDCl_3$) δ: 1.24 (3H, t, $J = 7.2$ Hz, $OCH_2C\underline{H}_3$), 1.67, 1.96 (each 2H, m, Ad–$CH_2C\underline{H}_2C\underline{H}_2$), 2.36 (2H, t, $J = 7.3$ Hz, CH_2CO), 4.12 (2H, q, $J = 7.2$ Hz, $OC\underline{H}_2CH_3$), 4.22 (2H, t, $J = 7.3$ Hz, Ad–CH_2), 5.73 (2H, br s, 6-NH_2 of Ad), 7.80 (1H, s, 8-H of Ad), 8.36 (1H, s, 2-H of Ad). MS *m/z* (rel. int., %): 263 (M^+, 25), 218 (36), 190 (36), 176 (25), 149 ($[AdCH_3]^+$, 100), 148 (48), 135 (36), 108 (14). HRMS (M^+) *m/z*: 263.1384 (Calcd for $C_{12}H_{17}N_5O_2$: 263.1381).

Ethyl 1-Thyminebutanoate (8a-T) Method A: Thymine, 2.00 g (15.9 mmol); ethyl 4-bromobutanoate, 4.54 mg (31.9 mmol); 60% NaH, 634 mg (15.9 mmol); DMF, 160 ml. Eluent: chloroform, diethyl 1,3-thyminepentanoate (1.70 g, 30%), a yellow oil. The structure of the diester was confirmed by IR, ^{1}H-NMR and mass spectrometry.

Eluent: C/M = 20/1, **8a-T** (1.50 g, 39%), colorless needles, mp 134—135 °C (from ethanol). IR (KBr) cm^{-1}: 3180 (NH of Th), 1720, 1680, 1650 (C=O of ester and Th). ^{1}H-NMR ($CDCl_3$) δ: 1.27 (3H, t, $OCH_2C\underline{H}_3$), 1.92 (3H, d, $J = 1.1$ Hz, 5-CH_3 of Th), 2.01 (2H, qu, $C\underline{H}_2CH_2CO$), 2.38 (2H, t, CH_2CO), 3.77 (2H, t, Th–CH_2), 4.15 (2H, q, $OC\underline{H}_2CH_3$), 7.03 (1H, d, $J = 1.1$ Hz, 6-H of Th), 8.54 (1H, br s, 3-H of Th). MS *m/z* (rel. int., %): 240 (M^+, 35), 153 ($[AdC_2H_4]^+$, 100). *Anal.* Calcd for $C_{11}H_{16}N_2O_4$: C, 54.99; H, 6.71; N, 11.66. Found: C, 54.99; H, 6.68; N, 11.60.

Ethyl 1-Thyminepentanoate (8b-T) Method A: Thymine, 2.00 g (15.9 mmol); ethyl 5-bromopentanoate, 3.00 ml (19.0 mmol); 60% NaH, 640 mg (16.0 mmol); DMF, 160 ml. Eluent: chloroform, diethyl 1,3-thyminepentanoate (1.03 g, 17%), a pale yellow oil. The structure of the diester was confirmed by IR, ^{1}H-NMR and mass spectrometry.

Eluent: C/M = 20/1, **8b-T** (1.66 g, 41%), colorless needles, mp 90—92 °C (from ethanol). IR (KBr) cm^{-1}: 3180 (NH of Th), 1740, 1700, 1650 (C=O of ester and Th). ^{1}H-NMR ($CDCl_3$) δ: 1.26 (3H, t, $OCH_2C\underline{H}_3$), 1.66, 1.73 (each 2H, m, $C\underline{H}_2C\underline{H}_2CH_2CO$), 1.92 (3H, d, $J = 1.1$ Hz, 5-CH_3 of Th), 2.36 (2H, t, CH_2CO), 3.71 (2H, t, Th–CH_2), 4.13 (2H, q, $OC\underline{H}_2CH_3$), 6.98 (1H, d, $J = 1.1$ Hz, 6-H of Th). MS *m/z* (rel. int., %): 254 (M^+, 50), 209 (80), 180 (37), 166 (36), 152 (56), 140 (34), 139 (35), 126 (65), 110 (42), 96 (100). HRMS (M^+) *m/z*: 254.1262 (Calcd for $C_{12}H_{18}N_2O_4$: 254.1265).

Ethyl 9-(2-Amino-6-chloropurine)butanoate (8a-P) Method B: 2-Amino-6-chloropurine, 2.00 mg (11.8 mmol); K_2CO_3, 2.40 g (17.4 mmol); freshly distilled DMF, 35 ml; ethyl 4-bromobutanoate, 1.60 ml (11.2 mmol). Eluent: C/M = 40/1, **8a-P** (2.41 g, 72%), colorless crystals, mp 139—141 °C (from methanol). IR (KBr) cm^{-1}: 3350, 3300, 3180 (NH_2), 1710 (C=O of ester), 1620, 1590 (Pu). ^{1}H-NMR (DMSO-d_6, 100 MHz) δ: 1.16 (3H, t, $OCH_2C\underline{H}_3$), 2.10 (2H, m, $C\underline{H}_2CH_2CO$), 2.28 (2H, m, CH_2CO), 3.98 (2H, q, $OC\underline{H}_2CH_3$), 4.08 (2H, t, Pu–CH_2), 6.86 (2H, br s, NH_2 of Pu), 8.08 (1H, s, 8-H of Pu). MS *m/z* (rel. int., %): 285, 283 (M^+, 25, 71), 240, 238 (14, 46), 212, 210 (12, 38), 198, 196 (24, 72), 185, 183 (33, 100). *Anal.* Calcd for $C_{11}H_{14}ClN_5O_2$: C, 46.57; H, 4.97; Cl, 12.50; N, 24.68. Found: C, 46.47; H, 8.84; Cl, 12.56; N, 24.40.

Eluent: C/M = 20/1, 7-(2-amino-6-chloropurine)butanoate (0.57 g, 17%), colorless crystals, mp 183—185 °C (ethanol). IR (KBr) cm^{-1}: 3400, 3300, 3170 (NH_2), 1730 (C=O of ester), 1630, 1600 (Pu). ^{1}H-NMR (DMSO-d_6, 100 MHz) δ: 1.14 (3H, t, $OCH_2C\underline{H}_3$), 2.10 (2H, m, $C\underline{H}_2CH_2CO$), 2.34 (2H, m, $C\underline{H}_2CO$), 3.98 (2H, q, $OC\underline{H}_2CH_3$), 4.33 (2H, t, Pu–CH_2), 6.60 (2H, br s, NH_2 of Pu), 8.33 (2H, s, 8-H of Pu). MS *m/z* (rel. int., %): 285, 283 (M^+, 34, 100), 240, 238 (9, 28), 198, 196 (12, 39), 184, 182 (14, 42). HRMS (M^+) *m/z*: 285.0815, 283.0841 (Calcd for $C_{11}H_{14}{}^{37}ClN_5O_2$ and $C_{11}H_{14}{}^{35}ClN_5O_2$: 285.0805 and 283.0835, respectively).

Ethyl 9-(2-Amino-6-chloropurine)pentanoate (8b-P) Method B: 2-Amino-6-chloropurine, 2.50 g (14.8 mmol); ethyl 5-bromopentanoate, 2.40 ml (15.2 mmol); K_2CO_3, 3.00 g (21.7 mmol); DMF, 45 ml. Eluent: C/M = 50/1, **8b-P** (3.00 g, 68%), mp 74—75 °C (from ethanol). IR (KBr) cm^{-1}: 3450, 3380, 3330, 3200 (NH_2), 1720 (C=O of ester), 1640, 1600 (Pu). ^{1}H-NMR (DMSO-d_6, 100 MHz) δ: 1.14 (3H, t, $OCH_2C\underline{H}_3$), 1.45, 1.75 (each 2H, m, $C\underline{H}_2C\underline{H}_2CH_2CO$), 2.30 (2H, t, $C\underline{H}_2CO$), 4.00 (2H, q, $OC\underline{H}_2CH_3$), 4.04 (2H, t, Pu–CH_2), 6.86 (2H, br s, NH_2 of Pu), 8.10 (2H, s, 8-H of purine). MS *m/z* (rel. int., %): 299, 297 (M^+, 20, 60), 254, 252 (8, 26), 226, 224 (11, 40), 212, 210 (10, 35), 185, 183 (35, 100). HRMS (M^+) *m/z*: 299.0958, 297.0990 (Calcd for $C_{12}H_{16}{}^{37}ClN_5O_2$ and $C_{12}H_{16}{}^{35}ClN_5O_2$: 299.0961 and 297.0991, respectively).

The band eluted with C/M = 20/1 yielded the corresponding 7-alkyl compound, but further purification was not carried out.

Ethyl 9-Guaninebutanoate (8a-G) Ethyl aminochloropurinebutanoate (**8a-P**) (500 mg, 1.76 mmol) was suspended in absolute ethanol (16 ml), and an ethanol solution of EtONa, which was prepared by addition of Na (0.27 g, 11.7 mmol) to ethanol (8.0 ml), was added, followed by 2-mercaptoethanol (0.56 ml, 8.00 mmol) and water (0.03 ml) was added. The mixture was refluxed for 90 min and the reaction was quenched by adding water (15 ml). The aqueous solution was adjusted to pH 5—6 by addition of acetic acid, and the resulting precipitate was filtered off, sufficiently washed with water and dried with P_2O_5 under reduced pressure. Guaninebutanoate (**8a-G**) (310 mg, 66%) was recrystallized from ethanol to give colorless crystals, mp 169—171 °C. IR (KBr) cm^{-1}: 3450, 3350, 3240 (NH_2), 1720 (C=O of ester), 1620, 1600 (Gu). ^{1}H-NMR (DMSO-d_6) δ: 1.36 (3H, t, $OCH_2C\underline{H}_3$), 2.00 (2H, qu, $C\underline{H}_2CH_2CO$), 2.21 (2H, t, CH_2CO), 4.03 (2H, t, Gu–CH_2), 4.45 (2H, q, $OC\underline{H}_2CH_3$), 5.33 (2H, br s, NH_2 of Gu), 7.83 (1H, s, 8-H of Gu), 12.13 (1H, br s, NH of Gu). MS *m/z* (rel. int., %): 265 (M^+, 100), 250 (11), 193 (45), 164 (41), 151 (26). HRMS (M^+) *m/z*: 265.1180 (Calcd for $C_{11}H_{15}N_5O_3$: 265.1174). *Anal.* Calcd for $C_{11}H_{15}N_5O_3 \cdot 5/6H_2O$: C, 47.14; H, 5.99; N, 24.99. Found: C, 47.12; H, 5.89; N, 24.87.

Ethyl 1-Cytosinebutanoate (8a-C) and 2-[3-(Ethoxycarbonyl)propoxy]-4-aminopyrimidine (8a-C′) Method A: Cytosine, 2.00 g (18.0 mmol); ethyl 4-bromobutanoate, 2.58 ml (17.5 mmol); 60% NaH, 720 mg (18.0 mmol); DMF, 200 ml. Eluent: C/M = 30/1, **8a-C′** (470 mg, 12%), colorless oil. IR (neat liq.) cm^{-1}: 3450, 3330, 3200 (NH_2), 1720 (C=O of ester), 1640, 1600 (Cy). ^{1}H-NMR ($CDCl_3$) δ: 1.25 (3H, t, $OCH_2C\underline{H}_3$), 2.10 (2H, m, $C\underline{H}_2CH_2CO$), 2.51 (2H, t, CH_2CO), 4.13 (2H, q, $OC\underline{H}_2CH_3$), 4.31 (2H, t, $C\underline{H}_2CH_2CH_2CO$), 4.88 (2H, br s, NH_2 of Cy), 6.09 (1H, d, *J* = 5.7 Hz, 5-H of Cy), 8.01 (1H, d, *J* = 5.7 Hz, 6-H of Cy). MS *m/z* (rel. int., %): 225 (M^+, 15), 180 (19), 138 (66), 112 (100). HRMS (M^+) *m/z*: 225.1114 (Calcd for $C_{10}H_{15}N_3O_3$: 225.1112).

Eluent: C/M = 10/1, **8a-C** (2.88 g, 71%), colorless needles, mp 171—173 °C (from ethanol). IR (KBr) cm^{-1}: 3300, 3100 (NH_2), 1730 (C=O of ester), 1665, 1620 (Cy). ^{1}H-NMR (DMSO-d_6) δ: 1.17 (3H, t, $OCH_2C\underline{H}_3$), 1.82 (2H, qu, $C\underline{H}_2CH_2CO$), 2.26 (2H, t, CH_2CO), 3.64 (2H, t, Cy–CH_2), 4.03 (2H, q, $OC\underline{H}_2CH_2$), 5.63 (1H, d, *J* = 7.3 Hz, 5-H of Cy), 6.93, 7.02 (each 1H, br s, NH_2 of Cy), 7.52 (1H, d, *J* = 7.3 Hz, 6-H of Cy). MS *m/z* (rel. int., %): 225 (M^+, 39), 180 (54), 152 (37), 138 (100), 125 (35), 111 (42). *Anal.* Calcd for $C_{10}H_{15}N_3O_3$: C, 53.32; H, 6.71; N, 18.66. Found: C, 53.32; H, 6.63; N, 18.50.

Ethyl 1-Cytosinepentanoate (8b-C) Method A: Cytosine, 2.00 g (18.0 mmol); ethyl 5-bromopentanoate, 3.80 ml (24.0 mmol); 60% NaH, 720 mg (18.0 mmol); DMF, 200 ml. The band eluted with C/M = 20/1 yielded the corresponding *O*-alkyl cytosine derivative, but further purification was not carried out. Eluent: C/M = 10/1, **8b-C** (1.85 g, 43%), colorless crystals, mp 202—205 °C (from ethanol). IR (KBr) cm^{-1}: 3520, 3330, 3200 (NH_2), 1735, 1710 (C=O of ester), 1670, 1610 (Cy). ^{1}H-NMR (DMSO-d_6, 100 MHz) δ: 1.16 (3H, t, $OCH_2C\underline{H}_3$), 1.50 (4H, m, $C\underline{H}_2C\underline{H}_2CH_2CO$), 2.29 (2H, t, CH_2CO), 3.60 (2H, t, Cy–CH_2), 4.01 (2H, q, $OC\underline{H}_2CH_3$), 5.60 (1H, d, *J* = 7.3 Hz, 5-H of Cy), 6.96 (2H, br s, NH_2 of Cy), 7.52 (1H, d, *J* = 7.3 Hz, 6-H of Cy). MS *m/z* (rel. int., %): 239 (M^+, 41), 210 (15), 194 (100), 166 (36), 152 (74), 138 (92), 125 (84), 111 (79). HRMS (M^+) *m/z*: 239.1268 (Calcd for $C_{11}H_{17}N_3O_3$: 239.1268). *Anal.* Calcd for $C_{11}H_{17}N_3O_3 \cdot 1/5H_2O$: C, 54.40; H, 7.22; N, 17.30. Found: C, 54.09; H, 6.99; N, 17.31.

General Procedure for Preparation of Nucleobase–Alkanoic Acid by Hydrolysis of the Corresponding Ester (1) Method C: An ester was dissolved in methanol, and aqueous $Ba(OH)_2$ (*ca.* 0.21 mol/l) was added to the solution. The reaction mixture was refluxed for 2 h and then neutralized with 15% aqueous H_2SO_4, and the resulting precipitate was filtered off. Water in the filtrate was removed as the benzene azeotrope by evaporation. The residue was dried under reduced pressure in a flask equipped with a phosphorus pentoxide reservoir. The crude free acid was used for the following amide formation reaction without further purification.

(2) Method D: An ester was dissolved in methanol, and aqueous NaOH (*ca.* 0.13 mol/l) was added to the solution. The mixture was refluxed for 2 h. It was neutralized with 10% aqueous HCl, and the resulting precipitate was filtered off, and sufficiently washed with water. When a precipitate was not obtained upon neutralization, methanol and water was removed under reduced pressure. The residue was taken up in methanol, and the mixture was filtered. The filtrate was evaporated. The resulting free acid was sufficiently dried with P_2O_5 in the same manner as in method C before usage for the following reaction.

9-Adeninebutanoic Acid (9a-A) Method C: **8a-A**, 1.00 g (4.02 mmol); methanol, 10 ml; $Ba(OH)_2$, 1.90 g (11.1 mmol); water, 50 ml. **9a-A**, 850 mg (95%), colorless powder, mp > 300 °C. IR (KBr) cm^{-1}: 3500—2150 (NH_2 and COOH), 1700 (COOH), 1680, 1620 (Ad).

9-Adeninepentanoic Acid (9b-A) Method D: **8b-A**, 735 mg (2.79 mmol); methanol, 7.0 ml; NaOH, 0.16 g (4.00 mmol); water, 30 ml. **9a-A**, 650 mg (quant.), colorless powder, mp 264—266 °C. IR (KBr) cm^{-1}: 3500—2200 (NH_2 and COOH), 1700 (COOH), 1680, 1620 (Ad). ^{1}H-NMR (DMSO-d_6) δ: 1.44, 1.81 (each 2H, qu, *J* = 7.3 Hz, $C\underline{H}_2C\underline{H}_2CH_2CO$), 2.24 (2H, t, *J* = 7.3 Hz, CH_2CO), 4.14 (2H, t, *J* = 7.3 Hz, Ad–CH_2), 7.18 (2H, s, 6-NH_2 of Ad), 8.13, 8.14 (each 1H, s, 2- and 8-H of Ad), 12.02 (1H, br s, COOH).

1-Thyminebutanoic Acid (9a-T) Method C: **8a-T**, 730 mg (3.04 mmol); methanol, 7.5 ml; $Ba(OH)_2$, 1.44 mg (8.41 mmol); water, 35 ml. **9a-T**, 640 mg (quant.), colorless powder. IR (KBr) cm^{-1}: 3500—2200 (COOH and NH of Th), 1705, 1700, 1670 (COOH and C=O of Th).

1-Thyminepentanoic Acid (9b-T) Method D: **8b-T**, 300 mg (1.18 mmol); methanol, 2.5 ml; NaOH, 100 mg (2.5 mmol); water, 16 ml. **9b-T**, 270 mg (quant.), colorless powder, mp 120—123 °C. IR (KBr) cm^{-1}: 3500—2300 (COOH), 1690, 1670 (COOH and C=O of Th). ^{1}H-NMR (D_2O, 60 MHz) δ: 1.78—1.96 (4H, m, $C\underline{H}_2C\underline{H}_2CH_2CO$), 2.10 (3H, br s, 5-$CH_3$ of Th), 2.50 (2H, t, CH_2CO), 4.20 (2H, t, Th–CH_2), 7.75 (1H, br s, 6-H of Th).

9-Guaninebutanoic Acid (9a-G) **8a-P** (1.20 g, 4.20 mmol) was added to 18% aqueous HCl (4.21 ml, 21 mmol) and the mixture was refluxed for 2 h. Chloroform was added, and the aqueous phase was neutralized with 10% aqueous NaOH. The resulting precipitate was filtered off, sufficiently washed with water and dried over P_2O_5 under reduced pressure. **9a-G**, 835 mg (84%), colorless crystals, mp > 300 °C. IR (KBr) cm^{-1}: 3500—2300 (NH_2 and COOH), 1700 (COOH), 1640, 1600 (Gu). ^{1}H-NMR (DMSO-d_6, 60 MHz) δ: 1.80—2.40 (4H, m, CH_2CH_2CO), 4.05 (2H, t, Gu–CH_2), 6.65 (2H, br s, NH_2 of Gu), 7.75 (1H, s, 8-H of Gu).

9-Guaninepentanoic Acid (9b-G) Hydrolysis of **8b-P** (1.20 g, 4.03 mmol) with 18% aqueous HCl (4.2 ml, 21 mmol) was carried out in the same manner as described for **8a-P**. **9b-P**, 805 mg (81%), colorless crystals, mp > 300 °C. IR (KBr) cm^{-1}: 3500—2250 (NH_2 and COOH), 1690 (COOH), 1640, 1600 (Gu). ^{1}H-NMR (DMSO-d_6, 60 MHz) δ: 1.30—1.80 (4H, m, $C\underline{H}_2C\underline{H}_2CH_2CO$), 2.35 (2H, t, CH_2CO), 4.00 (2H, t, Gu–CH_2), 6.45 (2H, br s, NH_2 of Gu), 7.75 (1H, s, 8-H of Gu).

1-Cytosinebutanoic Acid (9a-C) Method C: **8a-C**, 2.00 g (8.89 mmol); methanol, 18 ml; $Ba(OH)_2$, 2.85 g (16.6 mmol); water, 75 ml. **9a-C**, 1.80 g (quant.), crystalline powder, mp > 300 °C. IR (KBr) cm^{-1}: 3500—2500 (NH_2 and COOH), 1710 (COOH). ^{1}H-NMR (D_2O, 60 MHz) δ: 2.20—2.90 (4H, m, $C\underline{H}_2C\underline{H}_2CO$), 4.25 (2H, t, Cy–$CH_2$), 6.40 (1H, d, 5-H of Cy), 8.00 (1H, d, 6-H of Cy).

2-(3-Carboxypropoxy)-4-aminopyrimidine (9a-C′) Method C: **8a-C′**, 650 mg (2.89 mmol); methanol, 7 ml; $Ba(OH)_2$, 910 mg (5.31 mmol); water, 22 ml. **9a-C′**, 565 mg (quant.), colorless crystalline powder, mp > 300 °C. IR (KBr) cm^{-1}: 3500—2500 (NH_2 and COOH), 1690 (COOH). ^{1}H-NMR (D_2O, 60 MHz) δ: 2.00—2.60 (4H, m, $C\underline{H}_2C\underline{H}_2CO$), 4.35 (2H, t, Cy–$CH_2$), 6.45 (1H, d, 5-H of Cy), 8.00 (1H, d, 6-H of Cy).

1-Cytosinepentanoic Acid (9b-C) Method D: **8b-C**, 1.00 g (4.18 mmol); methanol, 9 ml; NaOH, 350 mg (8.75 mmol); water, 56 ml. **9b-C**, 0.90 g (quant.), colorless crystalline powder, mp > 300 °C. IR (KBr) cm^{-1}: 3550—2150 (NH_2 and COOH), 1715 (COOH), 1650 (Cy). ^{1}H-NMR (DMSO-d_6, 60 MHz) δ: 1.65 (4H, m, $C\underline{H}_2C\underline{H}_2CH_2CO$), 2.30 (2H, t, CH_2CO), 3.75 (2H, t, Cy–CH_2), 5.90 (1H, d, 5-H of Cy), 7.75 (1H, d, 6-H of Cy).

***anti*- and *syn*-5-[2-(Benzyloxycarbamido)phenyl]-15-(2-aminophenyl)-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrins (11 and 17)** The starting materials, *anti*- and *syn*-5,15-bis(2-aminophenyl)-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrins (**10** and **16**), were prepared by a modification of the method reported by Young and Chang.[42]

(1) Preparation of **11**: Benzyloxycarbonyl (carbobenzyloxy: CBZ) chloride (0.86 ml, 6.03 mmol) and anhydrous K_2CO_3 (1.00 g) were added to a solution of **10** (1.00 g, 1.52 mmol) in CH_2Cl_2 (160 ml). The reaction mixture was stirred at room temperature overnight and then eluted through a short column packed with silica gel. The solvent was evaporated, and the residue was column-chromatographed on silica gel with chloroform to afford three fractions. The starting material (**10**) (334 mg, 33%) was recovered from the third fraction. The first fraction yielded **12** (275 mg, 20%), purple crystals whose structure was confirmed by ^{1}H-NMR [in $CDCl_3$, δ: 4.78 (4H, s, CH_2 of CBZ), 6.47 (2H, s, NHCO), 6.85, 6.96, 7.01 (4H, 4H, 2H, an A_2M_2Y system, Ph-H of

CBZ)] and FD-mass [m/z: 928 (M$^+$)] spectroscopies.

The second fraction yielded **11** (548 mg, 45%), purple crystals. IR (KBr) cm^{-1}: 3500—3200 (NH$_2$, $\underline{\mathrm{NH}}$CO), 1740 (NH$\underline{\mathrm{CO}}$). ^{1}H-NMR (CDCl$_3$) δ: −2.46 (2H, br s, inner NH of Por), 1.77, 1.79 (each 6H, t, Por–CH$_2$C$\underline{\mathrm{H}}_3$), 2.54, 2.70 (each 6H, s, Por–CH$_3$), 3.69 (2H, br s, NH$_2$), 3.96—4.08 (8H, m, Por–C$\underline{\mathrm{H}}_2$CH$_3$), 4.77 (2H, s, CH$_2$ of CBZ), 6.46 (1H, s, NHCO), 6.83, 6.95, 6.99 (2H, 2H, 1H, an A$_2$M$_2$Y system, Ph-H of CBZ), 7.11, 7.17, 7.46, 7.60, 7.78, 7.82, 8.57 (1H, 1H, 1H, 2H, 1H, 1H, 1H, dd, dt, dt, m, dd, dt, br d, Ph-H of Por moiety), 10.24 (2H, s, 10- and 20-H of Por). FD-MS m/z: 794 (M$^+$).

(2) Preparation of **17**: A 50% solution of CBZ chloride (2.02 ml, 5.92 mmol) in toluene and anhydrous K$_2$CO$_3$ (1.00 g) were added to a solution of **16** (1.00 g, 1.52 mmol) in CH$_2$Cl$_2$ (160 ml). The reaction and work-up were carried out in the same manner as for **10**. Column chromatography of the crude product on silica gel gave three compounds. The starting material (**16**) (355 mg, 35%) was recovered from the third fraction eluted with chloroform/diethyl ether (20/1). The first fraction eluted with chloroform yielded **18** (146 mg, 10%), purple crystals, whose structure was confirmed by ^{1}H-NMR [in CDCl$_3$, δ: 4.75 (4H, s, CH$_2$ of CBZ), 6.33 (2H, s, NHCO), 6.82, 6.94, 7.00 (4H, 4H, 2H, an A$_2$M$_2$Y system, Ph-H of CBZ)] and FD-mass [m/z: 928 (M$^+$)] spectroscopies.

The second fraction eluted with chloroform/diethyl ether (40/1) yielded **17** (645 mg, 53%), purple crystals. IR (KBr) cm^{-1}: 3500—3150 (NH$_2$ and $\underline{\mathrm{NH}}$CO), 1740 (NH$\underline{\mathrm{CO}}$). ^{1}H-NMR (CDCl$_3$) δ: −2.47 (2H, br s, inner NH of Por), 1.77, 1.78 (each 6H, t, Por–CH$_2$C$\underline{\mathrm{H}}_3$), 2.54, 2.70 (each 6H, s, Por–CH$_3$), 3.58 (2H, br s, NH$_2$), 3.97—4.08 (8H, m, Por–C$\underline{\mathrm{H}}_2$CH$_3$), 4.75 (2H, s, CH$_2$ of CBZ), 6.39 (1H, s, NHCO), 6.82, 6.94, 6.98 (2H, 2H, 1H, an A$_2$M$_2$Y system, Ph-H of CBZ), 7.09, 7.19, 7.47, 7.61, 7.70, 7.83, 8.56 (1H, 1H, 1H, 1H, 1H, 2H, 1H, dd, dt, dt, dt, dd, m, br d, Ph-H of Por moiety), 10.24 (2H, s, 10- and 20-H of Por). FD-MS m/z: 794 (M$^+$).

General Procedure of Condensation of 2-Aminophenylporphyrin Derivatives with Nucleobase–Alkanoic Acids (9) by Mixed Anhydride Method Method E. A solution of pyridinium chloride (5.0 mol eq) in freshly distilled DMF was added to a suspension of nucleobase–alkanoic acid (**9**) (1.0 mol eq to porphyrin) in DMF; the acid was soluble in DMF. The resulting solution was cooled to −15 °C in an ice-salt bath under an argon atmosphere, and ethoxycarbonyl (carboethoxy: CET) chloride or benzyloxy chloride (5.0 molar eq) and triethylamine or *N*,*N*-diisopropylethylamine (*ca.* 5.0 molar equiv.) were added to the chilled solution. The mixture was stirred at −15 °C for 20 min, and a solution of (2-aminophenyl)porphyrin derivative in THF was then added. The reaction mixture was stirred in the dark at room temperature under an argon atmosphere for 1—2 d. A large quantity of chloroform was added to the reaction mixture, then the organic layer was washed with 10% aqueous NaOH and saturated aqueous NaCl, and dried over Na$_2$SO$_4$. The volatile solvent was evaporated; DMF was removed as the toluene azeotrope under reduced pressure. The crude products were isolated by column chromatography of the residue on silica gel, and each compound was further purified by column or thin-layer chromatography repeated several times.

***anti*-5-[2-{4-(9-Adenine)butanamido}phenyl]-15-[2-(ethoxycarbamido)phenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (1a-A)** Method E: **10**, 300 mg (0.455 mmol); **9a-A**, 100 mg (0.452 mmol); ethoxycarbonyl chloride, 246 mg (2.27 mmol); triethylamine, 230 mg (2.28 mmol); DMF, 32 ml; THF, 18 ml; pyridinium chloride, 263 mg (2.28 mmol). Three compounds were isolated by chromatography. The first eluate with chloroform: **14** (172 mg, 47%), purple crystals, whose structure was confirmed by ^{1}H-NMR [in CDCl$_3$, δ: 0.74 (6H, t, OCH$_2$C$\underline{\mathrm{H}}_3$ of CET), 3.80 (4H, q, OC$\underline{\mathrm{H}}_2$CH$_3$ of CET), 6.38 (2H, s, NHCO)] and FD-mass [m/z: 804 (M$^+$)] spectroscopies. The second eluate with chloroform: starting material (**10**) (58 mg, 19%).

Eluent: chloroform/methanol = 20/1, **1a-A** (133 mg, 31%), lustrous purple crystals. IR (KBr) cm^{-1}: 3430 ($\underline{\mathrm{NH}}$CO), 3350—3150 (NH, NH$_2$ and $\underline{\mathrm{NH}}$CO), 1740 (NH$\underline{\mathrm{COO}}$), 1650 (NH$\underline{\mathrm{CO}}$CH$_2$). ^{1}H-NMR (CDCl$_3$) δ: −2.79 (2H, br s, inner NH of Por), 0.74 (3H, t, OCH$_2$C$\underline{\mathrm{H}}_3$ of CET), 1.37 (2H, qu, Ad-CH$_2$C$\underline{\mathrm{H}}_2$), 1.55 (2H, t, CH$_2$CO), 1.78, 1.80 (each 6H, t, Por–CH$_2$C$\underline{\mathrm{H}}_3$), 2.56, 2.58 (each 6H, s, Por–CH$_3$), 2.76 (2H, t, Ad–CH$_2$), 3.60 (2H, q, OC$\underline{\mathrm{H}}_2$CH$_3$ of CET), 3.96—4.07 (8H, m, Por–C$\underline{\mathrm{H}}_2$CH$_3$), 4.40 (2H, br s, NH$_2$ of Ad), 6.40 (1H, s, NHCO), 6.44 (1H, s, 8-H of Ad), 6.71 (1H, s, 2-H of Ad), 7.47, 7.59, 7.78, 7.83, 7.87, 8.01, 8.56, 8.59 (each 1H, dt, dt, dd, dt, dt, dd, br d, br d, Ph-H of Por moiety), 8.06 (1H, s, N$\underline{\mathrm{H}}$COCH$_2$), 10.18 (2H, s, 10- and 20-H of Por). FD-MS m/z: 935 (M$^+$).

***anti*-5-[2-{5-(9-Adenine)pentanamido}phenyl]-15-[2-(ethoxycarbamido)phenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (1b-A)** Method E: **10**, 840 mg (1.27 mmol); **9b-A**, 300 mg (1.28 mmol); ethoxycarbonyl chloride, 700 mg (6.45 mmol); triethylamine, 780 mg (7.72 mmol); DMF, 50 ml; THF, 50 ml; pyridinium chloride, 740 mg (6.41 mmol).

Eluent: C/M = 30/1, **1b-A** (500 mg, 41%), lustrous purple crystals. IR (KBr) cm^{-1}: 3500—3150 (NH$_2$ and $\underline{\mathrm{NH}}$CO), 1740 (NH$\underline{\mathrm{COO}}$), 1660—1630 (NH$\underline{\mathrm{CO}}$CH$_2$ and NH$_2$). ^{1}H-NMR (CDCl$_3$) δ: −2.48 (2H, br s, inner NH of Por), 0.74 (2H, t, Ad–CH$_2$), 0.83, 1.07 (each 2H, qu, Ad–CH$_2$C$\underline{\mathrm{H}}_2$C$\underline{\mathrm{H}}_2$), 1.35 (3H, t, OCH$_2$C$\underline{\mathrm{H}}_3$ of CET), 1.75, 1.77 (each 6H, t, Por–CH$_2$C$\underline{\mathrm{H}}_3$), 2.53, 2.55 (each 6H, s, Por–CH$_3$), 3.18 (2H, t, CH$_2$CO), 3.80 (2H, q, OC$\underline{\mathrm{H}}_2$CH$_3$ of CET), 3.95—4.07 (8H, m, Por–C$\underline{\mathrm{H}}_2$CH$_3$), 5.45 (2H, br s, NH$_2$ of Ad), 6.38, 6.96 (each 1H, s, 2-H, 8-H of Ad), 6.89 (1H, s, NHCOO), 7.45, 7.53, 7.74, 7.82, 7.84, 7.88, 8.58, 8.71 (each 1H, dt, dt, dd, dt, dt, dd, br d, br d, Ph-H of Por moiety), 7.92 (1H, s, N$\underline{\mathrm{H}}$COCH$_2$), 10.27 (2H, s, 10- and 20-H of Por). FD-MS m/z: 849 (M$^+$).

***anti*-5-[2-{4-(9-Adenine)butanamido}phenyl]-15-[2-benzyloxycarbamido)phenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (2a-A)** Method E: **11**, 500 mg (0.630 mmol); **9a-A**, 140 mg (0.633 mmol); ethoxycarbonyl chloride, 342 mg (3.15 mmol); *N*,*N*-diisopropylethylamine, 489 mg (3.79 mmol); DMF, 50 ml; THF, 25 ml; pyridinium chloride, 364 mg (3.15 mmol). Three compounds were isolated by chromatography. The first eluate with chloroform: **15** (85 mg, 16%), whose structure was confirmed by observation of the signal of the ethoxycarbonyl group [δ 0.73 (3H, t) and 3.79 (2H, q)] and the molecular ion (m/z 866) in the ^{1}H-NMR and FD-mass spectra, respectively. The second eluate with chloroform: the starting material (**11**).

Eluent: C/M = 20/1, **2a-A** (196 mg, 31%), lustrous purple crystals. IR (KBr) cm^{-1}: 3450—3150 (NH$_2$ and $\underline{\mathrm{NH}}$CO), 1740 (NH$\underline{\mathrm{COO}}$), 1650 (NH$\underline{\mathrm{CO}}$CH$_2$). ^{1}H-NMR (CDCl$_3$) δ: −2.80 (2H, br s, inner NH of Por), 1.37 (2H, qu, C$\underline{\mathrm{H}}_2$CH$_2$CO), 1.53 (2H, t, CH$_2$CO), 1.78, 1.79 (each 6H, t, Por–CH$_2$C$\underline{\mathrm{H}}_3$), 2.54, 2.57 (each 6H, s, Por–CH$_3$), 2.76 (2H, t, Ad–CH$_2$), 3.96—4.04 (8H, m, Por–C$\underline{\mathrm{H}}_2$CH$_3$), 4.42 (2H, br s, Ad–NH$_2$), 4.79 (2H, s, OCH$_2$ of CBZ), 6.44 (1H, s, 8-H of Ad), 6.51 (1H, s, NHCOO), 6.72 (1H, s, 2-H of Ad), 6.85, 6.96, 7.00 (2H, 2H, 1H, an A$_2$M$_2$Y system, Ph-H of CBZ), 7.47, 7.58, 7.78, 7.83, 7.86, 8.01, 8.56, 8.58 (each 1H, dt, dt, dd, dt, dt, dd, br d, br d, Ph-H of Por moiety), 8.03 (1H, s, N$\underline{\mathrm{H}}$COCH$_2$), 10.17 (2H, s, 10- and 20-H of Por). FD-MS m/z: 998 ([M + 1]$^+$).

***anti*-5-[2-{5-(9-Adenine)pentanamido}phenyl]-15-[2-benzyloxycarbamido)phenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (2b-A)** Method E: **11**, 300 mg (0.378 mmol); **9b-A**, 89 mg (0.378 mmol); ethoxycarbonyl chloride, 205 mg (1.89 mmol); triethylamine, 109 mg (1.08 mmol); DMF, 28 ml; THF, 18 ml; pyridinium chloride, 220 mg (1.90 mmol). The first and second eluates with chloroform in chromatography yielded **15** (162 mg, 50%) and the starting material **11** (85 mg, 28%), respectively.

Eluent: C/M = 40/1, **2b-A** (48 mg, 13%), lustrous purple crystals. IR (KBr) cm^{-1}: 3500—3150 ($\underline{\mathrm{NH}}$CO and NH$_2$), 1740 (NHCOO), 1690, 1640 (NH$\underline{\mathrm{CO}}$CH$_2$ and NH$_2$). ^{1}H-NMR (CDCl$_3$) δ: −2.49 (2H, br s, inner NH of Por), 0.85, 1.10 (each 2H, qu, Ad–CH$_2$C$\underline{\mathrm{H}}_2$C$\underline{\mathrm{H}}_2$), 1.35 (2H, t, CH$_2$CO), 1.75, 1.76 (each 6H, t, Por–CH$_2$C$\underline{\mathrm{H}}_3$), 2.53, 2.54 (each 6H, s, Por–CH$_3$), 3.26 (2H, t, Ad–CH$_2$), 3.96—4.07 (8H, m, Por–C$\underline{\mathrm{H}}_2$CH$_3$), 4.79 (2H, s, OC$\underline{\mathrm{H}}_2$Ph of CBZ), 5.36 (2H, br s, NH$_2$ of Ad), 6.47 (1H, s, NHCOO), 6.83 (1H, s, N$\underline{\mathrm{H}}$COCH$_2$), 6.85, 6.96, 7.00 (2H, 2H, 1H, an A$_2$M$_2$Y system, Ph-H of CBZ), 7.02, 7.96 (each 1H, s, 8- and 2-H of Ad), 7.46, 7.54, 7.73, 7.83, 7.84, 7.89, 8.57, 8.71 (each 1H, dt, dt, dd, dt, dt, dd, br d, br d, Ph-H of Por moiety), 10.26 (2H, s, 10- and 20-H of Por). FD-MS m/z: 1011 (M$^+$).

***anti*-5-[2-{4-(9-Adenine)butanamido}phenyl]-15-(2-aminophenyl)-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (3a-A)** The CBZ-derivative of the *anti*-adenine–porphyrin (**2a-A**) (200 mg, 0.200 mmol) was dissolved in CH$_2$Cl$_2$ (5 ml), and the solution was cooled to −10 °C in an ice-bath under an argon atmosphere. A solution of BBr$_3$ (1.0 mol/l; 1.0 ml, 1.0 mmol) in CH$_2$Cl$_2$ was added dropwise, and the reaction mixture was stirred at −10 °C for 1 h and then at room temperature for 2 h. Water and then 10% aqueous NaOH were slowly added to the mixture. The organic layer was separated, washed with saturated aqueous NaCl, and dried over Na$_2$SO$_4$. The solvent was evaporated and the resulting residue was column-chromatographed on silica gel. The deprotected product (**3a-A**) (157 mg, 91%) was obtained from the eluate with chloroform/methanol (20/1). IR (KBr) $\mathrm{cm^{-1}}$: 3500—3150 ($\mathrm{\underline{NH}CO}$ and $\mathrm{NH_2}$), 1660 ($\mathrm{NH\underline{CO}}$), 1640 ($\mathrm{NH_2}$). ^{1}H-NMR ($\mathrm{CDCl_3}$) δ: −2.79 (2H, br s, inner NH of Por), 1.35 (2H, q, Ad–$\mathrm{CH_2C\underline{H}_2}$), 1.52 (2H, t, $\mathrm{CH_2CO}$), 1.77, 1.80 (each 6H, t, Por–$\mathrm{CH_2C\underline{H}_3}$), 2.57, 2.70 (each 6H, s, Por–$\mathrm{C\underline{H}_3}$), 2.76 (2H, t, Ad–$\mathrm{CH_2}$), 3.71 (2H, br s, $\mathrm{NH_2}$ of Ph), 4.00—4.03 (each 4H, m, Por–$\mathrm{C\underline{H}_2CH_3}$), 4.39 (2H, br s, $\mathrm{NH_2}$ of Ad), 6.42 (1H, s, 8-H of Ad), 6.73 (1H, s, 2-H of Ad), 7.11, 7.19, 7.58, 7.61, 7.62, 7.86, 8.03, 8.56 (each 1H, dd, dt, dt, dd, dt, dt, dd, br d, Ph-H of Por moiety), 8.01 (1H, s, $\mathrm{N\underline{H}COCH_2}$), 10.15 (2H, s, 10- and 20-H of Por). FD-MS m/z: 863 ($\mathrm{M^+}$).

3a-A was also prepared by dehydration reaction of **10** and **9a-A** with dicyclohexylcarbodiimide (DCC). A solution of **10** (1.00 mg, 1.50 mmol) in DMF was added to a suspension of **9a-A** (850 mg, 3.85 mmol) and DCC (1.00 mg, 3.39 mmol) in DMF. The mixture was stirred at room temperature for 3 d. DMF was removed as the toluene azeotrope under reduced pressure, and chloroform was added to the residue. Insoluble materials were filtered off, then the chloroform solution was washed with saturated aqueous NaCl and dried over $\mathrm{Na_2SO_4}$. The solvent was evaporated and the residue was column-chromatographed. Eluent: chloroform, starting material **10** (220 mg, 22%). Eluent: C/M = 20/1, **3a-A** (21 mg, 1.6%), which was identical with the compound obtained by deprotection of the amino group of **2a-A**.

***anti*-5-[2-{5-(9-Adenine)pentanamido}phenyl]-15-(2-aminophenyl)-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (3b-A)** DCC (630 mg, 3.00 mmol) was added to a solution of the adenine derivative **9b-A** (480 mg, 2.00 mmol) and pyridinium chloride (740 mg, 6.40 mmol) in DMF (50 ml). The solution was stirred at room temperature for 2 h. Then a solution of **10** (840 mg, 1.27 mmol) and triethylamine (600 mg, 5.9 mmol) in THF (50 ml) was added dropwise. The mixture was stirred at room temperature for 2 d. DMF was removed as the toluene azeotrope under reduced pressure, and the residue was extracted with chloroform. The extracts were washed with 10% aqueous NaOH and saturated aqueous NaCl and dried over $\mathrm{Na_2SO_4}$. The solvent was evaporated and the residue was column-chromatographed. Eluent: C/M = 20/1, **3b-A** (50 mg, 4.5%), purple crystals. IR (KBr) $\mathrm{cm^{-1}}$: 3500—3150 ($\mathrm{\underline{NH}CO}$ and $\mathrm{NH_2}$), 1700 ($\mathrm{NH\underline{CO}}$), 1640 ($\mathrm{NH_2}$). ^{1}H-NMR ($\mathrm{CDCl_3}$) δ: −2.48 (2H, br s, inner NH of Por), 0.79, 1.06 (each 2H, qu, Ad–$\mathrm{CH_2C\underline{H}_2C\underline{H}_2}$), 1.32 (2H, t, Ad–$\mathrm{C\underline{H}_2}$), 1.75, 1.77 (each 6H, t, Por–$\mathrm{CH_2C\underline{H}_3}$), 2.52, 2.69 (each 6H, s, Por–$\mathrm{C\underline{H}_3}$), 3.16 (2H, t, $\mathrm{COC\underline{H}_2}$), 3.71 (2H, br s, $\mathrm{NH_2}$ of Ph), 3.95—4.05 (each 2H, m, Por–$\mathrm{C\underline{H}_2CH_3}$), 5.41 (2H, br s, $\mathrm{NH_2}$ of Ad), 6.83, 6.94 (each 1H, s, 8- and 2-H of Ad), 7.09, 7.17, 7.53, 7.57, 7.59, 7.83, 7.91, 8.70 (each 1H, dd, dt, dt, dd, dt, dt, dd, br d, Ph-H of Por moiety), 7.96 (1H, s, $\mathrm{N\underline{H}COCH_2}$), 10.24 (2H, s, 10- and 20-H of Por). FD-MS m/z: 877 ($\mathrm{M^+}$).

***anti*-5-[2-{4-(1-Thymine)butanamido}phenyl]-15-[2-(ethoxycarbamido)phenyl)-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (1a-T)** Method E: **10**, 300 mg (0.455 mmol); **9a-T**, 96 mg (0.453 mmol); ethoxycarbonyl chloride, 246 mg (2.27 mmol); triethylamine (230 mg (2.28 mmol); DMF, 32 ml; THF, 18 ml, pyridinium chloride, 263 mg (2.28 mmol). Four compounds were isolated by column chromatography. Eluent: chloroform, **14** (160 mg, 44%); **13** (66 mg, 20%), the starting material (**10**) (34 mg, 11%). The structure of **13** was determined by ^{1}H-NMR and FD-mass spectroscopies [FD-MS m/z: 732 ($\mathrm{M^+}$)].

Eluent: C/M = 50/1, **1a-T** (101 mg, 24%), lustrous purple crystals. IR (KBr) $\mathrm{cm^{-1}}$: 3450—3150 ($\mathrm{\underline{NH}CO}$ and NH of Th), 1740 ($\mathrm{NH\underline{COO}}$), 1690, 1670, 1650 ($\mathrm{NH\underline{CO}CH_2}$ and CO of Th). ^{1}H-NMR ($\mathrm{CDCl_3}$) δ: −2.53 (2H, br s, inner NH of Por), 0.74 (3H, t, $\mathrm{OCH_2C\underline{H}_3}$ of CET), 1.20 (3H, br d, 5-$\mathrm{CH_3}$ of Th), 1.25 (2H, q, Th–$\mathrm{CH_2C\underline{H}_2}$), 1.36 (2H, t, $\mathrm{C\underline{H}_2CONH}$), 1.77, 1.79 (each 6H, t, Por–$\mathrm{CH_2C\underline{H}_3}$), 2.53, 2.56 (each 6H, s, Por–$\mathrm{C\underline{H}_3}$), 2.69 (2H, t, Th–$\mathrm{C\underline{H}_2}$), 3.80 (2H, q, $\mathrm{OC\underline{H}_2CH_3}$ of CET), 3.80—4.08 (8H, m, Por–$\mathrm{C\underline{H}_2CH_3}$), 6.05 (1H, m, 6-H of Th), 6.37 (1H, s, $\mathrm{N\underline{H}COO}$), 6.88 (1H, br s, NH of Th), 7.11 (1H, s, $\mathrm{N\underline{H}COCH_2}$), 7.47, 7.55, 7.79, 7.83, 7.85, 7.91, 8.61 (1H, 1H, 1H, 1H, 1H, 1H, 2H, dt, dt, dd, dt, dt, dd, dd, Ph-H of Por moiety), 10.25 (2H, s, 10- and 20-H of Por). FD-MS m/z: 926 ($\mathrm{M^+}$).

***anti*-5-[2-{5-(1-Thymine)pentanamido}phenyl]-15-[2-(ethoxycarbamido)phenyl)-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (1b-T)** Method E: **10**, 186 mg (0.282 mmol), **9b-T**, 63 mg (0.279 mmol); ethoxycarbonyl chloride, 153 mg (1.41 mmol); triethylamine, 141 mg (1.40 mmol; DMF, 20 ml); THF, 13 ml; pyridinium chloride, 162 mg (1.40 mmol). Four compounds were isolated by chromatography. Eluent: chloroform, **14** (113 mg, 50%); **13** (32 mg, 16%); the starting material (**10**) (12 mg, 6.5%).

Eluent: C/M = 50/1, **1b-T** (30 mg, 11%), lustrous purple crystals. IR (KBr) $\mathrm{cm^{-1}}$: 3450—3150 ($\mathrm{\underline{NH}CO}$ and NH of Th), 1740 ($\mathrm{NH\underline{COO}}$), 1690, 1670, 1650 ($\mathrm{NH\underline{CO}CH_2}$ and CO of Th). ^{1}H-NMR ($\mathrm{CDCl_3}$) δ: −2.48 (2H, br s, inner NH of Por), 0.75 (3H, t, $\mathrm{OCH_2C\underline{H}_3}$ of CET), 0.80 (4H, m, Th–$\mathrm{CH_2C\underline{H}_2C\underline{H}_2}$), 1.37 (3H, d, J = 1.0 Hz, 5-$\mathrm{CH_3}$ of Th), 1.38 (2H, t, $\mathrm{C\underline{H}_2CONH}$), 1.78, 1.79 (each 6H, t, Por–$\mathrm{CH_2C\underline{H}_3}$), 2.54, 2.56 (each 6H, s, Por–$\mathrm{C\underline{H}_3}$), 2.65 (2H, t, Th–$\mathrm{C\underline{H}_2}$), 3.97—4.10 (8H, m, Por–$\mathrm{C\underline{H}_2CH_3}$), 5.77 (1H, m, 6-H of Th), 6.35 (1H, s, $\mathrm{N\underline{H}COO}$), 6.88 (1H, s, $\mathrm{N\underline{H}COCH_2}$), 7.50 (1H, br s, NH of Th), 7.46, 7.54, 7.72, 7.83, 7.85, 7.90, 8.58, 8.71 (each 1H, dt, dt, dd, dt, dt, dd, dd, dd, Ph-H of Por moiety), 10.29 (2H, s, 10- and 20-H of Por). FD-MS m/z: 940 ($\mathrm{M^+}$).

***anti*-5-[2-{4-(1-Thymine)butanamido}phenyl]-15-[2-benzyloxycarbamido)phenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (2a-T)** Method E: **11**, 235 mg (0.296 mmol); **9a-T**, 63 mg (0.297 mmol); ethoxycarbonyl chloride, 163 mg (1.50 mmol); triethylamine, 177 mg (1.75 mmol); DMF, 22 ml; THF, 11 ml; pyridinium chloride, 173 mg (1.50 mmol). Three compounds were isolated by column chromatography. Eluent: chloroform, **15** (122 mg, 47%); the starting material (**11**) (36 mg, 15%).

Eluent: C/M = 50/1, **2a-T** (32 mg, 11%), lustrous purple crystals. IR (KBr) $\mathrm{cm^{-1}}$: 3450—3150 ($\mathrm{\underline{NH}CO}$ and $\mathrm{NH_2}$), 1740 ($\mathrm{NH\underline{COO}}$), 1700, 1670, 1650 ($\mathrm{NH\underline{CO}CH_2}$ and CO of Th). ^{1}H-NMR ($\mathrm{CDCl_3}$) δ: −2.54 (2H, br s, inner NH of Por), 1.01 (3H, br d, 5-$\mathrm{CH_3}$ of Th), 1.20 (2H, q, Th–$\mathrm{CH_2C\underline{H}_2}$), 1.32 (2H, t, $\mathrm{CH_2CO}$), 1.77, 1.78 (each 6H, t, Por–$\mathrm{CH_2C\underline{H}_3}$), 2.53, 2.55 (each 6H, s, Por–$\mathrm{CH_3}$), 2.56 (2H, t, Th–$\mathrm{C\underline{H}_2}$), 3.95—4.08 (8H, m, Por–$\mathrm{C\underline{H}_2CH_3}$), 4.80 (2H, s, $\mathrm{OCH_2}$ of CBZ), 5.83 (1H, m, 6-H of Th), 6.47 (1H, s, $\mathrm{N\underline{H}COO}$), 6.88 (1H, br s, NH of Th), 6.86, 6.97, 7.01 (2H, 2H, 1H, an $\mathrm{A_2M_2Y}$ system, Ph-H of CBZ), 7.14 (1H, s, $\mathrm{N\underline{H}COCH_2}$), 7.49, 7.55, 7.79, 7.84, 7.85, 7.89, 8.59, 8.65 (each 1H, dt, dt, dd, dt, dt, dd, dd, dd, Ph-H of Por moiety), 10.24 (2H, s, 10- and 20-H of Por). FD-MS m/z: 988 ($\mathrm{[M+1]^+}$).

***anti*-5-[2-{5-(1-Thymine)pentanamido}phenyl]-15-[2-benzyloxycarbamido)phenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (2b-T)** Method E: **11**, 300 mg (0.378 mmol); **9b-T**, 85 mg (0.376 mmol); ethoxycarbonyl chloride, 205 mg (1.89 mmol); triethylamine, 145 mg (1.44 mmol); DMF, 28 ml; THF, 18 ml; pyridinium chloride, 218 mg (1.89 mmol). Three compounds were isolated by column chromatography. Eluent: chloroform, **15** (122 mg, 37%); the starting material (**11**) (88 mg, 29%).

Eluent: C/M = 100/1, **2b-T** (53 mg, 14%), lustrous purple crystals. IR (KBr) $\mathrm{cm^{-1}}$: 3450—3150 ($\mathrm{\underline{NH}CO}$ and NH), 1730 ($\mathrm{NH\underline{COO}}$), 1690, 1670, 1640 ($\mathrm{NH\underline{CO}CH_2}$ and CO of Th). ^{1}H-NMR ($\mathrm{CDCl_3}$) δ: −2.48 (2H, br s, inner NH of Por), 0.77 (4H, m, Th–$\mathrm{CH_2C\underline{H}_2C\underline{H}_2}$), 1.34 (3H, d, J = 1.0 Hz, 5-$\mathrm{CH_3}$ of Th), 1.36 (2H, t, $\mathrm{CH_2CO}$), 1.77 (12H, t, Por–$\mathrm{CH_2C\underline{H}_3}$), 2.53, 2.54 (each 6H, s, Por–$\mathrm{CH_3}$), 2.60 (2H, t, Th–$\mathrm{C\underline{H}_2}$), 3.95—4.10 (8H, m, Por–$\mathrm{C\underline{H}_2CH_3}$), 4.79 (2H, s, $\mathrm{OCH_2}$ of CBZ), 5.71 (1H, m, 6-H of Th), 6.45 (1H, s, $\mathrm{N\underline{H}COO}$), 6.86 (1H, s, $\mathrm{N\underline{H}COCH_2}$), 6.84, 6.96, 7.00 (2H, 2H, 1H, an $\mathrm{A_2M_2Y}$ system, Ph-H of CBZ), 7.56 (1H, br s, NH of Th), 7.46, 7.54, 7.71, 7.83, 7.84, 7.89, 8.58, 8.67 (each 1H, dt, dt, dd, dt, dt, dd, dd, dd, Ph-H of Por moiety), 10.27 (2H, s, 10- and 20-H of Por). FD-MS m/z: 1002 ($\mathrm{M^+}$).

***anti*-5-[2-{4-(9-Adenine)butanamido}phenyl]-15-[2-{4-(1-thymine)-butanamido}phenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (6)** Method E: **3a-A**, 126 mg (0.146 mmol); **9a-T**, 30 mg (0.142 mmol); 50% solution of benzyloxycarbonyl chloride in toluene, 1.09 ml (3.29 mmol); *N*,*N*-diisopropylethylamine, 112 mg (0.868 mmol); DMF, 12 ml; THF, 6 ml; pyridinium chloride, 81 mg (0.702 mmol). Two compounds were isolated by column chromatography. Eluent: C/M = 40/1, the starting material **3a-A** (59 mg, 47%).

Eluent: C/M = 20/1, **6** (28 mg, 18%), lustrous purple crystals. IR (KBr) $\mathrm{cm^{-1}}$: 3500—3150 ($\mathrm{\underline{NH}CO}$, NH and $\mathrm{NH_2}$), 1710, 1690, 1650 ($\mathrm{NH\underline{CO}CH_2}$ and CO of Th). ^{1}H-NMR ($\mathrm{CDCl_3}$) δ: −2.90 (2H, br s, inner NH of Por), 1.24 (2H, t, Th–$\mathrm{CH_2C\underline{H}_2}$), 1.26 (3H, br d, 5-$\mathrm{CH_3}$ of Th), 1.37 (4H, m, Th–$\mathrm{CH_2CH_2C\underline{H}_2CO}$, Ad–$\mathrm{CH_2C\underline{H}_2}$), 1.57 (2H, t, Ad–$\mathrm{CH_2CH_2C\underline{H}_2CO}$), 1.77 (12H, t, Por–$\mathrm{CH_2C\underline{H}_3}$), 2.52, 2.57 (each 6H, s, Por–$\mathrm{CH_3}$), 2.73 (2H, t, Th–$\mathrm{C\underline{H}_2}$), 2.75 (2H, t, Ad–$\mathrm{C\underline{H}_2}$), 3.98 (8H, q, Por–$\mathrm{C\underline{H}_2CH_3}$), 4.40 (2H, br s, $\mathrm{NH_2}$ of Ad), 6.12 (1H, m, 6-H of Th), 6.46 (1H, s, 8-H of Ad), 6.58 (1H, s, 2-H of Ad), 7.05 (1H, s, NHCO of Th side chain), 7.51 (1H, br s, NH of Th), 7.55, 7.59, 7.85, 7.86, 7.93, 8.02, 8.56, 8.64 (each 1H, dt, dt, dt, dt, dd, dd, dd, dd, Ph-H of Por moiety), 8.11 (1H, s, $\mathrm{N\underline{H}COCH_2}$ of Ad side chain), 10.13 (2H, s, 10- and 20-H of Por). FD-MS m/z: 1057 ($\mathrm{M^+}$).

***syn*-5-[2-{4-(9-Adenine)pentanamido}phenyl]-15-[2-benzyloxycarbamido)phenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (4a-A)** Method E: **17**, 1.76 mg (2.22 mmol); **9a-A**, 489 mg (2.21 mmol);

ethoxycarbonyl chloride, 1.20 mg (1.11 mmol); *N,N*-diisopropylethylamine, 1.71 mg (13.3 mmol); DMF, 180 ml; THF, 90 ml; pyridinium chloride, 1.28 mg (11.1 mmol). Three compounds were isolated by column chromatography. Eluent: chloroform, **19** (129 mg, 6.7%), whose structure was confirmed by observation of the ethoxycarbonyl group [δ: 0.69 (3H, t) and 3.75 (2H, q)] and the molecular ion (*m/z* 866) in the ^{1}H-NMR and FD-mass spectra, respectively. Eluent: C/M = 40/1, the starting material **17** (1.29 g, 73%).

Eluent: C/M = 20/1, **4a-A** (458 mg, 21%), lustrous purple crystals. IR (KBr) cm^{-1}: 3500—3150 (NH$_2$ and $\underline{\text{NH}}$CO), 1735 (NH$\underline{\text{CO}}$O), 1690 (NH$\underline{\text{CO}}$CH$_2$). ^{1}H-NMR (CDCl$_3$) δ: −1.34, −3.13 (each 1H, br s, inner $\underline{\text{NH}}$ of Por), 0.83 (2H, q, Ad–CH$_2$C$\underline{\text{H}}_2$), 1.47 (2H, t, Ad–CH$_2$CH$_2$C$\underline{\text{H}}_2$CO), 1.81, 1.83 (each 6H, t, Por–CH$_2$C$\underline{\text{H}}_3$), 2.54, 2.61 (each 6H, s, Por–CH$_3$), 3.91 (2H, br s, NH$_2$ of Ad), 3.92—4.08 (8H, m, Por–C$\underline{\text{H}}_2$CH$_3$), 4.47 (1H, s, 8-H of Ad), 4.83 (2H, s, OC$\underline{\text{H}}_2$ of CBZ), 5.99 (1H, s, 2-H of Ad), 6.81, 6.88, 6.95 (2H, 2H, 1H, an A$_2$M$_2$Y system, Ph-H of CBZ), 7.65 (1H, s, N$\underline{\text{H}}$COO), 7.53, 7.69, 7.85, 7.86, 8.03, 8.21, 8.46, 8.57 (each 1H, dt, dt, dt, dt, dd, dd, dd, dd, Ph-H of Por moiety), 8.68 (1H, s, N$\underline{\text{H}}$COCH$_2$), 10.05 (2H, s, 10- and 20-H of Por). FD-MS *m/z*: 997 (M$^+$).

***syn*-5-[2-{4-(9-Adenine)pentanamido}phenyl]-15-[2-aminophenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (5a-A)** Removal of the CBZ group of **4a-A** (458 mg, 0.459 mmol) in dichloromethane (12 ml) with a solution of BBr$_3$ (1.0 mol/l; 2.3 ml, 2.3 mmol) in dichloromethane was carried out according to the same procedure as used for **2a-A**. The product was purified by column chromatography on silica gel with chloroform/methanol (20/1) to give **5a-A** (301 mg, 76%). IR (KBr) cm^{-1}: 3500—3150 (NH$_2$ and $\underline{\text{NH}}$CO), 1670 (NH$\underline{\text{CO}}$), 1640 (NH$_2$). ^{1}H-NMR (CDCl$_3$) δ: −3.49, −3.33 (each 1H, br s, inner NH of Por), 0.82 (2H, m, Ad–CH$_2$C$\underline{\text{H}}_2$), 1.45 (2H, t, CH$_2$CO), 1.86, 1.88 (each 6H, t, Por–CH$_2$C$\underline{\text{H}}_3$), 2.68, 2.87 (each 6H, s, Por–C$\underline{\text{H}}_3$), 3.92—4.11 (10H, m, Por–C$\underline{\text{H}}_2$CH$_3$ and NH$_2$ of Por moiety), 4.30 (2H, br s, NH$_2$ of Ad), 4.40 (1H, s, 8-H of Ad), 5.37 (1H, s, 2-H of Ad), 7.05, 7.32, 7.63, 7.72, 7.86, 8.14, 8.16, 8.61 (each 1H, dd, dt, dt, dt, dt, dd, dd, dd, Ph-H of Por moiety), 8.80 (1H, s, N$\underline{\text{H}}$COCH$_2$), 10.02 (2H, s, 10- and 20-H of Por). FD-MS *m/z*: 863 (M$^+$).

***syn*-5-[2-{4-(1-Thymine)butanamido}phenyl]-15-[2-benzyloxycarbamido)phenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (4a-T)** Method E: **17**, 1.29 g (1.62 mmol); **9a-T**, 345 mg (1.63 mmol); ethoxycarbonyl chloride, 878 mg (8.09 mmol); *N,N*-diisopropylethylamine, 1.26 g (9.77 mmol); DMF, 128 ml; THF, 64 ml; pyridinium chloride, 936 mg (8.10 mmol). Three compounds were isolated by column chromatography. Eluent: **19** (783 mg, 56%). Eluent: C/M = 20/1, the starting material **17** (385 mg, 30%).

Eluent: C/M = 20/1, **4a-T** (390 mg, 24%), lustrous purple crystals. IR (KBr) cm^{-1}: 3450—3150 ($\underline{\text{NH}}$CO and NH), 1740 (NH$\underline{\text{CO}}$O), 1700, 1680 (NH$\underline{\text{CO}}$CH$_2$ and CO of Th). ^{1}H-NMR (CDCl$_3$) δ: −2.61, −2.55 (each 1H, br s, inner NH of Por), 1.00 (3H, br d, 5-CH$_3$ of Th), 1.11 (2H, qu, Th–CH$_2$C$\underline{\text{H}}_2$), 1.38 (2H, t, CH$_2$CO), 1.78 (12H, t, Por–CH$_2$C$\underline{\text{H}}_3$), 2.34 (2H, t, Th–C$\underline{\text{H}}_2$), 2.55, 2.56 (each 6H, s, Por–CH$_3$), 3.95—4.08 (8H, m, Por–C$\underline{\text{H}}_2$CH$_3$), 4.83 (2H, s, OCH$_2$ of CBZ), 4.96 (1H, br s, NH of Th), 5.78 (1H, m, 6-H of Th), 6.85, 6.94, 6.98 (2H, 2H, 1H, an A$_2$M$_2$Y system, Ph-H of CBZ), 7.29, 7.31 (each 1H, s, N$\underline{\text{H}}$COCH$_2$, N$\underline{\text{H}}$COO), 7.45, 7.58, 7.75, 7.83, 7.86, 8.07, 8.62, 8.64 (each 1H, dt, dt, dd, dt, dt, dd, dd, dd, Ph-H of Por moiety), 10.23 (2H, s, 10- and 20-H of Por). FD-MS *m/z*: 988 (M$^+$).

***syn*-5-[2-{4-(1-Thymine)butanamido}phenyl]-15-(2-aminophenyl)-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (5a-T)** Removal of the CBZ group of **4a-T** (350 mg, 0.354 mmol) in dichloromethane (9 ml) with a solution of BBr$_3$ (1.0 mol/l; 1.8 ml, 1.8 mmol) in dichloromethane was carried out according to the same procedure as used for **2a-A**. Eluent: C/M = 20/1, **5a-T** (148 mg, 49%), lustrous crystals. IR (KBr) cm^{-1}: 3450—3150 (NH$_2$, $\underline{\text{NH}}$CO and NH), 1700, 1670 (NH$\underline{\text{CO}}$ and CO of Th). ^{1}H-NMR (CDCl$_3$) δ: −2.63, −2.60 (each 1H, br s, inner NH of Por), 0.83 (3H, br d, 5-CH$_3$ of Th), 1.05 (2H, qu, Th–CH$_2$C$\underline{\text{H}}_2$), 1.34 (2H, t, CH$_2$CO), 1.77, 1.79 (each 6H, t, Por–CH$_2$C$\underline{\text{H}}_3$), 2.01 (2H, t, Th–C$\underline{\text{H}}_2$), 2.53, 2.71 (each 6H, s, Por–CH$_3$), 3.46 (2H, s, NH$_2$ of Por moiety), 3.94—4.07 (8H, m, Por–C$\underline{\text{H}}_2$CH$_3$), 4.69 (1H, br s, NH of Th), 5.48 (1H, m, 6-H of Th), 7.42 (1H, s, N$\underline{\text{H}}$COCH$_2$), 7.08, 7.15, 7.56, 7.59, 7.60, 7.84, 8.06, 8.57 (each 1H, dd, dt, dt, dt, dd, dt, dd, dd, Ph-H of Por moiety), 10.18 (2H, s, 10- and 20-H of Por). FD-MS *m/z*: 854 (M$^+$).

***syn*-5-[2-{4-(9-Adenine)butanamido}phenyl]-15-[2-{4-(1-thymine)butanamido}phenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (7)** (1) Method E: Adenine derivative **5a-A**, 136 mg (0.158 mmol); **9a-T**, 167 mg (0.788 mmol); 50% solution of benzyloxycarbonyl chloride in toluene, 1.34 ml (4.05 mmol); *N,N*-diisopropylethylamine, 222 mg (1.72 mmol); DMF, 21 ml; THF, 7 ml; pyridinium chloride, 181 mg (1.57 mmol). Three compounds were isolated by column chromatography. Eluent: C/M = 40/1, **4a-T** (21 mg, 13%); the starting material **5a-A** (63 mg, 46%).

Eluent: C/M = 20/1, **7** (20 mg, 12%), lustrous purple crystals. IR (KBr) cm^{-1}: 3450—3150 ($\underline{\text{NH}}$CO, NH and NH$_2$), 1700, 1680, 1640 (NH$\underline{\text{CO}}$ and CO of Th). ^{1}H-NMR (DMSO-d_6) δ: −2.62, −2.57 (each 1H, br s, inner NH of Por), 0.72 (3H, br d, 5-CH$_3$ of Th), 1.15 (2H, qu, Th–CH$_2$C$\underline{\text{H}}_2$), 1.27 (2H, qu, Ad–CH$_2$C$\underline{\text{H}}_2$), 1.57 (4H, m, Th–CH$_2$CH$_2$C$\underline{\text{H}}_2$CO, Ad–CH$_2$CH$_2$C$\underline{\text{H}}_2$CO), 1.68, 1.69 (each 6H, t, Por–CH$_2$C$\underline{\text{H}}_3$), 2.49 (12H, s, Por–CH$_3$), 2.64 (2H, t, Th–C$\underline{\text{H}}_2$), 2.89 (2H, t, Ad–C$\underline{\text{H}}_2$), 3.90—4.00 (8H, m, Por–C$\underline{\text{H}}_2$CH$_3$), 6.21 (1H, m, 6-H of Th), 6.80 (2H, br s, NH$_2$ of Ad), 6.46, 7.14 (each 1H, s, 2- and 8-H of Ad), 7.59, 7.87, 8.18, 8.24 (2H, 4H, 4H, 1H, m, m, dd, dd Ph-H of Por moiety), 8.77, 8.88 (each 1H, s, N$\underline{\text{H}}$CO), 10.06 (2H, s, 10- and 20-H of Por), 10.54 (1H, br s, NH of Th). FD-MS *m/z*: 1057 (M$^+$).

(2) Method E. Thymine–porphyrin **5a-T**, 137 mg (0.160 mmol); **9a-A**, 35 mg (0.158 mmol); 50% solution of benzyloxycarbonyl chloride in toluene, 1.34 ml (4.05 mmol); *N,N*-diisopropylethylamine, 124 mg (0.961 mmol); DMF, 12 ml; THF, 6 ml; pyridinium chloride, 92 mg (0.800 mmol). Chromatographic separation in a manner similar to procedure (1) afforded three compounds: **4a-T** (76 mg, 48%); the starting material **5a-T** (37 mg, 27%); **7** (14 mg, 8.3%). The IR, ^{1}H-NMR and FD-mass spectra of **7** completely coincided with those of the product in procedure (1).

***anti*-5-[2-{4-(9-Guanine)butanamido}phenyl]-15-[2-benzyloxycarbamido)phenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (2a-G)** Method E: **11**, 1.50 g (1.89 mmol); **9a-G**, 479 mg (2.02 mmol); ethoxycarbonyl chloride, 1.00 g (9.22 mmol); *N,N*-diisopropylethylamine, 1.50 g (11.6 mmol); DMF, 150 ml; THF, 75 ml; pyridinium chloride, 1.10 mg (9.52 mmol). Three compounds were isolated by column chromatography. Eluent: chloroform, **15** (360 mg, 22%); the starting material **11** (730 mg, 49%).

Eluent: C/M = 10/1, **2a-G** (296 mg, 16%), lustrous purple crystals. IR (KBr) cm^{-1}: 3600—3150 ($\underline{\text{NH}}$CO, NH and NH$_2$), 1740 (NH$\underline{\text{CO}}$O), 1690, 1630 (NH$\underline{\text{CO}}$CH$_2$ and CO of Gu). ^{1}H-NMR (DMSO-d_6) δ: −2.50, −2.49 (each 1H, br s, inner NH of Por), 1.29 (2H, qu, C$\underline{\text{H}}_2$CH$_2$CO), 1.50 (2H, t, CH$_2$CO), 1.67, 1.69 (each 6H, t, Por–CH$_2$C$\underline{\text{H}}_3$), 2.47, 2.48 (each 6H, s, Por–C$\underline{\text{H}}_3$), 3.12 (2H, t, Gu–C$\underline{\text{H}}_2$), 3.92—4.02 (8H, m, Por–C$\underline{\text{H}}_2$CH$_3$), 4.74 (2H, s, OCH$_2$ of CBZ), 6.07 (2H, br s, NH$_2$ of Gu), 6.76, 6.87, 6.95 (2H, 2H, 1H, an A$_2$M$_2$Y system, Ph-H of CBZ), 6.84 (1H, s, 8-H of Gu), 7.55, 7.80, 7.84, 8.17, 8.22 (2H, 3H, 1H, 1H, 1H, m, m, dt, dd, dd, Ph-H of Por moiety), 8.33, 8.69 (each 1H, s, N$\underline{\text{H}}$COCH$_2$), 10.16 (2H, s, 10- and 20-H of Por), 10.30 (1H, NH of Gu). FD-MS *m/z*: 1013 (M$^+$).

***anti*-5-[2-{5-(9-Guanine)pentanamido}phenyl]-15-[2-benzyloxycarbamido)phenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (2b-G)** Method E: **11**, 1.10 g (1.39 mmol); **9b-G**, 371 mg (1.48 mmol); ethoxycarbonyl chloride, 7.21 mg (6.64 mmol); triethylamine, 813 mg (8.05 mmol); DMF, 106 ml; THF, 53 ml; pyridinium chloride, 767 mg (6.64 mmol). Three compounds were isolated by column chromatography. Eluent: chloroform, **15** (340 mg, 28%); the starting material **11** (150 mg, 14%).

Eluent: C/M = 10/1, **2b-G** (483 mg, 34%), lustrous purple crystals. ^{1}H-NMR (DMSO-d_6) δ: −2.484, −2.481 (each 1H, s, inner NH of Por), 0.78, 0.95 (each 2H, qu, Gu–CH$_2$C$\underline{\text{H}}_2$C$\underline{\text{H}}_2$), 1.53 (2H, t, C$\underline{\text{H}}_2$CONH), 1.70, 1.71 (each 6H, t, Por–CH$_2$C$\underline{\text{H}}_3$), 2.47, 2.48 (each 6H, s, Por–CH$_3$), 3.16 (2H, t, Gu–CH$_2$), 3.93—4.05 (8H, m, Por–C$\underline{\text{H}}_2$CH$_3$), 4.76 (2H, s, OCH$_2$ of CBZ), 6.13 (2H, br s, NH$_2$ of Gu), 6.77, 6.90, 6.98 (2H, 2H, 1H, an A$_2$M$_2$Y system, Ph-H of CBZ), 7.03 (1H, s, 8-H of Gu), 7.55, 7.80, 7.86, 8.17, 8.24 (2H, 3H, 1H, 1H, 1H, m, m, dt, dd, dd, Ph-H of Por moiety), 8.38, 8.55 (each 1H, s, N$\underline{\text{H}}$COCH$_2$), 10.20 (2H, s, 10- and 20-H of Por), 10.35 (1H, NH of Gu). FD-MS *m/z*: 1027 (M$^+$).

***anti*-5-[2-{4-(1-Cytosine)butanamido}phenyl]-15-[2-benzyloxycarbamido)phenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (2a-C)** Method E: **11**, 1.40 g (1.76 mmol); **9a-C**, 345 mg (1.76 mmol); ethoxycarbonyl chloride, 950 mg (8.76 mmol); *N,N*-diisopropylethylamine, 1.30 g (10.1 mmol); DMF, 280 ml; THF, 70 ml; pyridinium chloride, 1.00 g (8.65 mmol). Three compounds were isolated by column chromatography. Eluent: chloroform, **15** (103 mg, 6.8%); the starting material **11** (866 mg, 62%).

Eluent: C/M = 10/1, **2a-C** (66 mg, 4.0%), lustrous purple crystals.

^{1}H-NMR (DMSO-d_6) δ: -2.48 (2H, br s, inner NH of Por), 1.15 (2H, qu, Cy–$CH_2C\underline{H}_2$), 1.51 (2H, t, $C\underline{H}_2CONH$), 1.71 (12H, t, Por–$CH_2C\underline{H}_3$), 2.48, 2.49 (each 6H, s, Por–$C\underline{H}_3$), 2.82 (2H, t, Cy–$C\underline{H}_2$), 3.94—4.05 (8H, m, Por–$C\underline{H}_2CH_3$), 4.75 (2H, s, OCH_2 of CBZ), 5.02, 6.65 (each 1H, an AX system, $J=7.0$ Hz, 5- and 6-H of Cy), 6.69 (2H, br s, NH_2 of Cy), 6.77, 6.89, 6.97 (2H, 2H, 1H, an A_2M_2Y system, Ph-H of CBZ), 7.56, 7.79—7.87, 8.18, 8.23 (2H, 4H, 1H, 1H, m, m, br d, br d, Ph-H of Por moiety), 8.34, 8.73 (each 1H, s, $N\underline{H}COO$, $N\underline{H}COCH_2$), 10.19 (2H, s, 10- and 20-H of Por). FD-MS m/z: 973 (M^+).

***anti*-5-[2-{5-(1-Cytosine)pentanamido}phenyl]-15-[2-benzyloxycarbamido)phenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (2b-C)** Method E: **11**, 1.10 g (1.39 mmol); **9b-C**, 310 mg (1.47 mmol); 50% solution of benzyloxycarbonyl chloride in toluene, 12.2 ml (36.9 mmol); *N*,*N*-diisopropylethylamine, 1.80 g (14.0 mmol); DMF (250 ml); THF, (60 ml); pyridinium chloride, 838 mg (7.26 mmol). Three compounds were isolated by column chromatography. Eluent: chloroform, **12** (603 mg, 47%); the starting material **11** (207 mg, 19%).

Eluent: C/M = 10/1, **2b-C** (16 mg, 1.2%), lustrous purple crystals. ^{1}H-NMR ($CDCl_3$) δ: -2.53 (2H, br s, inner NH of Por), 0.55, 0.87 (each 2H, qu, Cy–$CH_2C\underline{H}_2C\underline{H}_2$), 1.41 (2H, t, $C\underline{H}_2CONH$), 1.77, 1.78 (each 6H, t, Por–$CH_2C\underline{H}_3$), 2.53, 2.54 (each 6H, s, Por–CH_3), 2.59 (2H, t, Cy–CH_2), 3.13, 4.99 (each 1H, br d, 5- and 6-H of Cy), 3.97—4.09 (8H, m, Por–$C\underline{H}_2CH_3$), 4.79 (2H, s, OCH_2 of CBZ), 6.44, 6.92 (each 1H, s, $N\underline{H}COO$, $N\underline{H}COCH_2$), 6.85, 6.96, 7.00 (2H, 2H, 1H, an A_2M_2Y system, Ph-H of CBZ), 7.46, 7.52, 7.71, 7.83, 7.58, 8.71 (1H, 1H, 1H, 3H, 1H, 1H, dt, dt, dd, m, dd, dd, Ph-H of Por moiety), 10.28 (2H, s, 10- and 20-H of Por). FD-MS m/z: 987 (M^+).

***anti*-5-[2-{4-(4-Aminopyrimidyl-2-oxy)butanamido}phenyl]-15-[2-benzyloxycarbamido)phenyl]-2,8,12,18-tetraethyl-3,7,13,17-tetramethylporphyrin (2a-C′)** Method E: **11**, 1.00 g (1.26 mmol); **9a-C′**, 256 mg (1.30 mmol); ethoxycarbonyl chloride, 462 mg (4.26 mmol) and *N*,*N*-diisopropylethylamine, 1.01 g (7.83 mmol); DMF, 104 ml; THF, 52 ml; pyridinium chloride, 752 mg (6.51 mmol). Three compounds were isolated by column chromatography. Eluent: chloroform, **15** (88 mg, 8.1%), **11** (874 mg, 87%).

Eluent: C/M = 30/1, **2a-C′** (40 mg, 3.3%), lustrous purple crystals. ^{1}H-NMR ($CDCl_3$) δ: -2.50 (2H, br s, inner NH of Por), 1.50 (2H, qu, Cy–$CH_2C\underline{H}_2$), 1.60 (2H, t, $C\underline{H}_2CONH$), 1.77 (12H, t, Por–$CH_2C\underline{H}_3$), 2.53, 2.54 (each 6H, s, Por–CH_3), 3.65 (2H, t, Cy–CH_2), 3.76 (2H, br s, NH_2 of Cy), 3.96—4.07 (8H, m, Por–$C\underline{H}_2CH_3$), 4.78 (2H, s, OCH_2 of CBZ), 5.28, 7.33 (each 1H, an AX system, $J=5.7$ Hz, 5- and 6-H of Cy), 6.44, 7.07 (each 1H, s, $N\underline{H}COO$, $N\underline{H}COCH_2$), 6.84, 6.96, 7.00 (2H, 2H, 1H, an A_2M_2Y system, Ph-H of CBZ), 7.46, 7.49, 7.76, 7.83, 7.58, 8.78 (1H, 1H, 2H, 2H, 1H, 1H, dt, dt, dd, m, dd, dd, Ph-H of Por moiety), 10.26 (2H, s, 10- and 20-H of Por). FD-MS m/z: 973 (M^+).

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