Synthesis and C.d. Spectra of 6,6a,7,11b-Tetrahydro-5*H*-indeno[2,1-c]-isoquinoline Derivatives

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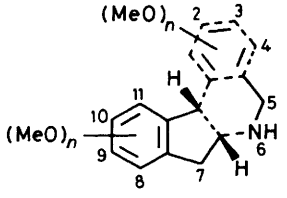
We have synthesized the title compounds having two pharmacophores of the β-phenethylamine moiety with a semi-rigid spatial arrangement. They are very suitable for studies on the limit of the effect of electron exchange between two aromatic chromophores.

X-Ray crystallography was carried out to determine the molecular structure of the skeleton compounds: 6,6a,7,11b-tetrahydro-5*H*-indeno[2,1-*c*]isoquinoline and 5,6,6a,7,8,12a-hexahydrobenz[*a*]phenanthridine. For compounds which showed positive Cotton effects, independent of the substituent pattern of the methoxy groups, in the region of the ^1L_b benzenoid transition and the longer wavelength part of the ^1B benzenoid transition, absolute configurations were determined by chemical correlation to (1*R*,2*R*)-(−)-2-aminoindan-1-ol and (1*R*,2*R*)-(−)-2-amino-5-methoxyindan-1-ol. The absolute configuration of the last-named was determined by *X*-ray crystallography. An empirical rule was applied to determine the absolute configuration of the other compounds and was supported by theoretical calculations.

The β-phenethylamine moiety is believed to be a pharmacophore producing dopaminetic activity. For example, dopamine agonists such as (*R*)-apomorphine[1] and (+)-butaclamole[2] are molecules possessing semi-rigid structures. In order to determine the structural requirements necessary for interaction with dopamine-receptor[3] binding sites some β-phenethylamine derivatives have been synthesized and studied.[4] We were interested in 6,6a,7,11b-tetrahydro-5*H*-indeno[2,1,*c*]-isoquinoline derivatives (**1**) which have two pharmacophores with a semi-rigid spatial arrangement.



(**1**)

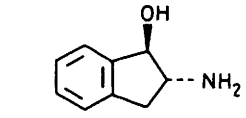
We have reported on the circular dichroism spectra (c.d.) resulting from intereaction of the two aromatic chromophores[5] and pointed out that charge-transfer transition plays an important role in determining the sequence of the transition energies arising from the dipole-dipole coupling. The present compounds are very suitable for extending our studies to see the limit of the effect of electron exchange between the two chromophores.

The present paper describes the synthesis of the optically active derivatives (**1**), together with their absolute configurations, chiroptical properties, and biological activities.

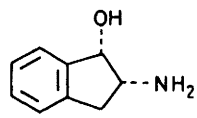
Synthesis.—2-Aminoindan-1-ols (**2**)—(**6**) and 2-amino-1,2,3,4-tetrahydro-1-naphthol (**7**) were selected as starting materials. Optically active compounds (**2**),[6] (**3**),[6,7] and (**7**)[8] have been prepared and their absolute configuration has already been determined by chemical correlation. Racemic (**4a**) has also been prepared.[9,10]

The optical resolution of (**4a**) was carried out with (+)- and (−)-tartaric acid to give the (−)- and (+)-isomers, respectively. The abolute configuration of (+)-(**4a**) was determined as 1*S*,2*S* by *X*-ray analysis of its diastereoisomeric salt with (−)-tartaric acid. Details are given later.

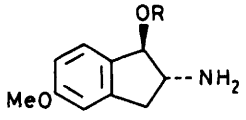
cis-2-Amino-4,5- and 5,6-dimethoxyindan-1-ol (**5a**)[7] and (**6**)[9–11] have already been prepared by catalytic hydrogenation



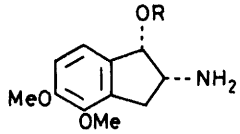
(−)-(**2**)



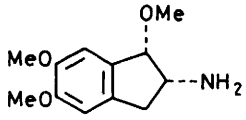
(−)-(**3**)



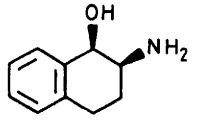
(−)-(**4a**) R = H
(−)-(**4b**) R = Me



(−)-(**5a**) R = H
(−)-(**5b**) R = Me



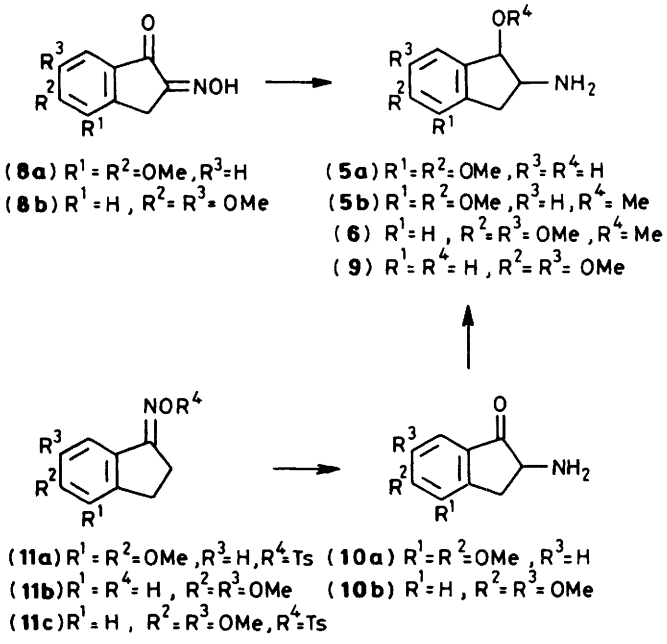
(+)-(**6**)



(−)-(**7**)

of the hydroxyimino derivatives (**8a**) and (**8b**), respectively (Scheme 1). The reduction was, however, difficult, probably owing to the insolubility of (**8a**)—(**8b**). The ketone[12] (**10a**), obtained by Neber rearrangement of the tosylate (**11a**) was reduced more easily to give (**5a, b**). By the same procedure, (**6**) was prepared from the oxime (**11b**)[13] together with a small amount of the *trans*-isomer. The relative configurations of the amino and methoxy groups were determined on the basis of spectroscopic correlations for the intramolecular hydrogen bonding of the amino group with the methoxy group in the 2-amino ether (**6**); this parallels similar correlations by which the configuration of (**2**), (**3**), (**4a**), (**7**) and (**9**) were determined.[11] In dilute solution, the major product showed hydrogen bonding (ν_{NH}^{as} 3 393 and ν_{NH}^{s} 3 328 cm^{-1}) and the minor one no hydrogen bonding (ν_{NH}^{as} 3 413 cm^{-1}).

The optical resolution of (**5a**) was achieved with (−)- and (+)-mandelic acid, to give (+)- and (−)-(**5a**), respectively. The hydroxylamine (**9**) failed to undergo such resolution, but the ether (**6**) could be resolved with (+)- and (−)-tartaric acid to furnish (+)- and (−)-(**6**), respectively.



Scheme 1.

The optical purity of (+)-(**4a**), (+)-(**5a**), and (−)-(**6**) was established from the n.m.r. spectra of their amide derivatives formed from (*R*)-(+)-α-methoxy-α-trifluoromethylphenylacetic acid,[14] signals assignable to other diastereoisomers being absent.

Although enamide photocyclization is known to be very useful for synthesizing heterocyclic compounds,[15,16] the method could not be applied in our work because of the absence of an asymmetric centre in the enamides. Schwan has reported the cyclization of 2-benzylaminoindan-1-ol and 2-benzylamino-1,2,3,4-tetrahydro-1-naphthol to 6,6a,7,11b-tetrahydro-5*H*-indeno[2,1-*c*]isoquinoline[17] and 5,6,6a,7,8,12a-hexahydro-[*a*]phenanthridine,[18] respectively. The stereochemistry of the starting materials and the products was not however given.

The benzylamino derivatives (−)-(**14a**) and (−)-(**16i**) were prepared from (−)-(**2**) *via* their Schiff base (−)-(**13a**) and from (−)-(**3**) *via* the oxazolidine derivatives (**15i**), respectively (see Scheme 2). The oxazolidine (**15i**) was a mixture of epimers.

Following Schwan's cyclization procedure we obtained an identical, optically active product (+)-(**19a**) from both (−)-(**14a**) and (−)-(**16i**) (see Scheme 2). The stereochemistry of the product was established from its 200 MHz n.m.r. spectrum, in which there was an 11b-H signal at δ 4.11 (d, *J* 5 Hz). The small coupling constant suggests that the ring-juncture has a *cis*-configuration.[11,19] The latter was confirmed by *X*-ray analysis and this will be described later.

The $[\alpha]_D$ value was very large (+220.6) and the same for the products from both (−)-(**14a**) and (−)-(**16i**). Racemization did not occur. From these results, the intermediate of the reaction must be a localized carbonium ion as shown in (**20**). The absolute configuration of (+)-(**19a**) was assigned as 6a*R*, 11b*R*-on the basis of an unambiguous synthesis (see later).

We then prepared *cis*- and *trans*-2-benzylamino-1,2,3,4-tetrahydro-1-tetralol[1] (**21**) and (**23**) (Scheme 3). The cyclization reactions of both (**21**) and (**23**), carried out by Schwan's procedure, gave the same product (**22**). Since in the n.m.r. spectrum the coupling constant for the 12b-H signal at δ 3.84 (d, *J* 4 Hz) was small we deduced that there was a *cis*-ring-juncture.[13,17] The latter was confirmed by *X*-ray analysis, the details of which are given later. Since the (−)-isomer (−)-(**22**) was obtained from (−)-(1*R*,2*S*)-(**7**) (see Scheme 3), the absolute configuration was determined as 6a*S*, 12b*R*.

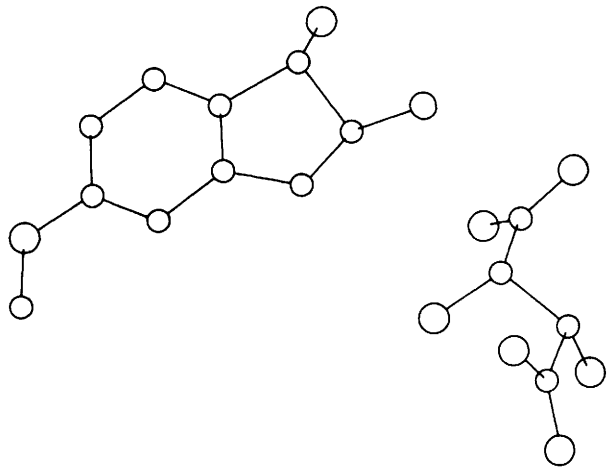


Figure 1. Stereodrawing of (+)-(**4a**)-(−)-(2*S*,3*S*)-tartaric acid

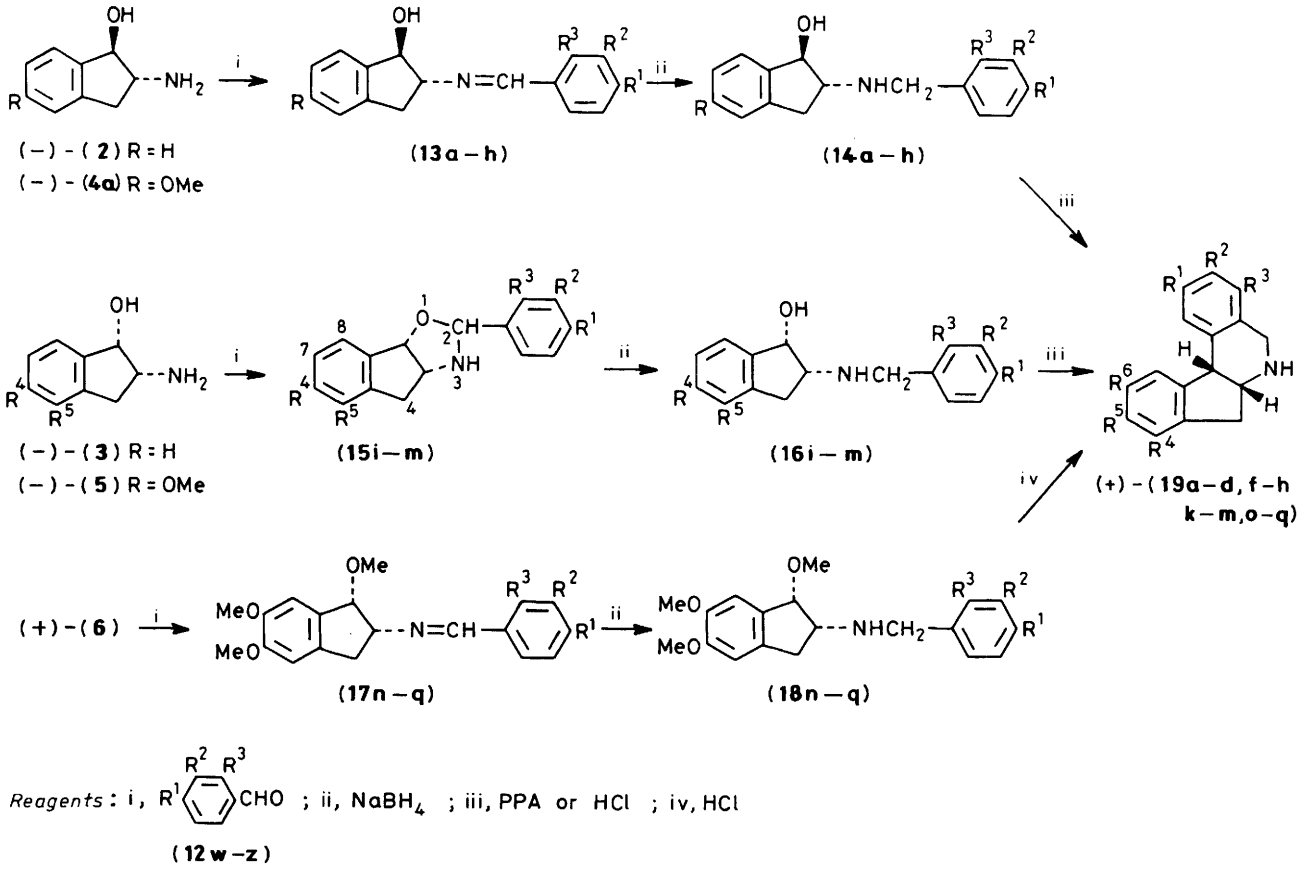
The methoxy substituted derivatives were prepared as shown in Scheme 2. The *trans*-amino alcohol (−)-(**4a**) gave the Schiff base and the *cis*-amino alcohol (−)-(**5a**) furnished a mixture of epimeric oxazolidine derivatives.

cis- and *trans*-Methoxy substituted benzylamino alcohols (**14b—d, f—h**) and (**16k—m**) and *cis*-methoxy substituted benzylamino ethers (**18o—q**) underwent ready ring closure when heated with concentrated hydrochloric acid to give compound (**24**). The latter was shown to have a *cis*-ring-junction from its n.m.r. spectrum. Benzylamino derivatives without methoxy groups at R^1, R^2 or R^3, (**14e**), (**16j**), and (**18n**), and the *trans*-methyl ether (−)-(**24**) could not however be cyclized either with polyphosphoric acid or hydrochloric acid.

Molecular Structure, C.d. Spectra, and Absolute Configuration.—As mentioned above, the absolute configurations of (−)-(**2**), (−)-(**3**), and (−)-(**7**) are known. To determine the absolute configuration of (+)-(**4a**), an *X*-ray analysis was performed on a single crystal of the (−)-salt of (+)-(**4a**)-D-(−)-tartaric acid. Figure 1 is a perspective drawing showing the correct conformation and configuration. Since the absolute configuration of D-(−)-tartaric acid is known to be 2*S*,3*S*, (+)-(**4a**) was assigned the 1*S*,2*S*-configuration.

We were unable to prepare a suitable crystal of (−)-(**5a,b**) and (+)-(**6**) for *X*-ray analysis. However, the c.d. spectra of the indan derivatives (**2**)—(**6**) were measured and the results are summarized in Table 1. Snatzke *et al.* have reported that for compounds (**2**) and (**3**) the sign of the first transition was governed not by the configuration of the 1-hydroxy group but by that of the 2-amino group.[20] The 5,6-dimethoxy compound, (+)-(**6**), which has an electric transition dipole moment in the same direction as that of (−)-(**3**) showed Cotton effects of the same sign in corresponding transitions. Thus, we concluded that (+)-(**6**) has the 1*S*,2*R*-configuration. The c.d. spectrum of the 4,5-dimethoxy compound (−)-(**5a**) was of the antipodal pattern to that of (+)-(**6**). However, the electric transition dipole moment of the aromatic chromophore itself differs from that of (+)-(**6**) as a result of the methoxy substituent on the benzene ring. Thus, the configuration of (−)-(**5a**) cannot be determined by comparison of the c.d. spectra.

X-Ray analyses were also carried out on (**19a**) and (**22**). The *cis*-ring-juncture was suggested by the n.m.r. spectra cited above and was confirmed by the *X*-ray analyses. Inspection of the models shows that there can be four stable conformers. One stable conformer was observed in the crystalline state of (**19a**) while in (**22**), two different conformers were contained pairwise in a unit cell. The structures are shown in Figures 2 and 3. The



Scheme 2.

(12)	w	x	y	z
R^1	H	H	OMe	H
R^2	H	OMe	OMe	OMe
R^3	H	H	H	OMe

(13)—(19)	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
R^1	H	H	OMe	H	H	H	OMe	H	H	H	H	OMe	H	H	H	OMe	H
R^2	H	OMe	OMe	OMe	H	OMe	OMe	OMe	H	H	OMe	OMe	OMe	H	OMe	OMe	OMe
R^3	H	H	H	OMe	H	H	H	OMe	H	H	H	H	OMe	H	H	H	OMe
R^4	H	H	H	H	H	H	H	H	H	OMe	OMe	OMe	OMe	H	H	H	H
R^5	H	H	H	H	OMe	OMe	OMe	OMe	H	OMe	OMe	OMe	OMe	OMe	OMe	OMe	OMe
R^6	H	H	H	H	H	H	H	H	H	H	H	H	H	OMe	OMe	OMe	OMe

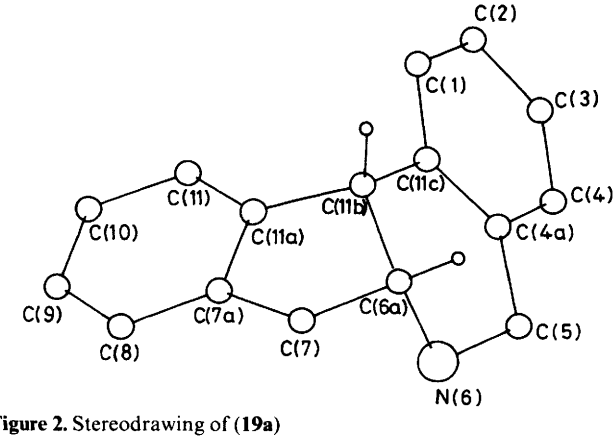
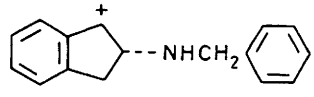


Figure 2. Stereodrawing of (**19a**)



(**20**)

difference in energy between the two conformers must be small, since replacement of the amino group by a methylene group in the molecule would give rise to a plane of symmetry.

In order to determine the most stable conformer present in a solution, the temperature-dependent c.d. spectra of (+)-(**19a**), (+)-(**19f**), and (−)-(**22**) (Figure 4, 5, and 6) were recorded. The Cotton effect increased in magnitude as the temperature was lowered for (+)-(**19a**) and (+)-(**19f**), although that of (+)-(**19a**) was not clear because of the over-lapping in the tail of the shorter wavelength region. Assuming that there is an equilibrium between two isomers for (+)-(**19f**), the free energy ΔG°, was calculated to be 5.0 kJ/mol by the method of Moscowitz *et al.*[21] and the mole fraction in the more stable conformation was *ca.* 0.90 at room temperature. We measured the c.d. spectra of crystalline (+)-(**19a**) and (+)-(**19f**) as KBr discs and found them to be very similar to those obtained for

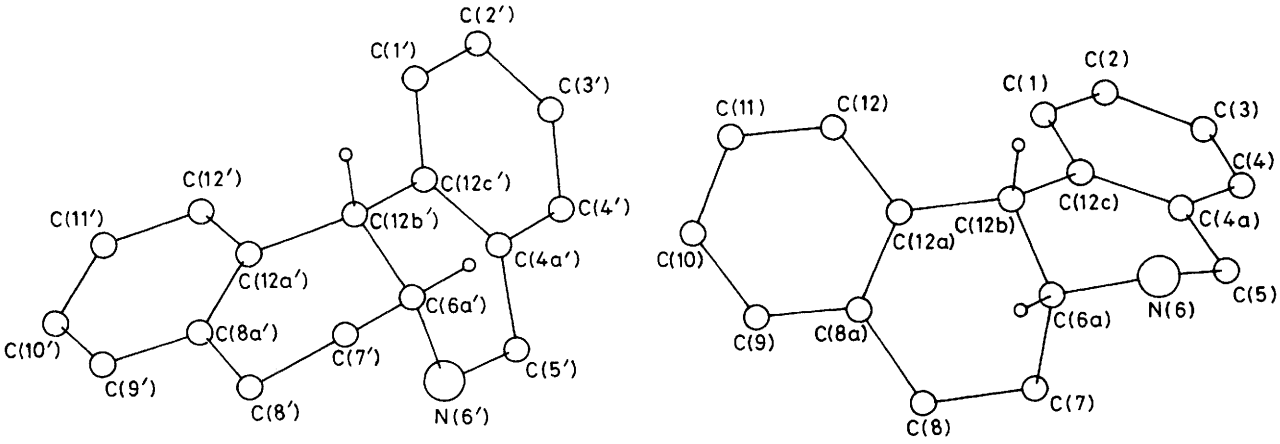
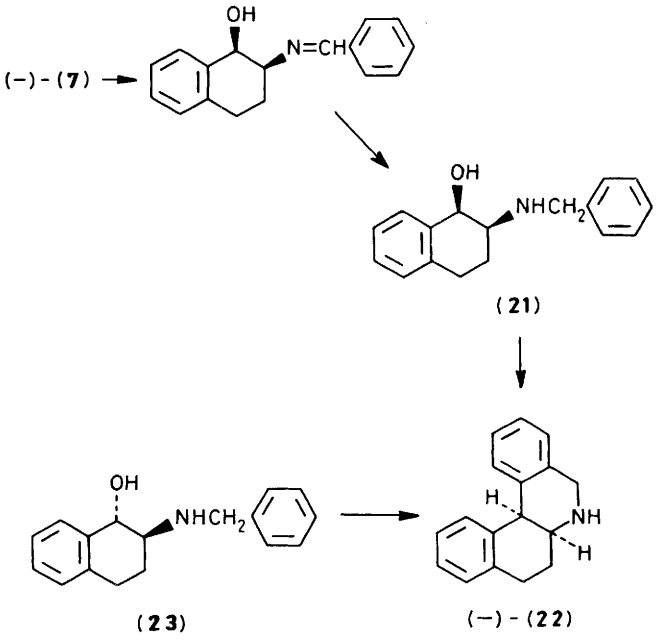
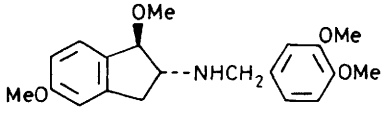


Figure 3. Stereodrawing of (**22**)



Scheme 3.



(−)-(**24**)

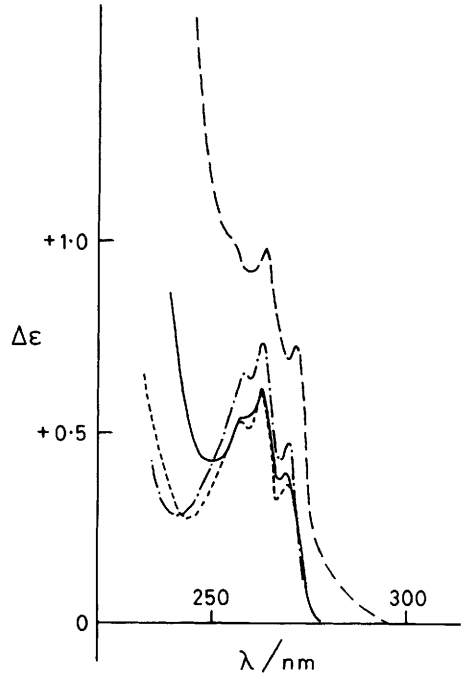


Figure 4. Temperature-dependent c.d. spectra of (+)-(**19a**) in EPA at +25 °C (——), at −68 °C (– – – –) and at −190 °C (– · – · –) and c.d. spectrum in a KBr disc (— — — —)

solutions (Figure 4 and 5). Thus, we can assume that the stable conformation must be the same both in solution and in the crystalline state.

On the other hand, the Cotton effect of (−)-(**22**) was not simple, becoming smaller in magnitude at −68 °C and then again larger at −190 °C. This suggested that there are more than three stable conformers.

The absolute configurations of (+)-(**19a—d, f—h**) and (−)-(**22**) were established by the synthetic sequences shown in Schemes 2 and 3. The c.d. spectra of these compounds are summarized in Table 2.

The aromatic chromophores of these compounds showed three absorption bands related to the ^1L_b, ^1L_a, and $^1B_{a,b}$ benzenoid transitions at *ca.* 290—260, 240—215, and 210—195 nm, respectively. In the 6a*R*,11b*R*-compounds, (**19a—d, f—h**), all the c.d. curves showed a positive Cotton effect at *ca.* 290—260 nm and a positive couplet at *ca.* 210—195 nm. However, the second region of the transition at *ca.* 240—215 nm shows a change in the sign of the Cotton effect as a result of a change in the methoxy group position. That is, (+)-(**19a, b, d,** and **h**) showed a positive Cotton effect and (+)-(**19c, f** and **g**), a negative one.

The experiments allow us to assign the 6a*R*, 11b*R* configuration on the basis of the positive Cotton effect at the longest wavelength region and the longer wavelength part of the ^1B benzenoid transition, independent of the substituent pattern. A similar empirical rule has been reported for protoberberin alkaloids [22] and lignans [23] in which the sign of the Cotton effect was not determined by the conformation but the configuration of the two aromatic chromophores.

Table 1. U.v. and c.d. spectra of indan derivatives

	Free amine				HCl salt			
	U.v		C.d.		U.v.		C.d.	
	λ/nm	ε*	λ/nm	Δε	λ/nm	ε*	λ/nm	Δε
(−)-(**2**)	272	957	269.5	−0.19			269	−0.15
	265.5	880	262.5	−0.23			261.5	−0.19
	259	573	257sh	−0.18			256sh	−0.15
	252sh	310						
			223.5	+0.18			218	−0.15
	215sh	7 530	218	−0.13			212	−0.21
	210	9 050	200	+1.33			198.5	+7.94
(−)-(**3**)	272	925	270	−0.130				
	265	834	264	−0.152				
	259	545	259sh	−0.106				
			240sh	−0.021				
	214sh	8 080	219	+0.236				
	211sh	9 120	205sh	−1.30				
			200	−1.97				
(−)-(**4**)	286	2 270	277.5	+0.430				
	280	2 500						
	277sh	2 430						
			235	−0.097				
	227	8 310	227	+0.363				
	198	44 100	206	−1.36				
(−)-(**5a**)	280	1 190	277	+0.147				
	276	1 190	272.5	+0.161				
	230	8 090	236	−2.86				
			225	−1.49				
	203	43 100	215	−1.21				
(+)-(**6**)	293sh	3 680	285	−0.391			285	+0.227
	288	4 590	280	−0.386				
	285	4 590					258	−0.049
	233	7 300	232	+3.79			234	−1.78
	202.5	45 500	200	−3.03			205	−0.767
(−)-(**4b**)			282	−0.227	284	2 300	275	−0.288
			273	−0.330	278	2 450		
					275sh	2 300		
			236	−0.515	229	9 950	236	−0.876
			220	+0.615			225	+0.154
							205	−1.00
			199	−0.421	199	48 300	195	−1.12
(+)-(**7**)	272.5	348	270	+0.309				
	265	350	263	+0.376				
	260sh	267	258sh	+0.355				
	216sh	7 460	215	+1.39				
	211	8 990	202.5	+1.15				
	195	49 900						

* In units of $dm^3\ mol^{-1}\ cm^{-1}$

The c.d. spectra of other compounds (+)-(**19k—m, o—q**) are also summarized in Table 2. Based on the empirical rule found, these (+)-derivatives can be assigned the 6a*R*, 11b*R* configuration, since the Cotton effects of both regions were positive. The assignment for (+)-(**19o—q**) agreed well with that predicted from the sector rule of the benzene chromophore of (−)-(**6**). The configuration of (−)-(**5a**) and (−)-(**5b**) was assigned as 1*S*,2*R*, although the sector rule could not be applied to them.

The sign of the Cotton effect in the second region depended on the position of the methoxy group on the isoquinoline chromophore. 2,3-Dimethoxy compounds, (+)-(**19c, g, l,** and **p**), showed a negative Cotton effect and 3,4-dimethoxy compounds, (+)-(**19d, h, m,** and **q**), a positive Cotton effect in the region of the second transition; 3-methoxy derivatives, (+)-(**19b, f, k,** and **o**), showed no such effects.

Protonation of the nitrogen atom enhanced the magnitude of the Cotton effect in the region of the ^1B transition of (+)-(**19l** and **m**) but caused no drastic change in the shape of the spectra for the other compounds.

Theoretical Treatment of the C.d. Spectra.—The signs of the Cotton effects related to the ^1L_b and ^1B transitions were not affected by a change in the methoxy group position in (**1**), but those attributable to the ^1L_a transition were. In order to explain the behaviour, we calculated the theoretical rotational strength.

We made up an idealized model for the 6a*R*,11b*R*-isomer based on the results of the *X*-ray analysis. The dihedral angles were 76.0° and −36.4° for C(1)–C(11c)–C(11b)–C(11a) and for C(11c)–C(11b)–C(11a)–C(11), respectively. The angle ∠C(11a)–C(11b)–C(11c) was 114.7°. The benzene rings were planar with a C–C bond length of 1.395 Å.

The rotational strengths of the compounds were calculated by the dynamic coupling method [24] using both a point dipole approximation at the centre of the benzene ring and u.v. data for tetralin, anisole, and *o*-dimethoxybenzene. Linear dichroism

Table 2. U.v. and c.d. spectra of (+)-(**19**)

	U.v. (MeOH)						C.d. (MeOH)					
	^1L_b		^1L_a		^1B		^1L_b		^1L_a		^1B	
Compound	λ/nm	ε*	λ/nm	ε*	λ/nm	ε*	λ/nm	Δε	λ/nm	Δε	λ/nm	Δε
(+)-(**19a**)	273	1 600	217sh	31 200	194.5	70 100	270	+0.533	215sh	+10.30	196	+34.2
	266	1 510					263	+0.673				
	260	1 040					257	+0.527				
(−)-(**19a**)	272	952	215	17 100	195	67 100	269	+0.461	215sh	+6.00	197	+28.5
HCl	265	964	211sh	19 700			262	+0.618				
	260	723					257	+0.503				
	252	440										
(+)-(**19b**)[E]	287	1 150	217sh	44 300			275sh	+2.01	218.5	+10.6	190	+1.24
	280	2 130					269.5	+2.50				
	273	2 780					264sh	+1.98				
	267	2 190										
	260sh	1 420										
(+)-(**19b**)[E]	286	1 660	226	11 500	202sh	51 100	275sh	+2.74	225	+10.3	200	+4.00
HCl	280	1 990			195	62 000	270	+3.18	210sh	+6.67		
	272	2 330					265sh	+2.35				
	266	1 780										
	260sh	1 170										
	252sh	661										
(+)-(**19c**)	292sh	3 570	231sh	9 770	203sh	33 500	281	+0.742	232	−7.73	202	+34.8
	286	4 320					270.5	+1.14				
	284	4 320					264	+1.03				
	273	3 610					258sh	+0.597				
	268	2 500										
(+)-(**19c**)	291sh	3 420	232	9 140	204	55 900	287	+0.696	234	−9.55	201	+33.9
HCl	286	4 000			194	58 200	281	+0.733				
	283	3 960					270	+1.06				
	273	3 180					263	+0.936				
	267	2 180					256	+0.882				
	260sh	1 400										
(+)-(**19d**)[E]	282	1 380	230sh	9 120	204sh	49 300	277	+0.985	232sh	+6.71	200	+7.03
	273	2 280					271	+1.78	222	+7.42		
	267	1 790					264	+1.67				
	261	1 180										
(+)-(**19d**)[E]	283	1 830	230sh	8 770	203	49 300	279	+0.776	230	+9.39	198	+26.1
HCl	272	2 210			194	54 000	270	+1.39				
	266	1 640					263.5	+1.35				
	260sh	1 050					258	+0.94				
(+)-(**19f**)	287	3 860	231	18 200	198	66 400	285	+3.27	228	−2.76	201	+19.5
	279	4 400					279	+3.39				
(+)-(**19f**)	287	4 020	232	20 400	199	73 400	285	+2.64	226	−2.21	201	+16.3
HCl	280	4 570					279	+2.64				
(+)-(**19g**)	287	6 350	229	16 400	199	64 200	279	+4.33	233	−9.82	203	+50.0
	283	6 640							215sh	+7.85	190	−10.8
(+)-(**19g**)[E]	287sh	6 170	232	17 100	203	62 400	278	+3.55	236	−15.3	203	+73.9
HCl	282	6 530			200	62 400			220sh	+8.52		
(+)-(**19h**)[E]	288	2 840	230	18 500	199	66 000	278	+3.97	233	+8.00	204	+11.0
	282	3 850									190	−3.58
	279	3 850										
(+)-(**19h**)[E]	287	3 730	231	18 700	205sh	64 400	278	+2.88	235	+14.2	202	+26.1
HCl	281	4 450			199	70 400			220	−1.30		
	279	4 430										
(+)-(**19k**)[E]	286sh	2 740	230sh	18 700	199	65 100	275	+2.70	233	−5.73	206	+7.00
	279	3 390									190	−3.61
(+)-(**19k**)[E]	287sh	2 760	228	19 300	204sh	60 700	276.5	+2.61	235	−6.58	202	+34.2
HCl	279	3 560			199	65 900			220sh	+5.70		
(+)-(**19l**)	291sh	4 060	230sh	4 850	202	69 500	290sh	+0.669	235.5	−12.6	209	+20.0
	283	5 780					271	+1.55				
	277sh	4 850										
(+)-(**19l**)	291sh	4 120	231sh	16 400	205	70 700	278	+2.87	237.5	−17.6	206	+73.6
HCl	283	5 900							222sh	+10.3	195	−47.9
	277sh	5 150										
(+)-(**19m**)[E]	282	2 810	230sh	17 600	202	65 800	273	+3.06	235	+5.88	208	+9.52
	278	2 840									191	−7.70
	276	2 820										

E: Enantiomer was measured. sh: shoulder. !: Lowest recorded value, not a maximum.

* In units of $dm^3\ mol^{-1}\ cm^{-1}$

Table 2. (*continued*)

	U.v. (MeOH)						C.d. (MeOH)					
	^1L_b		^1L_a		^1B		^1L_b		^1L_a		^1B	
(+)-(**19m**)[E]	283	3 430	228sh	17 500	204	66 100	275	+2.28	235	+10.7	206	+24.1
HCl	279	3 440									195!	−13.5
(+)-(**19o**)	297sh	3 440	227	16 300	200	65 400	286	+1.06	235	+5.79	200	+37.0
	287	6 840					280sh	+0.076	222	−3.24		
	282sh	6 240										
(+)-(**19o**)	295sh	3 880	231	16 400	203sh	62 100	284	+0.539	236	+8.00	200	+35.5
HCl	287	6 440			200	63 300	276	+0.670	222	−8.58		
	281sh	5 890										
(+)-(**19p**)	286.5	7 870	231	13 500	203	62 300	289	+2.86	247	−0.491	205	+74.8
									227	−5.36	193	−31.7
(+)-(**19p**)	286	8 620	233	15 100	203	69 100	288	+1.85	250	−0.179	205	+84.8
HCl									228	−10.3		
(−)-(**19q**)	291sh	5 260	229sh	15 700	202	68 400	294	+0.20	234	+35.2	202	+35.2
	285	6 240					273	+4.55				
(+)-(**19q**)	285	6 010	233	13 300	204	61 900	286	−0.718	233	+15.0		
HCl							271	+1.67				
(+)-(**22**)[E]	273	646	215sh	2 110	195	64 500	267	+0.152	212.5	+4.85	206	+5.61
	266	759					261	+0.203				
	259sh	610					243sh	+0.088				
(+)-(**22**)[E]	272	416	212sh	20 300	194	63 000	271.5	+0.206	215	−2.45		
HCl	268sh	442					264	+0.218				
	265	549					257	+0.112				
	263	554										

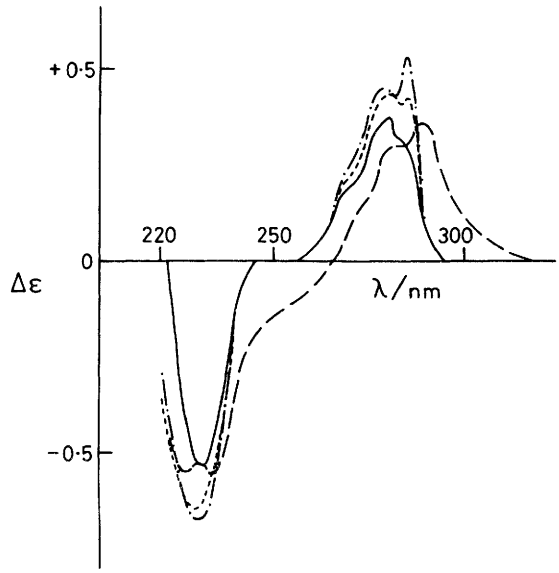


Figure 5. Temperature-dependent c.d. spectra of (+)-(**19f**) in EPA at +25 °C (——), at −68 °C (– – – –) and at −190 °C (– · – · –) and c.d. spectrum in a KBr disc (– – — – — –)

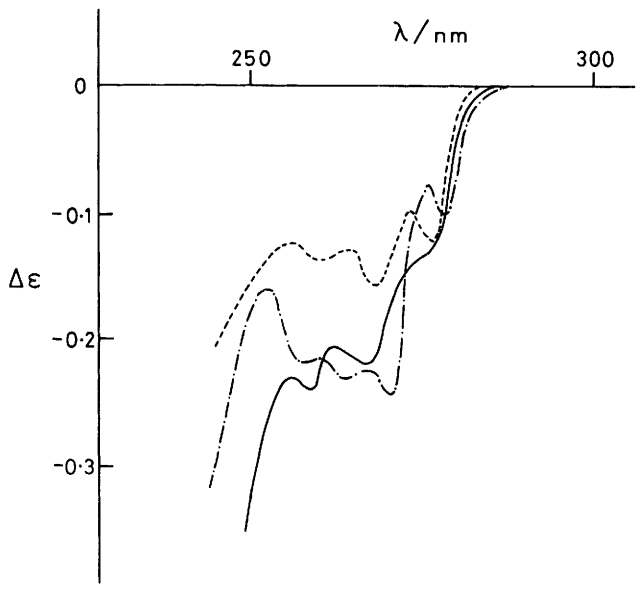


Figure 6. Temperature-dependent c.d. spectra of (−)-(**22**) in EPA at +27 °C (——), at −68 °C (– – – –) and at −190 °C (– · – · –)

measurements have shown that the ^1B transition moments of benzene, anisole, and *o*-dimethoxybenzene are degenerate in energy and of the same order of magnitude for benzene and *o*-dimethoxybenzene. We have used the following values for the transition energy (eV) and the transition dipole moment ($\mu \times 10^{19}$ c.g.s.): tetralin 4.643 (6.54), 5.820 (24.5), 6.309 (38.6), and 6.309 (38.6); anisole 4.59 (11.42), 5.78 (28.08), 6.68 (36.72), and 6.68 (48.13); *o*-dimethoxybenzene 4.467 (13.97), 5.461 (24.16), 6.261 (46.96), and 6.261 (46.96) (Method 1).

The rotational strengths were also calculated by the dipole velocity method using the composite molecular orbitals without taking the charge-transfer term into consideration[4] (Method 2). The calculated energies and the rotational strengths were converted into a theoretical c.d. spectrum on the assumption that the spectrum represented a sum of Gaussian bands.[4]

Discussion

As can be seen by the results summarized in Table 3, the sign of the Cotton effect from the calculations agreed well with the experimental results in both regions of the ^1L_b and ^1B

Table 3. Theoretical c.d. spectra.*

	Method 1						Method 2					
	^1L_b		^1L_a		^1B		^1L_b		^1L_a		^1B	
Compound	λ/nm	Δε	λ/nm	Δε	λ/nm	Δε	λ/nm	Δε	λ/nm	Δε	λ/nm	Δε
(+)-(**19a**)	270	+0.20	217	+35.47	202	+108.50						
					192	−152.02						
(+)-(**19b**)	272	+0.78	218	+31.66	197	+75.40						
					185	−115.49						
(+)-(**19c**)	279	+1.13	226sh	+14.35	203	+152.28						
	257	−0.08			193	−208.19						
(+)-(**19d**)	269	+0.85	227sh	+13.84	203	+146.74						
			214sh	+41.21	193	−213.72						
(+)-(**19f**)	274	+1.67	216	+1.53	190	+124.27	275	+1.35	215	+2.84	195	+167.12
	251	−0.02			181	−129.77					183	−144.45
(+)-(**19g**)	273	+3.99	228	−18.89	199	+97.77	278	+3.28	216	+17.52	195	+218.54
					185	−108.37					182	−208.52
(+)-(**19h**)	270	+0.48	228	+22.30	199	+96.41	278	+3.52	230	−8.35	195	+180.00
			214	−15.51	185	−121.17			215	+19.30	183	−171.68
(+)-(**19k**)	272	+2.82	230	−2.37	199	+97.92	278	+4.23	232	−0.80	195	+231.27
			215	+16.61	185	−133.83			216	+11.73	182	−206.63
(+)-(**19l**)	282	+2.28	231	+20.19	203	+239.48	279	+4.59	233	+2.47	198	+323.52
	257	−0.04			193	−278.69			220	−0.47	188	−286.05
(+)-(**19m**)	282	+0.72	231	+36.74	203	+230.40	276	+4.30	240	−0.06	198	+271.62
					193	−286.20			226	+1.09	187	−253.52
(+)-(**19o**)	270	+0.64	228	+22.35	199	+96.83	277	+2.90	233	−0.42	194	+152.36
					185	−139.12			216	+13.01	183	−153.63
(+)-(**19p**)	284	+1.53	231	+29.29	203	+236.94	278	+4.05	229	+9.37	198	+231.11
	263	−0.18	219	−1.78	193	−280.09					187	−230.66
(+)-(**19q**)	272	+2.68	277	+35.28	203	+226.36	278	+5.10	236	−5.00	198	+186.59
					193	−287.11			223	+7.10	187	−196.20

* sh: shoulder

transitions. Since the ^1B benzenoid transitions of benzene and *o*-dimethoxybenzene are degenerate in energy and of the same order of magnitude,[25] the rotational strengths associated with the ^1B transitions of (+)-(**19a, l, m, p,** and **q**) were independent of the choice of polarization modes but could be determined by the geometry according to the dipole-dipole approximation, as shown earlier.[26] The empirical rule was supported by both Methods 1 and 2.

The ^1B transition of anisole was also degenerate in energy but different in magnitude.[25] Although the polarization is not isotropic in the benzene plane, both methods showed that the rotational strengths were of the positive couplet pattern for compound (+)-(**19f**).

Compounds (+)-(**19c** and **d**) have two chromophores, benzene and *o*-dimethoxybenzene, which have degenerate local transition energies. Compounds (+)-(**19b, g, h, k,** and **o**) are made up from two chromophores having degenerate local transition energies, but that for one of the chromophores, anisole, is different in magnitude. Method 1 indicated that the main configuration of the transition is located on one of the benzenoid transitions. But the orientation of the local transition dipole moment was little affected by the position of the methoxy substituents. The empirical rule still holds in these compounds and the couplet pattern in the ^1B transition can be used to determine the absolute configuration of the compounds containing two benzene chromophores.

In the second region of the transition, 240—215 nm, four compounds (+)-(**19c, f, l,** and **p**), showed Cotton effect signs the reverse of the theoretical ones obtained by Method 1. Method 2 also failed to explain the sign for this region.

The question arises as to whether the conformation in the crystalline state is the same as that in a solution. The stable conformation was estimated by molecular mechanics (MM2) calculations on the *N*-methyl derivative of (**19a**). This suggested that the stable conformation has a dihedral angles of C(1)–C(11c)–C(11b)–C(11a) 68.7°; C(11c)–C(11b)–C(11a)–C(11) −35.9°; and ∠C(11c)–C(11b)–C(11a) 118.0°. The difference in the geometries obtained from the results of the *X*-ray analysis and the MM2 calculation were very small. We obtained the theoretical curves using the geometry from the MM2 calculations, assuming that the benzene rings were planar, in order to determine if the small differences in the geometry affected the c.d. curve. The two theoretical curves were almost identical, but fail to explain the observed c.d. for the second region of the transition. In the second region, 2,3-dimethoxy derivatives, (+)-(**19c, g, l,** and **p**), and 3,4-dimethoxy compounds (+)-(**19d, h, m,** and **q**) showed, respectively, negative and positive Cotton effects.

The sign seemed to be determined by the isoquinoline chromophore. This tendency led to the sector rule as depicted in Figure 7, in which the arrows in the formula indicate the direction of projection for the isoquinoline chromophore. Projections A and B show 2,3- and 3,4-dimethoxy compounds respectively. However, Snazke *eta al.* have reported that the sector rule is difficult to formulate for the ^1L_a transition of the substituted benzene chromophore,[27] although they have put forward a sector rule for the chiral ^1L_b transition of substituted benzene chromophores.[28] Thus, the above rule cannot be generalized.

Thus, the coupled oscillator theory seems to be suitable for the analysis of the c.d. spectrum of these compounds and, in fact, the Cotton effect could be explained by this theory in both regions of the ^1L_b and ^1B transitions. However in the ^1L_a transition, the α-bond perturbation may play an important role and this band should not be used to determine absolute configurations.

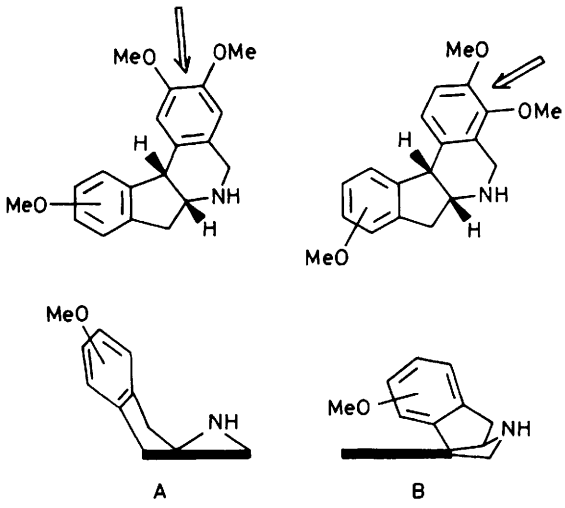


Figure 7. Projection diagrams of 2,3-dimethoxy (A) and 3,4-dimethoxy (B) compounds. The arrows indicate the direction of the projection

Pharmacological Screening.—The products were subjected to preliminary pharmacological screening but were devoid of any noteworthy activity. The skeleton allows for considerable conformational flexibility, but the most stable conformer did not attain the extended (*trans*) form as shown by the *X*-ray analysis. The benzene ring and nitrogen are of *cis* orientation and the distances are 3.8 and 4.0 Å which are shorter than that necessary for dopamine-like activity. Compound (**19**) probably cannot interact with the receptor owing to the shorter distance.

Experimental

Melting points are uncorrected. Optical rotations were determined with a Perkin-Elmer Model 141 polarimeter, using a 1.0-dm microcell. C.d. curves were obtained using a JASCO Model J-40 spectropolarimeter. I.r. spectra were recorded on a JASCO-A-702 spectrophotometer. ^{1}H N.m.r. spectra were measured with Varian XL200 and EM390 spectrometers using tetramethylsilane as the internal standard. U.v. spectra were obtained on a Hitachi Model 323 spectrometer. Mass spectra were taken with a Hitachi M-68 Mass Spectrometer. *X*-Ray diffraction data were collected with a Rigaku diffractometer using graphite-monochromatized Cu-K_α radiation (λ = 1.541 78 Å).

trans-2-*Amino*-5-*methoxyindan*-1-*ol* (**4a**) *and* trans-1,5-*Dimethoxy*-2-*aminoindan* (**4b**).—A mixture of 2-hydroxyiminoindan-1-one[9] (52.5 g) and 5% Pd-C (3.0 g) in methanol (700 ml) and water (100 ml) was stirred at room temperature under a H_2 atmosphere for 7 h. Two equivalents of H_2 were absorbed. The catalyst was filtered off and washed with methanol. To the filtrate, $NaBH_4$ (11 g) was added in small portions with cooling in ice under a N_2 atmosphere. The mixture was stirred at 0 °C for 2 h after which dilute HCl was added. The mixture was concentrated under reduced pressure. at 60 °C to dryness and methanol was added to the residue. The insoluble materials were removed by filtration. Ether was added and the solid was collected by filtration. The crude product (33.1 g) was fractionally recrystallized from methanol–ether to give (**4a**) (11.7 g) and (**4b**) (14.3 g).

5,6-*Dimethoxyindan*-1-*one* O-p-*Tolylsulphonyloxime* (**11c**).—5,6-Dimethoxyindan-1-one oxime[13] (**11b**) (36.2 g) was added in small portions to a solution of toluene-*p*-sulphonyl chloride (63.4 g) in pyridine (400 ml) with ice cooling and stirring. The mixture was stirred at 0 °C for 2 h, allowed to stand at 4 °C overnight, and then poured into ice–water. The solid was collected by filtration, washed with water, and dried (60.6 g). A small portion of the product was recrystallized from acetone; it had m.p. 174—178 °C (decomp.); $\nu_{max.}$(Nujol) 1 598 cm^{-1} (Found: C, 59.8; H, 5.3; N, 3.9; S, 8.85. $C_{18}H_{19}NO_5S$ requires C, 59.2; H, 4.9; N, 3.75; S, 8.85%).

5,6-*Dimethoxy*-2-*aminoindan*-1-*one Hydrochloride* (**10b**).—A suspension of the tolylsulphonyl oxime (**11c**) (60.0 g) in dry benzene (400 ml) was added to a solution of freshly prepared KOEt in ethanol (K, 6.6 g in 210 ml) with ice cooling and stirring. The mixture was stirred at 0 °C for 6 h and then kept at 0 °C overnight. The solid was filtered off and washed with dry benzene. The filtrate was extracted with ice-cold dilute HCl. The solution was washed with benzene and concentrated under reduced pressure at 40 °C. The residue was crystallized from methanol–ether to give a product (17.0 g; 42%) which was used in the next procedure without further purification owing to its instability.

The solid (35.8 g, 59.1%) from the reaction mixture was washed with water and dried and found to be the starting material.

cis-2-*Amino*-1,5,6-*trimethoxyindan* (**6**).—Aqueous NaOH (2.0 g/10ml) was added to a suspension of the salt (**10b**) (8.5 g) in methanol (50 ml) with ice cooling and stirring under a nitrogen atmosphere. $NaBH_4$ (3.2 g) was then added in small portions to the solution with ice cooling. The mixture was stirred at 0 °C under a nitrogen atmosphere for 2 h after which dilute HCl was added. The mixture was concentrated under reduced pressure at 40 °C and the residue was extracted with methanol. The solution was treated with charcoal and concentrated under reduced pressure at 40 °C. The crystalline residue was recrystallized from methanol–ether and gave a colourless powder (3.9g, 45.5%), m.p. 150 °C (decomp.).

The salt was shaken with aqueous NaOH and extracted with chloroform. The solution was washed with water, dried (Na_2SO_4), and concentrated under reduced pressure. The residue was distilled at 150 °C (bath temp.) at 1 mmHg. The n.m.r. spectra showed a small amount of contamination of the *trans*-isomer. The product was used without further purification in the next optical resolution.

cis-2-*Amino*-4,5-*dimethoxyindan*-1-*ol* (**5a**).—2-Amino-4,5-dimethoxyindan-1-one (**10a**) ·HCl[12] (15.5 g) was treated by the same procedure cited above. The salt (14.4 g, 92.1%) was recrystallized from methanol–ether; it had m.p. 200—202 °C (decomp.).

The free amine was recrystallized from ethyl acetate and had m.p. 135—136 °C; δ($CDCl_3$) 2.72 (1 H, dd, *J* 16 Hz), 3.16 (1 H, dd, *J* 16 Hz), 3.66 (1 H, m), 3.83 (6 H, s), 4.73 (1 H, d, *J* 5 Hz), 6.80 (1 H, d, *J* 9 Hz), and 7.11 (1 H, d, *J* 9 Hz).

Optical Resolution of trans-2-*Amino*-5-*methoxyindan*-1-*ol* (**4e**).—A methanol solution (30 ml) of the amino alcohol (**4a**), prepared from the HCl salt (11.7 g), was added to a solution of L-(+)-tartaric acid (8.2 g) in water. The salt was collected by filtration, washed with water, and recrystallized three times from water to give a pure diastereoisomer (4.25 g), m.p. 171—172 °C (decomp.); $[\alpha]_D^{23}$ +12.3° ± 0.5 (*c* 0.932, H_2O) (Found: C, 45.8; H, 6.25; N, 4.15. $C_{14}H_{19}NO_8 \cdot 2H_2O$ requires C, 46.05; H, 6.35; N, 3.85%).

The salt was shaken with aqueous NaOH. The crystals were collected by filtration, washed with water, and recrystallized from methanol–ether to give a colourless powder (1.85 g), m.p. 179—180 °C; $[\alpha]_D^{24}$ −8.3° ± 0.4 (*c* 0.996, MeOH); $\nu_{max.}$(Nujol) 3 365 and 3 290 cm^{-1}; $\nu_{max.}$ (dilute solution in CCl_4) 3 627,

3 596, and 3 388 cm $^{-1}$; δ[$(CD_3)_2SO$] 2.2—2.5 (1 H, m), 2.8—3.4 (2 H, m), 3.71 (3 H, s), 4.48 (1 H, d, *J* 6 Hz), 6.6—6.9 (2 H, m), and 7.1—7.3 (1 H, m) (Found: C, 65.85; H, 7.25; N, 7.65. $C_{10}H_{13}NO_2$ requires C, 67.0; H, 7.3; N, 7.8%).

Partially resolved (+)-isomer was recovered from the mother-liquor and the optically pure (+)-amine, (+)-(**4a**) was obtained in the same manner with D-(−)-tartaric acid; yield 1.75 g; $[\alpha]_D^{25}$ +8.7° ± 0.5 (*c* 1.057, MeOH).

Optical Resolution of cis-2-*Amino*-4,5-*dimethoxyindan*-1-*ol* (**5a**).—A warm solution of the amino alcohol (**5a**) (1.24 g) in ethanol (5 ml) was added to a solution of D-(−)-mandelic acid (0.95 g) in ethanol (3 ml). The solution was warmed briefly and then left at room temperature. The salt was collected by filtration, washed with ethanol, and recrystallized twice from ethanol to give a pure diastereoisomer (1.1 g), m.p. 208—209 °C; $[\alpha]_D^{23}$ −32.5° ± 0.6 (*c* 1.047, MeOH).

The salt treated as above gave the free amine (0.554 g), m.p. 129—130 °C; $[\alpha]_D^{23}$ +15.5° ± 0.6 (*c* 0.896, MeOH); $\nu_{max.}$(Nujol) 3 355, 3 280, 1 075, and 1 025 cm $^{-1}$; $\nu_{max.}$ (dilute solution in CCl_4) 3 612, 3 473, 3 412, and 3 333 cm $^{-1}$ (Found: C, 62.6; H, 7.15; N, 6.6. $C_{11}H_{15}NO_3$ requires C, 63.15; H, 7.25; N, 6.7%).

The (+)-amine was obtained with L-(+)-mandelic acid after recovery of the mother-liquor; $[\alpha]_D^{23}$ −15.1° ± 0.5 (*c* 1.105, MeOH).

Optical Resolution of cis-2-*Amino*-1,5,6-*trimethoxyindan* (**6**).—A solution of the amine (**6**) (5.15 g) in ethanol (20 ml) was added to a solution of L-(+)-tartaric acid (3.8 g) in water. The solution was concentrated under reduced pressure and the residue was crystallized from methanol–ethanol and recrystallized from methanol (×4) to give a pure diastereoisomer (1.3 g), m.p. 176 °C (decomp.); $[\alpha]_D^{23}$ +19.8° ± 0.5 (*c* 1.160, MeOH) (Found: C, 50.5; H, 6.1; N, 3.95. $C_{16}H_{23}NO_9$ requires C, 51.45; H, 6.2; N, 3.75%).

The free amine (+)-(**6**) was subjected to short-path distillation at 150 °C (bath temp.) at 1 mmHg, $[\alpha]_D^{23}$ +13.3° ± 0.3 (*c* 1.635, MeOH); $\nu_{max.}$(film): 3 375 and 1 120 cm $^{-1}$; $\nu_{max.}$ (dilute solution in CCl_4) 3 393 and 3 328 cm $^{-1}$; δ($CDCl_3$): 2.70 (1 H, dd, *J* 15, 6 Hz), 3.00 (1 H, dd, *J* 15, 6 Hz), 3.46 (3 H, s), 3.70 (1 H, m), 3.85 (3 H, s), 3.88 (3 H, s), 4.35 (1 H, d, *J* 5 Hz), and 6.78 (1 H, s) (Found: C, 64.25; H, 7.55; N, 6.1. $C_{12}H_{17}NO_3$ requires C, 64.55; H, 7.65; N, 6.3%).

Optical Resolution of trans-1,5-*Dimethoxy*-2-*aminoindan* (**4b**).—A solution of the amine (**4b**) in dichloromethane, prepared from the HCl salt (15.1 g), was added to an aqueous solution of L-(+)-tartaric acid (10.5 g). The mixture was concentrated under reduced pressure and the residue diluted with water. The crystals were collected by filtration, washed with water, and recrystallized (×3) from methanol to give a pure diastereoisomer (4.3 g); $[\alpha]_D^{23}$ −3.0° ± 0.5, $[\alpha]_{436}^{23}$ −13.6° ± 0.5 (*c* 0.993, MeOH).

The salt was treated with aqueous NaOH as above and gave an oily residue; δ($CDCl_3$) 2.74 (1 H, dd, *J* 18, 9 Hz), 3.00 (1 H, dd, *J* 18, 9 Hz), 3.38 (3 H, s), 3.5—3.8 (1 H, m), 3.76 (3 H, s), 4.27 (1 H, d, *J* 5 Hz), 6.6—6.8 (2 H, m), and 7.25 (1 H, d, *J* 9 Hz).

The HCl salt had m.p. *ca.* 170 °C (decomp.); $[\alpha]_D^{24}$ −24.4° ± 0.7 (*c* 0.803, MeOH); $\nu_{max.}$(Nujol) 1 090 cm $^{-1}$; *m/z* 193 (Found: C, 57.2; H, 6.95; Cl, 15.4; N, 6.15. $C_{11}H_{16}ClNO_2$ requires C, 57.5; H, 6.95; Cl, 15.45 N, 6.1%).

Determination of the Optical Purity of (−)-(**4a**), (+)-(**5a**), *and* (−)-(**6**).—A solution of *R*-(+)-α-methoxy-α-trifluoromethylphenylacetic acid chloride [14] (50 mg) in pyridine (2.3 ml) was added to the (+)-amino alcohol (+)-(**5a**) (15 mg). After 2 days at room temperature the solution was poured into ice-cold dilute HCl and extracted with dichloromethane. The solution was washed with aqueous $NaHCO_3$ and water and concentrated under reduced pressure. The residue was heated in 5% methanolic KOH (10 ml) under reflux for 1 h after which the mixture was poured into water and extracted with dichloromethane. The solution was washed with dilute HCl and water, dried (Na_2SO_4), and concentrated under reduced pressure to give a crystalline residue; δ($CDCl_3$) 2.87 (1 H, dd, *J* 15, 8 Hz), 3.41 (3 H, d, *J* 1 Hz), 3.47 (1 H, dd, *J* 15, 8 Hz), 3.85 (6 H, s), 4.58 (1 H, m), 4.97 (1 H, d, *J* 6 Hz), 6.80 (1 H, d, *J* 8 Hz), 7.09 (1 H, d, *J* 8 Hz), and 7.3—7.7 (5 H, m). The residue was recrystallized from benzene–hexane and had m.p. 148—149 °C; $[\alpha]_D^{23}$ +11.2° ± 0.5 (*c* 0.919, $CHCl_3$); $\nu_{max.}$($CHCl_3$) 3 610, 3 410, and 1 690 cm $^{-1}$; $\nu_{max.}$ [2.980 mg in CCl_4 (10 ml)] 3 615, 3 422, and 1 701 cm $^{-1}$ (Found: C, 59.3; H, 5.3; F, 13.35; N, 3.3%. $C_{21}H_{22}F_3NO_5$ requires C, 59.3; H, 5.2; F, 13.4; N, 3.3%).

Compounds (−)-(**4a**) and (−)-(**6**) were treated as above. The amide of (−)-(**4a**): δ($CDCl_3$) 2.74 (1 H, dd, *J* 15, 8 Hz), 3.42 (3 H, d, *J* 1 Hz), 3.2—3.6 (1 H, m), 4.30 (1 H, m), 5.08 (1 H, d, *J* 5 Hz), 6.6—6.9 (2 H, m), and 7.1—7.7 (6 H, m); $\nu_{max.}$($CDCl_3$) 3 420 and 1 685 cm $^{-1}$; $\nu_{max.}$ (dilute solution of CCl_4) 3 593, 3 477, 3 425, 1 703sh, and 1 691 cm $^{-1}$.

The amide of (−)-(**6**): δ($CDCl_3$) 2.89 (1 H, dd, *J* 6, 17 Hz), 3.25 (1 H, dd, *J* 6, 17 Hz), 3.29 (3 H, s), 3.40 (3 H, d, *J* 1 Hz), 3.89 (6 H, s), 4.56 (1 H, d, *J* 4 Hz), 4.72 (1 H, m), 6.78 (1 H, s), 6.88 (1 H, s), and 7.3—7.7 (5 H, m); $\nu_{max.}$($CHCl_3$) 3 420 and 1 693 cm $^{-1}$.

The racemic compounds (**4a**), (**5a**), and (**6**) were treated as above. The amide of (±)-(**4a**): doublet signals at δ 5.01 and 3.40 in addition to 5.08 and 3.42. The amide of (±)-(**5a**): doublet signal at δ 3.46 and 5.03 in addition to 3.41 and 4.97. The amide of (±)(**6**): singlet signal at δ 3.51 in addition to one at 3.29 (1-MeO).

General Procedure for Preparation of the Schiff Base and the Oxazolidine.—The amine (0.1 mol) and the aldehyde (0.3 mol) in benzene were heated under reflux for 10 h with continuous water removal. Either the crystals were collected by filtration or the solution was concentrated under reduced pressure and at 150 °C (bath temp.) at 1 mmHg and crystallized from benzene–hexane.

(+)-(1S,2S)-2-*Benzylideneaminoindan*-1-*ol* (+)-(**13a**): 98.5% yield; m.p. 187 °C; $[\alpha]_D^{23}$ +26.5° ± 0.6 (*c* 1.046, $CHCl_3$); $\nu_{max.}$(Nujol) 3 250, 1 641, and 1 067 cm $^{-1}$; δ[$(CD_3)_2SO$] 2.92 (1 H, dd, *J* 8, 15 Hz), 3.16 (1 H, dd, *J* 8, 15 Hz), 3.94 (1 H, m), 5.62 (1 H, d, *J* 8 Hz), 7.2—7.6 (7 H, m), 7.82 (2 H, m), and 8.48 (1 H, s); u.v. $\lambda_{max.}$(MeOH) 287sh (ε 1 610), 279sh (2 910), 272 (6 200), 249 (22 700), 210sh (31 900), 205 (42 100), and 195.5 nm (60 400); c.d. $\lambda_{max.}$(MeOH): 271 (Δε −1.84), 243 (+7.85), 220sh (+2.82), 207 (−2.28), and 197 nm (−4.03) (Found: C, 81.1; H, 6.45; N, 5.9. $C_{16}H_{15}NO$ requires C, 81.0; H, 6.35; N, 5.9%).

(+)-(1S,2S)-2-(3-*Methoxybenzylideneamino*)*indan*-1-*ol* (+)-(**13b**):83.0% yield; m.p. 132—133 °C; $[\alpha]_D^{24}$ +25.9° ± 0.7 (*c* 0.842, $CHCl_3$); $\nu_{max.}$(Nujol) 3 230 and 1 640 cm $^{-1}$; δ($CDCl_3$) 3.05 (1 H, s), 3.14 (1 H, s), 3.79 (3 H, s), 3.94 (1 H, m), 5.28 (1 H, d, *J* 7 Hz), 6.8—7.5 (8 H, m), and 8.35 (1 H, s); u.v. $\lambda_{max.}$(MeOH) 303 (ε 3 690), 271 (5 940), 257sh (16 200), 253 (17 000), and 212 nm (32 900); c.d. $\lambda_{max.}$(MeOH) 272 (Δε −1.74), 247 (+4.30), 225sh (+2.78), and 197 nm (−1.67) (Found: C, 76.1; H, 6.35; N, 5.15. $C_{17}H_{17}NO_2$ requires C, 76.4; H, 6.4; N, 5.25%).

(+)-(1S,2S)-2-(3,4-*Dimethoxybenzylideneamino*)*indan*-1-*ol* (+)-(**13c**): 88.9% yield; m.p. 155—156 °C; $[\alpha]_D^{23}$ +33.4° ± 0.6 (*c* 0.995, $CHCl_3$); $\nu_{max.}$(Nujol) 3 220 and 1 634 cm $^{-1}$; δ($CDCl_3$) 3.07 (2 H, d, *J* 9 Hz), 3.89 (6 H, s), 3.9 (1 H, m), 5.30 (1 H, d, *J* 6 Hz), 7.0—7.5 (6 H, m), and 8.19 (1 H, s); u.v. $\lambda_{max.}$(MeOH) 303 (ε 13 100), 272 (19 900), 268 (19 300), 225sh (19 700), and 209 nm (32 900); c.d. $\lambda_{max.}$(MeOH) 300 (Δε +0.84), 268 (+1.20), 260 (+1.66), 255 (+1.48), 223 (+4.42), and 200 nm (−2.85)

(Found: C, 72.15; H, 6.5; N, 4.7. $C_{18}H_{19}NO_3$ requires C, 72.7; H, 6.45; N, 4.7%).

(+)-(1S,2S)-2-(2,3-*Dimethoxybenzylideneamino*)*indan*-1-*ol* (+)-(**13d**): 97.1% yield; m.p. 168—169 °C; $[\alpha]_D^{24}$ +14.1° ± 0.5 (*c* 0.937, $CHCl_3$); $\nu_{max.}$(Nujol) 3 225 and 1 645 cm^{-1}; δ($CDCl_3$) 3.08 (1 H, s), 3.18 (1 H, s), 3.88 (6 H, s), 3.8—4.2 (1 H, m), 5.39 (1 H, d, *J* 7 Hz), 6.9—7.4 (6 H, m), 7.63 (1 H, dd, *J* 2, 7 Hz), and 8.83 (1 H, s); u.v. $\lambda_{max.}$(MeOH) 306 (ε 2 430), 271 (10 400), 265sh (15 500), 258(17 400), and 218 (35 800); c.d. $\lambda_{max.}$(MeOH) 278 (Δε −1.43), 245 (+2.86), 235sh (+2.16), 220sh (+0.818), and 198 (−0.364) (Found: C, 72.55; H, 6.4; N, 4.8. $C_{18}H_{19}NO_3$ requires C, 72.7; H, 6.45; N, 4.7%).

(−)-(1R,2R)-2-*Benzylideneamino*-5-*methoxyindan*-1-*ol* (−)-(**13e**): 96.3% yield; m.p. 143—145 °C; $[\alpha]_D^{25}$ −3.7° ± 0.7 (*c* 1.150, $CHCl_3$); $\nu_{max.}$(Nujol) 3 230 and 1 635 cm^{-1}; δ($CDCl_3$) 3.07 (1 H, s), 3.15 (1 H, s), 3.80 (3 H, s), 3.95 (1 H, m), 5.22 (1 H, d, *J* 6 Hz), 6.7—6.9 (2 H, m), 7.2—7.5 (4 H, m), 7.7—7.9 (2 H, m), 8.41 (1 H, s,); u.v. $\lambda_{max.}$(MeOH) 286 (ε 4 860), 280sh (6 250), 249 (21 700), 234sh (17 000), 212sh (24 900), and 201 nm (65 500); c.d. $\lambda_{max.}$(MeOH) 285sh (Δε +0.315), 275 (+0.676), 238 (+0.676), 225 (−1.89), 214 (−2.16), and 200 nm (−2.70) (Found: C, 75.95; H, 6.2; N, 5.2. $C_{17}H_{17}NO_2$ requires C, 76.4; H, 6.4; N, 5.25%).

(−)-(1R,2R)-2-(3-*Methoxybenzylideneamino*)-5-*methoxyindan*-1-*ol* (−)-(**13f**): 92.0% yield; m.p. 140—141 °C; $[\alpha]_D^{24}$ −2.8° ± 0.5, $[\alpha]_{365}^{24}$ +47.3° ± 1.3 (*c* 0.974, $CHCl_3$); $\nu_{max.}$(Nujol) 3 240, 1640, and 1 078 cm^{-1}; δ($CDCl_3$) 3.04 (1 H, s), 3.12 (1 H, s), 3.78 (3 H, s), 3.82 (3 H, s), 3.7—4.1 (1 H, m), 5.21 (1 H, d, *J* 6 Hz), 6.7—7.1 (3 H, m), 7.2—7.4 (4 H, m), and 8.31 (1 H, s); u.v. $\lambda_{max.}$(MeOH) 302 (ε 3 810), 287 (5 520), 280sh (5 840), 253 (17 300), 220 (32 600), and 199 nm (56 500); c.d. $\lambda_{max.}$(MeOH) 276 (Δε +2.35), 259.5 (−0.379), and 220 nm (+1.62) (Found: C, 72.1; H, 6.15; N, 5.0. $C_{18}H_{19}NO_3$ requires C, 72.7; H, 6.45, N, 4.7%).

(+)-(1S,2S)-2-(3,4-*Dimethoxybenzylideneamino*)-5-*methoxyindan*-1-*ol* (+)-(**13g**): 82.1% yield; m.p. 169—170 °C; $[\alpha]_D^{24}$ +2.3° ± 0.5, $[\alpha]_{365}^{24}$ 6.6° ± 0.5 (*c* 0.922, $CHCl_3$); $\nu_{max.}$(Nujol); 3 230 and 1 635 cm^{-1}; δ($CDCl_3$) 3.07 (1 H, s), 3.15 (1 H, s), 3.81 (3 H, s), 3.93 (6 H, s), 3.7—4.1 (1 H, m), 5.24 (1 H, d, *J* 7 Hz), 6.7—7.6 (6 H, m), and 8.31 (1 H, s); u.v. $\lambda_{max.}$(MeOH) 303 (ε 13 100), 287sh (14 100), 272 (19 600), 227 (26 400), and 199 nm (52 700); c.d. $\lambda_{max.}$(MeOH) 275 (Δε −2.29), 239 (+1.24), 227 (+1.12), and 190 nm (−0.73) (Found: C, 69.2; H, 6.35; N, 4.20%. $C_{19}H_{21}NO_4$ requires C, 69.7; H, 6.45; N, 4.3%).

(+)-(1S,2S)-2-(2,3-*Dimethoxybenzylideneamino*)-5-*methoxyindan*-1-*ol* (+)-(**13h**): 85.9% yield; m.p. 194 °C; $[\alpha]_D^{24}$ +3.5° ± 0.4, $[\alpha]_{365}^{24}$ −62.1° ± 0.6 (*c* 1.297, $CHCl_3$); $\nu_{max.}$(Nujol) 3 205 and 1 642 cm^{-1}; δ($CDCl_3$) 3.09 (1 H, s), 3.18 (1 H, s), 3.81 (3 H, s), 3.90 (3 H, s), 3.95 (1 H, m), 5.23 (1 H, d, *J* 6 Hz), 6.7—7.7 (6 H, m), and 8.83 (1 H, s); u.v. $\lambda_{max.}$(MeOH) 305 (ε 2 510), 286 (5 670), 258 (17 100), 223 (38 300), and 198 nm (52 600); c.d. $\lambda_{max.}$(MeOH) 278 (Δε −3.58), 250 (+3.00), 230 (+4.61), 200 (+7.61), and 190 nm (−3.45) (Found: C, 69.6; H, 6.4; N, 4.15. $C_{19}H_{21}NO_4$ requires c, 69.7; H, 6.45; N, 4.3%).

(−)-(1S,2R)-2-*Benzylideneamino*-1,5,6-*trimethoxyindan* (−)-(**17n**): 80.5% yield; m.p. 163—164 °C; $[\alpha]_D^{23}$ −16.6° ± 0.4 (*c* 1.246, $CHCl_3$); $\nu_{max.}$(Nujol) 1 640 cm^{-1}; δ($CDCl_3$) 2.98 (1 H, dd, *J* 7, 15 Hz), 3.23 (1 H, dd, *J* 7, 15 Hz), 3.42 (3 H, s), 3.86 (3 H, s), 3.88 (3 H, s), 4.31 (1 H, m), 4.75 (1 H, dd, *J* 5 Hz), 6.79 (1 H, s), 6.95 (1 H, s), 7.3—7.5 (3 H, m), and 8.45 (1 H, s); u.v. $\lambda_{max.}$(MeOH) 288sh (ε 7 360), 284 (7 640), 243 (21 400), and 203 nm (71 100); c.d. $\lambda_{max.}$(MeOH) 292sh (Δε +0.568), 285 (+0.727), 250 (−2.48), 227 (+3.36), 212 (+5.67), and 203.5 nm (−4.97) (Found: C, 73.4; H, 6.85; N, 4.4. $C_{19}H_{21}NO_3$ requires C, 73.3; H, 6.8; N, 4.5%).

(+)-(2S,2R)-2-(3-*Methoxybenzylideneamino*)-1,5,6-*trimethoxyindan* (+)-(**17o**): 68.0% yield; m.p. 107—108 °C; $[\alpha]_D^{23}$ +11.1° ± 0.4 (*c* 1.104, $CHCl_3$); $\nu_{max.}$(Nujol) 1 638 cm^{-1}; δ($CDCl_3$) 2.98 (1 H, dd, *J* 7, 15 Hz), 3.25 (1 H, dd, *J* 7, 15 Hz), 3.43 (3 H, s), 3.82 (3 H, s), 3.87 (3 H, s), 3.89 (3 H, s), 4.33 (1 H, m), 4.77 (1 H, d, *J* 5 Hz), 6.81 (1 H, s), 6.96 (1 H, s), 7.2—7.5 (4 H, m), and 8.43 (1 H, s); u.v. $\lambda_{max.}$(MeOH) 310sh (ε 3 510), 289 (8 180), 252 (16 400), 219sh (31 500), and 203 (58 300); c.d. $\lambda_{max.}$(MeOH) 310 (Δε −0.182), 288.5 (+0.867), 250 (−2.58), 230 (+4.12), 215 (−0.606), and 204 nm (+4.27) (Found: C, 70.35; H, 6.65; N, 4.0. $C_{20}H_{23}NO_4$ requires C, 70.35; H, 6.8; N, 4.1%).

(−)-(2S,2R)-2-(3,4-*Dimethoxybenzylideneamino*)-1,5,6-*trimethoxyindan* (−)-(**17p**): 80.5% yield; m.p. 132—133 °C; $[\alpha]_D^{23}$ −7.9° ± 0.4 (*c* 1.101, $CHCl_3$); $\nu_{max.}$(Nujol) 1 640 cm^{-1}; δ($CDCl_3$) 2.98 (1 H, dd, *J* 7, 15 Hz), 3.25 (1 H, dd, *J* 7, 15 Hz), 3.44 (3 H, s), 3.90 (6 H, s), 3.92 (6 H, s), 4.29 (1 H, m), 4.75 (1 H, d, *J* 5 Hz), 6.81 (1 H, s), 6.87 (1 H, d, *J* 9 Hz), 6.96 (1 H, s), 7.31 (1 H, d, *J* 9 Hz), 7.49 (1 H, d, *J* 2 Hz), and 8.37 (1 H, s); u.v. $\lambda_{max.}$(MeOH) 310sh (ε 10 900), 295 (15 000), 272 (18 600), 226 (23 800), and 203 nm (57 500); c.d. $\lambda_{max.}$(MeOH) 305 (Δε −0.609), 291 (+0.633), 265 (−2.13), 230 (+2.23), and 220 nm (+3.51) (Found: C, 67.8; H, 6.75; N, 3.8. $C_{21}H_{25}NO_5$ requires C, 67.9; H, 6.8; N, 3.75%).

(−)-(2S,2R)-2-(2,3-*Dimethoxybenzylideneamino*)-1,5,6-*trimethoxyindan* (−)-(**17q**): 67.3% yield; m.p. 120 °C; $[\alpha]_D^{23}$ −10.1° ± 0.5 (*c* 1.078, $CHCl_3$); $\nu_{max.}$(Nujol) 1 640cm^{-1}; ($CDCl_3$) 3.01 (1 H, dd, *J* 7, 16 Hz), 3.25 (1 H, dd, *J* 7, 16 Hz), 3.43 (3 H, s), 3.88 (6 H, s), 3.90 (6 H, s), 4.37 (1 H, m), 4.79 (1 H, d, *J* 5 Hz), 6.82 (1 H, s), 6.97 (1 H, s), 6.9—7.3 (2 H, m), 7.65 (1 H, dd, *J* 3, 7 Hz), and 8.84 (1 H, s); u.v. $\lambda_{max.}$(MeOH) 310sh (ε 2 500), 285 (8 490), 257 (16 000), 222 (36 900), and 202 nm (54 100); c.d. $\lambda_{max.}$(MeOH) 310 (Δε −0.15), 291sh (+0.473), 288 (+0.603), 282.5 (+0.603), 254 (−1.32), 227 (+6.61), and 203 nm (−3.00) (Found: C, 67.6; H, 6.6; N, 3.5. $C_{21}H_{25}NO_5$ requires C, 67.9; H, 6.8; N, 3.75%).

(−)-(2RS,4R,5S)-2-*Phenyl*-3,3a,4,8b-*tetrahydro*-2H-*indeno*-[2,1-d]*oxazole* (−)-(**15i**): 81.7% yield; m.p. 61—62 °C; $\nu_{max.}$(Nujol) 3 280 cm^{-1}. The n.m.r. spectrum showed this to be a mixture of the epimers.

(−)-(2RS,4R,5S)-5,6-*Dimethoxy*-2-*phenyl*-3,3a,4,8b-*tetrahydro*-2H-*indeno*[2,1-d]*oxazole* (−)-(**15j**): 84.4% yield; m.p. 93—95 °C; $\nu_{max.}$(Nujol) 3 315, 1 078, and 1 020 cm^{-1}. The n.m.r. spectrum showed this to be a mixture of the epimers (Found: C, 72.6; H, 6.35; N, 4.65. $C_{18}H_{19}NO_3$ requires C, 72.7; H, 6.45; N, 4.7%).

(−)-(1R,2R)-1,5-*Dimethoxy*-2-(3,4-*dimethoxybenzylideneamino*)*indan*, (+)-(2RS,4S,5R)-5,6-*dimethoxy*-2-(m-*methoxyphenyl*)-3,3a,4,8b-*tetrahydro*-2H-*indeno*[2,1-d]*oxazole* (+)-(**15k**), (−)-(2RS,4R,5S)-2-(3,4-*dimethoxyphenyl*)-5,6-*dimethoxy*-3,3a,4,8b-*tetrahydro*-2H-*indeno*[2,1-d]*oxazole* (−)-(**15l**) *and* (+)-(2RS,4S,5R)-2-(2,3-*dimethoxyphenyl*)-5,6-*dimethoxy*-3,3a,4,8b-*tetrahydro*-2H-*indeno*[2,1-d]*oxazole* (+)-(**15m**). These compounds could not be crystallized and were used in the next procedures without further purification.

General Procedure for Preparation of the Benzylamino Derivatives.—$NaBH_4$ (0.15 mol) was added to a suspension of the Schiff base or the oxazolidine derivatives (0.093 mol) in methanol (500 ml) with ice cooling and stirring under a nitrogen atmosphere. The solution was stirred at 0 °C for 2 h. Dilute HCl was added and the mixture was concentrated under reduced pressure. The residue was extracted with methanol and ether was added. The crystals were collected by filtration and dried. With concentration in an acidic medium, the compounds (**14f**), (**14h**), (**16k**), (**16m**), (**18o**), (**18p**), and (**18q**) cyclized to (**19f, h, k, m, o, p,** and **q**), and the benzylamino derivatives could not be isolated.

(+)-(1S,2S)-2-*Benzylaminoindan*-1-*ol* (+)-(**14a**): 91.3% yield; m.p. 135—136 °C; $[\alpha]_D^{23}$ +50.7° ± 0.7 (*c* 1.023, MeOH); $\nu_{max.}$(Nujol) 3 260 cm^{-1}; $\nu_{max.}$ (dilute solution in CCl_4) 3 625, 3 596, and 3 403 cm^{-1}; δ($CDCl_3$) 2.4—2.8 (1 H, m), 3.0—3.5

(2 H, m), 3.78 (1 H, d, *J* 15 Hz), 3.95 (1 H, d, *J* 15 Hz), 4.92 (1 H, d, *J* 6 Hz), and 7.1—7.5 (9 H, m); u.v. $\lambda_{max.}$(MeOH) 272 (ε 1 140), 265.5 (1 160), 259 (859), 253sh (550), 214sh (14 800), and 206 nm (20 400); c.d. $\lambda_{max.}$(MeOH) 269.5 (Δε +0.315), 263 (+0.382), 258sh (+0.297), 227 (−0.158), and 213 nm (+0.970) (Found: C, 79.9; H, 7.2; N, 5.85. $C_{16}H_{17}NO$ requires C, 80.3; H, 7.15; N, 5.85%).

The HCl salt: m.p. 221—222 °C; $[\alpha]_D^{23}$ +30.3° ± 0.6 (*c* 1.071, MeOH).

(+)-(1S,2S)-2-(3-*Methoxybenzylamino*)*indan*-1-*ol* (+)-(**14b**): 95.3% yield; m.p. 147—148 °C; $[\alpha]_D^{24}$ +38.0° ± 0.5 (*c* 1.387, MeOH); $\nu_{max.}$($CHCl_3$) 3 590 and 1 030 cm^{-1}; δ($CDCl_3$) 2.4—2.8 (1 H, m), 3.0—3.5 (2 H, m), 3.79 (6 H, s). 3.88 (2 H, s), 4.90 (1 H, d, *J* 5 Hz), 6.6—7.0 (5 H, m), and 7.1—7.4 (2 H, m); u.v. $\lambda_{max.}$(MeOH) 281 (ε 1 860), 272.5 (2 940), 266 (2 250), 260sh (1 370), 215sh (15 600), and 211sh nm (17 100); c.d. $\lambda_{max.}$(MeOH) 270 (Δε +0.342), 272 (+0.342), 272 (+0.370), 232 (−0.133), 211 (+1.19), and 205 nm (+1.19) (Found: C, 72.15; H, 7.05; N, 4.65. $C_{18}H_{21}NO_3$ requires C, 72.2; H, 7.05; N, 4.85%).

The HCl salt: m.p. 201—205 °C (decomp.); $[\alpha]_D^{25}$ +30.6° ± 0.6 (*c* 0.984, MeOH).

(+)-(1S,2S)-2-(3-*Dimethoxybenzylamino*)*indan*-1-*ol* (+)-(**14c**): 98.0% yield; m.p. 114—115 °C; $[\alpha]_D^{23}$ +35.3° ± 0.5 (*c* 1.189, $CHCl_3$); $\nu_{max.}$(Nujol) 3 250, 1 064, and 1 030 cm^{-1}; u.v. $\lambda_{max.}$(MeOH) 285sh (ε 2 600), 280 (3 040), 278 (3 040), 273 (3 460), 266 (2 470), 230 (8 910), 216sh (14 400), 201sh (61 600), and 196 nm (76 300) (Found: C, 71.9; H, 7.0; N, 4.7. $C_{18}H_{21}NO_4$ requires C, 72.2; H, 7.05; N, 4.7).

The HCl salt: m.p. 218—219 °C; $[\alpha]_D^{24}$ +29.7° ± 0.6 (*c* 0.948, MeOH).

(+)-(1S,2S)-2-(2,3-*Dimethoxybenzylamino*)*indan*-1-*ol* (+)-(**14d**): 70.4% yield; m.p. 141 °C $[\alpha]_D^{24}$ +57.6° ± 3.7 (*c* 0.187, MeOH); $\nu_{max.}$(Nujol) 3 290, 3 160, and 1 066 cm^{-1}; δ($CDCl_3$) 2.63 (1 H, m), 3.0—3.5 (2 H, m), 3.85 (3 H, s), 3.87 (3 H, s), 4.95 (1 H, d, *J* 7 Hz), and 6.7—7.4 (7 H, m); u.v. $\lambda_{max.}$(MeOH) 278sh (ε 1 620), 272 (2 600), 266 (2 040), 215sh (18 000), and 196 nm (54 000); c.d. $\lambda_{max.}$(MeOH) 269 (Δε +0.436), 262 (+0.436), 235 (−0.12), and 205 nm (+2.03) (Found: C, 72.0; H, 7.05; N, 4.7. $C_{18}H_{21}NO_3$ requires C, 72.2; H, 7.05; N, 4.7%).

(+)-(1S,2S)-2-*Benzylamino*-5-*methoxyindan*-1-*ol* (+)-**14e**): 91.2% yield; m.p. 152 °C; $[\alpha]_D^{24}$ +37.8° ± 0.5 (*c* 1.191, MeOH); $\nu_{max.}$(Nujol) 3 500 and 3 180 cm^{-1}; δ($CDCl_3$) 2.4—2.8 (1 H, m), 3.0—3.5 (2 H, m), 3.78 (3 H, s), 3.91 (2 H, s), 4.91 (1 H, d, *J* 6. Hz), 6.6—6.9 (2 H, m), and 7.1—7.5 (6 H, m); u.v. $\lambda_{max.}$(MeOH) 286 (ε 2 390), 280 (2 610), 278sh (2 550), 227 (15 600), and 198 nm (56 600); c.d. $\lambda_{max.}$(MeOH) 283 (Δε −0.582), 278.5 (−0.645, 230 (+0.852), and 200 nm (+7.82).

The HCl salt: m.p. 292 °C; $[\alpha]_D^{25}$ +16.9° ± 0.5 (*c* 1.065, MeOH) (Found: C, 66.45; H, 6.6; Cl, 11.45; N, 4.55. $C_{17}H_{20}ClNO_2$ requires C, 66.75; H, 6.5; Cl, 11.6; N, 4.6%).

(+)-(1S,2S)-2-(3,4-*Dimethoxybenzylamino*)-5-*methoxyindan*-1-*ol* (+)-(**14g**): m.p. 128—129 °C; $[\alpha]_D^{24}$ +35.2 ± 0.7 (*c* 0.885, MeOH); δ($CDCl_3$) 2.60 (1 H, m), 3.0—3.5 (2 H, m), 3.77 (3 H, s), 3.83 (3 H, s), 3.87 (3 H, s), 3.8—4.1 (2 H, m), 4.90 (1 H, d, *J* 6 Hz), and 6.6—7.2 (6 H, m); u.v. $\lambda_{max.}$(MeOH) 287 (ε 9 110), 230sh (15 600), and 202 nm (21 000); c.d. $\lambda_{max.}$(MeOH) 279 (Δε −0.558), 230 (+1.00), and 204 nm (+2.91) (Found : C, 68.7; H, 6.95; N, 4.3. $C_{19}H_{23}NO_4$ requires C, 69.3; H, 7.05; N, 4.25%).

The HCl salt: m.p. 204 °C (decomp.); $[\alpha]_D^{24}$ +14.3° ± 0.7 (*c* 0.753, MeOH); $\nu_{max.}$(Nujol) 3 270 and 1 042 cm^{-1}.

(−)-(1S,2S)-2-*Benzylamino*-4,5-*dimethoxyindan*-1-*ol* (−)-(**16j**): m.p. 156—157 °C; $[\alpha]_D^{23}$ −30.9° ± 0.7 (*c* 0.810, MeOH); $\nu_{max.}$($CDCl_3$) 3 590, 1 077, and 1 022 cm^{-1}; δ($CDCl_3$) 2.58 (1 H, m), 3.2—3.5 (2 H, m), 3.83 (6 H, s), 3.94 (2 H, s), 4.91 (1 H, d, *J* 5 Hz), 6.80 (1 H, d, *J* 9 Hz), 7.04 (1 H, d, *J* 9 Hz), and 7.2—7.4 (5 H, m); $\lambda_{max.}$(MeOH) 281 (ε 1 330), 276 (1 340), 274 (1 330), 227sh (8 960), and 203 nm (55 000).

(−)-(1S,2S)-2-(3,4-*Dimethoxybenzylamino*)-4,5-*dimethoxyindan*-1-*ol* (−)-(**16l**): 79.0% yield; m.p. 57 °C; $[\alpha]_D^{23}$ −13.8° ± 0.5 (*c* 1.043, MeOH); $\nu_{max.}$(Nujol) 3 290, 3 060, and 1 028 cm^{-1} δ($CDCl_3$) 2.78 (1 H, dd, *J* 7, 15 Hz), 3.16 (1 H, dd, *J* 7, 15 Hz), 3.41 (1 H, m), 3.83 (6 H, s), 3.86 (6 H, s), 3.88 (2 H, s), 4.79 (1 H, d, *J* 5 Hz), and 6.7—7.2 (5 H, m); u.v. $\lambda_{max.}$(MeOH) 280 (ε 4 100), 276sh (4 020), 231 (17 800), and 202 nm (92 100); c.d. $\lambda_{max.}$(MeOH) 276 (Δε +0.170), 269 (+0.145), 231 (−2.27), 200 (+3.39), and 190 nm (+1.97).

The HCl salt: m.p. 213—214 °C; $[\alpha]_D^{23}$ −15.9° ± 0.5 (*c* 0.980, MeOH) (Found: C, 59.8; H, 6.65; Cl, 8.75 N, 3.45. $C_{20}H_{26}ClNO_5$ requires C, 60.7; H, 6.6; Cl, 8.95; N, 3.55%).

(−)-(1S,2S)-2-*Benzylamino*-1,2,3,4-*tetrahydro*-1-*naphthol* (−)-(**21**): m.p. 80—81 °C; $[\alpha]_D^{24}$ −78.9 ± 0.4 (*c* 2.065, MeOH); $\nu_{max.}$(Nujol) 3 160; $\nu_{max.}$ (dilute solution in CCl_4) 3 616 and 3 443 cm^{-1}; δ($CDCl_3$) 1.5—2.3 (2 H, m), 2.7—3.1 (3 H, m), 3.78 (2 H, s), 4.65 (1 H, d, *J* 4 Hz), and 7.0—7.6 (9 H, m); u.v. $\lambda_{max.}$(MeOH) 272.5 (ε 408), 265 (521), 259 (479), 254 (360), 216sh (12 600), 206sh (19 500), and 195sh nm (68 100); c.d. $\lambda_{max.}$(MeOH) 270 (Δε −0.255), 262.5 (−0.312), and 217 nm (−0.682).

The HCl salt: m.p. 250 °C; $[\alpha]_D^{24}$ −68.6° ± 0.7 (*c* 1.157, MeOH) (Found: C, 70.6; H, 6.95; Cl, 12.1. N, 4.9. $C_{17}H_{20}ClNO$ requires C, 70.45; H, 6.95; Cl, 12.25; N, 4.85%).

General Procedure for Cyclization of the Benzylamino Derivatives.—(A) The benzylamino derivatives were treated according to the procedure cited in the literature.[17,18]

(B) The benzylamino derivatives were treated with concentrated hydrochloric acid at 70 °C for 10 min. The solution was then concentrated to dryness under reduced pressure or the crystalline salt was collected by filtration. Aqueous sodium hydroxide was added to the salt and the mixture was extracted with chloroform. The solution was washed with water, dried (Na_2SO_4), and concentrated under reduced pressure. The amine was crystallized from ether–hexane. The HCl salt was recrystallized from methanol–ether.

(+)-(6aR,11bR)-6,6a,7,11b-*Tetrahydro*-5H-*indeno*[2,1-c]*isoquinoline* (+)-(**19a**). Method A; (−)-(1*R*,2*R*)- and (−)-(1*S*,2*R*)-2-benzylaminoindan-1-ol gave an identical product: 77.9% yield; m.p. 80 °C; $[\alpha]_D^{23}$ +293.6° ± 1.6 (*c* 1.180, MeOH); $\nu_{max.}$(Nujol) 3 310 cm^{-1}; δ($CDCl_3$) 2.85 (1 H, d, *J* 16 Hz), 3.31 (1 H, dd, *J* 6, 16 Hz), 3.81 (1 H, d, *J* 17 Hz), 3.86 (1 H, dd, *J* 5, 6 Hz), 4.01 (1 H, d, *J* 17 Hz), 4.11 (1 H, d, *J* 5 Hz), and 6.9—7.5 (8 H, m) (Found: C, 87.1; H, 6.75; N, 6.5. $C_{16}H_{15}N$ requires C, 86.85; H, 6.85; N, 6.35%).

The HCl salt: m.p. 272—275 °C; $[\alpha]_D^{24}$ +220.0° ± 1.6 (*c* 0.993, H_2O); *m/z*: 221.

(−)-(6aS,11bS)-3-*Methoxy*-6,6a,7,11b-*tetrahydro*-5H-*indeno*[2,1-c]*isoquinoline* (−)-(**19b**). Method B; the amine could not be crystallized, δ($CDCl_3$) 2.82 (1 H, d, *J* 16 Hz), 3.30 (1 H, dd, *J* 5, 16 Hz), 3.77 (3 H, s), 3.6—4.4 (4 H, m), 6.56 (1 H, d, *J* 3 Hz), 6.85 (1 H, dd, *J* 3, 9 Hz), and 7.0—7.5 (5 H, m).

The HCl salt: m.p. 235—240 °C (decomp.); $[\alpha]_D^{24}$ +257.5° ± 2.4 (*c* 0.722, MeOH); $\nu_{max.}$(Nujol) 2 780, 2 700, 2 600, and 1 032 cm^{-1} (Found: C, 70.55; H, 6.3; Cl, 12.35; N, 4.9. $C_{17}H_{18}ClNO$ requires C, 70.95; H, 6.3; Cl, 12.3; N, 4.85%).

(+)(6aR,11bR)-2,3-*Dimethoxy*-6,6a,7,11b-*tetrahydro*-5H-*indeno*[2,1-c]*isoquinoline* (+)-(**19c**). Method B; m.p. 112—114 °C; $[\alpha]_D^{24}$ +278.7° ± 1.9 (*c* 0.963, MeOH); δ($CDCl_3$) 2.86 (1 H, d, *J* 17 Hz), 3.36 (1 H, dd, *J* 5, 17 Hz), 3.86 (3 H, s), 3.99 (3 H, s), 3.6—4.2 (4 H, m), 6.57 (1 H, s), 7.00 (1 H, s), and 7.1—7.4 (4 H, m).

The HCl salt: m.p. 259—261 °C (decomp.); $\nu_{max.}$(Nujol) 1 120 cm^{-1}; *m/z* 281 (Found: C, 67.5; H, 6.4; Cl, 10.7; N, 4.4. $C_{18}H_{20}ClNO_2$ requires C, 68.05; H, 6.35; Cl, 11.15; N, 4.4%).

(−)-(6aS,11bS)-3,4-*Dimethoxy*-6,6a,7,11b-*tetrahydro*-5H-*indeno*[2,1-c]*isoquinoline* (−)-(**19d**). Method B; m.p. 114—116 °C; $[\alpha]_D^{23}$ −242.3° ± 1.7 (*c* 0.974, MeOH); δ($CDCl_3$) 2.85

(1 H, d, *J* 16 Hz), 3.32 (1 H, dd, *J* 6, 16 Hz), 3.78 (3 H, s), 3.87 (3 H, s), 3.6—4.3 (4 H, m), 6.88 (1 H, d, *J* 8 Hz), and 7.0—7.4 (5 H, m).

The HCl salt: m.p. 229—231 °C (decomp.); $[\alpha]_D^{24}$ −177.6° ± 1.2 (*c* 1.063, MeOH); $\nu_{max.}$(Nujol) 2 575, 2 485, and 1 100 cm^{-1}; *m/z* 281 (Found: C, 67.35; H, 6.35; Cl, 10.85; N, 4.45. $C_{18}H_{20}ClNO_2$ requires C, 68.05; H, 6.05; Cl, 11.15; N, 4.4%).

(+)-(6aR,11bR)-3,9-*Dimethoxy*-6,6a,7,11b-*tetrahydro*-5H-*indeno*[2,1-c]*isoquinoline* (+)-(**19f**). Method B; m.p. 86—88 °C; $[\alpha]_D^{24}$ +218.1° ± 1.6 (*c* 0.968, MeOH); δ ($CDCl_3$) 2.80 (1 H, d, *J* 16 Hz), 3.28 (1 H, dd, *J* 6, 16 Hz), 3.74 (3 H, s), 3.76 (3 H, s), 3.6—4.2 (4 H, m), 6.5—7.0 (4 H, m), 7.13 (1 H, d, *J* 8 Hz), and 7.37 (1 H, d, *J* 8 Hz).

The HCl salt: m.p. 250—252 °C (decomp.); $[\alpha]_D^{24}$ −170.7° ± 1.6 (*c* 0.776, MeOH); $\nu_{max.}$(Nujol) 1 035 and 1 024 cm^{-1}; *m/z* 281 (Found: C, 67.55; H, 6.4; Cl, 11.2; N, 4.45. $C_{18}H_{20}ClNO_2$ requires C, 68.05; H, 6.35; Cl, 11.15; N, 4.4%).

(−)-(6aS,11bS)-2,3,9-*Trimethoxy*-6,6a,7,11b-*tetrahydro*-5H-*indeno*[2,1-c]*isoquinoline* (−)-(**19g**). Method B; m.p. 116—118 °C; δ($CDCl_3$) 2.82 (1 H, d, *J* 16 Hz), 3.31 (1 H, dd, *J* 6, 16 Hz), 3.5—4.2 (4 H, m), 3.78 (3 H, s), 3.85 (3 H, s), 3.96 (3 H, s), 6.56 (1 H, s), 6.5—6.9 (2 H, m), 6.96 (1 H, s), and 7.18 (1 H, d, *J* 8 Hz).

The HCl salt: m.p. 212—215 °C (decomp.); $[\alpha]_D^{25}$ −208.8° ± 1.4 (*c* 1.106, MeOH); $\nu_{max.}$(Nujol) 2 610 and 1 026 cm^{-1}; *m/z* 311 (Found: C, 64.95; H, 6.6; Cl, 9.5; N, 4.0. $C_{19}H_{22}ClNO_3 \cdot 1/4H_2O$ requires C, 64.75; H, 6.45; Cl, 10.05; N, 4.0%).

(−)-(6aS,11bS)-3,4,9-*Trimethoxy*-6,6a,7,11b-*tetrahydro*-5H-*indeno*[2,1-c]*isoquinoline* (−)-(**19h**). Method B; m.p. 101—102 °C; $[\alpha]_D^{24}$ −230.8° ± 1.9 (*c* 0.856, MeOH); δ($CDCl_3$) 2.81 (1 H, d, *J* 17 Hz), 3.30 (1 H, dd, *J* 6, 17 Hz), 3.5—4.2 (4 H, m), 3.77 (3 H, s), 3.79 (3 H, s), 3.88 (3 H, s), 6.68 (1 H, dd, *J* 2, 8 Hz), 6.91 (2 H, d, *J* 8 Hz), and 7.18 (2 H, d, *J* 8 Hz).

The HCl salt: m.p. 243—245 °C (decomp.); $[\alpha]_D^{24}$ −186.1° ± 1.8 (*c* 0.769, MeOH); $\nu_{max.}$(Nujol) 2 580 and 1 097 cm^{-1}; *m/z* 311 (Found: C, 65.0; H, 6.4; Cl, 10.3; N, 4.1. $C_{18}H_{22}ClNO_3$ requires C, 65.6; H, 6.4; Cl, 10.2; N, 4.05%).

(−)-(6aS,11bS)-3,8,9-*Trimethoxy*-6,6a,7,11b-*tetrahydro*-5H-*indeno*[2,1-c]*isoquinoline* (−)-(**19k**). Method B; m.p. 96—97 °C; $[\alpha]_D^{24}$ −206.9° ± 1.4 (*c* 1.043, MeOH); $\nu_{max.}$(Nujol) 2 580 and 1 074 cm^{-1}; δ($CDCl_3$) 2.95 (1 H, dd, *J* 2, 18 Hz), 3.27 (1 H, dd, *J* 5, 18 Hz), 3.5—4.2 (4 H, m), 3.78 (3 H, s), 3.80 (3 H, s), 3.84 (3 H, s), 6.5—7.0 (4 H, m), and 7.35 (1 H, d, *J* 5 Hz) (Found: C, 73.15; H, 6.85; N, 4.55. $C_{19}H_{21}NO_3$ requires C, 73.3; H, 6.8; N, 4.5%).

The HCl salt: m.p. 237—240 °C (decomp.); $[\alpha]_D^{23}$ −154.1° ± 1.1 (*c* 1.003, MeOH); *m/z* 311.

(+)-(6aR,11bR)-2,3,8,9-*Tetramethoxy*-6,6a,7,11b-*tetrahydro*-5H-*indeno*[2,1-c]*isoquinoline* (+)-(**19l**). Method B; m.p. 105 °C; $[\alpha]_D^{23}$ +273.8° ± 1.6 (*c* 1.137, MeOH); $\nu_{max.}$(Nujol) 3 330 and 1 080 cm^{-1}; δ($CDCl_3$) 2.96 (1 H, dd, *J* 2, 16 Hz), 3.28 (1 H, dd, *J* 5, 16 Hz), 3.8—4.2 (4 H, m), 3.82 (3 H, s), 3.85 (3 H, s), 3.89 (3 H, s), 3.97 (3 H, s), 6.56 (1 H, s), 6.72 (1 H, d, *J* 9 Hz), 6.94 (1 H, d, *J* 9 Hz), and 6.95 (1 H, s) (Found: C, 70.05; H, 6.5; N, 3.9. $C_{20}H_{23}NO_4$ requires C, 70.35; H, 6.8; N, 4.1%).

The HCl salt: m.p. 239—241 °C (decomp.); $[\alpha]_D^{24}$ +206.1° ± 1.5 (*c* 0.997, MeOH), *m/z* 341.

(−)-(6aS,11bS)-3,4,8,9-*Tetramethoxy*-6,6a,7,11b-*tetrahydro*-5H-*indeno*[2,1-c]*isoquinoline* (−)-(**19m**) Method B; m.p. 138—140 °C; $[\alpha]_D^{24}$ −220.6° ± 1.3 (*c* 1.218, MeOH); δ($CDCl_3$) 2.77 (1 H, d, *J* 16 Hz), 3.27 (1 H, dd, *J* 6, 16 Hz), 3.5—4.2 (4 H, m), 3.80 (6 H, s), 3.84 (3 H, s), 3.88 (3 H, s), 6.82 (1 H, s), 6.85 (1 H, s), 6.91 (1 H, d, *J* 8 Hz), and 7.18 (1 H, d, *J* 8 Hz).

The HCl salt: m.p. 239—241 °C (decomp.); $[\alpha]_D^{24}$ −168.6° ± 1.5 (*c* 0.849, MeOH); $\nu_{max.}$(Nujol) 2 590 and 1 030 cm^{-1}; *m/z* 341 (Found: C, 63.0; H, 6.4; Cl, 9.5; N, 3.8. $C_{20}H_{24}ClNO_4$ requires C, 63.55; H, 6.4; Cl, 9.4; N 3.7%).

(+)-(6aR,11bR)-3,9,10-*Trimethoxy*-6,6a,11b-*tetrahydro*-5H-*indeno*[2,1-c]*isoquinoline* (+)-(**19o**). Method B; m.p. 127—128 °C; $[\alpha]_D^{23}$ +168.5° ± 1.4 (*c* 0.868, $CHCl_3$); $\nu_{max.}$(Nujol) 3 290 and 1 034 cm^{-1}; δ($CDCl_3$) 2.77 (1 H, d, *J* 16 Hz), 3.28 (1 H, dd, *J* 5, 16 Hz), 3.79 (6 H, s), 3.84 (3 H, s), 3.7—4.2 (4 H, m), 6.59 (1 H, d, *J* 3 Hz), 6.76 (1 H, s), 6.82 (1 H, s), 6.88 (1 H, dd, *J* 3, 9 Hz), and 7.36 (1 H, d, *J* 9 Hz) (Found: C, 72.8; H, 6.65; N, 4.6. $C_{19}H_{21}NO_3$ requires C, 73.3; H, 6.8; N, 4.5%).

The HCl salt: m.p. 157—158 °C; $[\alpha]_D^{24}$ +120.5° ± 0.9 (*c* 1.092, MeOH); *m/z* 341.

(+)-(6aR,11bR)-2,3,9,10-*Tetramethoxy*-6,6a,7,11b-*tetrahydro*-5H-*indeno*[2,1-c]*isoquinoline* (+)-(**19p**). Method B; m.p. 164—165 °C; $[\alpha]_D^{23}$ +225.1° ± 2.6 (*c* 0.581, MeOH); $\nu_{max.}$(Nujol) 3 325 and 1 082 cm^{-1}; δ($CDCl_3$) 2.75 (1 H, d, *J* 16 Hz), 3.26 (1 H, dd, *J* 5, 16 Hz), 3.6—4.2 (4 H, m), 3.78 (3 H, s), 3.83 (6 H, s), 3.95 (3 H, s), 6.57 (1 H, s), 6.83 (2 H, s), and 6.94 (1 H, s) (Found: C, 69.45; H, 6.8; N, 4.15. $C_{20}H_{23}NO_4$ requires C, 70.35; H, 6.8; N, 4.1%).

The HCl salt: m.p. 242—244 °C (decomp.); $[\alpha]_D^{23}$ +172.5° ± 1.1 (*c* 1.193, MeOH); *m/z* 341.

(+)-(6aR,11bR)-3,4,5,10-*Tetramethoxy*-6,6a,7,11b-*tetrahydro*-5H-*indeno*[2,1-c]*isoquinoline* (+)-(**19q**). Method B; m.p. 108—109 °C; $[\alpha]_D^{23}$ +183.4° ± 1.5 (*c* 0.891, MeOH); $\nu_{max.}$(Nujol) 3 310 and 1 043 cm^{-1}; δ($CDCl_3$) 2.77 (1 H, d, *J* 16 Hz), 3.27 (1 H, dd, *J* 6, 16 Hz), 3.5—4.2 (4 H, m), 3.80 (6 H, s), 3.84 (3 H, s), 3.88 (3 H, s), 6.82 (1 H, s), 6.85 (1 H, s), 6.91 (1 H, d, *J* 8 Hz), and 7.18 (1 H, d, *J* 8 Hz) (Found: C, 70.05; H, 6.8; N, 4.0. $C_{20}H_{23}NO_4$ requires C, 70.35; H, 7.8; N, 4.1%).

The HCl salt: m.p. 144—147 °C; $[\alpha]_D^{23}$ +127° ± 1.0 (*c* 1.103, MeOH); *m/z* 341.

(−)-(6aS,12aS)-5,6,6a,7,8,12a-*Hexahydrobenz*[a]*phenanthridine* (−)-(**22**). Method A; m.p. 62—63 °C; $[\alpha]_D^{24}$ −87.2° ± 0.8 (*c* 1.092, MeOH); $\nu_{max.}$(Nujol) 3 330, 3 320, and 746 cm^{-1}; δ($CDCl_3$) 1.61 (1 H, ddd, *J* 6, 13, 20 Hz), 2.26 (1 H, ddd, *J*, 6, 13 20 Hz), 2.82 (2 H, m), 3.48 (1 H, d, *J* 4 Hz), 3.91 (1 H, d, *J* 17 Hz), 4.14 (1 H, d, *J* 17 Hz), and 6.9—7.4 (8 H, m).

The HCl salt: m.p. 248—250 °C; $[\alpha]_D^{24}$ +12.9° ± 0.5 (*c* 0.952, MeOH); *m/z* 235 (Found: C, 75.15; H, 6.8; Cl, 13.3; N, 5.2. $C_{17}H_{18}ClN$ requires C, 75.15; H, 6.7; Cl, 13.05; N, 5.15%).

Racemic (**21**) and (**23**) gave an identical product.

X-*Ray Structure Determination of* (**4a**), (**19a**), *and* (**22**).—Crystals with dimensions of 0.3 × 0.3 × 0.2 mm (−)-tartarate of (+)-(**4a**), 0.4 × 0.3 × 0.2 mm (**19a**), and 0.4 × 0.3 × 0.3 mm (**22**) were used. Integrated intensities were measured in the range of θ ≦ 65° with an ω—2θ scan, a constant scan speed of 0.05° s^{-1}, and an ω scan range of (1.0 + 0.2 tan θ)°. The background was counted for 5 s at each end of the scan and 1 723, 1 203, and 2 323 independent reflections were recorded for the salts of (**4a**), (**19a**), and (**22**), respectively. Lorentz and polarization corrections were applied, but not the absorption correction.

Crystal Data.—The salt of (**4a**): $C_{14}H_{19}NO_8 \cdot 2H_2O$, orthorhombic, space group $P2_12_12_1$, a = 8.191(1), b = 28.760(3), c = 7.282(1) Å, Z = 4. (**19a**): $C_{16}H_{15}N$, orthorhombic, space group $P2_12_12_1$, a = 11.769(1), b = 13.439(1), c = 7.670(1) Å, Z = 4. (**22**): $C_{17}H_{17}N$, monoclinic, space group $P2_1$, a = 16.125(2), b = 7.820(1), c = 10.421(1) Å, β = 105.91(1)°, Z = 4.

The structures were solved using the program MULTAN 78.[29] A difference electron density map was calculated after block-diagonal least-squares refinement, which revealed the positions of all the hydrogen atoms. Successive refinement of the positional parameters of all the atoms and the anisotropic thermal parameters of the non-hydrogen atoms gave the R value ($\Sigma|\Delta F|/\Sigma|F_o|$) of 0.043 (1 455 observed reflections) for the salt of (**4a**), 0.041 (1 085) for (**19a**), and 0.042 (2 195) for (**22**).[30]

Atomic co-ordinates for the crystal structure determinations

Table 4. Atomic co-ordinates ($\times 10^4$, and $\times 10^3$ for H) with their standard deviations in parentheses for salt of (**4a**)

	x	*y*	*z*
C(1)	3 326(3)	3 994(1)	4 720(3)
C(2)	4 172(3)	3 620(1)	5 869(3)
C(3)	4 217(4)	3 821(1)	7 839(3)
C(3a)	4 435(3)	4 337(1)	7 389(3)
C(4)	5 036(4)	4 682(1)	8 550(4)
C(5)	5 118(3)	5 135(1)	7 819(4)
C(6)	4 580(4)	5 231(1)	6 039(4)
C(7)	3 966(4)	4 881(1)	4 938(4)
C(7a)	3 941(3)	4 432(1)	5 646(3)
O(8)	3 635(3)	3 959(1)	2 788(2)
N(9)	3 335(3)	3 160(1)	5 769(3)
O(10)	5 691(3)	5 511(1)	8 804(3)
C(11)	6 147(6)	5 449(1)	10 637(5)
C(12)	3 159(3)	2 359(1)	11 643(3)
C(13)	3 821(3)	1 911(1)	12 441(3)
O(14)	4 028(2)	2 745(1)	12 363(2)
O(15)	5 447(2)	1 831(1)	11 954(2)
C(16)	3 233(3)	2 351(1)	9 542(3)
O(17)	2 406(2)	2 044(1)	8 726(2)
O(18)	4 164(2)	2 642(1)	8 787(2)
C(19)	3 760(3)	1 924(1)	14 542(3)
O(20)	2 410(2)	2 064(1)	15 248(2)
O(21)	4 964(3)	1 815(1)	15 431(3)
O(w1)	820(3)	3 568(1)	1 261(2)
O(w2)	8 108(3)	6 073(1)	6 872(4)
H(1)	202(4)	395(1)	484(5)
H(2)	545(4)	356(1)	546(6)
H(3)	283(4)	377(1)	852(6)
H′(3)	495(4)	366(1)	870(6)
H(4)	561(4)	456(1)	985(6)
H(6)	440(5)	558(1)	561(7)
H(7)	361(6)	497(1)	374(6)
H(8)	452(4)	405(1)	289(7)
H(9)	344(4)	302(1)	446(6)
H′(9)	241(4)	318(1)	597(6)
H″(9)	396(4)	294(1)	673(6)
H(11)	503(6)	535(2)	1 120(9)
H′(11)	684(7)	524(2)	1 087(9)
H″(11)	645(6)	575(1)	1 118(8)
H(12)	195(4)	239(1)	1 189(5)
H(13)	315(4)	166(1)	1 216(6)
H(14)	498(4)	282(1)	1 175(6)
H(15)	550(5)	176(1)	1 038(7)
H(20)	255(3)	206(1)	1 681(6)

Table 5. Atomic co-ordinates ($\times 10^4$, and $\times 10^3$ for H) with their standard deviations for (**19a**)

C(1)	3 672(2)	1 593(1)	8 967(3)
C(2)	2 664(2)	2 126(2)	9 029(3)
C(3)	1 640(2)	1 639(1)	9 214(2)
C(4)	1 629(2)	616(2)	9 290(2)
C(4a)	2 626(2)	62(1)	9 218(2)
C(5)	2 582(1)	−1 066(1)	9 195(2)
N(6)	3 619(2)	−1 564(1)	9 705(2)
C(6a)	4 623(1)	−1 170(1)	8 844(2)
C(7)	5 689(2)	−1 624(2)	9 688(3)
C(7a)	5 953(1)	−901(1)	11 145(3)
C(8)	6 617(2)	−1 033(2)	12 616(4)
C(9)	6 738(2)	−256(2)	13 781(3)
C(10)	6 211(2)	659(2)	13 492(3)
C(11)	5 535(1)	797(1)	12 012(3)
C(11a)	5 419(1)	23(1)	10 836(2)
C(11b)	4 771(1)	−23(1)	9 116(2)
C(11c)	3 666(1)	546(1)	9 100(2)
H(1)	446(2)	188(2)	887(4)
H(2)	267(2)	282(2)	894(4)
H(3)	92(2)	216(2)	919(4)
H(4)	81(2)	23(2)	928(4)
H(5)	240(2)	−132(2)	804(4)
H′(5)	193(2)	−128(2)	1 004(4)
H(6)	378(2)	−147(2)	1 084(4)
H(6a)	453(2)	−129(2)	750(4)
H(7)	646(3)	−161(2)	887(4)
H′(7)	561(2)	−242(2)	1 005(5)
H(8)	702(2)	−171(2)	1 280(5)
H(9)	720(2)	−33(2)	1 465(5)
H(10)	632(3)	123(2)	1 438(5)
H(11)	503(2)	150(2)	1 184(3)
H(11b)	524(2)	21(2)	813(3)

Table 6. Atomic co-ordinates ($\times 10^4$, and $\times 10^3$ for H) with their standard deviations for (**22**)

	x	*y*	*z*		*x*	*y*	*z*
C(1)	3 870(1)	5 108(4)	5 086(2)	H(1)	377(2)	524(5)	602(3)
C(2)	4 362(1)	6 383(5)	4 750(3)	H(2)	462(2)	722(6)	542(3)
C(3)	4 506(2)	6 371(5)	3 498(3)	H(3)	488(2)	722(6)	324(3)
C(4)	4 170(1)	5 074(6)	2 616(3)	H(4)	422(2)	515(6)	173(3)
C(4a)	3 678(1)	3 735(5)	2 944(2)	H(5)	390(2)	169(6)	193(4)
C(5)	3 364(2)	2 302(6)	1 982(3)	H′(5)	301(2)	270(6)	106(4)
N(6)	2 826(1)	1 053(0)	2 386(2)	H(6)	221(2)	150(6)	209(3)
C(6a)	3 089(1)	735(5)	3 829(3)	H(6a)	367(2)	48(5)	410(3)
C(7)	2 570(1)	−728(5)	4 207(3)	H(7)	268(2)	−179(6)	369(4)
C(8)	1 605(2)	−296(5)	3 777(4)	H′(7)	277(2)	−94(6)	535(3)
C(8a)	1 413(1)	1 531(5)	4 073(2)	H(8)	132(2)	−101(6)	399(3)
C(9)	549(1)	1 968(5)	3 917(2)	H′(8)	139(2)	−56(6)	273(4)
C(10)	308(1)	3 620(5)	4 091(2)	H(9)	15(2)	95(5)	370(3)
C(11)	931(1)	4 888(5)	4 427(2)	H(10)	−28(2)	388(5)	392(3)
C(12)	1 789(1)	4 470(4)	4 580(2)	H(11)	78(2)	621(5)	450(3)
C(12a)	2 041(1)	2 800(4)	4 410(4)	H(12)	222(2)	544(4)	484(3)
C(12b)	3 001(1)	2 368(4)	4 600(2)	H(12b)	328(2)	206(5)	559(3)
C(12c)	3 518(1)	3 790(4)	4 192(2)	H(1′)	279(2)	278(5)	838(3)
C(1′)	3 170(1)	3 708(5)	8 431(2)	H(2′)	421(2)	217(5)	868(3)
C(2′)	4 038(1)	3 367(5)	8 608(2)	H(3′)	521(2)	431(6)	882(3)

Table 6. *contd.*

	x	*y*	*z*		*x*	*y*	*z*
C(3′)	4 603(1)	4 701(6)	8 700(3)	H(4′)	473(3)	734(5)	872(4)
C(4′)	4 312(1)	6 353(5)	8 596(2)	H(5′)	346(2)	898(6)	938(4)
C(4′a)	3 438(1)	6 721(5)	8 413(2)	H′(5′)	340(2)	915(6)	763(3)
C(5′)	3 160(2)	8 583(5)	8 346(3)	H(6′)	212(2)	977(6)	814(4)
N(6′)	2 226(2)	8 760(5)	7 995(3)	H(6′a)	124(2)	798(5)	852(3)
C(6′a)	1 818(2)	7 560(5)	8 708(3)	H(7′)	218(2)	867(6)	1 067(4)
C(7′)	2 187(2)	7 593(5)	10 240(3)	H′(7′)	290(2)	721(6)	1 061(3)
C(8′)	1 710(2)	6 378(6)	10 906(3)	H(8′)	213(2)	611(6)	1 189(4)
C(8′a)	1 403(1)	4 750(5)	10 160(2)	H′(8′)	117(2)	709(6)	1 104(3)
C(9′)	999(1)	3 518(6)	10 752(2)	H(9′)	92(2)	380(6)	1 161(3)
C(10′)	653(1)	2 059(5)	10 087(3)	H(10′)	35(2)	117(6)	1 053(3)
C(11′)	688(2)	1 802(5)	8 783(3)	H(11′)	43(2)	56(5)	834(3)
C(12′)	1 088(1)	3 017(5)	8 181(2)	H(12′)	114(2)	284(5)	727(3)
C(12′a)	1 460(1)	4 475(4)	8 863(2)	H(12′b)	160(2)	584(5)	724(3)
C(12′b)	1 904(1)	5 770(5)	8 191(2)				
C(12′c)	2 859(1)	5 379(4)	8 347(2)				

are given in Tables 4, 5, and 6. Bond lengths and angles of the structure factors for the determinations are given in a Supplementary Publication [SUP No. 23892 (40 pages)].

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