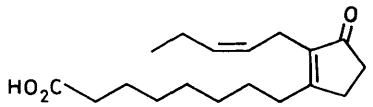
# Synthesis of Tetrahydrodicranenone B [1]

**Christopher J. Moody,*[,a] Stanley M. Roberts,[b] and Judy Toczek[a]**
[a] *Department of Chemistry, Imperial College of Science and Technology, London SW7 2AY*
[b] *Department of Microbiological Chemistry, Glaxo Group Research, Greenford Road, Greenford, Middlesex UB6 0HE*

The naturally occurring cyclopentenone, tetrahydrodicranenone B (**1**), has been synthesized from the cyclopentenone (**3**), prepared by Birch reduction/alkylation of 6-methoxyindanone followed by ozonolysis of the dihydroindanone (**2**). The lower side chain was elongated by selective addition of a five-carbon Grignard reagent to the aldehyde (**6**), obtained from the ester (**3**), to give the alcohol (**7**). The alcohol (**7**) could also be prepared from the 7-methoxyindanone (**14**), in which all the carbons of the lower side chain are already present, by a similar reductive alkylation/ozonolysis sequence (Scheme 3). The alcohol (**7**) was converted into the natural product by radical deoxygenation, followed by functional group manipulation.

In the preceding paper we have described a new approach to the preparation of 2,3-disubstituted cyclopent-2-en-1-ones based on the reductive alkylation of a 6-methoxyindanone.[2] We now report in full the application of this chemistry to the first synthesis of tetrahydrodicranenone B (**1**), one of a group of



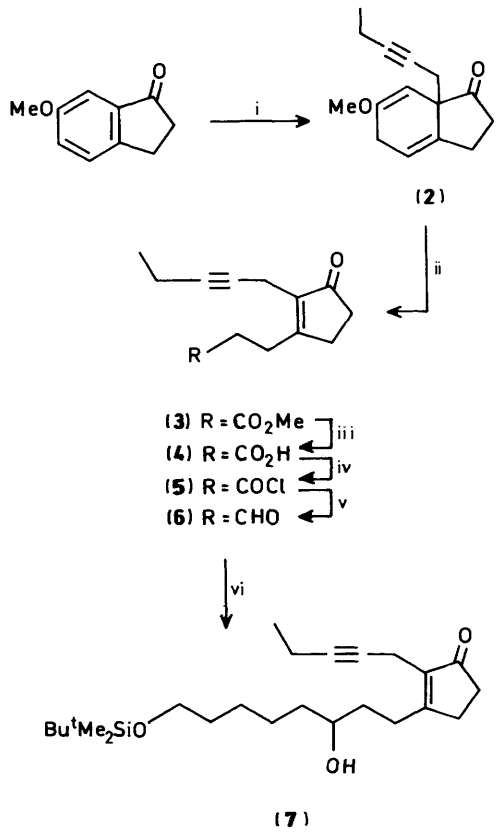
(**1**)

naturally occurring, antimicrobial fatty acids isolated from Japanese mosses.[3–5]

## Results and Discussion

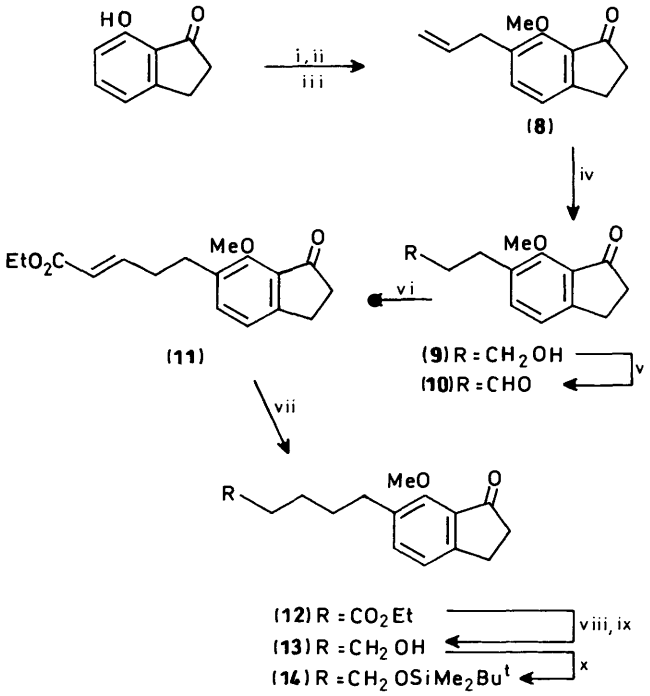
Reductive alkylation of 6-methoxyindan-1-one using 1-iodopent-2-yne gave the dihydroindanone (**2**), ozonolysis and oxidation of which gave, after decarboxylation, the key cyclopentenone (**3**) exactly as described in the preceding paper.[2] Elongation of the lower side chain with a suitable 5-carbon unit was planned to occur by a selective Grignard reaction on the corresponding aldehyde (**6**). Unfortunately, direct, selective reduction of the cyclopentenone ester (**3**) to the aldehyde (**6**) using di-isobutylaluminium hydride under a variety of conditions proved unsuccessful and, therefore, the transformation was achieved indirectly. Hydrolysis of the ester (**3**) gave the corresponding acid (**4**), which was converted into the acid chloride (**5**) using preformed dimethylformiminum chloride,[6] more usual reagents such as thionyl chloride, oxalyl chloride, and triphenylphosphine/carbon tetrachloride being unsatisfactory. Selective reduction of the acid chloride (**5**) using lithium (tri-t-butoxy)aluminium hydride[7] gave the required aldehyde (**6**) (38% overall). As expected, the aldehyde (**6**) underwent selective addition of the Grignard reagent derived from the t-butyldimethylsilyl ether of 5-bromopentan-1-ol to give the chain extended cyclopentenone (**7**) in 67% yield (Scheme 1).

The cyclopentenone (**7**) could also be prepared by an alternative route in which all the carbon atoms of the lower side chain of tetrahydrodicranenone B are already present in the starting aromatic ketone, the 7-methoxyindanone (**14**). The indanone (**14**) was prepared by a straightforward but lengthy route from 7-hydroxyindanone (Scheme 2). Thus 7-hydroxyindanone was converted into 6-allyl-7-methoxyindanone (**8**) *via*

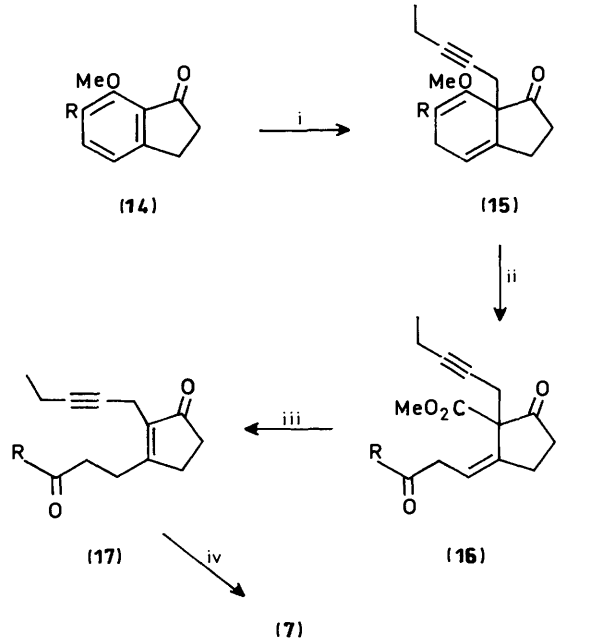


**Scheme 1.** *Reagents:* i, K, $NH_3$ Bu$^t$OH, −78 °C; LiBr, $EtC{\equiv}CCH_2I$; ii, $O_3$, MeOH, then Zn, AcOH; Jones reagent; iii, KOH, MeOH, $H_2O$; iv, dimethylformiminium chloride, $C_6H_6$; v, $LiAlH(OBu^t)_3$, THF; vi, $Bu^tMe_2SiO(CH_2)_5MgBr$, THF

a Claisen rearrangement followed by methylation (78% overall). Hydroboration of the allyl double bond of compound (**8**) under carefully controlled conditions proceeded without simultaneous reduction of the ketone, and gave, after treatment with alkaline hydrogen peroxide, the alcohol (**9**) in excellent (96%) yield. Swern oxidation (dimethyl sulphoxide–oxalyl chloride) of the alcohol (**9**) gave the aldehyde (**10**) (83%), which underwent Wittig reaction to give the alkene (**11**) (86%), hydrogenation of




**Scheme 2.** *Reagents:* i, allyl bromide, $K_2CO_3$, THF; ii, $PhNMe_2$, reflux; iii, $Me_2SO_4$, NaOH, $H_2O$; iv, $BH_3$–THF; NaOH, $H_2O_2$; v, DMSO, $(COCl)_2$, $CH_2Cl_2$, −60 °C; vi, $Ph_3P{=}CHCO_2Et$, THF; vii, $H_2$, Pd–C, MeOH; viii, $LiAlH_4$, $Et_2O$; ix, $MnO_2$, $CH_2Cl_2$; x, $Bu^tMe_2SiCl$, $Pr^i_2NEt$, DMF

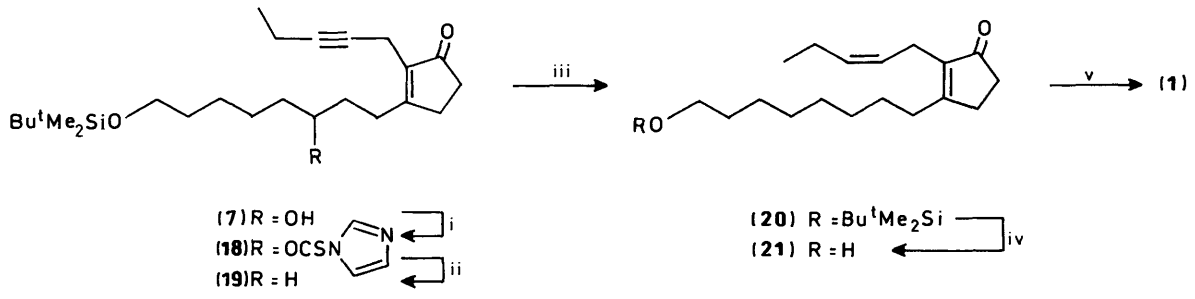



**Scheme 3.** [R = $Bu^tMe_2SiO(CH_2)_5$] *Reagents:* i, K, $NH_3$, $Bu^tOH$, THF, −78 °C; LiBr, $EtC{\equiv}CCH_2Br$; ii, $O_3$, MeOH, then Zn, AcOH; iii, LiI, 2,6-dimethylpyridine, $H_2O$; iv, $LiAlH(OBu^t)_3$, THF

which gave the indanone (**12**). Birch reduction/alkylation of the indanone (**12**) under the usual conditions [2] gave only a low yield of the desired dihydroindanone. Similarly the carboxylic acid derived by hydrolysis of the ester (**12**) also gave unsatisfactory results when subjected to the Birch reduction/alkylation conditions, and therefore recourse was made to the protected alcohol indanone derivative (**14**). This was easily prepared from the ester (**12**) by reduction with lithium aluminium hydride, followed by selective reoxidation of the resulting indanol with manganese(IV)oxide to give the indanone (**13**) (69%), and protection (98%).

Birch reduction of the indanone (**14**) followed by alkylation with 1-bromopent-2-yne gave the dihydroindanone (**15**) in 42% yield, ozonolysis of which gave the expected cyclopentanone (**16**) (77%). The hydrolysis and decarboxylation of cyclopentanone β-keto esters is often difficult to effect, with ring-cleavage reactions occurring in preference to hydrolysis, and the β-keto ester (**16**) was no exception. The demethoxycarbonylation of ester (**16**) could only be achieved in 34% yield (39% based on conversion) by treatment with lithium iodide in refluxing 2,6-dimethylpyridine. The resulting ketone (**17**) was then converted into the alcohol (**7**) by selective reduction [8] with lithium tri-t-butoxyaluminium hydride (Scheme 3). Although this variant illustrates the versatility of the reductive alkylation/ozonolysis approach to cyclopentanones in that the *complete* carbon skeleton can be assembled in just two steps from the appropriate indanone, the inaccessibility of the indanone (**14**) and the poor yielding demethoxycarbonylation step, meant that the original route to the alcohol (**7**) was the preferred one.

The synthesis of tetrahydrodicranenone B (**1**) was completed (Scheme 4) by radical deoxygenation [9] of the alcohol (**7**) *via* the thiocarbonylimidazolide (**18**) to give the cyclopentenone (**19**). Catalytic hydrogenation of the triple bond in (**19**) over a poisoned palladium catalyst gave the *Z*-alkene (**20**) (100%), deprotection of which gave the alcohol (**21**). Although Jones oxidation of the primary alcohol (**21**) was not successful, oxidation with oxygen in the presence of prereduced Adams catalyst [10] gave the carboxylic acid (**1**), tetrahydrodicranenone B, the spectra of which were identical to those of the natural product.




**Scheme 4.** *Reagents:* i, 1,1′-thiocarbonyldi-imidazole; ii, $Bu_3SnH$, azoisobutyronitrile, toluene; iii, $H_2$, Pd–$BaSO_4$, pyridine; iv, AcOH, $H_2O$, THF; v, Pt, $O_2$, acetone

## Experimental

For general points, see ref. 2.

*Methyl 3-(3-Oxo-2-pent-2-ynylcyclopent-1-enyl)propionate* (**3**).—Prepared as previously described.[2]

*3-(3-Oxo-2-pent-2-ynylcyclopent-1-enyl)propionic Acid* (**4**).—A solution of potassium hydroxide (0.016 g, 0.30 mmol) in aqueous methanol (3:1; 0.25 ml) was added to a solution of the ester (**3**) (0.023 g, 0.10 mmol) in methanol (0.5 ml) under nitrogen at room temperature. After being stirred overnight, the orange-brown solution was diluted with water (5 ml) and washed with ethyl acetate (2 × 5 ml). The aqueous layer was made acidic with dilute hydrochloric acid (3M) and extracted with ethyl acetate (3 × 5 ml). The latter organic extracts were combined, washed with water (5 ml) and with brine (5 ml), dried, and evaporated to give the *carboxylic acid* (**4**) (0.023 g, 100%) as a pale yellow oil (Found: $M^+$, 220.1101. $C_{13}H_{16}O_3$ requires $M$, 220.1100); $\nu_{max.}$($CHCl_3$) 3 500—3 000br, 1 720—1 685, and 1 640 $cm^{-1}$; $\delta_H$(250 MHz; $CDCl_3$) 3.09 (2 H, m, $C{\equiv}CCH_2$), 2.93 (2 H, br t, $J$ 8 Hz, 3-$CH_2$), 2.68 (2 H, br t, $J$ 8 Hz, 2-$CH_2$), 2.57—2.52 (2 H, m, $CH_2CH_2CO$), 2.45—2.39 (2 H, m, $CH_2CH_2CO$), 2.13 (2 H, qt, $J$ 7.5 and 2.5 Hz, $CH_3CH_2$), and 1.08 (3 H, t, $J$ 7.5 Hz, $CH_3CH_2$), $CO_2H$ not observed; $m/z$ 220 ($M^+$, 100%), 205 (20), 191 (11), 175 (16), and 161 (91).

*3-(3-Oxo-2-pent-2-ynylcyclopent-1-enyl)propionaldehyde* (**6**).—A solution of the carboxylic acid (**4**) (0.46 g, 2.1 mmol) in dry benzene (2 ml) was added to a mixture of dimethylformiminium chloride[6] (0.25 g, 2.0 mmol) in dry benzene (15 ml) under nitrogen at room temperature. The resulting mixture was warmed to 45 °C and additional portions of the dimethylformiminium salt added until t.l.c. analysis indicated the absence of starting material. The benzene was allowed to evaporate under nitrogen and the crude acid chloride (**5**) was dissolved in THF (15 ml). The solution was cooled to −78 °C and lithium aluminium tri-t-butoxyhydride (0.52 g, 2.1 mmol) in THF (3 ml) was slowly added. The mixture was stirred for 30 min and then after removal of the cooling bath poured at 0 °C onto brine (20 ml). The resulting solid was filtered off, washed well with methanol, and the combined filtrate and washings were evaporated to dryness. The residue was partitioned between water (20 ml) and ethyl acetate (3 × 10 ml). The organic extracts were combined, dried, and evaporated, and the residue purified by flash chromatography eluting with ethyl acetate to give the *title compound* (**6**) (0.16 g, 38%) as a pale yellow liquid (Found: $M^+$, 204.1144. $C_{13}H_{16}O_2$ requires $M$, 204.1150); $\nu_{max.}$($CHCl_3$) 2 840, 2 740, 1 730, 1 700, and 1 645 $cm^{-1}$; $\delta_H$(250 MHz; $CDCl_3$) 9.86 (1 H, br s, CHO), 3.12—3.06 (2 H, m, $C{\equiv}CCH_2$), 2.92 (2 H, m, 3-$CH_2$), 2.78 (2 H, m, 2-$CH_2$), 2.56—2.50 (2 H, m, $CH_2CH_2CO$), 2.44—2.36 (2 H, m, $CH_2CH_2CO$), 2.14 (2 H, qt, $J$ 7.5 and 2.5 Hz, $CH_3CH_2$), and 1.07 (3 H, t, $J$ 8 Hz, $CH_3CH_2$); $m/z$ 204 ($M^+$, 35%), 189 (8), 175 (38), 161 (100), and 147 (39).

*3-(8-t-Butyldimethylsiloxy-3-hydroxyoctyl)-2-pent-2-ynylcyclopent-2-enone* (**7**).—1-t-Butyldimethylsiloxy-5-bromopentane (0.30 g, 1.07 mmol) was added to magnesium turnings (1.04 g, 42.8 mmol) in THF (0.5 ml). An additional portion of the bromide (0.70 g, 2.5 mmol) in THF (2.5 ml) was introduced to the refluxing mixture, and the heating continued for an additional 30 min. After cooling, the supernantant Grignard reagent (0.1 ml) was added to a solution of the aldehyde (**6**) (0.024 g, 0.117 mmol) in THF (0.5 ml) at room temperature under nitrogen. After 10 min, water (5 ml) was added, following by hydrochloric acid (3M; 1 ml). The aqueous layer was extracted with ethyl acetate (3 × 10 ml), and the combined organic extracts were dried and evaporated. The residue was purified by flash chromatography eluting with ether to give the *title compound* (**7**) (0.032 g, 67%) as a colourless oil (Found: $M^+$, 406.2902. $C_{24}H_{42}O_3Si$ requires $M$, 406.2903); $\nu_{max.}$($CHCl_3$) 3 600—3 200, 1 690, 1 640, and 1 090 $cm^{-1}$; $\delta_H$(250 MHz; $CDCl_3$) 3.75—3.45 (3 H, m, $SiOCH_2$ and $CHOH$), 3.09 (2 H, m, $C{\equiv}CCH_2$), 2.77—2.62 (2 H, m, $CHOHCH_2CH_2$), 2.58—2.52 (2 H, m, 4-$CH_2$), 2.43—2.38 (2 H, m, 5-$CH_2$), 2.12 (2 H, qt, $J$ 7 and 2 Hz, $CH_2CH_2$), 1.80—1.67 (2 H, m, $CHOHCH_2CH_2$), 1.55—1.20 (9 H, m, 4 × $CH_2$ and OH), 1.09 (3 H, t, $J$ 6 Hz, $CH_3CH_2$), 0.90 (9 H, s, Bu$^t$Si), and 0.01 (6 H, s, $Me_2Si$); $m/z$ 406 ($M^+$, 5%), 391 (4), 349 (100), 331 (6), 175 (10), 161 (14), and 149 (12).

*6-Allyl-7-methoxyindan-1-one* (**8**).—A mixture of 7-hydroxyindan-1-one (10.0 g, 68 mmol), potassium carbonate (9.3 g), allyl bromide (8.18 g, 68 mmol), and THF (90 ml) was heated under reflux for 14 h. The cooled reaction mixture was poured into water (100 ml) and extracted with dichloromethane (3 × 50 ml). The organic extracts were washed with sodium hydroxide (2M; 2 × 50 ml) and water, dried ($K_2CO_3$), and evaporated. The residue was crystallised from dichloromethane–petroleum to give *7-allyloxyindan-1-one* (11.4 g, 90%), m.p. 36.5—37.5 °C (Found: C, 76.6; H, 6.5. $C_{12}H_{12}O_2$ requires C, 76.6; H, 6.4%). Unchanged 7-hydroxyindan-1-one (0.9 g) was recovered from the sodium hydroxide washings.

A solution of 7-allyloxyindan-1-one (11.05 g) in *N,N*-dimethylaniline (120 ml) was heated at reflux under nitrogen for 8 h. The cooled mixture was partitioned between dilute hydrochloric acid (10%) and dichloromethane and the organic layer was separated and extracted with sodium hydroxide (2M). The alkaline extracts were acidified, extracted with dichloromethane, and the extracts dried and evaporated to give 6-allyl-7-hydroxyindan-1-one (11.04 g, 100%); $\delta_H$(90 MHz; $CDCl_3$) 9.25 (1 H, s, OH), 7.36 (1 H, d, $J$ 7 Hz, 5-H), 6.90 (1 H, d, $J$ 7 Hz, 4-H), 6.00 (1 H, m, $H_2C{=}CH$), 5.11 (2 H, m, $H_2C{=}$), 3.43 (2 H, br d, $=CHCH_2$), 3.10 (2 H, t, $J$ 6 Hz, 3-$CH_2$), and 2.72 (2 H, t, $J$ 6 Hz, 2-$CH_2$), used without further purification.

Dimethyl sulphate (4.1 ml) and sodium hydroxide (10%; 18.6 ml) were added to a refluxing mixture of 6-allyl-7-hydroxyindan-1-one (9.71 g) and THF (50 ml). After 10 min, 2 further portions of dimethyl sulphate (2.1 ml) and sodium hydroxide (11.6 ml) were added, and the mixture was heated under reflux for a further 10 min. The cooled mixture was extracted with chloroform (3 × 50 ml), and the extracts were combined, dried, and evaporated. The residue was purified by chromatography to give the *title compound* (**8**) (9.04 g, 87%), m.p. 32.5—33.5 °C (from light petroleum) (Found: C, 77.0; H, 6.9. $C_{13}H_{14}O_2$ requires C, 77.2; H, 7.0); $\nu_{max.}$(film) 1 705 $cm^{-1}$; $\delta_H$(90 MHz; $CDCl_3$) 7.44 (1 H, d, $J$ 7 Hz, 5-H), 7.14 (1 H, d, $J$ 7 Hz, 4-H), 6.00 (1 H, m, $H_2C{=}CH$), 5.10 (2 H, m, $H_2C{=}$), 4.01 (3 H, s, OMe), 3.46 (2 H, br d, $=CHCH_2$), 3.12 (2 H, t, $J$ 6 Hz, 3-$CH_2$), and 2.70 (2 H, t, $J$ 6 Hz, 2-$CH_2$); $m/z$ 202 ($M^+$, 38%), 171 (85), and 145 (100).

*6-(3-Hydroxypropyl)-7-methoxyindan-1-one* (**9**).—A solution of borane in THF (1.0M; 6.8 ml, 6.8 mmol) was added dropwise to a stirred solution of 6-allyl-7-methoxyindan-1-one (**8**) (4.13 g, 20.5 mmol) in THF (160 ml) at 0 °C under nitrogen. After the addition was complete, the mixture was stirred at room temperature for 2 h, and then treated with a mixture of sodium hydroxide (3M; 3.5 ml) and hydrogen peroxide (30%; 2.9 ml). The mixture was heated to 50 °C for 1 h, cooled to room temperature, treated with dilute hydrochloric acid (3M; 5.8 ml), and extracted with ether (3 × 40 ml). The ether extracts were combined, dried, evaporated and the residue was chromatographed to give the *title compound* (**9**) (4.28 g, 96%), b.p. 145 °C/0.01 mmHg (Kugelrohr) (Found: C, 70.8; H, 7.4. $C_{13}H_{16}O_3$ requires C, 70.9; H, 7.3%), $\nu_{max.}$(film) 3 400br and

1 700 $cm^{-1}$; $\delta_H$(90 MHz; $CDCl_3$) 7.46 (1 H, d, *J* 7 Hz, 5-H), 7.14 (1 H, d, *J* 7 Hz, 4-H), 4.01 (3 H, s, OMe), 3.66 (2 H, t, *J* 6 Hz, $HOCH_2$), 3.11 (2 H, t, *J* 6 Hz, 3-$CH_2$), 2.76 (4 H, m, $ArCH_2$ and 2-$CH_2$), 2.51 (1 H, s, OH), and 1.87 (2 H, m, $CH_2CH_2CH_2$); *m/z* 220 ($M^+$, 2%), 188 (100), 175 (44), 161 (34), and 145 (50).

*Ethyl* 5-(7-*Methoxy*-1-*oxoindan*-6-*yl*)*pent*-2-*enoate* (**11**).—A solution of dimethyl sulphoxide (3.3 ml) in dichloromethane (12.6 ml) was added dropwise to a stirred solution of oxalyl chloride (1.83 ml) in dichloromethane (48 ml) at −60 °C under nitrogen. After 10 min, a solution of the alcohol (**9**) (4.22 g) in dichloromethane (21 ml) was added, and the mixture was stirred at −60 °C for 20 min. Triethylamine (13.4 ml) was added, and the mixture was allowed to warm to room temperature. Water (60 ml) was added, and the mixture was stirred at room temperature for 10 min. The layers were separated, and the aqueous layer was extracted with dichloromethane (2 × 30 ml). The combined organic layers were washed with dilute hydrochloric acid (1%; 50 ml), water (50 ml), sodium carbonate (5%; 50 ml), and water (50 ml), dried, and evaporated. The residue was chromatographed to give the aldehyde (**10**) (3.48 g, 83%) used without further purification.

A solution of the aldehyde (**10**) (3.48 g, 16.0 mmol) in THF (40 ml) was added to a stirred solution of ethyl (triphenylphosphoranylidene)acetate (10.0 g, 28.8 mmol) in THF (160 ml) at room temperature. The yellow solution was heated under reflux under nitrogen for 1 h, cooled to room temperature, and evaporated. The residue was purified by chromatography to give the *title compound* (**11**) (3.97 g, 86%), m.p. 33—35 °C (Found: C, 70.6; H, 7.1. $C_{17}H_{20}O_4$ requires C, 70.8; H, 7.0%); $\nu_{max.}$(film) 1 710br and 1 660 $cm^{-1}$; $\delta_H$(90 MHz; $CDCl_3$) 7.41 (1 H, d, *J* 6 Hz, indan 5-H), 7.12 (1 H, d, *J* 6 Hz, indan 4-H), 7.02 (1 H, 3-H), 5.88 (1 H, d, *J* 15 Hz, 2-H), 4.23 (2 H, q, *J* 6 Hz, $OCH_2CH_3$), 4.03 (3 H, s, OMe), 3.11 (2 H, t, $CH_2CH_2CO$), 2.70 (6 H, m, 4-$CH_2$, 5-$CH_2$ and $CH_2CH_2CO$), and 1.30 (3 H, t, *J* 6 Hz, $OCH_2CH_3$); *m/z* 288 ($M^+$, 4%), 243 (5), 175 (100), and 145 (24).

*Ethyl* 5-(7-*Methoxy*-1-*oxoindan*-6-*yl*)*pentanoate* (**12**).—A mixture of the alkene (**11**) (2.97 g), palladium-on-charcoal (10%; 0.4 g) and methanol (150 ml) was shaken under an atmosphere of hydrogen until uptake of hydrogen ceased. The mixture was filtered, and evaporated to give the *title compound* (**12**) (3.80 g, 95%) as a colourless oil, b.p. 190 °C/0.35 mmHg (Kugelrohr) (Found: C, 70.4; H, 7.9. $C_{17}H_{22}O_4$ requires C, 70.3; H, 7.6%); $\nu_{max.}$(film) 1 740—1 700br $cm^{-1}$; $\delta_H$(90 MHz; $CDCl_3$) 7.45 (1 H, d, *J* 6 Hz, indan 5-H), 7.14 (1 H, d, *J* 6 Hz, indan 4-H), 4.17 (2 H, q, *J* 6 Hz, $OCH_2CH_3$), 4.01 (3 H, s, OMe), 3.10 (2 H, t, $CH_2CH_2CO$), 2.70 (4 H, m, 5-$CH_2$ and $CH_2CH_2CO$), 2.36 (2 H, ~ t, 2-$CH_2$), 1.65 (4 H, m, 3-$CH_2$, 4-$CH_2$), and 1.27 (3 H, t, *J* 6 Hz); *m/z* 290 ($M^+$, 82%), 245 (61), 187 (67), 175 (100), and 145 (66).

6-(5-*Hydroxypentyl*)-7-*methoxyindan*-1-*one* (**13**).—A solution of the ester (**12**) (3.87 g, 13.4 mmol) in ether (30 ml) was added to a stirred suspension of lithium aluminium hydride (0.76 g, 20 mmol) in ether (150 ml) at 0 °C. The cooling bath was removed and the mixture was stirred for a further 20 min. Standard work-up gave crude 6-(5-hydroxypentyl)-7-methoxyindan-1-ol (3.30 g, 99%) used immediately without further purification.

A mixture of the above diol (3.30 g), manganese(IV)oxide (30 g), and dichloromethane (70 ml) was stirred at room temperature for 1 h. The mixture was filtered, the solid material washed with hot dichloromethane, and the combined filtrate and washings were evaporated. The residue was purified by chromatography and distillation to give the *title compound* (**13**) (2.29 g, 70%), b.p. 130 °C/0.05 mmHg (Kugelrohr) (Found: C, 72.5; H, 8.2. $C_{15}H_{20}O_3$ requires C, 72.55; H, 8.1%); $\nu_{max.}$(film) 3 400br and 1 705 $cm^{-1}$; $\delta_H$(90 MHz; $CDCl_3$) 7.45 (1 H, d, *J* 8 Hz, 5-H), 7.15 (1 H, d, *J* 8 Hz, 4-H), 4.00 (3 H, s, OMe), 3.68 (2 H, t, *J* 6 Hz, $HOCH_2$), 3.10 (2 H, t, *J* 7 Hz, 3-$CH_2$), 2.71 (4 H, m, 2-$CH_2$ and $ArCH_2$), and 1.80—1.45 (7 H, m, 3 × $CH_2$ and OH); *m/z* 248 ($M^+$, 9%), 215 (10), 189 (38), 175 (100), 161 (56), and 145 (18).

6-(5-*t*-*Butyldimethylsiloxypentyl*)-7-*methoxyindan*-1-*one* (**14**).—A mixture of the alcohol (**13**) (2.22 g, 8.95 mmol), t-butyldimethylsilyl chloride (1.62 g, 10.73 mmol), and (diisopropyl)ethylamine (1.73 g, 13.4 mmol) in dry DMF (75 ml) was stirred at room temperature for 1 h. Aqueous work-up and chromatography gave the *title compound* (**14**) (3.18 g, 98%), b.p. 145 °C at 0.15 mmHg (Found: C, 69.5; H, 9.7. $C_{21}H_{34}O_3Si$ requires 69.6; H, 9.45%); $\nu_{max.}$(film) 1 710 $cm^{-1}$; $\delta_H$(250 MHz; $CDCl_3$) 7.38 (1 H, d, *J* 8 Hz, 5-H), 7.07 (1 H, d, *J* 8 Hz, 4-H), 3.95 (3 H, s, OMe), 3.60 (2 H, t, *J* 7 Hz, $SiOCH_2$), 3.06 (2 H, t, *J* 7 Hz, 3-$CH_2$), 2.73—2.62 (4 H, m, 2-$CH_2$, $ArCH_2$), 1.65—1.34 (6 H, m, 3 × $CH_2$), 0.88 (9 H, s, Bu$^t$Si), and 0.04 (6 H, s, $Me_2Si$); *m/z* 361 ($M^+$ − 1, 0.2%), 347 (2), 306 (24), 305 (100), and 75 (45).

6-(5-*t*-*Butyldimethylsiloxypentyl*)-5,7a-*dihydro*-7-*methoxy*-7a-*pent*-2-*ynylindan*-1-*one* (**15**).—A solution of the 7-methoxyindanone (**14**) (2.05 g, 5.66 mmol) in dry THF (9 ml) and dry t-butyl alcohol (1.2 ml, 12.5 mmol) was slowly added to a solution of potassium (0.67 g, 17.2 mmol) in liquid ammonia (50 ml) under nitrogen at −78 °C. After the mixture had been stirred for 30 min a solution of lithium bromide (1.30 g, 15.3 mmol) in THF (9 ml) was introduced, and stirring continued for 30 min. 1-Bromopent-2-yne (0.85 g, 5.78 mmol) and aqueous THF (50%; 16 ml) were then simultaneously added rapidly, and the ammonia was subsequently removed under reduced pressure. Water (100 ml) was added and the aqueous layer was extracted with ether (3 × 50 ml). The combined organic extracts were dried ($Na_2SO_4$), evaporated, and the residue was purified by flash chromatography, eluting with ether–light petroleum to give the title compound (**15**) (1.01 g, 42%) as a colourless oil; $\nu_{max.}$(film) 2 250, 1 754, 1 705, 1 655, and 1 100 $cm^{-1}$; $\delta_H$(250 MHz; $CDCl_3$) 5.87—5.82 (1 H, m, 4-H), 3.65—3.57 (2 H, t, $SiOCH_2$), 3.62 (3 H, s, OMe), 2.94—2.20 (10 H, m, 5-H, $C{\equiv}CCH_2$, $CH_2$-ring, 2-H and 3-H), 2.15—2.05 (2 H, m, $CH_3CH_2$), 1.60—1.35 (6 H, m, 3 × $CH_2$), 1.05 (3 H, t, *J* 7 Hz, $CH_2CH_2$), 0.90 (9 H, s, Bu$^t$Si), and 0.03 (6 H, s, $Me_2Si$), used without further purification.

*Ozonolysis of the Dihydroindanone* (**15**).—The dihydroindanone (**15**) (0.95 g, 2.21 mmol) was dissolved in dry methanol (15 ml), and the solution was cooled to −78 °C. Ozone was then bubbled through it until t.l.c. analysis indicated the absence of starting material. The mixture was allowed to warm up to −30 °C and zinc powder (0.25 g, 3.83 mmol) was added, followed by the dropwise addition of aqueous acetic acid (50%; 1.0 ml). After warming up to room temperature, the mixture was filtered, and the filtrate was evaporated. Water (20 ml) and chloroform (20 ml) were added to the residue, and the aqueous layer washed with chloroform (2 × 20 ml). The combined organic extracts were washed with saturated aqueous sodium hydrogen carbonate (30 ml), water (30 ml), and brine (30 ml), dried, and evaporated. Purification of the oily residue by flash chromatography, eluting with ether–light petroleum gave the *cyclopentanone* (**16**) (0.79 g, 77%) as a colourless oil (Found: $M^+$, 405.2093. $C_{26}H_{42}O_5Si$-$C_4H_9$ requires $M^+$, 405.2097); $\nu_{max.}$(film) 1 760, 1 730, 1 720, 1 250, and 1 100 $cm^{-1}$; $\delta_H$(250 MHz; $CDCl_3$) 5.85 (1 H, t, *J* 8 Hz, =CH), 3.62 (3 H, s, $CO_2Me$), 3.58 (2 H, t, *J* 5.5 Hz, $SiOCH_2$), 3.14 (2 H, br d, *J* 8 Hz, $COCH_2CH$=), 2.88 (2 H, dt, *J* 5.5 and 5 Hz, $C{\equiv}CCH_2$), 2.83—2.72 (2 H, m, $CH_2CO$), 2.70—2.45 (2 H, m, $CH_2CH_2CO$), 2.39

(2 H, t, *J* 8 Hz, $CH_2CH_2CO$), 2.04 (2 H, qt, 7.5 and 2 Hz, $CH_3CH_2$), 1.63—1.25 (6 H, m, 3 × $CH_2$), 1.03 (3 H, t, *J* 8 Hz, $CH_3CH_2$), 0.87 (9 H, s, Bu$^t$Si), and 0.03 (6 H, s, $Me_2Si$); *m/z* 463 ($M^+$ + H, 2%), 405 (23), 345 (12), 305 (12), 287 (7), 203 (41), 171 (44), and 75 (100).

3-(8-*t-Butyldimethylsiloxy*-3-*oxo-octyl*)-2-*pent*-2-*ynylcyclopent*-2-*enone* (**17**).—A solution of the β-keto ester (**16**) (0.57 g, 1.23 mmol) in 2,6-dimethylpyridine (2 ml) was added dropwise to a solution of lithium iodide (0.62 g, 4.63 mmol) in 2,6-dimethylpyridine (15 ml) and water (0.022 ml) at 130 °C. After 10 min at 130—135 °C, the yellow solution turned dark brown. The mixture was allowed to cool, poured onto water (20 ml), and extracted with ether (3 × 20 ml). The extracts were combined, dried, evaporated, and the residue was purified by dry flash chromatography, eluting with ether–light petroleum to give the β-keto ester (**16**) (0.068 g) and the *title compound* (**17**) (0.17 g, 34%, 39% based on conversion) as a colourless oil (Found: $M^+$, 404.2750. $C_{24}H_{40}O_3Si$ requires *M*, 404.2747), $\nu_{max.}$(film) 1 700, 1 645, and 1 100 $cm^{-1}$; $\delta_H$(250 MHz; $CDCl_3$) 3.59 (2 H, t, *J* 6 Hz, $SiOCH_2$), 3.07 (2 H, m, $C{\equiv}CCH_2$), 2.83 (2 H, br t, *J* 6.5 Hz, $COCH_2CH_2$), 2.71 (2 H, br t, *J* 7 Hz, $COCH_2CH_2$), 2.53—2.42 (4 H, m, 3-H and $CH_2CO$), 2.42—2.36 (2 H, m, 2-H), 2.12 (2 H, qt, *J* 7.5 and 2 Hz, $CH_3CH_2$), 1.67—1.28 (6 H, m, 3 × $CH_2$), 1.08 (3 H, t, *J* 7.5 Hz, $CH_3CH_2$), 0.88 (9 H, s, Bu$^t$Si), and 0.02 (6 H, s, $Me_2Si$); *m/z* 404 ($M^+$, 8%), 289 (5), 347 (100), 289 (3). 175 (34), 161 (17), and 147 (5).

3-(8-*t-Butyldimethylsiloxy*-3-*hydroxyoctyl*)-2-*pent*-2-*ynylcyclopent*-2-*enone* (**7**).—A solution of the ketone (**17**) (0.088 g, 0.22 mmol) in THF (0.5 ml) was added to a solution of lithium aluminium tri-t-butoxyhydride (0.097 g, 0.38 mmol) in THF (2 ml) under nitrogen at −10 °C. After 20 min, the reaction mixture was quenched by the addition of aqueous acetic acid (5%; 0.5 ml). Water (20 ml) was added, and the mixture was extracted with ethyl acetate (3 × 15 ml). The combined organic extracts were washed with saturated aqueous sodium hydrogen carbonate (10 ml), and water (10 ml), dried, and evaporated. Purification of the crude product by flash chromatography, eluting with ether, gave the unchanged ketone (**17**) (0.025 g) and the alcohol (**7**) (0.038 g, 43%, 61% based on consumed ketone), identical with the previously prepared sample.

3-(8-*t-Butyldimethylsiloxyoctyl*)-2-*pent*-2-*ynylcyclopent*-2-*enone* (**19**).—A mixture of the alcohol (**7**) (0.038 g, 0.094 mmol) and thiocarbonyldi-imidazole (0.033 g, 0.187 mmol) in 1,2-dichloroethane (0.5 ml) was heated at reflux under an atmosphere of nitrogen. Additional amounts of thiocarbonyldi-imidazole were introduced until t.l.c. indicated the absence of starting material. After the mixture had cooled, dichloromethane (10 ml) was added, and the organic layer separated and sequentially washed with water (5 ml), hydrochloric acid (1M, 5 ml), aqueous sodium hydrogen carbonate (5%; 5 ml), water (5 ml), and brine (5 ml), and then dried ($Na_2SO_4$) and evaporated. The crude thiocarbonylimidazolide (**18**) (0.039 g) was dissolved in dry toluene (1 ml) and the solution heated at reflux under nitrogen. Azoisobutyronitrile (0.001 g) and tri-butyltin hydride (0.026 g, 0.091 mmol) were added. After 10 min, the reaction mixture was allowed to cool, and the solvent was removed under reduced pressure to afford an oily residue. Purification by flash chromatography, eluting with ether–light petroleum gave the *title compound* (**19**) (0.012 g, 33%) as a colourless oil (Found: $M^+$, 333.2252. $C_{24}H_{42}O_2Si$-$C_4H_9$ requires *M*, 333.2250), $\nu_{max.}$($CHCl_3$) 2 240, 1 690, 1 635, and 1 100 $cm^{-1}$; $\delta_H$(250 MHz; $CDCl_3$) 3.58 (2 H, t, *J* 6 Hz, $SiOCH_2$), 3.03 (2 H, m, $C{\equiv}CCH_2$), 2.59—2.48 (4 H, m, 4-$CH_2$ and $CH_2C$), 2.40—2.34 (2 H, m, 5-$CH_2$), 2.12 (2 H, qt, *J* 7 and 2 Hz, $CH_3CH_2$), 1.55—1.25 (12 H, m, 6 × $CH_2$), 1.07 (3 H, t, *J* 7 Hz, $CH_3CH_2$), 0.88 (9 H, s, Bu$^t$Si), and 0.03 (6 H, s, $Me_2Si$); *m/z* 390 ($M^+$, 3%), 375 (2), 333 (100), 170 (6), and 149 (1).

3-(8-*t-Butyldimethylsiloxyoctyl*)-2-[(*Z*)-*pent*-2-*enyl*]*cyclopent*-2-*enone* (**20**).—A mixture of the acetylene (**19**) (0.0085 g, 0.0218 mmol) in dry pyridine (1 ml) and 10% palladium-on-barium sulphate (0.002 g) was hydrogenated at atmospheric pressure for 6 h at room temperature. The catalyst was filtered off and washed well with ethyl acetate (20 ml). The organic layer was washed with dilute hydrochloric acid (1M, 5 × 5 ml), saturated aqueous sodium hydrogen carbonate (5 ml), and water (5 ml), dried, and evaporated to give the *title compound* (**20**) (0.0085 g, 100%) as a colourless oil (Found: $M^+$, 335.2406. $C_{24}H_{44}O_2Si$-$C_4H_9$ requires *M*, 335.2406), $\nu_{max.}$($CHCl_3$) 1 690, 1 630, and 1 090 $cm^{-1}$; $\delta_H$(250 MHz; $CDCl_3$) 5.44—5.15 (2 H, m, CH=CH), 3.60 (2 H, t, *J* 5 Hz, $SiOCH_2$), 2.94 (2 H, d, *J* 6 Hz, $=CHCH_2$), 2.53—2.36 (6 H, m, 4-$CH_2$, 5-$CH_2$ and $CH_2C$), 2.16 (2 H, m, $CH_3CH_2$), 1.62—1.25 (12 H, m, 6 × $CH_2$), 0.99 (3 H, t, *J* 7 Hz, $CH_3CH_2$), 0.90 (9 H, s, Bu$^t$Si), and 0.04 (6 H, s, $Me_2Si$); *m/z* 392 ($M^+$, 1%), 377 (3), 335 (100), 177 (2), 163 (4), and 149 (9).

3-(8-*Hydroxyoctyl*)-2-[(*Z*)-*pent*-2-*enyl*]*cyclopent*-2-*enone* (**21**).—A mixture of the silyl ether (**20**) (0.006 g, 0.015 mmol), acetic acid (0.3 ml), THF (0.1 ml), and water (0.1 ml) was heated at 60 °C for 30 min. After the mixture had cooled, it was diluted with water (5 ml) and ethyl acetate (10 ml) and neutralized with saturated aqueous sodium hydrogen carbonate. The aqueous layer was extracted with ethyl acetate (4 × 10 ml), and the combined organic extracts were dried and evaporated. Purification of the residue by flash chromatography eluting with ethyl acetate gave the *alcohol* (**21**) (0.002 g, 50%) as a colourless oil (Found: $M^+$, 278.2238. $C_{18}H_{30}O_2$ requires *M*, 278.2246). $\delta_H$(250 MHz; $CDCl_3$) 5.44—5.16 (2 H, m, CH=CH), 3.63 (2 H, t, *J* 5 Hz, $HOCH_2$), 2.92 (2 H, d, *J* 6 Hz, $=CHCH_2$), 2.52—2.35 (6 H, m, 5-$CH_2$, 4-$CH_2$ and $CH_2C$), 2.16 (2 H, m, $CH_3CH_2$), 1.60—1.30 (12 H, m, 6 × $CH_2$), and 0.99 (3 H, t, *J* 7 Hz, $CH_3CH_2$), OH not observed; *m/z* 278 ($M^+$, 38%), 277 (3), 260 (3), 249 (2), 177 (27), 149 (41), and 94 (100).

8-{3-*Oxo*-2-[(*Z*)-*pent*-2-*enyl*]*cyclopent*-1-*enyl*}*octanoic Acid* (**1**) (*Tetrahydrodicranenone B*).—Adams catalyst (0.006 g) in water (0.7 ml) was hydrogenated at atmospheric pressure and room temperature for 30 min. To this black suspension, with oxygen bubbling through it, was added sodium hydrogen carbonate (0.009 g, 0.1 mmol), and a solution of the alcohol (**21**) (0.0023 g, 0.0083 mmol) in aqueous acetone (3:2; 1 ml). The reaction mixture was heated at 60 °C for 6 h. After cooling, dilute hydrochloric acid (3M, 2 ml) and ethyl acetate (10 ml) were added to it and the aqueous layer was separated and extracted with ethyl acetate (2 × 5 ml). The combined organic fractions were filtered, washed with water (2 × 10 ml), dried, and evaporated to give the carboxylic acid (**1**) (0.0022 g, 96%) as a pale yellow oil, $\nu_{max.}$($CHCl_3$) 3 500—2 500, 1 720—1 700, 1 690, and 1 630 $cm^{-1}$; $\delta_H$(250 MHz; $CDCl_3$) 5.44—5.16 (2 H, m, CH=CH), 2.94 (2 H, d, *J* 7 Hz, $=CHCH_2$), 2.54—2.32 (8 H, m, 2-$CH_2$, 8-$CH_2$, and $CH_2CH_2CO$), 2.16 (2 H, m, $CH_3CH_2$), 1.70—1.25 (10 H, m, 5 × $CH_2$), and 0.99 (3 H, t, *J* 7 Hz, $CH_3CH_2$), $CO_2H$ not observed; *m/z* 292 ($M^+$, 28%), 274 (5), 263 (5), 246 (9), 217 (14), 177 (90), 149 (85), and 41 (100).

## Acknowledgments

We thank Glaxo Group Research, Greenford, for their generous support of this work (fellowship to J. T.), and Professor K. Sakai for copies for the spectra of natural tetrahydrodicranenone B.

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*Received* 19*th May* 1986; *Paper* 7/890