$[\alpha]_{546}^{25}$ +6° (*c* 1, CH_3OH); nmr ($CDCl_3$), δ 7.6–8.0 (m, 1, aromatic proton), 7.0–7.6 (m, 3, aromatic protons), 3.5–4.2 (m, 4, OCH and $COOCH_3$), 2.5–3.5 (crude t, 2, $ArCH_2$), and 0.9–2.5 ppm (m, 20, 1 removable by deuteration, OH, CCH_2C, and $OCCH_3$, the CH_3 doublet is visible, centered at 1.2 ppm, J = 6 Hz); ir (film), 3325 (OH) and 1715 cm^{-1} (C=O); uv max (CH_3OH) 230 mμ (ε 7300) and 1270).

Anal. Calcd for $C_{19}H_{30}O_3$: C, 74.5; H, 9.87. Found: C, 74.6; H, 9.95.

(+)-Dideoxyzearalane (2) by Cyclization of (+) 7a.—To a cold (8°), stirred solution of (+) **7a** (2.10 g, 0.0072 mol) and triethylamine (1.68 g, 0.017 mol) in benzene (2050 ml) was added 8 ml of phosgene solution (12.5% in benzene). The mixture was stirred at 8° for 2 hr, at room temperature for several days, and at reflux for 43 hr. The reaction mixture was then washed with water and 3 *N* hydrochloric acid, dried (Na_2SO_4), and evaporated finally at high vacuum to yield 2.08 g of an oil. This oil was separated into fractions by column and preparative plate chromatography to yield 0.47 g (24%) of (+)-dideoxyzearalane: $[\alpha]_{546}^{25}$ +90° (*c* 1, CH_3OH); tlc, homogeneous (four solvent systems) and identical with the behavior of the (+)-dideoxyzearalane obtained by hydrogenolysis of **10b**. The nmr, ir, and uv spectra were also all identical with the corresponding spectra of (+)-dideoxyzearalane obtained by hydrogenolysis of **10b**.

Anal. Calcd for $C_{18}H_{26}O_2$: C, 78.8; H, 9.55. Found: C, 78.8; H, 9.93.

The other major, partially purified, product (0.5 g) had a low R_f on tlc plates and an nmr spectrum resembling that of dideoxyzearalane except in the aromatic and benzylic hydrogen regions as described in the discussion section.

(±)-Dideoxyzearalane (2).—A solution of (±) **7a** (0.9 g, 0.0031 mol), triethylamine (0.72 g, 0.007 mol), and 3.5 ml of phosgene solution (12.5% in benzene), prepared at 8°, was stirred at 8° for 2 hr, at room temperature overnight, and at reflux for 79 hr. The product, isolated as described for recyclized (+)-dideoxyzearalane, was obtained as an oil (0.21 g, 25%) identical in tlc behavior with that of (+)-dideoxyzearalane. The nmr, ir, and uv spectra were also all identical with the corresponding spectra of (+)-dideoxyzearalane.

Anal. Calcd for $C_{18}H_{26}O_2$: C, 78.8; H, 9.55. Found: C, 78.5; H, 10.0.

Registry No.—2 (+), 17397-59-0; 2 (±), 17397-60-3; **3**, 17393-24-7; **4**, 17393-25-8; **5**, 17414-48-1; **7a**, 17393-26-9; **7a** (+), 17397-61-4; **7b**, 17393-27-0; **7b** (+), 17397-22-7; **10b**, 17393-28-1; 10-undecenoic anhydride, 17393-29-2.

The Synthesis of DL-Zearalenone[1]

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DL-Zearalenone (1) has been synthesized by a Wittig reaction between (deca-5,9-dion-1-yl)triphenylphosphonium bromide, diethylene ketal (**17**), and ethyl 4,6-dihydroxy-2-formylbenzoate dimethyl ether (**5**), followed by base-catalyzed lactonization of the derived hydroxy ester **21**, and cleavage of protecting groups.

Zearalenone[3,4] (**1**), a metabolite of pathogenic fungi, has been isolated[5,6] from infected corn by groups at Purdue and at the University of Minnesota. Other structurally related resorcylic acid lactones[7-9] are notable for their antifungal and antibiotic activity. Potent steroidlike anabolic and uterotrophic activity ascribed[5] to zearalenone was therefore of particular interest and prompted the synthesis described here. Syntheses of zearalenone and a related substance, curvularin, have also been completed by other groups.[10-12]

Of the three principal approaches to macrolides which have been described, Baeyer–Villiger oxidation[13] of macrocyclic ketones, per acid oxidation[14] of bicyclic enol ethers, and the direct cyclization of hydroxy acids and esters,[15-17] the last is synthetically most direct and was selected in the present case. The synthesis was further divided into the construction of aromatic (**5**) and aliphatic (**17**) portions, to be linked by a Wittig reaction.

The aromatic portion was readily constructed from ethyl *o*-orsellinate diacetate[18] (**2**) by oxidation with chromium trioxide in acetic acid–acetic anhydride to the aldehyde tetraacetate **3**, followed by hydrolysis to the phenolic aldehyde **4**, and methylation to the required ethyl 4,6-dihydroxy-2-formylbenzoate dimethyl ether (**5**) (Scheme I).

The aliphatic part was constructed as follows. Carbethoxylation[19] of 1-hexen-5-one (**6**) with diethyl carbonate and sodium hydride gave the β-keto ester **7**. Michael addition to methyl vinyl ketone then extended the carbon chain to the required length forming the diketo ester **8**. Hydrolysis and decarboxylation of this substance led, not unexpectedly, to a cyclic product **9** rather than the required *n*-decyl derivative **12**. However, basic hydrolysis of the keto ester **8** was achieved by way of the intermediate ketal **10** in which the reactive functions are protected. Decarboxylation and ketal cleavage under acidic conditions then gen-

(1) Presented in part at the 154th National Meeting of the American Chemical Society, Chicago, Ill., 1967, Publication No. 338 from the Syntex Institute of Steroid Chemistry, p 7P. For Publication No. 337, see F. Alvarez, E. Denot, E. Necoechea, J. Calva, P. Crabbé, and A. Bowers, submitted for publication.

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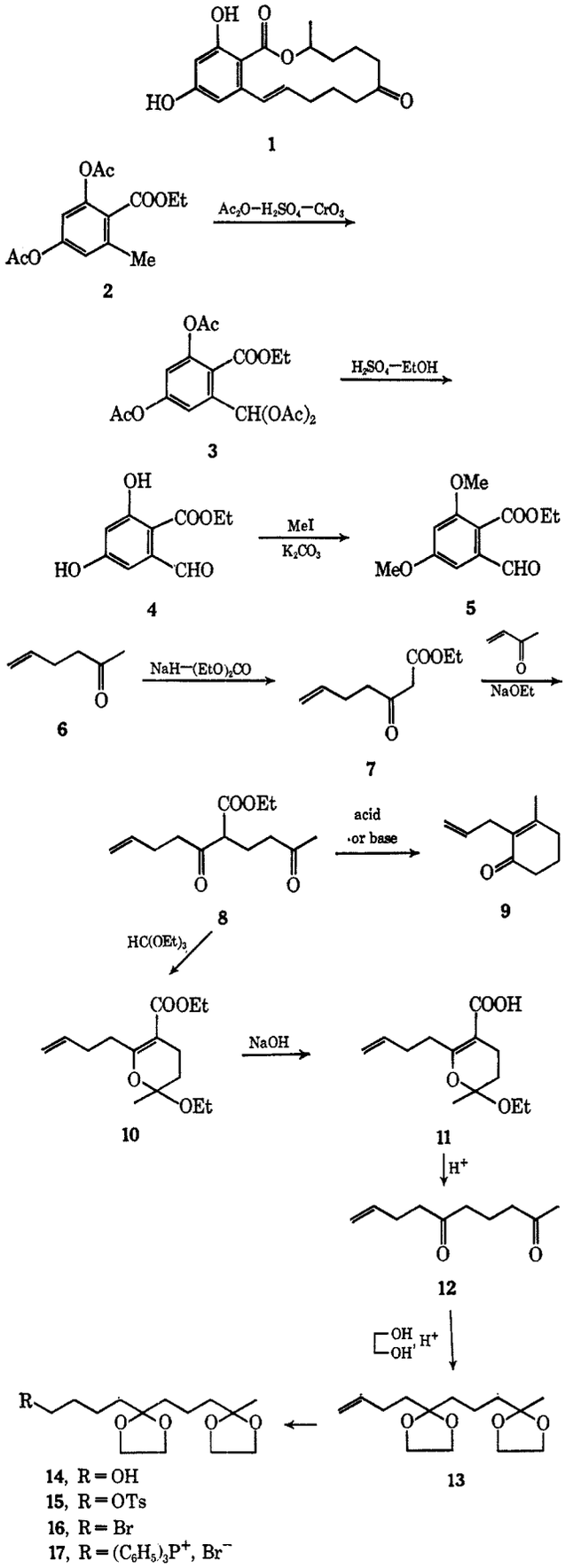
SCHEME I

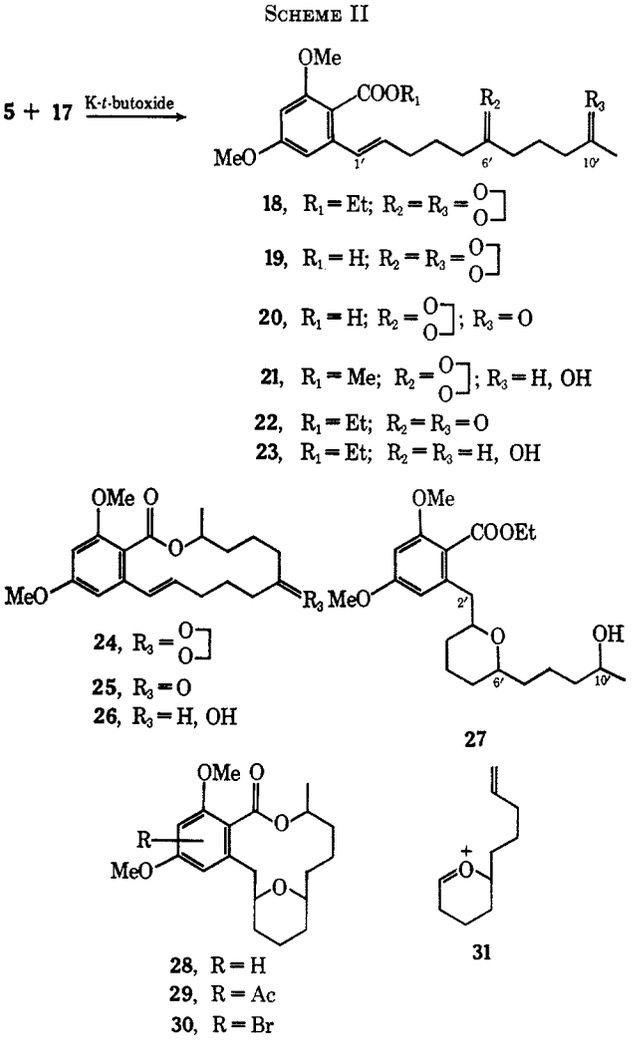


erated 1-decene-5,9-dione (**12**) containing the carbon skeleton and correctly positioned oxygen atoms of the aliphatic portion.

Ethylene ketal formation and hydroboration[20] of the olefinic bond gave the alcohol **14** which was further converted into the amorphous phosphonium salt **17** *via* the *p*-toluenesulfonate ester **15** and the bromide **16** intermediates.

Coupling of the aldehyde **5** and phosphonium salt **17** by a Wittig reaction in dimethyl sulfoxide proceeded normally leading to the ester **18**, containing the carbon skeleton of zearalenone and the 1′ double bond but lacking differentiation between functional groups at positions 6′ and 10′. The configuration of the double bond was not determined at this stage; however, completion of the synthesis gave DL-zearalenone of known *trans* stereochemistry. (See Scheme II.)

SCHEME II



The mass spectrum of the ester **18** showed a molecular ion (*m/e* 478), and also peaks at *m/e* 87, 201, and 349 corresponding to the predicted fission α to the ketal groups.[21] Specific cleavage of the ketal at C-10 of the side chain of the acid **19** in aqueous acetone containing *p*-toluenesulfonic acid proceeded in 85% yield forming the monoketal **20**. By contrast, the corresponding ester **18** was cleaved to a mixture of monoketals and the diketone **22**. It has been shown[22] that a neighboring

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carboxyl group does not catalyze the acidic hydrolysis of a ketal. In our case, there appears to be an inhibition of cleavage of the C-6 ketal by a somewhat distant carboxyl group but not by the corresponding ester.

The keto acid **20** was esterified with diazomethane, and then the ketone at C-10 was reduced by sodium borohydride yielding **21**. The lactone ring was formed in 8% yield by base-catalyzed intramolecular ester exchange of the hydroxy ester **21** in the presence of *t*-amyl alcohol as a proton source, the methanol formed being fractionally distilled out of the mixture to displace the ester–lactone equilibrium in favor of the lactone **24**. Cleavage of the remaining ketal group gave 4,6-dihydroxy-2-(10′-hydroxy-1-undecen-6′-on-1′-yl)-benzoic acid lactone dimethyl ether (**25**), DL-zearalenone dimethyl ether, which exhibited an infrared (ir) spectrum indistinguishable from that of a specimen prepared from natural zearalenone.[23] Although the yield at the lactonization stage was low (8%), it was quite sufficient to allow completion of the synthesis. Similar yields have been reported in the direct lactonization of simple α,ω-hydroxy acids.[24]

Several reagents were considered for the final stage, removal of the ether-protecting groups. Reaction of the dimethyl ether **25** with boron trifluoride etherate or with sodium diphenylphosphide[25] led only to monoethers while boron tribromide[26] in dichloromethane gave complete cleavage in 34% yield to DL-zearalenone (**1**).

Differentiation of the two ketonic functions of the diketo ester **22** and lactonization was also achieved in another way. Reduction with sodium borohydride gave the diol **23**. Base-catalyzed addition of the 6′-hydroxyl group to the aromatic ester activated double bond then led to ethyl 4,6-dihydroxy-2-(10′-hydroxy-2′,6′-oxyundec-1′-yl)benzoate dimethyl ether (**27**). This in turn was converted by sodium hydride into the lactone **28** in 15% yield. The mass spectrum showed the molecular ion and a fragment *m/e* 153 which is probably due to the ion **31**. Cleavage of the pyran ring by acidic reagents to the alcohol **26**, or other derivatives, which would be convertible into zearalenone (**1**) was not achieved. For example, treatment with acetic anhydride and *p*-toluenesulfonic acid resulted in acylation of the aromatic system forming **29**. Neither was it possible to introduce bromine selectively at the benzylic carbon atom of **28** for subsequent generation of the double bond by reductive methods.

Experimental Section[27]

Ethyl 4,6-Dihydroxy-2-dihydroxymethylbenzoate Tetraacetate (3).—A solution of 3 g of the ester **2**[18] in 25 ml of acetic acid, 17 ml of acetic anhydride, and 3 ml of sulfuric acid was cooled to 0°, and 3 g of chromium trioxide was added in small portions during 2 hr. After another 3 hr the reaction mixture was poured onto ice; excess sodium metabisulfite solution was added; and the products were extracted with ether. Chromatography on silica gel and crystallization from ether gave 900 mg of the tetraacetate, mp 97–98°.

Anal. Calcd for $C_{18}H_{20}O_{10}$: C, 54.54; H, 5.09; O, 40.37. Found: C, 54.61; H, 5.36; O, 39.81.

Ethyl 4,6-Dihydroxy-2-formylbenzoate (4).—A solution of 850 mg of the tetraacetate **3** in 20 ml of ethanol, 5 ml of water, and 0.5 ml of sulfuric acid was heated under reflux for 2 hr. Excess sodium bicarbonate solution was added, and the mixture was evaporated *in vacuo*. Trituration of the residue with ether, filtration, and evaporation of solvent from the filtrate gave the phenol **4** in crude form.

Ethyl 4,6-Dihydroxy-2-formylbenzoate Dimethyl Ether (5).—A mixture of 900 mg of the crude phenol **4** and 14 g of potassium carbonate in 84 ml of acetone and 24 ml of methyl iodide was heated under reflux for 4 hr. The mixture was filtered to remove inorganic salts and evaporated to drynesss, and the residue was dissolved in ether which was then washed with water. Evaporation of the solvent and crystallization of the residue from acetone–hexane gave 650 mg of the dimethyl ether: mp 110–111°; ir (Nujol) 1605, 1625, and 1770 cm^{-1}.

Anal. Calcd for $C_{21}H_{14}O_5$: C, 60.50; H, 5.92; O, 33.58. Found: C, 60.18; H, 5.81; O, 33.47.

Ethyl 1-Hepten-5-on-7-oate (7).—A solution of 81 g of 1-hexen-5-one (**6**) in 100 ml of ether was added during 2 hr to a boiling mixture of 179 g of diethyl carbonate and 37 g of sodium hydride (50% dispersion in oil) in 300 ml of ether. After the solution was heated under reflux for 2 hr more, ethanol was added to destroy the excess hydride, and the mixture was poured onto ice and acidified with acetic acid. Extraction with ether and distillation gave 124 g of ester, bp 85–95° (0.5 mm).

Anal. Calcd for $C_9H_{14}O_3$: C, 63.51; H, 8.29; O, 28.20. Found: C, 63.32; H, 8.45; O, 28.27.

6-Carbethoxy-1-decene-5,9-dione (8).—A solution of 88 g of the keto ester **7** in 1 l. of absolute ethanol was cooled to −10°, and sodium ethoxide (from 0.5 g of sodium) was added. To this solution was added 37 g of methyl vinyl ketone during 1 hr, and the mixture was kept at −10° for another 2 hr. Excess acetic acid was then added to neutralize the base, and the solvents were evaporated *in vacuo*. The residue was extracted with ether which was then washed with sodium bicarbonate solution and with water. Evaporation of the solvent and distillation gave 71 g of the diketo ester **8**: bp 140–150° (0.6 mm); *m/e* 195 ($M^+ - OEt$).

9-Ethoxy-5,9-oxy-1,5-decadiene-6-carboxylic Acid (11).—Treatment of the diketo ester **8** with 5% ethanolic sodium hydroxide or with sulfuric acid in acetic acid led to an oily product, **9**: nmr 1.90 (s, 3, CH_3), 2.97, 3.07 (d, 2, CH_2), and 4.6–5.3 ppm (m, 3, $CH{=}CH_2$).

A solution of 13 g of the diketo ester **8** in 120 ml of dioxane and 13 ml of triethyl orthoformate containing 3 g of *p*-toluenesulfonic acid was kept at 20° for 3 hr. Pyridine was added to neutralize the acid; the solution was diluted with water; and the product was extracted with ether. The ether solution was dried over magnesium sulfate, and the solvent was removed *in vacuo*. Chromatography on silica gel gave 8 g of the ester **10** which was not further purified. Basic hydrolysis of the ester **8** gave the enone **9**: nmr 1.90 (s, 3, CH_3), 2.97, 3.07 (d, 2, CH_2), 4.6–5.3 (m, 2, $=CH_2$), and 5.3–6.1 ppm (m, 1, $=CH$).

A solution of 8.3 g of the ester **10** in 13 ml of water and 9 ml of ethanol containing 9 g of potassium hydroxide was heated under reflux for 48 hr. The cooled solution was extracted with ether to remove neutral substances and acidified with dilute hydrochloric acid. Extraction with ether gave, after drying with magnesium sulfate, evaporation of the solvent, and crystallization from hexane, 5.6 g of acid **11**: mp 110–111°; uv max (methanol) 242 mμ (ϵ 11,990); nmr 1.13 (t, J = 7 cps, CH_2CH_3) and 1.45 ppm (s, CH_3).

Anal. Calcd for $C_{13}H_{20}O_4$: C, 64.98; H, 8.39; O, 26.63. Found: C, 64.77; H, 8.63; O, 26.6.

1-Decene-5,9-dione (12) and 1-Decene-5,9-dione Diethylene Ketal (13).—A solution of 8.1 g of the acid **11** in 45 ml of dioxane and 15 ml of water containing 1.3 g of *p*-toluenesulfonic acid was allowed to stand at 20° for 15 hr. Ether was added; the mixture was washed with sodium bicarbonate solution and with water and dried over magnesium sulfate; and the solvent was removed *in vacuo*. Chromatography on silica gel gave 4.0 g of the dione **12**: bp 80° (0.03 mm); nmr 2.12 (s, $COCH_3$) and 4.8–6.2 ppm (m, $CH{=}CH_2$).

Anal. Calcd for $C_{10}H_{16}O_2$: C, 71.39; H, 9.59; O, 19.02. Found: C, 71.20; H, 9.94; O, 18.87.

(23) Supplied by Professor C. J. Mirocha to whom we are indebted.

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A solution of 55 g of the diketone **12** in 500 ml of benzene and 81 g of ethylene glycol containing 6 g of *p*-toluenesulfonic acid was heated under reflux for 6 hr with separation of the water formed (Dean–Stark separator). Pyridine was added to the cooled solution which was then washed with water and dried over magnesium sulfate. Evaporation of the solvent and distillation of the residue gave 33 g of the diketal **13**: bp 145–150° (0.4 mm); nmr 1.28 (s, CH_3) and 3.91 ppm (OCH_2CH_2O).

1-Hydroxydeca-5,9-dione Diethylene Ketal (14).—A solution of 33 g of the olefin **13** in 100 ml of diglyme was treated with 3.5 g of sodium borohydride followed by 25 ml of boron trifluoride etherate in 20 ml of diglyme. The mixture was cooled, and 30 ml of 3 *N* sodium hydroxide and 30 ml of 30% hydrogen peroxide simultaneously added with care. The mixture was diluted with water and extracted with ether. The ether solution was dried over magnesium sulfate, and the solvent was removed *in vacuo* to give 28 g of the alcohol **14**, nmr 3.61 ppm ($-CH_2O$). For analytical purposes a sample was hydrolyzed with aqueous acetone containing *p*-toluenesulfonic acid to 1-hydroxydeca-5,9-dione, mp 51–53° from hexane–benzene.

Anal. Calcd for $C_{10}H_{18}O_3$: C, 64.49; H, 9.74. Found: C, 64.92; H, 9.55.

1-Bromodeca-5,9-dione Diethylene Ketal (16).—A solution of 2 g of the alcohol **14** in 5 ml of pyridine was treated with 3 g of *p*-toluenesulfonyl chloride. The mixture was allowed to stand at 20° for 2 hr and then cooled in ice–water, and 1 ml of water was added. After the mixture stood for 1 hr at 20°, to allow hydrolysis of the unreacted reagent, hexane was added, the mixture was filtered, and the filtrate was washed ten times with water. Evaporation of the solvent gave the tosylate ester **15**, which was used in the next reaction without further purification.

The crude tosylate ester **15** was dissolved in 30 ml of acetone containing 10 g of lithium bromide, and the mixture was stirred for 6 hr. The acetone was removed *in vacuo*, and the residue was treated with water and extracted with ether. The extract was dried over magnesium sulfate, and the solvent was removed *in vacuo*. Chromatography on silica gel gave 1.6 g of the oily bromide **16**: nmr 3.41 (t, J = 7 cps, CH_2Br) and 3.91 ppm (OCH_2CH_2O); m/e 321 ($M^+ - CH_3$).

(Deca-5,9-dion-1-yl)triphenylphosphonium Bromide Diethylene Ketal (17).—A solution of 1.7 g of the bromide **16** and 2 g of triphenylphosphine in 7 ml of benzene was heated under reflux for 48 hr. The solvent was evaporated *in vacuo*, and the residue washed five times with ether. Removal of ether *in vacuo* gave 2.3 g of the phosphonium salt **17** as a hygroscopic gum: nmr (d_6-dimethyl sulfoxide), 1.22 (s, CH_3), 3.83 (s, OCH_2CH_2O), and 7.81–7.91 ppm (aromatic H).

Ethyl 4,6-Dihydroxy-2-(1′-undecen-6′,10′-dion-1′-yl)benzoate Diethylene Ketal Dimethyl Ether (18).—A solution of 0.30 g of the aldehyde **5** and 1.1 g of the phosphonium salt **17** in 11 ml of dimethyl sulfoxide was dried over molecular sieves and then transferred to another flask, and a solution of 0.30 g of potassium *t*-butoxide in 1 ml of dimethyl sulfoxide added under nitrogen. After heating at 47° for 5 hr, the mixture was poured into water and extracted with ether. Evaporation of the solvent and chromatography on silica gel gave 0.35 g of the ester **18**: bp 180–185° (7×10^{-3} mm); nmr 1.28 (s, CH_3), 3.88 (s, OCH_2CH_2O), and 6.0–6.6 ppm (m, 4, Ar–H and =CH); m/e 478 (M^+), 433 ($M^+ - OEt$), 349, 201, 129, and 87 (α-ketal cleavage).

Methyl 4,6-Dihydroxy-2-(10′-hydroxy-1′-undecen-6′-on-1′-yl)benzoate Dimethyl Ether 6′-Ethylene Ketal (21).—A solution of 13 mg of the ester **18** and 0.5 g of potassium hydroxide in 5 ml of dimethyl sulfoxide was heated at 75° under nitrogen for 4 hr. The solution was acidified with dilute hydrochloric acid, diluted with water, and extracted with dichloromethane. Evaporation of the solvent gave the acid **19** which was further treated with 1 ml of acetone containing 0.1 ml of water and 1 ml of *p*-toluenesulfonic acid for 8 hr. Addition of water, extraction with benzene, and evaporation of the solvent gave the acid **20**: nmr 2.14 (s, $COCH_3$) and 3.90 ppm (s, OCH_2CH_2O).

Addition of diazomethane in ether to the acid **20** gave the methyl ester which was further treated with 20 mg of sodium borohydride in 1 ml of ethanol for 10 min followed by the addition of 0.2 ml of acetone. The solution was evaporated to dryness, and the residue was extracted with benzene. Concentration of the extracts gave the ester **21** in 85% over-all yield from **18**. Acid-catalyzed ketal cleavage gave methyl 4,6-dihydroxy-2(10′-hydroxyundec-1′-en-6′-on-1′-yl)benzoate dimethyl ether: m/e 360 ($M^+ - H_2O$), 329 ($M^+ - OMe$), and 248.

4,6-Dihydroxy-2-(10′-hydroxy-1′-undecen-6′-on-1′-yl)benzoic Acid Lactone 4,6-Dimethyl Ether (24).—To 5 ml of *t*-amyl alcohol was added 30 mg of sodium, and the mixture was heated until dissolution was complete. A solution of 10 mg of the hydroxy ester **21** in 100 ml of dry toluene was added, and the solution was distilled through a Dufton column during a period of 6 hr, a total of 20 ml of distillate being collected. Excess acetic acid was added, and the solvents was removed *in vacuo*. Extraction of the residue with dichloromethane and evaporation of the solvent gave the lactone **24**. This product was treated with 5 mg of *p*-toluenesufonic acid in 0.5 ml of acetone, followed by addition of excess triethylamine and evaporation to dryness. Extraction of the residue with dichloromethane and preparative tlc of the product on silica gel gave 0.8 mg of the lactone **25**: mp 128–129° from hexane (lit.[10] mp 124–126°); ir (supercooled film) 1720 cm^{-1} (lactone) (the spectrum was identical with that of an authentic specimen of zearalenone dimethyl ether); m/e 346 (M^+).

4,6-Dihydroxy-2-(10′-hydroxy-1′-undecen-6′-on-1′-yl)benzoic Acid Lactone, DL-Zearalenone (1).—A solution of 0.4 mg of the lactone **25** in 0.1 ml of dry methylene dichloride was treated with 0.01 ml of boron tribromide. After 1 hr at 20°, the mixture was added to sodium bicarbonate solution at 0°, and the product was extracted with ether. Tlc and distillation gave 0.2 mg of DL-zearalenone (**1**): bp 115–120° (7×10^{-3} mm) (natural zearalenone had bp 115–120° at 8×10^{-3} mm); R_f on silica gel chromatoplate 0.41 (hexane–acetone 7:3), identical with that of the natural product;[23] the synthetic and natural compounds had the same retention time on gas chromatography (SE-30 on Diatoport S at 220°); m/e 318 (M^+), 300, 284, 256, 189, and 188. These peaks occur in the mass spectrum of natural zearalenone.

Ethyl 4,6-Dihydroxy-2-(10′-hydroxy-2′,6′-oxyundec-1′-yl)-benzoate Dimethyl Ether (27) and 4,6-Dihydroxy-2-(10′-hydroxy-2′,6′-oxyundec-1′-yl)benzoic Acid Lactone Dimethyl Ether (28).—A solution of 30 mg of the diketone **22** in 2 ml of methanol was treated with 50 mg of sodium borohydride. After 30 min the excess borohydride was destroyed with acetone, and the solvent was evaporated *in vacuo*. Water was added to the residue, and the product was extracted with ether. Chromatography on silica gel gave 22 mg of the diol **23**.

A solution of 22 mg of the diol **23** in 150 ml of dry benzene containing 2 mg of sodium hydride (50% dispersion in oil) was slowly distilled during 2 hr (50 ml of distillate collected). Addition of water, separation of the benzene layer, and evaporation gave the pyran **27**: nmr 1.13 (d, J = 6 cps, $OCHCH_3$), 1.34 (t, J = 6 cps, OCH_2CH_3), 2.50–3.00 (m, $ArCH_2$ and CH–O), and 4.32 ppm (q, J = 6 cps, OCH_2CH_3).

A solution of 107 mg of the diol **23** in 400 ml of dry toluene containing 11 mg of sodium hydride (50% dispersion in oil) was distilled during 26 hr with collection of 100 ml of distillate. Excess acetic acid was added to the cooled solution, followed by distilled during 26 hr with collection of 100 ml of distillate. Excess acetic acid was added to the cooled solution, followed by evaporation *in vacuo*. The benzene-soluble part of the residue was purified by preparative tlc yielding 16 mg of the lactone **28**: nmr 1.34 (d, J = 6.5 cps, $OCHCH_3$), 2.31 (q, J_{gem} = 16, J_{vic} = 2.5 cps, $ArCH_2CH$–O), 3.24–3.70 (m, CH–O), 3.75, 3.76 (OCH_3), and 6.18–6.40 ppm (m, Ar–H); m/e 348 (M^+), 196, 178, and 153.

Reactions of 4,6-Dihydroxy-2-(10′-hydroxy-2′,6′-oxyundec-1′-yl)benzoic Acid Lactone Dimethyl Ether (28). A.—A solution of 20 mg of the pyran **28** in 1 ml of acetic anhydride containing 30 mg of *p*-toluenesulfonic acid was heated at 60° for 60 hr. The solution was poured into water, and the products were extracted by benzene. Evaporation of the solvent and chromatography of the residue gave 10 mg of **29**: nmr 2.40 (s, CH_3CO) and 6.35 ppm (s, 1, Ar–H); m/e 390 (M^+).

B.—A mixture of 5.0 mg of the pyran **28** and 2.6 mg of N-bromosuccinimide in 0.3 ml of carbon tetrachloride was refluxed for 45 min while irradiating with uv light. The solution was evaporated, 1 ml of ethanol containing 1% of acetic acid and 100 mg of zinc dust were added. After stirring for 15 hr, the mixture was filtered, and the solvent was removed *in vacuo*. Chromatography on silica gel gave a mixture of **30** and starting material: nmr 6.42 (s, 1, Ar–H); m/e 426 (M^+).

Registry No.—**1**, 14328-07-5; **3**, 17605-04-8; **5**, 17605-05-9; **7**, 17605-06-0; **8**, 17605-07-1; **9**, 17605-08-2; **11**, 17605-09-3; **12**, 17605-10-6; **13**, 17605-11-7; **14**, 17605-12-8; **16**, 17605-13-9; **17**, 17605-14-0; **18**, 17605-15-1; **21**, 17605-16-2; **27**, 17605-17-3; **28**, 17605-18-4.