mg, 30% in paraffin) to give a deep blue solution. A solution of ketone **12** (100 mg, 0.36 mmol) and *tert*-butyl alcohol (27 mg, 0.36 mmol) in 2 mL of THF was added dropwise over 5 min. After the addition was completed, the NH_3 was evaporated under a stream of N_2. The residue was diluted with dilute aqueous HCl and extracted with Et_2O. The combined organic extracts were dried over Na_2SO_4 and concentrated in vacuo.

The residue was combined with Me_2SO[12] (3 mL), NaCl (100 mg), and water (10 drops) and maintained at 165 °C for 2 h. The cooled reaction mixture was partitioned between petroleum ether and water. The combined organic extracts were dried over Na_2SO_4. The petroleum ether was removed by atmospheric pressure distillation through a 10-cm Vigreux column, and replaced with 10 mL of absolute EtOH. DNP solution[23] (0.5 mL) was added. After 5 min the mixture was diluted with water and extracted with CH_2Cl_2. The combined organic extracts were dried over Na_2SO_4 and concentrated in vacuo.

Repeated column chromatography of the residue failed to separate the desired DNP, **15**, from traces of menthol. The partially purified **15** was therefore submitted to preparative high-performance LC.[24] This yielded **15**: 9.8 mg (10% from **12**); R_f (10% EtOAc/hexane) 0.20; ^1H NMR 1.09–1.26 (m, 5 H), 1.6–2.6 (m, 6 H), 7.91 (d, J = 11, 1 H), 8.30 (dd, J = 3, 11, 1 H), 9.12 (d, J = 3, 1 H); IR 3320, 1630, 1330; mass spectrum, m/z (relative intensity) 278 (100), 246 (12), 189 (11), 151 (20), 140 (23); $[\alpha]^{28}_D$ −18.4 ± 1° (*c* 0.98, EtOH). Commercial (+)-3-methylcyclopentanone yielded a DNP that after purification by silica gel chromatography [R_f (10% EtOAc/hexane) 0.20] showed $[\alpha]^{28}_D$ +21.1 ± 1° (*c* 0.80, EtOH).

Acknowledgment. This work was supported by the National Institutes of Health (Grant No. GM-15431), DHHS. Mass spectrometric and FT NMR instrumentation was partially supported by NIH Biomedical Research Grant RR-05424.

Registry No. **1**, 2216-51-5; **2**, 59557-05-0; **3**, 74965-53-0; **3** diazo ester, 74978-09-9; **4**, 75023-17-5; **5**, 74965-54-1; **6**, 74965-55-2; **7**, 74965-56-3; **8**, 74965-57-4; **9**, 74965-58-5; **10**, 74965-59-6; **10** diazo ester, 74965-60-9; **11**, 74965-61-0; **12**, 74985-54-9; **13**, 74965-62-1; **14**, 6672-24-8; **15**, 74965-63-2; diketene, 674-82-8; 4-iodo-1-butene, 7766-51-0; 3-bromopropene, 106-95-6.

(23) Vogel, A. I. "Practical Organic Chemistry", 3rd ed.; Logman: London, 1974; p 344.

(24) This separation was carried out on a Waters semipreparative μ-Porasil column, eluting with 2% EtOAc/petroleum ether.

Prostaglandins and Congeners. 28.[1] Synthesis of 2-(ω-Carbalkoxyalkyl)cyclopent-2-en-1-ones, Intermediates for Prostaglandin Syntheses

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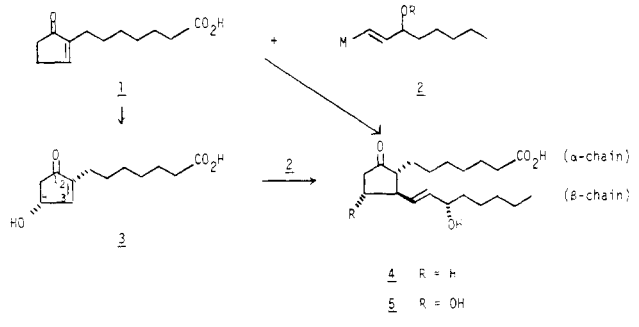
Received April 23, 1980

A methodology is described for the synthesis of the 2-substituted cyclopentenone precursors required for the preparation of 11-deoxyprostaglandins by the conjugate addition procedure. Among the cyclopentenones so prepared were some with features designed to inhibit or prevent fatty acid β-oxidative metabolism of the ultimate prostaglandin analogue. These features include methyl, ethyl, phenyl, and fluorine substituents at the α position of the fatty acid side chain and replacement of the β-methylene group with oxygen, sulfur, or *gem*-dimethylmethylene moieties. Cyclopentenones with side chains varying in length from two to nine carbon atoms were also prepared.

For a program aimed at the synthesis of 11-deoxyprostaglandin congeners via the conjugate addition of β-chain organometallic reagents (**1** + **2** → **4**, Scheme I) we required a variety of 2-(ω-carbalkoxyalkyl)cyclopent-2-en-1-ones.[3a] The ω-carbalkoxyalkyl moiety (α chain) of these cyclopentenones was varied with respect to length, substituents, and heteroatom substitution, so that the

Scheme I



effects of these modifications upon the biological activities and metabolism of the derived prostaglandins could be studied. Of particular interest were the preparations of prostaglandin analogues, in which β-oxidative fatty acid metabolism would be blocked or at least hindered. The various cyclopentenones were of further interest, since,

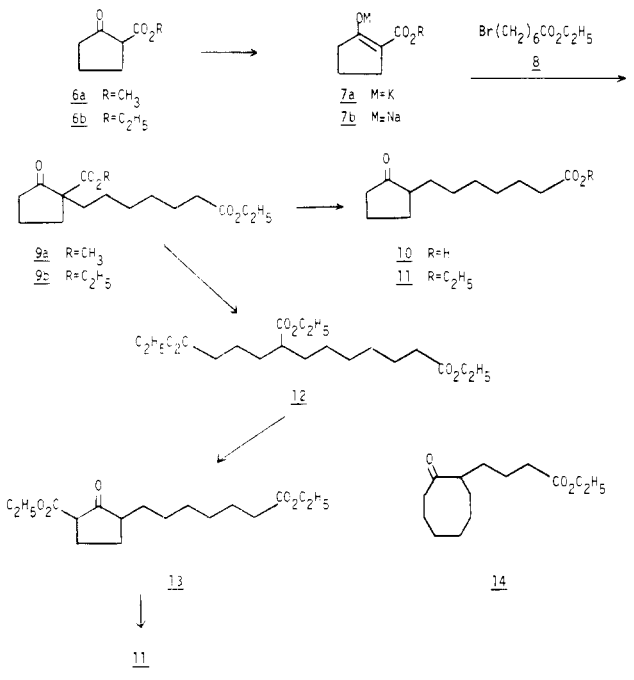
(1) For the previous paper in this series, see S.-M. L. Chen and C. V. Grudzinskas, *J. Org. Chem.*, **45**, 2278 (1980).

(2) To whom correspondence should be addressed at the Pharmaceutical Process Research Department, American Cyanamid Co., Bound Brook, NJ 08805.

(3) (a) K. F. Bernady and M. J. Weiss, *Tetrahedron Lett.*, 4083 (1972); K. F. Bernady and M. J. Weiss, *Prostaglandins*, **3**, 505 (1973); K. F. Bernady, J. F. Poletto, and M. J. Weiss, *Tetrahedron Lett.*, 765 (1975); John F. Poletto, K. F. Bernady, D. Kupfer, R. Partridge, and M. J. Weiss, *J. Med. Chem.*, **18**, 359 (1975); J. S. Skotnicki, R. E. Schaub, M. J. Weiss, and F. Dessy, *ibid.*, **20**, 1042 (1977); J. S. Skotnicki, R. E. Schaub, K. F. Bernady, G. J. Siuta, J. F. Poletto, M. J. Weiss, and F. Dessy, *ibid.*, **20**, 1551 (1977); J. S. Skotnicki, R. E. Schaub, M. J. Weiss, and F. Dessy, *ibid.*, **20**, 1662 (1977). (b) See K. F. Bernady, M. B. Floyd, J. F. Poletto, and M. J. Weiss, *J. Org. Chem.*, **44**, 1438 (1979), ref 14.

0022-3263/80/1945-4702$01.00/0

Scheme II

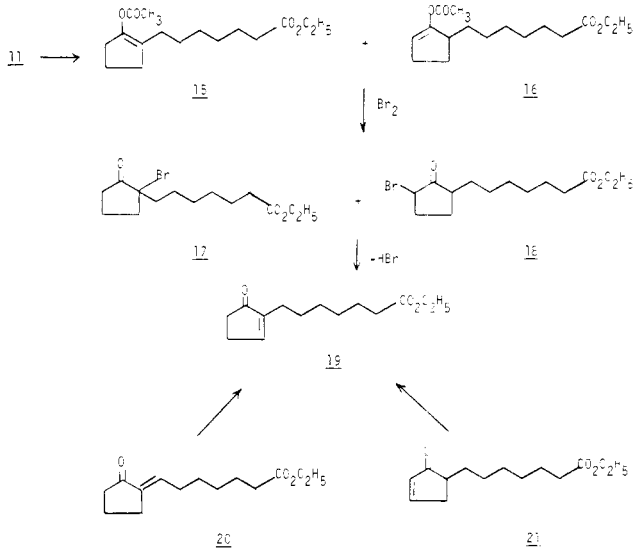


upon conversion to the 4-hydroxy derivatives, they could also serve as precursors to the corresponding 11-hydroxyprostaglandin analogues (**3** + **2** → **5**).[3b] In this paper we describe the syntheses of several of these cyclopentenones.[4]

In general, the 2-(ω-carboxyalkyl)cyclopent-2-en-1-ones were synthesized from 2-carbalkoxycyclopentanones and ω-carboxyalkyl halides by the sequence alkylation, decarboxylation, enol acetylation, bromination, and dehydrobromination or by subsequent chain-extension techniques. In many cases the intermediate products could be relayed without purification, and the processes were found convenient for relatively large-scale preparations. The synthesis of 2-(6-carbethoxyhexyl)cyclopent-2-en-1-one (**19**)[5] serves as an example of this procedure.

The standard method[6] for the alkylation in toluene of the potassium enolate, **7a**, of 2-carbalkoxycyclopentanone

Scheme III



(**6**) was found wanting when conducted on a multimolar scale. We encountered problems in obtaining a completely anhydrous preparation of potassium enolate **7a**, and its insolubility in toluene led to caking and thermal decomposition. The sodium salt **7b**, prepared in situ with sodium hydride, is soluble in hot dimethoxyethane and its preparation proved more convenient. Treatment of **7b** with ethyl 7-bromoheptanoate (**8**; 26-h reflux) provided keto diester **9** in 85% yield (Scheme II). Almost complete C-alkylation was observed. O-Alkylation products would not have interfered, since, if present, they would have been hydrolyzed during the subsequent decarboxylation step. Tetrahydrofuran can also be employed as the reaction solvent,[7] especially with a reactive alkyl halide such as ethyl bromoacetate. However, alkylation with **8** is much slower in refluxing THF, requiring >120 h for completion.

Mineral acid hydrolysis and decarboxylation of 2-alkyl-2-carbalkoxycyclopentanones yield the corresponding 2-alkylcyclopentanones. This reaction is slow for the longer chain alkyl derivatives, because of their poor solubility. However, use of acetic acid as cosolvent allows a smooth reaction. Under these latter conditions followed by Fisher esterification, 2-(6-carbethoxyhexyl)cyclopentanone (**11**) was obtained from **9** in 79% yield. An alternate decarboxylation procedure, which eliminated the reesterification step, consisted of refluxing the keto ester with sulfuric acid in absolute ethanol.[8]

Decarboxylation also could be accomplished effectively by base-induced ring fission of **9** to triester **12**, Dieckmann recyclization to **13**, mineral acid treatment, and reesterification to **11**, all without isolation of intermediates.[9] Acid decarboxylation of **13** was more facile than for the hindered **9**. Cyclooctanone **14**, the product from an alternate mode of Dieckmann cyclization of **12**, was not observed. This method was especially useful when the alkylation product **9** was contaminated with triester **12** (see Experimental Section). Thus, by this procedure, cyclopentanone **11** was obtained in 69% overall yield from a 3:1 mixture of **9** and **12**.

The conversion of cyclopentanone **11** to cyclopentenone **19** was accomplished by halogenation of enol acetate **15** and subsequent dehydrohalogenation (Scheme III). Direct halogenations of **11** with sulfuryl chloride or elemental

(4) Application of this general procedure to cyclohexanes has been described: M. B. Floyd and M. J. Weiss, *J. Org. Chem.*, **44**, 71 (1979). For other methods of cyclopentenone synthesis see: (a) L. Novak and C. Szantay, *Synthesis*, 353 (1974); (b) S. B. Thakuv, K. S. Jadhav, and S. C. Bhattacharyya, *Indian J. Chem.*, **12**, 893 (1974); (c) P. D. Gokhale, V. S. Dalavoy, A. S. C. Prakasa Rao, U. R. Nayak, and S. Dev, *Synthesis*, 718 (1974); (d) M. P. L. Caton, E. C. J. Coffee, T. Parker, and G. L. Watkins, *Synth. Commun.*, **4**, 303 (1974); (e) V. Ravid and R. Ikan, *ibid.*, **5**, 137 (1975); **7**, 185 (1977); (f) E. Wada, T. Nakai, and M. Okawara, *Chem. Lett.*, 1121 (1977); (g) P. Bakvzis and M. L. F. Bakvzis, *J. Org. Chem.*, **42**, 2362 (1977); (h) E. Wenkert, B. L. Buckwalter, A. A. Craveiro, E. L. Sandez, and S. S. Sathe, *J. Am. Chem. Soc.*, **100**, 1267 (1978); (i) L. Novak, G. Baan, J. J. Marosfalvi, and C. Szantay, *Tetrahedron Lett.*, 487 (1978); (j) T. Wakamatsu, K. Hashimoto, M. Ogura, and Y. Ban, *Synth. Commun.*, **8**, 319 (1978); (k) C. S. Subramanian, P. J. Thomas, V. R. Mamdabur, and M. S. Chadha, *Indian J. Chem., Sect. B*, **16B**, 840 (1978); (l) J. M. Reuter and R. G. Salomon, *J. Org. Chem.*, **43**, 4248 (1978); (m) R. F. Abdulla and K. H. Fuhr, *ibid.*, **43**, 4248 (1978); (n) Y. Naoshima, S. Mizobuchi, and S. Wakabayashi, *Agric. Biol. Chem.*, **43**, 1765 (1979); (o) J. H. Babler and R. K. Moy, *Synth. Commun.*, **9**, 669 (1979). For recent reviews, see: (p) T. Ho, *ibid.*, **4**, 265 (1974); (q) R. A. Ellison, *Synthesis*, 397 (1973).

(5) For an earlier synthesis of the parent carboxylic acid to **19**, see J. F. Bagli and T. Bogri, *J. Org. Chem.*, **37**, 2132 (1972). In our hands the described method gave the desired cyclopentenone but always contaminated with significant amounts of the corresponding cyclopentanone, even when excess bromine was employed. An acid-catalyzed debromination appears to be operating as a side reaction.

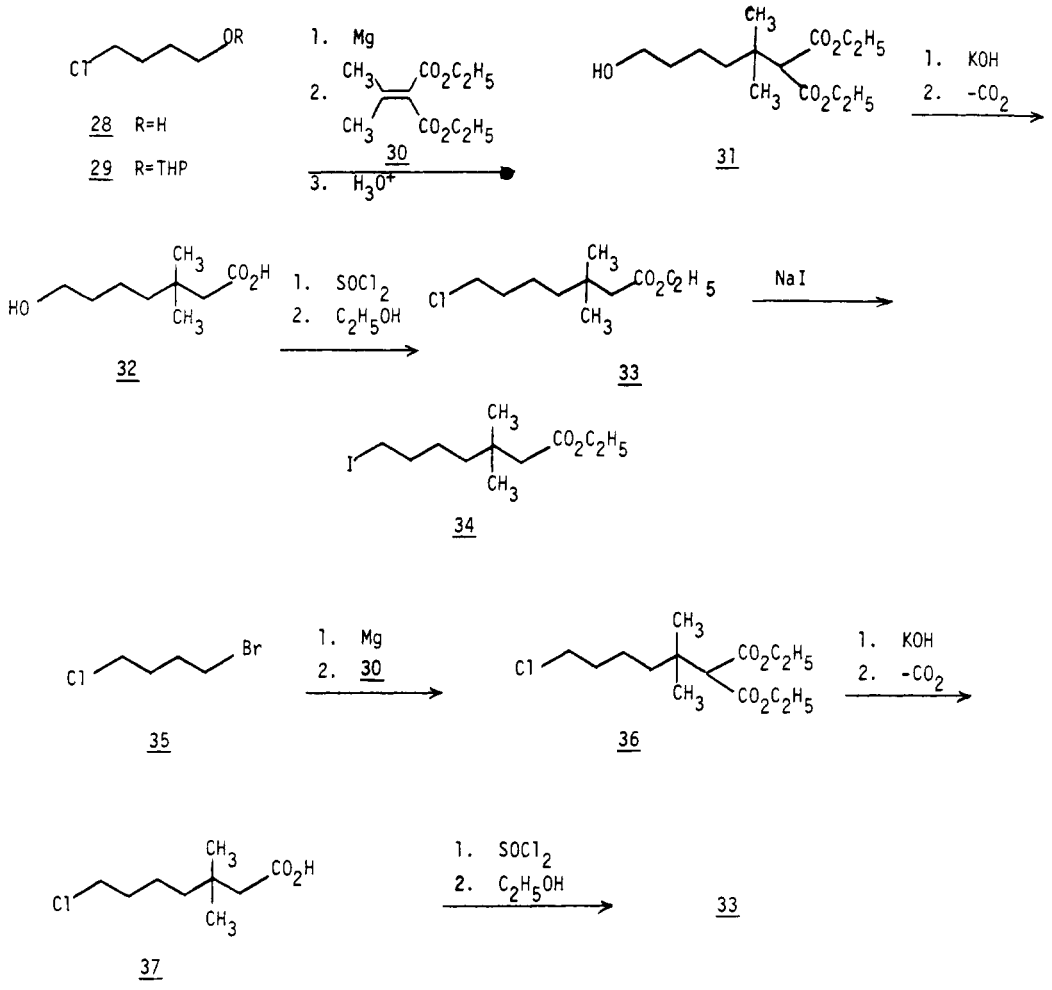
(6) Roland Mayer in "Newer Methods of Preparative Organic Chemistry", Vol. II, Wilhelm Foerst, Ed., Academic Press, New York, 1963, p 101.

(7) K. Gato, S. Guzuki, and Y. Kojima, *J. Org. Chem.*, **32**, 339 (1967).

(8) We thank Mr. R. Littel of these laboratories for this procedure.

(9) K. Sisido, K. Utimoto, and T. Isida, *J. Org. Chem.*, **29**, 2781 (1964).

Scheme IV



bromine were not clean reactions, leading to mixtures of starting ketone **11** with monohalogenated and polyhalogenated ketones. Bromination of **15** was both cleaner and more efficient.

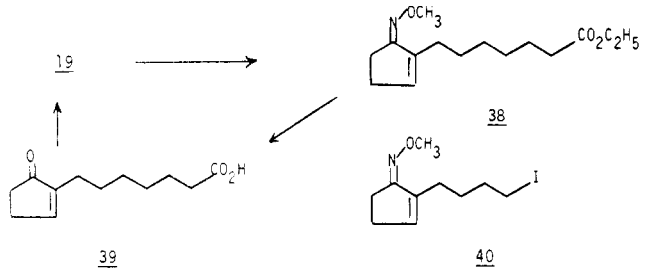
Enol acetylation of **11** with refluxing acetic anhydride and *p*-toluenesulfonic acid (*p*-TSA) catalyst proceeded only to 97% completion (8 h) and gave the thermodynamic equilibrium mixture of isomers **15** and **16** in the ratio of 98:2.[10] With perchloric acid as catalyst[11] the same isomer composition was rapidly (15 min) attained at room temperature, but the reaction could not be pushed to more than 90% completion, possibly because the byproduct acetic acid could not be removed. This maximum conversion was reached with an optimum amount of perchloric acid, beyond which unidentified byproducts were noted. Enol acetylation with isopropenyl acetate and *p*-TSA gave >99% conversion to a kinetic mixture of enol acetates **15** and **16** in a ratio of 80:20, respectively. Isomerization to the thermodynamic mixture was accomplished by refluxing the mixture with acetic anhydride and *p*-TSA. However, an unexplained concomitant formation of 3% of starting cyclopentanone **11** could not be prevented. In practice, enol acetylation with acetic anhydride and *p*-TSA was the method of choice, and since the saturated ketone **11** did not brominate appreciably in the subsequent step, its removal from the product cyclopentenone was required.[12]

Bromination of the enol acetates was accomplished in a three-phase reaction medium.[13] Addition of a carbon tetrachloride solution of bromine to a mixture consisting of a chloroform solution of enol acetates **15** and **16** and an aqueous suspension of calcium carbonate resulted in a rapid uptake of 1 equiv of bromine. Any excess of bromine persisted until the mixture was worked up. The crude bromo ketones **17** and **18** were then dehydrobrominated without delay.

Of the several dehydrobromination procedures investigated, lithium bromide and lithium carbonate in refluxing dimethylformamide or calcium carbonate in hot dimethylacetamide were found to be most effective.[14] Treatment of crude bromo ketones **17** and **18** with the $LiBr/Li_2CO_3$/DMF reagent gave cyclopentenone **19** contaminated with less than 5% of what we presume to be the isomeric cyclopentenones **20** and **21**. Heating the product with *p*-TSA in ethanol isomerized **20** and **21** to **19**.[15] Unreacted cyclopentanone **11** from the enol acetylation step was conveniently removed via selective oxime or *p*-carboxyphenylhydrazone formation. Thus, in a typ-

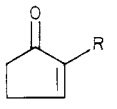
(10) H. O. House and V. Kramar, *J. Org. Chem.*, **28**, 3362 (1963).
(11) D. H. R. Barton, R. M. Evans, J. C. Hamlet, P. G. Jones, and T. Walker, *J. Chem. Soc.*, 747 (1954); B. E. Edwards and P. N. Rao, *J. Org. Chem.*, **31**, 324 (1966).
(12) The boiling points of **11** and **15** are sufficiently close to require efficient fractional distillation to completely remove the contaminating cyclopentanone from **15**.
(13) I. N. Nazarov, L. D. Bergelson, I. V. Torgov, and S. N. Ananchenko, *Izv. Akad. Nauk, SSSR, Ser. Khim.*, 889 (1953); *Chem. Abstr.*, **49**, 1082 (1955).
(14) R. Joly, J. Warnant, G. Nomine, and D. Bertin, *Bull. Soc. Chim. Fr.*, 366 (1958); G. F. H. Green and A. G. Long, *J. Chem. Soc.*, 2532 (1961).
(15) G. W. K. Cavill, B. S. Goodrich, and D. G. Laing, *Aust. J. Chem.*, **23**, 83 (1970).

Scheme V



ical large-scale preparation, high-quality cyclopentenone **19** was obtained in 60% yield (51–87%) from enol acetate **15** and in 37% overall yield from cyclopentanone **11**.

By the sequence exemplified above, cyclopentenones **22–27** were prepared.



22, R = $CH_2CO_2C_2H_5$
23, R = $(CH_2)_3CO_2C_2H_5$
24, R = $(CH_2)_4CO_2C_2H_5$
25, R = $(CH_2)_5CO_2C_2H_5$
26, R = $(CH_2)_4C(CH_3)_2CH_2CO_2C_2H_5$
27, R = $(CH_2)_5OCOCH_3$

Ethyl 3,3-dimethyl-7-iodoheptanoate (**34**), precursor for cyclopentenone **26**, was synthesized (see Scheme IV) from diethyl isopropylidenemalonate (**30**) and either 1-chloro-4-butanol (**28**) or 1-bromo-4-chlorobutane (**35**). Conjugate addition[16] of 4-(tetrahydropyranyloxy)butylmagnesium chloride to **30** in the presence of (tri-*n*-butylphosphine)-copper(I) iodide followed by acid hydrolysis of the blocking group produced diester **31**. Saponification of **31** and thermal decarboxylation of the intermediate diacid gave hydroxy acid **32**, which was converted to chloro ester **33** by treatment with excess thionyl chloride followed by ethanol. Iodide displacement upon **33** then afforded iodo ester **34**. A more efficient sequence proceeded via conjugate addition to diethyl isopropylidenemalonate (**30**) of the mono Grignard reagent prepared from 1-bromo-4-chlorobutane (**35**), yielding chloro diester **36**. Saponification of **36** in aqueous 2-propanol followed by thermal decarboxylation gave chloro acid **37**, which was esterified to chloro ester **33**.

Several of the cyclopentenones were obtained by synthesis from other members of the series. In order to perform the requisite transformations, we found it necessary to protect the carbonyl function, for which the methoximino group was found particularly useful. For example, methoxime **38** was prepared in 96% yield as a single isomer by ^1H NMR, TLC, and VPC. Complete hydrolysis of the protecting function was achieved by refluxing **38** in 3:1 acetone–2 N hydrochloric acid for 5 h.[17] This reaction does not appear to be an exchange reaction with acetone, since refluxing **38** in acetone and *p*-TSA leads to complete recovery of starting methoxime **38**. Ester hydrolysis was concomitant with methoxime cleavage, necessitating reesterification. Thus, cyclopentenone **19** was recovered in 87% yield from **38** (Scheme V). Methoxime cleavage with hot pyruvic acid was also successful but less convenient to work up.

The methoximinocyclopentene moiety possesses characteristic spectral absorptions: UV λ_{max} 243 nm (ϵ ~13 000); IR 1634, 1050, 885, 775 cm^{-1}; ^1H NMR δ 3.88 (OCH_3), 6.25 (vinylic). The moiety is stable to a variety of reactants and conditions: acidic quenching conditions, strong aqueous base, diisobutylaluminum hydride reduction, oxidations with Collins or pyridine–dichromate reagents, sulfonylations, internal alkoxide formation (vide infra), and malonate, cyanide, and mercaptide anions. Only when the preparation of the Grignard reagent of iodide **40** was attempted did the methoximino function participate, leading to unidentified products.

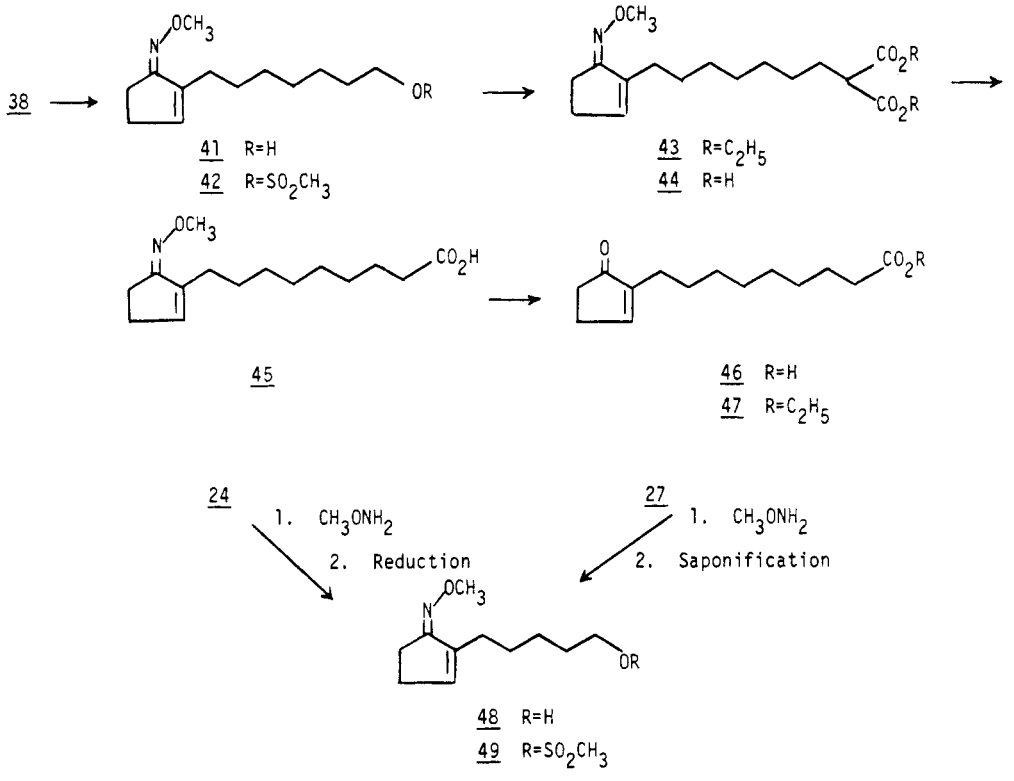
The malonate chain-extension procedure proved especially useful for the preparation of several of the desired cyclopentenones. For example, the nine-carbon α-chain cyclopentenone **47** was obtained in 34% overall yield from **38** by the following sequence: diisobutylaluminum hydride reduction to alcohol **41**, conversion to mesylate **42**, malonate displacement to diester **43**, saponification to diacid **44**, thermal decarboxylation to acid **45**, methoxime hydrolysis to cyclopentenone **46**, and esterification to **47** (Scheme VI). In a similar manner the five-carbon alcohol **48**, via its mesylate **49**, was converted to the α-methyl-, α-ethyl-, α-phenyl-, and α-fluorocyclopentenones **50–53** as well as to **19**. Cyanide displacement upon mesylate **49**, followed by basic hydrolysis and esterification, provided the six-carbon cyclopentenone **54**. Alcohol **48** was obtained from cyclopentenone **24** by methoxime formation followed by ester reduction or from cyclopentenone **27** by methoxime formation followed by acetate hydrolysis.

The 5-oxacyclopentenone **59** was prepared from methoxime **55** by the following sequence: reduction to alcohol **56**, condensation of alkoxide **57** with lithium chloroacetate to ether **58**, methoxime hydrolysis, and esterification to **59** (Scheme VII). The 5-thiacyclopentenone **62** was obtained from alcohol **56**, via its mesylate **60**, by displacement with sodium mercaptoacetate to **61**, deblocking, and reesterification. The homologous 6-thiacyclopentenone **63** was similarly prepared from mesylate **49**.

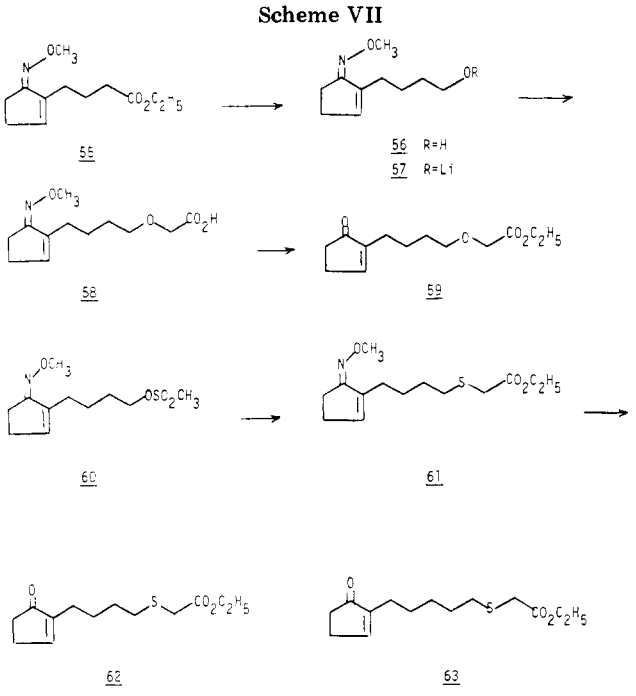
Of several alternate cyclopentenone syntheses explored, two are worthy of comment. Direct halogenation of keto diester **9**[5] with 1 equiv of bromine in our hands did not give bromo ketone **64** cleanly but in an admixture with starting ketone **9** and dibromo ketone **65** (Scheme VIII). To improve the efficiency of this halogenation, we investigated enol acetylation of **9**. This approach also proved unsatisfactory. Enol acetylation of **9** with acetic anhydride and *p*-TSA was slow (120 h) and did not go beyond 80% conversion. With isopropenyl acetate and *p*-TSA, the reaction was somewhat faster (48 h) and did proceed to a maximum 95% conversion. When bromo ketone **64** was prepared from enol acetate **66** and treated with $LiBr/Li_2CO_3$ in hot dimethylformamide, both dehydrobromination and methyl ester cleavage were observed.[18] Cyclopentenones **67**, **71**, and, unexpectedly, **19** were present in the product as inferred from spectral data. Submission of this mixture to decarboxylation conditions followed by reesterification produced **19** in 42% yield, contaminated with an additional 7% of saturated ketone **11**. Similarly, carbomethoxy enol acetate **66a** gave directly a mixture of cyclopentenones **71** and **19** in ratio of 3:1 upon bromination and dehydrobromination. It is not apparent whether **19** is formed by isomerization of **71** under the basic conditions of this reaction or is produced via HBr elimination from the presumed bromo enolate **70**, formed by initial decarbomethoxylation of **64**.

(16) H. O. House, W. L. Respess, and G. M. Whitesides, *J. Org. Chem.*, 31, 3128 (1966).
(17) We thank Dr. J. Duzza of these laboratories for suggesting this procedure.
(18) F. Elsinger, *Org. Synth.*, 45, 7 (1965).

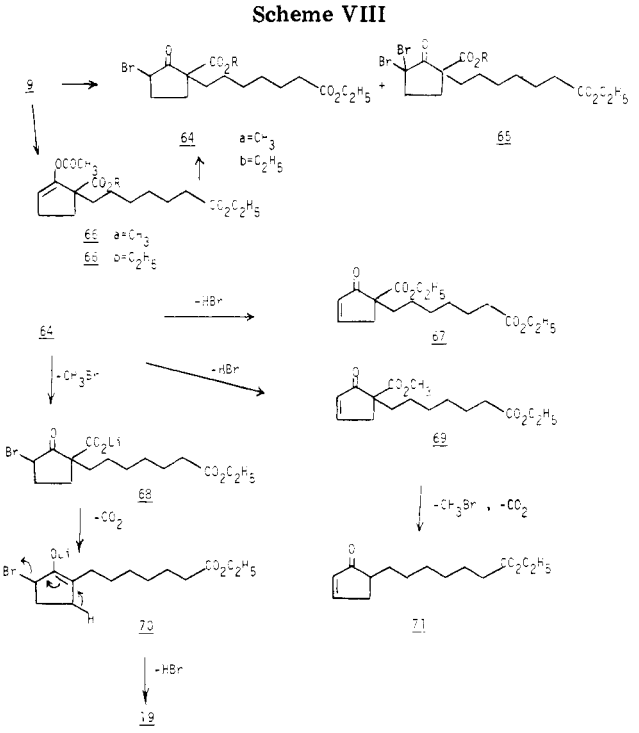
Scheme VI



Scheme VII



Scheme VIII



In the course of an allied investigation toward the preparation of bromo ketone **76**, an alternate route to 2-substituted cyclopentenones was discovered. Treatment of bromoethoxalkyl ketone **74**, prepared as indicated,[19] with 1 equiv of methanolic sodium methoxide directly

Table I

alkyl halide (XR_α)	alkylation[a] no.	alkylation[a] % yield	alkylation[a] bp, °C (mmHg)	decarboxylation[b] no.	decarboxylation[b] method	decarboxylation[b] mp/bp, °C (mmHg)	enol acetylation[c] no.	enol acetylation[c] % yield	enol acetylation[c] bp, °C (mmHg)	dehydrobromination[d] no.	dehydrobromination[d] % yield	dehydrobromination[d] bp, °C (mmHg)
$BrCH_2CO_2C_2H_5$ (86)	87[e]	93	94–97 (0.25)		A[f]	g	88	83	125–126 (15)	89	71	76–79 (0.12)	22	22	70–71 (0.12)
$I(CH_2)_3CO_2C_2H_5$ (90)	91	80	134–136 (0.40)		B	g	92	78	102–105 (0.30)	93	81	105–108 (0.30)	23	48	106–108 (0.35)
$Br(CH_2)_4CO_2C_2H_5$ (94)	95	84	148–150 (0.40)	96	A	mp 58–60	97	74	100–102 (0.10)	98	89	120–122 (0.25)	24	64	95–98 (0.10)
$Br(CH_2)_5CO_2C_2H_5$ (99)	100	66	156–158 (0.80)	101	A	mp 40–41	102	74	110–112 (0.20)						
$Br(CH_2)_6CO_2C_2H_5$ (8)	9	85	140–148 (0.10)	10	A	bp 143–145 (0.05)	11	79	128–125 (0.10)	15	90	126–128 (0.09)	19	60–88	117–120 (0.05)
$Br(CH_2)_7CO_2C_2H_5$ (103)	104	85	135–148 (0.10)		B	g	105	87	140–145 (0.20)			g	25	45[h]	153–158 (0.20)
$I(CH_2)_4C(CH_3)_2CH_2CO_2C_2H_5$ (34)	106	88	165–170 (0.30)	107	A	mp 48–50	108	50	130–134 (0.10)			g	26	65[h]	123–125 (0.05)

[a] Prepared as for cyclopentanone 9. [b] Prepared as for cyclopentanone 11 or 92. [c] Prepared as for enol acetate 15 with acetic anhydride and *p*-toluenesulfonic acid. [d] Prepared as for cyclopentenone 19. [e] Reference 7. [f] Method A: hydrochloric and acetic acids. Method B: concentrated sulfuric acid and ethanol. [g] Used crude without purification. [h] Yield based upon cyclopentanone. [i] R = CH_3 (a) or C_2H_5 (b). [j] For these products the alkyl chain consists of the R_α chain with a CO_2H group instead of a $CO_2C_2H_5$ group on the end.

Table II. Elemental Analyses

compd	formula	calcd C	calcd H	found C	found H
88	$C_9H_{14}O_3$	63.51	8.29	63.19	8.18
91	$C_{13.5}H_{14}O_3$	61.58	8.04	62.02	8.08
92	$C_{11}H_{18}O_3$	66.64	9.15	66.69	9.10
93	$C_{13}H_{20}O_4$	64.98	8.39	64.57	8.34
95	$C_{14.5}H_{23}O_5$	62.80	8.36	62.65	8.19
96	$C_{10}H_{16}O_3$	65.19	8.75	65.58	8.70
97	$C_{12}H_{20}O_3$	67.89	9.50	67.64	9.30
98	$C_{14}H_{22}O_4$	66.12	8.72	65.87	8.57
100	$C_{15.5}H_{25}O_5$	63.90	8.65	62.55	9.07
101	$C_{11}H_{18}O_3$	66.64	9.15	66.52	9.28
102	$C_{13}H_{22}O_3$	68.99	9.80	68.84	10.12
9	$C_{16.5}H_{27}O_5$	64.89	8.91	65.12	8.94
10	$C_{12}H_{20}O_3$	67.89	9.50	67.95	9.51
11	$C_{14}H_{24}O_3$	69.96	10.07	70.22	9.98
15	$C_{16}H_{26}O_4$	68.06	9.28	67.78	9.17
104	$C_{17.5}H_{29}O_5$	65.80	9.15	67.00	9.33
105	$C_{15}H_{26}O_3$	70.83	10.30	70.89	10.22
106	$C_{18.5}H_{31}O_5$	66.64	9.37	67.13	9.32
107	$C_{14}H_{24}O_3$	69.96	10.07	69.92	10.00
108	$C_{16}H_{28}O_3$	71.60	10.52	71.84	10.74

produced cyclopentenone **78** in 76% yield (Scheme IX). Cyclopentenone **78** can be rationalized as having been formed via bromo enolate **77**, which presumably exists in equilibrium with the initially formed bromo enolate **75** and bromo ketone **76**. Alternatively, base-induced dehydrobromination of **76** to afford cyclopentenone **79** followed by isomerization to **78** is also conceivable. Under conditions of high dilution in methanol, solvolysis of bromo ketone **76** competes with elimination to yield cyclopentenone **78** (<5%) and a mixture of α-methoxy ketones **81** and **82** (40%), of which **81** predominates (30%). The formation of methoxy ketones implies the intermediacy of enol carbonium ion **80**.[20] When the bromination–dehydrobromination conditions were applied to ethoxalkylcyclopentanone **83**, only a modest yield (32%) of cyclopentenone **19** was obtained, and this was contaminated, presumably with α-ethoxy ketones **84** and **85** (9.8%).

Experimental Section

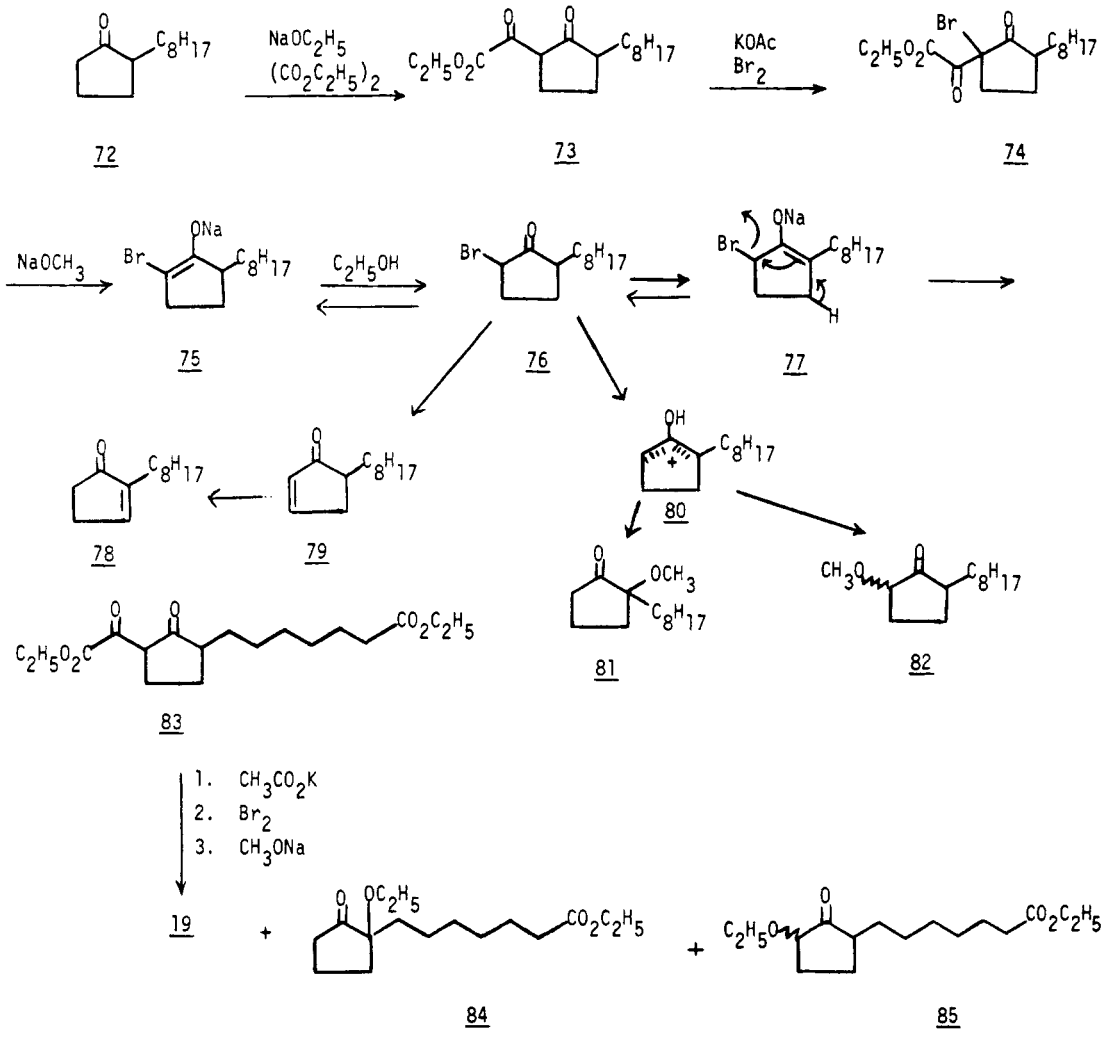
2-(Carbomethoxy)- and 2-carbethoxycyclopentanones (**6a,b**) and the various alkyl halides were purchased commercially. Ethyl 7-bromoheptanoate (**8**) also was prepared synthetically on multigram scale in good overall yield.[21] The standard workup method employed involved extracting the aqueous phase with the indicated solvent, washing the organic phase with water and saturated saline solution, drying with anhydrous sodium sulfate, and evaporating the solvent at reduced pressure with a rotary evaporator. All boiling points are uncorrected. Melting points were determined in open capillary tubes with a Mel-Temp apparatus and are uncorrected. Infrared spectra were determined as neat samples on a Perkin-Elmer Model 21 spectrophotometer. UV spectra were determined in methanol with a Cary recording spectrophotometer. ^1H NMR spectra were recorded on either a Varian A-60 or a Varian HA-100D instrument, and the chemical shifts are in parts per million downfield relative to internal tetramethylsilane (0.00 ppm). Mass spectra were determined on an AEI MS-9 instrument at 70 eV. VPC data were obtained from an F&M Model 720 isothermally by using the following columns:

(19) R. E. Schaub, G. R. Allen, Jr., and M. J. Weiss, *J. Am. Chem. Soc.*, **81**, 4962 (1959); G. R. Allen, Jr., and M. J. Weiss, *ibid.*, **81**, 4968 (1959); H, Ruschig, *Chem. Ber.*, **88**, 878 (1955).

(20) F. G. Bordwell, R. G. Scamehorn, and W. R. Springer, *J. Am. Chem. Soc.*, **91**, 2087 (1969); F. G. Bordwell and M. W. Carlson, *ibid.*, **91**, 3951 (1969); **92**, 3370, 3377 (1970).

(21) D. E. Ames, R. E. Bowman, and R. G. Mason, *J. Chem. Soc.*, 174 (1950).

Scheme IX



A, 6 ft, 5% SE-30 on Chromosorb W-AW-DMCS; B, 3 ft, 3% diethylene glycol succinate on Chromosorb G-AW-DMCS; C, 3 ft, 0.75% diethylene glycol succinate on Chromosorb G-AW-DMCS. Gas flow rates are given in milliliters per minute. The latter two columns were excellent in resolving the cyclopentenones from their corresponding cyclopentanones.

Product yields are given in Table I and elemental analyses are given in Table II.

2-(6-Carbethoxyhexyl)-2-(carbomethoxy)- and -2-carbethoxycyclopentanones (9a,b). To a slurry of 51.3 g of 57.2% (1.22 mol) sodium hydride–mineral oil dispersion, washed free of oil with hexane, in 1.2 L of dry dimethoxyethane was added 179 g (1.20 mol) of methyl and ethyl cyclopentanone-2-carboxylates (**6a,b**) at a rate to maintain a controlled evolution of hydrogen. When gas evolution was complete, 265 g (1.12 mol) of ethyl 7-bromoheptanoate (**8**) was added, and the mixture was refluxed for 26 h, cooled, and filtered. The solids were washed with ether, and the filtrate and ether washings were evaporated. The residue was poured into water, acidified with hydrochloric acid, and worked up with ether to yield an oil. Distillation produced 290 g (85%) of **9** as a colorless oil: bp 140–148 °C (0.10 torr); VPC (column A, 240 °C, 65 mL/min) exhibited **9a** and **9b** at 4.9 and 5.5 min, respectively; IR 1748 (C=O), 1733 (C=O), 1030 cm^{-1}; ^1H NMR δ 1.24 (t, OCH_2CH_3), 2.28 (t, CH_2CO_2), 3.71 (s, OCH_3), 4.13 (q, OCH_2CH_3), 4.17 (q, OCH_2CH_3). Anal. Calcd for $C_{16.5}H_{27}O_5$: C, 64.89; H, 8.91. Found: C, 64.81; H, 8.83.

2-(6-Carbethoxyhexyl)cyclopentanone (11). A mixture of 290 g (0.950 mol) of 2-(6-carbethoxyhexyl)-2-(carbomethoxy)- and -2-carbethoxycyclopentanones (**9a,b**) in 300 mL of acetic acid and 400 mL of 25% hydrochloric acid was refluxed for 18 h, cooled, and partitioned between water and benzene. The organic phase was worked up to yield 2-(6-carboxyhexyl)cyclopentanone (**10**) as an oil. An analytical sample had a boiling point of 143–145 °C (0.05 torr) and solidified at 25 °C. Anal. Calcd for $C_{12}H_{20}O_3$: C, 67.89; H, 9.50. Found: C, 67.95; H, 9.51. Semicarbazone, mp 184–186 °C. Anal. Calcd for $C_{13}H_{23}N_3O_3$: C, 57.97; H, 8.61; N, 15.60. Found: C, 57.80; H, 8.54; N, 15.34. The crude oil, **10**, was refluxed for 18 h in 2 L of absolute ethanol with 1 g of *p*-toluenesulfonic acid and cooled, and the solvent was evaporated. The oil was poured into 5% sodium bicarbonate and worked up with ether to an oil. Distillation produced 181 g (79.3%) of **11** as a colorless oil: bp 123–125 °C (0.10 torr); IR 1736 (C=O), 1156, 1030 cm^{-1}; ^1H NMR δ 1.24 (t, 3 H, OCH_2CH_3), 2.28 (t, 2 H, CH_2CO_2), 4.13 (q, 2 H, OCH_2CH_3). Anal. Calcd for $C_{14}H_{24}O_3$: C, 69.96; H, 10.07. Found: C, 70.22; H, 9.98. Semicarbazone, mp 157–158 °C. Anal. Calcd for $C_{15}H_{27}N_3O_3$: C, 60.58; H, 9.15; N, 14.13. Found: C, 60.63; H, 9.13; N, 14.16. Thiosemicarbazone, mp 99–100 °C. Anal. Calcd for $C_{15}H_{27}N_3O_2S$: C, 57.48; H, 8.68; N, 13.41; S, 10.23. Found: C, 57.52; H, 8.72; N, 13.23; S, 10.32.

2-(6-Carbethoxyhexyl)cyclopentanone (11) via Reversed Dieckman Cyclization.[9] A mixture of 915 g (3.0 mol) of 2-(6-carbethoxyhexyl)-2-(carbomethoxy)- and -2-carbethoxycyclopentanones (**9a,b**), containing approximately 25% of 1,4,10-tricarbethoxydecane (**12**) (VPC, column A, 240 °C, 65 mL/min, retention time (r_t) 8.1 min) and 165 g (3.05 mol) of sodium methoxide in 4.5 L of absolute ethanol, was refluxed for 20 h.[9] The alcohol, 2.2 L, was then distilled off, and 2.2 L of toluene was added. The remainder of the alcohol was fractionally distilled off with continuous addition of toluene to maintain the original volume. When the boiling point of toluene had been reached, the toluene was then distilled off until the reaction volume was reduced to half the original. The mixture was cooled, poured onto 1000 g of ice and 300 mL of concentrated hydrochloric acid, and worked up to yield 900 g of crude 5-(6-carbethoxyhexyl)-2-carbethoxycyclopentanone (**13**). This material was refluxed with 750 mL of glacial acetic acid and 1 L of 25% hydrochloric acid for

16 h, cooled, and worked up with benzene to yield 610 g of crude **10**. This was refluxed for 18 h with 3.5 L of absolute ethanol and 6.0 g of *p*-toluenesulfonic acid and cooled, and the solvent was evaporated. The oil was poured into 5% sodium bicarbonate, worked up with ethyl acetate, and distilled to yield 497 g (68.9%) of **11**, bp 122–126 °C (0.15 torr).

1-Acetoxy-2-(6-carbethoxyhexyl)-1-cyclopentene (15). (a) Via Acetic Anhydride and *p*-Toluenesulfonic Acid. A solution of 200 g (0.832 mol) of 2-(6-carbethoxyhexyl)cyclopentanone (**11**) and 1.9 g of *p*-toluenesulfonic acid in 400 mL of acetic anhydride was refluxed, while the acetic acid which formed was fractionally distilled off through a glass-helices-packed column. Acetic anhydride was added periodically to maintain the original volume. When the acetic acid ceased to distill over, i.e., after 8 h, the mixture was heated until the boiling point of acetic anhydride was reached. The mixture was cooled and poured onto 800 mL of saturated sodium bicarbonate and 500 mL of hexane. Additional solid sodium bicarbonate was added, and the mixture was stirred until gas evolution ceased. The organic phase was worked up to yield an oil. Distillation produced 212 g (90.2%) of **15** as a colorless oil: bp 126–128 °C (0.09 torr); VPC (column A, 180 °C, 75 mL/min) indicated the presence of two isomers, **15** and **16**,[10] with retention times of 10.0 and 10.8 min, respectively, in a ratio of 98:2 and the presence of 3% of cyclopentanone **11**, r_t = 7.8 min; IR 1760 (C=O), 1742 (C=O), 1376 (CH_3), 1214, 1030 cm^{-1}; ^1H NMR δ 1.27 (t, 3 H, OCH_2CH_3), 2.12 (s, $OCOCH_3$), 4.17 (q, 2 H, OCH_2CH_3). Anal. Calcd for $C_{16}H_{26}O_4$: C, 68.06; H, 9.28. Found: C, 67.78; H, 9.17.

(b) Via Acetic Anhydride and Perchloric Acid.[11] To a stirred solution of 2.40 g (0.010 mol) of 2-(6-carbethoxyhexyl)-cyclopentanone (**11**) and 4.6 g (0.045 mol) of acetic anhydride in 12 mL of carbon tetrachloride at ambient temperatures was added 1 drop of 70% perchloric acid. After 15 min VPC of a sample indicated an 85–90% conversion of ketone to enol acetate, which remained constant. Addition of another drop of perchloric acid resulted in no further conversion of **11** to **15** but in a diminishment in amount of **15** and the appearance of a new product in the chromatogram (r_t = 13.7 min).

(c) Via Isopropenyl Acetate and *p*-Toluenesulfonic Acid. A solution of 28.8 g (0.120 mol) of 2-(carbethoxyhexyl)cyclopentanone (**11**) and 0.40 g of *p*-toluenesulfonic acid in 50 mL of isopropenyl acetate was refluxed, while the acetone which formed was fractionally distilled off through a glass-helices-packed column. Additional isopropenyl acetate was added to maintain the original volume. The distillation was continued until acetone no longer distilled out and the boiling point of isopropenyl acetate was reached. The mixture was cooled, poured onto cold 5% sodium bicarbonate, and worked up with ether to yield an oil. Distillation produced 29.2 g (86.3%) of **15** as a colorless oil, bp 126–129 °C (0.10 torr). VPC indicated the presence of two isomers, **15** and **16**,[10] in a ratio of 80:20, respectively, and less than 0.5% of ketone **11**.

(d) Via Isomerization of Kinetically Formed Enol Acetate Mixture. A solution of 1.16 g (0.004 11 mol) of the 80:20 **15** and **16** enol acetate mixture from above and 0.050 g of *p*-toluenesulfonic acid in 10 mL of acetic anhydride was refluxed for 3 h and cooled. VPC of this mixture indicated a ratio of **15** and **16** of 98:2, respectively, and the presence of 3% of cyclopentanone **11**.

2-(6-Carbethoxyhexyl)cyclopent-2-en-1-one (19). To a well-stirred mixture of 340 g (3.40 mol) of calcium carbonate in 3.5 L of chloroform cooled to 0–5 °C were added simultaneously during 1 h a solution of 880 g (3.12 mol) of 1-acetoxy-2-(6-carbethoxyhexyl)-1-cyclopentene (**15**) in 400 mL of chloroform and a solution of 544 g (3.40 mol) of bromine in 500 mL of carbon tetrachloride.[13] The mixture was stirred with cooling for 0.5 h, and the phases were separated. The aqueous phase was washed with chloroform. The combined organic phase and the washings were washed with 5% sodium thiosulfate, water, and saturated brine, dried, and evaporated in vacuo at <40 °C to yield bromo ketone **17**. This was then immediately added to a refluxing mixture of 600 g (6.91 mol) of anhydrous lithium bromide and 575 g (7.78 mol) of anhydrous lithium carbonate in 5 L of dry dimethylformamide and refluxed for 0.5 h.[14] The mixture of lithium salts and DMF was dried before use by azeotropic distillation of water with benzene and finally distillation of the benzene. The reaction mixture was cooled, poured into 15 L of ice–water, acidified with hydrochloric acid, and worked up with ether to yield an oil. For removal of the isomeric cyclopentenones **20** and **21** which formed, the oil was refluxed for 18 h with 7.5 L of absolute ethanol and 7.5 g of *p*-toluenesulfonic acid, cooled, evaporated, poured into 5% sodium bicarbonate, and worked up with ether. Distillation of the residue gave 443 g (59.7%) of **19** as a colorless oil, bp 126–130 °C (0.10 torr). VPC (column B, 180 °C, 75 mL/min) indicated this oil to contain 94% of **19** (r_t = 13.2 min), 5% of cyclopentanone **11** (r_t = 7.5 min), and less than 1% of isomeric cyclopentenones **20** and **21** [r_t = 14.7 min; λ_{max} 228 nm (ϵ 9900)].

Purification of 2-(6-Carbethoxyhexyl)cyclopent-2-en-1-one (19). To an ice-cold solution of 120 g (0.504 mol) of 2-(6-carbethoxyhexyl)cyclopent-2-en-1-one (**19**), which by VPC contained 5% of saturated ketone **11** and 3% of isomeric cyclopentenones **20** and **21**, in 400 mL of absolute ethanol was added 7.67 g (0.0504 mol) of *p*-carboxyphenylhydrazine. The mixture was stirred with ice cooling for 4 h and then at ambient temperatures overnight. The solvent was evaporated, and the residue was dissolved in 150 mL of chloroform and filtered through a column of 450 g of alumina. Additional chloroform was used to elute the ketone, which was obtained as a colorless oil upon concentration. For removal of the isomeric cyclopentenones, the oil was refluxed in 400 mL of absolute ethanol with 1.0 g of *p*-toluenesulfonic acid for 18 h and cooled, and the solvent was evaporated. The residue was poured into dilute sodium bicarbonate, worked up with ether, and distilled to yield 97.0 g (89.7%) of **19** as a colorless oil. VPC indicated <0.5% of the isomeric cyclopentenones: IR 1736 (ester C=O), 1709 (C=O), 1637 (C=C), 1178, 790 cm^{-1}; UV λ_{max} 228 nm (ϵ 10 500); ^1H NMR (CCl_4) δ 1.23 (t, 3 H, OCH_2CH_3), 2.10 (m, 2 H, allylic), 2.20 (m, 2 H, CH_2CO_2), 2.30 (m, 2 H, allylic), 2.53 (m, 2 H, allylic), 4.06 (q, 2 H, OCH_2CH_3), 7.18 (m, 1 H, vinylic). Anal. Calcd for $C_{14}H_{22}O_3$: C, 70.56; H, 9.30. Found: C, 70.73; H, 9.45.

2-(3-Carbethoxypropyl)cyclopentanone (92) via an Alternate Decarboxylation Procedure. To a solution of 726 g (2.76 mol) of 2-(3-carbethoxypropyl)-2-(carbomethoxy)- and -2-carbethoxycyclopentanones (**91a,b**) in 2 L of absolute ethanol was cautiously added 450 mL of concentrated sulfuric acid, and the mixture was refluxed for 18 h.[8] The mixture was cooled, poured onto 3 kg of ice, and extracted into benzene. The organic phase was washed with saturated sodium bicarbonate and worked up to yield an oil. Distillation produced 424 g (77.6%) of **92** as a colorless oil: bp 102–105 °C (0.30 torr); IR 1736 (C=O's), 1176, 1159, 1034 cm^{-1}; ^1H NMR δ 1.24 (t, 3 H, OCH_2CH_3), 2.30 (t, 2 H, CH_2CO_2), 4.13 (q, 2 H, OCH_2CH_3). Anal. Calcd for $C_{11}H_{18}O_3$: C, 66.64; H, 9.15. Found: C, 66.69; H, 9.10.

2-(Carbethoxymethyl)cyclopent-2-en-1-one (22): VPC (column C, 140 °C, 60 mL/min) 3.2 (**22**), 1.5 min (**88**); IR 1736 (C=O), 1704 (C=O), 1645 (C=C), 1028, 790 cm^{-1}; UV λ_{max} 224 nm (ϵ 10 300); ^1H NMR δ 1.25 (t, 3 H, OCH_2CH_3), 2.35 (m 2 H, ring CH_2), 2.65 (m, 2 H, ring CH_2), 3.12 (m, 2 H, CH_2CO_2), 4.12 (q, 2 H, OCH_2CH_3), 7.53 (m, 1 H, vinylic). Anal. Calcd for $C_9H_{12}O_3$: C, 64.27; H, 7.19. Found: C, 64.08; H, 7.01.

2-(3-Carbethoxypropyl)cyclopent-2-en-1-one (23): VPC (column C, 140 °C, 60 mL/min) 7.2 (**23**), 3.8 min (**92**); IR 1739 (C=O), 1709 (C=O), 1639 (C=C), 792 cm^{-1}; UV λ_{max} 227 nm (ϵ 10 100); ^1H NMR δ 1.24 (t, 3 H, OCH_2CH_3), 1.84 (m, 2 H, $CH_2CH_2CH_2$), 2.24 (m, 2 H, CH_2CO_2), 2.30 (m, 2 H, $CH_2CH_2CH_2$), 2.38 (m, 2 H, ring CH_2), 2.58 (m, 2 H, ring CH_2), 4.13 (q, 2 H, OCH_2CH_3), 7.34 (m, 1 H, vinylic). Anal. Calcd for $C_{11}H_{16}O_3$: C, 67.32; H, 8.22. Found: C, 67.07; H, 8.14.

2-(4-Carbethoxybutyl)cyclopent-2-en-1-one (24): VPC (column C, 160 °C, 60 mL/min) 5.3 (**24**), 2.8 min (**97**); IR 1736 (ester C=O), 1709 (C=O), 1639 (C=C); UV λ_{max} 228 nm (ϵ 10 200); ^1H NMR δ 1.25 (t, 3 H, OCH_2CH_3), 4.13 (q, 2 H, OCH_2CH_3), 7.32 (m, 1 H, vinylic). Anal. Calcd for $C_{12}H_{18}O_3$: C, 68.55; H, 8.63. Found: C 68.32; H, 8.60.

2-(7-Carbethoxyheptyl)cyclopent-2-en-1-one (25): IR 1736 (ester C=O), 1704 (C=O), 1631 (C=C), 1034, 789 cm^{-1}; UV λ_{max} 228 nm (ϵ 9800); ^1H NMR δ 1.23 (t, 3 H, OCH_2CH_3), 4.12 (q, 2 H, OCH_2CH_3), 7.30 (m, 1 H, vinylic). Anal. Calcd for $C_{15}H_{24}O_3$: C, 71.39; H, 9.59. Found: C, 71.68; H, 10.07.

2-(6-Carboxy-5,5-dimethylhexyl)cyclopentanone (107) and 2-(6-Carbethoxy-5,5-dimethylhexyl)cyclopentanone (108). A

mixture of 200 g (0.60 mol) of keto diester **106** in 180 mL of glacial acetic acid and 240 mL of 25% hydrochloric acid was refluxed 24 h, cooled, and worked up with benzene. The organic phase was washed with dilute caustic solution, dried, evaporated, and distilled to yield 65 g (40%) of **108** as a colorless oil: bp 130–134 °C (0.10 torr); IR 1736 (C=O), 1034 cm^{-1}; ^1H NMR δ 0.99 (s, 6 H, $C(CH_3)_2$), 1.25 (t, 3 H, OCH_2CH_3), 4.13 (q, 2 H, OCH_2CH_3). Anal. Calcd for $C_{16}H_{28}O_3$: C, 71.60; H, 10.52. Found: C, 71.84; H, 10.52.

The caustic extract was acidified with concentrated HCl and worked up with ether to yield 79 g (55%) of **107** as an oil. An analytical sample was crystallized from hexane: mp 48–50 °C; IR (KBr) 1736 (C=O), 1700 (C=O), 1321 cm^{-1}; ^1H NMR δ 1.02 (s, 6 H, $C(CH_3)_2$), 2.24 (s, 2 H, CH_2CO_2). Anal. Calcd for $C_{14}H_{24}O_3$: C, 69.96; H, 10.07. Found: C, 69.92; H, 10.00.

2-(6-Carbethoxy-5,5-dimethylhexyl)cyclopent-2-en-1-one (26): VPC (column C, 180 °C, 60 mL/min) 3.5 (**26**) 2.2 min (**108**); bp 123–125 °C (0.050 torr); IR 1733 (ester C=O), 1704 (C=O), 1634 (C=C), 1366, 1225, 1033, 790 cm^{-1}; UV λ_{max} 228 nm (ϵ 10400); ^1H NMR δ 0.97 (s, 6 H, $C(CH_3)_2$), 1.24 (t, 3 H, OCH_2CH_3), 1.31 (m, 6 H, CH_2's), 2.15 (m, 2 H, allylic), 2.17 (s, 2 H, CH_2CO_2), 2.37 (m, 2 H, allylic), 2.56 (m, 2 H, allylic), 4.11 (q, 2 H, OCH_2CH_3), 7.30 (m, 1 H, vinylic). Anal. Calcd for $C_{16}H_{26}O_3$: C, 72.14; H, 9.84. Found: C, 71.82; H, 9.80.

1-Chloro-4-(tetrahydropyranyloxy)butane (29). An ice-cooled solution of 189 g (1.74 mol) of 1-chloro-4-hydroxybutane (**28**) and 175 g (2.08 mol) of dihydropyran was treated with 3 drops of phosphorus oxychloride, stoppered, and allowed to stand at room temperature for 20 h. The mixture was treated with 6 drops of triethylamine and filtered through a column of Florisil with hexane as eluent. The resulting oil was distilled to yield 241 g (72%) of **29** as a colorless oil, bp 64–65 °C (0.07 torr). The material was converted directly to its Grignard reagent.

1-Hydroxy-6,6-dicarbethoxy-5,5-dimethylhexane (31). To a stirred slurry of 9.72 g (0.400 mol) of magnesium in 25 mL of dry tetrahydrofuran and 100 mL of toluene at 80 °C was added ~5 g of a total of 77.2 g (0.401 mol) of 1-chloro-4-(tetrahydropyranyloxy)butane (**29**). After the reaction had been initiated, the remainder of the halide was added dropwise during 2 h, while the temperature was maintained at 90 °C. The mixture was maintained at 90 °C for 4 h, cooled to 50 °C, and diluted with 180 mL of tetrahydrofuran. The Grignard reagent was then added to an ice-cooled solution of 30.0 g (0.150 mol) of diethyl isopropylidenemalonate[22] (**30**) and 7.84 g (0.0200 mol) of tetrakis[iodo(tri-*n*-butylphosphine)copper][23] in 250 mL of tetrahydrofuran, and the mixture was stirred at ambient temperature for 4 h. The mixture was poured onto ice and dilute hydrochloric acid and worked up with ether to yield a crude oil. This material was stirred at room temperature with 15 mL of concentrated hydrochloric acid in 350 mL of absolute ethanol for 18 h, evaporated, and poured into water. The mixture was worked up with ether to yield an oil. Distillation produced 33.3 g (80.8%) of **31** as a colorless oil, bp 155–165 °C (0.50 torr). An analytical sample had the following: bp 115–117 °C (0.050 torr); IR 3378 (OH), 1747 (C=O), 1724 (C=O), 1364, 1227, 1135, 1036 cm^{-1}; ^1H NMR δ 1.12 (s, 6 H, $C(CH_3)_2$), 1.28 (t, 6 H, OCH_2CH_3), 1.45 (m, 6 H, CH_2's), 1.61 (s, 1 H, exchangeable, OH), 3.36 (s, 1 H, $CH(CO_2CH_2CH_3)_2$), 3.68 (m, 2 H, CH_2OH), 4.21 (q, 4 H, OCH_2CH_3). Anal. Calcd for $C_{14}H_{26}O_5$: C, 61.29; H, 9.55. Found: C, 61.36; H, 9.42.

1-Iodo-6-carbethoxy-5,5-dimethylhexane (34). A mixture of 32.0 g (0.117 mol) of 1-hydroxy-6,6-dicarbethoxy-5,5-dimethylhexane (**31**) and 25 g (0.45 mol) of potassium hydroxide in 600 mL of 1:1 aqueous methanol was refluxed for 8 h and cooled, and the alcohol was evaporated. The mixture was poured into water and washed with ether. The aqueous phase was acidified with hydrochloric acid and worked up with ether to yield a crude diacid. This material was refluxed with 200 mL of bis(2-ethoxyethyl) ether for 3.5 h, cooled, and evaporated to yield 19.1 g (94.0%) of 1-hydroxy-6-carboxy-5,5-dimethylhexane (**32**) as an oil. The acid (11.4 g, 0.0654 mol) was refluxed for 3 h with 31.7 g (0.266 mol) of thionyl chloride and 0.5 mL of dimethylformamide in 75 mL of chloroform for 6 h, cooled, and concentrated. The residue was poured into a solution of 35 mL of absolute ethanol and 8.8 mL of collidine in 65 mL of benzene and the mixture refluxed for 30 min. The mixture was cooled and evaporated. The residue was poured into water, acidified with hydrochloric acid, and worked up with ether to yield 12.1 g of 1-chloro-6-carbethoxy-5,5-dimethylhexane (**33**) as a yellowish oil. This material was refluxed for 12 h with 16.3 g (0.109 mol) of sodium iodide in 200 mL of 2-butanone, cooled, filtered, and concentrated. The residue was poured into water and worked up with ether to yield an oil. Distillation produced 6.46 g (31.6%) of **34** as a yellowish oil: bp 86–87 °C (0.18 torr); IR 1733 (C=O), 1364, 1221, 1136, 1035 cm^{-1}; ^1H NMR δ 1.00 (s, 6 H, $C(CH_3)_2$), 1.25 (t, 3 H, OCH_2CH_3), 1.40 (m, 4 H, $ICH_2CH_2CH_2CH_2$), 1.82 (m, 2 H, ICH_2CH_2), 2.20 (s, 2 H, CH_2CO_2), 3.22 (t, 2 H, ICH_2CH_2), 4.13 (q, 2 H, OCH_2CH_3). Anal. Calcd for $C_{11}H_{21}IO_2$: C, 42.32; H, 6.78; I, 40.65. Found: C, 42.22; H, 6.99; I, 40.26.

1-Chloro-6,6-dicarbethoxy-5,5-dimethylhexane (36). To a room-temperature slurry of 71.0 g (2.92 mol) of magnesium in 1 L of ether was added a few milliliters of 485 g (2.83 mol) of 1-bromo-4-chlorobutane (**35**). After the reaction was initiated, the mixture was cooled to 0 °C, and the remainder of the halide was added during 1 h while the temperature was maintained at 0–5 °C. The mixture was then allowed to warm to 20 °C, maintained there for 15 min, and recooled to 0 °C. To a solution of 440 g (2.20 mol) of diethyl isopropylidenemalonate[22] (**30**) and 57.0 g (0.145 mol) of tetrakis[iodo(tri-*n*-butylphosphine)copper][23] in 1 L of ether cooled to −10 °C was added the precooled Grignard reagent dropwise during 1 h, and the mixture was then stirred at ambient temperature for 3 h. The mixture was poured onto 4 kg of ice and 500 mL of concentrated hydrochloric acid and stirred overnight. The mixture was worked up with ether to yield an oil. Fractional distillation produced 336 g (52.2%) of **36** as a colorless oil, bp 120–130 °C (0.30 torr). An analytical sample had the following: bp 120 °C (0.30 torr); IR 1754 and 1730 (ester C=O), 1368, 1037 cm^{-1}; ^1H NMR δ 1.12 (s, 6 H, $C(CH_3)_2$), 1.26 (t, 6 H, OCH_2CH_3), 3.34 (s, 1 H, $CH(CO_2CH_2CH_3)_2$), 3.55 (t, 2 H, CH_2Cl), 4.19 (q, 4 H, OCH_2CH_3). Anal. Calcd for $C_{14}H_{25}ClO_4$: C, 57.43; H, 8.61; Cl, 12.11. Found: C, 57,58; H, 8.46; Cl, 12.46.

1-Chloro-6-carbethoxy-5,5-dimethylhexane (33). A mixture of 590 g (2.01 mol) of 1-chloro-6,6-dicarbethoxy-5,5-dimethylhexane (**36**) and 336 g (5.99 mol) of potassium hydroxide in 8 L of 1:1 aqueous 2-propanol was stirred at ambient temperature for 26 h. The mixture was evaporated to remove the alcohols and washed with ether. The aqueous phase was acidified with hydrochloric acid and worked up with ether to yield crude 1-chloro-6,6-dicarboxy-5,5-dimethylhexane. This material was dissolved in 2.5 L of bis(2-ethoxyethyl) ether and refluxed for 18 h. The mixture was cooled and stripped of solvent to yield crude 1-chloro-6-carboxy-5,5-dimethylhexane (**37**). To this material and 5 mL of dimethylformamide dissolved in 2.5 L of chloroform was added 450 g (3.78 mol) of thionyl chloride, and the mixture was refluxed for 3 h. The solvent and excess thionyl chloride were distilled. The crude acid chloride was added to a solution of 1 L of absolute ethanol and 265 mL of collidine in 2.5 L of benzene, refluxed for 30 min, and stirred at ambient temperature overnight. The mixture was evaporated, and the residue was poured into water. The mixture was extracted with ether, and the organic phase was washed with dilute hydrochloric acid and worked up to yield an oil. Distillation produced 278 g (62.5%) of **33** as a colorless oil: bp 75–80 °C (0.30 torr); IR 1735 (C=O), 1365, 1035 cm^{-1}; ^1H NMR δ 1.00 (s, 6 H, $C(CH_3)_2$), 1.25 (t, 3 H, OCH_2CH_3), 1.10–1.85 (m, 6 H, $ClCH_2CH_2CH_2CH_2$), 2.20 (s, 2 H, CH_2CO_2), 3.55 (t, 2 H, $ClCH_2$), 4.12 (q, 2 H, OCH_2CH_3). Anal. Calcd for $C_{11}H_{21}ClO_2$: C, 59.85; H, 9.59; Cl, 16.06. Found: C, 59.93; H, 9.45; Cl, 15.08.

2-(6-Carbethoxyhexyl)-1-methoximino-2-cyclopentene (38). A mixture of 36.0 g (0.151 mol) of ketone **19**, 15.0 g (0.180 mol) of CH_3ONH_2·HCl, 25 mL of pyridine, and 300 mL of absolute ethanol was stirred at ambient temperature for 22 h, concentrated in vacuo, and partitioned between water and ether. The organic extract was worked up to yield an oil. Distillation produced 38.7 g (95.8%) of **38** as a colorless oil: bp 115–118 °C (0.075 torr); IR 1742 (C=O), 1631, 1048, 885, 774 cm^{-1}; UV λ_{max} 243 nm (ϵ 13100); ^1H NMR ($CDCl_3$) δ 1.26 (t, 3 H, OCH_2CH_3), 2.00–2.78 (m, 6 H, C-4, C-5, C-1 hexyl), 2.32 (m, 2 H, CH_2CO_2), 3.89 (s, 3 H, OCH_3), 4.15 (q, 2 H, OCH_2CH_3), 6.23 (m, 1 H, vinylic). Anal. Calcd for

(22) A. C. Cope and E. M. Hancock, *J. Am. Chem. Soc.*, **60**, 2644 (1938).

(23) G. B. Kauffman and L. A. Teter, *Inorg. Synth.*, **7**, 9 (1963).

$C_{15}H_{25}NO_3$: C, 67.38; H, 9.42; N, 5.24. Found: C, 67.58; H, 9.46; N, 5.12.

2-(6-Carbethoxyhexyl)cyclopent-2-en-1-one (19) via Hydrolysis of Methoxime 38. A solution of 2.905 g (0.010 87 mol) of 2-(6-carbethoxyhexyl)-1-methoximino-2-cyclopentene (**38**) and 20 mL of 2 N hydrochloric acid in 55 mL of acetone was refluxed for 5 h and cooled, and the acetone was evaporated in vacuo.[17] The residue was poured into water and worked up with ether to yield 2-(6-carboxyhexyl)cyclopent-2-en-1-one (**39**) as an oil. The latter was refluxed for 17 h with 0.020 g of *p*-toluenesulfonic acid in 100 mL of absolute ethanol, cooled, and evaporated. The residue was poured into 5% sodium bicarbonate and worked up with ether to yield an oil. Distillation produced 2.263 g (87.0%) of **19** as a colorless oil: bp 118–122 °C (0.005 torr); UV (MeOH) λ_{max} 228 nm (ϵ 10 500). Anal. Calcd for $C_{14}H_{22}O_3$: C, 70.56; H, 9.30. Found: C, 70.21; H, 9.62; N, 0.00.

2-(7-Hydroxyheptyl)-1-methoximino-2-cyclopentene (41). To an ice-cooled, stirred solution of 34.1 g (0.128 mol) of ester **19** in 200 mL of benzene was added dropwise 225 mL of 25% (0.278 mol) $(i\text{-Bu})_2$AlH in hexane. The solution was stirred at 0–5 °C for 1.5 h, poured cautiously into 500 g of ice and 75 mL of concentrated HCl, and stirred for 15 min. The phases were separated, and the aqueous phase was washed with ether. The combined organic extracts were worked up to yield an oil, which solidified. The latter was crystallized from 100 mL of hexane to afford 24.3 g (84.6%) of **41** as crystals: mp 62–64 °C; IR (KBr) 3252 (OH), 1634, 1057, 851, 779, 723 cm^{-1}; UV λ_{max} 243 nm (ϵ 14 000); ^{1}H NMR (CCl_4) δ 1.37 (br s, 10 H, CH_2's), 2.00–2.73 (m, 6 H, C-4, C-5, C-1 heptyl), 2.37 (s, exchangeable, OH), 3.52 (m, 2 H, CH_2OH), 3.82 (s, 3 H, OCH_3), 6.14 (m, 1 H, vinyl). Anal. Calcd for $C_{13}H_{23}NO_2$: C, 69.29; H, 10.29; N, 6.22. Found: C, 68.99; H, 10.37; N, 6.18.

2-[7-[(Methylsulfonyl)oxy]heptyl]-1-methoximino-2-cyclopentene (42). To an ice-cooled solution of 164 g (0.728 mol) of 2-(7-hydroxyheptyl)-1-methoximino-2-cyclopentene (**41**) and 115 g (1.14 mol) of triethylamine in 2 L of dichloromethane was added dropwise with stirring 95 g (0.829 mol) of methanesulfonyl chloride, and the mixture was stirred with cooling for 0.5 h.[24] The mixture was then poured into 5 L of water and acidified with hydrochloric acid, and the phases were separated. The organic phase was washed with saturated sodium bicarbonate and saturated brine, dried, and evaporated to an oil. The latter was taken up into 100 mL of ether and refrigerated, and the crystals were filtered off to yield 172 g (77.9%) of **42** as a white solid, mp 62–64 °C. A sample was crystallized from ether–dichloromethane: mp 63–64 °C; IR 1618, 1351, 1166, 1059, 980, 950, 845, 750 cm^{-1}; UV λ_{max} 242 nm (ϵ 12 400); ^{1}H NMR δ 2.23 (m, 2 H, allylic), 2.44 (m, 2 H, allylic), 2.60 (m, 2 H, allylic), 3.00 (s, 3 H, OSO_2CH_3), 3.88 (s, 3 H, OCH_3), 4.13 (t, 2 H, $CH_2OSO_2CH_3$), 6.23 (m, 1 H, vinylic). Anal. Calcd for $C_{14}H_{25}NSO_4$: C, 55.42; H, 8.30; N, 4.62; S, 10.57. Found: C, 55.06; H, 8.09; N, 4.33; S, 10.36.

2-(8,8-Dicarboxyoctyl)-1-methoximino-2-cyclopentene (44). To a slurry of 37 g (0.88 mol) of 57% sodium hydride–mineral oil dispersion, washed free of oil with hexane, in 1 L of dry dimethoxyethane was added dropwise 220 g (1.37 mol) of diethyl malonate. When hydrogen evolution had ceased, a solution of 167 g (0.5504 mol) of 2-[6-[(methylsulfonyl)oxy]heptyl]-1-methoximino-2-cyclopentene (**42**) in 1.5 L of dimethoxyethane was added, and the mixture was refluxed for 18 h. The mixture was cooled and filtered. The solids were washed with ether, and the filtrate and washings were concentrated. The oily residue was partitioned between dilute hydrochloric acid and ether, and the organic phase was washed with water and saturated brine, dried, and evaporated to an oil. The excess diethyl malonate was distilled off in vacuo, and the oily diester **43** was refluxed for 18 h with 250 g (4.46 mol) of potassium hydroxide in 3 L of 1:1 aqueous methanol. The mixture was cooled, and the solvent was partially removed in vacuo. The residue was washed with ether. The aqueous phase was acidified with hydrochloric acid and worked up with ether to yield a solid. Crystallization from benzene produced 110 g (64.2%) of **44** as colorless crystals: mp 135–137 °C; IR (KBr) 1736 (C=O), 1715 (C=O), 1626, 1184, 1050, 899, 726 cm^{-1}; UV λ_{max} 243 nm (ϵ 13 100); ^{1}H NMR δ 3.32 (m, 1 H, $CH(CO_2H)_2$), 3.88 (s, 3 H, OCH_3), 6.24 (m, 1 H, vinylic). Anal. Calcd for $C_{16}H_{25}NO_5$: C, 61.72; H, 8.09; N, 4.50. Found: C, 61.79; H, 8.20; N, 4.39.

2-(8-Carboxyoctyl)-1-methoximino-2-cyclopentene (45). A mixture of 105 g (0.337 mol) of 2-(8,8-dicarboxyoctyl)-1-methoximino-2-cyclopentene (**44**) in 500 mL of bis(2-methoxyethyl) ether was refluxed until carbon dioxide evolution ceased. The mixture was cooled, and the solvent was evaporated. The residue was crystallized from a small amount of ether to yield 76 g (84%) of **45** as colorless crystals, mp 75–76 °C. Anal. Calcd for $C_{15}H_{25}NO_3$: C, 67.38; H, 9.42; N, 5.24. Found: C, 67.80; H, 9.46; N, 5.08.

2-(8-Carboxyoctyl)cyclopent-2-en-1-one (46). A mixture of 72.0 g (0.269 mol) of 2-(8-carboxyoctyl)-1-methoximino-2-cyclopentene (**45**) and 450 mL of 2 N hydrochloric acid in 1 L of acetone was refluxed for 5 h, cooled, and partially evaporated. The mixture was extracted with ether. The organic phase was washed with water and saturated brine, dried, and evaporated. The residue was crystallized from benzene to yield 58 g (90%) of **46** as colorless crystals: mp 66–67 °C; IR (KBr) 1739 (C=O), 1666 (C=O), 1623 (C=C), 1168, 1004 cm^{-1}; UV λ_{max} 227 nm (ϵ 10 200); ^{1}H NMR δ 2.00–2.68 (m's, 9 H, allylic, $CHCO_2H$), 7.31 (m, 1 H, vinylic). Anal. Calcd for $C_{14}H_{22}O_3$: C, 70.56; H, 9.30. Found: C, 70.46; H, 9.35.

2-(8-Carbethoxyoctyl)cyclopent-2-en-1-one (47). Acid **46** (2.80 g, 11.7 mmol) was esterified with ethanol as in the preparation of **19** from **39** to afford 2.97 g (94.9% of **47** as a colorless oil: bp 137–139 °C (0.05 torr); IR 1742 (ester C=O), 1712 (C=O), 1642 (C=C), 792 cm^{-1}; UV λ_{max} 228 nm (ϵ 10 100); ^{1}H NMR δ 1.25 (t, 3 H, OCH_2CH_3), 1.32 (br s, 12 H, CH_2's), 2.00–2.73 (m, 6 H, C-4, C-5, C-1 octyl), 2.20 (m, 2 H, CH_2CO_2), 4.15 (q, 2 H, OCH_2CH_3), 7.30 (m, 1 H, vinylic). Anal. Calcd for $C_{16}H_{26}O_3$: C, 72.14; H, 9.84. Found: C, 71.98; H, 9.71.

A **2-(5-acetoxypentyl)-2-(carbomethoxy)- and -2-carbethoxycyclopentanone (109a,b)** mixture was prepared in 77.9% yield as for **9** from 1-acetoxy-5-chloropentane[25] in the presence of 1 equiv of sodium iodide, bp 155–160 °C (0.60 torr). Anal. Calcd for $C_{14.5}H_{23}O_5$ (mol wt 277.342): C, 62.80; H, 8.36. Found: C, 63.57; H, 8.71.

2-(5-Acetoxypentyl)cyclopentanone (110) and 2-(5-Hydroxypentyl)cyclopentanone (111). Treatment of **109a,b** with hydrochloric acid and acetic acid as for the preparation of **10** from **9** gave a mixture of **110** and **111** in an approximate ratio of 70:30, respectively, by VPC. The mixture was used directly without further purification.

1-Acetoxy-2-(5-acetoxypentyl)-1-cyclopentene (112) was prepared in 79.3% yield as for **15** from the crude mixture of **110** and **111** with acetic anhydride/*p*-toluenesulfonic acid; bp 121–123 °C (1.3 torr). Anal. Calcd for $C_{14}H_{22}O_4$: C, 66.12; H, 8.72. Found: C, 65.88; H, 8.68.

2-(5-Acetoxypentyl)cyclopent-2-en-1-one (27) was prepared in 71.2% yield as for **19** from 1-acetoxy-2-(5-acetoxypentyl)-1-cyclopentene (**112**): bp 116–118 °C (0.25 torr); IR 1736 (ester C=O), 1700 (C=O), 1626 (C=C), 1238 cm^{-1}; UV λ_{max} 228 nm (ϵ 7800); ^{1}H NMR δ 2.05 (s, 3 H, O_2CCH_3), 4.09 (m, 2 H, $CH_2O_2CCH_3$), 7.34 (m, 1 H, vinylic). Anal. Calcd for $C_{12}H_{18}O_3$: C, 68.55; H, 8.63. Found: C, 68.44; H, 8.64.

1-Methoximino-2-(5-acetoxypentyl)-2-cyclopentene (113) was prepared in 85% yield as for **38** from 2-(5-acetoxypentyl)-cyclopent-2-en-1-one (**27**): bp 101–103 °C (0.20 torr); IR 1739 (C=O), 1618, 1238, 1048, 883 cm^{-1}; UV λ_{max} 243 nm (ϵ 8600); ^{1}H NMR δ 2.04 (s, 3 H, O_2CCH_3), 3.90 (s, 3 H, OCH_3), 4.09 (m, 2 H, $CH_2O_2CCH_3$), 6.26 (m, 1 H, vinylic). Anal. Calcd for $C_{13}H_{21}NO_3$: C, 65.25; H, 8.84; N, 5.85. Found: C, 64.87; H, 9.18; N, 6.12.

1-Methoximino-2-(5-hydroxypentyl)-2-cyclopentene (48) was prepared in 80% yield by saponification of 1-methoximino-2-(5-acetoxypentyl)-2-cyclopentene (**113**) as for **44**: bp 108–110 °C (0.050 torr); mp 35–36 °C (hexane). Anal. Calcd for $C_{11}H_{19}NO_2$: C, 66.97; H, 9.71; N, 7.10. Found: C, 66.84; H, 9.88; N, 6.92.

1-Methoximino-2-(4-carbethoxybutyl)-2-cyclopentene (114) was prepared in 84.1% yield as for **38** from 2-(4-carbethoxybutyl)cyclopent-2-en-1-one (**24**): bp 107–109 °C (0.040 torr); IR 1742 (C=O), 1633, 1052, 848, 776 cm^{-1}; UV λ_{max} 243 nm (ϵ 13 600);

(24) R. K. Cross and K. L. Servis, *J. Org. Chem.*, **35**, 3195 (1970).

(25) M. E. Synerholm, *J. Am. Chem. Soc.*, **69**, 2581 (1947).

^{1}H NMR δ 1.27 (t, 3 H, OCH_2CH_3), 1.65 (m, 4 H, $CH_2CH_2CH_2CH_2CO_2$), 2.10–2.78 (m, 8 H, allylic, CH_2CO_2), 3.90 (s, 3 H, OCH_3), 4.17 (q, 2 H, OCH_2CH_3), 6.27 (m, 1 H, vinylic). Anal. Calcd for $C_{13}H_{21}NO_3$: C, 65.25; H, 8.84; N, 5.85. Found: C, 65.22; H, 8.82; N, 6.17.

1-Methoximino-2-(5-hydroxypentyl)-2-cyclopentene (48) was prepared in 85.9% yield by reduction of 1-methoximino-2-(4-carbethoxybutyl)-2-cyclopentene (**114**) as for **41**: mp 33–35 °C (petroleum ether); IR (KBr) 3413 (OH), 1634, 1050, 885, 778 cm^{-1}; UV λ_{max} 243 nm (ϵ 11 800); ^{1}H NMR δ 1.55 (m, 7 H, 1 H exchangeable, CH_2's, OH), 2.07–2.80 (m, 6 H, allylic), 3.68 (m, 2 H, CH_2OH), 3.90 (s, 3 H, OCH_3), 6.25 (m, 1 H, vinylic). Anal. Calcd for $C_{11}H_{19}NO_2$: C, 66.97; H, 9.71; N, 7.10. Found: C, 66.69; H, 9.59; N, 7.22.

1-Methoximino-2-[5-[(methylsulfonyl)oxy]pentyl]-2-cyclopentene (49) was prepared in 86.2% yield as for **42**[24] from 1-methoximino-2-(5-hydroxypentyl)-2-cyclopentene (**48**); mp 81–83 °C (hexane). Anal. Calcd for $C_{12}H_{21}NO_4S$: C, 52.34; H, 7.69; N, 5.09; S, 11.64. Found: C, 52.05; H, 7.72; N, 4.83; S, 11.57.

2-(6-Carboxyheptyl)cyclopent-2-en-1-one (115). To a stirred slurry of 100 g of 50.0% (2.08 mol) sodium hydride–mineral oil dispersion, washed free of oil with hexane, in 4 L of dimethoxyethane was added dropwise at ambient temperatures 500 g (2.87 mol) of diethyl methylmalonate, and the mixture was stirred for 1 h. The mixture was then treated with 380 g (1.38 mol) of 1-methoximino-2-[5-[(methylsulfonyl)oxy]pentyl]-2-cyclopentene (**49**) in 2 L of dimethoxyethane and was refluxed for 20 h. The mixture was cooled and filtered. The solids were washed with ether. The filtrate and washings were evaporated, and the residue was poured into ice-cold dilute hydrochloric acid and worked up with ether. The excess diethyl methylmalonate was distilled off in vacuo to yield 500 g of crude 2-(6,6-dicarbethoxyheptyl)-1-methoximino-2-cyclopentene (**116**) as an oil. This material was saponified as for **44** to yield 330 g of 2-(6,6-dicarboxyheptyl)-1-methoximino-2-cyclopentene (**117**) as a solid, mp 118–122 °C. An analytical sample was crystallized from methylene chloride to afford colorless crystals, mp 125–128 °C. Anal. Calcd for $C_{15}H_{23}NO_5$: C, 60.59; H, 7.80; N, 4.71. Found: C, 60.24; H, 7.54; N, 4.52. Diacid **117** was decarboxylated as for **45** to yield 271 g of 2-(6-carboxyheptyl)-1-methoximino-2-cyclopentene (**118**) as an oil. This material was directly hydrolyzed as for **46** to yield 235 g of crude **115** as an oil. A 62.0-g portion was distilled to yield 43.8 g (53.8%) of **115** as a colorless oil: bp 167–175 °C (0.050 torr); IR 1706, 1629 cm^{-1}; UV λ_{max} 228 nm (ϵ 10 100); ^{1}H NMR δ 1.17 (d, 3 H, J = 7 H_2, CH_3), 2.18 (m, 2 H, allylic), 2.40 (m, 2 H, allylic), 2.56 (m, 2 H, allylic), 2.35–2.50 (m, 1 H, $CHCH_3$), 7.29 (m, 1 H, vinylic). Anal. Calcd for $C_{13}H_{20}O_3$: C, 69.61; H, 8.99. Found: C, 68.71; H, 8.80.

2-(6-Carbomethoxyheptyl)cyclopent-2-en-1-one (119) was prepared in 66.6% yield as for ester **33** from 2-(6-carboxyheptyl)cyclopent-2-en-1-one (**115**) as a colorless oil: bp 128–132 °C (0.050 torr); IR 1739 (ester C=O), 1706 (C=O), 1637, 1196, 1157, 1002, 791 cm^{-1}; UV λ_{max} 228 nm (ϵ 9900); ^{1}H NMR δ 1.13 (d, 3 H, J = 7.5, $CHCH_3$), 2.18, (m, 2 H, allylic), 2.30–2.50 (m, 1 H, $CHCH_3$), 2.37 (m, 2 H, allylic), 2.55 (m, 2 H, allylic), 3.66 (s, 3 H, OCH_3), 7.29 (m, 1 H, vinylic). Anal. Calcd for $C_{14}H_{22}O_3$: C, 70.56; H, 9.30. Found: C, 70.31; H, 9.61.

2-(6-Carbethoxyheptyl)cyclopent-2-en-1-one (50) was prepared in 38.9% yield as for ester **33** from 2-(6-carboxyheptyl)-cyclopent-2-en-1-one (**115**) as a colorless oil: bp 138–140 °C (0.11 torr); IR 1733 (ester C=O), 1706 (C=O), 1629 (C=C), 1182, 1155, 790 cm^{-1}; UV λ_{max} 228 nm (ϵ 9800); ^{1}H NMR δ 1.10 (d, 3 H, J = 7.5 Hz, $CHCH_3$), 1.24 (t, 3 H, OCH_2CH_3), 2.17 (m, 2 H, allylic), 2.30–2.50 (m, 1 H, $CHCH_3$), 2.38 (m, 2 H, allylic), 2.56 (m, 2 H, allylic), 4.12 (q, 2 H, OCH_2CH_3), 7.28 (m, 1 H, vinylic). Anal. Calcd for $C_{15}H_{24}O_3$: C, 71.39, H, 9.59. Found: C, 70.69; H, 9.72.

2-(6-Carboxyoctyl)cyclopent-2-en-1-one (120). To a stirred slurry of 104 g of 50.0% (2.17 mol) sodium hydride–mineral oil dispersion, washed free of oil with hexane, in 3 L of dimethoxyethane was added dropwise at ambient temperature 650 g (3.45 mol) of diethyl ethylmalonate, and the mixture was stirred for 1 h. The mixture was then treated with 384 g (1.39 mol) of 1-methoximino-2-[5-[(methylsulfonyl)oxy]pentyl]-2-cyclopentene (**49**) in 2 L of dimethoxyethane and was refluxed for 20 h. The mixture was cooled and filtered. The solids were washed with ether. The filtrate and washings were evaporated, and the residue was poured into ice-cold dilute hydrochloric acid and worked up with ether. The excess diethyl ethylmalonate was distilled off in vacuo to yield 530 g of crude 2-(6,6-dicarbethoxyoctyl)-1-methoximino-2-cyclopentene (**121**) as an oil. This material was saponified as for **44** to yield 430 g of crude 2-(6,6-dicarboxyoctyl)-1-methoximino-2-cyclopentene (**122**) as a solid. An analytical sample was crystallized from hexane–ether to afford colorless crystals, mp 98–100 °C. Anal. Calcd for $C_{16}H_{25}NO_5$: C, 61.72; H, 8.09; N, 4.50. Found: C, 61.42; H, 8.18; N, 4.22. Diacid **122** was decarboxylated as for **45** to yield 370 g of 2-(6-carboxyoctyl)-1-methoximino-2-cyclopentene (**123**) as an oil. This material was directly hydrolyzed as for **46** to yield 275 g of crude **120** as a tan oil. A 50-g portion of this material was distilled to yield 35 g (58%) of **120** as a colorless oil: bp 180–185 °C (0.09 torr); IR 1730 (acid C=O), 1706 (C=O), 1631 (C=C), 1199, 1000, 789 cm^{-1}; UV λ_{max} 228 nm (ϵ 10 100); ^{1}H NMR δ 0.95 (t, 3 H, CH_3), 2.20 (m, 3 H, allylic and $CHCO_2H$), 2.40 (m, 2 H, allylic), 2.56 (m, 2 H, allylic), 7.28 (m, 1 H, vinylic). Anal. Calcd for $C_{14}H_{22}O_3$: C, 70.56; H, 9.30. Found: C, 70.72; H, 9.58.

2-(6-Carbomethoxyoctyl)cyclopent-2-en-1-one (124) was prepared in 98% yield as for ester **33** from 2-(6-carboxyoctyl)-cyclopent-2-en-1-one (**120**) as a colorless oil: bp 134–136 °C (0.050 torr); IR 1736 (ester C=O), 1706 (C=O), 1634 (C=C), 1194, 1168, 1000, 791 cm^{-1}; UV λ_{max} 228 nm (ϵ 9600); ^{1}H NMR δ 0.88 (t, 3 H, CH_3), 2.20 (m, 3 H, allylic and $CHCO_2$), 2.40 (m, 2 H, allylic), 2.56 (m, 2 H, allylic), 3.67 (s, 3 H, OCH_3), 7.28 (m, 1 H, vinylic). Anal. Calcd for $C_{15}H_{24}O_3$: C, 71.39; H, 9.59. Found: C, 71.20; H, 9.30.

2-(6-Carbethoxyoctyl)cyclopent-2-en-1-one (51) was prepared in 69.2% yield as for ester **33** from 2-(6-carboxyoctyl)-cyclopent-2-en-1-one (**120**) as a colorless oil: bp 140–141 °C (0.15 torr); IR 1739 (ester C=O), 1712 (C=O), 1639 (C=C), 1179, 1031, 791 cm^{-1}; UV λ_{max} 228 nm (ϵ 11 300); ^{1}H NMR δ 0.90 (t, 3 H, CH_3), 1.27 (t, 3 H, OCH_2CH_3), 2.20 (m, 3 H, allylic and $CHCO_2$), 2.40 (m, 2 H, allylic), 2.56 (m, 2 H, allylic), 4.18 (q, 2 H, OCH_2CH_3), 7.28 (m, 1 H, vinylic). Anal. Calcd for $C_{16}H_{26}O_3$: C, 72.14; H, 9.84. Found: C, 71.77; H, 9.69.

2-(6-Carboxy-6-phenylhexyl)cyclopent-2-en-1-one (125). To a stirred slurry of 29.0 g of 50% (0.604 mol) of sodium hydride–mineral oil dispersion, washed free of oil with hexane, in 1.5 L of dimethoxyethane was added dropwise 200 g (0.846 mol) of diethyl phenylmalonate. The mixture was stirred for 0.5 h and then treated with 110 g (0.399 mol) of 1-methoximino-2-[5-[(methylsulfonyl)oxy]pentyl]-2-cyclopentene (**49**) dissolved in 1 L of dimethoxyethane, and the mixture was refluxed for 48 h. The mixture was cooled and filtered, and the solids were washed with ether. The combined filtrate and washings were evaporated, and the residue was poured into cold dilute hydrochloric acid. The mixture was worked up with ether to yield an oil. The excess diethyl phenylmalonate was distilled off in vacuo to yield 170 g of crude 2-(6,6-dicarbethoxy-6-phenylhexyl)-1-methoximino-2-cyclopentene (**126**). This was saponified as for the preparation of **44** to yield 113 g of an oil, which by TLC consisted of a mixture of mono- and dicarboxylic acids. This material was subjected to decarboxylation as for the preparation of **45** to yield 105 g of crude 2-(6-carboxy-6-phenylhexyl)-1-methoximino-2-cyclopentene (**127**) as a semisolid. An analytical sample was crystallized from hexane–ether; mp 71–73 °C. Anal. Calcd for $C_{19}H_{25}NO_3$: C, 72.35; H, 7.99; N, 4.44. Found: C, 72.52; H, 8.15; N, 4.33. Crude **127** was subjected to methoxime hydrolysis as for **46** to yield 97 g of crude **125**. This was purified by dry-column chromatography upon 880 g of silica gel with 70:40:3 (v/v/v) hexane–ether–acetic acid as eluent to yield 56 g (49.0%) of pure **125** as a colorless oil: IR 1703, 1622 cm^{-1}; UV λ_{max} 227 nm (ϵ 10 600); ^{1}H NMR δ 2.12 (2 H, m, allylic), 2.39 (2 H, m, allylic), 2.54 (2 H, m, allylic), 3.54 (1 H, m, $CHCO_2H$), 7.28 (1 H, m, vinylic), 7.30 (s, 5 H, phenyl). Anal. Calcd for $C_{18}H_{22}O_3$: C, 75.50; H, 7.74. Found: C, 75.74; H, 7.91.

2-(6-Carbethoxy-6-phenylhexyl)cyclopent-2-en-1-one (52) was prepared in 56.7% yield as for ester **33** from 2-(6-carboxy-6-phenylhexyl)cyclopent-2-en-1-one (**125**) as a colorless oil: IR 1733 (ester C=O), 1715 (C=O), 1629 (C=C), 1597, 1160, 1029, 789, 730, 698 cm^{-1}; UV λ_{max} 224 nm (ϵ 11 600); ^{1}H NMR δ 1.20 (t, 3 H, OCH_2CH_3), 2.12 (m, 2 H, allylic), 2.38 (m, 2 H, allylic), 2.53 (m, 2 H, allylic), 3.52 (t, 1 H, J = 7 Hz, $CHCO_2$), 4.12 (q, 2 H, OCH_2CH_3), 7.28 (m, 1 H, vinylic), 7.30 (s, 5 H, phenyl). Anal.

Calcd for $C_{20}H_{26}O_3$: C, 76.40; H, 8.33. Found: C, 76.11; H, 8.64.

2-(6-Carbethoxy-6-fluorohexyl)cyclopent-2-en-1-one (53). To a stirred slurry of 2.062 g of 57.2% (0.0491 mol) sodium hydride-mineral oil dispersion, washed free of oil with hexane, in 40 mL of dry dimethylformamide was added dropwise 8.174 g (0.0459 mol) of diethyl fluoromalonate. The mixture was stirred at ambient temperature for 0.5 h, treated with 11.32 g (0.0411 mol) of 1-methoximino-2-[5-[(methylsulfonyl)oxy]pentyl]-2-cyclopentene (**49**) dissolved in 60 mL of dimethylformamide, and refluxed for 2 h. The mixture was cooled and evaporated, and the residue was poured into cold dilute hydrochloric acid and worked up with ether to yield 13.6 g of crude 2-(6,6-dicarbethoxy-6-fluorohexyl)-1-methoximino-2-cyclopentene (**128**) as an oil. This was saponified as for the preparation of **44** to yield 10.5 g of crude 2-(6,6-dicarboxy-6-fluorohexyl)-1-methoximino-2-cyclopentene (**129**) as a solid. An analytical sample was crystallized from ether–petroleum ether; mp 143–145 °C (CO_2↑). Anal. Calcd for $C_{14}H_{20}FNO_5$: C, 55.81; H, 6.69; F, 6.30; N, 4.65. Found: C, 55.85; H, 6.83; F, 6.14; N, 4.42. Crude **129** was decarboxylated as for the preparation of **45** to yield 8.5 g of 2-(6-carboxy-6-fluorohexyl)-1-methoximino-2-cyclopentene (**130**) as a solid. An analytical sample was crystallized from ether–petroleum ether; mp 99–100 °C. Anal. Calcd for $C_{13}H_{20}FNO_3$: C, 60.68; H, 7.83; F, 7.38; N, 5.44. Found: C, 60.76; H, 7.94; F, 7.63; N, 5.22. This material was hydrolyzed as for **46** to yield 7.6 g of crude 2-(6-carboxy-6-fluorohexyl)cyclopent-2-en-1-one (**131**), which was directly esterified as for **19** to yield 7.31 g (69.5%) of **53** as a colorless oil: VPC (column C, 180 °C, 60 mL/min) 5.9 (**53**), 3.95 min (**19**); IR 1760 (ester C=O), 1704 (C=O), 1637 (C=C), 1208, 1099, 1028, 791 cm^{-1}; UV λ_{max} 228 nm (ϵ 10300); ^1H NMR δ 1.31 (t, 3 H, J = 7 Hz OCH_2CH_3), 2.16 (m, 2 H, allylic), 2.38 (m, 2 H, allylic), 2.56 (m, 2 H, allylic), 4.26 (q, 2 H, OCH_2CH_3), 4.88 (dt, 1 H, $J_{CH_2,H}$ = 6 Hz, $J_{F,H}$ = 49 Hz CHF), 7.30 (m, 1 H, vinylic). Anal. Calcd for $C_{14}H_{21}FO_3$: C, 65.60; H, 8.26; F, 7.41. Found: C, 65.46; H, 8.26; F, 7.59.

2-(6-Carboxyhexyl)cyclopent-2-en-1-one (39). To a stirred slurry of 175 g of 57% (4.16 mol) sodium hydride–mineral oil dispersion, washed free of oil with hexane, in 3 L of dimethoxyethane was added dropwise 1000 g (6.243 mol) of diethyl malonate, and the mixture was stirred for 1 h. The mixture was treated with 760 g (2.76 mol) of 1-methoximino-2-[5-[(methylsulfonyl)oxy]pentyl]-2-cyclopentene (**49**) in 3 L of dimethoxyethane and then refluxed for 16 h. The mixture was cooled and filtered, and the solids were washed well with ether. The filtrate and washings were evaporated, and the residue was poured into cold dilute hyrochloric acid and worked up with ether to yield an oil. The excess diethyl malonate was distilled off in vacuo to yield 935 g of crude 2-(6,6-dicarbethoxyhexyl)-1-methoximino-2-cyclopentene (**132**) as an oil. This material was saponified with potassium hydroxide in aqueous methanol as for **44** to yield 595 g of 2-(6,6-dicarboxyhexyl)-1-methoximino-2-cyclopentene (**133**) as a solid, mp 95–99 °C. An analytical sample had a melting point of 116–118 °C. Anal. Calcd for $C_{14}H_{21}NO_5$: C, 59.35; H, 7.47; N, 4.94. Found: C, 59.43; H, 7.68; N, 4.59. This material was decarboxylated as for **45** to yield 318 g of 2-(6-carboxyhexyl)-1-methoximino-2-cyclopentene (**134**) as a solid, mp 72–74 °C. An analytical sample had a melting point of 72–73 °C. Anal. Calcd for $C_{13}H_{21}NO_3$: C, 65.25; H, 8.84; N, 5.85. Found: C, 65.30; H, 8.96; N, 5.57. This material was hydrolyzed as for **46** to yield 281 g (48.4% overall from **49**) of **39**, mp 42–45 °C (ether–hexane). Anal. Calcd for $C_{12}H_{18}O_3$: C, 68.55; H, 8.63. Found: C, 68.30; H, 8.50.

2-(6-Carbomethoxyhexyl)cyclopent-2-en-1-one (135). A solution of 100 g (0.476 mol) of 2-(6-carboxyhexyl)cyclopent-2-en-1-one (**39**) and 1.2 g of *p*-toluenesulfonic acid in 600 mL of absolute methanol was refluxed for 5 h, cooled, evaporated, poured into dilute sodium bicarbonate, and worked up with ether to yield an oil. Distillation produced 86.0 g (80.6%) of **135** as a colorless oil, bp 112–114 °C (0.20 torr). Anal. Calcd for $C_{13}H_{20}O_3$: C, 69.61; H, 8.99. Found: C, 69.23; H, 8.88.

2-(5-Carboxypentyl)cyclopent-2-en-1-one (136). A mixture of 125 g (0.454 mol) of 1-methoximino-2-[5-[(methylsulfonyl)-oxy]pentyl]-2-cyclopentene (**49**) and 67.0 g (1.37 mol) of sodium cyanide in 910 mL of dimethylformamide was stirred at 70 °C for 3 h, cooled, and poured into cold water.[26] The mixture was worked up with ether to yield 90.6 g of 2-(5-cyanopentyl)-1-methoximino-2-cyclopentene (**137**) as an oil. This material (88.4 g) was refluxed for 3 days with 47.0 g (1.18 mol) of sodium hydroxide in 2.5 L of 1:1 aqueous ethanol. The mixture was cooled, evaporated to one-third the volume, poured into water, and extracted with ether. The aqueous phase was acidified with hydrochloric acid and worked up with ether to yield 86.8 g of crude 2-(5-carboxypentyl)-1-methoximino-2-cyclopentene (**138**). This material was hydrolyzed with acetone and hydrochloric acid as for **46** to yield 55.0 g (63.3%) of **136** as colorless crystals: mp 70–72 °C (petroleum ether); IR (KBr) 1736 (C=O), 1672 (acid C=O), 1634 (C=C); UV λ_{max} 228 nm (ϵ 10500). Anal. Calcd for $C_{11}H_{16}O_3$: C, 67.32; H, 8.22. Found: C, 67.29; H, 8.05.

2-(5-Carbethoxypentyl)cyclopent-2-en-1-one (54) was prepared in 87.3% yield as for **19** from 2-(5-carboxypentyl)cyclopent-2-en-1-one (**136**) as a colorless oil: bp 115–118 °C (0.50 torr); IR 1736 (ester C=O), 1706 (C=O), 1637 (C=C), 1176, 1032, 790 cm^{-1}; UV λ_{max} 228 nm (ϵ 9800); ^1H NMR δ 1.25 (t, 3 H, OCH_2CH_3), 2.00–2.80 (m, 8 H, allylic, CH_2CO_2), 4.13 (q, 2 H, OCH_2CH_3), 7.30 (m, 1 H, vinylic). Anal. Calcd for $C_{13}H_{20}O_3$: C, 69.61; H, 8.99. Found: C, 69.89; H, 8.91.

2-(3-Carbethoxypropyl)-1-methoximino-2-cyclopentene (55) was prepared in 91% yield as for **38** from **23**: bp 88–91 °C (0.05 torr); IR 1742 (C=O), 1634, 1053, 887, 775 cm^{-1}; UV λ_{max} 243 nm (ϵ 12400); ^1H NMR δ 1.25 (t, 3 H, OCH_2CH_3), 1.90 (m, 2 H, $CH_2CH_2CO_2$), 2.14–2.54 (m, 6 H, allylic, CH_2CO_2), 2.64 (m, 2 H, allylic), 3.88 (s, 3 H, OCH_3), 4.14 (q, 2 H, OCH_2CH_3), 6.26 (m, 1 H, vinylic). Anal. Calcd for $C_{12}H_{19}NO_3$: C, 63.98; H, 8.50; N, 6.22. Found: C, 64.09; H, 8.85; N, 5.95.

2-(4-Hydroxybutyl)-1-methoximino-2-cyclopentene (56) was prepared in 60% yield as for **41** from **55**: bp 106–108 °C (0.20 torr); IR 3367, 1631, 1105, 883, 831, 775 cm^{-1}; UV λ_{max} 243 nm (ϵ 10800); ^1H NMR δ 1.61 (m, 4 H, $CH_2CH_2CH_2CH_2OH$), 2.12–2.52 (m, 5 H, 1 H exchangeable, allylic, OH), 2.64 (m, 2 H, allylic), 3.66 (m, 2 H, CH_2OH), 3.88 (s, 3 H, OCH_3), 6.25 (m, 1 H, vinylic). Anal. Calcd for $C_{10}H_{17}NO_2$: C, 65.54; H, 9.35; N, 7.64. Found: C, 65.31; H, 9.49; N, 7.14.

2-(6-Carbethoxy-5-oxahexyl)cyclopent-2-en-1-one (59). To a cold solution of 29.3 g (0.160 mol) of 2-(4-hydroxybutyl)-1-methoximino-2-cyclopentene (**56**) in 400 mL of dimethoxyethane was added dropwise 100 mL of 1.6 M (0.16 mol) of *n*-butyllithium in hexane. The mixture was then treated with lithium chloroacetate, prepared by addition of 125 mL of a 1.6 M solution (0.20 mol) of *n*-butyllithium in hexane to a cold solution of 18.9 g (0.200 mol) of dry chloroacetic acid in 100 mL of dimethoxyethane, and the resulting mixture was refluxed for 48 h. The mixture was cooled, and the solvent was evaporated. The residue was partitioned between water and ether. The organic phase was worked up to yield 11.0 g (37.5%) of recovered **56**. The aqueous phase was acidified with hydrochloric acid and worked up with ether to yield 29.5 g of 2-(6-carboxy-5-oxahexyl)-1-methoximino-2-cyclopentene (**58**). This was refluxed for 5 h with 212 mL of 2 N hydrochloric acid and 590 mL of acetone, cooled, evaporated partially, and worked up with ether to yield 25.3 g of 2-(6-carboxy-5-oxahexyl)cyclopent-2-en-1-one (**139**). This was esterified with absolute ethanol and *p*-toluenesulfonic acid, worked up, and distilled to yield 19.7 g (51.3% yield, 82.1% based upon nonrecovered **56**) of **59** as a colorless oil: bp 139–141 °C (0.07 torr); IR 1761 (ester C=O), 1709 (C=O), 1642 (C=C), 1202, 1138, 792 cm^{-1}; UV λ_{max} 228 nm (ϵ 10600); ^1H NMR δ 1.27 (t, 3 H, OCH_2CH_3), 1.65 (m, 4 H, C-2 and C-3 hexyl), 2.00–2.75 (m, 6 H, C-4, C-5, C-1 hexyl), 3.58 (m, 2 H, CH_2CH_2O), 4.07 (s, 2 H, OCH_2CO_2), 4.25 (q, 2 H, OCH_2CH_3), 7.37 (m, 1 H, vinylic). Anal. Calcd for $C_{13}H_{20}O_4$: C, 64.98; H, 8.39. Found: C, 64.98; H, 8.29.

2-[4-[(Methylsulfonyl)oxy]butyl]-1-methoximino-2-cyclopentene (60) was prepared in 87% yield as for **42** from **56**: mp 67–68 °C (from petroleum ether);[24] IR (KBr) 1629, 1348, 1333, 1170, 1041, 982, 956, 885, 840, 835, 750 cm^{-1}; UV λ_{max} 243 nm (ϵ 13600). Anal. Calcd for $C_{11}H_{19}NO_4S$: C, 50.56; H, 7.33; N, 5.36; S, 12.27. Found: C, 50.63; H, 7.40; N, 5.20; S, 12.08.

2-(6-Carbethoxy-5-thiahexyl)cyclopent-2-en-1-one (62). To 7.55 g of 57.2% (0.180 mol) sodium hydride–mineral oil dispersion, washed free of oil with hexane, in 200 mL of dry dimethoxyethane

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was added dropwise 21.4 g (0.178 mol) of ethyl mercaptoacetate, and the resulting mixture was stirred at ambient temperature for 1 h. The mixture was then treated with 31.0 g (0.119 mol) of 2-[4-[(methylsulfonyl)oxy]butyl]-1-methoximino-2-cyclopentene (**60**) in 50 mL of dimethoxyethane, stirred at ambient temperatures for 18 h, and then refluxed for 1 h. This mixture was cooled, and the solvent was evaporated. The residue was poured into water, the mixture was acidified with hydrochloric acid and worked up with ether to yield crude 2-(6-carbethoxy-5-thiahexyl)-1-methoximino-2-cyclopentene (**61**). This was refluxed for 5 h with 236 mL of 2 N hydrochloric acid and 700 mL of acetone, cooled, evaporated partially, and worked up with ether to yield crude 2-(6-carboxy-5-thiahexyl)cyclopent-2-en-1-one (**140**). This was esterified with absolute ethanol and *p*-toluenesulfonic acid, worked up, and distilled to yield 18.5 g (60.9%) of **62** as a nearly colorless oil: bp 153–155 °C (0.10 torr); IR 1739 (ester C=O), 1709 (C=O), 1642 (C=C), 1274, 1127, 1032, 793 cm^{-1}; UV λ_{max} 228 nm (ϵ 11 500); ^1H NMR δ 1.32 (t, 3 H, OCH_2CH_3), 1.63 (m, 4 H, C-2 and C-3 hexyl), 2.00–2.83 (m, 8 H, allylic, CH_2CH_2S), 3.22 (s, 2 H, SCH_2CO_2), 4.23 (q, 2 H, OCH_2CH_3), 7.35 (m, 1 H, vinylic). Anal. Calcd for $C_{13}H_{20}O_3S$: C, 60.91; H, 7.86; S, 12.51. Found: C, 60.34; H, 7.76; S, 13.11.

2-(7-Carbethoxy-6-thiaheptyl)cyclopent-2-en-1-one (63) was prepared in 65% yield from 2-[5-[(methylsulfonyl)oxy]-pentyl]-1-methoximino-2-cyclopentene (**49**) as for **62**; bp 147–150 °C (0.07 torr). Anal. Calcd for $C_{14}H_{22}O_3S$: C, 62.19; H, 8.20; S, 11.86. Found: C, 61.66; H, 8.37; S, 12.04.

1-Acetoxy-5-(carbomethoxy)- and -5-carbethoxy-5-(6-carbethoxyhexyl)-1-cyclopentenes (66a,b). A mixture of 40.2 g (0.132 mol) of **9a** and **9b** and 0.50 g of *p*-toluenesulfonic acid in 70 mL of isopropenyl acetate was refluxed with a slow fractional distillation of the acetone formed. Isopropenyl acetate was added to maintain the original volume, and after 48 h <5% of the starting ketone remained and the boiling point of isopropenyl acetate had been reached. The mixture was cooled, poured into dilute sodium bicarbonate, and worked up with ether to yield an oil. Distillation produced 36.6 g (80.0%) of **66** as a slightly yellowish oil: bp 140–148 °C (0.12 torr); VPC (column A, 240 °C, 70 mL/min) 6.9 (**66a**), 8.1 (**66b**), 5.5 (**9a**), 6.3 min (**9b**), <5% **9**; IR 1770 (C=O), 1742 (C=O), 1661 (C=C), 1376 ($OCOCH_3$), 1200, 1104, 1036 cm^{-1}; ^1H NMR δ 1.25 (t, OCH_2CH_3), 2.15 (s, $OCOCH_3$), 3.72 (s, OCH_3), 4.18 (q, OCH_2CH_3), 5.73 (m, vinylic).

Bromination–Dehydrobromination of 66a,b. To an ice-cooled stirred solution of 36.5 g (0.105 mol) of a mixture of **66a** and **66b** in 300 mL of glacial acetic acid and 80 mL of pyridine was added 17.6 g (0.110 mol) of bromine in 100 mL of acetic acid during 20 min. The mixture was stirred at ambient temperature for 45 min, poured into 1 L of half-saturated brine containing 1 g of sodium sulfite, and worked up with ether to yield an oil. This was added immediately to a hot mixture of 22.1 g (0.254 mol) of lithium bromide and 23.3 g (0.315 mol) of lithium carbonate in 150 mL of dimethylformamide previously dried by azeotroping with benzene. The mixture was refluxed for 20 min, cooled, poured into cold water, acidified with hydrochloric acid, and worked up with ether to yield an oil. Distillation produced two fractions: (1) bp 126–135 °C (0.11 torr); 6.30 g; IR 1739 (ester C=O), 1709 (C=O), 1637 (C=C of **19**), 1592 (C=C of **71**); UV λ_{max} 221 nm (ϵ 7400 based upon mol wt 238); (2) bp 135–154 °C (0.11 torr); 16.76 g; IR 1739 (ester C=O), 1709 (C=O), 1592 (C=C of **67**); UV λ_{max} 221 nm (ϵ 7900 based upon mol wt 310); ^1H NMR δ 1.27 (t, OCH_2CH_3), 2.28 (m, CH_2CO_2), 2.67 (d of apparent t, J_{gem} = 19.5 Hz, $J_{3,4} \approx J_{3,5}$ = 2 Hz, C-3), 3.30 (d of apparent t, C-3), 4.18 (q, OCH_2CH_3), 4.21 (q, OCH_2CH_3), 6.32 (d of apparent t, $J_{4,5}$ = 6 Hz, C-5), 7.85 (d of apparent t, C-4). The two fractions were combined and refluxed for 18 h with 200 mL of 25% hydrochloric acid and 200 mL of acetic acid. The mixture was cooled, poured into water, and worked up with ether to yield 16.02 g of an oil. This material was esterified with ethanol and *p*-toluenesulfonic acid as for **19**, worked up, and distilled to yield 12.26 g (49.0%) of **19** as a colorless oil [bp 115–118 °C (0.10 torr)], which by VPC (column B) contained 15% of saturated ketone **11**: IR 1739, 1709, 1639, 794 cm^{-1}; UV λ_{max} 228 nm (ϵ 8400); VPC (column B, 180 °C, 75 mL/min) 14.5 (**19**), 8.1 min (**11**).

2-(Carbomethoxy)-2-(6-carbethoxyhexyl)cyclopentanone (9a) was prepared in 56% yield as for **9a,b** from ethyl 7-bromoheptanoate (**8**)[21] and 2-(carbomethoxy)cyclopentanone (**6a**) as a colorless oil, bp 155–158 °C (0.27 torr). Anal. Calcd for $C_{16}H_{26}O_5$: C, 64.41; H, 8.78. Found: C, 64.60; H, 8.83.

1-Acetoxy-5-(carbomethoxy)-5-(6-carbethoxyhexyl)-1-cyclopentene (66a) was prepared in 82% yield as for **66a,b** by refluxing 2-(carbomethoxy)-2-(6-carbethoxyhexyl)cyclopentanone (**9a**) with *p*-toluenesulfonic acid and isopropenyl acetate with acetone removal. The product had a boiling point of 155–160 °C (0.20 torr) and by VPC (column A, 240 °C, 75 mL/min) contained 95% of **66a** (r_t = 3.5 min) and 5% of **9a** (r_t = 2.9 min): IR 1761, 1733, 1647, 1366, 1196 cm^{-1}.

Bromination–Dehydrobromination of 66a. To an ice-cold stirred mixture of 17.0 g (0.0499 mol) of 1-acetoxy-5-(carbomethoxy)-5-(6-carbethoxyhexyl)-1-cyclopentene (**66a**) in 50 mL of carbon tetrachloride and 5.5 g (0.055 mol) of calcium carbonate in 50 mL of water was added dropwise 8.80 g (0.0551 mol) of bromine in 25 mL of carbon tetrachloride.[13] The mixture was stirred at 0–5 °C for 30 min, and the phases were separated. The organic phase was washed with dilute sodium thiosulfate solution and worked up to yield a colorless oil. This was added immediately to a hot mixture of 10.5 g (0.121 mol) of lithium bromide and 11.1 g (0.150 mol) of lithium carbonate in 100 mL of dimethylformamide, previously dried by azeotroping with benzene. The mixture was refluxed for 30 min, cooled, poured into water, acidified with hydrochloric acid, and worked up with ether to yield an oil. Distillation produced 5.81 g (48.9%) of a colorless oil, bp 133–139 °C (0.30 torr). Based upon ^1H NMR integration, this oil contained ketones **71** and **19** in a ratio of 3:1, respectively: IR 1739, 1709, 1639 (C=C of **19**), 1592 (C=C of **71**) cm^{-1}; UV λ_{max} 221 nm (ϵ 8900); ^1H NMR (CCl_4) for **19** δ 1.22 (t, OCH_2CH_3, 2.22 (m, CH_2CO_2), 4.07 (q, OCH_2CH_3), 4.33 (m, C-3); for **71** δ 1.22 (t, OCH_2CH_3), 2.22 (m, CH_2CO_2), 2.38 (d of apparent t, J_{gem} = 19.5 Hz, $J_{3,4} \approx J_{3,5}$ = 2.5 Hz, C-3), 2.90 (d of apparent t, C-3), 4.07 (q, OCH_2CH_3), 6.05 (d of apparent t, $J_{4,5}$ = 5.5 Hz, C-5), 7.59 (d of apparent t, C-4); VPC (column A or B) could not resolve **71** and **19** but indicated the presence of approximately 8% of **11**.

2-Octylcyclopentanone (72) and 2-Carbethoxy-2-octylcyclopentanone (141). A mixture of 107 g (0.571 mol) of the potassium salts of the 2-(carbomethoxy)- and 2-carbethoxycyclopentanones (**7a**) and 144 g (0.600 mol) of *n*-octyl iodide in 500 mL of xylene was refluxed for 9 h, cooled, poured into ice–water, and worked up to yield 145 g of an oil. An 86-g portion was heated with 81.1 g (0.606 mol) of anhydrous lithium iodide at 160–165 °C for 18 h, cooled, and poured onto ice and dilute hydrochloric acid. The mixture was worked up with ether to yield an oil. Fractional distillation produced *n*-octyl iodide [bp 38–42 °C (0.50 torr)], a ketone fraction [bp 81–95 °C (0.50 torr)], and a keto ester fraction (bp 120–128 °C). The ketone fraction was redistilled to yield 12.6 g (11.2%) of 2-octylcyclopentanone (**72**), bp 78–79 °C (0.40 torr). Anal. Calcd for $C_{13}H_{24}O$: C, 79.53; H, 12.32. Found: C, 79.48; H, 12.32. Semicarbazone, mp 180.5–182.5 °C. Anal. Calcd for $C_{14}H_{27}N_3O$: C, 66.36; H, 10.74; N, 16.58. Found: C, 66.53; H, 10.62; N, 16.77.[27] The keto ester fraction was redistilled to yield 18.2 g (11.8%) of 2-carbethoxy-2-*n*-octylcyclopentanone (**141**): bp 116–118 °C (0.20 torr); IR 1757 (ester C=O), 1727 (C=O), 1224, 1030 cm^{-1}; ^1H NMR δ 0.87 (m, 3 H, CH_3), 1.25 (t, OCH_2CH_3), 4.15 (q, OCH_2CH_3). Anal. Calcd for $C_{16}H_{28}O_3$: C, 71.60; H, 10.52. Found: C, 71.34; H, 10.42. Semicarbazone, mp 121–122 °C. Anal. Calcd for $C_{17}H_{31}N_3O_3$: C, 62.74; H, 9.60; N, 12.91. Found: C, 62.66; H, 9.51; N, 12.50. The remainder of the crude reaction mixture was fractionally distilled to yield 27.8 g (18.6%) of a mixture of 2-(carbomethoxy)- and 2-carbethoxy-2-*n*-octylcyclopentanones, bp 122–125 °C (0.50 torr).

2-*n*-Octylcyclopentanone (72). A solution of 104.6 g (0.400 mol) of 2-(carbomethoxy)- and 2-carbethoxy-2-*n*-octylcyclopentanones and 39.84 g (0.585 mol) of sodium ethoxide in 1 L of absolute ethanol was refluxed for 16 h. Ethanol (700 mL) was then distilled out, 1.1 L of toluene was added, and the mixture was fractionally distilled until the boiling point of toluene was reached. The distillation was continued until the volume of the reaction mixture was ~500 mL. The mixture was cooled, the remaining toluene was evaporated in vacuo, and the oily residue was refluxed with 1 L of 25% hydrochloric acid for 24 h. The

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mixture was cooled and worked up with ether to yield an oil. Distillation produced 70.6 g (89.8%) of **72** as a colorless oil, bp 71–74 °C (0.15 torr).

Ethyl 2-*n*-Octylcyclopentanone-5-glyoxalate (73). A mixture of 11.45 g (0.0583 mol) of 2-*n*-octylcyclopentanone (**72**), 8.60 g (0.0588 mol) of diethyl oxalate, and 4.85 g (0.0713 mol) of sodium ethoxide in 150 mL of absolute ethanol was refluxed for 5 h, cooled, and poured into ice–water. The mixture was washed with ether. The aqueous phase was acidified with hydrochloric acid and worked up with ether to yield an oil. Distillation produced 13.8 g (79.8%) of **73** as a slightly yellowish oil: bp 144.5–145.0 °C (0.25 torr); IR 1733 (C=O), 1672 (C=O), 1608 (C=C), 1235, 982 cm^{-1}; UV λ_{max} 299 nm (ϵ 4700); ^1H NMR δ 0.92 (m, 3 H, CH_2CH_3), 1.28 (br s, CH_2's), 1.37 (t, OCH_2CH_3), 1.70–2.67 (m, C-2, C-3, OH), 2.67–3.08 (m, C-4), 4.33 (q, OCH_2CH_3). Anal. Calcd for $C_{17}H_{28}O_4$: C, 68.89; H, 9.52. Found: C, 68.35; H, 9.52. A 1-g sample was saponified as for **44** to yield 0.85 g (94%) of 2-*n*-octylcyclopentanone-5-glyoxylic acid (**142**), mp 80.0–81.5 °C (from hexane). An analytical sample was crystallized from hexane; mp 80.5–81.5 °C. Anal. Calcd for $C_{15}H_{24}O_4$: C, 67.14; H, 9.01. Found: C, 67.24; H, 9.19.

2-*n*-Octylcyclopent-2-en-1-one (78). To an ice-cooled stirred solution of 4.04 g (0.0136 mol) of ethyl 2-*n*-octylcyclopentanone-5-glyoxalate (**73**) and 1.47 g (0.0150 mol) of potassium acetate in 100 mL of absolute methanol was added dropwise 35.0 mL of 3.89 M (0.0136 mol) bromine in carbon tetrachloride. The mixture was stirred for 5 min, treated with 0.735 g (0.0136 mol) of sodium methoxide, and refluxed for 1 h. The mixture was cooled, the methanol was evaporated, and the residue was poured into water and worked up with ether to yield an oil. Fractional distillation produced 2.00 g (75.7%) of **78** as a colorless oil: bp 78–80 °C (0.18 torr); IR 1709 (C=O), 1637 (C=C), 1000, 789 cm^{-1}; UV λ_{max} 228 nm (ϵ 9900); ^1H NMR δ 1.03 (m, 3 H, CH_3), 1.30 (br s, 12 H, CH_2's), 2.13 (m, 2 H, allylic), 2.40 (m, 2 H, allylic), 2.57 (m, 2 H, allylic), 7.32 (m, 1 H, vinylic). Anal. Calcd for $C_{13}H_{22}O$: C, 80.35; H, 11.41. Found: C, 80.12; H, 11.55. Semicarbazone, mp 192.0–193.5 °C. Anal. Calcd for $C_{14}H_{25}N_3O$: C, 66.89; H, 10.02; N, 16.72. Found: C, 66.74; H, 10.21; N, 16.53.

2-Methoxy-2-*n*-octylcyclopentanone (81). A solution of 5.77 g (0.0195 mol) of ethyl 2-*n*-octylcyclopentanone-5-glyoxalate (**73**) and 2.05 g (0.0209 mol) of potassium acetate in 1.1 L of cold absolute methanol was treated with 3.12 g (0.0195 mol) of bromine in 100 mL of absolute methanol and then with 1.09 g (0.0202 mol) of sodium methoxide. The mixture was refluxed for 48 h and cooled, and the solvent was evaporated. The residue was extracted into ether, filtered, evaporated, and distilled to yield 2.60 g of a colorless oil, bp 84–93 °C (0.15 torr). VPC (column A, 200 °C, 60 mL/min) of this oil indicated the presence of a major component (r_t 6.4 min) and four minor components, one of which was identical with 2-*n*-octylcyclopent-2-en-1-one (**78**). The oil was chromatographed upon silica gel with a hexane–ether gradient as eluent. The major component was eluted in the early fractions and the minor components in the later fractions. The major component was distilled to yield 1.30 g (29.5%) of a colorless oil [bp 77.0–77.5 °C (0.13 torr)] characterized as 2-methoxy-2-*n*-octylcyclopentanone (**81**): IR 1745 (C=O), 1072 (COC) cm^{-1}; ^1H NMR δ 1.03 (m, 3 H, CH_2CH_3), 1.28 (br s, 14 H, CH_2's), 1.88 (m, 4 H, C-3, C-4), 2.20 (m, 2 H, C-5), 3.17 (s, 3 H, OCH_3). Anal. Calcd for $C_{14}H_{26}O_2$: C, 74.29; H, 11.58. Found: C, 74.51; H, 11.58. The minor components appeared for the most part to be isomeric with **81**, e.g., *cis*- and *trans*-5-methoxy-2-*n*-octylcyclopentanones (**82**) and possibly a methyl ester(s): IR 1745, 1072 cm^{-1}; ^1H NMR δ 1.03 (m, CH_2CH_3), 1.28 (broad s, CH_2's), 1.67–2.10 (m), 2.10–2.63 (m), 3.17, 3.45, 3.50, 3.67 (all s in ratio of 5:25:35:35, OCH_3's).

Ethyl 2-(6-Carbethoxyhexyl)cyclopentanone-5-glyoxalate (83). A mixture of 12.39 g (0.0516 mol) of 2-(6-carbethoxyhexyl)cyclopentanone (**11**), 7.63 g (0.0522 mol) of diethyl oxalate, and 3.55 g (0.0522 mol) of sodium ethoxide in 70 mL of absolute ethanol was stirred at ambient temperatures for 3 h. The mixture was poured into ice–water and extracted with ether. The aqueous phase was acidified with hydrochloric acid and worked up with ether to yield 15.86 g (90.4%) of **83** as a pale yellow oil: IR 1736 (C=O), 1661, 1603 (C=C), 1235, 1025 cm^{-1}; ^1H NMR δ 1.25 (t, $CH_2CO_2CH_2CH_3$), 1.37 (t, $(C=O)CO_2CH_2CH_3$), 2.28 (m, $CH_2CO_2CH_2CH_3$), 2.90 (m, 2 H, C-4), 4.13 (q, 2 H, $CH_2CO_2CH_2CH_3$), 4.37 (q, 2 H, $(C=O)CO_2CH_2CH_3$). Anal. Calcd for $C_{18}H_{28}O_6$: C, 63.51; H, 8.29. Found: C, 63.48, H, 8.19.

Bromination–Dehydrobromination of 83. To an ice-cold stirred solution of 15.76 g (0.0463 mol) of **83** and 5.90 g (0.0601 mol) of potassium acetate in 250 mL of absolute ethanol was added dropwise a solution of 7.52 g (0.0471 mol) of bromine in 50 mL of carbon tetrachloride. The mixture was then treated with 2.54 g (0.0470 mol) of sodium methoxide and refluxed for 1 h. The mixture was cooled, poured into cold water, and worked up with ether to yield an oil. Distillation produced 3.70 g (55%) of diethyl oxalate followed by 4.80 g of a colorless oil: bp 121–138 °C (0.15 torr); VPC (column A, 180 °C, 75 mL/min) 8.0 (**19**), 8.4 and 8.6 min (**84** or **85**); IR 1739, 1709, 1637, 1181, 1034, 791 cm^{-1}; UV λ_{max} 228 nm (ϵ 7700); ^1H NMR δ 1.25 (t, OCH_2CH_3), 4.13 (q, OCH_2CH_3), 7.32 (m, vinylic); integration of δ 7.32 vs. δ 4.13 calculates for 70% of **19**. The yield of **19** based upon the UV and ^1H NMR spectra is estimated as 32%.

Acknowledgment. The authors thank Dr. P. Kohlbrenner and his staff for supplying key intermediates used in this work, Mr. L. Brancone and his staff for elemental analyses, and Mr. W. Fulmor and his staff for the spectral data.

Registry No. 6a, 10472-24-9; **6b**, 611-10-9; **7a** (R = Me), 61114-30-5; **7a** (R = Et), 36370-12-4; **8**, 29823-18-5; **9a**, 58707-68-9; **9b**, 5239-91-8; **10**, 5288-67-5; **10** semicarbazone, 31235-91-3; **11**, 40687-10-3; 11 semicarbazone, 74845-06-0; 11 thiosemicarbazone, 74845-07-1; **12**, 74845-08-2; **13**, 74845-09-3; **15**, 41301-67-1; **16**, 74845-10-6; **17**, 58707-69-0; **19**, 40098-44-0; **22**, 40098-47-3; **23**, 59759-29-4; **24**, 40098-46-2; **25**, 74845-11-7; **26**, 55756-49-5; **27**, 52477-91-5; **28**, 928-51-8; **29**, 41302-05-0; **30**, 6802-75-1; **31**, 41302-07-2; **32**, 41302-08-3; **33**, 41302-09-4; **34**, 41302-10-7; **35**, 6940-78-9; **36**, 41302-11-8; **37**, 28186-90-5; **38**, 41301-73-9; **39**, 5239-43-0; **41**, 41301-74-0; **42**, 74845-12-8; **43**, 41301-76-2; **44**, 41301-77-3; **45**, 41301-78-4; **46**, 41301-79-5; **47**, 41349-46-6; **48**, 41301-95-5; **49**, 52477-93-7; **50**, 64270-01-5; **51**, 41301-98-8; **52**, 55756-48-4; **53**, 52518-10-2; **54**, 52477-89-1; **55**, 74845-13-9; **56**, 63178-04-1; **58**, 60950-68-7; **59**, 41302-81-2; **60**, 60950-69-8; **61**, 41302-21-0; **62**, 41302-83-4; **63**, 62408-07-5; **64a**, 74845-14-0; **64b**, 74845-15-1; **66a**, 74845-16-2; **66b**, 74845-17-3; **67**, 74845-18-4; **71**, 57112-65-9; **72**, 40566-23-2; **72** semicarbazone, 16769-51-0; **73**, 74845-19-5; **74**, 74854-31-2; **78**, 54625-13-7; **78** semicarbazone, 56239-82-8; **81**, 74845-20-8; *cis*-**82**, 74845-21-9; *trans*-**82**, 74845-22-0; **83**, 74845-23-1; **84**, 74845-24-2; **85**, 74845-25-3; **86**, 105-36-2; **87a**, 41301-65-9; **87b**, 41301-66-0; **88**, 20826-94-2; **89**, 41301-68-2; **90**, 7425-53-8; **91a**, 41301-53-5; **91b**, 41301-54-6; **92**, 41301-56-8; **93**, 41301-69-3; **94**, 14660-52-7; **95a**, 41349-44-4; **95b**, 41301-51-3; **96**, 35074-08-9; **97**, 41301-52-4; **98**, 41301-70-6; **99**, 25542-62-5; **100a**, 74845-26-4; **100b**, 69187-32-2; **101**, 40942-89-0; **102**, 63135-03-5; **103**, 29823-21-0; **104a**, 74845-27-5; **104b**, 74845-28-6; **105**, 74845-29-7; **106a**, 74845-30-0; **106b**, 74845-31-1; **107**, 41302-15-2; **108**, 41302-16-3; **109a**, 52477-86-8; **109b**, 52478-11-2; **110**, 52478-12-3; **111**, 52477-85-7; **112**, 52477-90-4; **113**, 52477-92-6; **114**, 41301-94-4; **115**, 74845-32-2; **116**, 74845-33-3; **117**, 74845-34-4; **118**, 74854-32-3; **119**, 55756-46-2; **120**, 61284-49-9; **121**, 41301-97-7; **122**, 60950-66-5; **123**, 60950-67-6; **124**, 55756-47-3; **125**, 74845-35-5; **126**, 74845-36-6; **127**, 74845-37-7; **128**, 52518-06-6; **129**, 52518-07-7; **130**, 52518-08-8; **131**, 52518-09-9; **132**, 52477-94-8; **133**, 52477-95-9; **134**, 52477-96-0; **135**, 34546-57-1; **136**, 51876-15-4; **137**, 52477-87-9; **138**, 52477-88-0; **139**, 41302-80-1; **140**, 41302-82-3; **141**, 55108-15-1; **141** semicarbazone, 74845-38-8; **142**, 74845-39-9; 1-chloro-6,6-dicarboxy-5,5-dimethylhexane, 74845-40-2; diethyl malonate, 510-20-3; 1-acetoxy-5-chloropentane, 20395-28-2; diethyl methylmalonate, 609-08-5; diethyl ethylmalonate, 133-13-1; diethyl phenylmalonate, 83-13-6; diethyl fluoromalonate, 685-88-1; ethyl mercaptoacetate, 623-51-8; *n*-octyl iodide, 629-27-6; 2-(carbomethoxy)-2-*n*-octylcyclopentanone, 74845-41-3; diethyl oxalate, 95-92-1.