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X-Ray Study of Cytochalasin M, a Secondary Metabolite from the Fungus *Chalara microspora*

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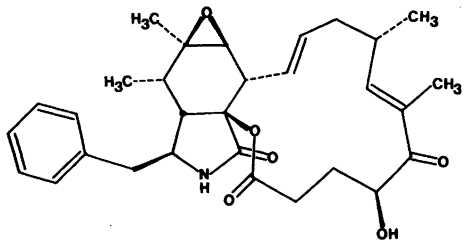
Cytochalasin M, $C_{30}H_{37}NO_6$, $M_r=507.63$, m.p. 162 °C, crystallizes in monoclinic space group $P2_1$ with $Z=2$, $a=9.9805(7)$, $b=10.5138(8)$, $c=13.4572(6)$ Å, $\beta=102.543(4)°$, $V=1378.4(2)$ Å^3 and $D_x=1.223$ g cm^{-3} at room temperature. X-Ray intensities were collected with a four-circle single crystal diffractometer and the structure solved by direct methods. The least-squares refinement converged to $R=0.0322$. The molecule is a 24-oxa-[14]cytochalasin with the following structure



The five and six-membered rings are *cis*-fused and adopt distorted half-chair and boat conformations, respectively. The 14- and 6-membered rings are *trans*-fused.

The cytochalasins are a group of fungal metabolites with interesting biologic activity.[1] They interfere with contractile proteins in the cell membrane thereby causing (among other effects) inhibition of cell movement. Three new cytochalasins, K, L and M, were isolated from the fungus *Chalara microspora* (Corda) Hughes. Their molecular structures were inferred from spectroscopic measurements (primarily ^{1}H and ^{13}C NMR).[2,3] However, in cytochalasin M the exact position and relative configuration of the CHOH group remained uncertain. In order to establish these features, and to verify the assigned structure of cytochalasin M an X-ray crystallographic analysis was undertaken.

EXPERIMENTAL

Well-developed colourless crystals of dimensions up to 1 mm were grown at room temperature from a solution of cytochalasin M in methanol containing some water. The monoclinic crystals are thick tabular a and bound by the form {011}. For the X-ray investigation a crystal of dimensions $0.17\times0.27\times0.36$ mm^3 was used. Cell dimensions (Table 1) were determined by least-squares from the θ angles for 45 reflexions, measured on a CAD4 diffractometer with Cu$K\alpha$ radiation and a graphite monochromator ($\lambda Ka_1=1.54056$ Å). Almost a full hemisphere of reciprocal space, with radius $\sin\theta/\lambda=0.61$ Å^{-1}, was then measured using $\omega-2\theta$ scans with $\Delta\omega=0.80°+0.50°\tan\theta$. A maximum counting time of 120 s resulted in $\sigma_c(I)/I\lesssim0.030$ [$\sigma_c(I)$ is based on counting statistics]. The intensities of three standard reflexions were measured every two hours. They declined linearly with exposure time (5.5 % decrease after a total of 109 h). The data set was rescaled with the fitted linear equation. Correc-

Table 1. Crystal data.

Cytochalasin M, $C_{30}H_{37}NO_6$
$M_r=507.63$, m.p. 162 °C
Monoclinic, space group $P2_1$ (No. 4)
$a=9.9805(7)$, $b=10.5138(8)$, $c=13.4572(6)$ Å
$\beta=102.543(4)°$, $V=1378.4(2)$ Å^3, $Z=2$
$D_x=1.223$ g cm^{-3}, $F(000)=544$, μ(Cu$K\alpha$)$=6.89$ cm^{-1}

0302-4369/81/100707-08$02.50

Table 2. Final atomic coordinates with estimated standard deviations of cytochalasin M. The *B* values for the nonhydrogen atoms were calculated from the anisotropic temperature factor coefficients.

	x	*y*	*z*	*B*/Å²
C(1)	.51320(17)	−.14345(0)	.75365(13)	3.9(0)
O(1′)	.44598(13)	−.17137(16)	.66956(10)	5.2(0)
N(2)	.58861(16)	−.22094(17)	.82129(12)	4.3(0)
C(3)	.68471(16)	−.16018(19)	.90534(13)	3.7(0)
C(4)	.64850(16)	−.01601(19)	.89094(12)	3.4(0)
C(5)	.62884(18)	.05612(19)	.98721(12)	3.7(0)
C(6)	.51596(18)	−.01007(19)	1.02811(12)	3.8(0)
O(6′)	.39245(13)	.06579(15)	1.02294(9)	4.4(0)
C(7)	.39184(18)	−.03545(19)	.95013(13)	3.7(0)
C(8)	.38165(16)	.01065(18)	.84157(12)	3.5(0)
C(9)	.51752(16)	−.01273(18)	.80449(11)	3.4(0)
C(10)	.83122(19)	−.19806(23)	.89873(14)	4.7(1)
C(11)	.76230(20)	.07745(22)	1.06492(15)	4.9(1)
C(12)	.55064(23)	−.08951(24)	1.12369(14)	5.1(1)
C(13)	.25777(18)	−.04436(21)	.77096(14)	4.0(0)
C(14)	.16389(17)	.01829(22)	.70481(14)	4.3(1)
C(15)	.04572(20)	−.04719(27)	.63600(16)	5.4(1)
C(16)	.02414(21)	−.01579(25)	.52243(16)	5.3(1)
C(16′)	−.07530(29)	−.11119(35)	.46068(22)	8.0(1)
C(17)	.15764(20)	−.00639(21)	.48813(14)	4.6(1)
C(18)	.17480(21)	.04886(21)	.40258(13)	4.7(1)
C(18′)	.05814(30)	.10540(30)	.32431(18)	7.2(1)
C(19)	.31072(24)	.05652(22)	.37688(14)	5.1(1)
O(19′)	.31940(18)	.07044(19)	.28814(10)	6.5(0)
C(20)	.44226(21)	.05876(27)	.45922(14)	5.3(1)
O(20′)	.55662(19)	.05289(26)	.41415(13)	8.3(1)
C(21)	.44585(23)	.18038(23)	.52127(14)	5.2(1)
C(22)	.58051(24)	.19836(28)	.59950(16)	6.3(1)
C(23)	.60823(20)	.08869(26)	.67271(14)	5.1(1)
O(23′)	.69761(15)	.00913(21)	.68064(10)	6.6(1)
O(24)	.51598(12)	.08973(14)	.73249(9)	4.3(0)
C(1′)	.93664(16)	−.18867(18)	.99662(12)	3.7(0)
C(2′)	.92853(18)	−.26872(20)	1.07688(16)	4.5(0)
C(3′)	1.02767(22)	−.26455(25)	1.16668(17)	5.6(1)
C(4′)	1.13389(19)	−.17949(25)	1.17697(16)	5.4(1)
C(5′)	1.14242(19)	−.09929(23)	1.09973(17)	5.2(1)
C(6′)	1.04518(18)	−.10455(20)	1.00934(15)	4.5(1)
H(N2)	.6023(41)	−.2956(40)	.8047(32)	8.0
H(C3)	.6675(39)	−.2056(41)	.9727(31)	8.0
H(C4)	.7297(40)	.0268(40)	.8688(31)	8.0
H(C5)	.5979(40)	.1406(41)	.9620(31)	8.0
H(C7)	.3332(44)	−.1093(40)	.9573(32)	8.0
H(C8)	.3721(41)	.1065(40)	.8414(33)	8.0
H(1C10)	.8272(43)	−.2937(42)	.8769(32)	8.0
H(2C10)	.8578(41)	−.1451(40)	.8505(33)	8.0
H(1C11)	.7434(40)	.1223(40)	1.1227(31)	8.0
H(2C11)	.8124(41)	−.0058(41)	1.0917(32)	8.0
H(3C11)	.8296(40)	.1218(40)	1.0370(32)	8.0
H(1C12)	.4706(40)	−.1292(41)	1.1297(31)	8.0
H(2C12)	.5847(39)	−.0339(40)	1.1876(32)	8.0
H(3C12)	.6318(40)	−.1464(41)	1.1235(32)	8.0
H(C13)	.2587(39)	−.1352(40)	.7775(32)	8.0
H(C14)	.1771(40)	.1127(40)	.6964(32)	8.0

Table 2. Continued

H(1C15)	.0660(39)	−.1426(40)	.6415(33)	8.0
H(2C15)	−.0520(39)	−.0239(42)	.6597(32)	8.0
H(C16)	−.0194(42)	.0807(41)	.5073(34)	8.0
H(1C16′)	−.0936(41)	−.0895(40)	.3885(31)	8.0
H(2C16′)	−.0241(37)	−.1981(43)	.4595(31)	8.0
H(3C16′)	−.1641(42)	−.1077(39)	.4870(32)	8.0
H(C17)	.2350(41)	−.0494(39)	.5282(31)	8.0
H(1C18′)	−.0380(41)	.1093(41)	.3537(32)	8.0
H(2C18′)	.0831(41)	.1886(41)	.3083(33)	8.0
H(3C18′)	.0397(38)	.0445(42)	.2650(31)	8.0
H(C20)	.4446(40)	−.0200(41)	.5037(34)	8.0
H(O20′)	.5575(41)	−.0339(41)	.4087(32)	8.0
H(1C21)	.4321(40)	.2570(40)	.4747(31)	8.0
H(2C21)	.3672(40)	.1830(41)	.5582(32)	8.0
H(1C22)	.6498(41)	.1957(41)	.5721(33)	8.0
H(2C22)	.5730(38)	.2846(42)	.6396(32)	8.0
H(C2′)	.8474(40)	−.3202(42)	1.0681(32)	8.0
H(C3′)	1.0187(40)	−.3270(41)	1.2212(32)	8.0
H(C4′)	1.2018(40)	−.1760(40)	1.2354(32)	8.0
H(C5′)	1.2140(40)	−.0312(41)	1.1132(31)	8.0
H(C6′)	1.0559(41)	−.0442(41)	.9542(31)	8.0

tions were also made for Lorentz, polarization and absorption effects. The transmission factors ranged from 0.814 to 0.897.

A total of 4688 structure amplitudes ($-12 \leq k \leq 7$) were measured for cytochalasin M; another 800 reflexions with index $k \geq 7$ were lost due to an error in the computer data handling. Reflexions $0k0$ with k odd are systematically extinct indicating that the space group is $P2_1$. After excluding as unobserved another 433 reflexions with $I < 3\sigma_c(I)$ 4248 observed data remained.

STRUCTURE SOLUTION AND REFINEMENT

The structure was solved using the MULTAN 78 program with magic integers.[4] After a long series of attempts a recognizable 19 atom fragment with correct orientation could be located. In the next run of MULTAN the fragment increased to 33 atoms with correct positions. The rest of the 37 non-hydrogen atoms appeared in the difference map after least-squares refinement of the model.

The positions of the hydrogen atoms in the CH_2 and CH groups were calculated assuming tetrahedral and trigonal carbon atoms, respectively, with C−H = 1.0 Å. The positions in the CH_3, NH and OH groups could be located in a difference map before the final stages of the refinement. The hydrogen atoms were assigned fixed isotropic thermal parameters $B = 8$ Å^2, while the other atoms were assumed to vibrate anisotropically within the simple harmonic approximation.

Atomic scattering factors and dispersion correction factors were taken from *International Tables for X-Ray Crystallography*.[5] In the final cycles of full-matrix least-squares refinement the weights were calculated from $w^{-1} = \sigma_c^2(|F_o|) + (0.030\ |F_o|)^2 + 0.060$. The function $\Sigma w(|F_o| - |F_c|)^2$ was minimized. Because of the large number of parameters in the structural model, a total of 445, only about a third of the parameters were refined at a time until all the shifts were well below their esd's. An isotropic extinction correction was made during the least-squares refinement, with coefficient $g = 0.24(3) \times 10^4$ resulting in a maximum correction of 12 % in F_o (020). The final conventional residual indices are $R = 0.0322$ and $R_w = 0.0451$ with the standard deviation of an observation of unit weight $S = 0.909$. A difference map showed only spurious peaks of height less than 0.3 e Å^{-3}. Atomic parameters are given in Tables 2 and 3. Data and final model were compared by probability plotting of ordered values of $\delta R_i = (|F_o|_i - |F_c|_i)/\sigma(|F_o|_i)$ *vs.* those expected for ordered normal deviates $[\sigma(|F_o|_i) = w_i^{-1/2}]$.[6] The result was a correlation coefficient of 0.999, a slope of 0.859(1) and an intercept of 0.041(1) indicating that the systematic errors are small and that $\sigma(|F_o|)$ is on average rather well

Table 3. Anisotropic temperature factor coefficients with estimated standard deviations. The form of the temperature factor is $\exp(-\beta_{11}h^2 - 2\beta_{12}hk\cdots)$.

	β_{11}	β_{22}	β_{33}	β_{12}	β_{13}	β_{23}
C(1)	.00941(16)	.01009(21)	.00513(10)	.00053(15)	.00153(11)	−.00085(12)
O(1′)	.01264(14)	.01484(20)	.00526(8)	.00256(14)	−.00024(9)	−.00310(10)
N(2)	.01222(17)	.00804(16)	.00632(10)	.00145(14)	−.00011(11)	−.00162(11)
C(3)	.00983(16)	.00880(20)	.00475(9)	.00098(15)	.00076(10)	−.00092(11)
C(4)	.00944(16)	.00824(19)	.00438(8)	−.00061(15)	.00141(9)	−.00051(11)
C(5)	.01184(19)	.00704(17)	.00482(9)	−.00004(15)	.00101(11)	−.00066(11)
C(6)	.01255(20)	.00767(19)	.00478(10)	.00108(16)	.00236(11)	−.00032(11)
O(6′)	.01333(15)	.00995(15)	.00574(7)	.00186(12)	.00283(9)	−.00120(9)
C(7)	.01163(19)	.00779(18)	.00499(10)	.00039(15)	.00282(11)	−.00037(11)
C(8)	.00981(17)	.00758(17)	.00479(9)	.00039(14)	.00167(10)	−.00008(10)
C(9)	.00977(16)	.00799(19)	.00415(8)	.00055(15)	.00162(10)	.00064(11)
C(10)	.01118(19)	.01321(26)	.00563(11)	.00299(18)	.00127(12)	−.00148(14)
C(11)	.01336(22)	.01113(25)	.00621(11)	−.00074(20)	.00060(13)	−.00223(14)
C(12)	.01798(29)	.01133(25)	.00506(11)	.00116(22)	.00256(15)	.00079(14)
C(13)	.01033(18)	.00963(21)	.00565(10)	−.00074(15)	.00238(11)	−.00034(12)
C(14)	.00960(18)	.01177(25)	.00605(11)	.00044(16)	.00192(12)	−.00021(13)
C(15)	.01065(21)	.01678(33)	.00679(13)	−.00208(20)	.00113(13)	.00013(16)
C(16)	.01256(23)	.01320(28)	.00700(13)	−.00167(21)	.00015(14)	−.00022(16)
C(16′)	.01882(36)	.02179(50)	.00921(19)	−.00691(34)	−.00109(22)	−.00123(26)
C(17)	.01374(22)	.00946(22)	.00574(11)	−.00150(19)	.00046(12)	−.00024(13)
C(18)	.01705(25)	.00852(20)	.00529(10)	.00001(18)	.00106(13)	.00006(13)
C(18′)	.02449(41)	.01598(35)	.00690(14)	.00628(31)	.00136(20)	.00191(18)
C(19)	.01973(28)	.00898(20)	.00535(11)	−.00213(21)	.00202(14)	.00033(12)
O(19′)	.02373(24)	.01586(21)	.00496(8)	−.00786(19)	.00218(11)	−.00002(10)
C(20)	.01474(23)	.01495(28)	.00548(10)	−.00108(22)	.00243(13)	.00043(15)
O(20′)	.01835(21)	.02801(36)	.00861(11)	.00079(23)	.00494(13)	−.00069(17)
C(21)	.01699(27)	.01200(24)	.00510(11)	−.00376(21)	.00071(14)	.00175(13)
C(22)	.01638(28)	.01858(36)	.00604(12)	−.00723(26)	.00140(16)	.00278(17)
C(23)	.01114(20)	.01669(31)	.00518(10)	−.00277(22)	.00171(12)	.00078(14)
O(23′)	.01305(17)	.02459(30)	.00626(9)	.00053(19)	.00334(10)	.00084(13)
O(24)	.01203(13)	.01066(15)	.00554(7)	−.00045(11)	.00211(8)	.00227(8)
C(1′)	.00964(16)	.00811(18)	.00557(10)	.00156(14)	.00194(10)	−.00029(11)
C(2′)	.01003(18)	.00901(20)	.00779(13)	−.00075(15)	.00103(13)	.00075(13)
C(3′)	.01390(24)	.01382(29)	.00728(14)	−.00028(21)	.00079(15)	.00320(16)
C(4′)	.01056(19)	.01534(30)	.00719(13)	−.00064(20)	−.00035(13)	−.00037(17)
C(5′)	.01138(20)	.01170(25)	.00873(15)	−.00273(18)	.00250(15)	−.00146(16)
C(6′)	.01194(20)	.00981(22)	.00714(12)	−.00012(16)	.00341(14)	.00037(14)

estimated (*cf.* the related *S* value). The observed and calculated structure amplitudes are available on request.

The configuration given in Table 2 is in accord with the postulated biosynthetic pathway starting at L-phenylalanine.[1,7] A structure factor calculation for the opposite absolute configuration of the cytochalasin M molecule resulted in $R = 0.0323$ and $R_w = 0.0452$. Though the first set of residual indices are only slightly lower than these, they agree[8] with the biologically inferred absolute configuration.

DESCRIPTION OF THE STRUCTURE

The molecular structure of cytochalasin M is shown in Fig. 1 together with the labelling of atoms and rings. The hydroxy group is connected to C(20) so the systematic name of the epimer given in Table 2 is 16,18-dimethyl-6,7-epoxy-20-hydroxy-10-phenyl-24-oxa[14]cytochalasa-13,17-diene-1,19,23-trione (7*S*, 13*E*, 16*S*, 17*E*, 20*S*). Bond lengths, bond angles and torsion angles involving the non-hydrogen atoms are given in Table 4. Fig. 2 is a

Table 4. Bond distances (Å), bond angles (°) and torsion angles (°) with estimated standard deviations.

(*a*) Bond distances

C(1)–N(2)	1.327(2)	C(17)–C(18)	1.335(3)
N(2)–C(3)	1.462(2)	C(18)–C(19)	1.473(3)
C(3)–C(4)	1.561(3)	C(19)–C(20)	1.523(3)
C(4)–C(9)	1.550(2)	C(20)–C(21)	1.523(3)
C(1)–C(9)	1.532(2)	C(21)–C(22)	1.528(3)
C(1)–O(1′)	1.219(2)	C(22)–C(23)	1.503(4)
C(3)–C(10)	1.537(3)	C(23)–O(24)	1.348(2)
C(4)–C(5)	1.550(2)	C(9)–O(24)	1.447(2)
C(5)–C(6)	1.525(3)	C(16)–C(16′)	1.524(4)
C(6)–C(7)	1.464(2)	C(18)–C(18′)	1.512(3)
C(7)–C(8)	1.521(2)	C(19)–O(19′)	1.225(2)
C(8)–C(9)	1.563(2)	C(20)–O(20′)	1.405(3)
C(5)–C(11)	1.521(3)	C(23)–O(23′)	1.211(3)
C(6)–C(12)	1.509(3)	C(10)–C(1′)	1.500(2)
C(6)–O(6′)	1.457(2)	C(1′)–C(2′)	1.385(3)
C(7)–O(6′)	1.446(2)	C(2′)–C(3′)	1.386(3)
C(8)–C(13)	1.502(2)	C(3′)–C(4′)	1.371(3)
C(13)–C(14)	1.320(3)	C(4′)–C(5′)	1.355(3)
C(14)–C(15)	1.499(3)	C(5′)–C(6′)	1.383(3)
C(15)–C(16)	1.532(3)	C(1′)–C(6′)	1.380(3)
C(16)–C(17)	1.505(3)		

(*b*) Bond angles

N(2)–C(1)–C(9)	106.7(1)	C(14)–C(15)–C(16)	116.0(2)
C(1)–N(2)–C(3)	116.2(2)	C(15)–C(16)–C(17)	112.2(2)
N(2)–C(3)–C(4)	103.5(1)	C(16)–C(17)–C(18)	125.6(2)
C(3)–C(4)–C(9)	104.5(1)	C(17)–C(18)–C(19)	121.6(2)
C(1)–C(9)–C(4)	104.6(1)	C(18)–C(19)–C(20)	121.5(2)
O(1′)–C(1)–N(2)	127.2(1)	C(19)–C(20)–C(21)	109.0(2)
O(1′)–C(1)–C(9)	125.9(1)	C(20)–C(21)–C(22)	113.2(2)
C(10)–C(3)–N(2)	108.3(2)	C(21)–C(22)–C(23)	111.5(2)
C(10)–C(3)–C(4)	116.2(2)	C(22)–C(23)–O(24)	109.4(2)
C(3)–C(4)–C(5)	116.1(1)	C(9)–O(24)–C(23)	119.0(2)
C(5)–C(4)–C(9)	112.2(1)	C(8)–C(9)–O(24)	102.3(1)
C(4)–C(5)–C(6)	108.4(2)	O(24)–C(9)–C(1)	112.0(1)
C(5)–C(6)–C(7)	113.6(1)	C(16′)–C(16)–C(15)	109.6(2)
C(6)–C(7)–C(8)	120.0(2)	C(16′)–C(16)–C(17)	113.0(2)
C(7)–C(8)–C(9)	112.0(1)	C(18′)–C(18)–C(17)	123.3(2)
C(4)–C(9)–C(8)	114.4(1)	C(18′)–C(18)–C(19)	115.1(2)
C(1)–C(9)–C(8)	110.0(1)	O(19′)–C(19)–C(18)	119.9(2)
C(11)–C(5)–C(4)	113.3(2)	O(19′)–C(19)–C(20)	118.4(2)
C(11)–C(5)–C(6)	115.1(1)	O(20′)–C(20)–C(19)	109.7(2)
C(12)–C(6)–C(5)	120.6(2)	O(20′)–C(20)–C(21)	110.4(2)
C(12)–C(6)–C(7)	120.8(2)	O(23′)–C(23)–C(22)	128.0(2)
O(6′)–C(6)–C(7)	59.3(1)	O(23′)–C(23)–O(24)	122.6(2)
O(6′)–C(7)–C(6)	60.1(1)	C(3)–C(10)–C(1′)	115.3(2)
C(6)–O(6′)–C(7)	60.6(1)	C(10)–C(1′)–C(2′)	119.7(2)
O(6′)–C(6)–C(5)	114.6(2)	C(10′)–C(1′)–C(6′)	122.2(2)
O(6′)–C(6)–C(12)	112.3(2)	C(2′)–C(1′)–C(6′)	118.0(2)
O(6′)–C(7)–C(8)	113.9(2)	C(1′)–C(2′)–C(3′)	120.6(2)
C(7)–C(8)–C(13)	110.0(2)	C(2′)–C(3′)–C(4′)	119.9(2)
C(9)–C(8)–C(13)	112.9(1)	C(3′)–C(4′)–C(5′)	120.3(2)
C(8)–C(13)–C(14)	126.9(2)	C(4′)–C(5′)–C(6′)	120.1(2)
C(13)–C(14)–C(15)	122.4(2)	C(1′)–C(6′)–C(5′)	121.1(2)

Table 4. Continued

(*c*) Torsion angles

C(9)–C(1)–N(2)–C(3)	−18.5(2)	C(18)–C(19)–C(20)–C(21)	−65.1(3)
C(1)–N(2)–C(3)–C(4)	7.0(2)	C(19)–C(20)–C(21)–C(22)	−174.3(2)
N(2)–C(3)–C(4)–C(9)	7.3(2)	C(20)–C(21)–C(22)–C(23)	−58.3(3)
C(3)–C(4)–C(9)–C(1)	−17.0(2)	C(21)–C(22)–C(23)–O(24)	−68.5(2)
C(4)–C(9)–C(1)–N(2)	21.7(2)	C(22)–C(23)–O(24)–C(9)	175.9(2)
O(1′)–C(1)–N(2)–C(3)	165.8(2)	C(23)–O(24)–C(9)–C(8)	−169.8(2)
C(10)–C(3)–C(4)–C(9)	126.0(2)	C(16′)–C(16)–C(17)–C(18)	72.8(2)
C(9)–C(4)–C(5)–C(6)	62.4(2)	C(18′)–C(18)–C(19)–C(20)	153.5(2)
C(4)–C(5)–C(6)–C(7)	−48.7(2)	C(18′)–C(18)–C(19)–O(19′)	−21.3(2)
C(5)–C(6)–C(7)–C(8)	−3.6(2)	O(19′)–C(19)–C(18)–C(17)	157.5(2)
C(6)–C(7)–C(8)–C(9)	43.0(2)	O(19′)–C(19)–C(20)–C(21)	109.8(2)
C(7)–C(8)–C(9)–C(4)	−27.1(2)	O(19′)–C(19)–C(20)–O(20′)	−11.3(3)
C(8)–C(9)–C(4)–C(5)	−23.2(2)	O(20′)–C(20)–C(21)–C(22)	−53.7(3)
C(11)–C(5)–C(6)–C(7)	−176.8(2)	O(23′)–C(23)–O(24)–C(9)	−4.2(3)
C(11)–C(5)–C(6)–C(12)	−21.5(3)	C(6′)–C(1′)–C(2′)–C(3′)	−0.6(3)
C(12)–C(6)–C(7)–C(8)	−158.8(2)	C(1′)–C(2′)–C(3′)–C(4′)	0.8(3)
C(4)–C(5)–C(6)–O(6′)	114.3(2)	C(2′)–C(3′)–C(4′)–C(5′)	0.1(4)
O(6′)–C(7)–C(8)–C(9)	111.0(2)	C(3′)–C(4′)–C(5′)–C(6′)	−1.2(3)
O(24)–C(9)–C(8)–C(13)	83.1(2)	C(4′)–C(5′)–C(6′)–C(1′)	1.5(3)
C(9)–C(8)–C(13)–C(14)	−103.1(2)	C(5′)–C(6′)–C(1′)–C(2′)	−0.6(3)
C(8)–C(13)–C(14)–C(15)	178.5(2)	C(3′)–C(2′)–C(1′)–C(10)	177.7(2)
C(13)–C(14)–C(15)–C(16)	−128.3(2)	C(2′)–C(1′)–C(10)–C(3)	66.2(2)
C(14)–C(15)–C(16)–C(17)	40.1(3)	C(1)–C(9)–C(4)–C(5)	−143.5(1)
C(15)–C(16)–C(17)–C(18)	−162.6(2)	C(8)–C(9)–C(4)–C(3)	−103.4(2)
C(16)–C(17)–C(18)–C(19)	178.2(2)	C(4)–C(4)–C(8)–C(13)	−153.3(2)
C(17)–C(18)–C(19)–C(20)	−27.7(3)	O(24)–C(9)–C(8)–C(7)	150.6(1)

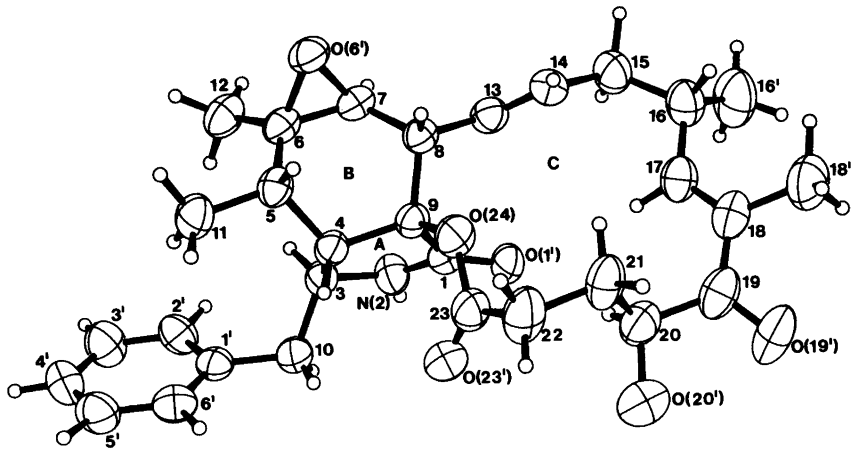


Fig. 1. A perspective drawing (ORTEP 2) of a molecule of cytochalasin M. The thermal ellipsoids of the non-hydrogen atoms are scaled to include 50 % of probability.

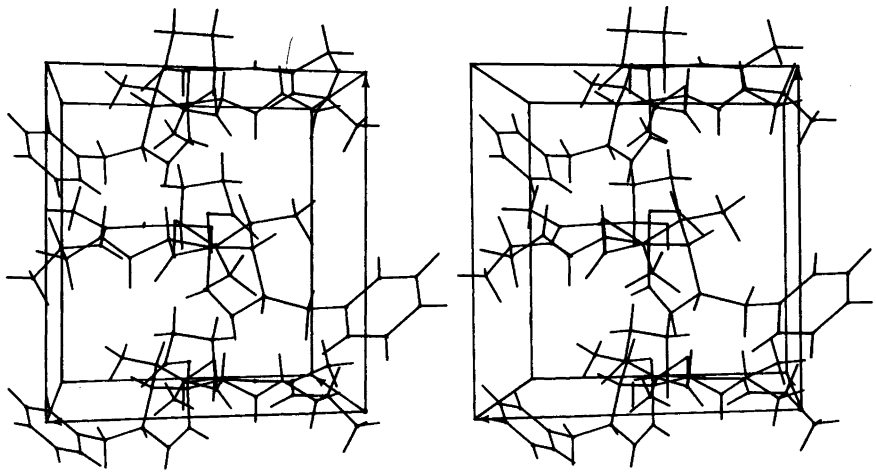


Fig. 2. Stereoscopic pair of drawings of the molecular packing in solid cytochalasin M. The unit cell is viewed approximately along the *c* axis direction.

stereo-view of the molecular packing. The molecules are van der Waals bonded. There is a weak intermolecular hydrogen bond N(2)–H(N2)···O(19′) to the molecule located at $1-x$, $-\frac{1}{2}+y$, $1-z$ with N(2)–O(19′)=2.900(2) Å.

The essential features of cytochalasin M, with the ester at C(23) replaced by a ketone, are similar to those of chaetoglobosin F,[9] but also to those of the chaetoglobosins A,[10] C[11] and K[12] (X-ray structures have been determined for the latter three compounds). The five-membered ring (A in Fig. 1) is distorted by the short C(1)–N(2) bond. Its dominating symmetry is a two-fold axis intersecting C(1)–C(9) and passing through C(3), so the ring conformation is a flat C(1), C(9)-half-chair with C(1) and C(9) deviating −0.146(1) and +0.192(1) Å, respectively from the plane through N(2), C(3) and C(4). The amide bond C(1)–N(2) and the carbonyl bond C(1)–O(1′) are both short. O(1′) is slightly out of the C(1)–N(2)–C(3) plane. The A/B ring junction is *cis*.

The 6-membered ring B is fused to A and the 14-membered ring C, and bears an epoxide ring. The B/C ring junction is *trans*. The B ring has a distorted boat conformation. C(5) is +0.748(2) and C(8) +0.364(2) Å from the least-squares plane through C(4), C(6), C(7) and C(9), with r.m.s. deviation 0.110 Å. The epoxide ring strains the angles C(12)–C(6)–C(5), C(12)–C(6)–C(7) and C(6)–C(7)–C(8).

Ring C has two double bonds, C(13)=C(14) and C(17)=C(18). Both are *trans*, *i.e.* C(8)–C(13) is antiplanar to C(14)–C(15) and C(16)–C(17) is antiplanar to C(18)–C(19). The least-squares plane through C(8)–C(13)=C(14)–C(15) meets the least-squares plane through C(16)–C(17)=C(18)–C(19) with the angle 67.5(2)°. O(19′) is located near the latter plane, the deviation being −0.395(2) Å, and since the torsion angle O(19′)–C(19)–C(20)–O(20′) is small, O(20′) is also near the same plane [+0.391(2) Å]. The C(23)=O(23′) bond is synplanar (*cis*) to O(24)–C(9) resulting in a contact distance C(1)–O(23′)=2.777(2) Å.

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