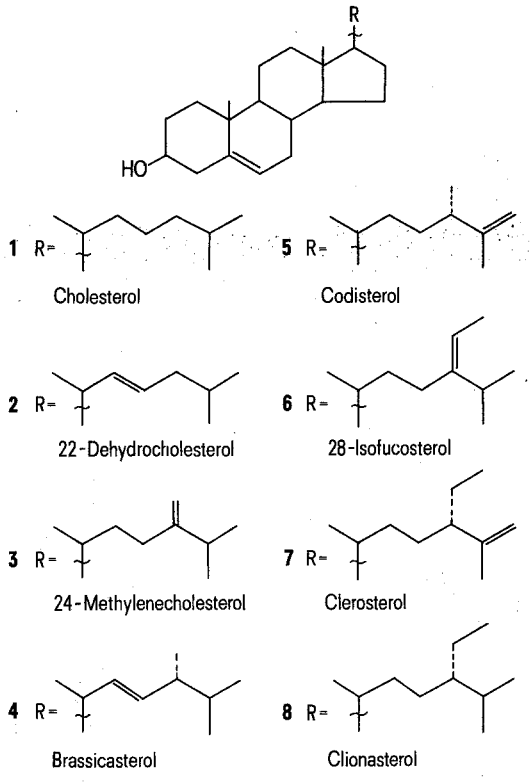
The distribution of sterols in some Mediterranean Chlorophyceae

| Order | Species | Sterol (mg/kg dry alga)* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Ulotrichales | *Ulva rigida* | 22 | t | t | t | – | 81 | – | – |
| | *Enteromorpha intestinalis* | t | – | t | – | – | 140 | – | – |
| Cladophorales | *Cladophora echinus* | 124 | t | 55 | – | – | t | – | 492 |
| Siphonales | *Codium aderens* | – | – | – | – | t | – | 629 | – |
| | *Codium bursa* | t | – | – | – | – | – | 250 | – |
| | *Codium tomentosum* | – | – | – | – | – | 122 | 429 | – |
| | *Halimedia tuna* | 92 | 31 | 72 | 15 | – | – | – | 509 |
| Siphonocladales | *Valonia utricularis* | 23 | t | 6 | t | – | – | – | 103 |

*Indicates not detectable, t indicates trace amounts.




seaweeds belonging to the order Ulotrichales. On the other hand the analysis of the only species of Cladophorales examined is consistent with the previous results: it contained a complex mixture of sterols with a high proportion of cholesterol. As far as the Siphonales are concerned, our analyses indicated that clerosterol is representative only of the genus *Codium*. In fact it is the dominant sterol of *C. tomentosum* and virtually the unique sterol in *C. aderens* and *C. bursa*, while it is absent in *Halimeda tuna*, where the most abundant sterol is clionasterol, the same as in the previously examined *H. incrassata*.

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## Synthesis of 6-deoxy-6-fluoro-L-ascorbic acid[1]

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*Summary.* 6-Deoxy-6-fluoro-L-ascorbic acid has been synthesized in 5 steps starting from 2,3-4,6-di-O-isopropylidene-2-keto-L-gulonic acid.

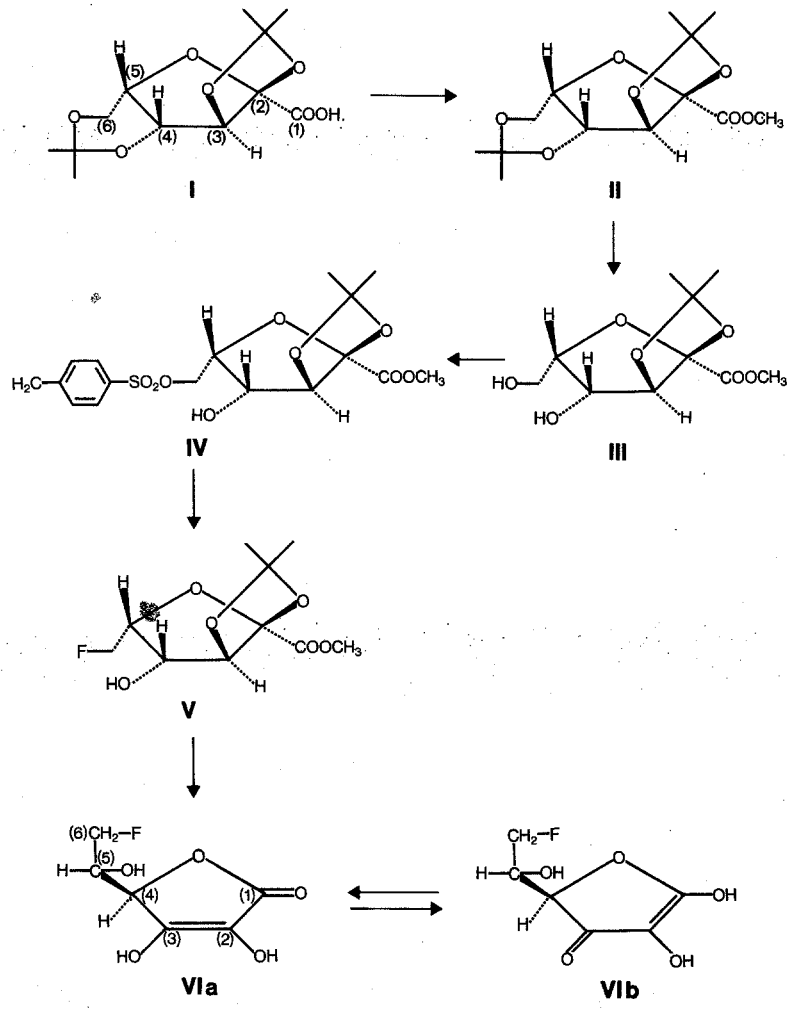
Fluoro derivatives of physiologically active compounds, such as nucleosides[2], amino acids[3], carbohydrates[4], corticosteroids[5] and vitamins have attracted considerable attention in medicinal and also in preparative organic chemistry[6].

As part of a synthetic programme on vitamin C derivatives we have synthesized 6-deoxy-6-fluoro-L-ascorbic acid, i.e. the primary hydroxyl group is substituted by fluorine.

The starting material of our synthesis was the well-known intermediary product of the Reichstein-synthesis[7] for L-ascorbic acid: the 2,3-4,6-di-O-isopropylidene-L-gulosonic acid (**I**). It was converted to its methyl ester **II** using methyl iodide in the presence of potassium carbonate in dimethylformamide solution. The selective cleavage of the 4,6-O-isopropylidene protecting group was carried out in water in the presence of cuprous acetate as catalyst[8].

Methyl 2,3-O-isopropylidene-α-L-gulosonate (**III**) was then converted into its 6-toluenesulfonate ester **IV** (m.p. 127–128 °C), which with KF in dry dimethylformamide at 150 °C gave the methyl 6-deoxy-6-fluoro-2,3-O-isopropylidene-L-gulosonate (**V**) (m.p. 98–100 °C).

The last step of the synthesis was the cleavage of the protecting group and the isomerization to 6-deoxy-6-fluo-




ro-L-ascorbic acid (**VI**). The isomerization was carried out by refluxing **V** with Amberlite JRC-120 ($H^+$-form) in aqueous solution. The crystalline material thus obtained was recrystallized from nitromethane and had a m.p. of 140–142 °C $[a]_D^{25} = 19.6°$ (c = 0,5 in $H_2O$)[9].

Main confirmation of the structures of compounds **V** and **VI** was obtained from their $^1$H- and $^{13}$C-NMR-spectra:

$^1$H-NMR of **V** ($CDCl_3$, 270 MHz): 1.41 ppm and 1.58 ppm, s, $CH_3-\dot{C}-CH_3$); ~2.4 ppm, broad, −OH; 3.90 ppm, s, $-COOCH_3$, 4.32 ppm, d, $J_{45} = 2.5$ Hz, 4-C*H*; ~4.6 ppm, m, 5-C*H*; 4.69 ppm, ddd, $J_{6F} = 46.5$ Hz, $J_{66'} = 10.2$ Hz, $J_{65} = 6$ Hz, one H of 6-$CH_2$; 4.71 ppm, d, $J_{3F} = 2$ Hz, 3-C*H*; 4.79 ppm, ddd, $J_{6'F} = 50$ Hz, $J_{6'5} = 4.4$ Hz, the other H of 6-$CH_2$.

$^{13}$C-NMR of **V** ($CDCl_3$, ~1 mmole/ml, 22.6 MHz, broad band decoupled): 25.8 and 26.9 ppm, $CH_3-\dot{C}-CH_3$; 53.5 ppm, $-OCH_3$; 74.9 ppm, d, $J_{CF} = 6.1$ Hz, 4-C; 81.3 ppm, d, $J_{CF} = 166{,}6$ Hz, 6-C; 81.8 ppm, d, $J_{CF} = 22.0$ Hz, 5-C; 87.9 ppm, 3-C; 110.1 ppm, 2-C; 114.8 ppm, $CH_3-\dot{C}-CH_3$; 168.8 ppm, −CO−. The assignment was checked by a gated decoupled spectrum, which confirmed the assignment derived from chemical shift and fluorine-coupling.

$^1$H-NMR of **VI** ($D_2O$, 270 MHz, only one tautomer is observed): 4.30 ppm, dddd, $J_{5F} = 16.6$ Hz, $J_{45} = 2.2$ Hz, $J_{56} = 7$ Hz, $J_{56'} = 4.7$ Hz, 5-C*H*; 4.61 ppm, ddd, $J_{6F} = 47.4$ Hz, $J_{66'} = 10.0$ Hz, one H of 6-$CH_2$; 4.68 ppm, ddd, $J_{6F} = 46.0$ Hz, the other H of 6-$CH_2$; 4.94 ppm, d, 4-C*H*.

$^{13}$C-NMR of **VI** ($D_2O$, ~1 mmole/ml, 22.6 MHz, broad band decoupled): 68.6 ppm, d, $J_{CF} = 20.1$ Hz, 5-C; 77.1 ppm, d, $J_{CF} = 7.3$ Hz, 4-C; 85.3 ppm, d, $J_{CF} = 167.2$ Hz, 6-C; 119.5 ppm, 2-C; 156.2 ppm, eventually broadened by an unresolved CF-coupling, 3-C; 174.4 ppm, 1-C. The assignment was additionally checked by a gated decoupled spectrum and corresponds to the assignment given for ascorbic acid[10].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