However, there are already enough clues to justify further investigation of the non-cholinergic biochemical and physiological functions of the cholinesterases. The possible involvement of cholinesterases in cell growth and movement has far-reaching implications for our understanding of the maturation of cells in the nervous system and blood.

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TEXTBOOK ERRORS

Propagation of an error: β-sheet structures

Arthur S. Edison

I have found mistakes in the diagram of both parallel and anti-parallel β-sheet diagrams in Linus Pauling's *The Nature of the Chemical Bond*[1] that have been propagated for 30 years by many of the most widely used textbooks in biochemistry.

WHILE STUDYING Creighton's *Proteins: Structures and Molecular Properties*[2], a required text for the course in biomolecular structure at the University of Wisconsin, I discovered that a short model of a polypeptide chain which I had built could not be oriented so that it corresponded to the diagram of β-sheet structures. Neither the parallel nor the anti-parallel drawings would fit my model, so I checked the model for the proper L-amino acids. Finding it to be correct, I soon discovered that both β-sheet diagrams in Creighton are drawn with D-amino acids.

These diagrams[2] were adapted from Pauling's *The Nature of the Chemical Bond* (3rd edn)[1]. I assumed that Creighton's diagrams had been inadvertently reversed during publication, but to my surprise, the β-sheet structures in Pauling's great text are drawn with D-amino acids. This apparent error prompted me to examine the original papers.

The first proposal of β-sheet structures was made by Pauling and Corey in 1951[3,4]. During the same period of time, Pauling, Corey and Branson proposed two hydrogen-bonded helices, one of which has become known as the right-handed α-helix[5]. This work was based upon model building which incorporated the authors' knowledge of the planar peptide bond, bond angles, and bond lengths. In each of these papers[3–5] the authors were discussing L-amino acids, but the diagrams contained what we now designate D-amino acids. However, in the publication on helical configurations[5] the authors state: 'An arbitrary assignment of the R groups has been made in the figures'. At the time of this initial work in 1951, the absolute configuration of the amino acids was not known, and the authors made a random guess that was later shown to be incorrect.

Around this same time, Bijvoet and co-workers[6–8] developed the method of isomorphous replacement for X-ray crystallography which enabled them to determine the absolute configurations of a wide range of optically active compounds, many of which could be related, by chemical methods, to the naturally occurring amino acids.

In 1955, Pauling, Corey and Marsh published a paper on the structure of silk fibroin[9]. In this paper, the diagram of the anti-parallel β-sheet was drawn with the correct configuration of L-amino acids which corresponds to *S* (except for cysteine) in the *R*/*S* system of Cahn, Ingold and Prelog[10,11].

This shows that the papers published in 1951 and 1955 by Pauling and colleagues were correct in their representation of β-sheet structures: in 1951 because the absolute configuration of amino acids had not yet been determined, and in 1955 because they cor-

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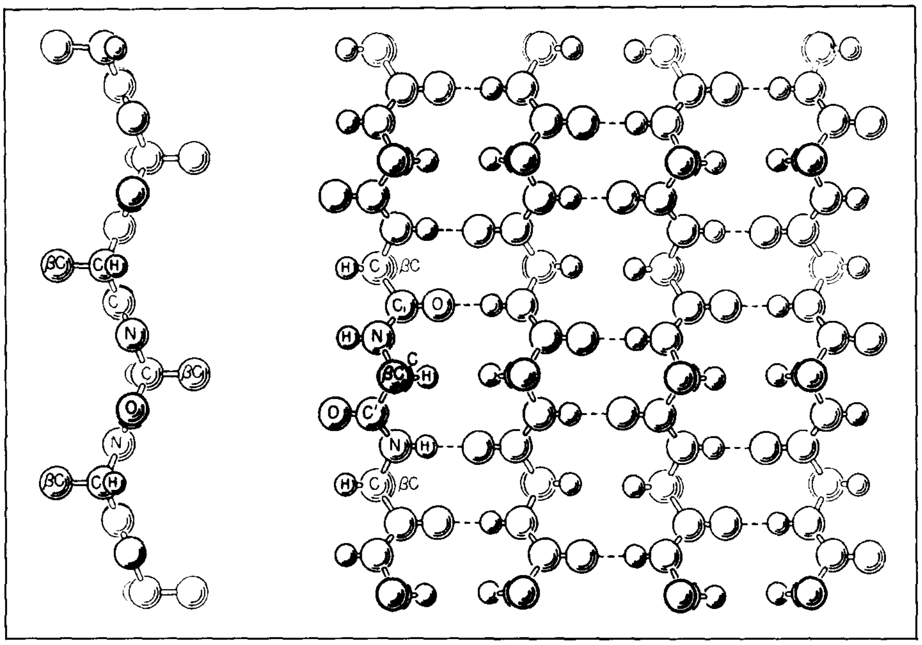

Figure 1
β-sheet diagram drawn with L-amino acids; reproduced, with permission, from Ref. 9.

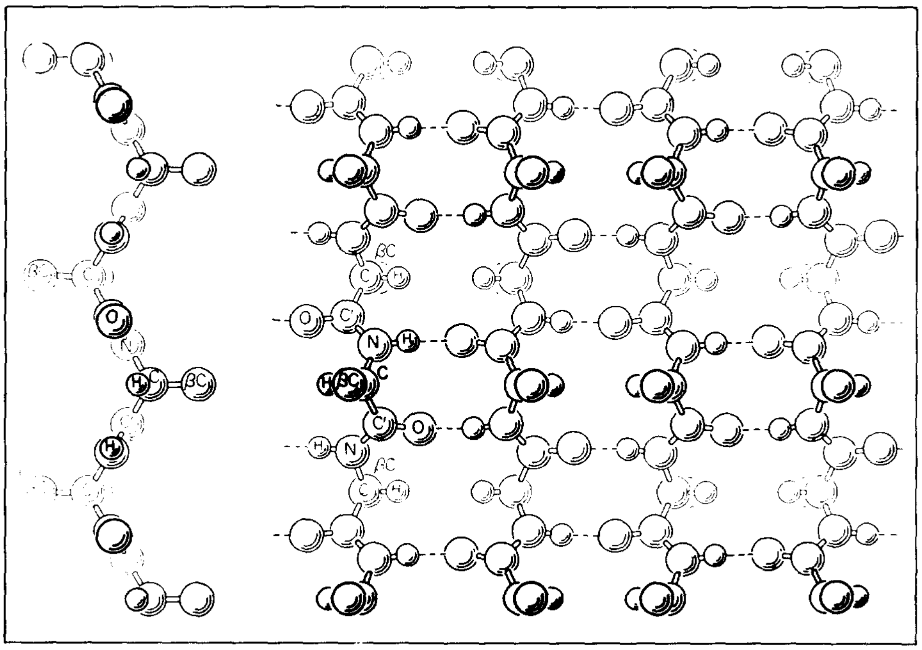

Figure 2
β-sheet diagram drawn with D-amino acids; reproduced, with permission, from Ref. 1.

rectly represented the known configurations of L-amino acids. However, in the third edition (1960) of *The Nature of the Chemical Bond*[1], the 1951 diagrams of β-sheets were used. As a result, the drawings incorrectly show D-amino acids.

The unfortunate, but amusing, outcome of this mistake is that many textbooks in biochemistry, biophysics and molecular biology have adapted the incorrect diagrams. During a short visit to the library, I found 11 other textbooks, including all four editions of Watson's *Molecular Biology of the Gene*, that have propagated this error[12-20]. This was just a random sampling, and I am sure that others could be found. I would doubt that an error such as this would have been propagated for 29 years had it not occurred in a book written by one of the world's greatest chemists[2].

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Erratum

In the article entitled 'Tissue-specific genes for respiratory proteins' by Margaret I. Lomax and Lawrence I. Grossman (*TIBS* 14, pp. 501–503), Table I contained two errors. The two cytochrome *c* oxidase subunits *COX4* and *COX6A* are both located on human chromosome 16 and not chromosome 15.