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REVIEW ARTICLE

A compendium of cyclic sugar amino acids and their carbocyclic and heterocyclic nitrogen analogues

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Abstract This compendium focuses on functionalised sugar amino acids (SAAs) and their 3- to 6-membered nitrogen heterocyclic and carbocyclic analogues. The main benefit of using SAAs and their related nitrogen and carbon congeners in the production of peptidomimetics and glycomimetics is that their properties can be readily altered via modification of their ring size, chemical manipulation of their numerous functional groups and fine-tuning of the stereochemical arrangement of their ring substituents. These building blocks provide access to hydrophilic and hydrophobic peptide isosteres whose physical properties allow entry to a region of chemotherapeutic space which is still under-explored by medicinal chemists. These building blocks are also important in providing amino acids whose inherent conformational bias leads to predisposition to secondary structure upon oligomerisation in relatively short sequences. These foldamers, particularly those containing ω-amino acids, provide an additional opportunity to expand access to the control of structures by artificial peptides. The synthesis and biological evaluation of these building blocks in glycomimetics and peptidomimetics systems keep expanding the reach of the glycosciences to the medical sciences, provide a greater outlook onto the wide range of cellular functions of saccharides and their derivatives involved and greater insight into the nature of oligosaccharide and protein folding.

Keywords Sugar amino acid · Isostere · Foldamer · Glycomimetics · Peptidomimetics · Carbohydrate

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Natural SAAs

Sugar amino acids (SAAs) are monosaccharide derivatives bearing an amine and a carboxylic acid functionalities (Soengas and Silva 2012; Seeberger and Werz 2005; Jensen and Brask 2005; Timmer et al. 2005; Chakraborty et al. 2002a, b, 2004a, 2005; Gruner et al. 2002a; Schweizer 2002; Knapp 1995; Lohof et al. 1999a; Dondoni and Marra 2000; Ishida and Inoue 1999). Known also as glycosamino acids, they are important in nature for their roles as antibiotics, glycosidase inhibitors, construction elements (Chakraborty et al. 2002b; Gruner et al. 2002a; Lohof et al. 1999b, 2001; Gervay-Hague and Weathers 2001) and for their involvement in inter- and intra-cellular molecular recognition events, to mention a few. Sialic acid (Fig. 1), found in almost all living organisms and located peripherally on glycoproteins and glycolipids, represents the most prominent and abundant example of the latter two.

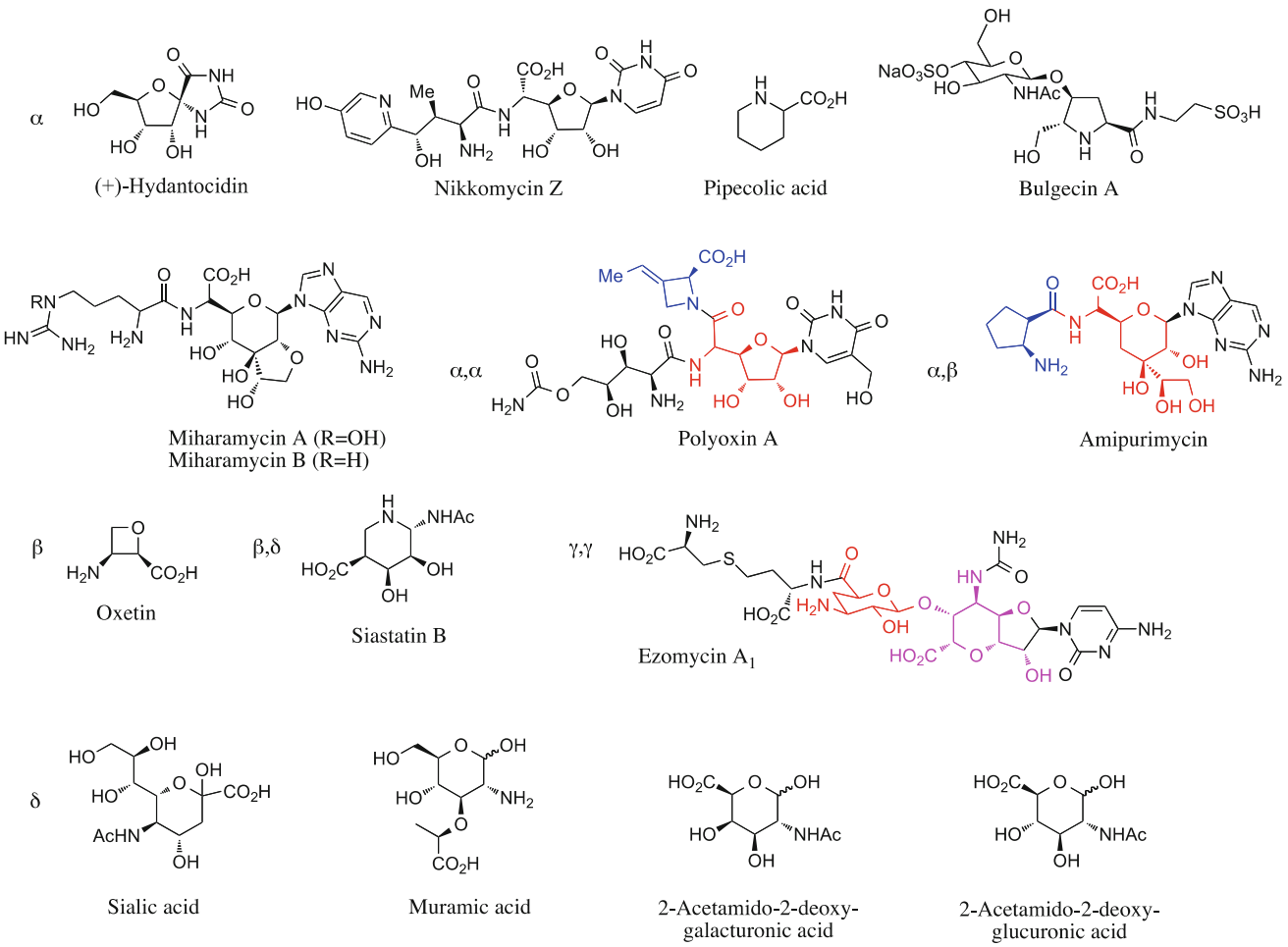


Fig. 1 A range of representative natural SAAs

Muramic acid also occurs widely in bacterial polysaccharides due to its involvement in peptidoglycan synthesis (Baschang 1989). Glycosaminuronic acids (Williamson and Zamenhof 1963) such as 2-acetamido-2-deoxy-glucuronic acid and 2-acetamido-2-deoxygalacturonic acid are found, respectively, as a component of bacterial cell walls (Williamson and Zamenhof 1963) and as a component of the *E. coli* V*i* antigen (Heyns et al. 1959).

Natural SAAs have also been widely found in nucleoside antibiotics (Knapp 1995) such as the naturally occurring spiro-furanoid (+)-hydantocidin (which exhibits herbicidal activity), the ezomycins (a class of complex nucleoside antibiotics, isolated from *Streptomyces* fermentation broths (Knapp et al. 1994; Haruyama et al. 1991; Nakajima et al. 1991; Siehl et al. 1996)), the polyoxins (Isono et al. 1969; Li et al. 2012; Isono 1988) and the nikkomycins (potent inhibitors of chitin synthetases in fungi and insects) (Isono 1988; Liao et al. 2009). Antibiotics such as amipurimycin (Wede et al. 2000; Fülöp 2000) and miharamycins (Marcelo et al. 2008; Czernecki et al. 1996), which display strong activity against the rice blast disease caused by *Pyricularia oryzae*, contain a core α-SAA. Additionally, amipurimycin also incorporates the carbocyclic β-SAA congener *cis*-2-aminocyclopentane carboxylic acid (*cis*-2-ACPC) (Wede et al. 2000; Fülöp 2000). The antibiotic oxetin (Barker et al. 2001; Kawahata et al. 1986) is the only naturally occurring β-AA yet reported based on an oxetane ring scaffold. It exhibits herbicidal activity and inhibits glutamine synthetase from spinach leaves (Omura et al. 1984). Other antibiotics include the more recently discovered tripropeptin (Hashizume et al. 2011) and empedopeptin (Müller et al. 2012).

Siastatin B (Umezawa et al. 1974), an inhibitor of β-glucuronidases, belongs to the class of SAAs which contain the amine within the pyranoid ring structure. Replacement of the endocyclic oxygen atom with a nitrogen atom leads to azasugar-based SAAs which have been found to, but are not limited to, interact with carbohydrate-active enzymes and include hydroxylated prolines (such as the antibacterial bulgecin) and pipecolic acids (Shinagawa et al. 1984; Návarová et al. 2012; Kadouri-Puchot and Comesse 2005). Hydroxylated prolines have additionally been shown to influence secondary structure in peptides significantly (Takeuchi and Marshall 1998; Bellier et al. 1998).

Synthetic amino acids

An important aspect of peptide chemistry involves the design, synthesis and applications of artificial amino acid building blocks. Some of the many advantages provided by the incorporation of an artificial amino acid residue in a particular peptide sequence include the introduction of a conformational bias or the achievement of a more proteolytically stable analogue. SAAs provide a set of peptide isosteres whose inherent conformational bias, chemical and physical properties can be tuned more effectively than other classes of peptidomimetics. These characteristics can be readily adjusted via the fine-tuning of the stereochemical arrangement of substituents of the sugar ring, ring size and the modification of functional groups. A number of synthetic routes to tailor-made SAA building blocks have been developed by the use of protective groups which have also allowed their incorporation into solid-phase synthesis protocols (Szabo et al. 1998; Well et al. 2003a).

Besides their potential as peptidomimetics, or as glycomimetics, SAAs have been used in the design and synthesis of foldamers—peptide-like molecules which display a predisposition towards the formation of well-defined secondary structures in relatively short oligomeric sequences (Baldauf and Hofmann 2012; Martinek and Fülöp 2012; Horne 2011; Bouillere et al. 2011; Cheng et al. 2001; Gellman 1998; Gademann et al. 1999; Hill et al. 2001; Pilsl and Reiser 2011; Roy and Balaram 2004; Seebach and Matthews 1997; Seebach et al. 2004; Seebach and Gardiner 2008; Soth and Nowick 1997).

Because dense functionalisation and correct absolute stereochemical configurations are required, these building blocks are most readily synthetically derived from carbohydrate starting materials. It still is the case that novel peptidomimetics provide a driving force for the invention of new drugs. The easy access to the potential candidates for such intermediates is the main intention of this paper.

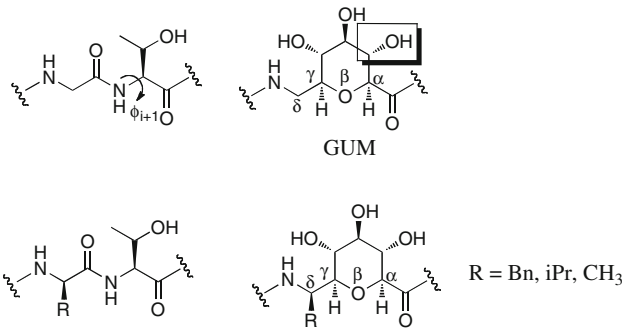


Fig. 2 *Top* comparison of the *cis*-pyranoid δ-SAA GUM with the dipeptide Gly-L-Thr (von Roedern and Kessler 1994; von Roedern et al. 1996) and *bottom* with the alkylated SAAs (Raunkjaer et al. 2004) that function as D-Phe-L-Thr, D-Val-L-Thr and as D-Ala-L-Thr mimic, respectively

The original compendium on SAAs gave a restricted set of structures confined to oxygen heterocycles (Risseeuw et al. 2007a). This review is expanded to include related functionalised nitrogen heterocyclic and carbocyclic amino acid building blocks.

Designed SAAs

Peptidomimetics

Kessler and co-workers (von Roedern and Kessler 1994) were the first to recognise that SAAs may serve as a bridge between the two worlds of glycomimetics and peptidomimetics. Thus, from this perspective, the δ-SAA glucosyluronic acid methylamine (GUM) functions as a conformationally restricted dipeptide isostere. Because of the preference of the sugar core for the $^4C_1$ chair

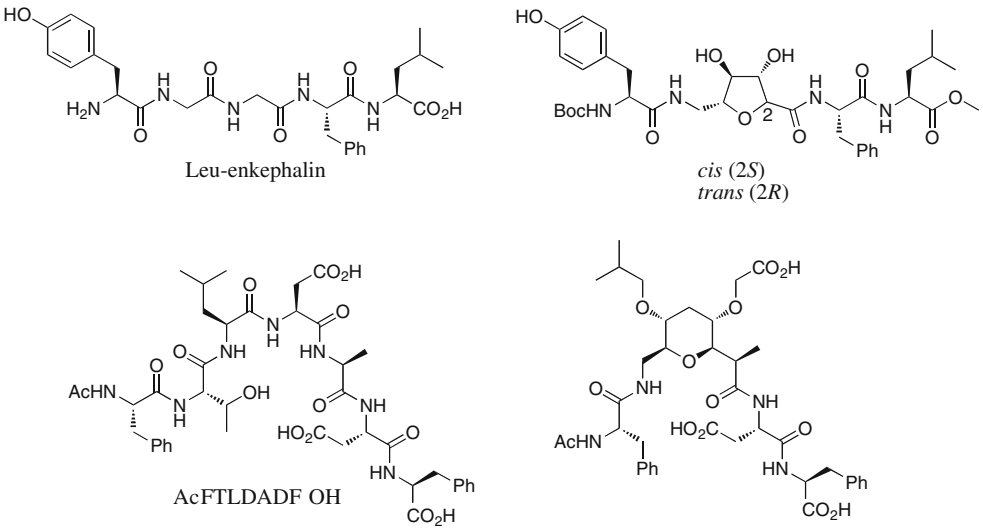


Fig. 3 *Top* the structure of two diastereoisomeric Leu-enkephalins containing a *cis*- and a *trans*-furanoid δ-SAAs (Chakraborty et al. 1998). *Bottom* design of an inhibitor of the mammalian ribonucleotide reductase (mRR) enzyme based on a *trans*-pyranoid ε-SAA (Smith et al. 1998a)

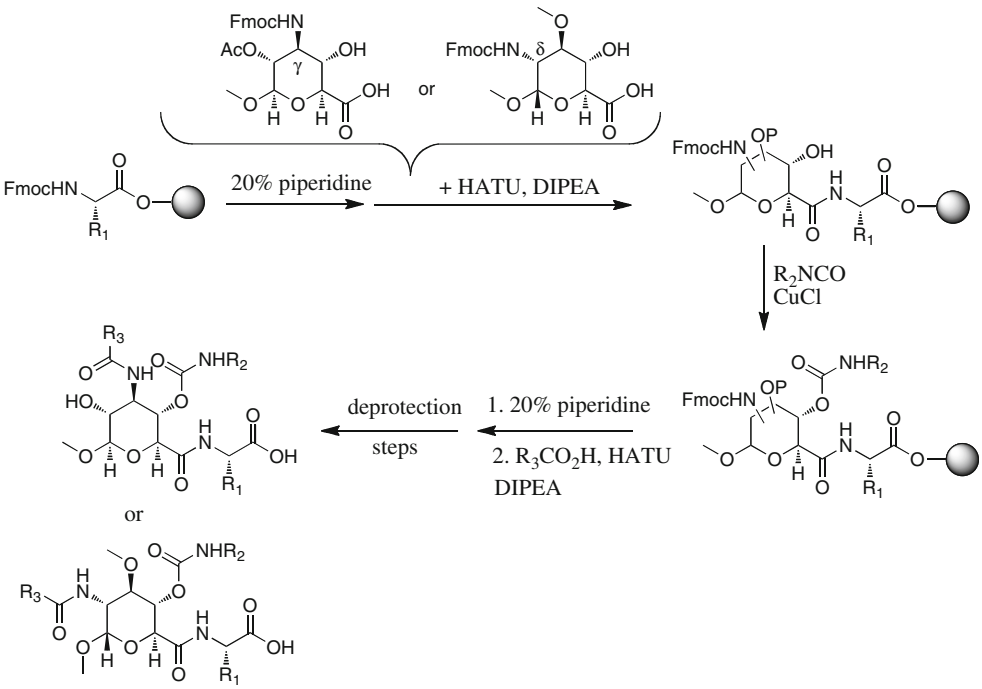
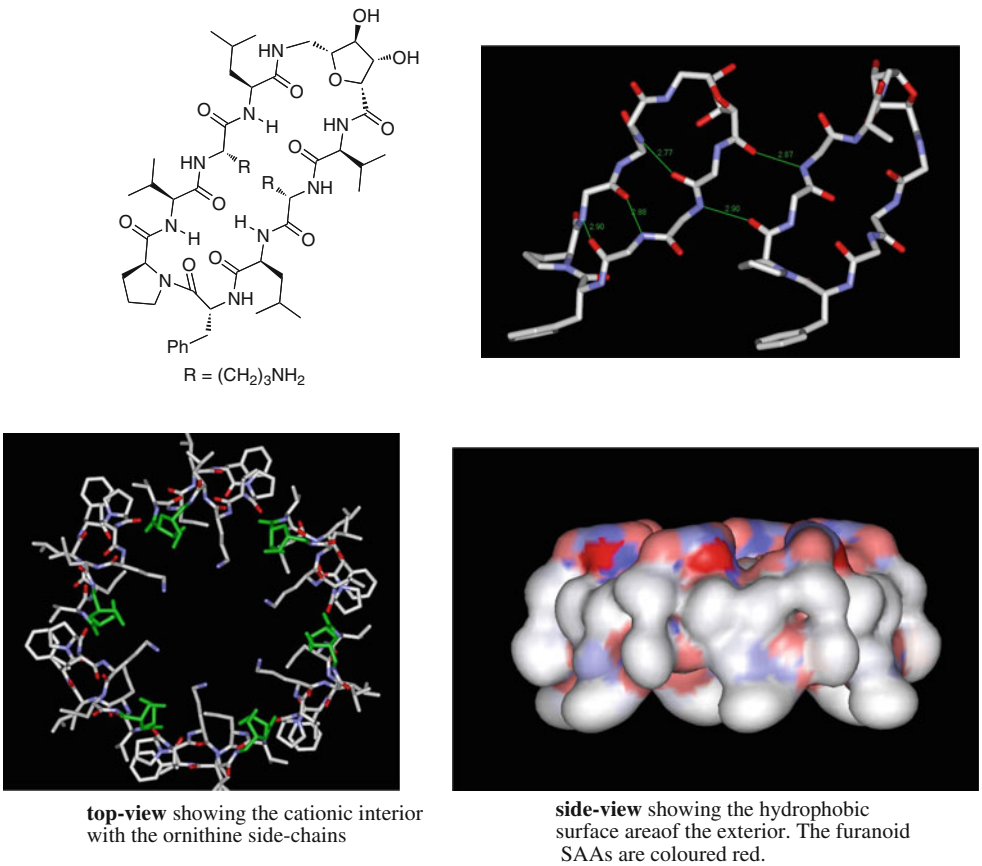


Fig. 4 The construction of a peptidomimetic compound libraries using SAAs at the branching core (Sofia et al. 1998)



top-view showing the cationic interior with the ornithine side-chains

side-view showing the hydrophobic surface areaof the exterior. The furanoid SAAs are coloured red.

Fig. 5 *Top left* a GS derivative containing a *cis*-furanoid δ-SAA. *Top right* Hydrogen bonding between two GS molecules. *Bottom* top and side views of the β-barrel-like assembly formed by six GS derivatives

conformation, which positions all substituents equatorially, the torsion angle of the SAA turn mimic between Cα and Oβ, corresponding to the ϕ_{i+1} torsion angle of a dipeptide (Fig. 2, top), is fixed at ~180°. As the α-position is functionalised as part of the sugar ring, GUM may be viewed as a very hydrophilic conformationally restricted Gly-L-Thr isostere (Fig. 2, top). From these observations, Kessler and co-workers (Gruner et al. 2002a; von Roedern

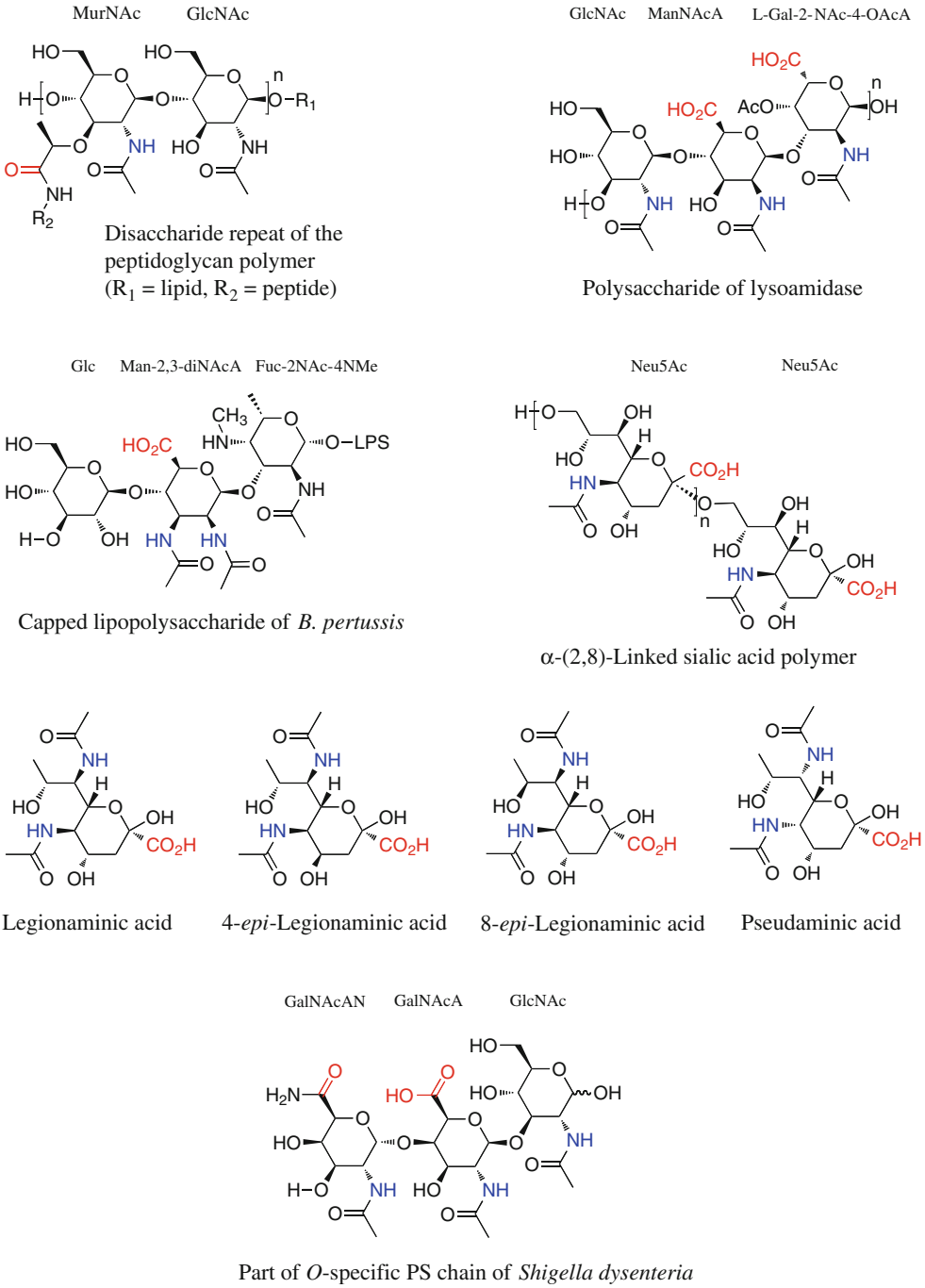


Fig. 6 The structures of some naturally occurring SAAs and their presence in many natural biopolymers

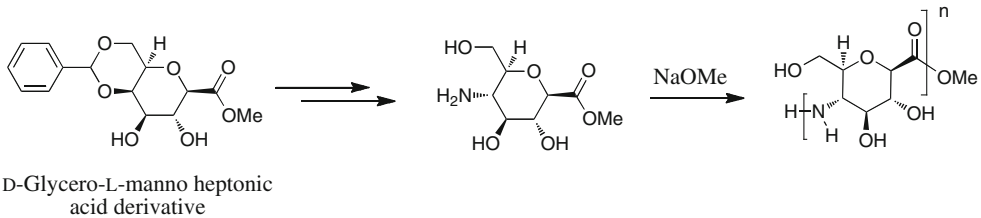


Fig. 7 The synthesis of amide linked SAA polymer

et al. 1996) and others research groups designed a range of conformationally restricted SAA scaffolds to impart a turn bias to "linear" peptide mimics. For the specific structures of these SAA building blocks, we refer to Tables 1, 2, 3, 4. For perusal, one type of alkylated SAA (Fig. 2, bottom) is illustrated (Raunkjaer et al. 2004).

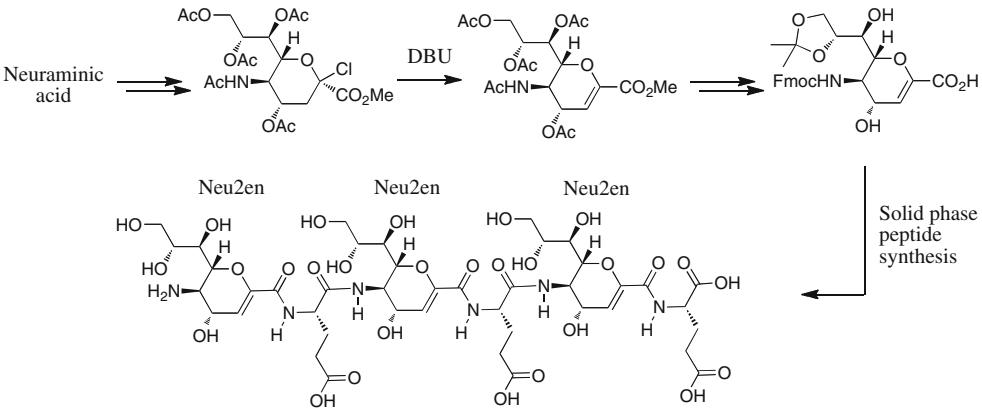


Fig. 8 A helical hexameric foldamer produced by alternating SAA Neu2en and AA L-Glu

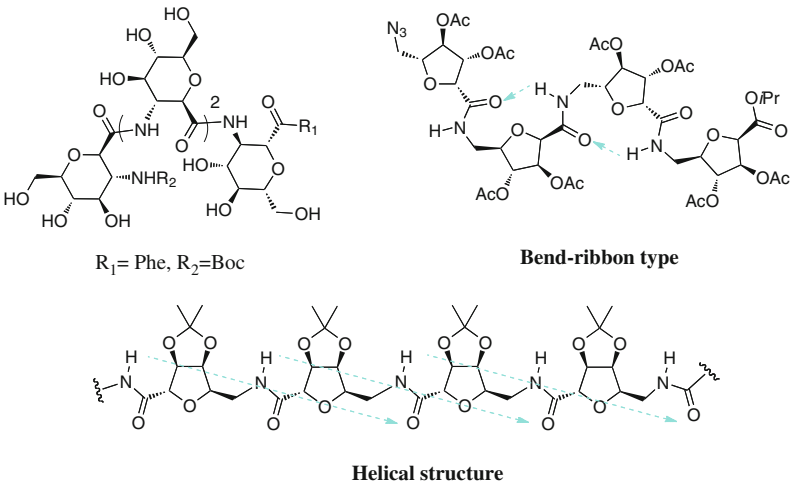


Fig. 9 Three different types of foldamers based on SAAs. The *blue arrows* indicate the hydrogen-bonding interactions which help stabilise the secondary structural conformations adopted by these foldamers (colour figure online)

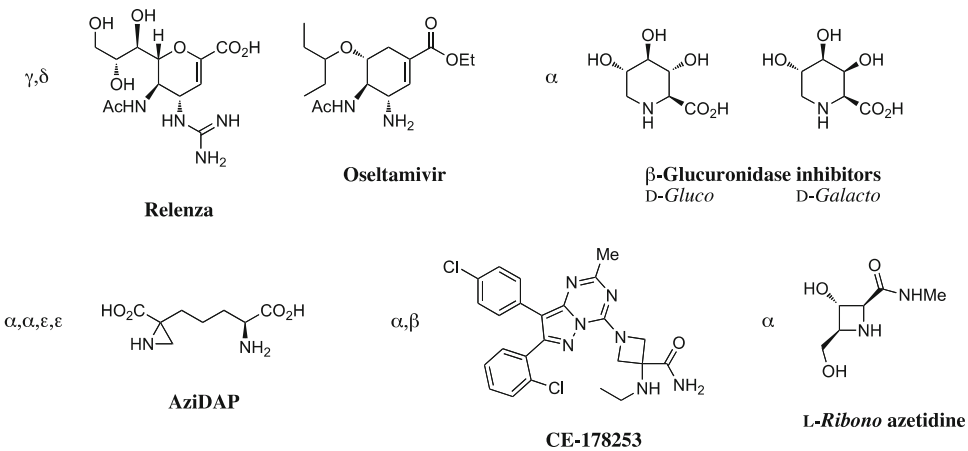


Fig. 10 A range of pharmacologically active compounds based on SAA scaffolds

Many examples of SAAs incorporated in linear and cyclic peptides have been reported. Several studies have used SAAs as the common dipeptide isostere in the production of peptidic compound libraries, as depicted in Figs. 3, 4 and 5. Chakraborty compared the conformational properties of a *cis*- and *trans*-furanoid δ-SAAs incorporated in a short Leu-enkephalin sequence (Fig. 3, *top*) and showed the induction of a turn conformation by the *cis*-isomer. This was established spectroscopically by NMR and CD analysis, and predicted by modelling studies (Chakraborty et al. 1998).

Another striking example of the use of SAAs to confer conformational bias in inhibitor design is provided by Smith et al. (Fig. 3, *bottom*), who showed how a highly functionalised *trans*-pyranoid ε-SAA imparts a turn conformational bias, thus effectively mimicking the turn region of the mammalian heptapeptide AcFTLDADF-OH, an inhibitor (IC_{50} 8.9 μM (Xu et al. 2008), K_i 15–20 μM (Smith et al. 1998a)) of mammalian ribonucleotide reductase (mRR). The SAA-containing peptidomimetic was found to inhibit the mRR with a much lower K_i of 400–500 μM (Smith et al. 1998a).

Sofia et al. used SAAs as the branching point for the development of a peptidomimetic compound library on solid support (Sofia et al. 1998; Sofia 1998). Their strategy involved the following steps: the attachment of a γ- or δ-SAA building block to an amino acid of choice, the functionalisation of a secondary hydroxyl group into a carbamate and the functionalisation of the amine group, as is outlined in Fig. 4. More recently, a variation on this theme was reported by Gomez et al. (2009) towards furanose-based carbohydrate templates.

Several examples of cyclic peptides containing one or more SAAs and macrocycles composed entirely of SAAs have been reported (Well et al. 2003a; Andreini et al. 2008; Bughin et al. 2007; Hirata et al. 2007; Fleet et al. 2006; Bream et al. 2006; Fujimura et al. 2006; Menand et al. 2005; Billing and Nilsson 2005a, b; Edwards et al. 2005; Bornaghi et al. 2004; Mayes et al. 2004; Chakraborty et al. 2003; Well et al. 2000, 2003c, b; Gruner et al. 2002b; Stöckle et al. 2002a, b; Chakraborty et al. 2002c; Locardi et al. 2001). One example involves the replacement of two AA residues by a *cis*-furanoid δ-SAA in one of the turn regions of the antibiotic gramicidin S (GS) (Fig. 5) (Grotenbreg et al. 2004a). Although this GS derivative proved not to be biologically active, it revealed appealing structural features. Incorporation of the SAA introduces a hairpin twist of ~45° in the cyclic β-hairpin structure of the monomeric macrocycle as shown crystallographically. Each GS analogue also binds inter-molecularly to two neighbouring molecules via four hydrogen bonds. These then form a supramolecular hexameric ensemble reminiscent of a β-barrel and possessing a cationic interior and a hydrophobic exterior (Fig. 5). Similar pore-forming assemblies of cationic antimicrobial peptides have been suggested to occur in bio-membranes (Lazaridis et al. 2013; Semrau et al. 2010; Hartmann et al. 2010).

Glycomimetics as foldamers

The peptidoglycan layer is an essential and specific component of the bacterial cell wall found on the outside of the cytoplasmic membrane of almost all bacteria (Vollmer et al. 2008). The main structural feature of peptidoglycan is its composition: an ensemble of linear glycan strands, each one made up of alternating β-(1→4)-connected *N*-acetylglucosamine (GlcNAc) and *N*-acetylmuramic acid (MurNAc) residues, further cross-linked by short peptide sequences (Fig. 6). In Fig. 6, further examples of naturally occurring oligomeric and polymeric glycans, containing natural SAAs, are shown with their respective biological sources (Codée et al. 2011; Schoenhofen et al. 2009; Liu et al. 2008; Lehmann et al. 2006; Caroff et al. 2000; Likhosherstov et al. 1995; Brisson et al. 1992; Kulaev et al. 1989; Knirel et al. 1988).

Taking inspiration from these natural constructs, numerous carbohydrate-derived oligomers containing amide linkages in place of glycosidic linkages, now known as carbopeptoids, have been reported and their secondary structural propensities have been analysed (Szabo et al. 1998; Dane and Grinstaff 2012; Blanco et al. 2010; Timpano et al. 2008; Suhara et al. 1996a, 2002, 2006; Kyas and Feigel 2005; Durrat et al. 2004; Gervay-Hague and Weathers 2002; Liang et al. 2001; Nishimura et al. 1998; Timmers et al. 1997; Müller et al. 1995; Wessel et al. 1996; Yoshimura et al. 1976).

Paulsen and co-workers were the first to report on the synthesis of a "designed" SAA (Heyns and Paulsen 1955). The earliest polymers entirely made of SAAs were described by Fuchs and Lehmann (1975a, b, 1976) (Fig. 7). These innovative early endeavours towards the construction of amide-linked glycomimetics involved the following steps: the multi-step conversion of a suitably protected heptonic acid derivative, the introduction of the amine functionality and the formation of polymeric materials (Fig. 7).

Sialic acid is of particular interest both from a structural and a design points of view, as it has been shown that short oligomers of α-(2→8) linked sialic acid (Neu5Ac) readily adopts a helical structure (Fig. 6) (Battistel et al. 2012).

Gervay-Haque et al. reported on the development of (helical) mimics of the sialic acids, oligomerised via amide linkages. Their monomeric building blocks were obtained by the subtle derivatisation of neuraminic acid (Neu) (Gregar and Gervay-Hague 2004; Gervay et al. 1997a). Another example of the use of SAA building blocks obtainable from Neu are the δ/α hybrid foldamers containing alternating SAA Neu2en and AA residue L-Glu

(Fig. 8) (Saludes and Ames 2009). A number of studies have revealed that stable foldamers could be obtained in water by oligomerisation of only six alternating AA (L-Glu)/SAA (Neu2en) residues (Saludes and Ames 2009). An example of this is provided by Saludes et al., who showed that this foldamer, in water, adopts a right-handed helical conformation with 3.7 residues per turn, 7.4 Å pitch and a length of about 18.5 Å. This helical structure is stabilised by both C = O···H–N backbone interactions and by another hydrogen bonding interaction between the pyranose ring oxygen and the L-Glu amide H–N. This type of construct have proven to be two to three orders of magnitude more stable than α-peptides in human blood plasma (Saludes et al. 2010). Several related SAA/AA hybrid foldamers are known which reveal further facets of the landscape of conformational preferences adopted by biopolymers (Sharma et al. 2009, 2011a; Suhara et al. 1997; Jagadeesh et al. 2009; Ramamoorthy and Gervay 1997; McDevitt and Lansbury 1996).

In 1996, Ichikawa et al. reported the synthesis of an oligomer composed of four *trans*-β-SAA attached to a *C*-terminal phenylalanine ester (Fig. 9) (Suhara et al. 1996b). In several follow-up papers, it was shown that longer oligomers of this type adopt helical structures (Suhara et al. 2006), resembling the helical structures studied by Appella and co-workers (Appella et al. 1996; Seebach et al. 1996) in oligomers of β-peptides. Related structures are obtained from β-amino acids having carbohydrates as their side-chains (Sharma et al. 2008; Palomo et al. 2002). Fleet demonstrated very neatly that a variety of interesting novel structures can be obtained using *cis*- or *trans*-substituted δ-furanoid amino acids (Fig. 8) (Claridge et al. 1999, 2001, 2005; Long et al. 1999; Smith et al. 1998b; Smith and Fleet 1999). Molecular dynamics simulations by van Gunsteren and co-workers classified this molecular conformational variability, consistent with the experimental data (Baron et al. 2005).

Ribbon- or stair-like foldameric behaviour was also displayed by oligomerisation of monomeric building block based on a β-SAA carbocyclic scaffold, such as 1-(aminomethyl)cyclopropanecarboxylic acid (Abele et al. 1999). On the other hand, short peptides of α-SAA 1-aminocyclobutane-1-carboxylic acid fold into β-turns and 3_{10}-helices as demonstrated by a number of groups (Toniolo et al. 2006). These encouraging results have spurred further investigations into the synthesis of novel building blocks (Žukauskaitė et al. 2011).

Synthesis of natural products, pharmaceutically active compounds and small molecule glycomimetics as glycosidase inhibitors

SAAs have been used in the synthesis of a plethora of natural products and their analogues, including hydantocidin (Dondoni et al. 1994; Brandstetter et al. 1995; Renard et al. 1998), kainic acid (Cantrell et al. 1996), plusbacin (Wohlrab et al. 2007), amipurimycin, miharamycin (Casiraghi et al. 1991) and domoic acid (Clayden et al. 2005).

SAAs have also been used as small molecule glycomimetics in the manipulation of the biological activities of carbohydrate-active enzymes, such as glycosidases. Their carbocyclic and especially their nitrogen congeners keep providing pharmacological leads in this area and the most remarkable class of glycosidase inhibitors to date.

A few examples (Fig. 10) are provided by the well-known γ,δ-SAA, marketed as Relenza (Itzstein et al. 1993), and its carbocyclic congener, marketed as Oseltamivir (Lew et al. 2000); both are neuraminidase inhibitors and used for the treatment of influenza of types A and B.

Pipecolic acid derivatives (Cant and Sutherland 2012) have been used in the synthesis of a number of natural products, including synthetic peptides in HIV therapy (Copeland et al. 1990), inhibitors of the Legionella MIP Protein (Juli et al. 2011) and as potent inhibitors of β-glucuronidase (Fig. 10, D-*gluco* and D-*galacto* analogues) (Yoshimura et al. 2008; Fleet et al. 1987).

Aziridine derivatives, such as AziDAP, irreversibly inhibit the diaminopimelate epimerase, which is a pivotal enzyme in the biosynthesis of lysine in plants (Pillai et al. 2006, 2009). An azetidine SAA derivative that has been incorporated in marketed drug CE-178253, used in the treatment of obesity as a CB_1 antagonist (Brandt et al. 2009).

The L-*ribono*-azetidine amide was found to be very specifically a potent inhibitor of several β-hexosaminidases, thereby corroborating indications in literature that acid amides of iminosugars could provide a novel family of inhibitors for this class of enzymes (Glawar et al. 2013).

Outlook

As outlined in this review, SAAs are readily accessible and versatile building blocks that have been applied to the construction of both peptido- and glycomimetics and have potential as the key constituents of new drugs. To fine-tune the properties and structures of SAA-containing molecules, subtle changes may be introduced using the corresponding nitrogen or carbocyclic analogues. Following such an approach, a plethora of related molecules emerge that may be exploited, such as in the European Innovative Medicines Initiative (IMI), in the search for new biologically active compounds.

The SAAs for 3-[epoxides], 4-[oxetanes], 5-[tetrahydrofuran] and 6-[tetrahydropyran] membered rings are shown in Tables 1, 2, 3 and 4, respectively. And the corresponding nitrogen heterocycles for 3-[aziridines], 4-[azetidines], 5-[prolines] and 6-[pipecolic acids and

morpholines] membered rings are shown in Tables 5, 6, 7, and 8, whereas analogous highly functionalised carbocyclic rings—cyclopropane, cyclobutane, cyclopentane, and cyclohexane and cycloheptane are shown in Tables 9, 10, 11 and 12, respectively.

The building block structures below only provide the tip of an iceberg in what is still a little explored section of potential chemotherapeutic space; the original review has expanded from 149 references in 2005 to 902 in 2013.

Table 1 Epoxide amino acids (depicted with unprotected amino and carboxylic acid functionalities)

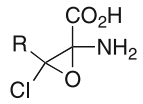
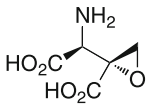
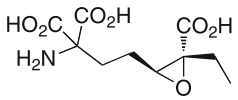
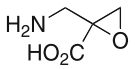
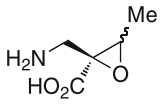
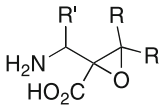
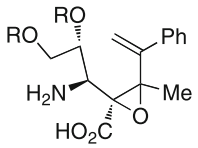
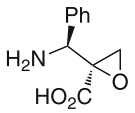
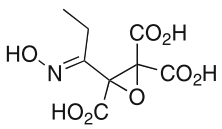
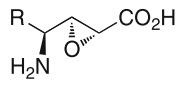
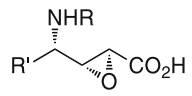
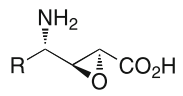
α	α,β	α,α,ε	β
			
R = Indole; Carvalho et al. (2010)	Wehbe et al. (2003)	Yoshioka et al. (1986)	Cramay et al. (1999) Cramay et al. (1998)
β	β	β	β
			
Colombani et al. (1997)	R = Me, (R,S) & (S,R), R' = Ph; R = Et, (S,R), R' = Ph; R' = Ph, R = cyclohexane, H (S,R); R = Me, H (S,R), R' = p-OMe-benzene; Luisi et al. (2003)	(S,S,S); R = Acetonide; Alcaide et al. (2007) Alcaide et al. (2004)	(S,S); Galeazzi et al. (2004)
β,γ,γ	γ	γ	γ
			
Kano et al. (2011)	R = Me, CH_2Ph, CH_2CHMe_2, CH_2O[Si]; Reetz and Lauterbach (1991)	R = CH_2OH, R' = ^{i}Bu, Bn; Yoo et al. (2005) R = H, R' = Bn; Fu et al. (2007) R = H, R' = ^{i}Pr; Yoo et al. (2005) R = H, R' = Me, CH_2Ph, CH_2CHMe_2, CH_2O[Si]; Reetz and Lauterbach (1991) R = H, R' = Bn; Ettmayer et al. (1996) R and R' = H; Limberg et al. (1999)	R = Bn; Ettmayer et al. (1996)

Table 1 continued

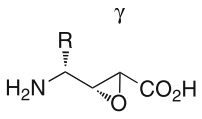
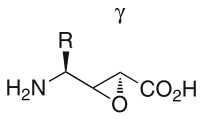
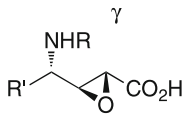
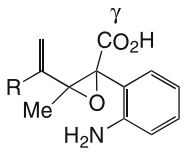
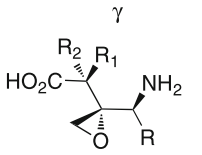
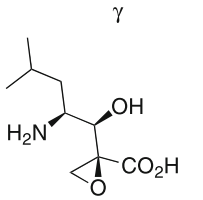
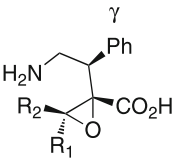
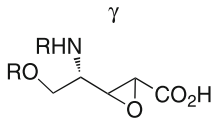
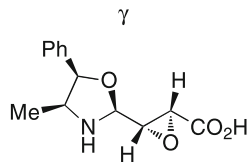
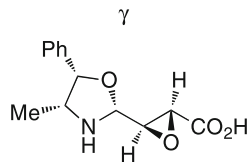
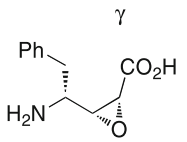
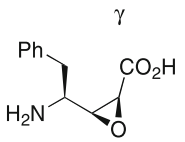
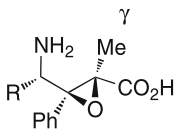
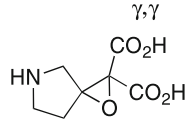
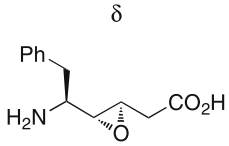
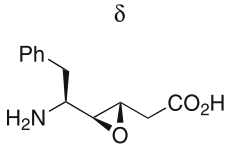
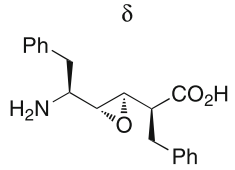
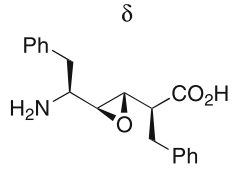
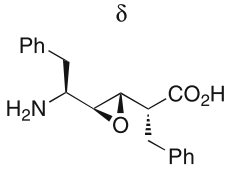
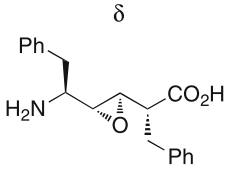
γ 	γ 	γ 	γ 
(2R), R = H; Limberg et al. (1999) Langlois and Moro (1999) Langlois (1999) R = CH_2OR'; Langlois et al. (1999) Langlois (2001)	(*syn*) and (*anti*), R = CH_2Ph; Scholz et al. (1994)	R = CH_2OH, R' = ^{i}Bu, Bn; Yoo et al. (2005) R = H, R' = Bn; Weber et al. (1995)	R = Ph; Alcaide et al. (2006)
γ 	γ 	γ 	γ 
R = Me, ^{i}Bu, Bn; R_1 and R_2 = H, Bn, Me; Concellón et al. (2002 a,b)	Iwabuchi et al. (2001)	R_1 = Ph, R_2 = Me; R_1 = H, R_2 = Ph; Alex et al. (2007)	R = Acetonide; Bösche and Nubbemeyer (1999)
γ 	γ 	γ 	γ 
Bernardi et al. (1990) Cardani et al. (1988)	Cardani et al. (1989)	R = CH_2OH; Yoo et al. (2011)	R = CH_2OH; Yoo et al. (2011)
γ 	γ,γ 	δ 	δ 
R = various aromatics and alkyl chains; Capriati et al. (2006)	R = CONH; Schultz and Sha (1980)	Wiktelius et al. (2006) Li et al. (1992) Jenmalm et al. (1994) Mixture of epoxides; Kaltenbronn et al. (1990)	Wiktelius et al. (2006)
δ 	δ 	δ 	δ 
Wiktelius et al. (2006)	Wiktelius et al. (2006)	Wiktelius et al. (2006) Jensen and Luthman (1998)	Wiktelius et al. (2006) Jensen and Luthman (1998)

Table 1 continued

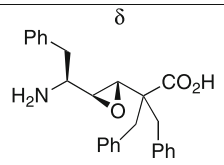
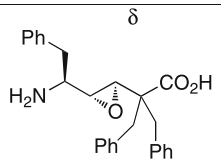
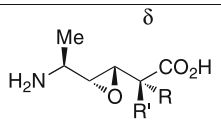
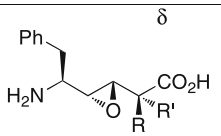
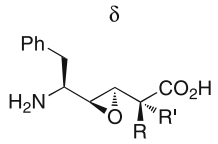
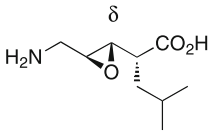
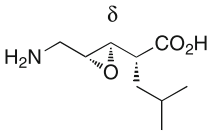
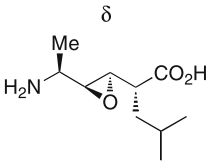
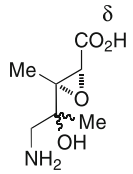
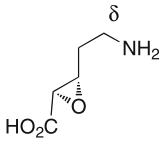
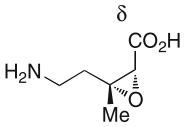
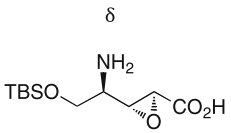
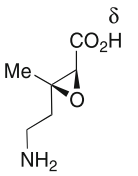
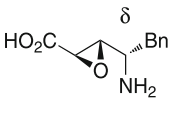
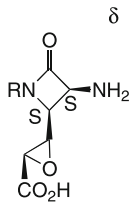
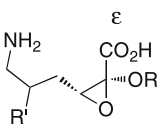
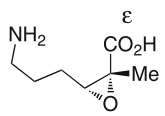
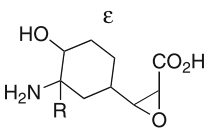
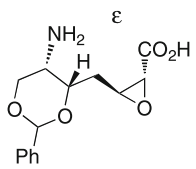
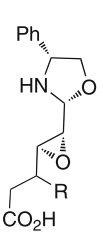
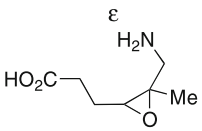
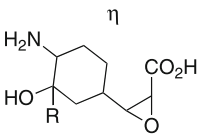
δ 	δ 	δ 	δ 
Wiktelius et al. (2006)	Wiktelius et al. (2006)	R and R' = Me; R = H, R' = $CH_2CH(CH_3)_2$; Mann et al. (1996)	R and R' = H, Bn; R = H, R' = Bn; R = Bn, R' = H; Jenmalm et al. (1994)
δ 	δ 	δ 	δ 
R and R' = H, Bn; R = H, R' = Bn; R = Bn, R' = H; Jenmalm et al. (1994)	Tomita et al. (2008)	Tomita et al. (2008)	Mann et al. (1996)
δ 	δ 	δ 	δ 
Tyvorskii et al. (1985) Stanishevskii et al. (1973) Zakharevskii et al. (1977)	Sinha et al. (2005)	Shen et al. (2003)	Kim et al. (2008)
δ 	δ 	δ 	ε 
(+) and (-); Shen et al. (2003)	Degel et al. (2008)	R = $CH_2CO_2C(CH_3)_3$; Frazier et al. (1992)	R = TES; R' = Ph; Boyce and Johnson (2010)
ε 	ε 	ε 	ε 
Wang et al. (2003)	R = Me, H; Mukhamedova et al. (1982 a,b)	Pandey et al. (2004)	R = CH_2OTBS, CH_2OBn; Agami et al. (2000) Agami et al. (2002)
ε 	η 		
Tamura et al. (1987)	R = Me, H; Mukhamedova et al. (1982 a,b)		

Table 2 Oxetane amino acids (depicted with unprotected amino and carboxylic acid functionalities)

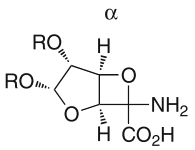
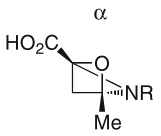
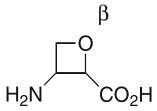
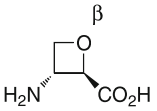
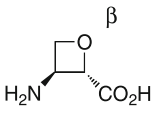
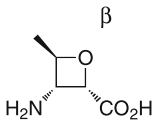
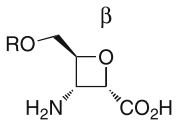
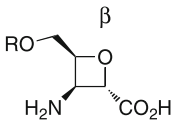
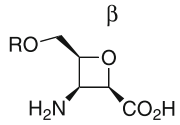
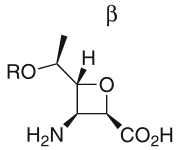
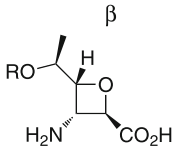
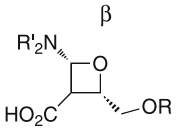
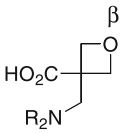
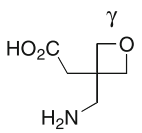
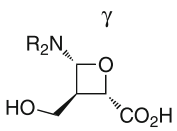
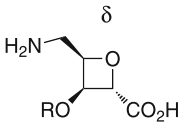
α 	α 	β 	β 
R = Acetonide; Choi et al. (1991)	R = allyl; Pirrung (1980)	(R,S) & (S,R); Kawahata et al. (1986) (+) & (-); Bach and Schröder (1997)	Kawahata et al. (1986)
β 	β 	β 	β 
Kawahata et al. (1986) Blauwelt and Howell (2008)	Jenkinson et al. (2004)	R = TBDMS, Bn; Claridge et al. (2001) Jenkinson et al. (2004) R = Bn; Barker et al. (2001) R = TBDPS; Elliott et al. (1990) R = TBDMS, Tr; Wang et al. (1991)	R = TBDMS, Bn; Jenkinson et al. (2004) R = Bn; Barker et al. (2001)
β 	β 	β 	β 
R = TBDMS; Wang et al. (1991)	R = TBDMS, Bn; Barker et al. (2001) R = TBDMS, Bn; Claridge et al. (2001) R = TBDMS, Bn; Johnson et al. (2004 a)	R = Bn; Barker et al. (2001) R = Bn; Johnson et al. (2004 a)	R'_2 = pyrimidines, purine (A); R = H, TBDMS; Norbeck and Kramer (1988)
β 	γ 	γ 	δ 
R_2 = thymine analogue; Kai et al. (2012)	Wuitschik et al. (2010)	R = purines; Nishii et al. (1992)	R = TBDMS, H; Johnson et al. (2004 a), (2005 a,b), Lucas et al. (2006), R = Me, Lucas et al. (2008)

Table 2 continued

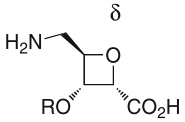
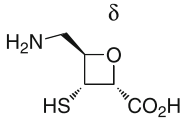
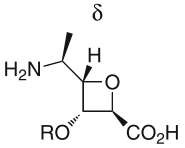
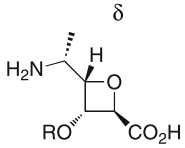
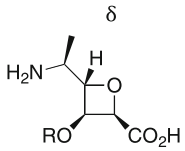
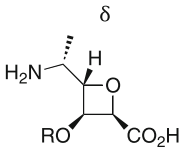
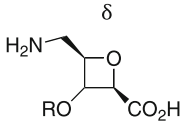
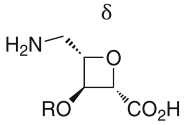
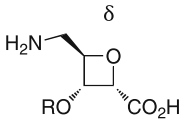
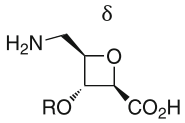
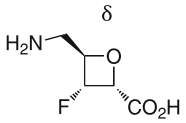
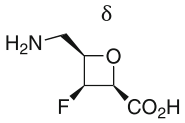
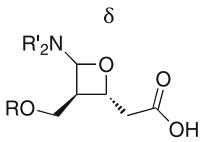
 R = TBDMS, H; Johnson et al. (2004)	 Sakya et al. (1997)	 R = TBDMS, H; Johnson et al. (2004a), (2005a,b) Fleet et al. (2006)	 R = TBDMS, H; Johnson et al. (2004a), (2005a,b) Fleet et al. (2006)
 R = TBDMS, H; Johnson et al. (2004a), (2005a,b)	 R = TBDMS, H; Johnson et al. (2004a), (2005a,b)	 R = OMe; Lucas et al. (2008), (2011)	 R = Bn; Lopez-Ortega et al. (2008)
 R = OMe; Lucas et al. (2008), (2011)	 R = Bn; Knijnenburg et al. (2011)	 Lucas et al. (2009), (2011)	 Lucas et al. (2009), (2011)
 (R/S); R'$_2$ = adenine; R = C=OPh; Vorbrueggen and Ruh-Pohlenz (1999)			

Table 3 Furanoid amino acids (depicted with unprotected amino and carboxylic acid functionalities)

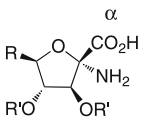
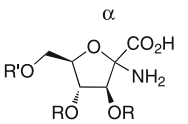
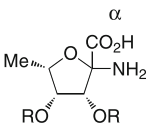
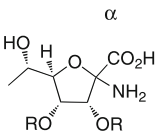
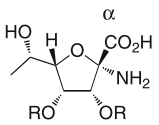
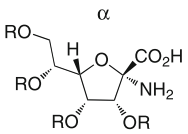
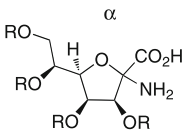
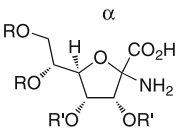
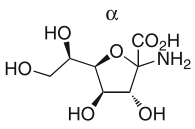
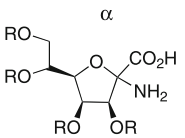
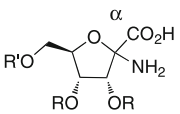
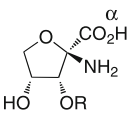
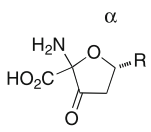
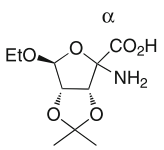
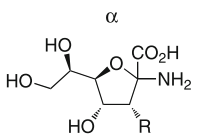
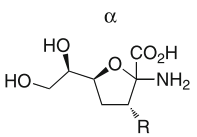
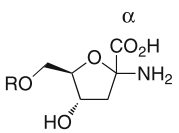
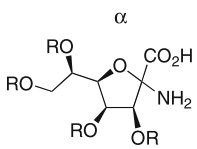
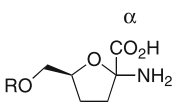
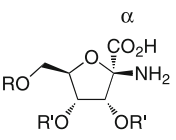
 R = H, CH_2OR^2; R' = acetonide; Lakhrissi and Chapleur (1998)	 R = Ac, R' = Trt; Schmidt et al.(2005) R and R' = TBDMS, H; Long et al. (2002)	 R = Acetonide, H; Bleriót et al. (2006) Watkin et al. (2004)	 (α/β); R = Acetonide; Estevez et al. (1996a)
 R = Acetonide, H; Estevez et al. (1996a,b)	 R = Acetonide; Lakhrissi and Chapleur (1998)	 (α/β); R = Acetonide, H; Estevez et al. (1998) (α); R = Acetonide; Lakhrissi and Chapleur (1998) (α/β); R = Acetonide; Dondoni et al. (1994)	 (α/β); R = Acetonide, R' = TBDMS; Brandstetter et al. (1996)
 Brandstetter et al. (1995)	 R = Acetonide; Fuentes et al. (2006)	 R = acetonide, R' = Bz; R and R' = H; Fuentes et al. (2006) R = acetonide, R' = Bz, PMB; R and R' = H; Shiokazi et al. (2002) R = acetonide, R' = Bz; Gasch et al. (2001) R = acetonide, R' = TBDMS; Farber et al. (2012)	 R = TBDMS, H; Soengas et al. (2003a)
 (α/β); R = Me, Ph; Padwa et al. (1997), (1999)	 (α/β); Reissig et al. (2007)	 R = H, SePh; Agasimundin et al. (1998)	 R = H, SePh; Agasimundin et al. (1998)
 R = Bn, H, trityl; Renard et al. (1998), (2000)	 R = Acetonide, H; Estevez et al. (1998), (1994a,b)	 (α and β); R = TBDMS; Paquette et al. (1999)	 R = TBDMS, R' = Ac; Paquette et al. (1999)

Table 3 continued

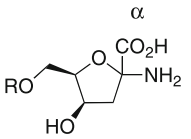
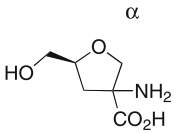
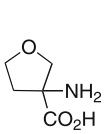
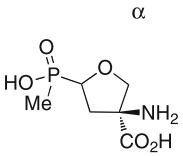
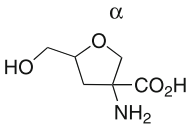
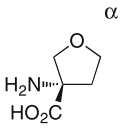
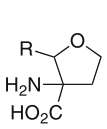
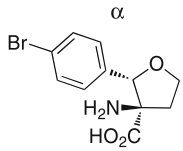
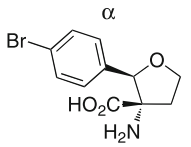
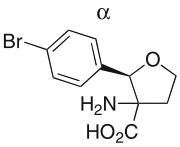
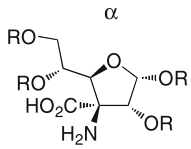
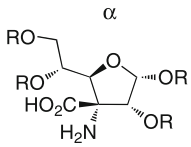
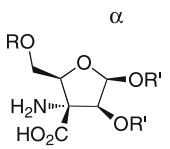
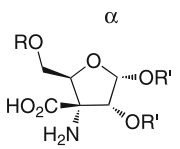
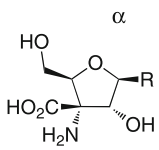
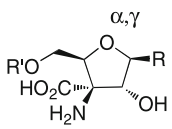
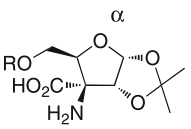
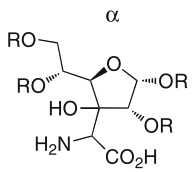
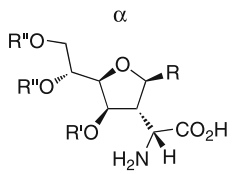
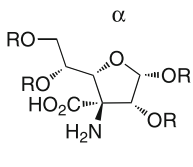
α 	α 	α 	α 
R = Bn, H; Renard et al. (1998)	Yoshimura et al. (1979), (1981), (1982)	Walker et al. (1989) Lavrador et al. (1998) Stamm et al. (2003)	Johnson et al. (1990)
α 	α 	α 	α 
Yoshimura et al. (1981)	Moriyama et al. (2008)	R = Aromatics or aliphatics; Grauer et al. (2009a) Maity et al. (2007)	Grauer et al. (2009 a,b) Grauer and König (2009 a,b) Maity et al. (2007)
α 	α 	α 	α 
Grauer and König (2009 a,b) Maity et al. (2007)	Grauer and König (2009b) Maity et al. (2007)	R = Acetonide; Gonda et al. (2006) Scaffidi et al. (2006), (2007) Forman et al. (2004) Gasch et al. (2009), (2010)	R = Acetonide; Scaffidi et al. (2004 a,b) Forman et al. (2004) Van Nhien et al. (2002)
α 	α 	α 	α,γ 
R = PMP, TBDMS, R' = acetonide; Sørensen et al. (2001)	R = H, Bz, R' = acetonide; Yanagisawa et al. (1970)	R = nucleobase; Yanagisawa et al. (1970)	R = NH_2, nucleobase, R' = Bn; Scaffidi et al. (2004a)
α 	α 	α 	α 
R = TBDMS; Martinková et al. (2006) R = Bn; Scaffidi et al. (2004a)	R = acetonide; Rosenthal and Cliff (1980)	R = nucleobase, R' = Bn, R'' = acetonide; Haveli et al. (2009)	R = Cyclohexylidene; Scaffidi et al. (2004 a,b) Forman et al. (2004)

Table 3 continued

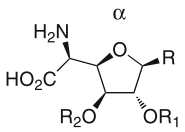
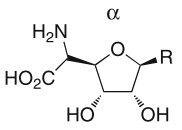
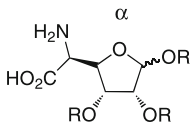
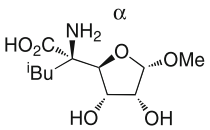
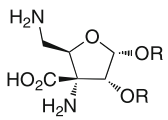
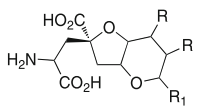
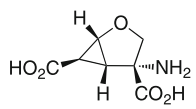
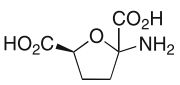
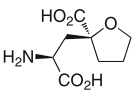
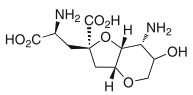
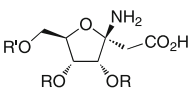
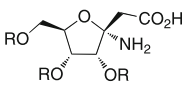
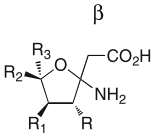
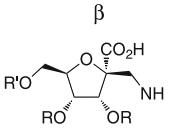
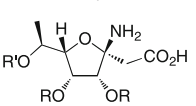
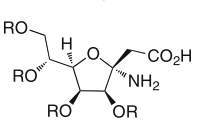
α 	α 	α 	α 
R = O-Acetonide, R_1 = acetonide, R_2 = Bn; R = OH, R_1 = H, R_2 = Bn; R = nucleobase, R_1 = Ac, R_2 = Bn; Gonda et al. (2011)	R = nucleobase; Uramoto et al. (1982) Boehm and Kingsbury (1986) Auberson and Vogel (1990) Barrett and Lebold (1990) Chida et al. (1994) Evina and Guillerm (1996) Dondoni et al. (1997) Chen et al. (1999)	R = Ac; Auberson and Vogel (1990) Chida et al. (1994) Dondoni et al. (1997) Chen et al. (1999)	Scaffidi et al. (2004a)
α,γ 	α,γ 	α,γ 	α,γ 
R = Acetonide; Ducatel et al. (2006)	R = H, OH; R_1 = H, CH_2OH; Cohen and Chamberlin (2007) Takahashi et al. (2006), (2007) Shoji et al. (2005), (2006) Sasaki et al. (1999), (2006), (2007) Snider and Hawryluk (2005) Sakai et al. (2001) Phillips and Chamberlin (2002) Further derivatives are available, e.g. Huang et al. (2003)	Wheeler et al. (2005) Imre (2007) Monn et al. (1999), (2007)	Pepper et al. (2002)
α,γ 	α,γ,δ 	β 	β 
Cohen et al. (2007)	Sasaki et al. (2008) Masaki et al. (2000)	R = Acetonide; R' = OMe; Taillefumier et al. (2002), (2004)	Taillefumier et al. (2004)
β 	β 	β 	β 
R = Me, aromatics, R_1 = H, alkyl, R_2 = H, alkyl, R_3 = H, alkyl; Sukhorukov et al. (2008)	R = Acetonide, R' = Bn; R and R' = H; Sano et al. (1994)	R = Acetonide; R' = OMe; Taillefumier et al. (2002)	R = Acetonide; Taillefumier et al. (2002), (2004) Enderlin et al. (2009)

Table 3 continued

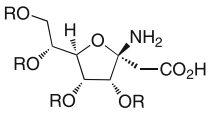
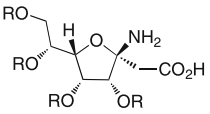
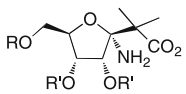
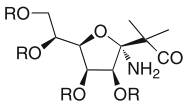
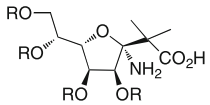
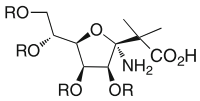
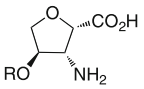
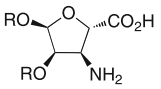
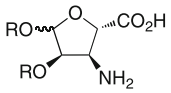
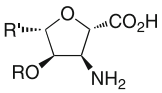
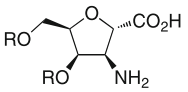
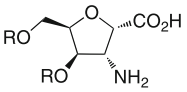
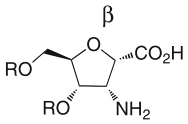
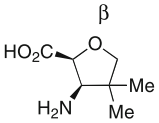
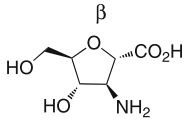
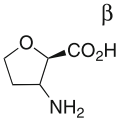
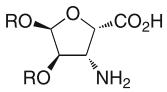
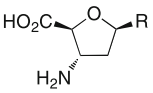
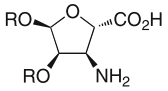
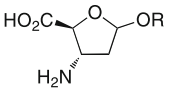
β  R = Acetonide; Taillefumier et al. (2002), (2004)	β  R = Acetonide; Taillefumier et al. (2002), (2004) Enderlin et al. (2009)	β  R = Bn; R' = acetonide; Soengas et al. (2010)	β  R = Acetonide; Soengas et al. (2010)
β  R = Acetonide; Soengas et al. (2010)	β  R = Acetonide; Soengas et al. (2010)	β  R = TBDPS; Sanjayan et al. (2003) Edwards et al. (2006a)	β  R = Acetonide; Gruner et al. (2001), (2002b) McDevitt and Lansbury (1996) R = Acetonide, Ac; Yamashita et al. (1984a,b) Van Rompaey et al. (2005) DeNinno et al. (2003)
β  R = Ac; Van Rompaey et al. (2005)	β  R = Ac, R = nucleobase derivatives; Van Rompaey et al. (2005)	β  R = H; Watterson et al. (1999)	β  R = H; Watterson et al. (1999)
β  R = H; Watterson et al. (1999) R = Ac; Vera-Ayoso et al. (2005) Franconetti et al. (2013)	β  Leemans et al. (2010)	β  Watterson et al. (1999)	β  Pandey et al. (2011)
β  R = Acetonide; Jagannadh et al. (2006) Ghorai et al. (2011) Chandrasekhar et al. (2007), (2009) Jagadeesh et al. (2007), (2009)	β  R = nucleobase; Chandrasekhar et al. (2008) (2010) Gogoi and Kumar (2008), Threlfall et al. (2006), (2008a,b) Efimov et al. (1998) Ghorai et al. (2010),	β  R = Acetonide;(α/β)R = Ac; Gao et al. (2006) Weber et al. (1986)	β  R = Me; Weber et al. (1986) Williams et al. (1985) Williams and Mosher (1985)

Table 3 continued

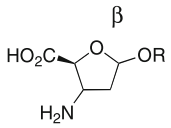
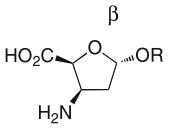
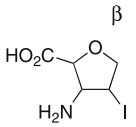
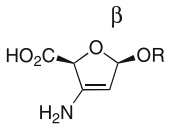
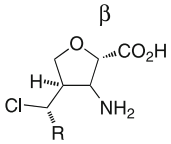
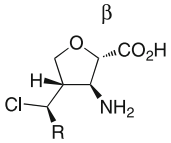
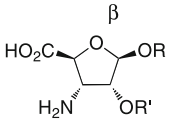
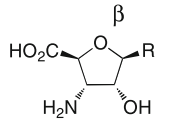
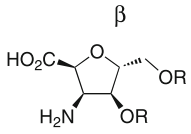
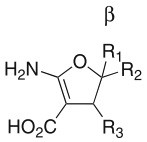
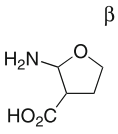
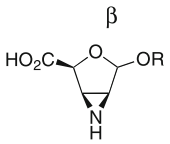
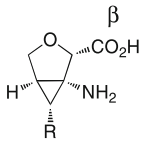
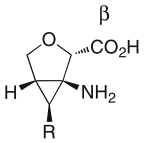
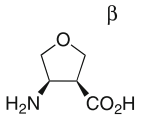
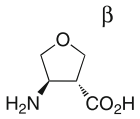
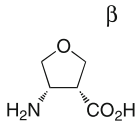
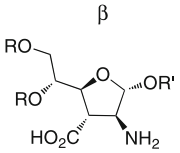
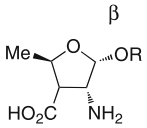
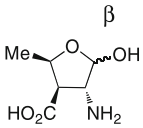
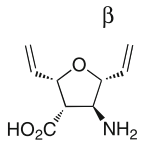
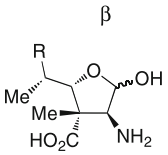
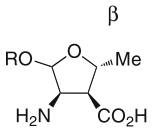
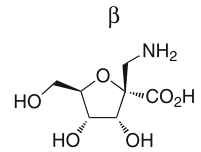
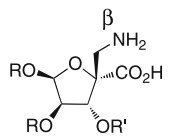
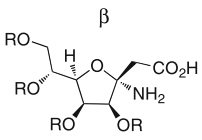
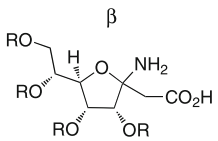
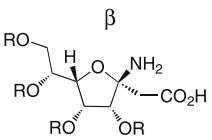
β  R = Me; Cheng et al. (1991)	β  Williams et al. (1985)	β  Burkhart et al. (1984)	β  R = Me; Weber et al. (1986)
β  R = H, Me; Jahn et al. (2012)	β  R = H, Me; Jahn et al. (2012)	β  R = Me; R' = H, Ac, Ms; Weber et al. (1986)	β  R = nucleobase derivatives; DeNinno et al. (2006) Gao et al. (2006) Komori et al. (1985) Yamashita et al. (1984 a,b)
β  R = Ac; Franconetti et al. (2010)	β  R_1, R_2, R_3 = H and/or alkyl; Wanhoff et al. (1983)	β  Wamhoff et al. (1970)	β  R = H, TBDMS; Dauban et al. (1996), (1999)
β  R = H, Me; Jahn et al. (2012)	β  R = H, Me; Jahn et al. (2012)	β  Wipf and Manojlovic (2011) Bunnage et al. (2004) Hanselmann et al. (2003) Mittendorf et al. (2003)	β  Ganji et al. (2011) Bunnage et al. (2004)
β  Ott et al. (2008 a,b)	β  R = Acetonide, R' = Me; Shiokazi et al. (1989)	β  R = Me; Tatsuta et al. (2000)	β  Tatsuta et al. (2000)
β  Winkler et al. (2004)	β  R = alkyl; Williams et al. (1999)	β  R = Bn; Shiozaki and Sato (1988)	β  Sano et al. (1994)
β  R = Acetonide, R' = Me; Sharma et al. (2011b)	β  R = Acetonide; Taillefumier et al. (2004) Andreini et al. (2009)	β  Taillefumier et al. (2004)	β  R = Acetonide; Taillefumier et al. (2004)

Table 3 continued

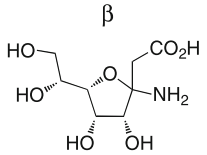
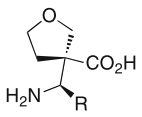
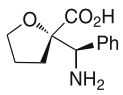
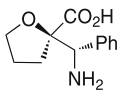
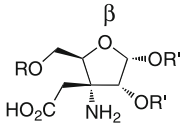
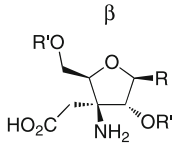
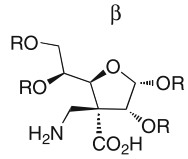
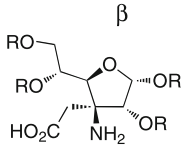
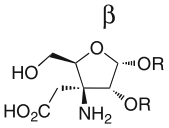
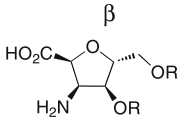
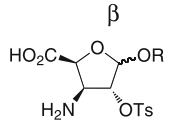
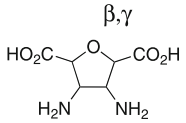
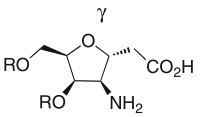
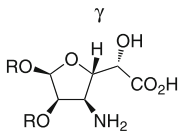
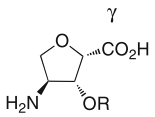
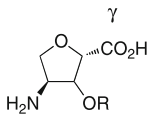
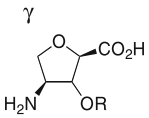
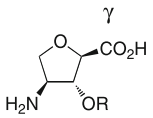
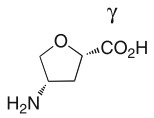
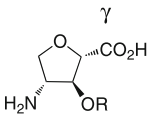
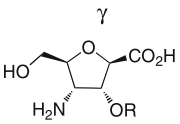
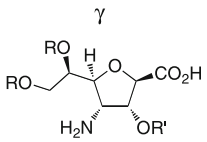
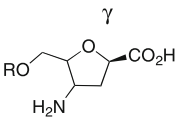
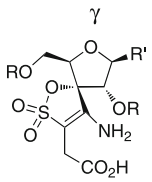
β  Taillefumier et al. (2004)	β  R = Aromatics; Alonso et al. (2002)	β  Alonso et al. (2002)	β  Alonso et al. (2002)
β  R = TMBDS, R' = acetonide; Tronchet et al. (2006)	β  R = nucleobase, R' = TMBDS; Tronchet et al. (2006)	β  R = Acetonide; Gasch et al. (2009)	β  R = Acetonide; Rosenthal and Ratcliffe (1978)
β  R = Acetonide; Rosenthal and Ratcliffe (1978)	β  R = OAc; Vera-Ayoso et al. (2010)	β  R = H, TBDMS, Me; Dauban et al. (1996), (1999)	β,γ  Traube and Lazar (1913)
γ  R = Acetonide; McDevitt and Lansbury (1996)	γ  R= Acetonide; Gruner et al. (2002b)	γ  R = H; Sanjayan et al. (2003) R = TES, H; Edwards et al. (2006a,b) R = Bn; Rao et al. (2010)	γ  (R) and (S), R = Bn; Reddy et al. (2008)
γ  (R) and (S), R = Bn; Reddy et al. (2008)	γ  R = Bn; Reiriz et al. (2009) R = Bn; Rao et al. (2010)	γ  Walker et al. (2011)	γ  R = TBDPS, H; Edwards et al. (2006a,b) Sanjayan et al. (2003)
γ  R = TBDMS; Hungerford and Fleet (2000)	γ  R = Acetonide, R' = TBDMS; Hungerford and Fleet (2000)	γ  R = TBDPS, TBDMS, H; All isomers; Watterson et al. (2003) Edwards et al. (2004)	γ  R = TBDMS, R' = nucleobase; Lobatón et al. (1999)

Table 3 continued

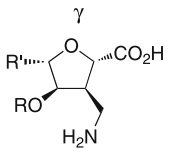
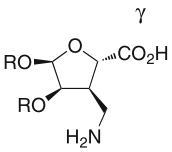
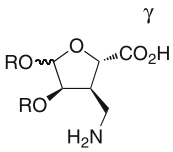
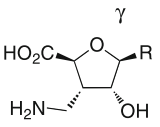
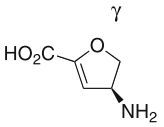
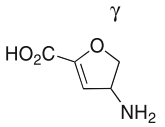
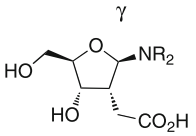
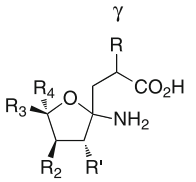
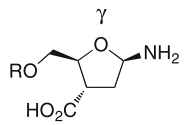
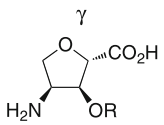
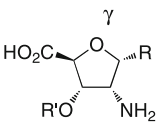
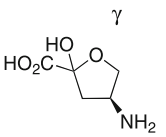
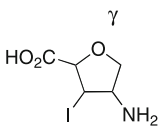
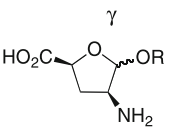
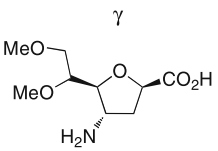
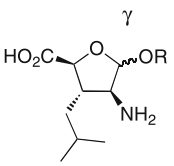
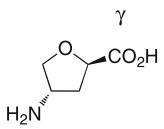
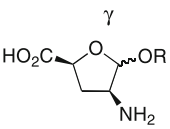
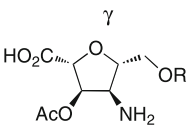
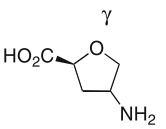
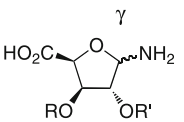
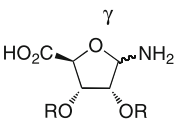
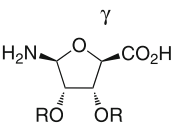
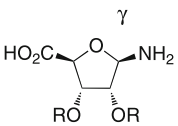
 R = Ac, R' = nucleobase derivatives; Van Rompaey et al. (2005)	 R = Acetonide; Van Rompaey et al. (2005)	 R = Ac; Van Rompaey et al. (2005)	 R = nucleobase; Gao et al. (2006)
 Burkhart et al. (1984)	 Burkhart et al. (1984)	 R_2 = uracil; Lawrence et al. (1997)	 R_1 = Me, Ar; R_2 = H, alkyl; R_3 = alkyl; R_4 = H, alkyl; R = alkyl; Sukhorukov et al. (2008)
 R = TBDPS; De Mesmaeker et al. (1994)	 R = H, TBDMS, 4-Nitrobenzophosphonate; Wentworth et al. (1998)	 R = $CH(OMe)_2$, R = H, Bn; Vera-Ayoso et al. (2005)	 Burkhart et al. (1984)
 Burkhart et al. (1984)	 R = H, Ac; Yoshimura (1981)	 Jeanneret et al. (1992)	 R = alkyl; Hanessian et al. (2000)
 Woods et al. (2002)	 R = Ac, H; Iwakawa et al. (1982) Yoshimura et al. (1981)	 R = 4-Nitrobenzoate; El Khadem et al. (1975)	 Allan and Tran (1984)
 R = Bn, R' = Bz; Boyer et al. (1995)	 R = Ac, acetonide; Schmidt et al. (1978)	 R = Acetonide; Schmidt and Lieberknecht (1978)	 R = Acetonide; Schmidt and Lieberknecht (1978)

Table 3 continued

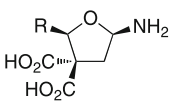
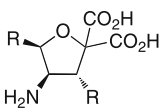
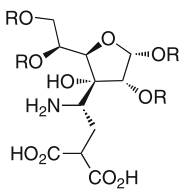
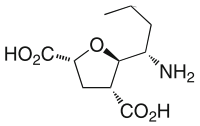
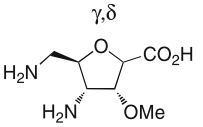
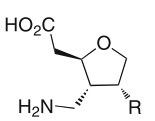
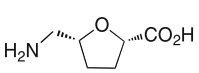
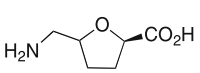
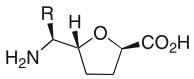
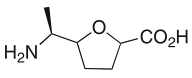
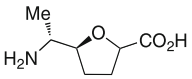
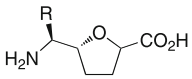
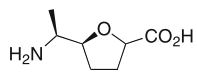
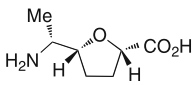
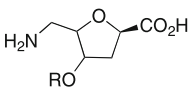
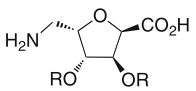
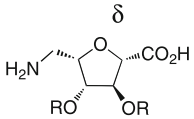
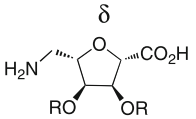
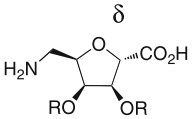
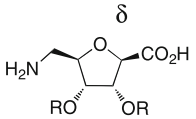
γ 	γ,γ 	γ,γ 	γ,δ 
R = alkyl, Ar; Benfatti et al. (2012)	R = Ar; Nair et al. (2004)	Maeda et al. (1996)	Wang et al. (2005)
γ,δ 	δ 	δ 	δ 
Chakraboty et al. (2008a)	R = Bn, alkyl; Enders et al. (2010)	Chakraborty et al. (2004b) Prasad et al. (2005) Walker et al. (2011)	Both isomers; Chakraborty et al. (2000a) (S); Chakraborty et al. (2004b) Prasad et al. (2005)
δ 	δ 	δ 	δ 
R = Me, Bn, $CHMe_2$, CH_2OR'; Chakraborty and Sudhakar (2005a)	All isomers; Chakraborty and Sudhakar (2005b)	(R,S) & (S,S); Chakraborty and Sudhakar (2005b)	(R/S), R = $(CH_2)_3NH_2$, R = $(CH_2)_3NHC{=}NHNH_2$; Osterkamp et al. (2000)
δ 	δ 	δ 	δ 
(R/S); Osterkamp et al. (2000) Schrey et al. (1999)	Vescovi et al. (2003)	All isomers; R = H; Watterson et al. (2003) (R,R); R = OH; Watkin et al. (2006) (S,S); R = TES; Edwards et al. (2006c)	R = Bn; Chakraborty et al. (2000a)
δ 	δ 	δ 	δ 
R = Bn, H; Gravier-Pelletier (1996)	R = Acetonide, H; Long et al. (1999) Hungerford et al. (2000)	R = Acetonide, H; Long et al. (1999) Hungerford et al. (2000) R = Acetonide; Claridge et al. (1999)	R = Acetonide, H; Long et al. (1999) R = Cyclohexylidene, acetonide, H; Hungerford et al. (2000) Claridge et al. (1999)

Table 3 continued

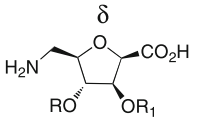
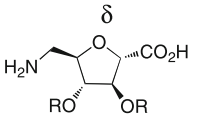
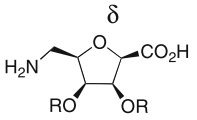
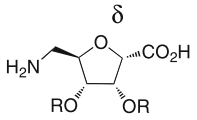
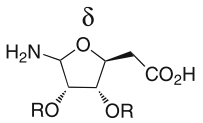
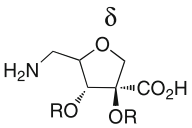
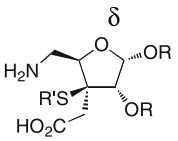
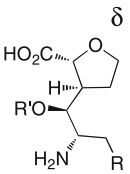
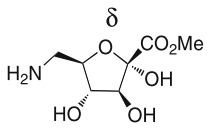
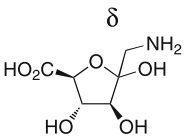
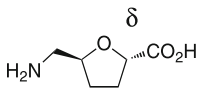
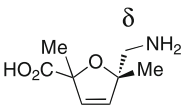
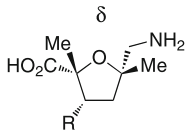
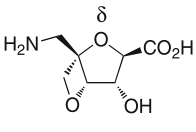
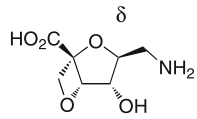
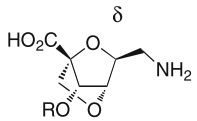
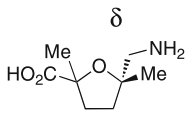
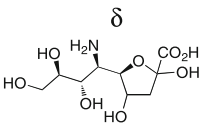
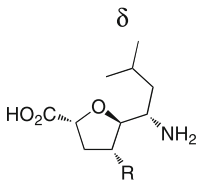
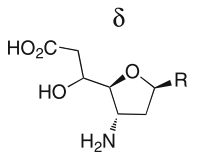
			
R and R_1 = Bn, H; Chakraborty et al. (1998), (2002d) Grotenbreg et al. (2004a) R = Aryl; R_1 = H; Grotenbreg et al. (2006) R and R_1 = Ac, H; Smith et al. (1999), (1998c) Long et al. (1998), (2002) Jockusch et al. (2006)	R = Bn, Chakraborty et al. (2000a,b) R = Ac, H; Smith et al. (1999) R = H; Long et al. (2002)	R = Acetonide, H; Brittain et al. (2000)	R = Cyclohexylidene, acetonide; Hungerford et al. (2000)
			
(R) and (S); R = Acetonide; Van Well et al. (2003e)	(R) and (S); R = TBDMS, Bn, Me, H; Simone et al. (2005), (2008), (2010a,b), (2011) Punzo et al. (2005), (2006)	R = Acetonide, R' = cyclohexyl; McDevitt and Lansbury (1996)	R = $CH(CH_3)_2$, R' = TBDMS, H; Hanessian and Brassard (2004) Hanessian et al. (2005a)
			
Schmidt et al. (2005)	α and β; Funcke (1978)	Uhrig et al. (2010)	McCulloch et al. (1981)
			
R = Furan derivatives; McCulloch et al. (1981)	Van Well et al.(2003d)	Van Well et al.(2003d)	R = Bn, Verhagen et al. (2006)
			
McCulloch et al. (1981)	(α/β); (R) and (S); Yamamoto et al. (1992)	R = Imidazole; Wang et al. (2005)	(R,S), R = thymine; Wang and Stoisavljevic (2000)

Table 3 continued

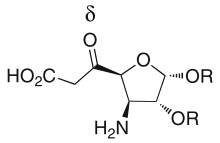
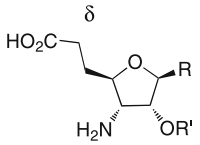
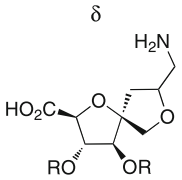
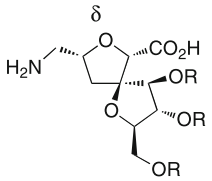
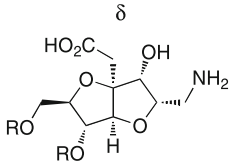
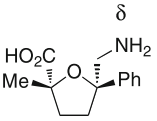
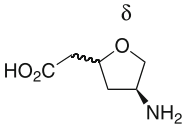
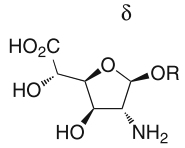
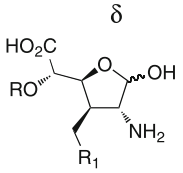
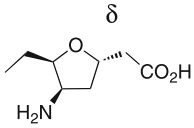
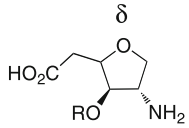
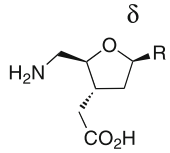
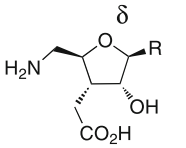
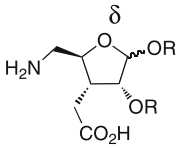
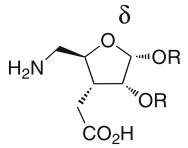
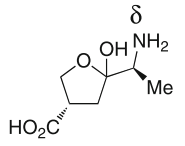
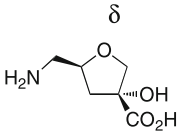
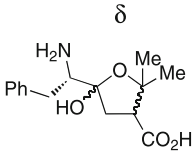
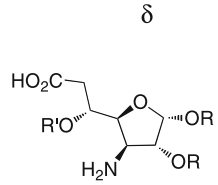
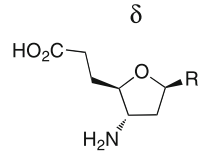
			
R = Acetonide; Vyavahare et al. (2007)	R = O-Acetonide, R' = acetonide; R = nucleobase, R' = Ac, H; Chakraborty et al. (2008b)	(R) and (S), R = Bn; Cipolla et al. (2002a)	R = Bn; Cipolla et al. (2002a)
			
R = Bn; Cipolla et al. (2002a)	Wu et al. (2003)	Bergmeier et al. (1999)	R = Me; Furneaux et al. (1993)
			
R_1 = H, TIPS; Pasquarello et al. (1999)	Bedford et al. (1999)	(R,S); R = Bn, Rao et al. (2010)	R = nucleobase; von Matt et al. (1999)
			
R = nucleobase; Lu et al. (1999) Peterson et al. (2009) Tanui et al. (2010) Iwase et al. (2006) Robins et al. (2000) Rozners and Liu (2003)	R = Ac; Robins et al. (2000)	R = Acetonide; Robins et al. (2000)	Lin et al. (2009)
			
Defant et al. (2011)	Lindsay and Skrydstrup (2006)	R = Acetonide, R' = Ac; Reckendorf (1968)	R = nucleobase; Tanaka et al. (1989) Fujii et al. (1997)

Table 3 continued

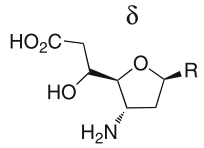
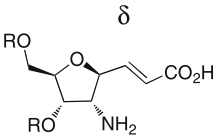
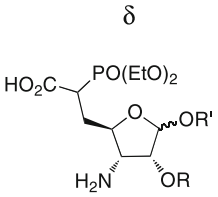
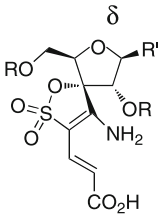
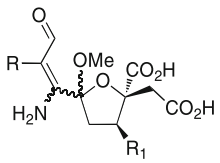
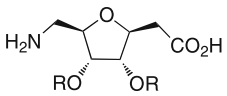
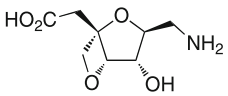
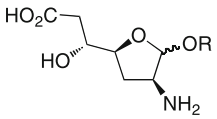
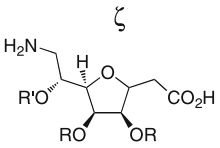
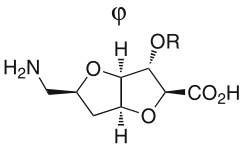
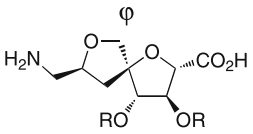
δ 	δ 	δ 	δ 
(R) and (S); Wang (1999)	R = Bz; Popsavin et al. (2000)	R = acetonide, R' = Bn; Shie et al. (2007)	R = TBDMS, R' = nucleobase; Lobatón et al. (1999)
δ,ε 	ε 	ε 	ε 
R = alkyl, R_1 = furan; Schmitt et al. (2011)	R = Ac; McDevitt and Lansbury (1996) van Well et al. (2003a,b,c) R = Acetonide, H; Grotenbreg et al. (2004b)	Van Well et al.(2003d)	R = Me; de Guchteneere et al. (1992)
ζ 	φ 	φ 	
(R/S); R = Acetonide, R' = Ms; McDevitt and Lansbury (1996)	R = Bn; Peri et al. (2000)	(R) & (S); Peri et al. (2000) Cipolla et al. (2002a)	

Table 4 Pyranoid amino acids (depicted with unprotected amino and carboxylic acid functionalities)

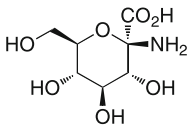
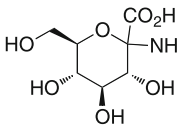
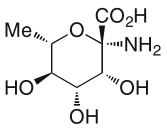
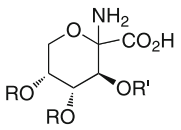
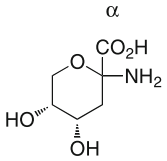
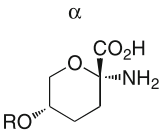
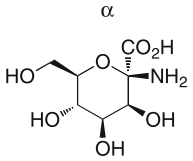
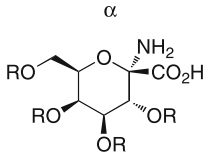
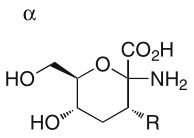
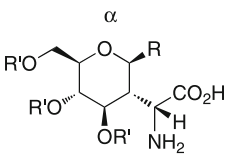
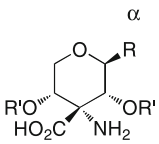
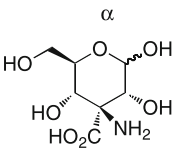
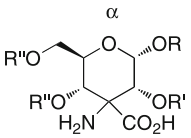
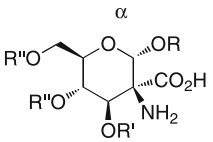
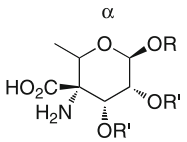
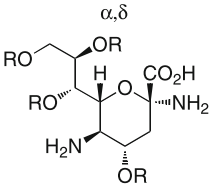
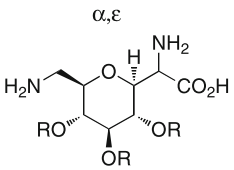
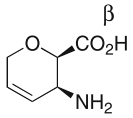
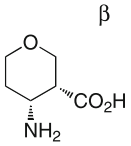
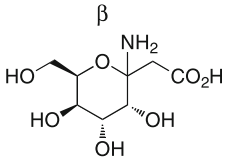
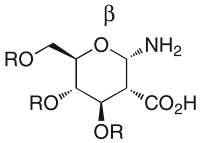
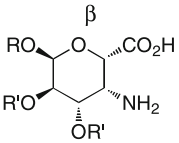
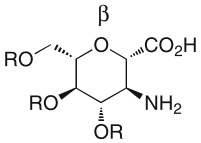
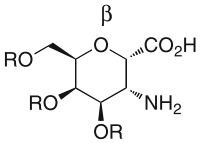
α  Somsák and Nagy (2000) Somsak et al. (2000) Gyémánt et al . (2003)	α  Bichard et al. (1995) Gregoriou et al. (1998) Ósz et al. (1999)	α  Estevez et al. (1996c)	α  R = Acetonide, R' = Bz; Gasch et al. (2001) R = Acetonide, R' = Bz; R and R' = H; Fuentes et al. (2006)
α  Renard et al. (1998),	α  R = TBDMS; Paquette et al. (1999)	α  Estevez et al. (1995) Long et al. (2001)	α  R = Bn; Dondoni et al. (1994)
α  R = SePh; Agasimundin et al. (1998)	α  R = nucleobase, R' = Bn; Haveli et al. (2009)	α  R = OMe, nucleobase, R' = H, Bz; Yanagisawa et al. (1970)	α  Gasch et al. (2010)
α  R = OMe, R' = Bn, R'' = acetonide; Scaffidi et al. (2004a) Forman et al. (2004)	α  R = OMe, R' = Bn, R'' = acetonide; Scaffidi et al. (2004 a,b) Forman et al. (2004)	α  (R) & (S); R = Me, R' = acetonide; Kóóš et al. (2000)	α,δ  R = Ac; Sabesan et al. (1997)
α,ε  (R) & (S); Zhang et al. (2007)	β  Mittendorf et al. (2003)	β  Ott et al. (2008)	β  Taillefumier et al. (2004)
β  R = Ac, Bn; Mostowicz and Chmielewski (1994)	β  R = Me, R' = Bn; Vogel and Gries (1994)	β  R = H; Lohof et al. (2000)	β  R = Bn; Burkhart and Kessler (1998)

Table 4 continued

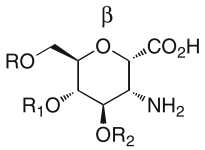
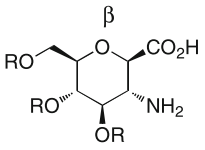
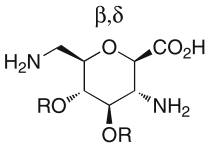
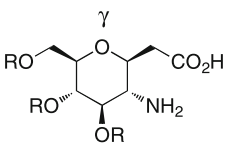
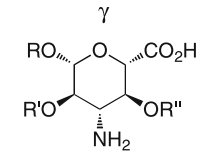
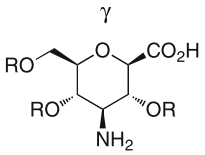
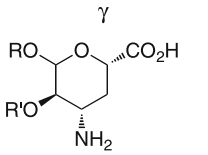
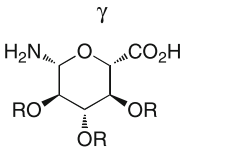
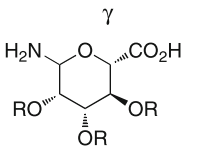
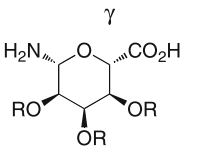
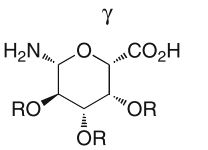
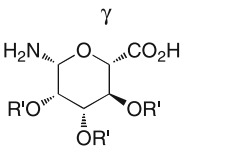
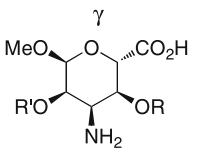
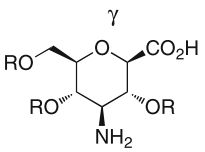
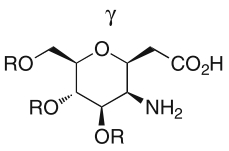
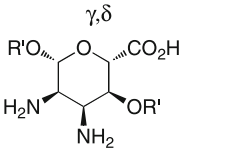
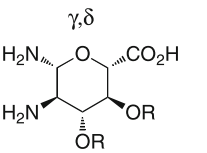
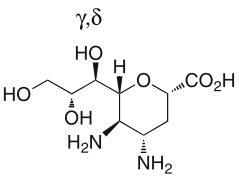
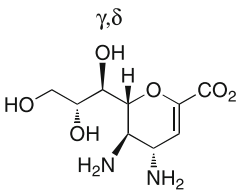
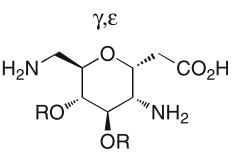
β 	β 	β,δ 	γ 
R and R_1 = Acetonide, R_2 = H; R and R_1 = acetonide, R_2 = lipid chains; R and R_1 = H, R_2 = lipid chains; R = CO_2Bn, R_1 = H, R_2 = lipid chains; R = CO_2Bn, R_1 = $P(O)(OPh)_2$, R_2 = lipid chains; R = H, R_1 = $P(O)(OPh)_2$, R_2 = lipid chains; Shiozaki et al. (1996)	R = H; Kessler et al. (1995) R = Bn, H; Hoffman et al. (1996)	R = MOM, H; Sicherl and Wittmann (2005) R' = H; Grotenbreg et al. (2004 b)	R = Bn; Von Roedern et al. (1996) R = Ac, H; Suhara et al. (1996 b) Sicherl and Wittmann (2005) R' = H; Grotenbreg et al. (2004 b) R = Ac; Kim and Hollingsworth (1994)
γ 	γ 	γ 	γ 
R = Me, R' = Ac, R" = H; R = Me, R' = Ac, R" = $CONH^iPr$; R = Me, R' = H, R" = $CONH^iPr$; Sofia et al. (1998)	R = Bn, H; Suhara et al. (2002)	R = Me, H; R' = Bz, H; Sakata et al. (1974)	R = Ac; Nitta et al. (1961) Györgydeák and Thiem (1995) R = Ac, H; Drouillat et al. (1997) R = Bn, Ac, H; Timmers et al. (1997) R = Ac; Von Roedern et al. (1996)
γ 	γ 	γ 	γ 
R = Ac; Györgydeák and Thiem (1995)	R = Ac; Györgydeák and Thiem (1995)	R = Ac; Györgydeák and Thiem (1995)	Revelskaya et al. (1973)
γ 	γ 	γ 	γ,δ 
R = H, R' = Bz; R, R' = H, Ac; Franconetti et al. (2010), (2013)	R = Bn, H; Suhara et al. (2002)	R = Ac, H; Sugiyama et al. (1991)	Hedenetz et al. (2000)
γ,δ 	γ,δ 	γ,δ 	γ,ε 
R = Ac; Györgydeák and Thiem (1995)	Chandler et al. (1995)	Chandler et al. (1995)	R = Bn; Xie (2003)

Table 4 continued

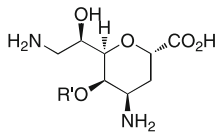
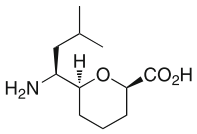
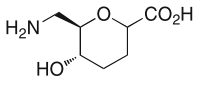
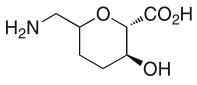
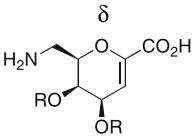
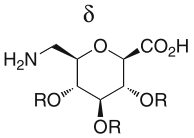
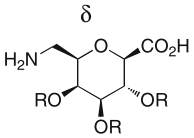
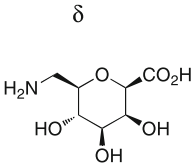
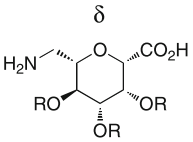
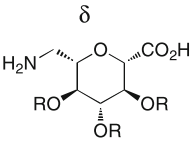
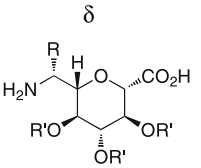
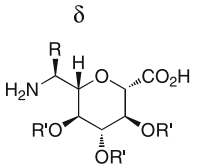
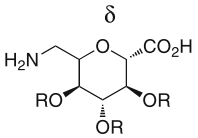
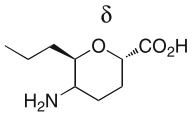
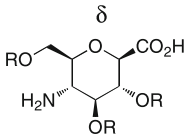
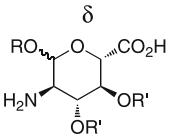
γ,ε  Adachi et al. (2008)	δ  Schröder et al. (2006)	δ  (R) & (S); Overkleeft et al. (1999) (cis); R = H, Bn; Knijnenburg et al. (2011)	δ  (R) & (S); Grotenbreg et al. (2004 b) Overkleeft et al. (1999) El Oualid et al. (2002), (2004), (2005) Aguilera et al. (2001) IJsselstein et al. (2004) Kriek et al. (2003)
δ  R = Acetonide; Chung et al. (2004)	δ  R = Ac, H; Fuchs and Lehmann (1975a) R = H; Locardi et al. (2001) R = Bn, SO_3Na, H; Suhara et al. (1996 a)	δ  R = ac, H; Fuchs and Lehmann (1975a)	δ  Haubner et al. (2001)
δ  R = Ac, H; Haubner et al. (2004) R = $SiMe_3$, Ac, H; Fuchs and Lehmann (1975 b) Lohof et al. (2000)	δ  R = H; von Roedern et al. (1996), (1994) H = H; Kessler et al. (1995) Lohof et al. (2000) R = Bn, H; Stöckle et al. (2002 b)	δ  R = Me, ^{i}Pr, Ph, Bn, R' = Bn, H; Raunkjaer et al. (2004)	δ  R = Me, iPr, iBu, Ph, R' = Bn, H; Risseeuw et al. (2007 b)
δ  R = Bn; (R) and (S); Lohof et al. (2000)	δ  (R) & (S); Kriek et al. (2003)	δ  R = H; Fuchs and Lehmann (1976) R = Bn, H; Suhara et al. (1997), (2002)	δ  (α), R = Bn, R' = H; R and R'= H; Heyns and Paulsen (1955) R = Vancomycin derivative; R' = H; Waltho et al.(1987) R = Me, R' = H; Chan et al.(1997) R = Me, R' = Me, $CONH^{i}Pr$; Sofia et al.(1998) R = Me, R' = Bz; Billing and Nilsson (2005 a,b) R and R' = Ac; R = H, R' = Ac; R = alkyl, R' = H; Nishimura et al.(1998) R = Bn, R' = H; Müller et al.(1995) R = Me, R' = H; von Roedern et al.(1996) Kessler et al.(1995)

Table 4 continued

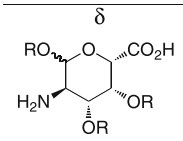
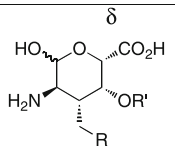
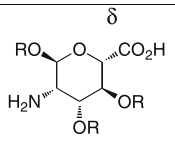
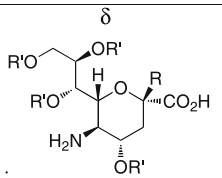
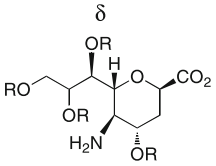
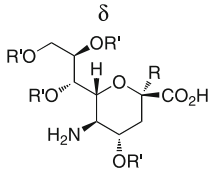
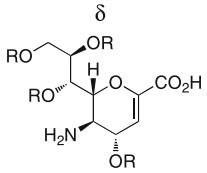
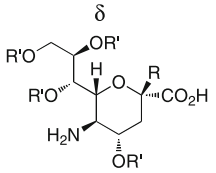
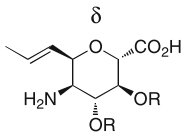
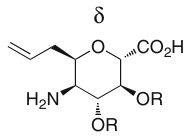
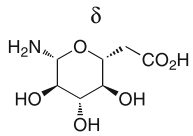
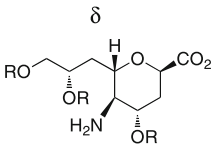
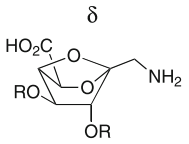
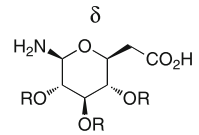
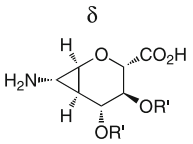
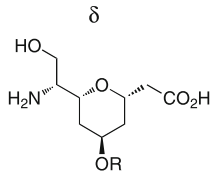
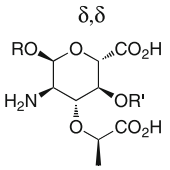
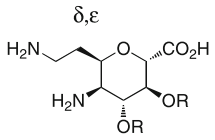
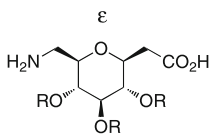
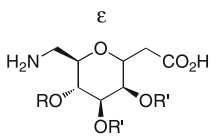
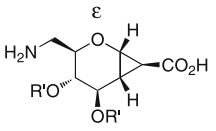
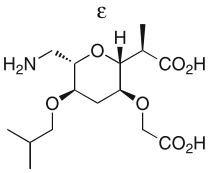
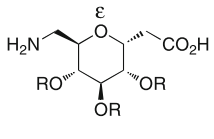
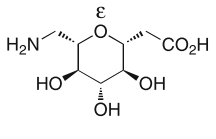
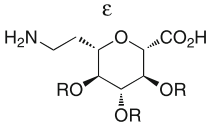
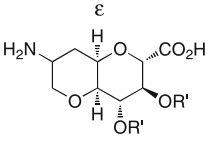
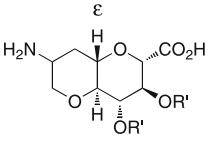
δ  R = H; Heyns et al. (1959)	δ  R_1 = Ac, R = H, TIPS; Pasquarello et al. (1999)	δ  R and R' = Ac; Nishimura et al. (1998)	δ  R = Cl, R' = Ac Sabesan et al. (1997)
δ  (R) & (S); R = TBDMS, Ac, H; Bandgar et al. (1990)	δ  R = OMe, R' = Ac, H; Szabo et al. (1998) R = OCH_2CH_2OH; R' = Ac; Ramamoorthy and Gervay (1997) R' = Ac, H; R = H; Schmid et al. (1988)	δ  R = Ac; R = H; Ramamoorthy and Gervay (1997) R = Ac, H; Gervay et al. (1997b)	δ  R = OAc and R' = Ac; R = OMe, R' = OH; Ramamoorthy and Gervay (1997) R' = Ac, H; R = H; R' = H, R = OMe; Schmidt et al. (1988) R = H, OH, OAc, OMe; R' = Ac, H; Gervay et al. (1997b)
δ  R = Bn; Xie (2003)	δ  R = Bn; Xie (2003)	δ  Kessler et al. (1995)	δ  R = Ac, H; Bandgar et al. (1990)
δ  R = Bn, H; Rommel et al. (2007)	δ  R = Bn, H; Van Well et al. (2003e)	δ  Risseeuw et al. (2009)	δ  R = TIPS; Pattenden and Plowright (2000)
δ,δ  R = Bn, R' = Ac, H; R = H(α/β), R' = Ac; Hecker et al. (1990)	δ,ε  R = Bn; Xie (2003)	ε  R = Bn; Xie (2002)	ε  (R) & (S); R and R' = Bn; R = H, R' = acetonide; McDevitt and Lansbury (1996)
ε  Risseeuw et al. (2009)	ε  Smith et al. (1998a)	ε  R = Bn; Xie (2002)	ε  Kessler et al. (1995)
ε  R = Bn; Xie (2002)	ε  (R) & (S); Grotenbreg et al. (2004c)	ε  (R) & (S); Risseeuw et al. (2006)	

Table 5 Pyranoid amino acids (depicted with unprotected amino and carboxylic acid functionalities)

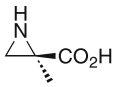
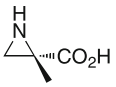
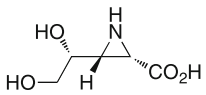
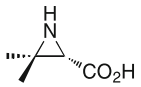
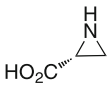
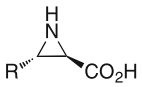
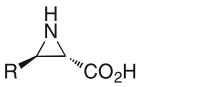
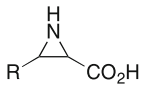
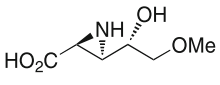
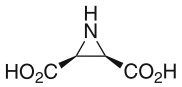
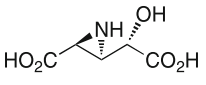
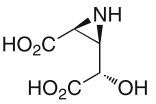
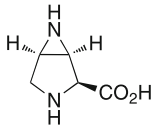
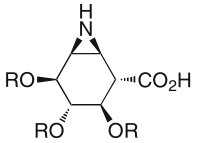
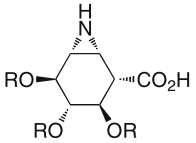
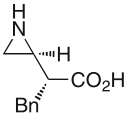
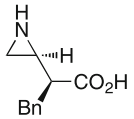
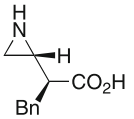
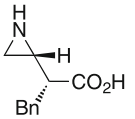
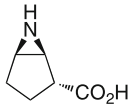
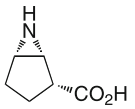
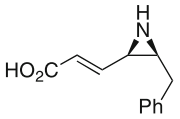
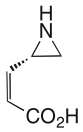
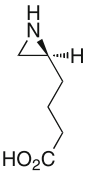
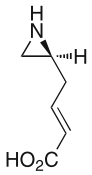
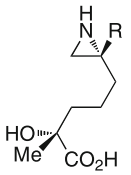
α	α	α	α
			
Shao et al. (1995)	Shao et al. (1995)	Egli and Dreiding (1986)	Wakimoto et al. (2011)
α	α	α	α
			
Tomita et al. (2008)	R = C_6H_{13}; Legters et al. (1992)	R = *p*-Cl-, *p*-F-, *p*-OMe-benzene, C_6H_{13}; Legters et al. (1992)	(R,R) and (S,S); R = aromatic, peptide; Degel et al. (2008)
α	α,α	α,β	α,β
			
Dauban et al. (1996)	Degel et al. (2008)	Dauban et al. (1996)	Dauban et al. (1996)
α,β	β	β	β
			
Herdeis et al. (1997)	Ohba et al. (1996)	Ohba et al. (1996)	Park and Kim (2001)
β	β	β	β
			
Park and Kim (2001)	Park and Kim (2001)	Park and Kim (2001)	Wydysh et al. (2010)
β	γ	γ	δ
			
Wydysh et al. (2010)	Li et al. (1992)	Tomita et al. (2008)	Bergmeier et al. (1999)
δ	ε		
			
Bergmeier et al. (1999)	R = Ph; Wu et al. (2003)		

Table 6 Azetidine amino acids (depicted with unprotected amino and carboxylic acid functionalities)

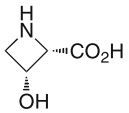
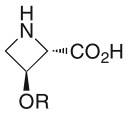
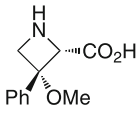
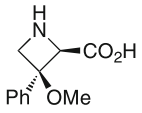
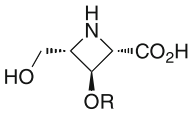
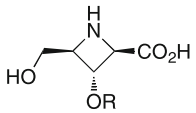
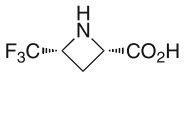
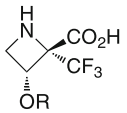
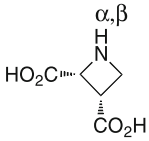
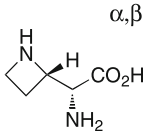
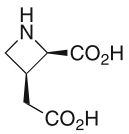
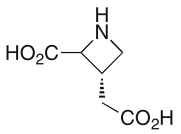
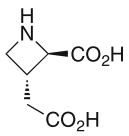
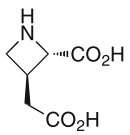
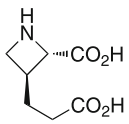
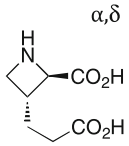
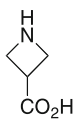
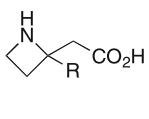
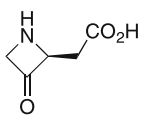
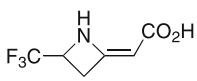
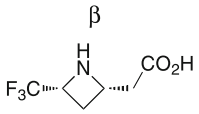
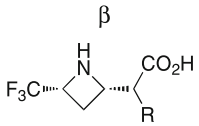
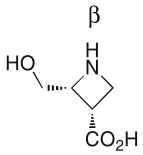
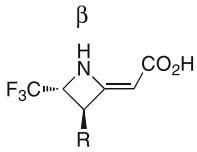
α  Shibasaki et al. (1999)	α  R = Bn; Duréault et al. (1993)	α  Wessig and Schwarz (1998)	α  Wessig and Schwarz (1998)
α  R = Bn, H; Glawar et al. (2013)	α  R = Bn, H; Glawar et al. (2013)	α  Jiang et al. (2003)	α  R = Bn; Bravo et al. (1999)
α,β  Burtoloso and Correira (2008)	α,β  Thander et al. (2009)	α,γ  Burtoloso and Correira (2005)	α,γ  (R) and (S); Burtoloso and Correira (2008)
α,γ  Kozikowski et al. (1996)	α,γ  Kozikowski et al. (1996)	α,δ  Kozikowski et al. (1996)	α,δ  Kozikowski et al. (1996)
β  Miller et al. (2003)	β  (R) and (S); R = Me, Bn, CH_2CH_2SMe; Kawabata et al. (2006)	β  Podlech and Seebach (1995)	β  (R) and (S); Jiang et al. (2003)
β  Jiang et al. (2003)	β  R = Me, H; Jiang et al. (2003)	β  Burtoloso and Correira (2008)	β  R = Me, aromatics; Jiang et al. (2003)

Table 6 continued

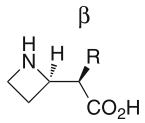
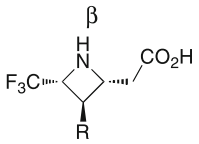
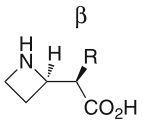
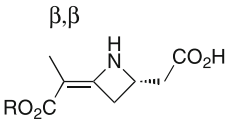
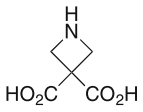
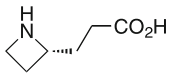
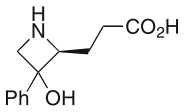
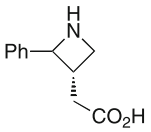
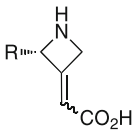
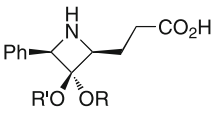
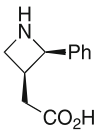
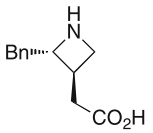
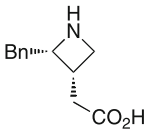
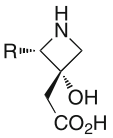
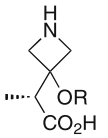
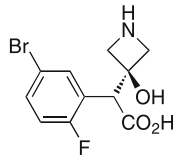
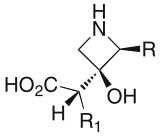
β 	β 	β 	β,β 
R = Aromatics; Deutsch et al. (2001)	R = Me, aromatics; Jiang et al. (2003)	R = Aromatics; Deutsch et al. (2001)	Baldwin et al. (1993)
β,β 	γ 	γ 	γ 
Miller et al. (2003)	Barrett et al. (2002)	Both isomers; Ouazzani-Chadi et al. (1990)	(R) and (S); Burtoloso and Correira (2008)
γ 	γ 	γ 	γ 
(R) and (S); R = Ph; Burtoloso and Correira (2008) R = Bn, Me; Podlech and Seebach (1995)	R = Me, R' = TBDMS; Kise et al. (2006)	Burtoloso and Correira (2005)	Podlech and Seebach (1995)
γ 	γ 	γ 	γ 
Podlech and Seebach (1995)	R = Me, Bn; Podlech and Seebach (1995)	Lamb (2008)	Burkhard et al. (2012)
γ 			
R = Me, ^{i}Bu, Bn, R' = Me, H; Concellón et al. (2002b)			

Table 7 Pyrrolidine amino acids (depicted with unprotected amino and carboxylic acid functionalities)

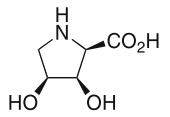
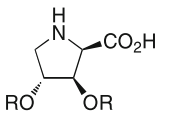
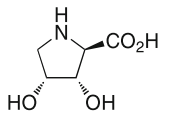
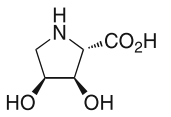
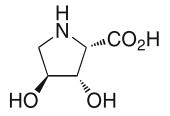
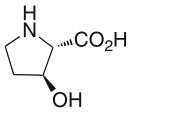
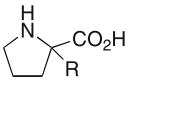
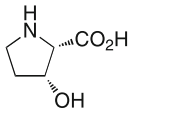
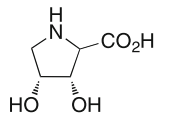
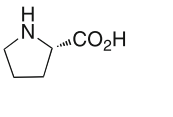
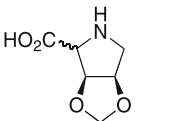
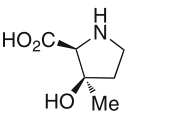
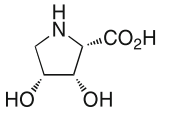
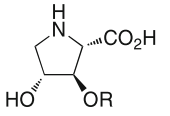
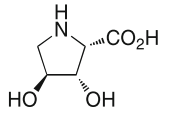
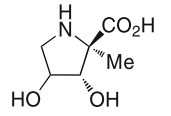
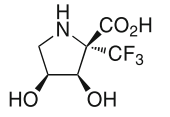
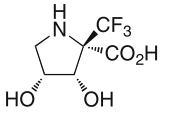
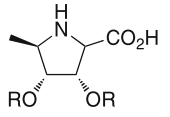
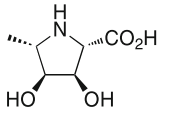
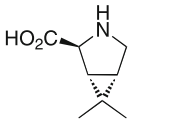
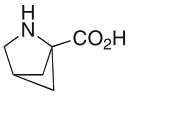
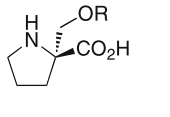
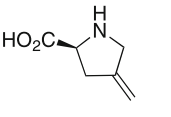
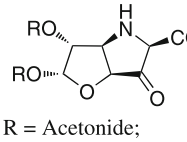
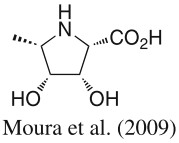
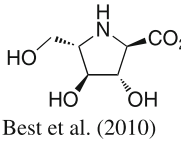
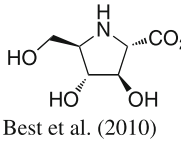
α  Taylor et al. (2002)	α  Lee et al. (2000)	α  Dho et al. (1986)	α  R = Acetonide, H; Fleet and Son (1988) Taylor et al. (2002)
α  Taylor et al. (2002)	α  Sinha et al. (2005)	α  (R) and (S); R = Me, Bn, CH_2CH_2SMe; Kawabata et al. (2006)	α  Shibasaki et al. (1999)
α  Soengas et al. (2003a)	α  Stamm et al. (2003)	α  Reissig et al. (2007)	α  Shen et al. (2003)
α  Austin et al. (1987)	α  R = H; Ohfune and Kurokawa (1985) R = Bn, H; Fleet and Witty (1990)	α  Ohfune and Kurokawa (1985)	α  (R) & (S); da Cruz et al. (2008)
α  Caupene et al. (2009)	α  Caupene et al. (2009)	α  (R) & (S); R = Acetonide, H; Palmer and Jäger (2001)	α  Behr et al. (1995)
α  Bogen et al. (2009)	α  Pirrung (1980) Rammeloo et al. (2002)	α  R = Bn, ^{t}Bu; Moriyama et al. (2008)	α  Mittendorf et al. (2003)
α  R = Acetonide; Vyavahare et al. (2007)	α  Moura et al. (2009)	α  Best et al. (2010)	α  Best et al. (2010)

Table 7 continued

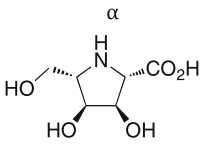
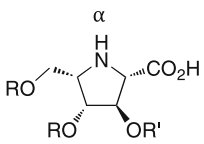
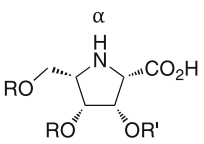
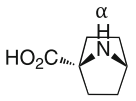
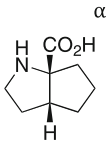
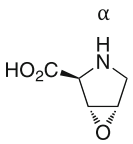
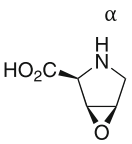
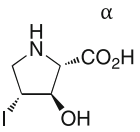
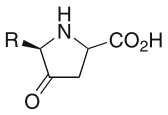
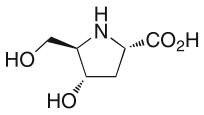
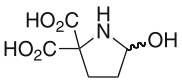
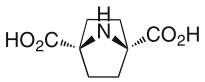
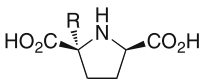
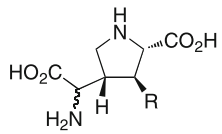
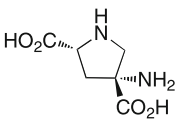
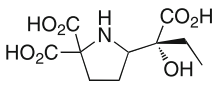
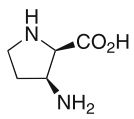
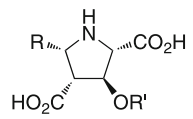
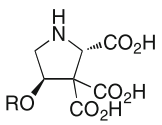
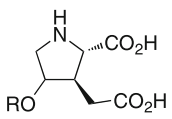
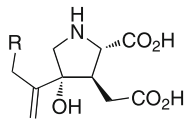
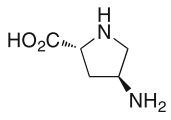
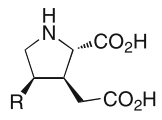
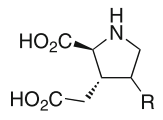
α  Malle et al. (2008)	α  R = $CHCH_3$, R' = Bn; Blanco et al. (2009)	α  R = $CHCH_3$, R' = Bn; Blanco et al. (2009) R = R' = H; Moura et al. (2009)	α  Avenoza et al. (2001a)
α  Fustero et al. (2010)	α  Herdeis et al. (1997) Ueda et al. (2007)	α  Shibasaki et al. (1999)	α  Ueda et al. (2007)
α  (R) & (S); R = ^{n}Bu, Me, Ph, *p*-$OMeC_6H_4$, alkyl; Wang and Ma (2001)	α  Bashyal et al. (1986)	α,α  Yoshioka et al. (1986)	α,α  Avenoza et al. (2001a) Kubyshkin et al. (2007)
α,α  R = CH_2CH_2Cl, H; Kubyshkin et al. (2007)	α,α  Epimeric mixture; R = OH, H; Ueda et al. (2007)	α,α,β,γ  Imre (2007)	α,α,γ  Yoshioka et al. (1986)
α,β  Mittendorf et al. (2003)	α,β  R = Ph, PMP, thiophene; R' = BX_2; Lopez-Perez et al. (2001)	α,β,β  R = Et, Me; Yamazaki and Takebayashi (2011)	α,γ  (R) and (S); R = Aromatic, H; Furuta et al. (2004)
α,γ  R = H, OH; Kozikowski et al. (1990)	α,γ  Woods et al. (2002)	α,γ  R = CHO, CCH, alkyl; Lemiére et al. (2011)	α,γ  (R) and (S); R = various aromatics; Ahmed et al. (2001) Baldwin et al. (1995)

Table 7 continued

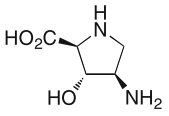
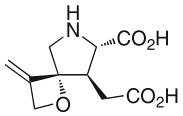
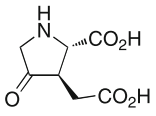
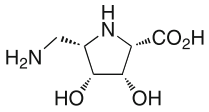
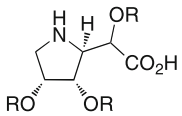
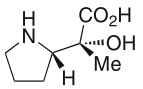
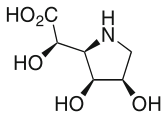
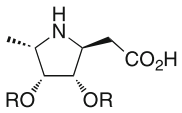
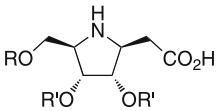
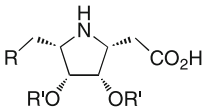
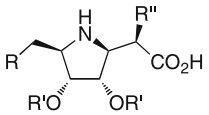
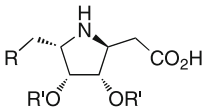
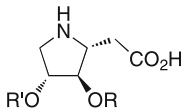
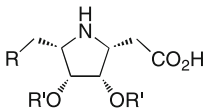
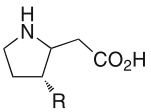
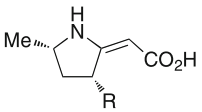
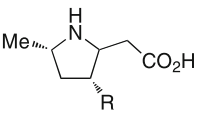
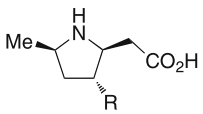
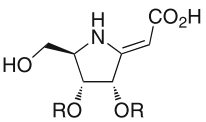
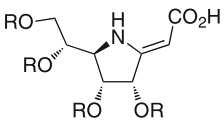
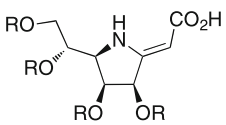
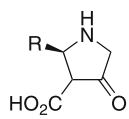
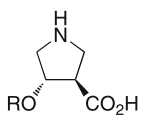
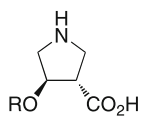
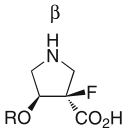
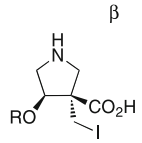
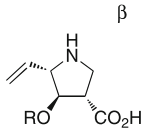
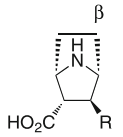
α,γ  Herdeis et al. (1997)	α,γ  Kozikowski et al. (1990)	α,γ  Baldwin et al. (1995)	α,δ  Moura et al. (2009)
β  Lundt and Madsen (1993)	β  Wang et al. (2003)	β  Lundt et al. (1994)	β  Chevrier et al. (2011)
β  R = I, R' = acetonide; R = OH, R' = H; Davies et al. (2009)	β  R = I, OAc, OH, R' = Acetonide, H; Davies et al. (2009)	β  R = I, OAc, H, R' = Acetonide, H, R'' = OH, H; Davies et al. (2009)	β  R = I, OAc, OH, R' = acetonide, H; Davies et al. (2009)
β  R = TMS, R' = Bn; Chaudari et al. (2006)	β  R = I, OAc, OH, R' = acetonide, H; Davies et al. (2009)	β  R = *p*-MeO(C_6H_4); Sukhorukov et al. (2008)	β  R = *p*-MeO(C_6H_4); Sukhorukov et al. (2008)
β  R = *p*-MeO(C_6H_4); Sukhorukov et al. (2008)	β  R = *p*-MeO(C_6H_4); Sukhorukov et al. (2008)	β  R = Acetonide; Enderlin et al. (2009)	β  R = Acetonide; Enderlin et al. (2009)
β  R = Acetonide; Enderlin et al. (2009)	β  R = ^{n}Bu; Wang and Ma (2001)	β  R = Ac, H; Clinch et al. (2006)	β  R = Ac, H; Clinch et al. (2006)
β  R = Ac, H; Mason et al. (2008)	β  Douelle et al. (2007)	β  Rives et al. (2009)	β  R = $COCH_3$, OH; Shafíee and Hite (1968)

Table 7 continued

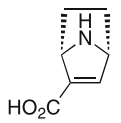
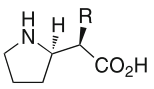
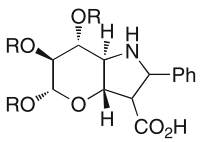
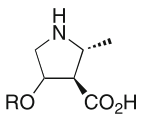
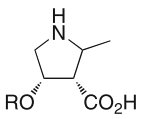
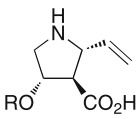
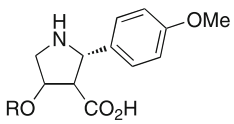
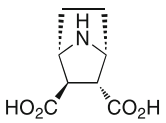
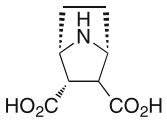
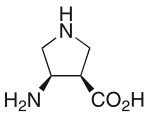
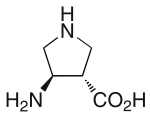
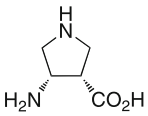
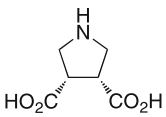
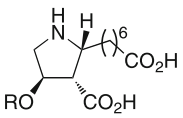
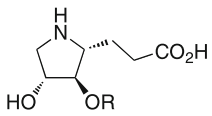
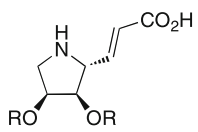
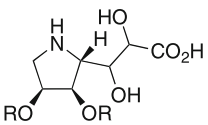
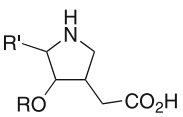
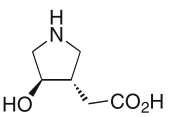
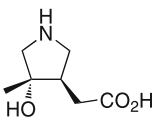
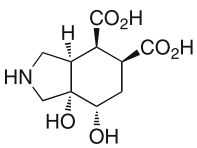
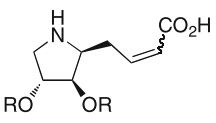
β  Shafíee and Hite (1968)	β  R = Aromatics; Deutsch et al. (2001)	β  (R,S) & (S,R); Zhang et al. (2010a,b)	β  (R) & (S); Rozing et al. (1981)
β  (R) & (S); Rozing et al. (1981)	β  Rozing et al. (1979)	β  (R,R) & (S,S); Wang and Ma (2001)	β,β  Shafíee and Hite (1968)
β,β  Shafíee and Hite (1968)	β,β  Hanselmann et al. (2003) Bunnage et al (2004)	β,β  Bunnage et al. (2004)	β,β  Ott et al. (2008a,b)
β,β  Ott et al. (2008a)	β,η  Rozing et al. (1976)	γ  R = Bn; Chaudari et al. (2006)	γ  (R,S) & (S,R); R = Acetonide; Carmona et al. (2004)
γ  (R,S) & (S,R); R = Acetonide; Carmona et al. (2004)	γ  (R) & (S); R = TBDPS, TBDMS, H; R' = H; R = TBDMS, R' = ^{n}pentane; Aurrecoechea et al. (2009)	γ  Parsons and Pettifer (1997)	γ  Lee et al. (1994)
γ,δ  Cui et al. (2011)	γ  R = Bn; Chaudari et al. (2006)		

Table 8 Piperidine and morpholine amino acids (depicted with unprotected amino and carboxylic acid functionalities)

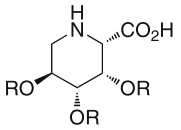
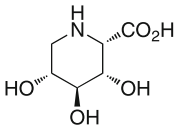
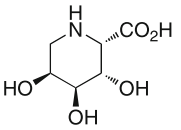
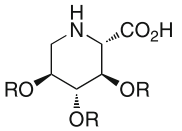
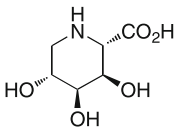
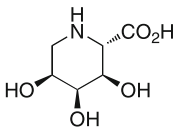
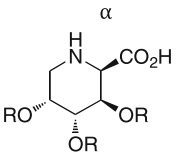
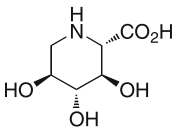
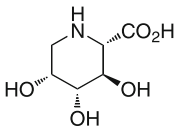
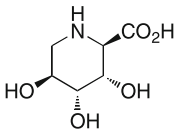
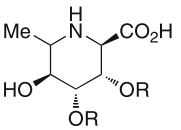
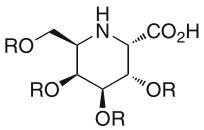
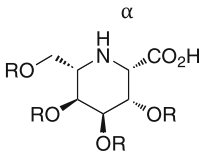
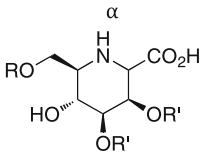
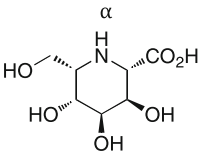
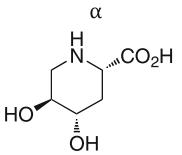
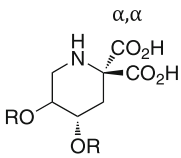
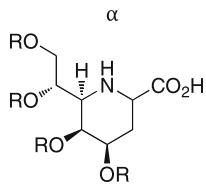
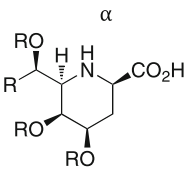
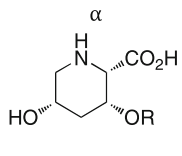
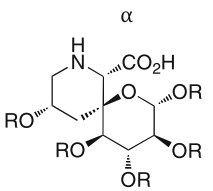
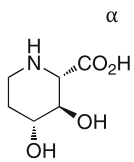
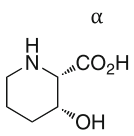
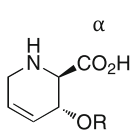
α  R = Bn, H; Tong et al. (1990) R = H; Yoshimura et al. (2008)	α  Yoshimura et al. (2008)	α  Yoshimura et al. (2008)	α  R = Bn; Bernotas and Ganem (1985) R = H; Kessler et al. (1995) Fleet et al. (1987)
α  Malle et al. (2008) Yoshimura et al. (2008)	α  Yoshimura et al. (2008)	α  Park (1995)	α  Bashyal et al. (1986) Yoshimura et al. (2008)
α  Malle et al. (2008) Yoshimura et al. (2008)	α  Malle et al. (2008)	α  (R) and (S); R = Acetonide, H; Shilvock et al. (1999)	α  Ye et al. (2005) R = Bn; Zhang et al. (2010a)
α  Ye et al. (2005) R = Bn; Zhang et al. (2010a)	α  (α and β); R = TBDMS, H, R' = Acetonide, H; Shilvock et al. (1998a)	α  Bruce et al. (1992)	α  Bashyal et al. (1986)
α,α  (R) and (S); Herdeis and Engel (1993)	α  (α and β); R = Acetonide, H; Norbeck and Kramer (1987)	α  R = CHO, $CHCH_2$; Voigtmann and Blechert (2000)	α  R = TBDMS; Miura and Kajimoto (2001)
α  Zhang and Schweizer (2005)	α  Fleet and Witty (1990)	α  Shibasaki et al. (1999)	α  Yoshimura et al. (2008)

Table 8 continued

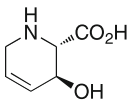
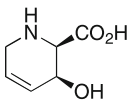
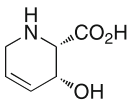
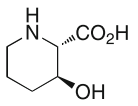
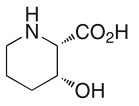
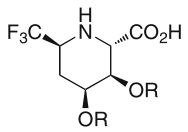
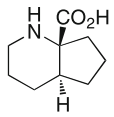
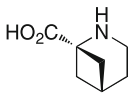
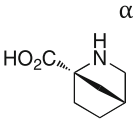
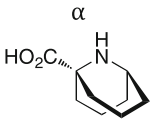
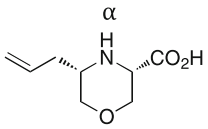
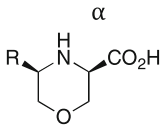
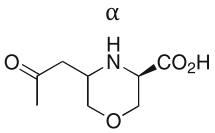
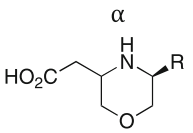
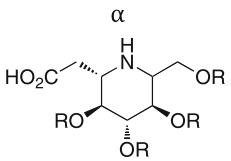
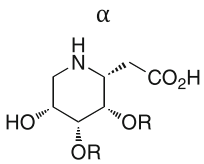
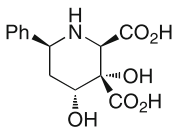
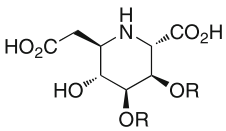
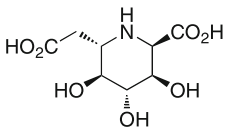
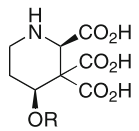
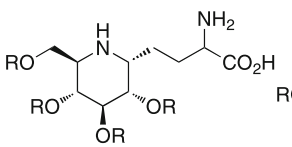
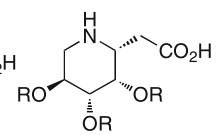
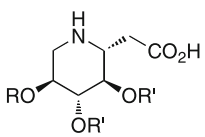
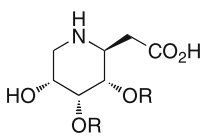
α  Yoshimura et al. (2008)	α  Yoshimura et al. (2008)	α  Yoshimura et al. (2008)	α  Yoshimura et al. (2008)
α  Yoshimura et al. (2008)	α  R = Ac, H; Dobbs et al. (2008)	α  Fustero et al. (2010)	α  Radchenko et al. (2009)
α  Radchenko et al. (2009)	α  Radchenko et al. (2009)	α  O'Neil et al. (2005)	α  R = ^{t}Bu, ^{i}Pr, cyclopropylmethyl; Li et al. (2010)
α  (R) and (S); Zhong et al. (2011)	α  (R) and (S); Zhong et al. (2011)	α  R = Bn, H; Orsato et al. (2011)	α  R = Acetonide, H; Herdeis and Schiffer (1996)
α,β  Wurz and Fu (2005)	α,β  R = Acetonide; Shilvock et al. (1998b)	α,β  Orsato et al. (2011)	α,β,β  R = Et; Yamazaki and Takebayashi (2011)
α,δ  Fuchss et al. (2000)	β  R = Bn; Pandey et al. (2006)	β  R = TMS, H; R' = acetonide, H; Kilonda et al. (1994)	β  R = Acetonide, H; Herdeis and Schiffer (1996) R = Bn; Yi et al. (2005)

Table 8 continued

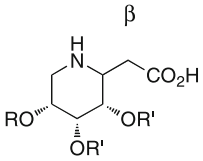
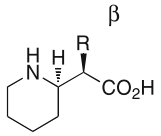
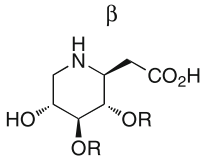
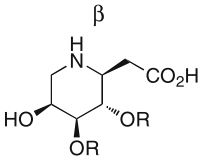
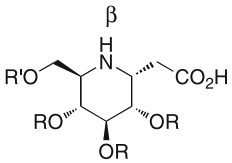
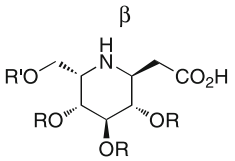
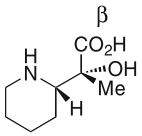
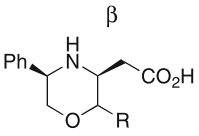
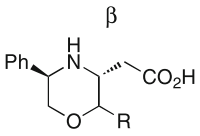
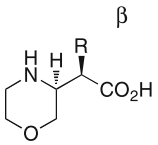
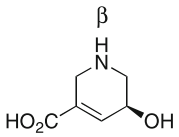
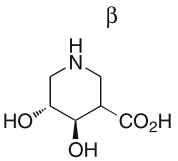
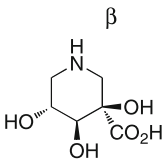
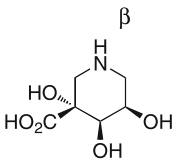
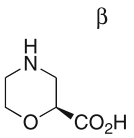
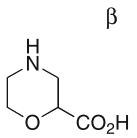
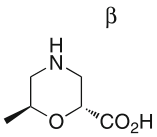
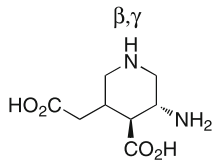
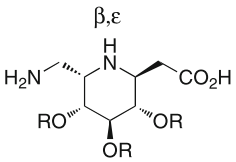
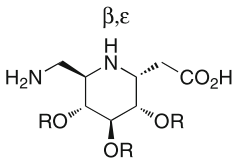
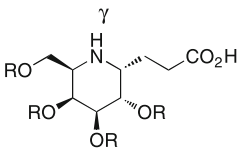
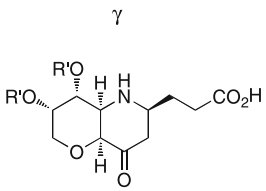
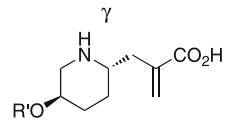
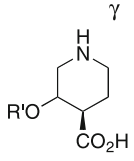
β  (R) and (S); R = Ac, R' = Acetonide; Davies et al. (2009) (R); Herdeis and Schiffer (1996)	β  R = Aromatics; Deutsch et al. (2001)	β  R = Bn; Yi et al. (2005)	β  R = Bn; Yi et al. (2005)
β  R and R' = Bn; Cipolla et al. (2002b) R = Bzl, R' = TBDPS, H; R and R' = H; La Ferla et al. (2004)	β  R = Bzl, R' = TBDPS, H; R and R' = H; La Ferla et al. (2004)	β  Wang et al. (2003)	β  (R) & (S); R = Me; Tiecco et al. (2003)
β  (R) & (S); R = Me; Tiecco et al. (2003)	β  R = Aromatics; Deutsch et al. (2001)	β  Zhao et al. (2001)	β  (R) and (S); Igarashi et al. (1996) Zhao et al. (2001)
β  Zhao et al. (2001)	β  Simone et al. (2012)	β  Henegar (2008)	β  (R) and (S); Fish et al. (2008)
β  Wang et al. (2011)	β,γ  Davies et al. (2005)	β,ε  (R) & (S); R = Bzl; La Ferla et al. (2004)	β,ε  (R) & (S); R = Bzl; La Ferla et al. (2004)
γ  R = Bn; Zhang et al. (2010a)	γ  Niethe and Blechert (2007)	γ  Bartels et al. (2004)	γ  (R) & (S); Seebach et al. (1987)

Table 8 continued

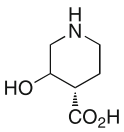
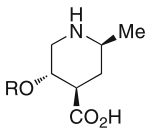
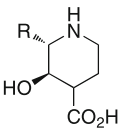
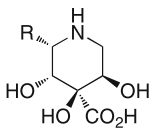
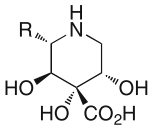
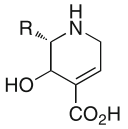
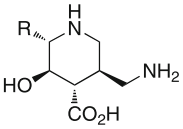
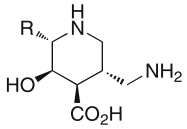
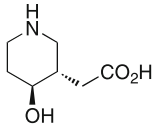
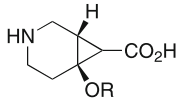
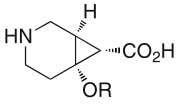
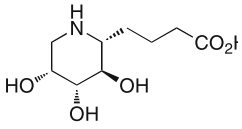
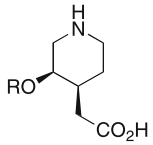
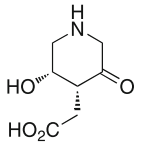
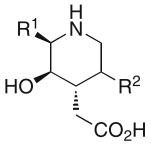
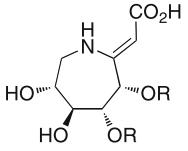
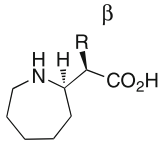
γ  (R) & (S); Guo et al. (2006)	γ  R = Me, H; Mann et al. (1988)	γ  (R) and (S); R = Bn; Krishna and Reddy (2008)	γ  R = Me, ^{i}Pr, Bn, (R-^{sec}Bu); Krishna and Reddy (2008)
γ  R = Me, ^{i}Pr, Bn, (R-^{sec}Bu); Krishna and Reddy (2008)	γ  (R) and (S); R = Me, ^{i}Pr, Bn, (R-^{sec}Bu); Krishna and Reddy (2008)	γ  R = Bn; Krishna and Reddy (2008)	γ  R = Bn; Krishna and Reddy (2008)
γ  Parsons and Pettifer (1997)	γ  (R) and (S); R = Me; Moustafa and Pagenkopf (2010)	γ  R = Me; Moustafa and Pagenkopf (2010)	δ  Pearson et al. (2000)
δ  Knight et al. (1998)	δ  Xavier et al. (2011)	δ  R^1 = indol-3-ylmethyl; R^2 = H, R-Et, S-Et; Sundberg et al. (1971)	β  R = Acetonide. Enderlin et al. (2009)
β  R = Aromatics; Deutsch et al. (2001)			

Table 9 Cyclopropyl amino acids (depicted with unprotected amino and carboxylic acid functionalities)

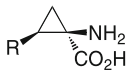
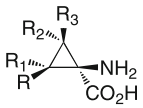
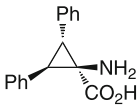
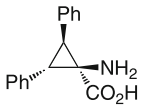
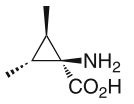
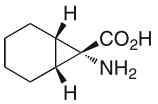
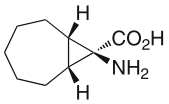
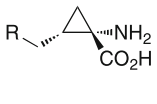
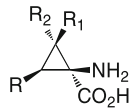
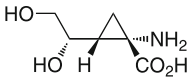
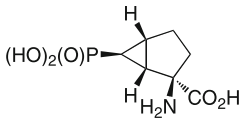
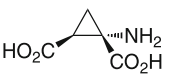
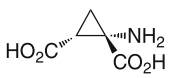
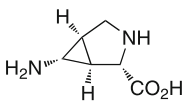
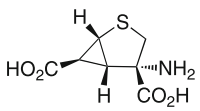
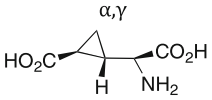
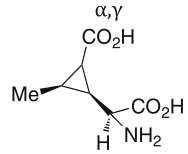
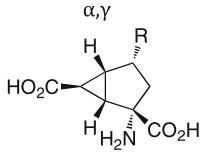
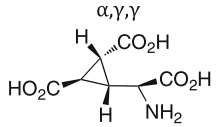
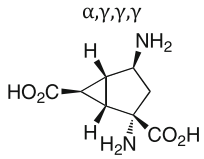
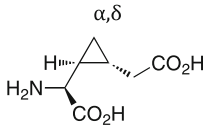
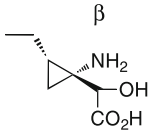
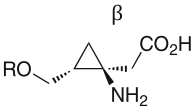
α 	α 	α 	α 
R = H, Me, Et, Ph; Hiyama and kai (1982)	R, R_1, R_2, R_3 = H, Me, Ph, OAc; O'Bannon and Dailey (1989)	Jimenez et al. (2001)	Jimenez et al. (2001)
α 	α 	α 	α 
Schoellkopf et al. (1986)	Schoellkopf et al. (1986)	Lecornue and Ollivier (2003)	R = OH; Wick et al. (1995) R = Me; Jimenez et al. (1995)
α 	α 	α 	α 
Venkatraman et al. (2010)	R = alkyl, Me, H; R_1 = alkyl, Me, H; R_2 = Me, H; Schöllkopf et al. (1986)	Jimenez et al. (1995)	Krysiak et al. (2010)
α,β 	α,β 	α,γ 	α,γ 
Kraus et al. (1990)	Jimenez et al. (1995) Wick et al. (1995)	Brackmann et al. (2005)	Imre (2007) Monn et al. (2007) Wheeler et al. (2005)
α,γ 	α,γ 	α,γ 	α,γ,γ 
Imre (2007)	(R) and (S); Collado et al. (2002)	R = H; Krysiak et al. (2010) R = Alkyl, aromatics; Hao et al. (2012)	Imre (2007)
α,γ,γ,γ 	α,δ 	β 	β 
Lee and Miller (2004)	Alcaraz and Bernabe (1994)	Venkatraman et al. (2010)	R = Bn, H; Kordes et al. (2005)

Table 9 continued

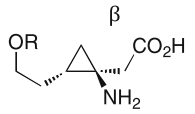
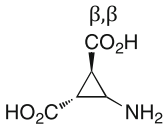
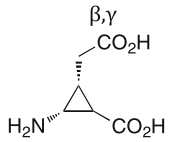
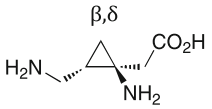
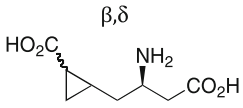
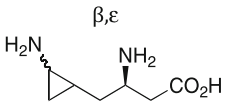
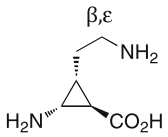
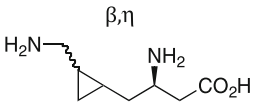
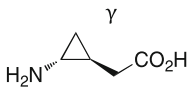
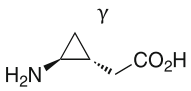
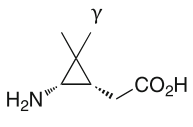
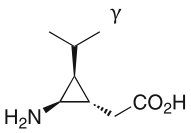
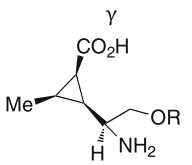
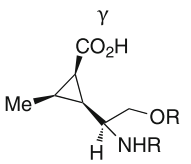
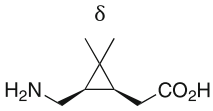
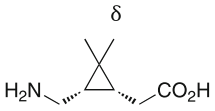
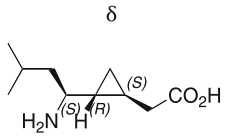
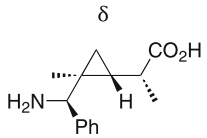
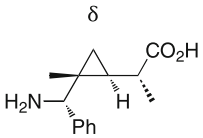
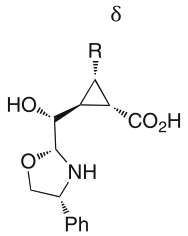
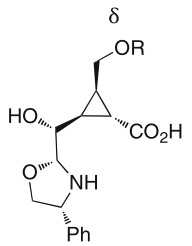
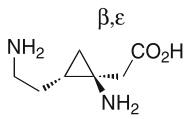
β 	β,β 	β,γ 	β,δ 
R = Bn, H; Kordes et al. (2005)	Bubert et al. (1997)	(R) and (S); Gnad et al. (2004)	Kordes et al. (2005)
β,δ 	β,ε 	β,ε 	β,η 
Raju et al. (2004)	Raju et al. (2004)	Gnad et al. (2004)	Raju et al. (2004)
γ 	γ 	γ 	γ 
Aitken et al. (2011)	Aitken et al. (2011)	Gaicy et al. (2010)	Reichelt et al. (2002)
γ 	γ 	δ 	δ 
R = H, TBMDS; Collado et al. (2002)	R = Acetonide; Collado et al. (2002)	Gaicy et al. (2010)	Gaicy et al. (2010)
δ 	δ 	δ 	δ 
Frantz et al. (2011)	Wipf and Xiao (2005)	Wipf and Xiao (2005)	R = CH_2OBn, $CH_2OTBDMS$; Agami et al. (2000)
δ 	β,ε 		
R = Bn; Agami et al. (2000)	Kordes et al. (2005)		

Table 10 Cyclobutyl amino acids (depicted with unprotected amino and carboxylic acid functionalities)

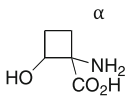
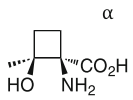
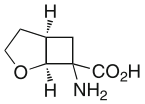
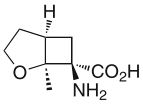
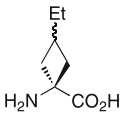
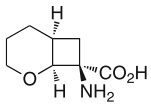
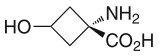
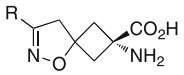
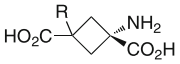
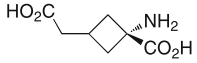
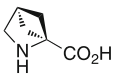
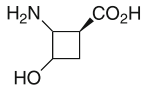
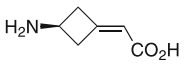
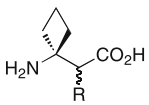
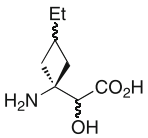
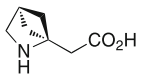
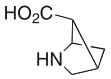
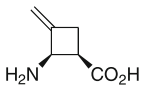
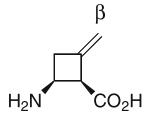
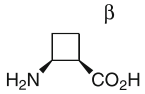
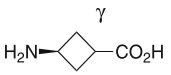
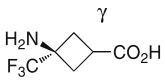
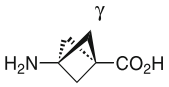
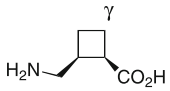
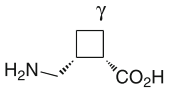
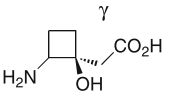
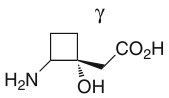
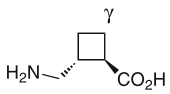
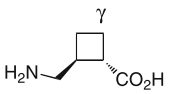
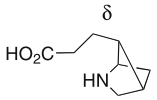
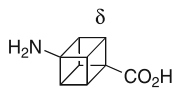
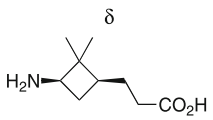
α  All stereoisomers; Avenoza et al. (2005)	α  Both isomers. Avenoza et al. (2010)	α  Avenoza et al. (2010)	α  Avenoza et al. (2010)
α  Venkatraman et al. (2010)	α  Avenoza et al. (2010)	α  Both isomers; Allan et al. (1990) Park and Kurth (2000)	α  Both isomers; R = Bu, Ph, 4-BrPh; Park and Kurth (2000)
α,γ  R = CO_2H, H; Allan et al. (1990)	α,δ  (R) and (S); Allan et al. (1990)	α,ε  Weatherhead et al. (2009)	α,ε  Weatherhead et al. (2009)
β  Malpass et al. (2003)	β  (cis, cis) and (trans, trans); Yuan et al. (1994)	δ  Burkhard et al. (2010)	β  R = Me, H; Seto et al. (2012)
β  Venkatraman et al. (2010)	β  Malpass et al. (2003)	β  Krow et al. (2006)	β  Mittendorf et al. (2003)
β  Mittendorf et al. (2003)	β  Mittendorf et al. (2003)	γ  Both isomers; Radchenko et al. (2011)	γ  Both isomers; Tkachenko et al. (2012)
γ  Patzel et al. (2004)	γ  André et al. (2011)	γ  André et al. (2011)	γ  Both isomers; Baldwin et al. (1986)
γ  Both isomers; Baldwin et al. (1986)	γ  O'Donnell et al. (1980)	γ  O'Donnell et al. (1980)	δ  Krow et al. (2006)
δ  Hasegawa et al. (1993)	δ  Blanco et al. (1996)		

Table 11 Cyclopentyl amino acids (depicted with unprotected amino and carboxylic acid functionalities)

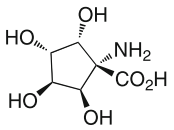
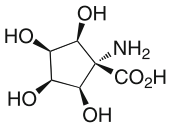
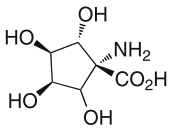
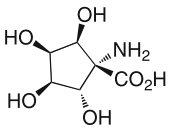
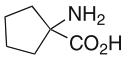
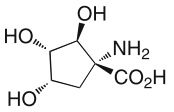
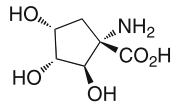
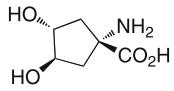
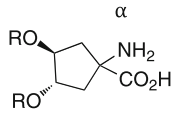
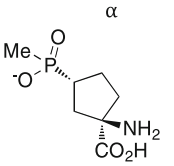
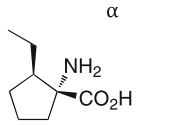
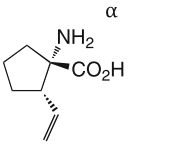
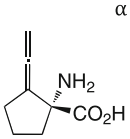
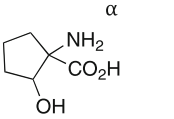
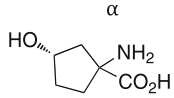
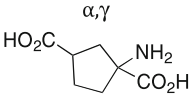
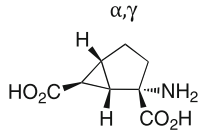
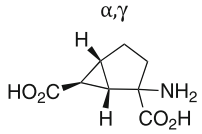
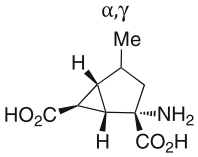
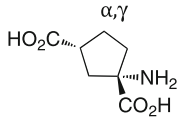
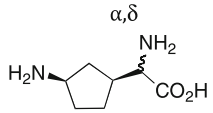
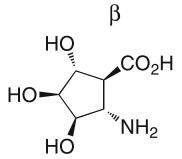
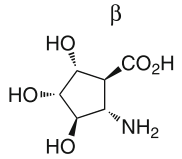
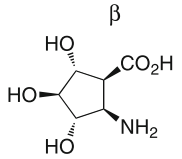
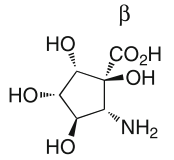
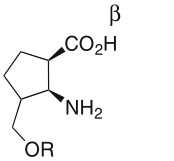
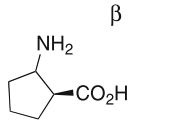
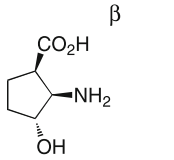
α  Fairbanks et al. (1994)	α  Fairbanks et al. (1994)	α  Both isomers; Hui et al. (1994) Fairbanks et al. (1994)	α  Hui et al. (1994)
α  Connors and Ross (1960)	α  Kummeter and Kazmaier (2003)	α  Kummeter and Kazmaier (2003)	α  Demizu et al. (2012)
α  R = Me; Tanaka et al. (2004)	α  Johnson et al. (1990)	α  Fustero et al. (2010)	α  Fustero et al. (2010)
α  Fustero et al. (2010)	α  All isomers; Meyer et al. (2004) Namba et al. (2001)	α  Both isomers; Howarth et al. (2003)	α,γ  Connors and Ross (1960)
α,γ  Imre (2007) Monn et al. (2007)	α,γ  Wheeler et al. (2005)	α,γ  Monn et al. (2007)	α,γ  Imre (2007)
α,δ  Raju et al. (2004)	β  Fernández et al. (2008)	β  Fernández et al. (2009)	β  Soengas et al. (2005)
β  Elliott et al. (1993)	β  R = H, Bn; Mittendorf et al. (2003)	β  Both isomers; Connors and Ross (1960)	β  Colombini et al. (1995) Wydysh et al. (2010)

Table 11 continued

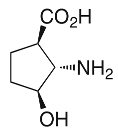
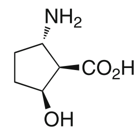
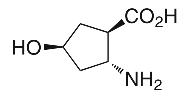
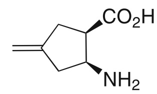
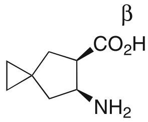
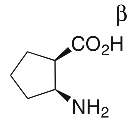
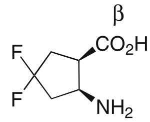
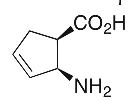
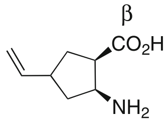
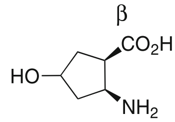
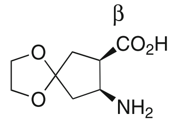
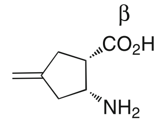
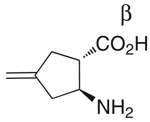
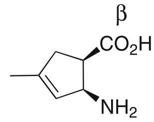
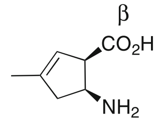
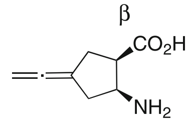
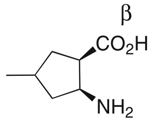
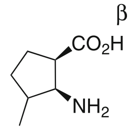
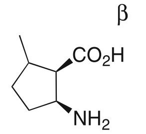
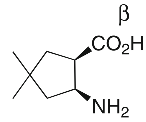
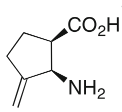
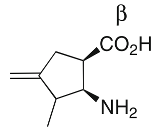
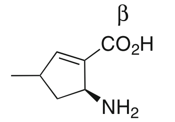
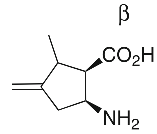
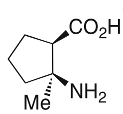
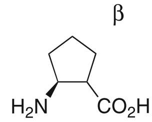
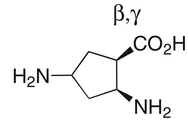
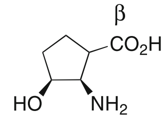
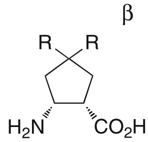
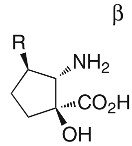
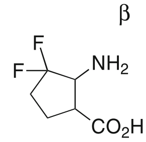
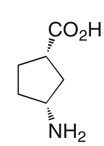
β  Colombini et al. (1995) Wydysh et al. (2010)	β  Davies et al. (2005)	β  Estevez et al. (2010)	β  Mittendorf et al. (2003)
β  Mittendorf et al. (2003)	β  Mittendorf et al. (2003) Hanselmann et al. (2003) Dener et al. (2001)	β  Mittendorf et al. (2003)	β  Mittendorf et al. (2003)
β  Mittendorf et al. (2003)	β  Mittendorf et al. (2003)	β  Mittendorf et al. (2003)	β  Mittendorf et al. (2003)
β  Mittendorf et al. (2003)	β  Mittendorf et al. (2003)	β  Mittendorf et al. (2003)	β  Mittendorf et al. (2003)
β  Mittendorf et al. (2003)	β  Mittendorf et al. (2003)	β  Mittendorf et al. (2003)	β  Mittendorf et al. (2003)
β  Mittendorf et al. (2003)	β  Mittendorf et al. (2003)	β  Mittendorf et al. (2003)	β  Mittendorf et al. (2003)
β  Mittendorf et al. (2003)	β  (*cis*) and (*trans*); Bunnage et al. (2004)	β,γ  Mittendorf et al. (2003)	β  (R) and (s); Matsushima and Kino (2009)
β  R = H, alkyl chains; Ott et al. (2008a) R = H; Dener et al. (2001)	β  R = Alkyl chains, aromatics; Boyce and Johnson (2010)	β  All isomers; Fustero et al. (2009)	β  Casiraghi et al. (2005)

Table 11 continued

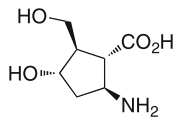
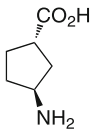
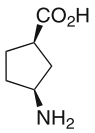
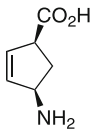
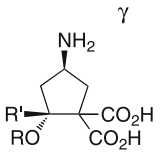
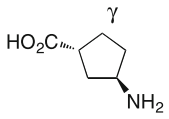
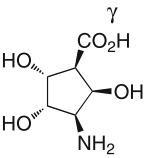
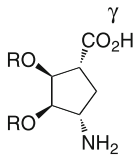
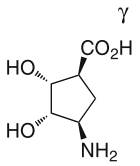
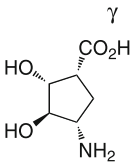
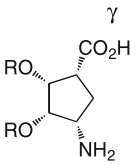
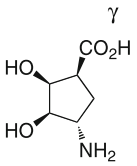
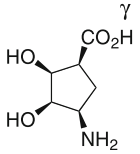
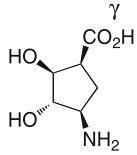
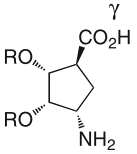
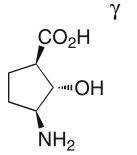
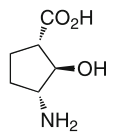
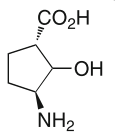
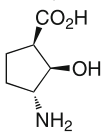
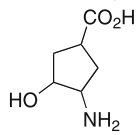
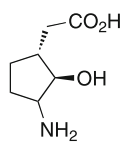
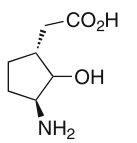
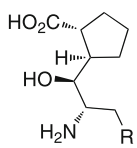
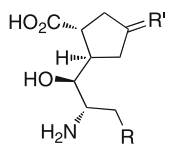
β 	γ 	γ 	γ 
Otvos et al. (1987)	Bergmeier et al. (1999) Casiraghi et al. (2005)	Reiriz et al. (2009) Bergmeier et al. (1999) Casiraghi et al. (2005)	Bergmeier et al. (1999)
γ 	γ 	γ 	γ 
R = TIPS, TMS, TBDMS; R' = aromatics; de Nanteuil and Waser (2011)	Woods et al. (2002) Casiraghi et al. (2005)	And enantiomer; Cheikh et al. (1988)	R = H; Katagiri et al. (1994) Casiraghi et al. (2005) R = Acetonide, H; Rommel et al. (2007)
γ 	γ 	γ 	γ 
Ikbal et al. (1989) Casiraghi et al. (2005) Donohoe et al. (2002)	Casiraghi et al. (2005)	R = Acetonide, H; Rommel et al. (2007)	Rommel et al. (2007)
γ 	γ 	γ 	γ 
Donohoe et al. (2002)	Casiraghi et al. (2005)	R = Acetonide, H; Rommel et al. (2007)	Colombini et al. (1995) Wydysh et al. (2010)
γ 	γ 	γ 	γ 
Wydysh et al. (2010)	Both isomers; Wydysh et al. (2010)	Colombini et al. (1995) Wydysh et al. (2010)	All stereoisomers; Smith et al. (2001) Casiraghi et al. (2005)
δ 	δ 	δ 	δ 
Both isomers; Wydysh et al. (2010)	Both isomers; Wydysh et al. (2010)	R = $CH(CH_3)_2$; Hanessian et al. (2005b)	R = $CH(CH_3)_2$; R' = O, CH_2; Hanessian et al. (2005b)

Table 12 Cyclohexyl amino acids parent structures and their oxygenated derivatives (depicted with unprotected amino and carboxylic acid functionalities)

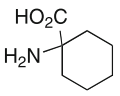
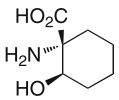
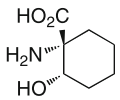
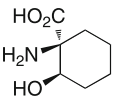
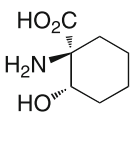
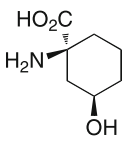
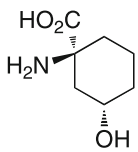
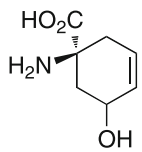
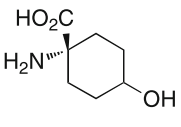
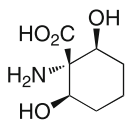
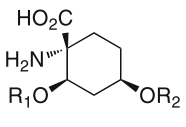
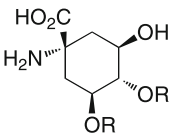
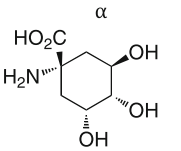
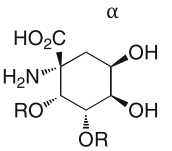
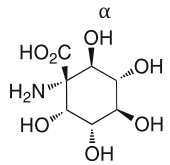
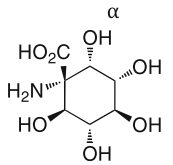
α 	α 	α 	α 
Cocker et al. (1931) Bucherer and Barsch (1934) Adkins and Billica (1948) Tailleur and Berlinguet (1961) Sudo and Ichihara (1963) Oldfield and Cashin (1965) Hayes et al. (1978) Krzyzanowska and Stec (1978) Tsang et al. (1984) Aboul-Enein et al. (1991) Kovachev et al. (1996) Naydenova et al. (2008) Wang et al. (2008) Rivero et al. (2011) Maurs et al. (2012)	Fondekar et al. (1999) Avenoza et al. (2001b) Shinada et al. (2006) Namba et al. (2001)	Fondekar et al. (1999) Namba et al. (2001) Avenoza et al. (2001b) Shinada et al. (2006)	Fondekar et al. (1999) Avenoza et al. (2001b)
α 	α 	α 	α 
Fondekar et al. (1999) Avenoza et al. (2001b)	Avenoza et al. (1996)	Hammer et al. (1998)	(R) and (S); Hammer et al. (1998)
α 	α 	α 	α 
(R) and (S); Avenoza et al. (1999)	Zen et al. (1967)	Racemic; $R_1 = CH_3$, $R_2 = SO_2CH_3$; Avenoza et al. (2002)	R = acetonide; Yamada and Achiwa (1964)
α 	α 	α 	α 
Achiwa and Yamada (1966) Yamada and Achiwa (1964)	R = H, acetonide; Skead et al. (1993) R = H; Fairbanks et al. (1994)	Soengas et al. (2003b)	Soengas et al. (2003b)

Table 12 continued

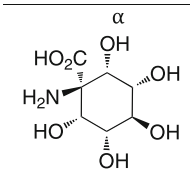
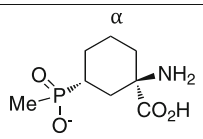
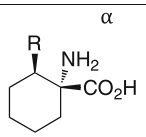
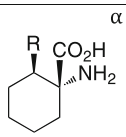
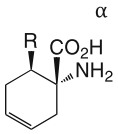
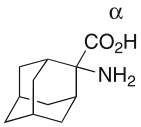
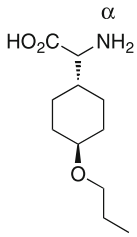
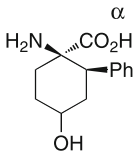
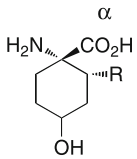
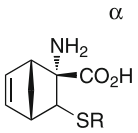
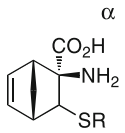
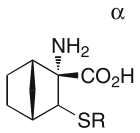
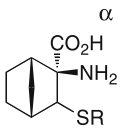
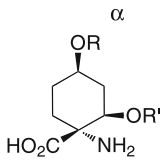
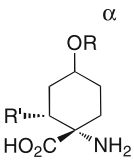
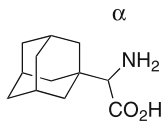
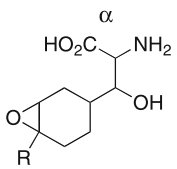
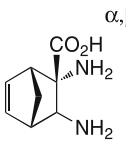
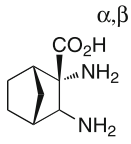
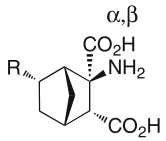
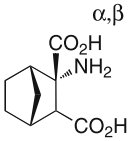
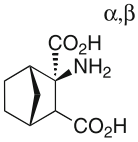
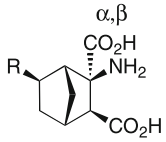
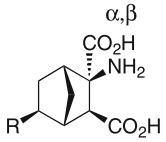
α  Soengas et al. (2003b)	α  Johnson et al. (1990)	α  R = CH=CH_2; CH_2-CH_3; Fustero et al. (2010)	α  R = Aromatics; Genady and Nakamura (2011)
α  R = Aromatics; Genady and Nakamura (2011)	α  Horvat et al. (2006)	α  Slade et al. (2005)	α  (R) & (S); Avenoza et al. (1995)
α  (R) & (S); R = alkyl; Buñuel et al. (2001)	α  R = Ph, Bn, Tr; Ruffoni et al. (2012)	α  R = Ph, Bn, Tr; Ruffoni et al. (2012)	α  R = Ph, Bn, Tr; Ruffoni et al. (2012)
α  R = Ph, Bn, Tr; Ruffoni et al. (2012)	α  R = Ms, R' = Me; Avenoza et al. (2002)	α  (R) & (S); R = Ms, R'= Ph; Gil et al. (2004)	α  (R) & (S); Basarić et al. (2007)
α  R = Me, H; Mukhamedova et al. (1982a,b)	α,β  (R) & (S); Caputo et al. (2006)	α,β  (R) & (S); Caputo et al. (2006)	α,β  R = H, CH=CH_2; Luethi et al. (2010)
α,β  (R) & (S); Luethi et al. (2010)	α,β  (R) & (S); Luethi et al. (2010)	α,β  R = Aromatics, alkyl; Luethi et al. (2010)	α,β  R = Aromatics, alkyl; Luethi et al. (2010)

Table 12 continued

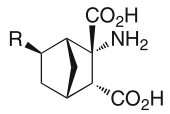
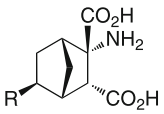
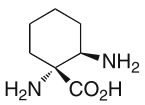
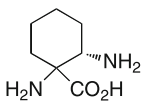
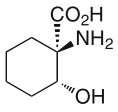
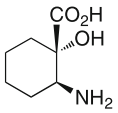
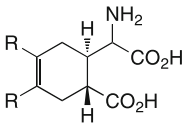
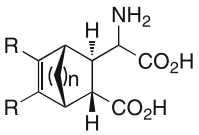
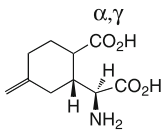
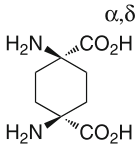
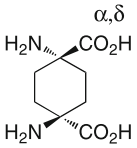
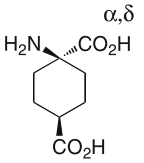
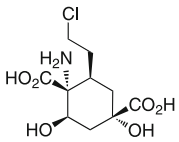
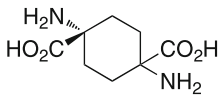
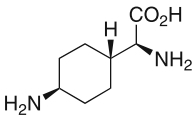
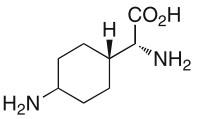
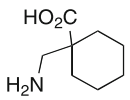
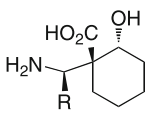
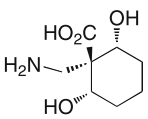
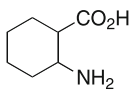
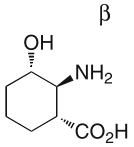
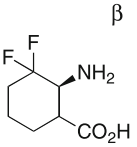
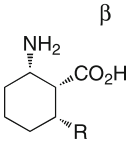
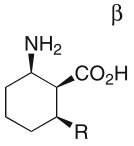
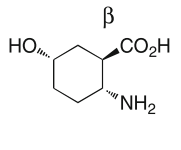
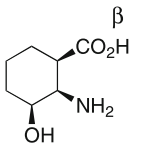
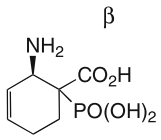
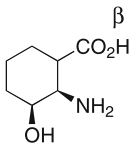
α,β 	α,β 	α,β 	α,β 
R = Aromatics, alkyl; Luethi et al. (2010)	R = Aromatics, alkyl; Luethi et al. (2010)	Fondekar et al. (2002)	(R) and (S); Fondekar et al. (2002)
α,β 	α,β 	α,γ 	α,γ 
Fringuelli et al. (2001)	Fringuelli et al. (2001)	(R) & (S); R = H, Me; Denton et al. (2002)	(R) & (S); R = H, Me; n = 1,2; Denton et al. (2002)
α,γ 	α,δ 	α,δ 	α,δ 
(R) & (S); Ohfune et al. (1998)	Chu et al. (2006)	Chu et al. (2006)	Casabona and Cativiela (2006)
α,δ 	α,δ 	α,ε 	α,ε 
Umezawa et al. (2006)	Cis & trans; Weatherhead et al. (2009)	Caldwell et al. (2004)	Cis & trans; Banfi et al. (1990)
β 	β 	β 	β 
Seebach et al. (1998)	R = Ph, aromatics; Hatano et al. (2010)	Gonzalez et al. (1990)	All stereoisomers; Dener et al. (2001) (R) & (S); Sosic et al. (2011) Priego et al. (2004) Berkessel et al. (2002)
β 	β 	β 	β 
Bunnage et al. (2003)	(R) & (S); Fustero et al. (2009)	R = alkyl, aromatics; Davies et al. (2008)	R = alkyl, aromatics; Davies et al. (2008)

Table 12 continued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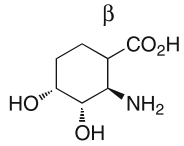
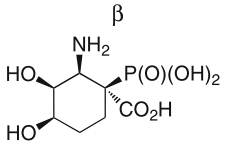
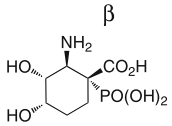
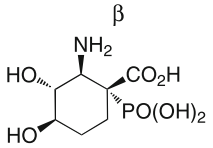
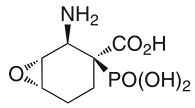
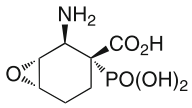
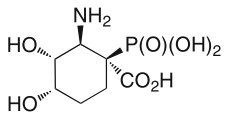
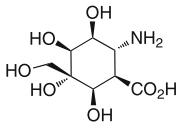
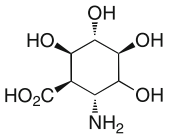
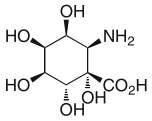
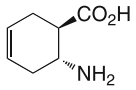
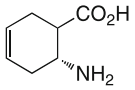
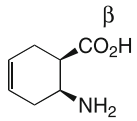
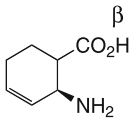
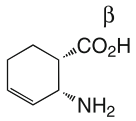
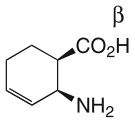
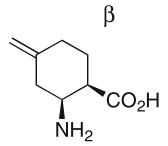
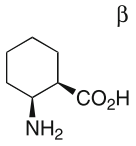
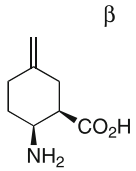
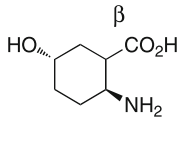
			
Benedek et al. (2009)	Defacqz et al. (2001)	Defacqz et al. (2001)	Defacqz et al. (2001)
			
Defacqz et al. (2001)	Defacqz et al. (2001)	Defacqz et al. (2001)	Cagide-Fagín and Alonso (2010)
			
(R) & (S); Otero et al. (2012)	Pilgrim et al. (2011)	Kiss et al. (2006) Fülöp et al. (2005)	(R) & (S); Benedek et al. (2009)
			
Kiss et al. (2008) Benedek et al. (2009) Fülöp et al. (2005) Mittendorf et al. (2003)	(R) & (S); Benedek et al. (2009) Szakonyi et al. (2005)	Songis et al. (2008a,b)	(+/-); Szakonyi et al. (2005) Mittendorf et al. (2003) Songis et al. (2008a,b)
			
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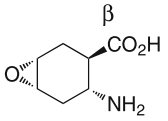	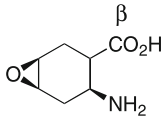	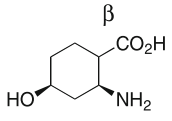	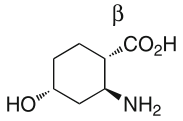
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Table 12 continued

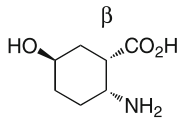
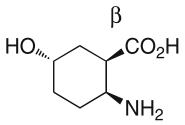
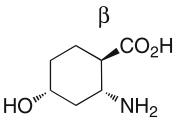
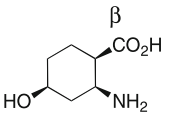
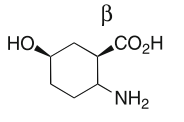
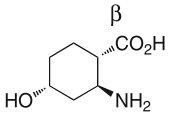
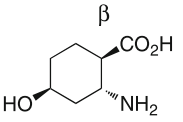
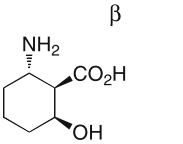
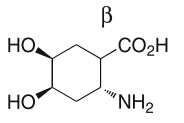
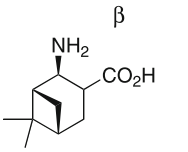
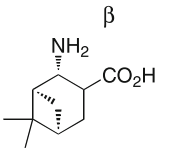
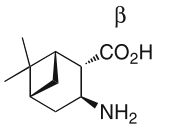
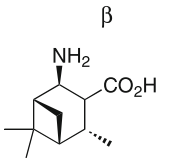
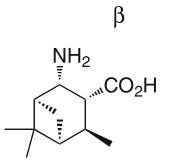
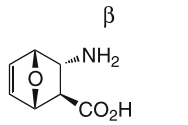
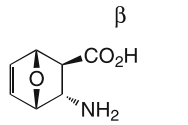
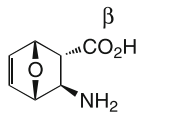
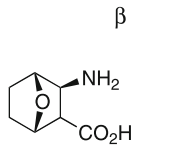
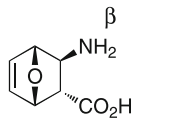
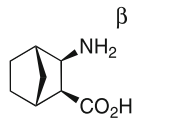
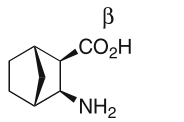
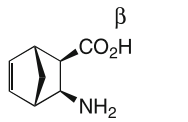
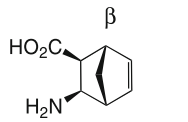
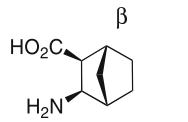
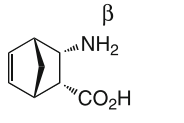
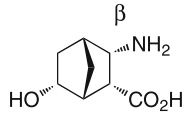
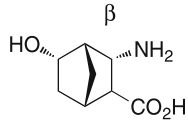
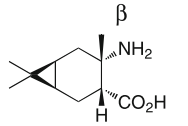
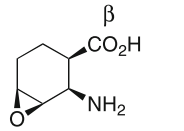
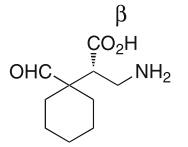
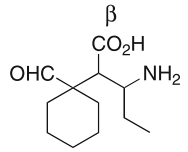
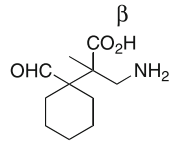
			
Kiss et al. (2008)	Kiss et al. (2008)	Fülöp et al. (2005)	(+/-); Fülöp et al. (2005) Szakonyi et al. (2005)
			
(R) & (S); Fülöp et al. (2005)	Kiss et al. (2008)	Kiss et al. (2008)	Davies et al. (2005)
			
(R) and (S); Benedek et al. (2009)	(R) and (S); Szakonyi et al. (2008)	(R) and (S); Szakonyi et al. (2008)	Szakonyi et al. (2010)
			
Szakonyi et al. (2007)	Szakonyi et al. (2007)	Bunnage et al. (2003)	Bunnage et al. (2003)
			
Bunnage et al. (2003)	(R) and (S); Basso et al. (2004)	Winkler et al. (2004)	Dener et al. (2001)
			
Forró and Fülöp (2004)	Forró and Fülöp (2004)	Forró and Fülöp (2004) Jagadeesh et al. (2009)	Forró and Fülöp (2004)
			
Palkó et al. (2005)	Palkó et al. (2005)	(R) and (S); Palkó et al. (2005)	Gyónfalvi et al. (2003)
			
Songis et al. (2008b)	Yoshida et al. (2012)	Yoshida et al. (2012)	Yoshida et al. (2012)

Table 12 continued

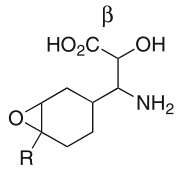
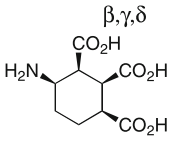
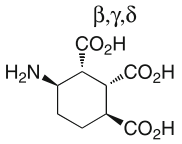
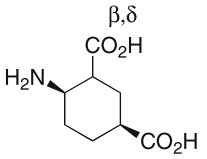
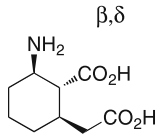
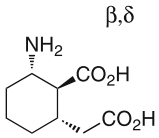
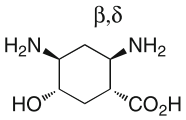
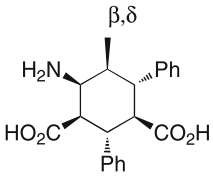
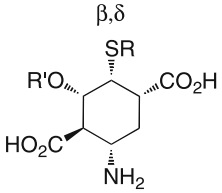
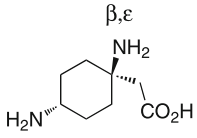
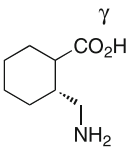
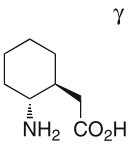
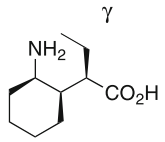
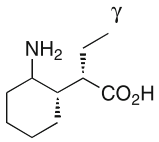
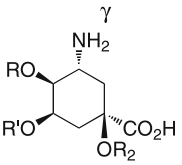
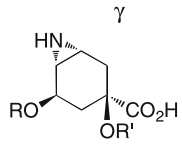
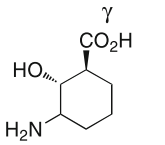
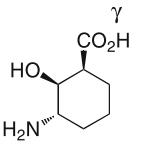
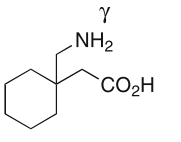
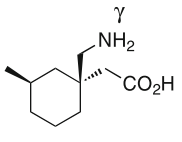
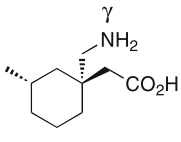
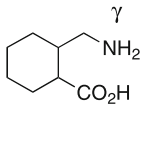
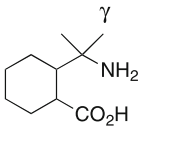
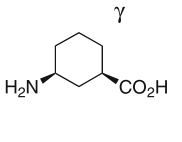
β 	β,γ,δ 	β,γ,δ 	β,δ 
R = Me, H; Mukhamedova et al. (1982a,b)	Arakawa et al. (2005)	Arakawa et al. (2005)	(R) & (S); Arakawa et al. (2005)
β,δ 	β,δ 	β,δ 	β,δ 
Garrido et al. (2006) Davies et al. (2005)	Davies et al. (2005) Garrido et al. (2006)	Udumula et al. (2011)	Koutsaplis et al. (2007)
β,δ 	β,ε 	γ 	γ 
R = aromatic; R' = alkyl; Ishikawa et al. (2010)	Raju et al. (2004)	(R) & (S); Guo et al. (2012a)	DeNinno et al. (2009)
γ 	γ 	γ 	γ 
Guo et al. (2012b)	(S); Guo et al. (2012b) (R) and (S); Guo et al. (2009)	R = Ms, H, R' = Bz, R_2 = Bn; Schwardt et al. (2010)	R = Bz, R' = Bn;Schwardt et al. (2010)
γ 	γ 	γ 	γ 
Wydysh et al. (2010)	Wydysh et al. (2010)	Wu et al. (2009) Vasudev et al. (2005) Guo et al. (2011) Rais et al. (2010) Mallesha et al. (2012) Amin et al. (2010) Braga et al. (2008)	Felluga et al. (2010)
γ 	γ 	γ 	γ 
Felluga et al. (2010)	Johnson et al. (2011)	Johnson et al. (2011)	Yamazaki et al. (2005)

Table 12 continued

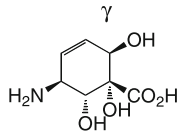
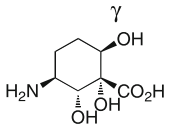
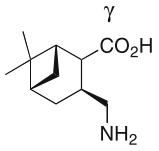
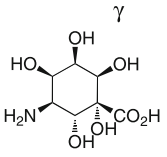
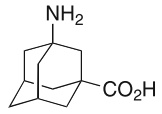
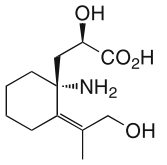
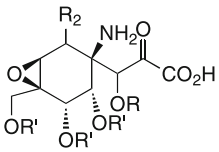
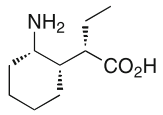
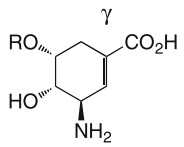
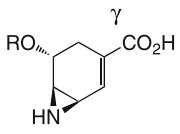
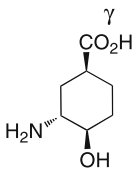
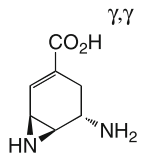
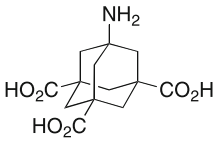
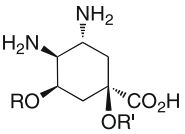
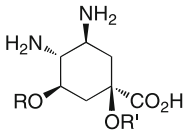
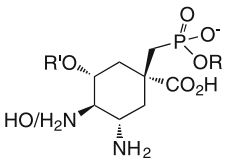
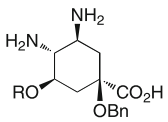
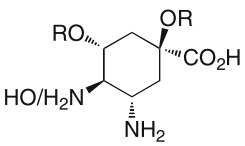
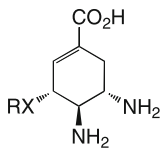
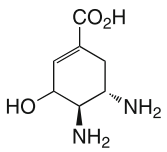
γ 	γ 	γ 	γ 
Pilgrim et al. (2011)	Pilgrim et al. (2011)	(R) & (S); Szakonyi et al. (2010)	Pilgrim et al. (2011)
γ 	γ 	γ 	γ 
Feldhoff et al. (1990) Basarić et al. (2007)	Creech and Kwon (2010)	R = Ac; R' = TES; R_2 = alkyl chain; Nishikawa et al. (2004)	Guo et al. (2011)
γ 	γ 	γ 	γ,γ 
Kim et al. (1997)	Kim et al. (1997)	Nagata et al. (2008)	Kim et al. (1997)
γ,γ,γ 	γ,δ 	γ,δ 	γ,δ 
Lamanna et al. (2011)	R = Bz, R' = Bn;Schwardt et al. 2010	R = CH_2CH_2OAc, Bz, H, R' = Bn; Schwardt et al. (2010)	R = sugar derivative; R' = alkyl, Ac, H; Schaub et al. (2000)
γ,δ 	γ,δ 	γ,δ 	γ,δ 
R = Bz, various alkyl and aromatic groups; Schwardt et al. (2010)	R = Ac; Schaub et al. (2000)	R = alkyl; X = O, S, CH_2; Lew et al. (1997) Kim et al. (1997), (1996) R = H, X = O; Bongaerts et al. (2011) Ishikawa et al. (2010)	(R) & (S); Yamatsugu et al. (2009) (S); Kim et al. (1997),

Table 12 continued

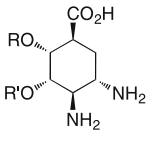
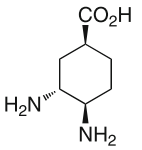
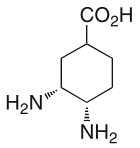
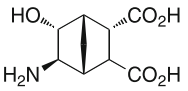
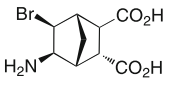
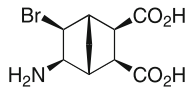
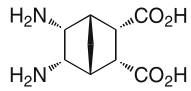
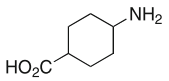
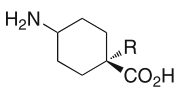
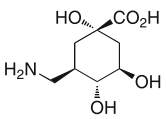
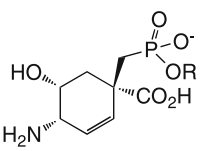
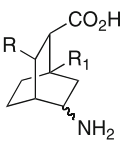
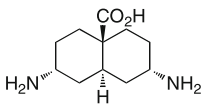
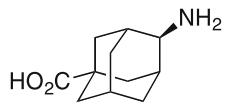
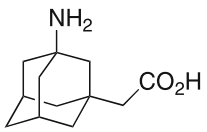
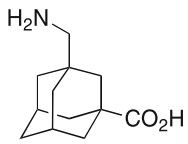
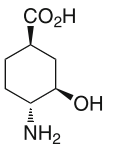
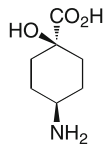
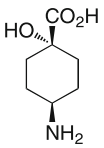
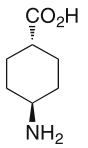
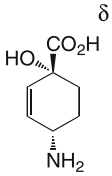
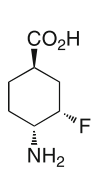
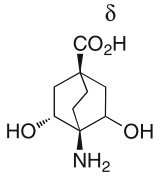
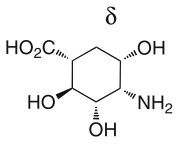
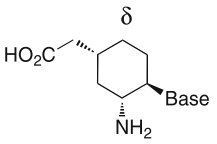
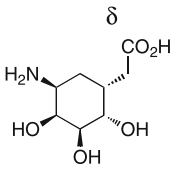
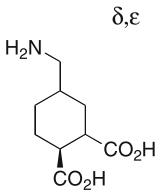
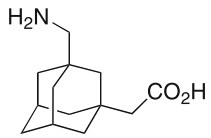
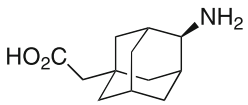
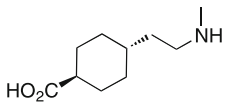
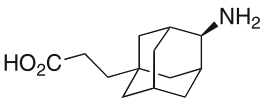
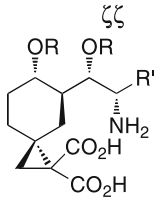
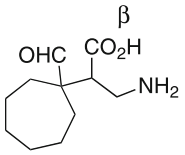
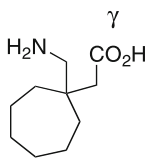
γ,δ 	γ,δ 	γ,δ 	γ,δ 
R = H, R′ = alkyl; R = alkyl, R′ = H; Yamatsugu et al. (2009)	Nagata et al. (2008)	(R) & (S); Nagata et al. (2008) Yoshikawa et al. (2009)	Zalkow and Kennedy (1964)
γ,δ 	γ,δ 	γ,δ 	δ 
Zalkow and Kennedy (1964)	Zalkow and Kennedy (1964)	Zalkow and Kennedy (1964)	Cis & trans; Richards et al. (2006) Rizzi et al. (2011) Marastoni et al. (2002) Girnys et al. (2011) Werner and Ricca (1958)
δ 	δ 	δ 	δ 
(R) & (S); R = aromatics; Takeda et al. (1977)	Nikolaides and Ganem (1989)	R = sugar derivative; Schaub et al. (2000)	R = H, Me; R_1 = various alkyl chains; Ley and Massi (2000)
δ 	δ 	δ 	δ 
Hussain et al. (2011)	Roche et al. (2009) Yeh et al. (2006)	Horvat et al. (2006)	Horvat et al. (2006)
δ 	δ 	δ 	δ 
Miles et al. (2011) Barfoot et al. (2010a)	Miles et al. (2011) Barfoot et al. (2010b)	Barfoot et al. (2010a)	Miles et al. (2011) Barfoot et al. (2010a)
δ 	δ 	δ 	
Barfoot et al. (2010a)	Barfoot et al. (2010a)	(R) & (S); Smith et al. (1999)	Reynolds et al. (2001)

Table 12 continued

δ 	δ 	δ 	δ,ε 
Rassu et al. (2004)	Karig et al. (2000)	Lastdrager et al. (2007)	All isomers; Isoda and Yamaguchi (1980)
ε 	ε 	ζ 	ζ 
Horvat et al. (2006)	Yeh et al. (2006)	Staedler et al. (2012)	Yeh et al. (2006)
ζζ 	β 	γ 	
R = Bn, R' = aromatics; Carson and Kerr (2009)	Yoshida et al. (2012)	Wustrow et al. (2009)	

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Conflict of interest The authors declare that they have no conflict of interest.

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