This invention relates to certain novel compounds and derivatives thereof, their synthesis, and their use as vitronectin receptor antagonists. The vitronectin receptor antagonist compounds of the present invention are \( \alpha \nu \beta 3 \) antagonists, \( \alpha \nu \beta 5 \) antagonists or dual \( \alpha \nu \beta 3/\alpha \nu \beta 5 \) antagonists useful for inhibiting bone resorption, treating and preventing osteoporosis, and inhibiting restenosis, diabetic retinopathy, macular degeneration, angiogenesis, atherosclerosis, inflammation and tumor growth.
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TITLE OF THE INVENTION
INTEGRIN ANTAGONISTS

5 CROSS-REFERENCE TO RELATED APPLICATIONS
The present invention is related to U.S. provisional applications Serial Nos. 60/029,223, filed October 30, 1996, the contents of which are hereby incorporated by reference.

10 FIELD OF THE INVENTION
The present invention provides novel compounds and derivatives thereof, their synthesis, and their use as vitronectin receptor ligands. More particularly, the compounds of the present invention are ανβ3 antagonists, ανβ5 antagonists or dual ανβ3/ανβ5 antagonists useful for inhibiting bone resorption, treating and preventing osteoporosis, and inhibiting vascular restenosis, diabetic retinopathy, macular degeneration, angiogenesis, atherosclerosis, inflammation and tumor growth.

20 BACKGROUND OF THE INVENTION
This invention relates to compounds for inhibiting bone resorption that is mediated by the action of a class of cells known as osteoclasts.

Osteoclasts are multinucleated cells of up to 400 μm in diameter that resorb mineralized tissue, chiefly calcium carbonate and calcium phosphate, in vertebrates. They are actively motile cells that migrate along the surface of bone. They can bind to bone, secrete necessary acids and proteases and thereby cause the actual resorption of mineralized tissue from the bone.

More specifically, osteoclasts are believed to exist in at least two physiological states. In the secretory state, osteoclasts are flat, attach to the bone matrix via a tight attachment zone (sealing zone), become highly polarized, form a ruffled border, and secrete lysosomal enzymes and protons to resorb bone. The adhesion of osteoclasts to bone
surfaces is an important initial step in bone resorption. In the migratory or motile state, the osteoclasts migrate across bone matrix and do not take part in resorption until they attach again to bone.

Integrins are transmembrane, heterodimeric, glycoproteins which interact with extracellular matrix and are involved in osteoclast attachment, activation and migration. The most abundant integrin in osteoclasts (rat, chicken, mouse and human) is the vitronectin receptor, or ανβ3, thought to interact in bone with matrix proteins that contain the RGD sequence. Antibodies to ανβ3 block bone resorption in vitro indicating that this integrin plays a key role in the resorptive process. There is increasing evidence to suggest that ανβ3 ligands can be used effectively to inhibit osteoclast mediated bone resorption in vivo in mammals.

The current major bone diseases of public concern are osteoporosis, hypercalcemia of malignancy, osteopenia due to bone metastases, periodontal disease, hyperparathyroidism, periarticular erosions in rheumatoid arthritis, Paget's disease, immobilization-induced osteopenia, and glucocorticoid treatment.

All these conditions are characterized by bone loss, resulting from an imbalance between bone resorption (breakdown) and bone formation, which continues throughout life at the rate of about 14% per year on the average. However, the rate of bone turnover differs from site to site, for example, it is higher in the trabecular bone of the vertebrae and the alveolar bone in the jaws than in the cortices of the long bones. The potential for bone loss is directly related to turnover and can amount to over 5% per year in vertebrae immediately following menopause, a condition which leads to increased fracture risk.

There are currently 20 million people with detectable fractures of the vertebrae due to osteoporosis in the United States. In addition, there are 250,000 hip fractures per year attributed to osteoporosis. This clinical situation is associated with a 12% mortality rate within the first two years, while 30% of the patients require nursing home care after the fracture.

Individuals suffering from all the conditions listed above would benefit from treatment with agents which inhibit bone resorption.
Additionally, \(\alpha \nu \beta 3\) ligands have been found to be useful in treating and/or inhibiting restenosis (recurrence of stenosis after corrective surgery on the heart valve), atherosclerosis, diabetic retinopathy, macular degeneration and angiogenesis (formation of new blood vessels). Moreover, it has been postulated that the growth of tumors depends on an adequate blood supply, which in turn is dependent on the growth of new vessels into the tumor; thus, inhibition of angiogenesis can cause tumor regression in animal models. (See, *Harrison's Principles of Internal Medicine*, 12th ed., 1991). \(\alpha \nu \beta 3\) antagonists, which inhibit angiogenesis, are therefore useful in the treatment of cancer for inhibiting tumor growth. (See e.g., Brooks et al., *Cell*, 79:1157-1164 (1994)). Moreover, compounds of this invention can also inhibit neovascularization by acting as antagonists of the integrin receptor \(\alpha \nu \beta 5\). A monoclonal antibody for \(\alpha \nu \beta 5\) has been shown to inhibit VEGF-induced angiogenesis in rabbit cornea and the chick chorioallantoic membrane model; M.C. Friedlander, et.al., *Science* 270, 1500-1502, 1995. Thus, compounds that antagonize \(\alpha \nu \beta 5\) are useful for treating and preventing macular degeneration, diabetic retinopathy, and tumor growth.

In addition, certain compounds of this invention antagonize both the \(\alpha \nu \beta 3\) and \(\alpha \nu \beta 5\) receptors. These compounds, referred to as "dual \(\alpha \nu \beta 3/\alpha \nu \beta 5\) antagonists," are useful for inhibiting bone resorption, treating and preventing osteoporosis, and inhibiting vascular restenosis, diabetic retinopathy, macular degeneration, angiogenesis, atherosclerosis, inflammation and tumor growth.

It is an object of the present invention to identify compounds which bind to the \(\alpha \nu \beta 3\) receptor, \(\alpha \nu \beta 5\) receptor or both the \(\alpha \nu \beta 3\) and \(\alpha \nu \beta 5\) receptors.

It is a further object of the invention to identify compounds which act as antagonists of the \(\alpha \nu \beta 3\) receptor. It is another object of the invention to identify \(\alpha \nu \beta 3\) antagonist compounds which are useful agents for inhibiting: bone resorption mediated by osteoclast cells, restenosis, atherosclerosis, inflammation, diabetic retinopathy,
macular degeneration and angiogenesis in animals, preferably mammals, especially humans. Still another object of the invention is to identify αβ3 antagonists which cause tumor regression and/or inhibit tumor growth in animals.

A further object of the invention is to identify αβ3 antagonists useful for preventing or treating osteoporosis. An additional object of the invention is to identify αβ3 antagonists useful for treating cancer.

It has now been found that the compounds of the present invention, αβ3 ligands, are useful for inhibiting bone resorption in mammals. Thus, the compounds of the present invention are useful for preventing or reducing the incidence of osteoporosis. Additionally, the αβ3 ligands of the present invention are also useful for treating and/or inhibiting restenosis, diabetic retinopathy, macular degeneration, atherosclerosis and/or angiogenesis in mammals.

SUMMARY OF THE INVENTION

The present invention provides compounds of the formula

\[ X-Y-Z\text{-Ring-A-B} \]

wherein:

Ring is a 4 to 10-membered mono- or polycyclic aromatic or nonaromatic ring system containing 0, 1, 2, 3 or 4 heteroatoms selected from N, O and S, and either unsubstituted or substituted with R27 and R28;

X is selected from

\[
\begin{align*}
&\text{NR}^2 \quad \text{NR}^2 \\
&\text{-NR}^1\text{R}^2, \quad \text{-NR}^1\text{-C-R}^3, \quad \text{-C-NHR}^4, \quad \text{-NR}^1\text{-C-NR}^3\text{R}^4, \\
&\text{NR}^1 \quad \text{NR}^2 \\
&\text{-aryl-NR}^1\text{R}^2, \quad \text{-aryl-C-NR}^2\text{R}^3, \quad \text{-aryl-NR}^1\text{-C-NR}^3\text{R}^4,
\end{align*}
\]

or a 4- to 10- membered mono- or polycyclic aromatic or
nonaromatic ring system containing 0, 1, 2, 3 or 4 heteroatoms selected from N, O and S and either unsubstituted or substituted with \( R_{13}^{\text{al}} \), \( R_{14}^{\text{al}} \), \( R_{15}^{\text{al}} \) or \( R_{16}^{\text{al}} \);

\[ \text{Y is selected from} \]
\[ \text{C}_0.8 \text{ alkylene,} \]
\[ \text{C}_3.10 \text{ cycloalkyl,} \]
\[ \text{C}_0.8 \text{ alkylene-NR}_5^\text{al}.\text{C}_0.8 \text{ alkylene,} \]
\[ \text{C}_0.8 \text{ alkylene-CO-C}_0.8 \text{ alkylene,} \]

\[ \text{Y is selected from} \]
\[ \text{C}_0.8 \text{ alkylene-O-C}_0.8 \text{ alkylene,} \]
\[ \text{C}_0.8 \text{ alkylene-NR}_5^\text{al}.\text{C}_0.8 \text{ alkylene,} \]
\[ \text{C}_0.8 \text{ alkylene-S(O)}_0.2 \text{C}_0.8 \text{ alkylene,} \]
\[ \text{C}_0.8 \text{ alkylene-SO}_2\text{-NR}_5^\text{al}.\text{C}_0.8 \text{ alkylene,} \]
\[ \text{C}_0.8 \text{ alkylene-NR}_5^\text{al}.\text{SO}_2\text{C}_0.8 \text{ alkylene,} \]

\[ \text{Z is selected from} \]
\[ \text{(CH}_2\text{)}_0.6 \text{aryl(CH}_2\text{)}_0.6, \]
\[ \text{(CH}_2\text{)}_0.6 \text{aryl-CO-(CH}_2\text{)}_0.6, \]
\[ \text{(CH}_2\text{)}_0.6 \text{aryl-CO-NR}_5^\text{al}.\text{(CH}_2\text{)}_0.6, \]
\[ \text{(CH}_2\text{)}_0.6 \text{aryl-NR}_5^\text{al}.\text{CO-(CH}_2\text{)}_0.6, \text{ or} \]
\[ \text{OH} \]
\[ \text{(CH}_2\text{)}_0.8 \text{CH(CH}_2\text{)}_0.8; \]
where \( m \) and \( n \) are each independently an integer from 0 to 6;

\[
A \text{ is selected from }
\]
\[
(\text{CH}_2)_m \text{O}(\text{CH}_2)_p, \ (\text{CH}_2)_m \text{NR}^6(\text{CH}_2)_p, \ (\text{CH}_2)_m \text{NR}^6\text{C}(\text{CH}_2)_p,
\]
\[
(\text{CH}_2)_m \text{CN}(\text{CH}_2)_p, \ (\text{CH}_2)_m \text{NR}^6(\text{CH}_2)_p, \ (\text{CH}_2)_m \text{C}(\text{CH}_2)_p,
\]
\[
(\text{CH}_2)_m \text{C}(\text{CH}_2)_p, \ (\text{CH}_2)_m \text{SO}(\text{CH}_2)_p, \ (\text{CH}_2)_m \text{S}(\text{CH}_2)_p,
\]
\[
(\text{CH}_2)_m \text{SO}(\text{CH}_2)_p, \ (\text{CH}_2)_m \text{SO}^6(\text{CH}_2)_p, \ (\text{CH}_2)_m \text{NR}^6\text{SO}(\text{CH}_2)_p,
\]
\[
(\text{CH}_2)_m \text{CR}^6=\text{CR}^7(\text{CH}_2)_p, \text{ or } (\text{CH}_2)_m \text{C}=-\text{C}(\text{CH}_2)_p;
\]

where \( p \) and \( q \) are each independently an integer from 0 to 6;
B is selected from

\[ \text{R}^8 \text{R}^9 \quad \text{O} \quad \text{R}^{12} \text{C}^{11} \text{C}^{10} \text{R}^{10} \]

\[ \text{or} \quad \text{R}^{11} \text{C}^{10} \text{R}^{10} \]

5 \[ \text{R}^1, \text{R}^2, \text{R}^3, \text{R}^4, \text{R}^5, \text{R}^6, \text{R}^{17}, \text{R}^{18}, \text{R}^{19}, \text{R}^{20}, \text{R}^{21}, \text{R}^{22}, \text{R}^{23}, \text{R}^{24}, \text{R}^{25}, \text{R}^{26}, \text{R}^{27}, \text{R}^{28}, \text{R}^{29} \text{and R}^{30} \text{are each independently selected from} \]

hydrogen,
halogen,
\text{C}_{1-10} \text{ alkyl},
\text{aryl C}_{0-8} \text{ alkyl},

10 amino \text{C}_{0-8} \text{ alkyl},
\text{C}_{1-3} \text{ acylamino C}_{0-8} \text{ alkyl},
\text{C}_{1-6} \text{ alkylamino C}_{0-8} \text{ alkyl},
\text{C}_{1-6} \text{ dialkylamino C}_{0-8} \text{ alkyl},
\text{aryl C}_{0-6} \text{ alkylamino C}_{0-6} \text{ alkyl},

15 \text{C}_{1-4} \text{ alkoxyamino C}_{0-8} \text{ alkyl},
\text{hydroxy C}_{1-6} \text{ alkylamino C}_{0-8} \text{ alkyl},
\text{C}_{1-4} \text{ alkoxy C}_{0-6} \text{ alkyl},
carboxy \text{C}_{0-6} \text{ alkyl},
\text{C}_{1-4} \text{ alkoxy carbonyl C}_{0-6} \text{ alkyl},

20 \text{carboxy C}_{0-6} \text{ alkyl},
\text{hydroxy C}_{1-6} \text{ alkylamino C}_{0-6} \text{ alkyl},
\text{hydroxy C}_{0-6} \text{ alkyl},

\[ \text{NR}^{17} \text{NR}^{18} \text{R}^{19} \quad \text{or} \quad \text{NR}^{18} \text{NR}^{17} \text{R}^{20} \]

-7-
$R^8$ and $R^9$ are each independently selected from:

- hydrogen,
- aryl,
- halogen,
- aryl-(CH$_2$)$_p$-,
- hydroxyl,
- C$_1$-8 alkylcarbonylamino,
- aryl C$_1$-5 alkoxy,
- C$_1$-5 alkoxy carbonyl,
- aminocarbonyl,
- C$_1$-8 alkylaminocarbonyl,
- C$_1$-6 alkylcarbonyloxy,
- C$_3$-8 cycloalkyl,
- amino,
- C$_1$-6 alkylamino,
- amino C$_1$-6 alkyl,
- arylaminocarbonyl,
- aryl C$_1$-5 alkylaminocarbonyl,
- aminocarbonyl,
- aminocarbonyl C$_1$-6 alkyl,
- hydroxycarbonyl,
- hydroxycarbonyl C$_1$-6 alkyl,
- C$_1$-8 alkyl, either unsubstituted or substituted, with one or more groups selected from: halogen, hydroxyl,
- C$_1$-5 alkylcarbonylamino, aryl C$_1$-5 alkoxy,
- C$_1$-5 alkoxy carbonyl, aminocarbonyl, C$_1$-5 alkylamino carbonyl, C$_1$-5 alkylcarbonyloxy, C$_3$-8 cycloalkyl, oxo, amino, C$_1$-3 alkylamino, amino C$_1$-3 alkyl, arylaminocarbonyl, aryl C$_1$-5 alkylaminocarbonyl, aminocarbonyl,
- aminocarbonyl C$_1$-4 alkyl, hydroxycarbonyl, or hydroxycarbonyl C$_1$-5 alkyl,

HC≡C(CH$_2$)$_r$ - 
C$_1$-6 alkyl-C≡C(CH$_2$)$_r$ -, 
C$_3$-7 cycloalkyl-C≡C(CH$_2$)$_r$ -,
aryl-C≡C(CH₂)r⁻,
C₁-6 alkylaryl-C≡C(CH₂)r⁻,
H₂C≡CH(CH₂)r⁻,
C₁-6 alkyl-CH=CH(CH₂)r⁻,
C₃-7 cycloalkyl-CH=CH(CH₂)r⁻,
aryl-CH=CH(CH₂)r⁻,
C₁-6 alkylaryl-CH=CH(CH₂)r⁻,
C₁-6 alkyl-SO₂(CH₂)r⁻,
C₁-6 alkylaryl-SO₂(CH₂)r⁻,
C₁-6 alkoxy,
aryl C₁-6 alkoxy,
aryl C₁-6 alkyl,
C₁-6 alkylamino C₁-6 alkyl,
arylamino,
arylamino C₁-6 alkyl,
aryl C₁-6 alkylamino,
aryl C₁-6 alkylamino C₁-6 alkyl,
arylcarnbonyloxy,
aryl C₁-6 alkylcarbonyloxy,
C₁-6 dialkylamino,
C₁-6 dialkylamino C₁-6 alkyl,
C₁-6 alkylaminocarbonyloxy,
C₈-8 alkylsulfonylamino,
C₈-8 alkylsulfonylamino C₁-6 alkyl,
aryl sulfonlamino C₁-6 alkyl,
aryl C₁-6 alkylsulfonylamino,
aryl C₁-6 alkylsulfonylamino C₁-6 alkyl,
C₈-8 alkoxy carbonylamino,
C₈-8 alkoxycarbonylamino C₁-8 alkyl,
aryl oxycarbonylamino C₁-8 alkyl,
aryl C₁-8 alkoxy carbonylamino,
aryl C₁-8 alkoxy carbonylamino C₁-8 alkyl,
C₁-8 alkylcarbonylamino,
C₁-8 alkylcarbonylamino C₁-6 alkyl,
arylcarbonylamino C₁₋₆ alkyl,
aryl C₁₋₆ alkylcarbonylamino,
aryl C₁₋₆ alkylcarbonylamino C₁₋₆ alkyl,
aminocarbonylamino C₁₋₆ alkyl,
C₁₋₈ alkylaminocarbonylamino,
C₁₋₈ alkylaminocarbonylamino C₁₋₆ alkyl,
arylaminocarbonylamino C₁₋₆ alkyl,
aryl C₁₋₈ alkylaminocarbonylamino,
aryl C₁₋₈ alkylaminocarbonylamino C₁₋₆ alkyl,
aminosulfonylelamino C₁₋₆ alkyl,
C₁₋₈ alkylaminosulfonylelamino,
C₁₋₈ alkylaminosulfonylelamino C₁₋₆ alkyl,
arylaminosulfonylelamino C₁₋₆ alkyl,
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aryl sulfonyl C₁₋₆ alkyl,
aryl C₁₋₆ alkylsulfonyl,
aryl C₁₋₆ alkylsulfonyl C₁₋₆ alkyl,
aryl C₁₋₆ alkylcarbonyl,
C₁₋₆ alkylcarbonyl C₁₋₆ alkyl,
arylcarbonyl C₁₋₆ alkyl,
aryl C₁₋₆ alkylcarbonyl,
aryl C₁₋₆ alkylcarbonyl C₁₋₆ alkyl,
aryl C₁₋₆ alkylthiocarbonylamino,
C₁₋₆ alkylthiocarbonylamino C₁₋₆ alkyl,
arylthiocarbonylamino C₁₋₆ alkyl,
arlyl C₁₋₆ alkylthiocarbonylamino,
arlyl C₁₋₆ alkylthiocarbonylamino C₁₋₆ alkyl,
arlyl C₁₋₆ alkylaminocarbonyl, or
aryl C₁₋₈ alkylaminocarbonyl C₁₋₆ alkyl,
wherein the alkyl or N atoms may be unsubstituted or substituted with one or more substituents selected from $R^{21}$ and $R^{22}$; or $R^{8}$ and $R^{9}$ are combined to form oxo;

5 $R^{10}$ and $R^{11}$ are each independently selected from hydrogen, aryl, halogen, aryl-(CH$_2$)$_p$, hydroxyl, C$_{1-8}$ alkylcarbonylamino, aryl C$_{1-5}$ alkoxy, C$_{1-5}$ alkoxy carbonyl, aminocarbonyl, C$_{1-8}$ alkylaminocarbonyl, C$_{1-6}$ alkylcarbonyloxy, C$_{3-8}$ cycloalkyl, amino, C$_{1-6}$ alkylamino, amino C$_{1-6}$ alkyl, aminocarbonyl, C$_{1-5}$ alkylaminocarbonyl, aminocarbonyl, aminocarbonyl C$_{1-6}$ alkyl, hydroxycarbonyl, hydroxycarbonyl C$_{1-6}$ alkyl, C$_{1-8}$ alkyl, either unsubstituted or substituted, with one or more groups selected from: halogen, hydroxyl, C$_{1-5}$ alkylcarbonylamino, aryl C$_{1-5}$ alkoxy, C$_{1-5}$ alkoxy carbonyl, C$_{1-5}$ alkylaminocarbonyl, C$_{1-5}$ alkylcarbonyloxy, C$_{3-8}$ cycloalkyl, oxo, amino, C$_{1-3}$ alkylamino, amino C$_{1-3}$ alkyl, arylaminocarbonyl, aryl C$_{1-5}$ alkylaminocarbonyl, aminocarbonyl, aminocarbonyl C$_{1-4}$ alkyl, hydroxycarbonyl, or hydroxycarbonyl C$_{1-5}$ alkyl,
HC≡C(CH₂)ᵣ⁻,  
C₁₋₆ alkyl-C≡C(CH₂)ᵣ⁻,  
C₃₋₇ cycloalkyl-C≡C(CH₂)ᵣ⁻,  
aryl-C≡C(CH₂)ᵣ⁻,  
C₁₋₆ alkylaryl-C≡C(CH₂)ᵣ⁻,  
H₂C≡CH(CH₂)ᵣ⁻,  
C₁₋₆ alkyl-CH≡CH(CH₂)ᵣ⁻,  
C₃₋₇ cycloalkyl-CH≡CH(CH₂)ᵣ⁻,  
aryl-CH≡CH(CH₂)ᵣ⁻,  
C₁₋₆ alkylaryl-CH≡CH(CH₂)ᵣ⁻,  
C₁₋₆ alkyl-SO₂(CH₂)ᵣ⁻,  
C₁₋₆ alkylaryl-SO₂(CH₂)ᵣ⁻,  
C₁₋₆ alkoxy,  
aryl C₁₋₆ alkoxy,  
artryl C₁₋₆ alkyl,  
C₁₋₆ alkylamino C₁₋₆ alkyl,  
arlylamino,  
arlylamino C₁₋₆ alkyl,  
arlyl C₁₋₆ alkylamino,  
aryl C₁₋₆ alkylamino,  
arlyl C₁₋₆ alkylamino C₁₋₆ alkyl,  
arlylcarbynoxyloxy,  
arlyl C₁₋₆ alkylcarbynoxyloxy,  
C₁₋₆ dialkylamino,  
C₁₋₆ dialkylamino C₁₋₆ alkyl,  
C₁₋₆ alkylaminocarbynoxyloxy,  
C₁₋₈ alkylsulfonlamino,  
C₁₋₈ alkylsulfonylamino C₁₋₆ alkyl,  
arlylsulfonlamino C₁₋₆ alkyl,  
arlyl C₁₋₆ alkylsulfonlamino,  
arlyl C₁₋₆ alkylsulfonlamino C₁₋₆ alkyl,  
C₁₋₈ alkoxybarbynoxyloxy,  
C₁₋₈ alkoxybarbynoxyloxy C₁₋₈ alkyl,  
arlyloxybarbynoxyloxy C₁₋₈ alkyl,  
arlyl C₁₋₈ alkoxybarbynoxyloxy,
aryl C_{1-8} alkoxy carbonylamino C_{1-8} alkyl, C_{1-8} alkyl carbonylamino, C_{1-8} alkyl carbonylamino C_{1-6} alkyl, aryl carbonylamino C_{1-6} alkyl, aryl C_{1-6} alkyl carbonylamino, aryl C_{1-6} alkyl carbonylamino C_{1-6} alkyl, aminocarbonylamino C_{1-6} alkyl, C_{1-8} alkylaminocarbonylamino, C_{1-8} alkylaminocarbonylamino C_{1-6} alkyl, arylaminocarbonylamino C_{1-6} alkyl, aryl C_{1-8} alkylaminocarbonylamino, aryl C_{1-8} alkylaminocarbonylamino C_{1-6} alkyl, aminosulfonylamino C_{1-6} alkyl, C_{1-8} alkylaminosulfonylamino, C_{1-8} alkylaminosulfonylamino C_{1-6} alkyl, arylaminosulfonylamino C_{1-6} alkyl, arylaminosulfonylamino C_{1-6} alkyl, aryl C_{1-8} alkylaminosulfonylamino, aryl C_{1-8} alkylaminosulfonylamino C_{1-6} alkyl, C_{1-6} alkylsulfonyl, C_{1-6} alkylsulfonyl C_{1-6} alkyl, arylsulfonyl C_{1-6} alkyl, aryl C_{1-6} alkyl sulfonyl, aryl C_{1-6} alkyl sulfonyl C_{1-6} alkyl, aryl C_{1-6} alkyl carbonyl, C_{1-6} alkyl carbonyl C_{1-6} alkyl, aryl carbonyl C_{1-6} alkyl, aryl C_{1-6} alkyl carbonyl, aryl C_{1-6} alkyl carbonyl C_{1-6} alkyl, C_{1-6} alkyl thiocarbonylamino, C_{1-6} alkyl thiocarbonylamino C_{1-6} alkyl, aryl thiocarbonylamino C_{1-6} alkyl, aryl C_{1-6} alkyl thiocarbonylamino, aryl C_{1-6} alkyl thiocarbonylamino C_{1-6} alkyl, C_{1-8} alkylaminocarbonyl C_{1-6} alkyl,
arylaminocarbonyl C\textsubscript{1-6} alkyl,
aryl C\textsubscript{1-8} alkylaminocarbonyl,
aryl C\textsubscript{1-8} alkylaminocarbonyl C\textsubscript{1-6} alkyl,
C\textsubscript{7-20} polycycyl C\textsubscript{0-8} alkysulfonlamino C\textsubscript{0-6} alkyl,
5 C\textsubscript{7-20} polycycyl C\textsubscript{0-8} alkylcarbonylamino C\textsubscript{0-6} alkyl,
C\textsubscript{7-20} polycycyl C\textsubscript{0-8} alkylaminosulfonlamino C\textsubscript{0-6} alkyl,
C\textsubscript{7-20} polycycyl C\textsubscript{0-8} alkylaminocarbonylamino C\textsubscript{0-6} alkyl, or
C\textsubscript{7-20} polycycyl C\textsubscript{0-8} alkyloxycarbonylamino C\textsubscript{0-6} alkyl
wherein the alkyl or N atoms may be unsubstituted or
substituted with one or more substituents selected from R\textsubscript{21} and
R\textsubscript{22}, wherein the polycycyl may be unsubstituted or substituted
with R\textsubscript{31}, R\textsubscript{32}, R\textsubscript{33} and R\textsubscript{34}, and provided that the carbon atom to
which R\textsubscript{10} and R\textsubscript{11} are attached is itself attached to no more than
one heteroatom; or R\textsubscript{10} and R\textsubscript{11} are combined to form oxo, in
which case the carbon atom to which R\textsubscript{10} and R\textsubscript{11} are attached
can itself be attached to more than one heteroatom;

R\textsubscript{12} is selected from
hydroxy,
C\textsubscript{1-8} alkoxy,
aryl C\textsubscript{0-6} alkoxy,
C\textsubscript{1-8} alkylcarbonyloxy C\textsubscript{1-4} alkoxy,
aryl C\textsubscript{0-8} alkylcarbonyloxy C\textsubscript{1-4} alkoxy,
C\textsubscript{1-6} dialkylaminocarbonylmethyloxy,
25 aryl C\textsubscript{1-6} dialkylaminocarbonylmethyloxy or
an L- or D-amino acid joined by an amide linkage and
wherein the carboxylic acid moiety of said amino acid
is as the free acid or is esterified by C\textsubscript{1-6} alkyl; and

30 R\textsubscript{13}, R\textsubscript{14}, R\textsubscript{15} and R\textsubscript{16} are each independently selected from
hydrogen,
C\textsubscript{1-10} alkyl,
aryl C\textsubscript{0-8} alkyl,
thio,
amino C0-8 alkyl,
C1-3 acylamino C0-8 alkyl,
C1-6 alkylamino C0-8 alkyl,
C1-6 dialkylamino C0-8 alkyl,
aryl C0-6 alkylamino C0-6 alkyl,
C1-4 alkoxyamino C0-8 alkyl,
hydroxy C1-6 alkylamino C0-8 alkyl,
C1-4 alkoxy C0-6 alkyl,
carboxy C0-6 alkyl,
C1-4 alkoxy carbonyl C0-6 alkyl,
carboxy C0-6 alkyloxy,
hydroxy C1-6 alkylamino C0-6 alkyl,
hydroxy C0-6 alkyl,
\[ \text{oxo;} \]
provided that Ring is not a 6-membered monocyclic aromatic ring;
provided further that when Ring is thiophene, then X is selected from
\[ \text{or} \]
provided further that when Ring is selected from isoxazole, isoxazoline, imidazole, imidazoline, benzofuran, benzothiophene, benzimidazole, indole, benzothiazole, benzoxazole,

then X is selected from

and the pharmaceutically acceptable salts thereof.

In one embodiment of the invention is the compound

wherein Y is selected from

C₀-₈ alkylene,
C₃-₁₀ cycloalkyl,
C₀-₈ alkylene-NR⁵-C₀-₈ alkylene,
C₀-₈ alkylene-CONR⁵-C₀-₈ alkylene,
C₀-₈ alkylene-O-C₀-₈ alkylene,
C₀-₈ alkylene-NR⁵-C₀-₈ alkylene,
C₀-₈ alkylene-S(O)₀-₂-C₀-₈ alkylene,
C₀-₈ alkylene-SO₂-NR⁵-C₀-₈ alkylene,
C₀-₈ alkylene-NR⁵-SO₂-C₀-₈ alkylene,
(CH₂)₀-₆ aryl(CH₂)₀-₆,
(CH₂)₀-₆ aryl-CO-(CH₂)₀-₆,
(CH₂)₀-₆ aryl-CO-NH-(CH₂)₀-₆, or
OH

(CH$_2$)$_{0.8}$CH(CH$_2$)$_{0.8}$

Z is (CH$_2$)$_m$ where $m$ is an integer from 0 to 3; preferably, $m$ is zero; and all other variables are as defined above; and the pharmaceutically acceptable salts thereof.

In a class of the invention is the compound of the formula

X-Y-Ring-A-B

wherein Ring is selected from

![Chemical structures]

X is selected from

- NR$^2$, NR$^2$, NR$^2$,
- NR$^1$R$^2$, -NR$^1$-C-R$^3$, -C-NHR$^4$, -NR$^1$-C-NR$^3$R$^4$,
- phenyl-NR$^1$R$^2$, -phenyl-C-NR$^2$R$^3$, -phenyl-NR$^1$-C-NR$^3$R$^4$,
Y is selected from
5
- C0-8 alkylene,
- C0-8 alkylene-NR5.CO-C0-8 alkylene,
- C0-8 alkylene-CO-NR5-C0-8 alkylene,
- C0-8 alkylene-O-C0-8 alkylene,
- C0-8 alkylene-NR5-C0-8 alkylene,
- C0-8 alkylene-S(O)-O-C0-8 alkylene,
- C0-8 alkylene-SO2-NR5-C0-8 alkylene,
- C0-8 alkylene-NR5-SO2-C0-8 alkylene or
- (CH2)0-6 aryl(CH2)0-6;

A is selected from

\[
\begin{align*}
O(CH_2)_p, & \quad NR^6(CH_2)_p, & \quad CNR^{29}(CH_2)_p, & \quad NR^{29}C(CH_2)_p, & \quad C(CH_2)_p, \\
SO_2(CH_2)_p, & \quad SO_2NR^{29}(CH_2)_p, & \quad NR^{29}SO_2(CH_2)_p & \quad or & \quad C≡C-(CH_2)_p;
\end{align*}
\]

where p is an integer from 0 to 3;

R1, R2, R3, R4, R5, R6, R17, R18, R19, R20, R23, R24, R25, R26, R27 and
R29 are each independently selected from
hydrogen,
C1-10 alkyl,
aryl C0-8 alkyl,
5 amino C0-8 alkyl,

C1-3 acylamino C0-8 alkyl,
C1-6 alkylamino C0-8 alkyl,
C1-6 dialkylamino C0-8 alkyl,
C1-4 alkoxy C0-6 alkyl,
10 carboxy C0-6 alkyl,

\[ NR^{17} \]
\[ NR^{18} R^{19} \], or
\[ NR^{18} \]
\[ -NR^{17} R^{19} R^{20} \];

15 \( R^8, R^9, R^{10}, \) and \( R^{11} \) are each independently selected from
hydrogen,
fluorine,
C1-8 alkyl,
hydroxyl,
20 C3-8 cycloalkyl,
aryl C0-6 alkyl,
C0-6 alkylamino C0-6 alkyl,
C0-6 dialkylamino C0-6 alkyl,
C1-8 alkylsulfonlamino C0-6 alkyl,
25 aryl C0-6 alkylsulfonlamino C0-6 alkyl,
C1-8 alkylxycarbonylamino C0-8 alkyl,
aryl C0-8 alkylxycarbonylamino C0-8 alkyl,
C1-8 alkylcarbonylamino C0-6 alkyl,
aryl C0-6 alkylcarbonylamino C0-6 alkyl,
C0-8 alkylaminocarbonylamino C0-6 alkyl,
aryl C0-8 alkylaminocarbonylamino C0-6 alkyl,
C0-8 alkylaminosulfonylamino C0-6 alkyl,
aryl C0-8 alkylaminosulfonylamino C0-6 alkyl,
5 C1-6 alkylsulfonyl C0-6 alkyl,
C1-6 alkylcarbonyl C0-6 alkyl or
aryl C0-6 alkylcarbonyl C0-6 alkyl;

R12 is selected from
10 hydroxy,
C1-8 alkyloxy,
aryl C0-6 alkyloxy,
C1-8 alkylcarbonyloxy C1-4 alkyloxy or
aryl C0-8 alkylcarbonyloxy C1-4 alkyloxy;
15 R13, R14, R15 and R16 are each independently selected from
hydrogen,
C1-10 alkyl,
aryl C0-8 alkyl,
20 amino C0-8 alkyl,
C1-3 acylamino C0-8 alkyl,
C1-6 alkylamino C0-8 alkyl,
C1-6 dialkylamino C0-8 alkyl,
C1-4 alkoxy C0-6 alkyl,
25 carboxy C0-6 alkyl,
C1-4 alkoxy carbonyl C0-6 alkyl,
carboxy C0-6 alkyloxy,
hydroxy C0-6 alkyl,
or

\[ \text{NR}^{23} \text{NR}^{24} \text{R}^{25} \]

\[ \text{or } \text{R}^{13}, \text{R}^{14}, \text{R}^{15} \text{ and } \text{R}^{16} \text{ are combined to form oxo; } \]

provided that when Ring is

\[ \begin{array}{c}
\text{R}^{27} \\
\end{array} \]

or

\[ \begin{array}{c}
\text{R}^{27} \\
\end{array} \]

5 then X is selected from

\[ \begin{array}{c}
\text{R}^{13} \text{S} \\
\end{array} \]

\[ \text{or } \text{R}^{13} \text{N} \]

and all other variables are as defined above;

and the pharmaceutically acceptable salts thereof.

In a subclass of the invention is the compound wherein X is

10 selected from

-21-
and all other variables are as defined above; and the pharmaceutically acceptable salts thereof.

Illustrative of the invention is the compound of the formula

\[
\begin{align*}
X &- Y - \text{Ring} \\
&- \begin{array}{c}
\text{N} \\
\text{H}
\end{array} \\
&- R^8 \\
&- \begin{array}{c}
\text{O} \\
\text{O}
\end{array} \\
&- R^{12}
\end{align*}
\]

wherein \(X\) is selected from

\[
\begin{align*}
&\begin{array}{c}
\text{N} \\
\text{H}
\end{array} \\
&- R^{13} \\
&- \begin{array}{c}
\text{N} \\
\text{H}
\end{array} \\
&- R^{13} \\
&- \begin{array}{c}
\text{N} \\
\text{H}
\end{array} \\
&- \begin{array}{c}
\text{N} \\
\text{H}
\end{array}
\end{align*}
\]

and

\[
\begin{align*}
&- R^{13}
\end{align*}
\]

\(Y\) is selected from

- \(C_0-8\) alkylene,
- \(C_0-8\) alkylene-\(NR^5\)-\(C_0-8\) alkylene; and

\(R^{12}\) is selected from

- hydroxy or
- \(C_1-8\) alkylloxy;
and all other variables are as defined above;
and the pharmaceutically acceptable salts thereof.

Exemplifying the invention is the compound selected from

5

[6-(5,6,7,8-Tetrahydro-[1,8]-naphthyridin-2-yl)naphthyl-2-yl]carbonyl-2(S)-phenylsulfonlamino-β-alanine ethyl ester;

[6-(5,6,7,8-Tetrahydro-[1,8]-naphthyridin-2-yl)naphthyl-2-yl]carbonyl-2(S)-phenylsulfonlamino-β-alanine;

6-([N-Pyridin-2-yl)aminomethyl]naphthyl-2-yl)carbonyl-2(S)-phenylsulfonlamino-β-alanine ethyl ester;

10 6-([N-Pyridin-2-yl)aminomethyl]naphthyl-2-yl)carbonyl-2(S)-phenylsulfonlamino-β-alanine;

4-(5,6,7,8-Tetrahydro-[1,8]naphthyridin-2-yl)piperidin-1-yl-carbonyl-2(S)-phenylsulfonlamino-β-alanine t-butyl ester;

15 4-(5,6,7,8-Tetrahydro-[1,8]naphthyridin-2-yl)piperidin-1-yl-carbonyl-2(S)-phenylsulfonlamino-β-alanine;

6-([Pyrimidiny1-2-yl)aminomethyl]naphthyl-2-yl)carbonyl-2(S)-phenylsulfonlamino-β-alanine ethyl ester;

6-([Pyrimidiny1-2-yl)aminomethyl]naphthyl-2-yl)carbonyl-2(S)-phenylsulfonlamino-β-alanine; or

20 6-([1,4,5,6-Tetrahydropyrimidiny1-2-yl)aminomethyl]naphthyl-2-yl)carbonyl-2(S)-phenylsulfonlamino-β-alanine;

and the pharmaceutically acceptable salts thereof.

Preferably, the compound is selected from
[6-(5,6,7,8-Tetrahydro-[1,8]-naphthyridin-2-yl)naphthyl-2-yl-carbonyl-
2(S)-phenylsulfonylamino-β-alanine;]

6-([N-Pyridin-2-yl)aminomethyl)naphthyl-2-yl)carbonyl-2(S)-
phenylsulfonylamino-β-alanine;}

4-(5,6,7,8-Tetrahydro-[1,8]naphthyridin-2-yl)piperidin-1-yl-carbonyl-2(S)-
phenylsulfonylamino-β-alanine; or

6-[(Pyrimidinyl-2-yl)aminomethyl]naphthyl-2-yl-carbonyl-2(S)-
phenylsulfonyl-β-alanine;

and the pharmaceutically acceptable salts thereof.

Exemplifying the invention is a pharmaceutical
composition comprising any of the compounds described above and a
pharmaceutically acceptable carrier. An example of the invention is a
pharmaceutical composition made by combining any of the compounds
described above and a pharmaceutically acceptable carrier. An
illustration of the invention is a process for making a pharmaceutical
composition comprising combining any of the compounds described
above and a pharmaceutically acceptable carrier.

Further illustrating the invention is a method of treating
and/or preventing a condition mediated by antagonism of a vitronectin
receptor in a mammal in need thereof, comprising administering to the
mammal a therapeutically effective amount of any of the compounds
described above. Preferably, the condition is selected from bone
resorption, osteoporosis, restenosis, diabetic retinopathy, macular
degeneration, angiogenesis, atherosclerosis, inflammation, cancer and
tumor growth. More preferably, the condition is selected from
osteoporosis and cancer. Most preferably, the condition is osteoporosis.

More specifically exemplifying the invention is a method of
eliciting a vitronectin antagonizing effect in a mammal in need thereof,
comprising administering to the mammal a therapeutically effective
amount of any of the compounds or any of the pharmaceutical
compositions described above. Preferably, the vitronectin antagonizing
- 24 -
effect is an $\alpha\nu\beta 3$ antagonizing effect; more specifically the $\alpha\nu\beta 3$
an antagonizing effect is selected from inhibition of bone resorption, inhibition
of restenosis, inhibition of atherosclerosis, inhibition of angiogenesis, inhibition
of diabetic retinopathy, inhibition of macular
degeneration, inhibition of inflammation or inhibition of tumor growth. Most
preferably, the $\alpha\nu\beta 3$ antagonizing effect is inhibition of bone
resorption. Alternatively, the vitronectin antagonizing effect is an $\alpha\nu\beta 5$
antagonizing effect or a dual $\alpha\nu\beta 3/\alpha\nu\beta 5$ antagonizing effect. Examples
of $\alpha\nu\beta 5$ antagonizing effects are inhibition of:
restenosis, atherosclerosis, angiogenesis, diabetic retinopathy, macular
degeneration, inflammation or tumor growth. Examples of dual
$\alpha\nu\beta 3/\alpha\nu\beta 5$ antagonizing effects are inhibition of:
bone resorption, restenosis, atherosclerosis, angiogenesis, diabetic retinopathy, macular
degeneration, inflammation or tumor growth.

Additional examples of the invention are methods of
inhibiting bone resorption and of treating and/or preventing osteoporosis
in a mammal in need thereof, comprising administering to the
mammal a therapeutically effective amount of any of the compounds or
any of the pharmaceutical compositions described above.

More specifically exemplifying the invention is any of the
compositions described above, further comprising a therapeutically
effective amount of a second bone resorption inhibitor; preferably, the
second bone resorption inhibitor is alendronate.

More particularly illustrating the invention is any of the
methods of treating and/or preventing osteoporosis and/or of inhibiting
bone resorption described above, wherein the compound is administered
in combination with a second bone resorption inhibitor; preferably, the
second bone resorption inhibitor is alendronate.

Additional illustrations of the invention are methods of
treating hypercalcemia of malignancy, osteopenia due to bone
metastases, periodontal disease, hyperparathyroidism, periarticular
erosions in rheumatoid arthritis, Paget's disease, immobilization-
induced osteopenia, and glucocorticoid treatment in a mammal in need
thereof, comprising administering to the mammal a therapeutically
effective amount of any of the compounds or any of the pharmaceutical compositions described above.

More particularly exemplifying the invention is the use of any of the compounds described above in the preparation of a medicament for the treatment and/or prevention of osteoporosis in a mammal in need thereof. Still further exemplifying the invention is the use of any of the compounds described above in the preparation of a medicament for the treatment and/or prevention of: bone resorption, tumor growth, cancer, restenosis, artherosclerosis, diabetic retinopathy and/or angiogenesis.

Another illustration of the invention is a drug which is useful for treating and/or preventing osteoporosis in a mammal in need thereof, the effective ingredient of the said drug being any of the compounds described above. More specifically illustrating the invention is a drug which is useful for treating and/or preventing: bone resorption, tumor growth, cancer, restenosis, artherosclerosis, diabetic retinopathy and/or angiogenesis in a mammal in need thereof, the effective ingredient of the said drug being any of the compounds described above.

Additional illustrations of the invention are methods of treating tumor growth in a mammal in need thereof, comprising administering to the mammal a therapeutically effective amount of a compound described above and one or more agents known to be cytotoxic or antiproliferative, e.g., taxol and doxorubicin.

DETAILED DESCRIPTION OF THE INVENTION

Representative compounds of the present invention are ανβ3 antagonists which display submicromolar affinity for the human ανβ3 receptor. Compounds of this invention are therefore useful for treating mammals suffering from a bone condition caused or mediated by increased bone resorption, who are in need of such therapy. Pharmacologically effective amounts of the compounds, including pharamaceutically acceptable salts thereof, are administered to the mammal, to inhibit the activity of mammalian osteoclasts.
The compounds of the present invention are administered in dosages effective to antagonize the ανβ3 receptor where such treatment is needed, as, for example, in the prevention or treatment of osteoporosis. For use in medicine, the salts of the compounds of this invention refer to non-toxic "pharmaceutically acceptable salts." Other salts may, however, be useful in the preparation of the compounds according to the invention or of their pharmaceutically acceptable salts. Salts encompassed within the term "pharmaceutically acceptable salts" refer to non-toxic salts of the compounds of this invention which are generally prepared by reacting the free base with a suitable organic or inorganic acid. Representative salts include the following:

Acetate, Benzenesulfonate, Benzoate, Bicarbonate, Bisulfate, Bitartrate, Borate, Bromide, Calcium, Camsylate, Carbonate, Chloride, Clavulanate, Citrate, Dihydrochloride, Edetate, Edisylate, Estolate, Esylate, Fumarate, Gluceptate, Gluconate, Gluconate, Glutamate, Glycollylarsanilate, Hexylresorcinolate, Hydramine, Hydrobromide, Hydrochloride, Hydroxynaphtoate, Iodide, Isothionate, Lactate, Lactobionate, Laurate, Maleate, Mandelate, Mesylate, Methyl bromide, Methyl nitrate, Methylsulfate, Mucate, Napsylate, Nitrate, N-methylglucamine ammonium salt, Oleate, Oxalate, Pamoate (Embionate), Palmitate, Pantothenate, Phosphate/diphosphate, Polygalacturonate, Salicylate, Stearate, Sulfate, Subacetate, Succinate, Tannate, Tartrate, Teoclate, Tosylate, Triethiodide and Valerate. Furthermore, where the compounds of the invention carry an acidic moiety, suitable pharmaceutically acceptable salts thereof may include alkali metal salts, e.g., sodium or potassium salts; alkaline earth metal salts, e.g., calcium or magnesium salts; and salts formed with suitable organic ligands, e.g., quaternary ammonium salts.

The compounds of the present invention, may have chiral centers and occur as racemates, racemic mixtures and as individual diastereomers, or enantiomers with all isomeric forms being included in the present invention. Therefore, where a compound is chiral, the separate enantiomers, substantially free of the other, are included within the scope of the invention; further included are all mixtures of
the two enantiomers. Also included within the scope of the invention are polymorphs and hydrates of the compounds of the instant invention.

The present invention includes within its scope prodrugs of the compounds of this invention. In general, such prodrugs will be functional derivatives of the compounds of this invention which are readily convertible in vivo into the required compound. Thus, in the methods of treatment of the present invention, the term "administering" shall encompass the treatment of the various conditions described with the compound specifically disclosed or with a compound which may not be specifically disclosed, but which converts to the specified compound in vivo after administration to the patient. Conventional procedures for the selection and preparation of suitable prodrug derivatives are described, for example, in "Design of Prodrugs," ed. H. Bundgaard, Elsevier, 1985. Metabolites of these compounds include active species produced upon introduction of compounds of this invention into the biological milieu.

The term "therapeutically effective amount" shall mean that amount of a drug or pharmaceutical agent that will elicit the biological or medical response of a tissue, system, animal or human that is being sought by a researcher or clinician.

The term "bone resorption," as used herein, refers to the process by which osteoclasts degrade bone.

The term "alkyl" shall mean straight or branched chain alkanes of one to ten total carbon atoms, or any number within this range (i.e., methyl, ethyl, 1-propyl, 2-propyl, n-butyl, s-butyl, t-butyl, etc.).

The term "alkenyl" shall mean straight or branched chain alkenes of two to ten total carbon atoms, or any number within this range.

The term "alkynyl" shall mean straight or branched chain alkynes of two to ten total carbon atoms, or any number within this range.

The term "cycloalkyl" shall mean cyclic rings of alkanes of three to eight total carbon atoms, or any number within this range (i.e., cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl or cyclooctyl).
The term "alkoxy," as used herein, refers to straight or branched chain alkoxides of the number of carbon atoms specified (e.g., C1-5 alkoxy), or any number within this range (i.e., methoxy, ethoxy, etc.).

The term "aryl," as used herein, refers to a monocyclic or polycyclic system composed of 5- and 6-membered fully unsaturated or partially unsaturated rings, such that the system comprises at least one fully unsaturated ring, wherein the rings contain 0, 1, 2, 3 or 4 heteroatoms chosen from N, O or S, and either unsubstiuted or substituted with one or more groups independently selected from hydrogen, halogen, C1-10 alkyl, C3-8 cycloalkyl, aryl, aryl C1-8 alkyl, amino, amino C1-8 alkyl, C1-3 acylamino, C1-3 acylamino C1-8 alkyl, C1-6 alkylamino, C1-6 alkylamino C1-8 alkyl, C1-6 dialkylamino, C1-6 dialkylamino C1-8 alkyl, C1-4 alkoxy, C1-4 alkoxy C1-6 alkyl, hydroxycarbonyl, hydroxycarbonyl C1-6 alkyl, C1-5 alkoxy carbonyl, C1-3 alkoxy carbonyl C1-6 alkyl, hydroxycarbonyl C1-6 alkyl, hydroxy, hydroxy C1-6 alkyl, cyano, trifluoromethyl, oxo or C1-5 alkylcarbonyloxy. Examples of aryl include, but are not limited to, phenyl, naphthyl, pyridyl, pyrazinyl, pyrimidinyl, benzimidazolyl, indolyl, thienyl, furyl, dihydrobenzofuryl, benzo(1,3) dioxolane, oxazolyl, isoxazolyl and thiazolyl, which are either unsubstituted or substituted with one or more groups independently selected from hydrogen, halogen, C1-10 alkyl, C3-8 cycloalkyl, aryl, aryl C1-8 alkyl, amino, amino C1-8 alkyl, C1-3 acylamino, C1-3 acylamino C1-8 alkyl, C1-6 alkylamino, C1-6 alkylamino C1-8 alkyl, C1-6 dialkylamino, C1-6 dialkylamino C1-8 alkyl, C1-4 alkoxy, C1-4 alkoxy C1-6 alkyl, hydroxycarbonyl, hydroxycarbonyl C1-6 alkyl, C1-5 alkoxy carbonyl, C1-3 alkoxy carbonyl C1-6 alkyl, hydroxycarbonyl C1-6 alkyl, hydroxycarbonyl C1-6 alkyl, hydroxy, hydroxy C1-6 alkyl, cyano, trifluoromethyl, oxo or C1-5 alkylcarbonyloxy. Preferably, the aryl group is unsubstituted, mono-, di-, tri- or tetra-substituted with one to four of the above-named substituents; more preferably, the aryl group is unsubstituted, mono-, di- or tri-substituted with one to three of the above-named substituents; most preferably, the aryl group is unsubstituted, mono- or di-substituted with one to two of the above-named substituents.
Whenever the term "alkyl" or "aryl" or either of their prefix roots appear in a name of a substituent (e.g., aryl C\textsubscript{0-8} alkyl) it shall be interpreted as including those limitations given above for "alkyl" and "aryl." Designated numbers of carbon atoms (e.g., C\textsubscript{1-10}) shall refer independently to the number of carbon atoms in an alkyl or cyclic alkyl moiety or to the alkyl portion of a larger substituent in which alkyl appears as its prefix root.

The terms "arylalkyl" and "alkylaryl" include an alkyl portion where alkyl is as defined above and to include an aryl portion where aryl is as defined above. The C\textsubscript{0-m} or C\textsubscript{1-m} designation where m may be an integer from 1-10 or 2-10 respectively refers to the alkyl component of the arylalkyl or alkylaryl unit. Examples of arylalkyl include, but are not limited to, benzyl, fluorobenzyl, chlorobenzyl, phenylethyl, phenylpropyl, fluorophenylethyl, chlorophenylethyl, thienylmethyl, thienylethyl, and thienylpropyl. Examples of alkylaryl include, but are not limited to, toluene, ethylbenzene, propylbenzene, methylpyridine, ethylpyridine, propylpyridine and butylpyridine.

When substituent Y, B, R\textsuperscript{1} to R\textsuperscript{28} includes the definition C\textsubscript{0} (e.g., aryl C\textsubscript{0-8} alkyl), the group modified by C\textsubscript{0} is not present in the substituent. Similarly, when any of the variables m, q, r or s is zero, then the group modified by the variable is not present; for example, when s is zero, the group "-(CH\textsubscript{2})\textsubscript{s} C=CH" is "-C=CH".

The term "halogen" shall include iodine, bromine, chlorine and fluorine.

The term "oxy" means an oxygen (O) atom. The term "thio" means a sulfur (S) atom. The term "oxo" shall mean =O.

The term "substituted" shall be deemed to include multiple degrees of substitution by a named substituent. Where multiple substituent moieties are disclosed or claimed, the substituted compound can be independently substituted by one or more of the disclosed or claimed substituent moieties, singly or plurally.

Under standard nonmenclature used throughout this disclosure, the terminal portion of the designated side chain is described first, followed by the adjacent functionality toward the point of
attachment. For example, a C_{1-5} alkylcarbonylamino C_{1-6} alkyl substituent is equivalent to

\[
\text{attachment. For example, a C}_{1-5} \text{ alkylcarbonylamino C}_{1-6} \text{ alkyl substituent is equivalent to}
\]

\[
\begin{align*}
\text{attachment: } & \quad \text{For example, a } C_{1-5} \text{ alkylcarbonylamino } C_{1-6} \text{ alkyl substituent is equivalent to} \\
& \quad \text{The present invention is also directed to combinations of the} \\
& \quad \text{compounds of the present invention with one or more agents useful in} \\
& \quad \text{the prevention or treatment of osteoporosis. For example, the} \\
& \quad \text{compounds of the instant invention may be effectively administered in} \\
& \quad \text{combination with effective amounts of other agents used in the} \\
& \quad \text{treatment of osteoporosis such as bisphosphonate bone resorption} \\
& \quad \text{inhibitors; preferably, the bone resorption inhibitor is the} \\
& \quad \text{bisphosphonate alendronate, now sold as FOSAMAX®. Preferred} \\
& \quad \text{combinations are simultaneous or alternating treatments of an } \alpha\nu\beta3 \\
& \quad \text{receptor antagonist of the present invention and FOSAMAX®. In} \\
& \quad \text{accordance with the method of the present invention, the individual} \\
& \quad \text{components of the combination can be administered separately at} \\
& \quad \text{different times during the course of therapy or concurrently in divided} \\
& \quad \text{or single combination forms. The instant invention is therefore to be} \\
& \quad \text{understood as embracing all such regimes of simultaneous or} \\
& \quad \text{alternating treatment and the term "administering" is to be interpreted} \\
& \quad \text{accordingly. It will be understood that the scope of combinations of the} \\
& \quad \text{compounds of this invention with other agents useful for treating } \alpha\nu\beta3 \\
& \quad \text{related conditions includes in principle any combination with any} \\
& \quad \text{pharmaceutical composition useful for treating osteoporosis.} \\
& \quad \text{As used herein, the term "composition" is intended to} \\
& \quad \text{encompass a product comprising the specified ingredients in the} \\
& \quad \text{specified amounts, as well as any product which results, directly or} \\
& \quad \text{indirectly, from combination of the specified ingredients in the specified} \\
& \quad \text{amounts.} \\
& \quad \text{The compounds of the present invention can be} \\
& \quad \text{administered in such oral dosage forms as tablets, capsules (each of} \\
& \quad \text{which includes sustained release or timed release formulations), pills,} \\
& \quad \text{powders, granules, elixers, tinctures, suspensions, syrups and}
\end{align*}
\]

- 31 -
emulsions. Likewise, they may also be administered in intravenous (bolus or infusion), intraperitoneal, subcutaneous, intramuscular or transdermal (e.g., patch) form, topical (e.g., ocular eyedrop) all using forms well known to those of ordinary skill in the pharmaceutical arts.

An effective but non-toxic amount of the compound desired can be employed as an \( \alpha \nu \beta 3 \) inhibitor.

The dosage regimen utilizing the compounds of the present invention is selected in accordance with a variety of factors including type, species, age, weight, sex and medical condition of the patient; the severity of the condition to be treated; the route of administration; the renal and hepatic function of the patient; and the particular compound or salt thereof employed. An ordinarily skilled physician, veterinarian or clinician can readily determine and prescribe the effective amount of the drug required to prevent, counter or arrest the progress of the condition.

Oral dosages of the present invention, when used for the indicated effects, will range between about 0.01 mg per kg of body weight per day (mg/kg/day) to about 100 mg/kg/day, preferably 0.01 to 10 mg/kg/day, and most preferably 0.1 to 5.0 mg/kg/day. For oral administration, the compositions are preferably provided in the form of tablets containing 0.01, 0.05, 0.1, 0.5, 1.0, 2.5, 5.0, 10.0, 15.0, 25.0, 50.0, 100 and 500 milligrams of the active ingredient for the symptomatic adjustment of the dosage to the patient to be treated. A medicament typically contains from about 0.01 mg to about 500 mg of the active ingredient, preferably, from about 1 mg to about 100 mg of active ingredient. Intravenously, the most preferred doses will range from about 0.1 to about 10 mg/kg/minute during a constant rate infusion. Advantageously, compounds of the present invention may be administered in a single daily dose, or the total daily dosage may be administered in divided doses of two, three or four times daily. Furthermore, preferred compounds for the present invention can be administered in intranasal form via topical use of suitable intranasal vehicles, or via transdermal routes, using those forms of transdermal skin patches well known to those of ordinary skill in the art. To be administered in the form of a transdermal delivery system, the dosage
administration will, of course, be continuous rather than intermittent throughout the dosage regimen.

In the methods of the present invention, the compounds herein described in detail can form the active ingredient, and are typically administered in admixture with suitable pharmaceutical diluents, excipients or carriers (collectively referred to herein as 'carrier' materials) suitably selected with respect to the intended form of administration, that is, oral tablets, capsules, elixirs, syrups and the like, and consistent with conventional pharmaceutical practices.

For instance, for oral administration in the form of a tablet or capsule, the active drug component can be combined with an oral, non-toxic, pharmaceutically acceptable, inert carrier such as lactose, starch, sucrose, glucose, methyl cellulose, magnesium stearate, dicalcium phosphate, calcium sulfate, mannitol, sorbitol and the like; for oral administration in liquid form, the oral drug components can be combined with any oral, non-toxic, pharmaceutically acceptable inert carrier such as ethanol, glycerol, water and the like. Moreover, when desired or necessary, suitable binders, lubricants, disintegrating agents and coloring agents can also be incorporated into the mixture. Suitable binders include starch, gelatin, natural sugars such as glucose or beta-lactose, corn sweeteners, natural and synthetic gums such as acacia, tragacanth or sodium alginate, carboxymethylcellulose, polyethylene glycol, waxes and the like. Lubricants used in these dosage forms include sodium oleate, sodium stearate, magnesium stearate, sodium benzoate, sodium acetate, sodium chloride and the like. Disintegrators include, without limitation, starch, methyl cellulose, agar, bentonite, xanthan gum and the like.

The compounds of the present invention can also be administered in the form of liposome delivery systems, such as small unilamellar vesicles, large unilamellar vesicles and multilamellar vesicles. Liposomes can be formed from a variety of phospholipids, such as cholesterol, stearylamine or phosphatidylcholines.

Compounds of the present invention may also be delivered by the use of monoclonal antibodies as individual carriers to which the compound molecules are coupled. The compounds of the present
invention may also be coupled with soluble polymers as targetable drug carriers. Such polymers can include polyvinylpyrrolidone, pyran copolymer, polyhydroxypropylmethacrylamide-phenol, polyhydroxy-ethylaspartamide-phenol, or polyethyleneoxide-polylysine substituted with palmitoyl residues. Furthermore, the compounds of the present invention may be coupled to a class of biodegradable polymers useful in achieving controlled release of a drug, for example, polylactic acid, polyglycolic acid, copolymers of polyactic and polyglycolic acid, polyeptilon caprolactone, polyhydroxy butyric acid, polyorthoesters, polyacetals, polydihydropyrans, polycyanoacrylates and crosslinked or amphipathic block copolymers of hydrogels.

In the schemes and examples below, various reagent symbols and abbreviations have the following meanings:

15 AcOH: Acetic acid.
BH3·DMS: Borane·dimethylsulfide.
BOC or Boc: t-Butyloxycarbonyl.
BOP: Benzotriazol-1-yloxytris(dimethylamino)-phosphonium hexafluorophosphate.

20 CBZ(Cbz): Carbobenzyloxy or benzyloxycarbonyl.
CDI: Carbonyldiimidazole.
CH2Cl2: Methylene chloride.
CHCl3: Chloroform.
DEAD: Diethyl azodicarboxylate.

25 DIAD: Diisopropyl azodicarboxylate.
DIBAH or DIBAL-H: Diisobutylaluminum hydride.
DIPEA: Diisopropylethylamine.
DMAP: 4-Dimethylaminopyridine.

30 DME: 1,2-Dimethoxyethane.
DMF: Dimethylformamide.
DMSO: Dimethylsulfoxide.
DPFN: 3,5-Dimethyl-1-pyrazolylformamidine nitrate.
EDC: 1-(3-Dimethylaminopropyl)-3-ethylcarbodiimide.

35 Et: Ethyl.
EtOAc: Ethyl acetate.
EtOH: Ethanol.
HOAc: Acetic acid.
HOBT: 1-Hydroxybenzotriazole.
LDA: Lithium diisopropylamide.
MeOH: Methanol.
NEt3: Triethylamine.
NMM: N-methylmorphpoline.
PCA-HCl: Pyrazole carboxamidine hydrochloride.
Pd/C: Palladium on activated carbon catalyst.
Ph: Phenyl.
pTSA or TsOH: p-Toluene sulfonic acid.
tBu: tertiary butyl.
TEA: Triethylamine.
TFA: Trifluoroacetic acid.
THF: Tetrahydrofuran.
TLC: Thin Layer Chromatography.
TMEDA: N,N,N',N'-Tetramethylethlenediamine.
TMS: Trimethylsilyl.

The novel compounds of the present invention were prepared according to the procedure of the following schemes and examples, using appropriate materials and are further exemplified by the following specific examples. The most preferred compounds of the invention are any or all of those specifically set forth in these examples. These compounds are not, however, to be construed as forming the only genus that is considered as the invention, and any combination of the compounds or their moieties may itself form a genus. The following examples further illustrate details for the preparation of the compounds of the present invention. Those skilled in the art will readily understand that known variations of the conditions and processes of the following preparative procedures can be used to prepare these compounds. All temperatures are degrees Celsius unless otherwise noted.

The following Schemes and Examples describe procedures for making representative compounds of the present invention.
Moreover, by utilizing the procedures described in detail in PCT International Application Publication Nos. WO 95/32710, published 7 December 1995, and WO 95/17397, published 29 June 1995, in conjunction with the disclosure contained herein, one of ordinary skill in the art can readily prepare additional compounds of the present invention claimed herein.

More specifically, procedures for preparing the N-terminus of the compounds of the present invention are described in WO 95/32710. Additionally, for a general review describing the synthesis of \( \beta \)-alanines which can be utilized as the C-terminus of the compounds of the present invention, see Cole, D.C., *Recent Stereoselective Synthetic Approaches to \( \beta \)-Amino Acids*, Tetrahedron, 1994, 50, 9517-9582; Juaristi, E, et al., *Enantioselective Synthesis of \( \beta \)-Amino Acids*, Aldrichemica Acta, 1994, 27, 3. In particular, synthesis of the 3-methyl \( \beta \)-alanine is taught in Duggan, M.F. et al., *J. Med. Chem.*, 1995, 38, 3332-3341; the 3-ethynyl \( \beta \)-alanine is taught in Zablocki, J.A., et al., *J. Med. Chem.*, 1995, 38, 2378-2394; the 3-pyrid-3-yl \( \beta \)-alanine is taught in Rico, J.G. et al., *J. Org. Chem.*, 1993, 58, 7948-7951; and the 2-amino and 2-tosylamino \( \beta \)-alanines are taught in Xue, C-B, et al., *Biorg. Med. Chem. Letts.*, 1996, 6, 339-344.
Scheme 1

\[ \text{HO}_2\text{C} \quad \text{CO}_2\text{CH}_3 \]

1-1

\[ \text{CHO} \]

1-3

\[ \text{Cl}_2, \text{ether} \]

\[ \text{Cl} \quad \text{CHO} \quad \text{NH}_2 \]

1-4

a) oxalyl chloride, toluene, DMF

\[ \text{CH}_3\text{CO}_2\text{CH}_3 \]

1-2

b) \text{Me}_2\text{Cd}

\[ \text{Cl} \quad \text{CO}_2\text{CH}_3 \]

1-5

ethanol, 20\% \text{KOH}

\[ \text{PtO}_2, \text{H}_2 \quad \text{HOAC}, \text{HCl} \]

\[ \text{CO}_2\text{CH}_3 \]

1-6

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Scheme 1 continued

\[
\text{H}_2\text{N-}
\text{H}^\rightarrow\text{CO}_2\text{Et} \cdot \text{pTSA} \quad \text{BOP, DMF, NMM}
\]

\[
\text{CO}_2\text{Et} \quad \text{NH}_2\text{SO}_2\text{Ph}
\]

\[
\text{CO}_2\text{H} \quad \text{NH}_2\text{SO}_2\text{Ph}
\]

\[
\text{CO}_2\text{H} \quad \text{NH}_2\text{SO}_2\text{Ph}
\]

6N HCl, 60°C

1-6

1-7

1-7a

1-8

1-9

-38-
2-Carbonyloxyoxmethy1-6-acetyl-naphthylene (1-2)

A suspension of the acid 1-1 (2.6 g, 11.5 mmol; for preparation, see Biotechnol. Lett. 17(7), 711-16, 1995) was suspended in toluene (50 mL) and treated sequentially with oxalyl chloride (1.5 mL, 17.5 mmol) and DMF (2 drops). After stirring at ambient temperature for 2 h, the reaction mixture was heated to 70°C for 30 min, cooled, and concentrated to dryness. The resulting acid chloride was redissolved in toluene (25 mL) and added to a 0.5 M solution of (CH₃)₂Cd in toluene/THF (3:1) at ambient temperature. [The 0.5 M solution of (CH₃)₂Cd was prepared as follows: CdCl₂ was added to MeMgBr (1.4 M in toluene/THF (75/25); 18.6 mL, 26 mmol) and the resulting mixture stirred at ambient temperature for 2 h] After warming the reaction mixture to 70°C for 1 h the yellow mixture was poured onto ice. EtOAc was added to the aqueous mixture, followed by washing with 20% H₂SO₄, brine, and sat. NaHCO₃, drying (MgSO₄), and concentration. Flash chromatography (silica, CH₂Cl₂) gave 1-2 as a solid. TLC Rf = 0.21 (CH₂Cl₂),

¹H NMR (300 MHz, CDCl₃) δ 8.63 (s, 1H), 8.49 (s, 1H), 8.15-8.00 (m, 4H), 4.00 (s, 3H), 2.75 (s, 3H).

2-Amino-3-carboxaldehyde-5-chloro-pyridine (1-4)

Cl₂ gas was bubbled through a solution of 1-3 (1.2 g, 10.0 mmol; for preparation see J. Org. Chem. 48, 3401, 1983) in ether (100 ml) at ambient temperature for 45 min. The resulting yellow solid was collected by filtration and then resuspended in H₂O. The pH of the aqueous suspension was adjusted to pH 8 with 6N NaOH and the solid collected by filtration and then dried overnight to give 1-4 as a yellow solid. TLC Rf = 0.59 (50% EtOAc/hexanes),

¹H NMR (300 MHz, CDCl₃) δ 9.83 (s, 1H), 8.22 (s, 1H), 7.79 (s, 1H), 6.77 (bs, 2H).
2-Methoxycarbonyl-6-(6-chloro-[1,8]-naphthyridin-2-yl)naphthylene (1-5)

A mixture of 1-2 (274 mg, 1.2 mmol), 1-4 (258 mg, 1.6 mmol), 20% KOH (3 drops), and ethanol (20 mL) was stirred at 80°C for 1 h. The cooled reaction mixture was filtered to give 1-5 as a solid. 

1H NMR (300 MHz, DMSO) δ 9.13 (s, 1H), 9.00 (s, 1H), 8.73-8.00 (m, 8H), 4.41 (q, J=7Hz, 2H), 1.40 (t, J=7Hz, 3H).

2-Methoxycarbonyl-6-(5,6,7,8-tetrahydro-[1,8]-naphthyridin-2-yl)naphthylene (1-6)

A mixture of 1-5 (344 mg, 1.0 mmol), 10% Pd/C (170 mg), 6N HCl (25 mL), and AcOH (50 mL) was shaken under a hydrogen atmosphere (50 psi) for 48 h. Filtration through a celite pad and concentration of the filtrate gave 1-6 as a yellow gum. 

1H NMR (300 MHz, CD3OD) δ 8.70-7.20 (m, 8H), 4.00 (s, 3H), 3.60 (m, 2H), 2.96 (m, 2H), 2.04 (m, 2H).

2-Carboxylic acid-6-(5,6,7,8-tetrahydro-[1,8]-naphthyridin-2-yl)naphthylene (1-7)

A mixture of 1-6 (417 mg, 1.1 mmol) and 6N HCl (50 mL) was heated at 60°C overnight. The heterogeneous reaction mixture was cooled and then filtered to give 1-7 as yellow solid. 

1H NMR (300 MHz, CD3OD) δ 8.70-7.20 (m, 8H), 3.60 (m, 2H), 2.96 (m, 2H), 2.04 (m, 2H).

[6-(5,6,7,8-Tetrahydro-[1,8]-naphthyridin-2-yl)naphthyl-2-yl]-carbonyl-2(S)-phenylsulfonylamino-β-alanine ethyl ester (1-8)

To a mixture of 1-7 (170 mg, 0.50 mmol), 1-7a (244 mg, 0.55 mmol; for preparation, see WO 95/32710, published 7 Dec. 1995), NMM (220 μL, 2.0 mmol), and DMF (10 mL) at ambient temperature was added BOP (243 mg, 0.55 mmol). After 20 h, the reaction mixture was concentrated to dryness. The residue was dissolved in EtOAc and then washed with sat. NaHCO3, H2O, and brine, dried (MgSO4), and concentrated. Flash chromatography (silica, 10%-20% acetone/CH2Cl2) gave 1-8 as a yellow foam.
TLC Rf = 0.61 (30% acetone/CH2Cl2),
1H NMR (300 MHz, CD3OD) δ 8.40-7.10 (m, 13H), 4.27 (m, 1H), 3.95 (q, J=7Hz, 2H), 3.75 (m, 1H), 3.62 (m, 1H), 3.43 (m, 2H), 2.80 (m, 2H), 1.95 (m, 2H), 1.06 (t, J=7Hz, 3H).

[6-(5,6,7,8-Tetrahydro-[1,8]-naphthyridin-2-yl)naphthyl-2-yl]-carbonyl-2(S)-phenylsulfonylamino-β-alanine hydrochloride (1-9)

A solution of 1-8 (162 mg, 0.29 mmol) CH3OH (10 mL), and 1N NaOH (3 mL) was stirred at ambient temperature for 16 h. The CH3OH was evaporated and the aqueous solution acidified with 1N HCl to give 1-9 as a yellow solid.

1H NMR (300 MHz, CD3OD) δ 8.40-7.20 (m, 13H), 4.30 (m, 1H), 3.80 (m, 1H), 3.60 (m, 3H), 2.95 (m, 2H), 2.03 (m, 2H).
Scheme 2

1-1 \[ \xrightarrow{\text{a) oxalyl chloride}} \] \[ \xrightarrow{\text{b) 2-aminopyridine}} \] 2-1

2-1 \[ \xrightarrow{\text{BH}_3\cdot\text{DMS, toluene}} \] 2-2

2-2 \[ \xrightarrow{6\text{N HCl}} \] 2-3

2-3 \[ \xrightarrow{\text{H}_2\text{NCO}_2\text{Et, BOP, DMF, NMM}} \] 1-7a

- 42 -
Scheme 2 continued

![Chemical Reaction Diagram]

- 43 -
2-((N-Pyridin-2-yl)aminocarboxyl)-6-methoxycarbonylnaphthylene (2-1)

To a suspension of naphthalene-2,6-dicarboxylic acid monomethyl ester 1-1 (1.22 g, 5.30 mmol) in toluene (26.5 mL) under Ar was added DMF (one drop) followed by dropwise addition of oxalyl chloride (0.683 mL). Gas was evolved. The lumpy, suspended solid gradually became a fine white precipitate while stirring for 2 h. The reaction was concentrated and the residue was dissolved in dichloromethane (26.5 mL). Triethylamine (1.48 mL) and 2-aminopyridine (0.748 g) were then added, and the solution stirred under Ar overnight. The mixture was diluted with dichloromethane (250 mL) and washed with water (2 x 25 mL) and brine (25 mL), then dried (MgSO₄) and concentrated to give an off-white foam. This residue was adsorbed onto silica and purified by flash chromatography, eluting with 1:1 [25% EtOAc/Hexane : dichloromethane] to give 2-1 as a white solid. TLC Rf = 0.29 (silica, 1:1 25% EtOAc/hexane : dichloromethane), 

1H NMR (300 MHz, d₆-DMSO+DCl) δ 3.90 (s, 3H), 7.66 (dt, 1H, J=12.3, 1.2Hz), 8.07 (dd, 1H, J=8.6, 1.6Hz), 8.41-8.19 (m, 4H), 8.49-8.60 (m, 2H), 8.70 (s, 1H), 9.06 (s, 1H).

2-((N-Pyridin-2-yl)aminomethyl)-6-methoxycarbonylnaphthylene (2-2)

To a suspension of 0.84 g 2-1 (which had been azeotroped with benzene) in dry toluene (14 mL) at 0°C under Ar was added borane-methyl sulfide complex (0.301 mL, 10.0 M in methyl sulfide) dropwise. After stirring at 0°C for several minutes, the ice bath was removed and the opaque, yellowish suspension was heated to reflux overnight. The resulting suspension was cooled to 0°C and quenched with aqueous 1N Na₂CO₃ solution (30 mL). This mixture was extracted with ethyl acetate (300 mL) and the organic phase washed with water (30 mL) and brine (30 mL), then dried (MgSO₄) and concentrated. The residual solid was purified by flash chromatography on silica by eluting with 7% acetone-dichloromethane to give 2-2 as a white solid. TLC Rf = 0.21 (silica; 7% acetone/dichloromethane),
1H NMR (400 MHz, d6-DMSO) δ 3.91 (s, 3H), 4.67 (d, 2H, J=6.0Hz), 6.48 (t, 1H, 6.0Hz), 6.55 (d, 1H, J=8.4Hz), 7.19 (t, 1H, J=6.0Hz), 7.38 (dt, 1H, J=7.7, 1.9Hz), 7.60 (dd, 1H, J=8.4, 1.5Hz), 7.89 (s, 1H), 7.94-7.98 (m, 2H), 8.08 (d, 1H, J=8.42Hz), 8.60 (s, 1H).

2-((N-Pyridin-2-ylaminomethyl)-6-carboxylic acid-naphthylene (2-3)

A solution of 2-2 (80 mg, 0.28 mmol) in aqueous 6N HCl solution (5.0 mL) was heated to 60°C overnight, then stirred at room temperature an additional 24 h. The mixture was concentrated to give 2-3 as a white solid.

1H NMR (300 MHz, d6-DMSO) δ 4.85 (d, 2Η, J=5.4Hz), 6.90 (t, 1H, J=6.3 Hz), 7.15 (d, 1H, J=9.0Hz), 7.63 (dd, 1H, J=8.5, 1.6Hz), 7.91-8.00 (m, 5H), 8.16 (d, 1H, J=8.5Hz), 8.61 (s, 1H), 9.31 (br s, 1H).

6-((N-Pyridin-2-yl)aminomethyl)naphthylene-2-yl)carbonyl-2(S)-phenylsulfonylamino-β-alanine ethyl ester (2-4)

A solution of 2-3 (0.080 g, 0.25 mmol), 4-methylmorpholine (0.11 mL), BOP (0.17 g), and 1-7a (0.12 g) in DMF (5.0 mL) was stirred at room temperature under N2 overnight. The reaction was concentrated and the oily residue dissolved in ethyl acetate (150 mL) and water (15 mL). The organic phase was then washed with saturated NaHCO3 solution (15 mL) and brine (15 mL), then dried with MgSO4 and concentrated to a clear, yellowish oil. Purification by flash chromatography (silica), eluting with ethyl acetate, gave 2-4 as a white foam.

TLC Rf = 0.47 (silica, ethyl acetate), 1H NMR (400 MHz, d6-DMSO) δ 0.93 (t, 3H, J=7.1Hz), 3.44 (m, 1H), 3.56 (m, 1H), 3.79 (q, 2H, J=7.1Hz), 4.14 (br t, 1H J=6.6Hz), 4.66 (d, 2H, J=5.9Hz), 6.48 (t, 1H, J=5.8Hz), 6.54 (d, 1H, J=8.4Hz), 7.17 (t, 1H, J=5.9Hz), 7.37 (m, 1H), 7.53 (m, 3H), 7.75-7.96 (m, 5H), 8.30 (s, 1H), 8.47 (br s, 1H), 8.67 (t, 1H, J=5.8Hz).

6-((N-Pyridin-2-yl)aminomethyl)naphthylene-2-yl)carbonyl-2(S)-phenylsulfonylamino-β-alanine trifluoroacetate (2-5)
To a solution of 24 (0.10 g, 0.188 mmol) in THF (1.9 mL) under N₂ was added aqueous 1N LiOH solution (0.469 mL). The cloudy solution was stirred at room temperature overnight. The reaction was concentrated to an off-white residue which was then purified by HPLC (Delta pak C₁₈, 0 to 60% acetonitrile-water over 60 min, 0.1% TFA-H₂O). Lyophilization gave 2-5 as a fluffy, white solid. TLC Rf = 0.38 (silica, 50% [20:1:1 EtOH/NH₄OH/H₂O - 50% EtOAc]), ¹H NMR (400 MHz, d₆-DMSO) δ 4.03 (dd, 1H, J=15.5, 6.8 Hz), 4.69 (d, 2H, J=3.7Hz), 6.74 (t, 1H, J=6.3Hz), 6.92 (d, 1H, J=8.4Hz), 7.39 (m, 2H), 7.53 (dd, 1H, J=8.5, 1.3Hz), 7.73 (m, 3H), 7.91 (m, 3H), 8.17 (d, 1H, J=9.0Hz), 8.27 (s, 1H), 8.56 (t, 1H, J=5.8Hz)
Scheme 3

1-3
\[
\text{Br}_2, \text{ ether} \rightarrow \]
\[
3-1
\]
\[
20\% \text{ KOH, ethanol, reflux} \rightarrow \]
\[
3-4 \rightarrow \text{NBOC} \]
\[
\text{TFA, CH}_2\text{Cl}_2 \rightarrow \]
\[
3-5 \rightarrow \text{NH} \]
Scheme 3 continued

HCl·H₂N\(\overset{\text{H}}{\text{NHSO₂Ph}}\)\(\overset{\text{CO₂Bu}}{\text{CO₂Bu}}\)

3-5a

3-5

\[\text{Br-}\text{NQH₂-}\text{CO₂Bu}\]

\[\text{CHCl₃}\]

a) triphosgene, DIPEA

b) DIPEA

10% Pd/C, H₂, ethanol

3-6

\(\text{NH₂-}\text{NHSO₂Ph}\)

\(\text{CO₂Bu}\)

3-7

TFA/CH₂Cl₂

3-8

\(\text{CO₂H}\)
2-Amino-5-bromo-pyridine-3-carboxaldehyde (3-1)

To a stirred solution of aldehyde 1-3 (2.4 g, 20.0 mmol) and Et₂O (200 ml) was added Br₂ (4.16 g, 26.0 mmol). After 30 minutes, the solid that formed was collected, dissolved in EtOAc and then washed with 1N NaOH, brine, dried (MgSO₄) and concentrated providing bromide 3-1 as a yellow solid.

TLC Rf = 0.88 (silica, 75% EtOAc/hexanes),

¹H NMR (300 MHz, CDCl₃) δ 9.82 (s, 1H), 8.29 (d, 1H, J=2Hz), 7.89 (d, 1H, J=2Hz), 6.73 (bs, 2H).

N-Boc-4-acetyl-piperidine (3-3)

To a stirred suspension of amine 3-2 (5.21 g, 31.8 mmol, Acros), NEt₃ (5.32 ml, 38.2 mmol) and DMF (100 ml) at 0°C was added BOC₂O followed by the removal of the cooling bath. After 18 h, the reaction was poured into 200 ml H₂O and then extracted with EtOAc. The organic portion was washed with H₂O, 5% KHSO₄, sat. NaHCO₃, brine, dried (MgSO₄) and concentrated. Flash chromatography (silica, 30% EtOAc/hexanes) gave ketone 3-3 as a colorless oil.

TLC Rf = 0.3 (silica, 30% EtOAc/hexanes),

¹H NMR (300 MHz, CDCl₃) δ 4.09 (bs, 2H), 2.78 (bt, 2H, J=12Hz), 2.45 (m, 1H), 2.17 (s, 3H), 1.83 (m, 2H), 1.52 (m, 2H), 1.46 (s, 9H).

N-Boc-4-(6-Bromo-1,8-naphthyridin-2-yl)piperidine (3-4)

A solution of bromide 3-1 (3.2 g, 15.8 mmol), ketone 2-2 (3.0 g, 13.2 mmol), 20% KOH (2.0 ml) and EtOH was heated to reflux for 18 h. The solution was concentrated. Flash chromatography (silica, 50% EtOAc/hexanes) provided bromide 3-4 as a yellow solid.

TLC Rf = 0.45 (silica, 6.0% EtOAc/hexanes),

¹H NMR (300 MHz, CDCl₃) δ 9.08 (d, 1H, J=3Hz), 8.31 (d, 1H, J=2Hz), 8.08 (d, 1H, J=8Hz), 7.44 (d, 1H, J=9Hz), 4.28 (m, 2H), 3.12 (m, 1H), 1.93 (m, 4H), 1.49 (s, 9H).
4-(6-Bromo-[1,8]naphthyridin-2-yl)piperidine (3-5)

A solution of bromide 3-4 (3.5 g, 8.92 mmol), CH₂Cl₂ (20 ml) and TFA (10 ml) was stirred for 1.0 h. The reaction was concentrated and then azeotroped with toluene. The residue was dissolved in 1N NaOH and then extracted with CHCl₃. The CHCl₃ portion was washed with brine, dried (MgSO₄) and concentrated providing amine 3-5 as a brown solid.

TLC Rf = 0.25 (silica, 10:1:1 EtOH/NH₄OH/H₂O),

₁H NMR (300 MHz, CD₃OD) δ 9.05 (d, 1H, J=2Hz), 8.64 (d, 1H, J=2Hz), 8.33 (d, 1H, J=9Hz), 7.65 (d, 1H, J=9Hz), 3.31 (m, 3H), 2.80 (td, 2H, J=3Hz, 12Hz), 1.95 (m, 4H).

4-(6-Bromo-[1,8]naphthyridin-2-yl)piperidin-1-yl-carbonyl-2-(S)-phenylsulfonlamino-β-alanine t-butyl ester (3-6)

To a stirred solution of amine 3-5 (100 mg, 0.3423 mmol), DIPEA (75 ml, 0.4108 mmol) and CHCl₃ (2.0 ml) was added triphosgene (36 mg, 0.1198 mmol). After 20 minutes, amine 3-5a (115 mg, 0.3423 mmol; for preparation, see WO 95/32710, published 7 Dec. 1995) and DIPEA (150 μl, 0.8216 mmol) was added and the reaction was stirred for 18 h. The reaction was diluted with EtOAc and then washed with sat. NaHCO₃, brine, dried (MgSO₄) and concentrated. Flash chromatography (silica, EtOAc) provided urea 3-6 as a white solid.

TLC Rf = 0.24 (silica, EtOAc),

₁H NMR (300 MHz, CDCl₃) δ 9.09 (d, 1H, J=2Hz), 8.32 (d, 1H, J=2Hz), 8.10 (d, 1H, J=8Hz), 7.85 (d, 2H, J=8Hz), 7.55 (m, 4H), 5.69 (bd, 1H, J=8Hz), 5.09 (m, 1H), 4.14 (m, 2H), 3.88 (m, 1H), 3.77 (m, 1H), 3.22 (m, 2H), 3.00 (bt, 2H, J=12Hz), 2.05 (m, 3H), 1.28 (s, 9H).

4-(5,6,7,8-Tetrahydro-[1,8]naphthyridin-2-yl)piperidin-1-yl-carbonyl-2-(S)-phenylsulfonlamino-β-alanine t-butyl ester (3-7)

A solution of bromide 3-6 (125 mg, 0.2021 mmol), 10% Pd/C (125 mg) and EtOH (5 ml) was stirred under 1 atm H₂ for 1.0 h. The reaction mixture was then filtered through a celite pad and the filtrate concentrated to give urea 3-7 as a colorless oil.

TLC Rf = 0.17 (silica, 10% CH₃OH/EtOAc),
1H NMR (300 MHz, CD3OD) δ 7.84 (d, 2H, J=8Hz), 7.53 (m, 4H), 6.70 (m, 1H), 6.62 (d, 1H, J=8Hz), 4.09 (m, 3H), 3.47 (t, 2H, J=6Hz), 3.21 (m, 1H), 2.83 (m, 5H), 1.91 (m, 5H), 1.71 (m, 2H), 1.24 (s, 9H).

4-(5,6,7,8-Tetrahydro-[1,8]naphthyridin-2-yl)piperidin-1-yl-carbonyl-2-(S)-phenylsulfonylamino-ß-alanine (3-8)

A solution of ester 3-7 (60 mg, 0.1106 mmol), TFA (2 ml) and CH2Cl2 (2 ml) was stirred for 2.0 h. The reaction solution was concentrated and then azeotroped with toluene. Flash chromatography (silica, 25:10:1:1 ÅE 15:10:1:1 EtOAc/EtOH/NH4OH/H2O) gave acid 3-8 as a white solid.

TLC Rf = 0.16 (silica, 10:10:1:1 EtOAc/EtOH/NH4OH/H2O),

1H NMR (300 MHz, CD3OD) δ 7.85 (m, 2H), 7.42 (m, 3H), 7.14 (d, 1H, J=8Hz), 6.37 (d, 1H, J=7Hz), 4.09 (bd, 2H, J=13Hz), 3.63 (m, 1H), 3.44 (m, 3H), 3.21 (m, 1H), 2.81 (bt, 2H, J=13Hz), 2.70 (t, 2H, J=6Hz), 2.60 (m, 1H), 1.88 (m, 4H), 1.60 (m, 2H).
Scheme 4

4-1 (Otsuka, A., et al., JACS, 115, 9439, 1993)

reflux, 1 hr. PBr₃, benzene

4-2

4-3

NaNH₂, toluene reflux

4-4

NaOH, MeOH

60°C, 1 hr.
Scheme 4 continued

4-5

\[
\text{H}_2\text{O} + \text{EtOH} \rightarrow \text{EtOH}
\]

1-7c

BOP, DMF, NMM

4-6

\[
\text{NaOH, MeOH}
\]

4-7

\[
10\% \text{ Pd/C}, \text{H}_2
\]

HOAc, HCl

4-8
Methyl 6-bromomethyl-naphthylene-2-carboxylate (4-2)

A benzene solution (50 ml) of alcohol 4-1 (1.08 g, 5.0 mmol; for preparation see Osuka, A., et al., JACS, 115, 9439, 1993) was treated with PBr3 and the solution refluxed for 1 h. The reaction was cooled and the solution decanted from a yellow residue and concentrated to a colorless solid which was partitioned between EtOAc and saturated NaHCO3 solution. The organic layer was washed with brine and dried (MgSO4). Evaporation gave 4-2 as a colorless solid.

TLC Rf = 0.53 (silica, 4:1, hexane/EtOAc),

1H NMR (300 MHz, CDCl3) δ 8.59 (s, 1H), 8.08 (dd, J=9Hz, 2Hz, 1H), 7.94 (d, J=9Hz, 1H), 7.87 (s, H), 7.85 (d, J=9Hz, 1H), 7.57 (dd, J=9Hz, 2Hz, 1H), 4.66 (s, 2H), 3.98 (s, 3H).

Methyl 6-[(pyrimidinyl-2-yl)aminomethyl]naphthylene-2-carboxylate (4-4)

A toluene solution (10 ml) of NaNH2 (161 mg, 4.1 mmol) and 4-3 (375 mg, 3.9 mmol) was heated at 110°C for 1 h before 4-2 (1100 mg, 3.9 mmol) was added. The reaction was heated 3 h at 110°C, cooled and poured into EtOAc. The resulting mixture was washed with H2O, dried (MgSO4) and concentrated to a yellow solid which was purified by flash chromatography (silica, 9:1, CH2Cl2/acetone) to provide 4-4 as a yellow solid.

TLC Rf 0.31 (silica, 9:1, CH2Cl2/acetone),

1H NMR (300 MHz, CDCl3) δ 8.58 (s, 1H), 8.32 (d, J=5Hz, 2H), 8.04 (dd, J=9Hz, 2Hz, 1H), 7.92 (d, J=9Hz, 1H), 7.84 (d, 8Hz, 1H), 7.83 (s, 1H), 7.54 (dd, J=8Hz, 2Hz, 1H), 6.59 (t, J=5Hz, 1H), 5.49 (bs, 1H), 4.84 (d, J=6Hz, 2H), 3.98 (s, 3H).

6-[(Pyrimidinyl-2-yl)amino methyl]naphthylene-2-carboxylic acid (4-5)

A methanol solution (20 mL) of 4-4 (107 mg, 0.36 mmol) and 1 NaOH (10 mL, 10 mmol) was stirred at 60°C for 1 h. The reaction was concentrated and the residue acidified with 6 N HCl to provide 4-5 as a solid.

1H NMR (300 MHz, CD3OD) δ 8.61 (s, 1H), 8.03, (m, 3H), 7.93 (m, 3H), 7.61 (dd, J=9Hz, 2Hz, 1H), 7.05 (t, J=6Hz, 1H), 4.95 (s, 2H).
6-[(Pyrimidinyl-2-yl)aminomethyl]naphthylene-2-carbonyl-2-(S)-phenylsulfonyl-β-alanine ethyl ester (4-6)

A DMF solution (5 mL) of 4-5 (114 mg, 0.36 mmol), 1-7a (178 mg, 0.40 mmol), NMM (176 ml, 1.6 mmol) and BOP (177 mg, 0.40 mmol) was stirred under ambient conditions for 18 h. The reaction was concentrated and the residue partitioned between EtOAc and H2O. The organic layer was washed with sat. NaHCO3 solution, brine and dried (MgSO4). Filtration and concentration gave a pale yellow foam which was purified by flash chromatography (silica, EtOAc) to provide 4-6 as a colorless foam.

TLC Rf 0.25 (silica, EtOAc),

1H NMR (300 MHz, CDCl3) δ 8.22 (s, 1H), 7.72-7.88 (m, 7H), 7.40-7.54 (m, 5H), 6.58 (t, J=5Hz, 1H), 4.81 (d, J=6Hz, 2H), 4.15 (m, 1H), 4.04 (q, J=7Hz, 2H), 3.95 (m, 1H), 3.78 (m, 1H), 1.13 (t, J=7Hz, 3H).

6-[(Pyrimidinyl-2-yl)aminomethyl]naphthylene-2-carbonyl-2-(S)phenylsulfonyl-β-alanine (4-7)

A MeOH solution (5 mL) of 1N NaOH (1.2 mL, 1.2 mmol) and 4-6 (129 mg, 0.24 mmol) was stirred under ambient condition for 18 h. The solution was neutralized with 1N HCl and concentrated to provide 4-7 as a viscous gum.

1H NMR (300 MHz, CD3OD) δ 8.30 (s, 1H), 7.80-8.02 (m, 7H), 7.61 (dd, J=7Hz, 2Hz, 1H), 7.40 (m, 4H), 7.05 (t, J=5Hz, 1H), 4.96 (s, 2H), 4.26 (m, 1H), 3.80 (m, 1H), 3.56 (m, 1H).

6-[(1,4,5,6-Tetrahydropyrimidinyl-2-yl)aminomethyl]naphthylene-2-carbonyl-2(S)-phenylsulfonylamino-β-alanine (4-8)

An acetic acid solution (20 mL) containing 12N HCl (1 mL), 4-7 (121 mg, 0.24 mmol) and 10% Pd/C (25 mg) was hydrogenated at 60 psi for 3 h. Filtration and concentration provided a gum which was purified by preparative HPLC (Delta-pak C18, 100% H2O-0.1% TFA Ε 50/50 H2O/CH3CN-0.1% TFA, 40 min) to provide 4-8 as a colorless solid.
$^1$H NMR (300 MHz, CD$_3$OD) δ 8.32 (s, H), 8.01 (d, J=9 Hz, 1H), 7.82-7.97 (m, 5H), 7.40-7.55 (m, 4H), 4.55 (s, 2H), 4.26 (m, 1H), 3.82 (m, 1H), 3.55 (m, 1H), 3.18-3.42 (m, 4H), 1.97 (m, 2H).
Scheme 5

5-1

\[
\begin{align*}
\text{H}_2\text{N} & \quad \text{CO}_2\text{H} \\
\text{O} & \\
\text{H} & \\
\text{NH}_2 & \\
\end{align*}
\]

\[
\begin{align*}
\text{I-} & \quad \text{SO}_2\text{Cl} \\
\text{NaOH, dioxane} & \\
\text{H}_2\text{O} & \\
\end{align*}
\]

5-2

5-3

1. \text{Br}_2, \text{NaOH}, \text{H}_2\text{O} \\
2. \text{HCl}

5-4

\[
\begin{align*}
\text{HCl} & \quad \text{H}_2\text{N} \\
\text{CO}_2\text{CH}_2\text{CH}_3 & \\
\text{HCl} & \\
\text{EtOH} & \\
\end{align*}
\]
Scheme 5 continued

\[
\begin{align*}
5-5a & \xrightarrow{\text{H}_2, \ 10\% \ Pd/C} \text{EtOH} \\
& \xrightarrow{6N \ HCl} \\
& \xrightarrow{\text{HCl}\cdot\text{H}_2\text{N} \cdot \text{CO}_2\text{CH}_2\text{CH}_3} \\
& \xrightarrow{\text{EDC}, \ \text{HOBT}, \ \text{NMM}, \ \text{DMF}} \\
5-7
\end{align*}
\]
Scheme 5 continued

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}_2\text{CCH}_3$$

$$\text{NH}$$

$$\text{NH}$$

$$6\text{N HCl}$$

$$60^\circ\text{C}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$(\text{CH}_3\text{Sn})_2, \text{Pd(PPh}_3)_4, \text{dioxane, 90}^\circ\text{C}$$

$$\text{Sn(CH}_3)_3$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$

$$\text{O}_2\text{S}$$

$$\text{CO}_2\text{H}$$

$$\text{H}_2\text{N}$$
N-(4-Iodo-phenylsulfonylamo)-L-asparagine (5-2)

To a stirred solution of acid 5-1 (4.39 g, 33.2 mmol), NaOH (1.49 g, 37.2 mmol), dioxane (30 ml) and H2O (30 ml) at 0°C was added pipsyl chloride (10.34 g, 34.2 mmol). After ~5 minutes, NaOH (1.49, 37.2 mmol) dissolved in 15 ml H2O, was added followed by the removal of the cooling bath. After 2.0 h, the reaction mixture was concentrated. The residue was dissolved in H2O (300 ml) and then washed with EtOAc. The aqueous portion was cooled to 0°C and then acidified with concentrated HCl. The solid was collected and then washed with Et2O to provide acid 5-2 as a white solid.

1H NMR (300 MHz, D2O) δ 7.86 (d, 2H, J=8Hz), 7.48 (d, 2H, J=8Hz) 3.70 (m, 1H), 2.39 (m, 2H).

2(S)-(4-Iodo-phenylsulfonylamo)-β-alanine (5-3)

To a stirred solution of NaOH (7.14 g, 181.8 mmol) and H2O (40 ml) at 0°C was added Br2 (1.30 ml, 24.9 mmol) dropwise over a ten minute period. After ~5 minutes, acid 5-2 (9.9 g, 24.9 mmol), NaOH (2.00 g, 49.8 mmol) and H2O (35 ml) were combined, cooled to 0°C and then added in a single portion to the reaction. After stirring for 20 minutes at 0°C, the reaction was heated to 90°C for 30 minutes and then recooled to 0°C. The pH was adjusted to ~7 by dropwise addition of concentrated HCl. The solid was collected, washed with EtOAc, and then dried in vacuo to provide acid 5-3 as a white solid.

1H NMR (300 MHz, D2O) δ 8.02 (d, 2H, J=8Hz), 7.63 (d, 2H, J=8Hz), 4.36 (m, 1H), 3.51 (dd, 1H, J=5Hz, 13Hz) 3.21 (m, 1H).

Ethyl 2(S)-(4-i-odo-phenylsulfonylamo)-β-alanine-hydrochloride (5-4)

HCl gas was rapidly bubbled through a suspension of acid 5-3 (4.0 g, 10.81 mmol) in EtOH (50 ml) at 0°C for 10 minutes. The cooling bath was removed and the reaction was heated to 60°C. After 18 h, the reaction was concentrated to provide ester 5-4 as a white solid.

1H NMR (300 MHz, CD3OD) δ 7.98 (d, 2H, J=8Hz), 7.63 (d, 2H, J=8Hz), 4.25 (q, 1H, J=5Hz), 3.92 (m, 2H), 3.33 (m, 1H), 3.06 (m, 1H), 1.01 (t, 3H, J=7Hz).

Ethyl 4-[2-(2-Aminopyridin-6-yl)ethyl]benzoate (5-5)
A mixture of ester 5-5a (700 mg, 2.63 mmol), (for preparation, see: Scheme 29 of PCT International Application Publication No. WO 95/32710, published December 7, 1995) 10% Pd/C (350 mg) and EtOH were stirred under 1 atm H₂. After 20 h, the reaction was filtered through a celite pad and then concentrated to provide ester 5-5 as a brown oil.

TLC Rf = 0.23 (silica, 40% EtOAc/hexanes),

1H NMR (300 MHz, CDCl₃) δ 7.95 (d, 2H, J=8Hz), 7.26 (m, 3H), 6.43 (d, 1H, J=7Hz), 6.35 (d, 1H, J=8Hz), 4.37 (m, 4H), 3.05 (m, 2H), 2.91 (m, 2H), 1.39 (t, 3H, J=7Hz).

4-(2-(2-Aminopyridin-6-yl)ethyl)benzoic acid hydrochloride (5-6)

A suspension of ester 5-5 (625 mg, 2.31 mmol) in 6N HCl (12 ml) was heated to 60°C. After ~20 h, the reaction was concentrated to give acid 5-6 as a tan solid.

1H NMR (300 MHz, CD₃OD) δ 7.96 (d, 2H, J=8Hz), 7.80 (m, 1H), 7.33 (d, 2H, J=8Hz), 6.84 (d, 1H, J=9Hz), 6.69 (d, 1H, J=7Hz), 3.09 (m, 4H).

Ethyl 4-(2-(2-Aminopyridin-6-yl)ethyl)benzoyl-2(S)-(4-iodophenylsulfonylamino)-β-alanine (5-7)

A solution of acid 5-6 (400 mg, 1.43 mmol), amine 5-4 (686 mg, 1.57 mmol), EDC (358 mg, 1.86 mmol), HOBT (252 mg, 1.86 mmol), NMM (632 μl, 5.72 mmol) and DMF (10 ml) was stirred for ~20 h. The reaction was diluted with EtOAc and then washed with sat NaHCO₃, brine, dried (MgSO₄) and concentrated. Flash chromatography (silica, EtOAc Æ 5% isopropanol/EtOAc) provided amide 5-7 as a white solid.

TLC Rf = 0.4 (silica, 10% isopropanol/EtOAc),

1H NMR (300 MHz, CD₃OD) δ 7.79 (d, 2H, J=9Hz) 7.61 (d, 2H, J=8Hz), 7.52 (d, 2H, J=9Hz), 7.29 (m, 1H), 7.27 (d, 2H, J=8Hz), 4.20 (m, 1H), 3.95 (q, 2H, J=7Hz), 3.66 (dd, 1H, J=6Hz, 14Hz), 3.49 (dd, 1H, J=8Hz, 13Hz), 3.01 (m, 2H), 2.86 (m, 2H), 1.08 (t, 3H, J=7Hz).

4-(2-(2-Aminopyridin-6-yl)ethyl)benzoyl-2(S)-(4-iodophenylsulfonylamino)-β-alanine (5-8)

- 61 -
A solution of ester 5-7 (200 mg, 0.3213 mmol) and 6N HCl (30 ml) was heated to 60°C. After ~20 h, the reaction mixture was concentrated. Flash chromatography (silica, 20:20:1:1 EtOAc/EtOH/NH4OH/H2O) provided acid 5-8 as a white solid.

TLC Rf = 0.45 (silica, 20:20:1:1 EtOAc/EtOH/NH4OH/H2O).

1H NMR (400 MHz, DMSO) δ 8.40 (m, 1H), 8.14 (Bs, 1H), 7.81 (d, 2H, J=8Hz), 7.62 (d, 2H, J=8Hz), 7.48 (d, 2H, J=8Hz), 7.27 (m, 3H), 6.34 (d, 1H, J=7Hz), 5.85 (bs, 2H), 3.89 (bs, 1H), 3.35 (m, 2H), 2.97 (m, 2H), 2.79 (m, 2H).

A solution of iodide 5-8 (70 mg, 0.1178 mmol), (CH3Sn)2 (49 µl, 0.2356 mmol), Pd(PPh3)4 (5 mg) and dioxane (7 ml) was heated to 90°C. After 2 h, the reaction was concentrated and then purified by prep HPLC (Delta-Pak C18 15 µM 100A°: 40 x 100 mm; 95:5 ᴇΕ 5:95 H2O/CH3CN) provided the trifluoroacetate salt. The salt was suspended in H2O (10 ml), treated with NH4OH (5 drops) and then lyophilized to provide amide 5-9 as a white solid.

1H NMR (400 MHz, DMSO) δ 8.40 (m, 1H), 8.18 (d, 1H, J=8Hz), 7.67 (m, 5H), 7.56 (d, 2H, J=8Hz), 7.29 (d, 2H, J=8Hz), 6.95-7.52 (m, 2H), 6.45 (bs, 2H), 4.00 (m, 1H), 3.50 (m, 1H), 3.33 (m, 1H), 2.97 (m, 2H), 2.86 (m, 2H).

An iodobead (Pierce) was added to a shipping vial of 5 mCi of Na125I (Amersham, IMS30) and stirred for five minutes at room temperature. A solution of 0.1 mg of 5-9 in 0.05 mL of 10% H2SO4/MeOH was made and immediately added to the Na125I/iodobead vial. After stirring for three minutes at room temperature, approximately 0.04-0.05 mL of NH4OH was added so the reaction mixture was at pH 6-7. The entire reaction mixture was injected onto the HPLC for purification [Vydac peptide-protein C-18 column, 4.6 x 250 mm, linear gradient of 10% acetonitrile (0.1% TFA):H2O (0.1% TFA) to 90% acetonitrile (0.1% TFA):H2O (0.1% TFA) over 30 minutes, 1 mL/min]. The retention time

- 62 -
of 8-10 is 17 minutes under these conditions. Fractions containing the majority of the radioactivity were pooled, lyophilized and diluted with ethanol to give approximately 1 mCi of 8-10, which coeluted on HPLC analysis with an authentic sample of 8-8.

Instrumentation: Analytical and preparative HPLC was carried out using a Waters 600E Powerline Multi Solvent Delivery System with 0.1 mL heads with a Rheodyne 7125 injector and a Waters 990 Photodiode Array Detector with a Gilson FC203 Microfraction collector. For analytical and preparative HPLC a Vydac peptide-protein C-18 column, 4.6 x 250 mm was used with a C-18 Brownlee modular guard column. The acetonitrile used for the HPLC analyses was Fisher Optima grade. The HPLC radiodetector used was a Beckman 170 Radioisotope detector. A Vydac C-18 protein and peptide column, 3.9 x 250 mm was used for analytical and preparative HPLC. Solutions of radioactivity were concentrated using a Speedvac vacuum centrifuge. Calibration curves and chemical concentrations were determined using a Hewlett Packard Model 8452A UV/Vis Diode Array Spectrophotometer. Sample radioactivities were determined in a Packard A5530 gamma counter.

EXAMPLE OF A PHARMACEUTICAL FORMULATION

As a specific embodiment of an oral composition, 100 mg of compound 1-9 is formulated with sufficient finely divided lactose to provide a total amount of 580 to 590 mg to fill a size 0 hard gel capsule.

The test procedures employed to measure avb3 binding and the bone resorption inhibiting activity of the compounds of the present invention are described below.

BONE RESORPTION-PIT ASSAY

When osteoclasts engage in bone resorption, they will literally cause the formation of pits in the surface of bone that they are acting upon. Therefore, when testing compounds for their ability to
inhibit osteoclasts, it is useful to measure the ability of osteoclasts to excavate these resorption pits when the inhibiting compound is present.

Consecutive 200 micron thick cross sections from a six mm cylinder of bovine femur diaphysis were cut with a low speed diamond saw (Isomet, Beuler, Ltd., Lake Bluff, IL). Bone slices were pooled, placed in a 10% ethanol solution and refrigerated until further use.

Prior to experimentation, bone slices were ultrasonicated twice, 20 minutes each in H2O. Cleaned slices were placed in 96 well plates such that two control lanes and one lane for each drug dosage are available. Each lane represents either triplicate or quadruplicate cultures. The bone slices in 96 well plates were sterilized by UV irradiation. Prior to incubation with osteoclasts, the bone slices were hydrated by the addition of 0.1 ml Medium 199, pH 6.9 containing 15% fetal bovine serum and 1% penicillin/streptomycin.

Osteoclasts were isolated from the long bones of 1 to 3 day old rat pups (Sprague-Dawley) by modifications of Chambers et al., (J. Cell. Science, 66:383-399). The resulting suspension (0.75 ml/bone) was gently triturated 90-120 times using a wide bore transfer pipet. The cellular population was separated from bone fragments by a cell strainer with a 100 micron nylon mesh. 100 μl of the cell suspension was placed onto each bone slice. Test compounds were then added at the desired experimental concentrations.

Bone slices exposed to osteoclasts for 20-24 hrs were processed for staining. Tissue culture media was removed from each bone slice. Each well was washed with 200 μl of H2O, and the bone slices were then fixed for 20 minutes in 2.5% glutaraldehyde, 0.1 M cacodylate, pH 7.4. After fixation, any remaining cellular debris was removed by 2 min. ultrasonication in the presence of 0.25 M NH4OH followed by 2 X 15 min ultrasonication in H2O. The bone slices were immediately stained for 6-8 min with filtered 1% toluidine blue and 1% borax.

After the bone slices have dried, resorption pits were counted in test and control slices. Resorption pits were viewed in a Microphot Fx (Nikon) fluorescence microscope using a polarizing Nikon IGS filter cube. Test dosage results were compared with controls and resulting IC50 values were determined for each compound tested.
The appropriateness of extrapolating data from this assay to utility and use in mammalian (including human) disease states is supported by the teaching found in Sato, M., et al., *Journal of Bone and Mineral Research*, Vol. 5, No. 1, 1990. That article teaches that certain bisphosphonates have been used clinically and appear to be effective in the treatment of Paget's disease, hypercalcemia of malignancy, osteolytic lesions produced by bone metastases, and bone loss due to immobilization or sex hormone deficiency. These same bisphosphonates are then tested in the resorption pit assay described above to confirm a correlation between their known utility and positive performance in the assay.

**EIB ASSAY**

Duong *et al.*, *J. Bone Miner. Res.*, 8:S 378, describe a system for expressing the human integrin αvβ3. It has been suggested that the integrin stimulates attachment of osteoclasts to bone matrix, since antibodies against the integrin, or RGD-containing molecules, such as echistatin (European Publication 382 451), can effectively block bone resorption.

**Reaction Mixture:**

1. 175 μl TBS buffer (50 mM Tris•HCl pH 7.2, 150 mM NaCl, 1% BSA, 1 mM CaCl2, 1 mM MgCl2).
2. 25 μl cell extract (dilute with 100 mM octylglucoside buffer to give 2000 cpm/25 μl).
3. 125I-echistatin (25 μl/50,000 cpm) (see EP 382 451).
4. 25 μl buffer (total binding) or unlabeled echistatin (non-specific binding).

The reaction mixture was then incubated for 1 h at room temp. The unbound and the bound αvβ3 were separated by filtration using a Skatron Cell Harvester. The filters (prewet in 1.5% polyethyleneimine for 10 mins) were then washed with the wash buffer (50 mM Tris HCl, 1mM CaCl2/MgCl2, pH 7.2). The filter was then counted in a gamma counter.
SPA ASSAY

MATERIALS:

1. Wheatgerm agglutinin Scintillation Proximity Beads (SPA): Amersham
2. Octylglucopyranoside: Calbiochem
3. HEPES: Calbiochem
4. NaCl: Fisher
5. CaCl2: Fisher
6. MgCl2: SIGMA
7. Phenylmethylsulfonylfluoride (PMSF): SIGMA
8. Optiplate: PACKARD
9. 5-10 (specific activity 500-1000 Ci/mmole)

PROCEDURE:

1. Pretreatment of SPA beads:
   500 mg of lyophilized SPA beads were first washed four times with 200 ml of 50-OG buffer and once with 100 ml of binding buffer, and then resuspended in 12.5 ml of binding buffer.

2. Preparation of SPA beads and receptor mixture
   In each assay tube, 2.5 μl (40 mg/ml) of pretreated beads were suspended in 97.5 μl of binding buffer and 20 ml of 50-OG buffer. 5 μl (~30 ng/μl) of purified receptor was added to the
beads in suspension with stirring at room temperature for 30 minutes. The mixture was then centrifuged at 2,500 rpm in a Beckman GPR Benchtop centrifuge for 10 minutes at 4°C. The pellets were then resuspended in 50 μl of binding buffer and 25 μl of 50-OG buffer.

3. **Reaction**

The following were sequentially added into Optiplate in corresponding wells:

(i) Receptor beads mixture (75 μl)

(ii) 25 μl of each of the following: compound to be tested, binding buffer for total binding or 5-8 for non-specific binding (final concentration 1 μM)

(iii) 5-10 in binding buffer (25 μl, final concentration 40 pM)

(iv) Binding buffer (125 μl)

(v) Each plate was sealed with plate sealer from PACKARD and incubated overnight with rocking at 4°C

4. Plates were counted using PACKARD TOPCOUNT

5. % inhibition was calculated as follows:

A = total counts

B = nonspecific counts

C = sample counts

% inhibition = \[ \frac{((A-B)-(C-B))/(A-B))}{(A-B)} \times 100 \]

**OCFORM ASSAY**

Osteoblast-like cells (1.8 cells), originally derived from mouse calvaria, were plated in CORNING 24 well tissue culture plates in a MEM medium containing ribo- and deoxyribonucleosides, 10% fetal bovine serum and penicillin-streptomycin. Cells were seeded at 40,000/well in the morning. In the afternoon, bone marrow cells were prepared from six week old male Balb/C mice as follows:

Mice were sacrificed, tibiae removed and placed in the above medium. The ends were cut off and the marrow was flushed out.
of the cavity into a tube with a 1 mL syringe with a 27.5 gauge needle. The marrow was suspended by pipetting up and down. The suspension was passed through >100 μm nylon cell strainer. The resulting suspension was centrifuged at 350 x g for seven minutes. The pellet was resuspended, and a sample was diluted in 2% acetic acid to lyse the red cells. The remaining cells were counted in a hemacytometer. The cells were pelleted and resuspended at 1 x 10^6 cells/mL. 50 μL was added to each well of 1.8 cells to yield 50,000 cells/well and 1,25-dihydroxy-vitamin D3(D3) was added to each well to a final concentration of 10 nM. The cultures were incubated at 37°C in a humidified, 5% CO2 atmosphere. After 48 h, the medium was changed. 72 h after the addition of bone marrow, test compounds were added with fresh medium containing D3 to quadruplicate wells. Compounds were added again after 48 h with fresh medium containing D3. After an additional 48 h the medium was removed, cells were fixed with 10% formaldehyde in phosphate buffered saline for 10 minutes at room temperature, followed by a 1-2 minute treatment with ethanol:acetone (1:1) and air dried. The cells were then stained for tartrate resistant acid phosphatase as follows:

The cells were stained for 10-15 minutes at room temperature with 50 mM acetate buffer, pH 5.0 containing 30 mM sodium tartrate, 0.3 mg/mL Fast Red Violet LB Salt and 0.1 mg/mL Naphthol AS -MX phosphate. After staining, the plates were washed extensively with deionized water and air dried. The number of multinucleated, positive staining cells were counted in each well.

Representative compounds of the present invention were tested and found to bind to human αvβ3 integrin. These compounds were found to have IC50 values in the range of 0.4 to 110 nM in the SPA assay.

While the invention has been described and illustrated in reference to certain preferred embodiments thereof, those skilled in the art will appreciate that various changes, modifications and substitutions can be made therein without departing from the spirit and scope of the invention. For example, effective dosages other than the preferred doses as set forth hereinabove may be applicable as a
consequence of variations in the responsiveness of the mammal being treated for severity of bone disorders caused by resorption, or for other indications for the compounds of the invention indicated above. Likewise, the specific pharmacological responses observed may vary according to and depending upon the particular active compound selected or whether there are present pharmaceutical carriers, as well as the type of formulation and mode of administration employed, and such expected variations or differences in the results are contemplated in accordance with the objects and practices of the present invention. It is intended, therefore, that the invention be limited only by the scope of the claims which follow and that such claims be interpreted as broadly as is reasonable.
WHAT IS CLAIMED IS:

1. A compound of the formula

\[ X-Y-Z-\text{Ring}-A-B \]

wherein:

Ring is a 4 to 10-membered mono- or polycyclic aromatic or nonaromatic ring system containing 0, 1, 2, 3 or 4 heteroatoms selected from N, O and S, and either unsubstituted or substituted with \( R^{27} \) and \( R^{28} \);

\( X \) is selected from

\[ \begin{align*}
&NR^2 & NR^2 & NR^2 \\
&-NR^1 R^2, &-NR^1-C-R^3, &-C-NR^4, &-NR^1-C-NR^3 R^4, \\
\end{align*} \]

or a 4- to 10- membered mono- or polycyclic aromatic or nonaromatic ring system containing 0, 1, 2, 3 or 4 heteroatoms selected from N, O and S and either unsubstituted or substituted with \( R^{13} \), \( R^{14} \), \( R^{15} \) or \( R^{16} \);

\( Y \) is selected from

- \( C_{0.8} \) alkylene,
- \( C_{3.10} \) cycloalkyl,
- \( C_{0.8} \) alkylene-NR\(^5\)-CO-\( C_{0.8} \) alkylene,
- \( C_{0.8} \) alkylene-CONR\(^5\)-\( C_{0.8} \) alkylene,
- \( C_{0.8} \) alkylene-O-\( C_{0.8} \) alkylene,
- \( C_{0.8} \) alkylene-NR\(^5\)-\( C_{0.8} \) alkylene,
- \( C_{0.8} \) alkylene-S(O)\(_{0.2}\)-\( C_{0.8} \) alkylene,
- \( C_{0.8} \) alkylene-SO\(_2\)-NR\(^5\)-\( C_{0.8} \) alkylene,
- \( C_{0.8} \) alkylene-NR\(^5\)-SO\(_2\)-\( C_{0.8} \) alkylene,
- \( C_{0.8} \) alkylene-CO-\( C_{0.8} \) alkylene,
(CH₂)₀-₆ aryl(CH₂)₀-₆,  
(CH₂)₀-₆ aryl-CO-(CH₂)₀-₆,  
(CH₂)₀-₆ aryl-CO-NR⁵-(CH₂)₀-₆,  
(CH₂)₀-₆ aryl-NR⁵-CO-(CH₂)₀-₆, or  
| OH  
| (CH₂)₀-₈CH(CH₂)₀-₈ |  

Z is selected from  

(Ch₂)ₐ. (Ch₂)ₐO(CH₂)ₐ. (Ch₂)ₐNR₆(CH₂)ₐ, (Ch₂)ₐNR₆CNR₇(CH₂)ₐ  
(Ch₂)ₐCN=CN(CH₂)ₐ, (Ch₂)ₐC(CH₂)ₐ,  
(Ch₂)ₐC(CH₂)ₐ, (Ch₂)ₐSO(CH₂)ₐ, (Ch₂)ₐSO₂CH₂₂(CH₂)ₐ, (Ch₂)ₐSO₂NR₆(CH₂)ₐ,  
(Ch₂)ₐCR₆=CR₇(CH₂)ₐ, (Ch₂)ₐC≡C-(CH₂)ₐ;  

where m and n are each independently an integer from 0 to 6;  

A is selected from
where p and q are each independently an integer from 0 to 6;

5 B is selected from

\[ R^8 R^9 R^{10} \quad \text{or} \quad R^{10} R^{11} \]

R1, R2, R3, R4, R5, R6, R7, R17, R18, R19, R20, R21, R22, R23, R24, R25, R26, R27, R28, R29 and R30 are each independently selected from

10 hydrogen, halogen, C1-10 alkyl, aryl C0-8 alkyl, amino C0-8 alkyl, C1-3 acylamino C0-8 alkyl, C1-6 alkylamino C0-8 alkyl,
C1-6 dialkylamino C0-8 alkyl,
aryl C0-6 alkylamino C0-6 alkyl,
C1-4 alkoxyamino C0-8 alkyl,
hydroxy C1-6 alkylamino C0-8 alkyl,
5  C1-4 alkoxy C0-6 alkyl,
carboxy C0-6 alkyl,
C1-4 alkoxy carbonyl C0-6 alkyl,
carboxy C0-6 alkyloxy,
hydroxy C1-6 alkylamino C0-6 alkyl,
hydroxy C0-6 alkyl,

\[ \text{NR}^{17} \text{NR}^{18} \text{R}^{19}, \text{ or } \]

\[ \text{-NR}^{17} \text{NR}^{18} \text{R}^{19}\text{R}^{20} ; \]

R8 and R9 are each independently selected from
hydrogen,
aryl,
halogen,
aryl-(CH2)p-,
hydroxyl,
C1-8 alkyl carbonylamino,
15  aryl C1-5 alkoxo,
C1-5 alkoxy carbonyl,
aminocarbonyl,
C1-8 alkylaminocarbonyl,
C1-6 alkyl carboxyloxy,
C3-8 cycloalkyl,
amino,
C1-6 alkylamino,
amino C1-6 alkyl,
arylaminocarbonyl,
aryl C_{1-5} alkylaminocarbonyl,
aminocarbonyl,
aminocarbonyl C_{1-6} alkyl,
hydroxycarbonyl,
hydroxycarbonyl C_{1-6} alkyl,
C_{1-8} alkyl, either unsubstituted or substituted, with one or more
groups selected from: halogen, hydroxyl,
C_{1-5} alkylcarbonylamino, aryl C_{1-5} alkoxy,
C_{1-5} alkoxy carbonyl, aminocarbonyl, C_{1-5} alkylamino-
carbonyl, C_{1-5} alkylcarbonyloxy, C_{3-8} cycloalkyl, oxo,
amino, C_{1-3} alkylamino, amino C_{1-3} alkyl, arylamino-
carbonyl, aryl C_{1-5} alkylaminocarbonyl, aminocarbonyl,
aminocarbonyl C_{1-4} alkyl, hydroxycarbonyl, or
hydroxycarbonyl C_{1-5} alkyl,

\[
\text{HC} = \text{C}(\text{CH}_2)_r -
\]

C_{1-6} alkyl-C=\text{C}(\text{CH}_2)_r -,
C_{3-7} cycloalkyl-C=\text{C}(\text{CH}_2)_r -,
aryl-C=\text{C}(\text{CH}_2)_r -,
C_{1-6} alkylaryl-C=\text{C}(\text{CH}_2)_r -,

\[
\text{H}_2\text{C}=\text{CH}(\text{CH}_2)_r -
\]

C_{1-6} alkyl-CH=\text{CH}(\text{CH}_2)_r -,
C_{3-7} cycloalkyl-CH=\text{CH}(\text{CH}_2)_r -,
aryl-CH=\text{CH}(\text{CH}_2)_r -,
C_{1-6} alkylaryl-CH=\text{CH}(\text{CH}_2)_r -,

\[
\text{C}_{1-6} \text{ alkyl-SO}_2(\text{CH}_2)_r -
\]

C_{1-6} alkylaryl-SO_2(\text{CH}_2)_r -,
C_{1-6} alkoxy,
aryl C_{1-6} alkoxy,
aryl C_{1-6} alkyl,

\[
\text{C}_{1-6} \text{ alkylamino} C_{1-6} \text{ alkyl},
\]

arylamino,
arylamino C_{1-6} alkyl,
aryl C_{1-6} alkylamino,
aryl C_{1-6} alkylaminocarbonyl C_{1-6} alkyl,
arylcarbonyloxy,
aryl C_{1-6} alkylcarbonyloxy,
C_{1-6} dialkylamino,
C_{1-6} dialkylamino C_{1-6} alkyl,
C_{1-6} alkyaminocarbonyloxy,
C_{1-8} alkylsulfonylamino,
C_{1-8} alkylsulfonylamino C_{1-6} alkyl,
aryl sulfonylamino C_{1-6} alkyl,
aryl C_{1-6} alkylsulfonylamino,
aryl C_{1-6} alkylsulfonylamino C_{1-6} alkyl,
aryl C_{1-8} alkoxy carbonylamino,
C_{1-8} alkoxy carbonylamino C_{1-8} alkyl,
aryl alkoxy carbonylamino C_{1-8} alkyl,
aryl C_{1-8} alkoxy carbonylamino,
aryl C_{1-8} alkoxy carbonylamino C_{1-8} alkyl,
C_{1-8} alkylcarbonylamino,
arylcarbonylamino C_{1-6} alkyl,
arylcarbonylamino,
C_{1-8} alkylcarbonylamino C_{1-6} alkyl,
arlycarbonylamino C_{1-6} alkyl,
arlycarbonylamino,
as_{1-8} alkyaminocarbonylamino,
arlyaminocarbonylamino C_{1-6} alkyl,
arlyaminocarbonylamino,
C_{1-8} alkylaminocarbonylamino,
arlyaminocarbonylamino C_{1-6} alkyl,
arlyaminocarbonylamino,
C_{1-8} alkyaminocarbonylamino,
arlyaminocarbonylamino C_{1-6} alkyl,
arlyaminocarbonylamino,
as_{1-8} alkyaminosulfonylamino,
arlyaminosulfonylamino C_{1-6} alkyl,
arlyaminosulfonylamino,
C_{1-8} alkyaminosulfonylamino C_{1-6} alkyl,
arlyaminosulfonylamino C_{1-6} alkyl,
arlyaminosulfonylamino,
C_{1-8} alkyaminosulfonylamino C_{1-6} alkyl,
arlyaminosulfonylamino C_{1-6} alkyl,
arlyaminosulfonylamino,
C_{1-6} alkylsulfonyl,
arlyaminosulfonylamino C_{1-6} alkyl,
arlyaminosulfonylamino,
C_{1-6} alkylsulfonyl,
arlyaminosulfonylamino C_{1-6} alkyl,
arlyaminosulfonylamino,
C_{1-6} alkylsulfonyl C_{1-6} alkyl,
arlyaminosulfonylamino C_{1-6} alkyl,
aryl C\textsubscript{1-6} alkylsulfonyl,
aryl C\textsubscript{1-6} alkylsulfonyl C\textsubscript{1-6} alkyl,
C\textsubscript{1-6} alkylcarbonyl,
C\textsubscript{1-6} alkylcarbonyl C\textsubscript{1-6} alkyl,
arylcarbonyl C\textsubscript{1-6} alkyl,
aryl C\textsubscript{1-6} alkylcarbonyl,
aryl C\textsubscript{1-6} alkylcarbonyl C\textsubscript{1-6} alkyl,
C\textsubscript{1-6} alkylthiocarbonylamino,
C\textsubscript{1-6} alkylthiocarbonylamino C\textsubscript{1-6} alkyl,
arylthiocarbonylamino C\textsubscript{1-6} alkyl,
aryl C\textsubscript{1-6} alkylthiocarbonylamino,
aryl C\textsubscript{1-6} alkylthiocarbonylamino C\textsubscript{1-6} alkyl,
C\textsubscript{1-8} alkylaminocarbonyl C\textsubscript{1-6} alkyl,
arylaminocarbonyl C\textsubscript{1-6} alkyl,
aryl C\textsubscript{1-8} alkylaminocarbonyl, or
aryl C\textsubscript{1-8} alkylaminocarbonyl C\textsubscript{1-6} alkyl,
wherein the alkyl or N atoms may be unsubstituted or
substituted with one or more substituents selected from \textit{R}\textsuperscript{21} and
\textit{R}\textsuperscript{22}; or \textit{R}\textsuperscript{8} and \textit{R}\textsuperscript{9} are combined to form oxo;

\[ \text{R}\textsuperscript{10} \text{ and } \text{R}\textsuperscript{11} \text{ are each independently selected from}
\]
hydrogen,
aryl,
halogen,
aryl-(CH\textsubscript{2})\textsuperscript{p},
hydroxyl,
C\textsubscript{1-8} alkylcarbonylamino,
aryl C\textsubscript{1-5} alkoxy,
C\textsubscript{1-5} alkoxycarbonyl,
aminocarbonyl,
C\textsubscript{1-8} alkylaminocarbonyl,
C\textsubscript{1-6} alkylcarbonyloxy,
C\textsubscript{3-8} cycloalkyl,
amino,
C_1.6_ alkylamino,
amino C_1.6_ alkyl,
arlyaminocarbonyl,
aryl C_1.5_ alkyaminocarbonyl,
aminocarbonyl,
aminocarbonyl C_1.6_ alkyl,
hydroxycarbonyl,
hydroxycarbonyl C_1.6_ alkyl,
C_1.8_ alkyl, either unsubstituted or substituted, with one or more groups selected from: halogen, hydroxyl,
C_1.5_ alkylcarbonylamino, aryl C_1.5_ alkoxy,
C_1.5_ alkoxy carbonyl, aminocarbonyl, C_1.5_ alkylaminocarbonyl, C_1.5_ alkylcarbonyloxy, C_3.8_ cycloalkyl, oxo,
amino, C_1.3_ alkylamino, aryl C_1.3_ alkyl, aminocarbonyl, aryl C_1.5_ alkyaminocarbonyl, aminocarbonyl,
aminocarbonyl C_1.4_ alkyl, hydroxycarbonyl, or hydroxycarbonyl C_1.5_ alkyl,
HC=CH(CH_2)_r-,
C_1.6_ alkyl-C≡(CH_2)_r-,
C_3.7_ cycloalkyl-C≡(CH_2)_r-,
aryl-C≡(CH_2)_r-,
C_1.6_ alkylaryl-C≡(CH_2)_r-,
H_2C=CH(CH_2)_r-,
C_1.6_ alkyl-CH=CH(CH_2)_r-,
C_3.7_ cycloalkyl-CH=CH(CH_2)_r-,
aryl-CH=CH(CH_2)_r-,
C_1.6_ alkylaryl-CH=CH(CH_2)_r-,
C_1.6_ alkyl-SO_2(CH_2)_r-,
C_1.6_ alkylaryl-SO_2(CH_2)_r-,
C_1.6_ alkoxy,
arly C_1.6_ alkoxy,
arly C_1.6_ alkyl,
C_1.6_ alkylamino C_1.6_ alkyl,
arlylamino,
arylamino C₁-₆ alkyl,
aryl C₁-₆ alkylamino,
aryl C₁-₆ alkylamino C₁-₆ alkyl,
arylcarbonyloxy,
aryl C₁-₆ alkylcarbonyloxy,
C₁-₆ dialkylamino,
C₁-₆ dialkylamino C₁-₆ alkyl,
C₁-₆ alkyaminocarbonyloxy,
C₁-₈ alkylsulfonylamino,
C₁-₈ alkylsulfonylamino C₁-₆ alkyl,
aryl C₁-₆ alkylsulfonylamino,
aryl C₁-₆ alkylsulfonylamino C₁-₆ alkyl,
C₁-₈ alkoxy carbonylamino,
C₁-₈ alkoxy carbonylamino C₁-₈ alkyl,
aryloxycarbonylamino C₁-₈ alkyl,
aryl C₁-₈ alkoxy carbonylamino,
aryl C₁-₈ alkoxy carbonylamino C₁-₈ alkyl,
C₁-₈ alky carbonylamino,
C₁-₈ alky carbonylamino C₁-₆ alkyl,
arylcarbonylamino C₁-₆ alkyl,
aryl C₁-₆ alky carbonylamino,
aryl C₁-₆ alky carbonylamino C₁-₆ alkyl,
amino carbonylamino C₁-₆ alkyl,
C₁-₈ alkyaminocarbonylamino,
C₁-₈ alkyaminocarbonylamino C₁-₆ alkyl,
arlyaminocarbonylamino C₁-₆ alkyl,
arly C₁-₈ alkyaminocarbonylamino,
arly C₁-₈ alkyaminocarbonylamino C₁-₆ alkyl,
amino sulfonylamino C₁-₆ alkyl,
C₁-₈ alkylaminosulfonylamino,
C₁-₈ alkylaminosulfonylamino C₁-₆ alkyl,
arlyaminosulfonylamino C₁-₆ alkyl,
arly C₁-₈ alkylaminosulfonylamino,
aryl C₁₋₈ alkylaminosulfonylethyl,  
C₁₋₆ alkylsulfonylethyl,  
C₁₋₆ alkylsulfonylethyl C₁₋₆ alkyl,  
aryl sulfonylethyl C₁₋₆ alkyl,  
aryl C₁₋₆ alkylsulfonylethyl,  
aryl C₁₋₆ alkylsulfonylethyl C₁₋₆ alkyl,  
C₁₋₆ alkylcarbonylethyl,  
C₁₋₆ alkylcarbonyl C₁₋₆ alkyl,  
arylcarbonylethyl C₁₋₆ alkyl,  
aryl C₁₋₆ alkylcarbonylethyl,  
aryl C₁₋₆ alkylcarbonyl C₁₋₆ alkyl,  
C₁₋₆ alkylthiocarbonylamino C₁₋₆ alkyl,  
arylthiocarbonylamino C₁₋₆ alkyl,  
aryl C₁₋₆ alkylthiocarbonylamino,  
aryl C₁₋₆ alkylthiocarbonylamino C₁₋₆ alkyl,  
C₁₋₈ alkylaminocarbonylethyl,  
arylaminocarbonylethyl C₁₋₆ alkyl,  
aryl C₁₋₈ alkylaminocarbonyl,  
aryl C₁₋₈ alkylaminocarbonyl C₁₋₆ alkyl,  
C₇₋₂₀ polycyclic C₀⁻₈ alkylaminocarbonyl C₀₋₆ alkyl,  
C₇₋₂₀ polycyclic C₀⁻₈ alkylaminocarbonyl C₀₋₆ alkyl,  
C₇₋₂₀ polycyclic C₀⁻₈ alkylaminosulfonylethyl C₀₋₆ alkyl,  
C₇₋₂₀ polycyclic C₀⁻₈ alkylaminocarbonylamino C₀₋₆ alkyl,  
C₇₋₂₀ polycyclic C₀⁻₈ alkylaminocarbonylamino C₀₋₆ alkyl, or  
C₇₋₂₀ polycyclic C₀⁻₈ alkylaminocarbonylamino C₀₋₆ alkyl  
wherein the alkyl or N atoms may be unsubstituted or  
substituted with one or more substituents selected from R²¹ and  
R²², wherein the polycyclic may be unsubstituted or substituted  
with R³¹, R³², R³³ and R³⁴, and provided that the carbon atom to  
which R¹⁰ and R¹¹ are attached is itself attached to no more than  
one heteroatom; or R¹⁰ and R¹¹ are combined to form oxo;  

R¹² is selected from  
hydroxy,
C₁-8 alkyloxy,
aryl C₀-6 alkyloxy,
C₁-8 alkylcarbonyloxy C₁-4 alkyloxy,
aryl C₀-8 alkylcarbonyloxy C₁-4 alkyloxy,
C₁-6 dialkylaminocarbonylmethyloxy,
aryl C₁-6 dialkylaminocarbonylmethyloxy or
an L- or D-amino acid joined by an amide linkage and
wherein the carboxylic acid moiety of said amino acid
is as the free acid or is esterified by C₁-6 alkyl; and

R¹³, R¹⁴, R¹⁵ and R¹⁶ are each independently selected from
hydrogen,
C₁-1₀ alkyl,
aryl C₀-8 alkyl,
thio,
amino C₀-8 alkyl,
C₁-3 acylamino C₀-8 alkyl,
C₁-6 alkylamino C₀-8 alkyl,
C₁-6 dialkylamino C₀-8 alkyl,
aryl C₀-6 alkylamino C₀-6 alkyl,
C₁-4 alkoxyamino C₀-8 alkyl,
hydroxy C₁-6 alkylamino C₀-8 alkyl,
C₁-4 alkoxy C₀-6 alkyl,
carboxy C₀-6 alkyl,
C₁-4 alkoxy carbonyl C₀-6 alkyl,
carboxy C₀-6 alkyl,
hydroxy C₁-6 alkylamino C₀-6 alkyl,
hydroxy C₀-6 alkyl,

\[ \begin{align*}
\text{or} & \\
\text{or} & \\
\end{align*} \]
are combined to form oxo;

\[ R^{31}, \ R^{32}, \ R^{33} \text{ and } R^{34} \text{ are each independently selected from} \]
\[ \text{hydrogen, halogen, } C_{1-10} \text{ alkyl, } C_{3-8} \text{ cycloalkyl, oxo, aryl, } \]
\[ \text{aryl } C_{1-8} \text{ alkyl, amino, amino } C_{1-8} \text{ alkyl, } C_{1-3} \text{ acylamino,} \]
\[ C_{1-3} \text{ acylamino } C_{1-8} \text{ alkyl, } C_{1-6} \text{ alkylamino, } C_{1-6} \text{ alkylamino-}\]
\[ C_{1-8} \text{ alkyl, } C_{1-6} \text{ dialkylamino, } C_{1-6} \text{ dialkylamino } C_{1-8} \text{ alkyl,} \]
\[ C_{1-4} \text{ alkoxy, } C_{1-4} \text{ alkoxy } C_{1-6} \text{ alkyl, hydroxycarbonyl, } \]
\[ \text{hydroxycarbonyl } C_{1-6} \text{ alkyl, } C_{1-3} \text{ alkoxy carbonyl, } \]
\[ C_{1-3} \text{ alkoxy carbonyl } C_{1-6} \text{ alkyl, hydroxycarbonyl-}\]
\[ C_{1-6} \text{ alkyl oxy, hydroxy, hydroxy } C_{1-6} \text{ alkyl, } C_{1-6} \text{ alkyl oxy-}\]
\[ C_{1-6} \text{ alkyl, nitro, cyano, trifluoromethyl, trifluoromethoxy,} \]
\[ \text{trifluoroethoxy, } C_{1-8} \text{ alkyl-}S(O)_{2} \text{q, } C_{1-8} \text{ alkyaminocarbonyl,} \]
\[ C_{1-8} \text{ dialkyaminocarbonyl, } C_{1-8} \text{ alkyl oxy carbonylamino, } \]
\[ C_{1-8} \text{ alkyaminocarbonyloxy or } C_{1-8} \text{ alkylsulfonylamino;} \]

provided that Ring is not a 6-membered monocyclic aromatic ring;

provided further that when Ring is thiophene, then X is selected from

\[ \text{provided further that when Ring is selected from isoxazole, isoxazoline,} \]
\[ \text{imidazole, imidazoline, benzo furan, benzothiophene, benzimidazole,} \]
\[ \text{indole, benzothiazole, benzo xazole,} \]
then \( X \) is selected from

\[
\begin{align*}
\text{and the pharmaceutically acceptable salts thereof.}
\end{align*}
\]

2. The compound of Claim 1, wherein

\( Y \) is selected from

\[
\begin{align*}
\text{C}_0^8 \text{ alkylene,} \\
\text{C}_8^3 \text{ cycloalkyl,} \\
\text{C}_0^8 \text{ alkylene-NR}_5^5 \text{-CO-C}_0^8 \text{ alkylene,} \\
\text{C}_0^8 \text{ alkylene-CO}_N^N \text{R}_5^5 \text{-C}_0^8 \text{ alkylene,} \\
\text{C}_0^8 \text{ alkylene-O-C}_0^8 \text{ alkylene,} \\
\text{C}_0^8 \text{ alkylene-NR}_5^5 \text{-C}_0^8 \text{ alkylene,} \\
\text{C}_0^8 \text{ alkylene-S(O)}_2^2 \text{-C}_0^8 \text{ alkylene,} \\
\text{C}_0^8 \text{ alkylene-NR}_5^5 \text{-SO}_2^2 \text{-C}_0^8 \text{ alkylene,} \\
\text{C}_0^8 \text{ alkylene-CO-C}_0^8 \text{ alkylene,} \\
\text{(CH}_2^2)^{0-6} \text{ aryl(CH}_2^2)^{0-6}, \\
\text{(CH}_2^2)^{0-6} \text{ aryl-CO-(CH}_2^2)^{0-6}, \\
\text{(CH}_2^2)^{0-6} \text{ aryl-CO-NH-(CH}_2^2)^{0-6}, \text{ or} \\
\text{OH} \\
\text{(CH}_2^2)^{0-8} \text{CH(CH}_2^2)^{0-8}
\end{align*}
\]
Z is \((\text{CH}_2)_m\) where \(m\) is zero; and

and the pharmaceutically acceptable salts thereof.

3. The compound of Claim 2, of the formula

\[\text{X-Y-Ring-A-B}\]

wherein Ring is selected from

\[
\begin{align*}
\text{[Diagram: Structures of Rings]} & \\
\text{[Diagram: Structures of X]} & \\
\end{align*}
\]

X is selected from

\[
\text{[Chemical Structures]} \quad \text{[Chemical Structures]}\]

\[
\begin{align*}
\text{[Structural Formulas]} & \\
\text{[Structural Formulas]} & \\
\end{align*}
\]
Y is selected from
- C₀₋₈ alkylene,
- C₀₋₈ alkylene-NR₅-C₀₋₈ alkylene,
- C₀₋₈ alkylene-CNR₅-C₀₋₈ alkylene,
- C₀₋₈ alkylene-O-C₀₋₈ alkylene,
- C₀₋₈ alkylene-NR₅-C₀₋₈ alkylene,
- C₀₋₈ alkylene-S(Ο)₀-2-C₀₋₈ alkylene,
- C₀₋₈ alkylene-SΟ₂-NR₅-C₀₋₈ alkylene,
- C₀₋₈ alkylene-NR₅-SΟ₂-C₀₋₈ alkylene or
- (CH₂)₀⁻₆ aryl(CH₂)₀⁻₆;

A is selected from
- O(CH₂)ₚ,
- NR₆(CH₂)ₚ,
- CNR₂⁹(CH₂)ₚ,
- NR₂⁹C(CH₂)ₚ,
- C(CH₂)ₚ,
- SO₂(CH₂)ₚ,
- SO₂NR₂⁹(CH₂)ₚ,
- NR₂⁹SO₂(CH₂)ₚ or
- C≡C-(CH₂)ₚ;

where p is an integer from 0 to 3;

R¹, R², R³, R⁴, R⁵, R⁶, R¹⁷, R¹⁸, R¹⁹, R²⁰, R²³, R²⁴, R²⁵, R²⁶, R²⁷ and R²⁹ are each independently selected from
hydrogen,  
C\textsubscript{1-10} alkyl,  
aryl C\textsubscript{0-8} alkyl,  
amino C\textsubscript{0-8} alkyl,  
C\textsubscript{1-3} acylamino C\textsubscript{0-8} alkyl,  
C\textsubscript{1-6} alkylamino C\textsubscript{0-8} alkyl,  
C\textsubscript{1-6} dialkylamino C\textsubscript{0-8} alkyl,  
C\textsubscript{1-4} alkoxy C\textsubscript{0-6} alkyl,  
carboxy C\textsubscript{0-6} alkyl,  
\begin{align*}
\text{R}^{10} \text{ and } \text{R}^{11} \text{ are each independently selected from} & \\
\text{hydrogen,} & \\
\text{fluorine,} & \\
\text{C}_{3-8} \text{ alkyl,} & \\
\text{hydroxyl,} & \\
\text{C}_{3-8} \text{ cycloalkyl,} & \\
\text{aryl C}_{0-6} \text{ alkyl,} & \\
\text{C}_{0-6} \text{ alkylamino C}_{0-6} \text{ alkyl,} & \\
\text{C}_{0-6} \text{ dialkylamino C}_{0-6} \text{ alkyl,} & \\
\text{C}_{1-8} \text{ alkylsulfonylamino C}_{0-6} \text{ alkyl,} & \\
\text{aryl C}_{0-6} \text{ alkylsulfonylamino C}_{0-6} \text{ alkyl,} & \\
\text{C}_{1-8} \text{ alkyloxycarbonylamino C}_{0-6} \text{ alkyl,} & \\
\text{aryl C}_{0-6} \text{ alkyloxycarbonylamino C}_{0-6} \text{ alkyl,} & \\
\text{C}_{1-8} \text{ alkylcarbonylamino C}_{0-6} \text{ alkyl,} & \\
\text{aryl C}_{0-6} \text{ alkylcarbonylamino C}_{0-6} \text{ alkyl,} & \\
\end{align*}

-85-
C₀-₈ alkylaminocarbonylamino C₀-₆ alkyl,  
aryl C₀-₈ alkylaminocarbonylamino C₀-₆ alkyl,  
C₀-₈ alkylaminosulfonylamino C₀-₆ alkyl,  
aryl C₀-₈ alkylaminosulfonylamino C₀-₆ alkyl,  
C₁-₆ alklysulfonyl C₀-₆ alkyl,  
C₁-₆ alkylicarbonyl C₀-₆ alkyl or  
arly C₀-₆ alkylicarbonyl C₀-₆ alkyl;

R¹² is selected from

dydroxy,  
C₁-₈ alkyloxy,  
arly C₀-₆ alkyloxy,  
C₁-₈ alkylicarbonyloxy C₁-₄ alkyloxy or  
arly C₀-₈ alkylicarbonyloxy C₁-₄ alkyloxy;

R¹³, R¹⁴, R¹⁵ and R¹⁶ are each independently selected from  
hydrogen,  
C₁-₁₀ alkyl,  
arly C₀-₈ alkyl,  
amino C₀-₈ alkyl,  
C₁-₃ acylamino C₀-₈ alkyl,  
C₁-₆ alkylamino C₀-₈ alkyl,  
C₁-₆ dialkylamino C₀-₈ alkyl,  
C₁-₄ alkoxy C₀-₆ alkyl,  
carboxy C₀-₆ alkyl,  
C₁-₄ alkoxy carbonyl C₀-₆ alkyl,  
carboxy C₀-₆ alkoxyloxy,  
hydroxy C₀-₆ alkyl,
provided that when Ring is

\[
\begin{align*}
\text{or } & \quad \text{or } \\
\end{align*}
\]

then \( X \) is selected from

\[
\begin{align*}
\text{or } & \quad \text{or } \\
\end{align*}
\]

and the pharmaceutically acceptable salts thereof.

4. The compound of Claim 3, wherein \( X \) is selected from
and the pharmaceutically acceptable salts thereof.

5. The compound of Claim 4, of the formula

\[ X \rightarrow Y \rightarrow \text{Ring} \rightarrow \text{NH} \rightarrow R^8 \]

5

X is selected from

and

Y is selected from

C\text{0-8 alkylene},

C\text{0-8 alkylene-NR}^5\text{C0-8 alkylene}; and

R^{12} \text{ is selected from }

hydroxy or

C\text{1-8 alkylloxy};

- 88 -
and the pharmaceutically acceptable salts thereof.

6. The compound of Claim 5, selected from

5 [6-(5,6,7,8-Tetrahydro-[1,8]-naphthyridin-2-yl)naphthylene-2-yl]-carbonyl-2(S)-phenylsulfonlamino-β-alanine ethyl ester;

[6-(5,6,7,8-Tetrahydro-[1,8]-naphthyridin-2-yl)naphthylene-2-yl]-carbonyl-2(S)-phenylsulfonlamino-β-alanine;

6-([N-Pyridin-2-yl]aminomethyl)naphthylene-2-yl)-carbonyl-2(S)-phenylsulfonlamino-β-alanine ethyl ester;

6-([N-Pyridin-2-yl]aminomethyl)naphthylene-2-yl)-carbonyl-2(S)-phenylsulfonlamino-β-alanine;

4-(5,6,7,8-Tetrahydro-[1,8]-naphthyridin-2-yl)piperidin-1-yl-carbonyl-2(S)-phenylsulfonlamino-β-alanine t-butyl ester;

4-(5,6,7,8-Tetrahydro-[1,8]-naphthyridin-2-yl)piperidin-1-yl-carbonyl-2(S)-phenylsulfonlamino-β-alanine;

6-[(Pyrimidinyl-2-yl)aminomethyl]naphthylene-2-yl-carbonyl-2(S)-phenylsulfonlamino-β-alanine ethyl ester;

6-[(Pyrimidinyl-2-yl)aminomethyl]naphthylene-2-yl-carbonyl-2(S)-phenylsulfonlamino-β-alanine; or

6-[(1,4,5,6-Tetrahydropyrimidinyl-2-yl)aminomethyl]naphthylene-2-yl-carbonyl-2(S)-phenylsulfonlamino-β-alanine;

and the pharmaceutically acceptable salts thereof.

7. The compound of Claim 6, selected from
[6-(5,6,7,8-Tetrahydro-[1,8]-naphthyridin-2-yl)naphthylen-2-yl]-carbonyl-2(S)-phenylsulfonylamino-β-alanine;

6-((N-Pyridin-2-yl)aminomethyl)naphthylen-2-yl)carbonyl-2(S)-phenylsulfonylamino-β-alanine;

4-(5,6,7,8-Tetrahydro-[1,8]naphthyridin-2-yl)piperidin-1-yl-carbonyl-2(S)-phenylsulfonylamino-β-alanine; or

6-[(Pyrimidinyl-2-yl)aminomethyl]naphthylen-2-yl-carbonyl-2(S)-phenylsulfonyl-β-alanine;

and the pharmaceutically acceptable salts thereof.

8. A pharmaceutical composition comprising the compound of Claim 1 and a pharmaceutically acceptable carrier.

9. A pharmaceutical composition made by combining a compound of Claim 1 and a pharmaceutically acceptable carrier.

10. A process for making a pharmaceutical composition comprising combining a compound of Claim 1 and a pharmaceutically acceptable carrier.

11. A method of eliciting a vitronectin antagonizing effect in a mammal in need thereof, comprising administering to the mammal a therapeutically effective amount of the compound of Claim 1.

12. The method of Claim 11, wherein the vitronectin antagonizing effect is selected from inhibition of bone resorption, inhibition of restenosis, inhibition of angiogenesis, inhibition of diabetic retinopathy, inhibition of macular degeneration or inhibition of tumor growth.
13. The method of Claim 12, wherein the vitronectin antagonizing effect is the inhibition of bone resorption.

14. A method of treating or preventing a condition mediated by antagonism of a vitronectin receptor in a mammal in need thereof, comprising administering to the mammal a therapeutically effective amount of the compound of Claim 1.

15. The method of Claim 14, wherein the condition is selected from the group consisting of osteoporosis and cancer.

16. The method of Claim 15, wherein the condition is osteoporosis.

17. A method of inhibiting bone resorption in a mammal in need thereof, comprising administering to the mammal a therapeutically effective amount of the compound of Claim 1.

18. A method of treating osteoporosis in a mammal in need thereof, comprising administering to the mammal a therapeutically effective amount of the compound of Claim 1.

19. A method of preventing osteoporosis in a mammal in need thereof, comprising administering to the mammal a therapeutically effective amount of the compound of Claim 1.

20. A method of eliciting a vitronectin antagonizing effect in a mammal in need thereof, comprising administering to the mammal a therapeutically effective amount of the composition of Claim 8.
21. A method of treating or preventing a condition mediated by antagonism of a vitronectin receptor in a mammal in need thereof, comprising administering to the mammal a therapeutically effective amount of the composition of Claim 8.

22. A method of inhibiting bone resorption in a mammal in need thereof, comprising administering to the mammal a therapeutically effective amount of the composition of Claim 8.

23. A method of treating osteoporosis in a mammal in need thereof, comprising administering to the mammal a therapeutically effective amount of the composition of Claim 8.


25. The use of the compound of Claim 1 in the preparation of a medicament for the treatment or prevention of a condition selected from: osteoporosis, bone resorption, tumor growth, cancer, restenosis, artherosclerosis, diabetic retinopathy, macular degeneration or angiogenesis in a mammal in need thereof.

26. A drug which is useful for treating or preventing a condition selected from: osteoporosis, bone resorption, tumor growth, cancer, restenosis, artherosclerosis, diabetic retinopathy, macular degeneration or angiogenesis in a mammal in need thereof, the effective ingredient of the said drug being the compound of Claim 1.

27. A method of treating tumor growth in a mammal in need thereof, comprising administering to the mammal a therapeutically effective amount of a compound of Claim 1 and one or more agents known to be cytotoxic or antiproliferative.
### A. CLASSIFICATION OF SUBJECT MATTER

**IPC(6)**: Please See Extra Sheet.
**US CL**: Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC.

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

- **U.S.**: Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched.

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

- **APS, CAS ONLINE**

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
</table>

Further documents are listed in the continuation of Box C. See patent family annex.

- * Special categories of cited documents:
  - "A": document defining the general state of the art which is not considered to be of particular relevance
  - "B": earlier document published on or after the international filing date
  - "L": document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  - "O": document referring to an oral disclosure, use, exhibition or other means
  - "P": document published prior to the international filing date but later than the priority date claimed
  - "T": later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
  - "X": document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
  - "Y": document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
  - "Z": document member of the same patent family

Date of the actual completion of the international search: 20 JANUARY 1998

Date of mailing of the international search report: 23 FEB 1998

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks
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Facsimile No. (703) 305-3230

Authorized officer:
CHANA AULAKH

Telephone No. (703) 308-1233

Form PCT/ISA/210 (second sheet) (July 1992)
### Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. □ Claims Nos.:  
   because they relate to subject matter not required to be searched by this Authority, namely:

2. □ Claims Nos.:  
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. □ Claims Nos.:  
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. X As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. □ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. □ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. □ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:  

**Remark on Protest**  
□ The additional search fees were accompanied by the applicant's protest.  
□ No protest accompanied the payment of additional search fees.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):
A61K 31/18, 31/19, 31/44, 31/47, 31/195, 31/405, 31/415, 31/425, 31/435, 31/505; C07C 63/00, 307/06, 307/08, 307/10; C07D 209/40, 213/89, 217/08, 233/44, 233/88, 239/08, 239/14, 239/42

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :
514/275, 300, 303, 310, 352, 357, 365, 371, 396, 398, 415, 563, 603, 613, 616; 544/323, 332; 546/118, 122, 143, 290, 291, 301, 304, 309, 310, 311, 312; 548/195, 300.1, 308.4, 335.5, 495; 560/34; 564/86, 147

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.
514/275, 300, 303, 310, 352, 357, 365, 371, 396, 398, 415, 563, 603, 613, 616; 544/323, 332; 546/118, 122, 143, 290, 291, 301, 304, 309, 310, 311, 312; 548/195, 300.1, 308.4, 335.5, 495; 560/34; 564/86, 147

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains claims directed to more than one species of the generic invention. These species are deemed to lack Unity of Invention because they are not so linked as to form a single inventive concept under PCT Rule 13.1. The species are as follows:
I. Compounds of formula of claim 1 where Ring or X is a 6-membered hetero ring containing O, S and N as the heteroatoms, classifiable in class 544, subclass 2+.  
II. Compounds of formula of claim 1 where Ring or X is a 6-membered hetero ring containing O and N as the heteroatoms, classifiable in class 544, subclass 63+.  
III. Compounds of formula of claim 1 where Ring or X is a 6-membered hetero ring containing four N as the heteroatoms, classifiable in class 544, subclass 179.  
IV. Compounds of formula of claim 1 where Ring or X is a 6-membered hetero ring containing three N as the heteroatoms, classifiable in class 544, subclass 180.  
V. Compounds of formula of claim 1 where Ring or X is a 6-membered hetero ring containing two N as the heteroatoms, classifiable in class 544, subclass 224+.  
VI. Compounds of formula of claim 1 where Ring or X is a 6-membered hetero ring containing only one N as the heteroatom, classifiable in class 546, subclass 26+.  
VII. Compounds of formula of claim 1 where Ring or X is a 5-membered hetero ring containing O, S and N as the heteroatoms, classifiable in class 548, subclass 122+.  
VIII. Compounds of formula of claim 1 where Ring or X is a 5-membered hetero ring containing four N as the heteroatoms, classifiable in class 548, subclass 250+.  
IX. Compounds of formula of claim 1 where Ring or X is a 5-membered hetero ring containing three N as the heteroatoms, classifiable in class 548, subclass 255+.  
X. Compounds of formula of claim 1 where Ring or X is a 5-membered hetero ring containing two N as the heteroatoms, classifiable in class 548, subclass 300.1+.  
XI. Compounds of formula of claim 1 where Ring or X is a 5-membered hetero ring containing only one N as the heteroatom, classifiable in class 548, subclass 400+.  
XII. Compounds of formula of claim 1 where Ring or X is a hetero ring containing only S as the heteroatoms, classifiable in class 549, subclass 1+.  

Form PCT/ISA/210 (extra sheet)(July 1992)
XIII. Compounds of formula of claim 1 where Ring or X is a hetero ring containing only O as the heteroatoms, classifiable in class 549, subclass 200+.

XIV. Compounds of formula of claim 1 containing carboxylic acid ester and either Ring or X is not a hetero ring, classifiable in class 560, subclass 11+.

XV. Compounds of formula of claim 1 containing amino nitrogen and either Ring or X is not a hetero ring, classifiable in class 564, subclass 1+.

The claims are deemed to correspond to the species listed above in the following manner:

Species V and VI. Claims 6 and 7.

The following claims are generic: Claims 1-5 and 8-27.

The species listed above do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, the species lack the same or corresponding special technical features for the following reasons:

There is no common core Which in the Markush Practice, is a significant structural element shared by all the alternatives; see PCT Administrative Instructions Annex B Part I (f) (i) (B) (1) and further, all alternatives do not belong to a recognized class of chemical compounds in the art to which the invention pertains; see supra (B) (2).