Abstract: A compound of formula (I) is disclosed. Compounds of formula (I) are useful as analgesics, anti-inflammatory agents, anti-diarrheal agents, anticonvulsants, antitussives and anti-addiction medications.
Carboxamide Bioisosteres of Opiates

Federally Sponsored Research
The following invention was made with Government support under contract number R01 DA12180 awarded by U.S. Dept of Health and Human Services. The Government has certain rights in this invention.

Cross Reference to Related Applications
This application claims priority of US provisional applications 61/316,175, filed March 22, 2010, 61/394,148, filed October 18, 2010, and 61/421,915, filed December 10, 2010, the entire disclosures of which are incorporated herein by reference.

Field of the Invention
The invention relates to opioid receptor binding compounds containing carboxamides that have large substituents on the nitrogen of the carboxamide. The compounds are useful as analgesics, anti-diarrheal agents, anticonvulsants, anti-obesity agents, antitussives, anti-cocaine, anti-inflammatory, and anti-addiction medications.

Background of the Invention
Opiates have been the subject of intense research since the isolation of morphine in 1805, and thousands of compounds having opiate or opiate-like activity have been identified. Many opioid receptor-interactive compounds including those used for producing analgesia (e.g., morphine) and those used for treating drug addiction (e.g., naltrexone and cyclazocine) in humans have limited utility due to poor oral bioavailability and a very rapid clearance rate from the body. This has been shown in many instances to be due to the presence of the 8-hydroxyl group (OH) of 2,6-methano-3-benzazocines, also known as benzomorphans [(e.g., cyclazocine and EKC (ethylketocyclazocine)] and the corresponding 3-OH group in morphinans (e.g., morphine). Furthermore, charts 1-3 depicts a set of opiate binding compounds that are used to treat diseases mediated by opiate receptors.
Chart 1. Opioid Receptor Ligands
Benzomorphinans (a.k.a. 2,6-Methano-3-benzazocines)

Cyclazocine, $R_3 = \text{CH}_2\text{-c-C}_3\text{H}_5$
Ketocyclazocine
Ethylketocyclazocine (EKC)

Metazocine, $R_3 = \text{CH}_3$
Phenazocine, $R_3 = \text{CH}_2\text{C}_6\text{H}_5$
SKF 10,047, $R_3 = \text{CH}_2\text{CH=CH}_2$
Pentazocine, $R_3 = \text{CH}_2\text{CH=C(CH}_3\text{)}_2$
(all racemic)

MR2034 - "Merz" core structure (opt. active)
MR2266
Bremazocine

WIN 44,441
Chart 2. Opioid Receptor Ligands
Morphine and Morphinans

Morphine

Naltrexone: \( R_{17} = \text{CH}_2\text{-C}_2\text{H}_5 \)
Naloxone: \( R_{17} = \text{CH}_2\text{CH} = \text{CH}_2 \)
Nalmexone: \( R_{17} = \text{CH}_2\text{CH} = \text{C}(\text{CH}_3)_2 \)
Oxymorphone: \( R_{17} = \text{CH}_3 \)

β-Naltrexamine
Nalmefene
Methyl naltrexone

Buprenorphine
Diprenorphine
Etorphine (N-Me; n-Pr vs Me)

Nalorphine
Naltrindole
Nalbuphine

β-Naltrexamine
Nalmefene
Methyl naltrexone
Chart 2 (continued). Opioid Receptor Ligands
Morphine and Morphinans

**Morphine and Morphinans**

- nor-BNI (Norbinaltorphimine)
  - Reg # = 10561-8-26-6

**Levorphanol**
- Levo; $R_{17} = \text{CH}_3$

**Cyclorphan**
- Cyclorphan; $R_{17} = \text{CH}_2\text{C}_2\text{H}_5$

**MCL 101**
- MCL 101; $R_{17} = \text{CH}_2\text{C}_4\text{H}_7$

**Butorphanol**
- Butorphanol; $R_{17} = \text{CH}_2\text{C}_4\text{H}_7$
  - and 14-OH

**Merz-morphinane hybrid core**
- Merz-morphinane hybrid core; $R_{17} = \text{CH}_2\text{-(S)-tetrahydrofurfuryl}$

**Dextrorphan**
- Dextrorphan; $R = \text{CH}_3$

**Dextromethorphan**
- Dextromethorphan; $R = \text{CH}_3$

(continue)
wherein, R is selected from \( \text{CH}_3 \), \( \text{CH}_2\text{CH}2\text{CH(OH)C}_6\text{Hn} \), \( \text{CH}_2\text{CH(}\text{CH}_2\text{Ph)CONHCH}_2\text{C}_0\text{2H} \), \( \text{(CH}_2\text{)}_3\text{CH(}\text{CH}_3\text{)}_2 \), and \( \text{(CH}_2\text{)}_3\text{-2-thienyl} \),

Meptazinol

Ketobemidone

Tramadol active metabolite
Registry Number 80456-81-1
Other opioid receptor ligands are described in Aldrich, J.V. "Analgesics" in Burger's Medicinal Chemistry and Drug Discovery, M.E. Wolff ed., John Wiley & Sons 1996, pages 321-44, the disclosures of which are incorporated herein by reference.

The high polarity of these hydroxyl groups retards oral absorption of the parent molecules. Furthermore, the 8-(or 3-)OH group is prone to sulfonation and glucuronidation (Phase II metabolism), both of which facilitate rapid excretion of the active compounds, leading to disadvantageously short half-lives for the active compounds. Until the publications of Wentland in 2001, the uniform experience in the art of the past seventy years had been that removal or replacement of the 8-(or 3-)OH group had led to pharmacologically inactive compounds.

US patent 6,784,187 (to Wentland) disclosed that the phenolic OH of opioids could be replaced by CONH₂. In the cyclazocine series of opioids, it was shown that 8-carboxamidocyclazocine (8-CAC) had high affinity for μ and κ opioid receptors. In studies in vivo, 8-CAC showed high antinociception activity and a much longer duration of action than cyclazocine (15 h vs. 2 h) when both were dosed at 1 mg/kg ip in mice. Preliminary structure-activity relationship studies for 8-CAC revealed that mono-substitution of the carboxamide nitrogen with methyl or phenyl reduced binding affinity for guinea pig μ receptors 75- and 2313-fold, respectively whereas dimethylation of the carboxamide group reduced binding affinity 9375-fold. The finding that substitution of the carboxamide nitrogen had such a detrimental effect suggested that the NH₂ of the amide was critical to opioid
binding.

We recently reported that the nitrogen of the carboxamide can be substituted with fairly large and relatively non-polar groups, and that such compounds exhibit good opioid binding and, presumably, good metabolic stability. (WO 2010/01 1619) Compounds with improved activity can be used to reduce dosage, side effects and costs.

Summary of the Invention

In one aspect, the invention relates to compounds of formula I:

\[
\begin{align*}
\text{I} \\
\text{R}^1 \text{ and } \text{R}^2 \text{ are each independently selected from hydrogen, halogen, } -\text{OH, } -\text{CN, } -\text{CHO, } -\text{OCH}_3, -\text{OCH}_2\text{CH}_3, -\text{OCH}(\text{CH}_3)_2, -\text{N}0_2, -\text{COR}^{10}, -\text{COOR}^{10}, -\text{SO}_2\text{R}^{10}, -\text{CONR}^{10}\text{R}^{11}, -\text{CSNR}^{10}\text{R}^{11}, -\text{CONR}^{10}\text{NR}^{10}\text{R}^{11}, -\text{CONR}^{10}\text{OR}^{11}, -\text{CONR}^{10}\text{((R}^{12}((\text{R}^{13}\text{)})_3)\text{C})\text{OOR}^{11}, -\text{C}=(\text{S})\text{R}^{10}, -\text{C}=(\text{NOR}^{11})\text{R}^{10}, -\text{C}=(\text{NR}^{10})\text{R}^{11}, -\text{SO}_2\text{NR}^{10}\text{R}^{11}, \text{heterocyclyl, optionally substituted lower alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted aryl, halo}(\text{Ci-Ce})\text{alkyl, halo}(\text{Ci-Ce})\text{alkoxy, and } (\text{Ci-Ce})\text{alkythio}; \\
or, \text{R}^1 \text{ and } \text{R}^2 \text{ together with the atoms to which they are attached, and a fragment selected from } -\text{OCH}_2\text{O}-, \text{ or } -\text{OCH}_2\text{CH}_2\text{O}-, \text{ form a ring,} \\
\text{wherein when Cy is an aromatic group } \text{R}^1 \text{ and } \text{R}^2 \text{ cannot both be hydrogen;} \\
\text{wherein when Cy is an aromatic group } \text{R}^1 \text{ and } \text{R}^2 \text{ cannot both be halogen;}
\end{align*}
\]

\[
\text{R}^3 \text{ is chosen from hydrogen, } \text{Ci-Cg hydrocarbon, heterocyclyl, aryl and hydroxyalkyl;}
\]
R⁴ is chosen from hydrogen, hydroxyl, amino, lower alkoxy, C1-C20 alkyl and C1-C20 alkyl substituted with hydroxyl or carbonyl;
R⁵ is lower alkyl;
R⁶ is lower alkyl;
R⁷ is chosen from hydrogen, NR⁰R¹¹ and -OR¹⁰; or
together R⁴, R⁵, R⁶ and R⁷ may form from one, two, three, or four rings, said rings
having optional additional substitution;
R⁸ and R⁸ᵃ are both hydrogen or taken together R⁸ and R⁸ᵃ are =0;
R⁹ is chosen from hydrogen and lower alkyl;
R¹⁰, R¹¹, R¹² and R¹³ are each independently hydrogen, optionally substituted lower alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted aryl, hydroxyl, -NR¹⁰R¹⁰ or optionally substituted lower alkoxy, or
R¹⁰ and R¹¹, together with the nitrogen atom to which they are attached, form an optionally substituted fused carbocyclic or heterocyclic ring having from 5 to 7 ring members of which up to 3 can be heteroatoms selected from N, O and S;
t is 0, 1, 2, 3, 4, 5, or 6;
R¹⁰⁰ and R¹⁰¹ are each independently hydrogen, optionally substituted lower alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted aryl, hydroxyl, or optionally substituted lower alkoxy, or
R¹⁰⁰ and R¹⁰¹, together with the nitrogen atom to which they are attached, form an optionally substituted fused carbocyclic or heterocyclic ring having from 5 to 7 ring members of which up to 3 can be heteroatoms selected from N, O and S;
Y is a direct bond or -(C(R¹⁰)(R¹¹))q-, wherein q is 0, 1, 2, 3, 4 or 5;
L is a direct bond or -(C(R¹⁰)(R¹³)q)q-; and
Cy is Ar¹-B-Ar², wherein
Ar¹ is absent, or an aryl or heteroaryl radical having from 1 to 4 N, O and/or S atoms, which may be unsubstituted or mono-, di- or trisubstituted by halogen, lower alkyl, alkenyl, alkynyl, cycloalkyl, -OR¹⁰, -NR¹⁰R¹¹, -CN, -COR¹⁰ or -COOR¹⁰;
B is a direct bond, -O-, -NR¹⁰, -S⁰², or -(C(R¹⁰)(R¹¹))s-, wherein s is 0, 1, 2, 3, 4 or 5; and
Ar² is aryl or heteroaryl radical having from 1 to 4 N, O and/or S atoms, which may be unsubstituted or mono-, di- or trisubstituted by halogen, lower alkyl, alkenyl, alkynyl, cycloalkyl, -OR¹⁰, -NR¹⁰R¹¹, -CN, -COR¹⁰ or -COOR¹⁰,
wherein when Cy is phenyl or biphenyl, Ri is other than –OCH₃.

In another aspect, the invention relates to compounds of formula Ia:

![Chemical Structure](image)

wherein L is a direct bond, and all other substituents are defined as above.

In one aspect of the invention, the compounds described in charts 1-3 are substituted at the phenolic hydroxyl position. For instance, compounds of charts 1-3 are substituted at the phenolic hydroxyl position with -C(0)N(R⁻⁹)LCy(R¹)(R³), wherein the carboxamido moiety replaces the hydroxyl group to give a compound of formula I or formula la.

In another aspect, the invention relates to a pharmaceutical formulation comprising a compound of formula I or formula la and a pharmaceutically acceptable carrier.

In another aspect, the invention relates to a method of preventing or treating a condition or disease associated with binding opioid receptors in a patient in need thereof, comprising the step of administering to said patient a composition comprising an effective amount of a compound of formula I or formula la.

The compounds of the invention are therefore useful as analgesics, anti-inflammatory agents, anti-pruritics, anti-diarrheal agents, anticonvulsants, antitussives, anorexics and as treatments for hyperalgesia, anti-addiction, respiratory depression, dyskinesia, pain (including neuropathic pain), irritable bowel syndrome and gastrointestinal motility disorders. As used herein, anti-addiction medications can be used interchangeably with the term drug addiction,
which includes alcohol, cocaine, heroin, amphetamine and nicotine addiction. There is evidence in the literature that the compounds may also be useful as immunosuppressants and antiinflammatories and for reducing ischemic damage (and cardioprotection), for improving learning and memory, and for treating urinary incontinence. In particular, the compounds of the invention are useful for the treatment of osteoarthritis.

In another aspect, the invention relates to a method of preventing or treating a condition or disease associated with binding opioid receptors in a patient in need thereof, comprising the step of administering to said patient a composition comprising an effective amount of a compound of formula I or formula Ia. In further embodiments, drug addiction encompasses heroin, cocaine, amphetamine, nicotine or alcohol addiction. In other embodiments, the condition is pain and the composition further comprises an effective amount of an opioid. In yet a further embodiment, the condition is osteoarthritis and the composition further comprises an effective amount of an opioid.

Detailed Description of the Invention
From many years of SAR studies, it is known that the hydroxyl of morphinans and benzomorphans interacts with a specific site in the opiate receptor. Our recent studies have found that the hydroxyl can be replaced with a carboxamide residue. A fairly wide range of secondary carboxamides exhibits binding in the desired range below 25 nanomolar. We recently reported a set of compounds with cyclic groups attached at the carboxamide position. (US 20070021457, WO 2010/01 1619, and 12/506,354, the entire contents of which are incorporated by reference herein). It has been surprisingly found that a selected groups of substituents on the cyclic group provides significantly improved binding properties.

In one aspect the invention relates to compounds of formula I:
wherein
R^1 and R^2 are each independently selected from hydrogen, halogen, -OH, -CN, -CHO, -OCH_3, -OCH(CH_3)_2, -N0_2, -COR^10, -COOR^10, -S0_2R^10, -CONR^10R^11, -CSNR^10R^11, -CONR^10NR^11R^12, -CONR^10OR^11, -CONR^10((C(R^1)^2)(R^1)^3))_4COOR^11, -C(=S)R^10, -C(=NOR^10)R^11, C(=NR^10)R^11, -SO_2NR^10R^11, heterocyclyl, optionally substituted lower alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted aryl, halo(Ci-Ce)alkyl, halo(Ci-Ce)alkoxy, and (Ci-Ce)alkylthio;
or, R^1 and R^2 together with the atoms to which they are attached, and a fragment selected from -OCH_2O-, or -OCH_2CH_2O-, form a ring,
wherein when Cy is an aromatic group R^1 and R^2 cannot both be hydrogen;
wherein when Cy is an aromatic group R^1 and R^2 cannot both be halogen;
R^3 is chosen from hydrogen, Ci-C_8 hydrocarbon, heterocyclyl, aryl and hydroxyalkyl;
R^4 is chosen from hydrogen, hydroxyl, amino, lower alkoxy, Ci-C_20 alkyl and Ci-C_20 alkyl substituted with hydroxyl or carbonyl;
R^5 is lower alkyl;
R^6 is lower alkyl;
R^7 is chosen from hydrogen, NR^10R^11 and -OR^10; or
together R^4, R^5, R^6 and R^7 may form from one, two, three, or four rings, said rings having optional additional substitution;
R^8 and R^8a are both hydrogen or taken together R^8 and R^8a are =0;
R^9 is chosen from hydrogen and lower alkyl;
R<sup>10</sup>, R<sup>11</sup>, R<sup>12</sup> and R<sup>13</sup> are each independently hydrogen, optionally substituted lower alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted aryl, hydroxyl, -NR<sup>100</sup>R<sup>101</sup> or optionally substituted lower alkoxy, or R<sup>10</sup> and R<sup>11</sup>, together with the nitrogen atom to which they are attached, form an optionally substituted fused carbocyclic or heterocyclic ring having from 5 to 7 ring members of which up to 3 can be heteroatoms selected from N, O and S;

R<sup>100</sup> and R<sup>101</sup> are each independently hydrogen, optionally substituted lower alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted aryl, hydroxyl, or optionally substituted lower alkoxy, or

R<sup>100</sup> and R<sup>101</sup>, together with the nitrogen atom to which they are attached, form an optionally substituted fused carbocyclic or heterocyclic ring having from 5 to 7 ring members of which up to 3 can be heteroatoms selected from N, O and S;

Y is a direct bond or -(C(R<sup>10</sup>)(R<sup>11</sup>))<sub>q</sub>- wherein q is 0, 1, 2, 3, 4 or 5;

L is a direct bond or -(C(R<sup>10</sup>)(R<sup>11</sup>))<sub>s</sub>-; and

Cy is Ar<sup>1</sup>-B-Ar<sup>2</sup>, wherein

Ar<sup>1</sup> is absent, or an aryl or heteroaryl radical having from 1 to 4 N, O and/or S atoms, which may be unsubstituted or mono-, di- or trisubstituted by halogen, lower alkyl, alkenyl, alkynyl, cycloalkyl, -OR<sup>10</sup>, -NR<sup>10</sup>R<sup>11</sup>, -CN, -COR<sup>10</sup> or -COOR<sup>10</sup>;

B is a direct bond, -O-, -NR<sup>10</sup>, -SO<sub>2</sub>, or -(C(R<sup>10</sup>)(R<sup>11</sup>))<sub>s</sub>- wherein s is 0, 1, 2, 3, 4 or 5; and

Ar<sup>2</sup> is aryl or heteroaryl radical having from 1 to 4 N, O and/or S atoms, which may be unsubstituted or mono-, di- or trisubstituted by halogen, lower alkyl, alkenyl, alkynyl, cycloalkyl, -OR<sup>10</sup>, -NR<sup>10</sup>R<sup>11</sup>, -CN, -COR<sup>10</sup> or -COOR<sup>10</sup>, wherein when Cy is phenyl or biphenyl, Ri is other than -OCH<sub>3</sub>.

In part, the invention provides a compound of formula II:
wherein, Cy, R¹, R², R³, R⁴, R⁵, R⁶, R⁷, R⁸, and R⁸⁺ are as defined above. In some embodiments, R¹ is selected from -OH, -CHO, -CONH₂, -CON(H)CH₂CONH₂, -CON(H)CH₂CH₂CONH₂, -CON(H)CH₂COOH, -CON(H)CH₂CON(H)CH₂COOH, -COOH and -COOCH₃; or R¹ and R² together with the atoms to which they are attached forms a -OCH₂O-fused ring.

In other embodiments, R² is H, and R¹ is selected from -OH, -CHO, -CONH₂, -CON(H)CH₂CONH₂, -CON(H)CH₂CON(H)CH₂CONH₂, -CON(H)CH₂COOH, -CON(H)CH₂CH₂COOH, -CON(H)CH₂COOH, -COOH and -COOCH₃.

In part, the invention provides a compound of formula III, IV, V or VI below:
wherein, R	extsuperscript{1}, R	extsuperscript{2}, R	extsuperscript{3}, R	extsuperscript{4} and Cy are as defined above;
each R	extsuperscript{20}, R	extsuperscript{21} and R	extsuperscript{22} is chosen from hydrogen, hydroxyl, amino, lower alkoxy, C	extsubscript{1}-C	extsubscript{20} alkyl and C	extsubscript{1}-C	extsubscript{2}0 alkyl substituted with hydroxyl or carbonyl; or together, R	extsuperscript{20} and R	extsuperscript{21} together with the carbon to which they are attached, form -CO, or -CS; or together, R	extsuperscript{20} and R	extsuperscript{21}, together with the carbon(s) to which they are attached, form a ring. In some embodiments, such a ring is a spiral ring.

In one embodiment, a compound of formula III, IV, V or VI is disclosed wherein R	extsuperscript{1} is selected from -OH, -CHO, -CONH	extsubscript{2}, -CON(H)CH	extsubscript{2}CONH	extsubscript{2}, -CON(H)CH	extsubscript{2}CH	extsubscript{2}CONH	extsubscript{2}, -CON(H)CH	extsubscript{2}COOH, -CON(H)CH	extsubscript{2}CH	extsubscript{2}COOH; or R	extsuperscript{1} and R	extsuperscript{2} together with the atoms to which they are attached forms a -OCH	extsubscript{2}0 - fused ring. In another embodiment, R	extsubscript{2} is H, and R	extsuperscript{1} is selected from -OH, -CHO, -CONH	extsubscript{2}, -CON(H)CH	extsubscript{2}CONH	extsubscript{2}, -CON(H)CH	extsubscript{2}CH	extsubscript{2}CONH	extsubscript{2}, -CON(H)CH	extsubscript{2}COOH, -CON(H)CH	extsubscript{2}CH	extsubscript{2}COOH.

In part, the invention provides a compound of formula I:

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\text{Y-R^3}
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where R	extsuperscript{1}, R	extsuperscript{2}, R	extsuperscript{3}, and R	extsuperscript{9} are as defined above.
Formula 1a

wherein L is a direct bond, and R^1, R^2, R^3, R^4, R^5, R^6, R^7, R^8, R^9 and Cy are as defined above.

R^1 and R^2 can be, independently, small, polar, neutral residues and, in particular, can be selected from the group consisting of substituted or unsubstituted amide groups, including but not limited to carboxamide, thiocarboxamide, acylamine and formamide groups; substituted or unsubstituted amines; substituted or unsubstituted amidines, such as hydroxamidines; and alkyls substituted by polar neutral residues.

For example, R^1 and R^2 can be, independently, Z, wherein Z is a polar neutral residue, such as CH_2OR_a, CH_2NR_bR_c, -CN, -NR_bSO_2-R_c, -C(=W)Ra, -NR_aCOR_b, -NR_aCSR_b, -SO_2NR_bR_c, -NR_b-Q_a-R_c, -C(=W)NR_bR_c, -C(0)OR_a, heterocycle, substituted heterocycle, heteroaryl, and substituted heteroaryl, such as

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

wherein l is 0, 1, 2, 3, 4 or 5; k is 0, 1 or 2; X is C, N, S or O and --- represents a single or double bond;

R_a, R_b, R_c are each independently selected from: hydrogen; aryl; substituted aryl; heteroaryl; substituted heteroaryl; heterocyclic or substituted heterocyclic; and substituted or unsubstituted alkyl, alkenyl, alkynyl, cycloalkyl, or cycloalkenyl each containing 0, 1, 2, or 3 or more heteroatoms selected from O, S, or N;

alternatively, R_a, R_b and R_c taken together with the attached atom form a heterocyclic or substituted heterocyclic;

Q_a is absent or selected from (C=0), (SO_2), (C=NH), (C=S), or (CONR_a); and

W is O, S, NOR_a or NR_a.

In other examples, R^1 and R^2 can be each independently selected from hydrogen, halogen, -OH, -CN, -CHO, -OCH_3, -OCH_2CH_3, -OCH(CH_3)_2, -NO_2, -COR^{10}, -COOR^{10}, -SO_2R^{10}, -CONR^{10}R^{11}, -CSNR^{10}R^{11}, -CONR^{10}NR^{11}R^{12}, -CONR^{10}OR^{11}, -
CONR^{10}((C(R^{1})(R^{1})))_{t}CONR^{10}R^{11}, -CONR^{10}((C(R^{2})(R^{1}))_{t}COOR^{11}, -C(=S)R^{10}, -C(=NOR^{11})R^{10}, C(=NR^{10})R^{11}, -SO_{2}NR^{10}R^{11}, heterocyclyl, optionally substituted lower alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted aryl, halo(Ci-C6)alkyl, halo(Ci-C6)alkoxy, and (Ci-C6)alkylthio.

In other examples, R^{1} and R^{2}, together with the atoms to which they are attached, and a fragment selected from -OCH_{2}0-, or -OCH_{2}CH_{2}-, form a ring.

In some embodiments, one of R^{1} or R^{2} is hydrogen or methyl and the other is -CONH_{2}, -COH, -C_{2}H, -C_{2}CH_{3}, -OH, (Ci-C6)alkoxy or CN.

In some embodiments, Cy is selected from:

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wherein W is selected from \([C(R^3)_2], CR^8 R^8a, O, NR^9, S and CR^9=CR^9\); and
n is 1, 2, 3, 4 or 5.

In some embodiments, \(R^3\) is hydrogen. In other embodiments, \(R^3\) is heterocyclyl. In still other embodiments, \(R^3\) is hydroxyalkyl. In yet other embodiments, \(R^3\) is \(\text{C}_8\) hydrocarbon. In further embodiments, \(R^3\) is cyclopropyl or cyclobutyl.

In some embodiments, \(R^4\) is hydrogen. In other embodiments, \(R^4\) is hydroxyl or amino. In still other embodiments, \(R^4\) is lower alkoxy. In yet other embodiments, \(R^4\) is \(\text{C}_{20}\) alkyl or \(\text{C}_{20}\) alkyl substituted with hydroxyl or carbonyl. In further embodiments, \(R^4\) is methyl or ethyl.

In some embodiments, \(R^5\) is lower alkyl. In some embodiments, \(R^5\) is methyl.

In some embodiments, \(R^6\) is lower alkyl. In some embodiments, \(R^6\) is methyl.
In some embodiments, R^7 is hydrogen. In other embodiments, R^7 is -OR^10. In further embodiments, R^7 is hydroxyl. In still other embodiments, R^7 is NR^9R^11. In further embodiments, R^7 is NH₂, NHCH₃ or NH(CH₃)₂.

In some embodiments, R^4, R^5, R^6 and R^7 may form from one, two, three or four rings, said rings having optional additional substitution.

In an embodiment of the invention, R^8 and R^8a are both hydrogen. In another embodiment, R^8 and R^8a are taken together to form =O.

In some embodiments, R^9 is hydrogen. In other embodiments, R^9 is lower alkyl.

In some embodiments, R^10 and R^11 are each independently hydrogen. In other embodiments, R^10 is optionally substituted lower alkoxy and R^11 is hydrogen or methyl. In still other embodiments, R^10 is optionally substituted lower alkyl and R^11 is hydrogen or methyl. In yet other embodiments, R^10 is optionally substituted aryl and R^11 is hydrogen or methyl. In yet other embodiments, R^10 is hydroxyl or amino and R^11 is hydrogen or methyl. In some embodiments, R^10 and R^11, together with the nitrogen atom to which they are attached, form an optionally substituted fused carbocyclic or heterocyclic ring having from 5 to 7 ring members of which up to 3 can be heteroatoms selected from N, O and S. In some embodiments, R^10 and/or R^11 is -NR^100R^101.

In these embodiments, R^100 and R^101 are each independently selected from hydrogen, optionally substituted lower alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted aryl, hydroxyl, and optionally substituted lower alkoxy. In some embodiments, R^100 and R^101, together with the nitrogen atom to which they are attached, form an optionally substituted fused carbocyclic or heterocyclic ring having from 5 to 7 ring members of which up to 3 can be heteroatoms selected from N, O and S.

In one aspect of the invention, the compounds described in charts 1-3 are substituted at the phenolic hydroxyl position. For instance, compounds of charts 1-3 are substituted at the phenolic hydroxyl position with -C(0)N(R^9)LCy(Ri)(R^2), wherein the carboxamido moiety replaces the hydroxyl group to give a compound of formula I or formula la.
In some embodiments, the compound of formula I or formula Ia is selected from:
In some embodiments, the invention provides a compound selected from table 1:

<table>
<thead>
<tr>
<th>No</th>
<th>Structure</th>
<th>No</th>
<th>Structure</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td><img src="image1.png" alt="Structure 1" /></td>
<td>2</td>
<td><img src="image2.png" alt="Structure 2" /></td>
</tr>
<tr>
<td>3</td>
<td><img src="image3.png" alt="Structure 3" /></td>
<td>4</td>
<td><img src="image4.png" alt="Structure 4" /></td>
</tr>
</tbody>
</table>
In some embodiments of the invention, Cy-$R^1R^2$ is of formula

\[
\begin{align*}
R^1 & \quad Z \quad Z \\
R^2 & \quad Z \quad Z \\
\end{align*}
\]

wherein $Z$ is $CR^{10}$ (with $R^{10}$ defined as above) or N. In these instances, $Z$ must be C at the point of attachment of the distal ring to the proximal ring. Additionally, at the points of attachment of $R^1$ and $R^2$, $Z$ will be $CR^1$ and $CR^2$, respectively. In some embodiments, Cy-$R^1R^2$ will have the structure:
In some of these embodiments, one of $R^1$ and $R^2$ is in the para position relative to $B$ (the point of attachment of the distal ring to the proximal ring) and the other of $R^1$ and $R^2$ is hydrogen.

In some embodiments of the invention, $A_r^2$ is phenyl and one of $R^1$ or $R^2$ is in the para position relative to $B$.

In some embodiments of the invention, $C_y-R^1R^2$ has the structure:

![Chemical structure](image)

The phenolic hydroxyls of benzomorphans and morphinans can be chemically converted to carboxamides by a simple, flexible and convenient route described in Patent Publications 6,784,187, 7,057,035, US 20070021457, and WO 2010/01 1619.

It is known in the art that compounds that are $\mu$, $\delta$ and $\kappa$ agonists exhibit analgesic activity; compounds that are selective $\mu$ agonists exhibit anti-diarrheal activity and are useful in treating dyskinesia; $\mu$ antagonists and $\kappa$ agonists are useful in treating heroin, cocaine, alcohol and nicotine addiction; $\kappa$ agonists are also anti-pruritic agents and are useful in treating hyperalgesia. Recently it has been found [Peterson et al. Biochem. Pharmacol. 61,
that κ agonists are also useful in treating retroviral infections. In general, the dextrorotatory isomers of morphinans of type III above are useful as antitussives and anticonvulsants. Opiate binding is also related to the treatment of arthritis. (Keates et al., Anesth Analg 1999;89:409-15). Furthermore it has been reported that in patients suffering from osteoarthritis, μ- and δ-opioid receptors are synthesized and located in synovial lining cells, lymphocytes, and macrophages surrounding the vessels in synovial tissues, and may play a role in the regulation and modulation of inflammation. (Tanaka et al., Modern Rheumatology, 2003, 13(4) 326-332).

Opioid receptor ligands having known high affinity are shown in charts 1-3. Replacement of the phenolic OH with the -C(0)N(R9)LCy(Ri)(Ri) residue in these compounds produces compounds that exhibit similar activity and better bioavailability.

Binding assays used to screen compounds are similar to those previously reported by Neumeyer et al., Design and Synthesis of Novel Dimeric Morphinan Ligands for κ and μ Opioid Receptors. J. Med. Chem. 2003, 46, 5162. Membrane protein from CHO cells that stably expressed one type of the human opioid receptor were incubated with 12 different concentrations of the compound in the presence of either 1 nM [3H]U69,593 10 (κ), 0.25 nM [3H]DAMGO 11 (μ) or 0.2 nM [3H]naltrindole 12 (δ) in a final volume of 1 mL of 50 mM Tris-HCl, pH 7.5 at 25°C. Incubation times of 60 min were used for [3H]U69,593 and [3H]DAMGO. Because of a slower association of [3H]naltrindole with the receptor, a 3 h incubation was used with this radioligand. Samples incubated with [3H]naltrindole also contained 10 mM MgCl2 and 0.5 mM phenylmethylsulfonyl fluoride. Nonspecific binding was measured by inclusion of 10 μM naloxone. The binding was terminated by filtering the samples through Schleicher & Schuell No. 32 glass fiber filters using a Brandel 48-well cell harvester. The filters were subsequently washed three times with 3 mL of cold 50 mM Tris-HCl, pH 7.5, and were counted in 2 mL Ecoscint A scintillation fluid. For [3H]naltrindole and [3H]U69,593 binding, the filters were soaked in 0.1% polyethyleneimine for at least 60 min before use. IC50 values were calculated by least squares fit to a logarithm-probit analysis. Ki values of unlabeled compounds were calculated from the equation

\[ K_i = \frac{(IC_{50})/1+S}{S} \]

where S = (concentration of radioligand)/(Kd of radioligand). 13 Data are the mean ± SEM from at least three experiments performed in triplicate.

[35SJGTPyS Binding Assays. In a final volume of 0.5 mL, 12 different concentrations of each
test compound were incubated with 15 µg (κ), 10 µg (δ) or 7.5 µg (μ) of CHO cell membranes that stably expressed either the human κ, δ or μ opioid receptor. The assay buffer consisted of 50 mM Tris-HCl, pH 7.4, 3 mM MgCl₂, 0.2 mM EGTA, 3 µM GDP, and 100 mM NaCl. The final concentration of [³⁵S]GTPyS was 0.080 nM. Nonspecific binding was measured by inclusion of 10 µM GTPyS. Binding was initiated by the addition of the membranes. After an incubation of 60 min at 30°C, the samples were filtered through Schleicher & Schuell No. 32 glass fiber filters. The filters were washed three times with cold 50 mM Tris-HCl, pH 7.5, and were counted in 2 mL of Ecoscint scintillation fluid. Data are the mean Emax and EC50 values ± S.E.M. from at least three separate experiments, performed in triplicate. For calculation of the Emax values, the basal [³⁵S]GTPyS binding was set at 0%. To determine antagonist activity of a compound at the μ opioid receptors, CHO membranes expressing the μ opioid receptor, were incubated with 12 different concentrations of the compound in the presence of 200 nM of the μ agonist DAMGO. To determine antagonist activity of a compound at the κ opioid receptors, CHO membranes expressing the κ opioid receptor, were incubated with the compound in the presence of 100 nM of the κ agonist U50,488. To determine if a compound was an antagonist at δ receptors, CHO membranes expressing the δ receptor were incubated with 12 different concentrations of the test compound in the presence of 10 nM of the δ-selective agonist SNC 80.

Examples - Cyclazocine subseries

\[
\frac{3}{4} \text{ (nM ± S.E.)}
\]
Antinociceptive activity is evaluated by the method described in Jiang et al. [J. Pharmacol. Exp. Ther. 264, 1021-1027 (1993), page 1022]. The ED₅₀'s of compounds of the invention are expected to be under 100 nmol in the mouse acetic acid writhing test when administered i.c.v., and an increase in the duration of action is expected for compounds of the invention compared to their "parents" when given by i.p. administration.

Definitions
Throughout this specification the terms and substituents retain their definitions.

Alkyl is intended to include linear, branched, or cyclic hydrocarbon structures and combinations thereof. A combination would be, for example, cyclopropylmethyl. Lower alkyl refers to alkyl groups of from 1 to 6 carbon atoms. Examples of lower alkyl groups include methyl, ethyl, propyl, isopropyl, cyclopropyl, butyl, s-and t-butyl, cyclobutyl and the like. Preferred alkyl groups are those of C₂₀ or below. Cycloalkyl is a subset of alkyl and includes cyclic hydrocarbon groups of from 3 to 8 carbon atoms. Examples of cycloalkyl groups include c-propyl, c-butyl, c-pentyl, norbornyl and the like.

Alkoxy or alkoxyl refers to groups of from 1 to 8 carbon atoms of a straight, branched, or
cyclic configuration and combinations thereof attached to the parent structure through an oxygen. Examples include methoxy, ethoxy, propoxy, isopropoxy, cyclopropyloxy, cyclohexyloxy and the like. Lower-alkoxy refers to groups containing one to four carbons.

Aryl and heteroaryl mean a 5- or 6-membered aromatic or heteroaromatic ring containing 0-3 heteroatoms selected from O, N, or S; a bicyclic 9- or 10-membered aromatic or heteroaromatic ring system containing 0-3 heteroatoms selected from O, N, or S; or a tricyclic 13- or 14-membered aromatic or heteroaromatic ring system containing 0-3 heteroatoms selected from O, N, or S. The aromatic 6- to 14-membered carbocyclic rings include, e.g., benzene, naphthalene, indane, tetralin, and fluorene and the 5- to 10-membered aromatic heterocyclic rings include, e.g., imidazole, pyridine, indole, thiophene, benzopyranone, thiazole, furan, benzimidazole, quinoline, isoquinoline, quinoxaline, pyrimidine, pyrazine, tetrazole and pyrazole. As used herein aryl and heteroaryl refer to residues in which one or more rings are aromatic, but not all need be.

Arylalkyl means an alkyl residue attached to an aryl ring. Examples are benzyl, phenethyl and the like. Heteroarylalkyl means an alkyl residue attached to a heteroaryl ring. Examples include, e.g., pyridinylmethyl, pyrimidinylethyl and the like.

Ci to C20 hydrocarbon means a linear, branched, or cyclic residue comprised of hydrogen and carbon as the only elemental constituents and includes alkyl, cycloalkyl, polycycloalkyl, alkenyl, alkynyl, aryl and combinations thereof. Examples include, e.g., benzyl, phenethyl, cyclohexylmethyl, camphoryl and naphthylethyl.

The term "halogen" means fluorine, chlorine, bromine or iodine. In one embodiment, halogen may be fluorine or chlorine.

The terms "haloalkyl" and "haloalkoxy" mean alkyl or alkoxy, respectively, substituted with one or more halogen atoms.

Heterocycle means a cycloalkyl or aryl residue in which one to four of the carbons is replaced by a heteroatom such as oxygen, nitrogen or sulfur. Heteroaryls form a subset of heterocycles. Examples of heterocycles that fall within the scope of the invention include, e.g., pyrrolidine, pyrazole, pyrrole, indole, quinoline, isoquinoline, tetrahydroisoquinoline,
benzofuran, benzodioxan, benzodioxole (commonly referred to as methylenedioxyphenyl, when occurring as a substituent), tetrazole, morpholine, thiazole, pyridine, pyridazine, pyrimidine, thiophene, furan, oxazole, oxazoline, isoxazole, dioxane, tetrahydrofuran and the like.

Substituted alkyl, aryl, cycloalkyl, heterocyclcyl etc. refer to alkyl, aryl, cycloalkyl, or heterocyclic wherein up to three H atoms in each residue are replaced with halogen, haloalkyl, alkyl, alkoxyalkyl, hydroxyloweralkyl, phenyl, heteroaryl, benzenesulfonyl, hydroxy, loweralkoxy, haloalkoxy, carboxy, carboalkoxy (also referred to as alkoxy carbonyl), alkoxycarbonylamino, carboxamido (also referred to as alkylaminocarbonyl), cyano, carbonyl, acetoxy, nitro, amino, alkylamino, dialkylamino, mercapto, alkylthio, sulfoxide, sulfone, sulfonylamino, acylamino, amidino, aryl, benzyl, heterocyclic, phenoxy, benzyloxy, heteroaryloxy, hydroxyimino, alkoxyimino, oxoalkyl, aminosulfonyl, trityl, amidino, guanidino, ureido, and benzyloxy.

Virtually all of the compounds described herein contain one or more asymmetric centers and may thus give rise to enantiomers, diastereomers, and other stereoisomeric forms that may be defined, in terms of absolute stereochemistry, as (R)- or (S)-. The present invention is meant to include all such possible isomers, as well as their racemic and optically pure forms. In general it has been found that the levo isomer of morphinans and benzomorphans is the more potent antinociceptive agent, while the dextro isomer may be useful as an antitussive or antispasmodic agent. Optically active (R)- and (S)- isomers may be prepared using chiral synthons or chiral reagents, or resolved using conventional techniques. When the compounds described herein contain olefinic double bonds or other centers of geometric asymmetry, and unless specified otherwise, it is intended that the compounds include both E and Z geometric isomers. Likewise, all tautomeric forms are also intended to be included.

Some of the compounds of the invention are quaternary salts, i.e. cationic species. Therefore they will always be presented as salts, and the term "pharmaceutically acceptable salt" refers to salts whose counter ion (anion) derives from pharmaceutically acceptable non-toxic acids including inorganic acids, organic acids and water (which formally furnishes the hydroxide anion). Suitable pharmaceutically acceptable anions for the compounds of the present invention include hydroxide, acetate, benzenesulfonate (besylate), benzoate, bicarbonate, bisulfate, carbonate, camphorsulfonate, citrate, ethanesulfonate, fumarate, gluconate,
glutamate, glycolate, bromide, chloride, isethionate, lactate, maleate, malate, mandelate, methanesulfonate, mucate, nitrate, pamoate, pantothenate, phosphate, succinate, sulfate, tartrate, trifluoroacetate, p-toluenesulfonate, acetamidobenzoate, adipate, alginate, aminosalicylate, anhydromethylenecitrinate, ascorbate, aspartate, calcium edetate, camphorate, camsylate, caprate, caproate, caprylate, cinnamate, cyclamate, dichloroacetate, edetate (EDTA), edisylate, embonate, estolate, esylate, fluoride, formate, gentisate, gluceptate, glucuronate, glycerophosphate, glycolate, glycolylarsanilate, hexylresorcinate, hippurate, hydroxynaphthoate, iodide, lactobionate, malonate, mesylate, napadisylate, napsylate, nicotinate, oleate, orotate, oxalate, oxoglutарате, palmitate, pectinate, pectinate polymer, phenylethylbarbiturate, picrate, pidoilate, propionate, rhodanide, salicylate, sebacate, stearate, tannate, theoclate, tosylate and the like. The desired salt may be obtained by ion exchange of whatever counter ion is obtained in the synthesis of the quat. These methods are well known to persons of skill. Although pharmaceutically acceptable counter ions will be preferred for preparing pharmaceutical formulations, other anions are quite acceptable as synthetic intermediates. Thus X may be pharmaceutically undesirable anions, such as iodide, oxalate, trifluoromethanesulfonate and the like, when such salts are chemical intermediates. When the compounds of the invention are bisquats, one may employ as counter ions either two monoanionic species (e.g. Cl\textsubscript{2}) or a single dianionic species (e.g. fumarate). Similarly, one could employ oligoanionic species and make salts having appropriate ratios of quat to counterion, such as (quat\textsubscript{3}) citrates. These would be obvious equivalents. In some embodiments, the nitrogen of the morphinan or benzomorphan core structure is quaternized. Quaternization can be achieved by methylation of a tertiary nitrogen atom.

Although this invention is susceptible to embodiment in many different forms, preferred embodiments of the invention are shown. It should be understood, however, that the present disclosure is to be considered as an exemplification of the principles of this invention and is not intended to limit the invention to the embodiments illustrated. It may be found upon examination that certain members of the claimed genus are not patentable to the inventors in this application. In this event, subsequent exclusions of species from the compass of applicants' claims are to be considered artifacts of patent prosecution and not reflective of the inventors' concept or description of their invention; the invention encompasses all of the members of the genus (I) that are not already in the possession of the public.
Abbreviations

The following abbreviations and terms have the indicated meanings throughout:

--- represents a single or double bond;

Ac = acetyl
BNB = 4-bromomethyl-3-nitrobenzoic acid
Boc = t-butyloxy carbonyl

BPE = 2(4-biphenylyl)ethyl = 

Bu = butyl
c- = cyclo

DAMGO = Tyr-ala-Gly-NMePhe-NHCH₂OH
DBU = diazabicyclo[5.4.0]undec-7-ene
DCM = dichloromethane = methylene chloride = CH₂Cl₂
DEAD = diethyl azodicarboxylate
DIC = diisopropylcarbodiimide
DIEA = N,N-diisopropylethyl amine
DMAP = 4-N,N-dimethylaminopyridine
DMF = N,N-dimethylformamide
DMSO = dimethyl sulfoxide
DOR = delta opioid receptor
DPPF = 1,1'-bis(diphenylphosphino)ferrocene
DVB = 1,4-divinylbenzene
EEDQ = 2-ethoxy-1-ethoxycarbonyl-1,2-dihydroquinoline
Fmoc = 9-fluorenylethoxycarbonyl
GC = gas chromatography
HATU = 0-(7-Azabenzotriazol-1-yl)-1,1,3,3-tetramethyluronium hexafluorophosphate
HOAc = acetic acid
HOBt = hydroxybenzotriazole
KOR = kappa opioid receptor
Me = methyl
mesyl = methanesulfonyl
MOR = mu opioid receptor
It may happen that residues in the substrate of interest require protection and deprotection during the conversion of the phenol hydroxyl. Terminology related to "protecting", "deprotecting" and "protected" functionalities occurs throughout this application. Such terminology is well understood by persons of skill in the art and is used in the context of processes which involve sequential treatment with a series of reagents. In that context, a protecting group refers to a group which is used to mask a functionality during a process step in which it would otherwise react, but in which reaction is undesirable. The protecting group prevents reaction at that step, but may be subsequently removed to expose the original
functionality. The removal or "deprotection" occurs after the completion of the reaction or reactions in which the functionality would interfere. Thus, when a sequence of reagents is specified, as it is below, the person of ordinary skill can readily envision those groups that would be suitable as "protecting groups". Suitable groups for that purpose are discussed in standard textbooks in the field of chemistry, such as Protective Groups in Organic Synthesis by T.W.Greene [John Wiley & Sons, New York, 1991], which is incorporated herein by reference.

The compounds of the invention are synthesized by one of the routes described below:

**Scheme 1. Synthesis via Suzuki coupling.**

In general, the method of replacing a phenolic -OH with triflate, is described in US patent 6,784,187, the contents of which are incorporated herein by reference.

Proton NMR spectra and in certain cases $^{13}$C NMR were obtained on a Varian Unity-300 or 500 NMR spectrometer with tetramethysilane as an internal reference for samples dissolved in CDCl3. Samples dissolved in CD3OD and DMSO-<i>d</i> were referenced to the solvent. Proton NMR multiplicity data are denoted by s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), dd (doublet of doublets), and br (broad). Coupling constants are in hertz. Direct insertion probe chemical ionization mass spectral data were obtained on a Shimadzu GC-17A GC-MS mass spectrometer. Direct infusion electrospray ionization (in positively charged ion mode) mass spectral data were obtained on an Agilent 1100 series LC/MSD system (Germany). Melting points were determined on a Meltemp capillary melting point apparatus.
and were uncorrected. Infrared spectral data were obtained on a Perkin-Elmer Paragon 1000 FT-IR spectrophotometer. Optical rotation data was obtained from a Perkin-Elmer 241 polarimeter. The assigned structure of all test compounds and intermediates were consistent with the data. Carbon, hydrogen, and nitrogen elemental analyses for all novel targets were performed by Quantitative Technologies Inc., Whitehouse, NJ, and were within ± 0.4% of theoretical values except as noted; the presence of water or other solvents was confirmed by proton NMR. Reactions were generally performed in an argon or nitrogen atmosphere. Commercially purchased chemicals were used without purification unless otherwise noted. The following reagents were purchased from Aldrich Chemical Company: N-hydroxysuccinimide, phenethylamine, 3-phenyl-1-propylamine, 4-aminobiphenyl, palladium acetate, 4-phenylbenzylamine and benzyl amine. The following reagent was purchased from Trans World Chemicals: 2-(4-biphenyl ethylamine). The following reagents were purchased from Strem Chemicals, Incorporated: 1,1'-bis(diphenyl-phosphino)ferrocene (dpff) and dichloro[1,1'-bis(diphenylphosphino)-ferrocene]palladium (II) dichloromethane adduct [PdCl₂(dpff)]. Pyridine was distilled from KOH. DMF and DMSO were distilled over CaH₂ under reduced pressure. Silica gel (Bodman Industries, ICN SiliTech 2-63 D 60A, 230-400 Mesh) was used for all flash chromatography. Amines were purchased from Aldrich Chemical Company and used as received unless otherwise indicated. Toluene and Et₂O were distilled from sodium metal. THF was distilled from sodium/benzophenone ketyl. Pyridine was distilled from KOH. Methylene chloride was distilled from CaH₂. DMF and DMSO were distilled from CaH₂ under reduced pressure. Methanol was dried over 3± molecular sieves prior to use. Silica gel (Bodman Industries, ICN SiliTech 2-63 D 60A, 230-400 Mesh) was used for flash column chromatography.

In general, the chemistry described above works in the presence of the variety of functional groups found on known core structures. The exceptions would be morphine and congeners having a free 6-OH, which can be protected by a TBDPS (t-butyldiphenylsilyl) group [see Wentland et al., "Selective Protection and Functionalization of Morphine. . .", J. Med. Chem. 43, 3558-3565 (2000)].
CLAIMS

1. A compound of formula I:

\[ \text{I} \]

wherein

- \( R^1 \) is selected from \(-\text{OH}, -\text{CN}, -\text{CHO}, -\text{OCH}_3, -\text{OCH}_2\text{CH}_3, -\text{OCH}(\text{CH}_3)_2, -\text{NO}_2, -\text{COR}^{10}, -\text{COOR}^{10}, -\text{SO}_2\text{R}^{10}, -\text{CONH}_2, -\text{CSNH}_2, -\text{CONR}^{10}\text{NR}^{11}\text{R}^{12}, -\text{CONR}^{10}\text{OR}^{11}, -\text{CONR}^{10}(\text{R}^{12})_2\text{CONR}^{10}\text{R}^{11}, -\text{CONR}^{10}(\text{R}^{12})_2\text{COOR}^{10}, -\text{C}(=\text{S})\text{R}^{10}, -\text{C}(=\text{NR}^{10})\text{R}^{10}, -\text{C}^{(=\text{NR}^{10})}\text{R}^{10}, -\text{SO}_2\text{NR}^{10}\text{R}^{11}, -\text{SO}_2\text{NR}^{10}\text{R}^{11}, \text{heterocyclyl}, \text{optionally substituted lower alkyl}, \text{optionally substituted alkenyl}, \text{optionally substituted alkynyl}, \text{optionally substituted aryl}, \text{halo(Ci-Ce)alkyl}, \text{halo(Ci-Ce)alkoxy}, \text{and (Ci-Ce)alkylthio};

- \( R^2 \) is selected from hydrogen, halogen, \(-\text{OH}, -\text{CN}, -\text{CHO}, -\text{OCH}_3, -\text{OCH}_2\text{CH}_3, -\text{OCH}(\text{CH}_3)_2, -\text{NO}_2, -\text{COR}^{10}, -\text{COOR}^{10}, -\text{SO}_2\text{R}^{10}, -\text{CONR}^{10}\text{R}^{11}, -\text{CSNR}^{10}\text{R}^{11}, -\text{CONR}^{10}\text{NR}^{11}\text{R}^{12}, -\text{CONR}^{10}\text{OR}^{11}, -\text{CONR}^{10}(\text{R}^{12})_2\text{CONR}^{10}\text{R}^{11}, -\text{CONR}^{10}(\text{R}^{12})_2\text{COOR}^{10}, -\text{C}(=\text{S})\text{R}^{10}, -\text{C}(=\text{NR}^{10})\text{R}^{10}, -\text{C}^{(=\text{NR}^{10})}\text{R}^{10}, -\text{SO}_2\text{NR}^{10}\text{R}^{11}, \text{heterocyclyl}, \text{optionally substituted lower alkyl}, \text{optionally substituted alkenyl}, \text{optionally substituted alkynyl}, \text{optionally substituted aryl}, \text{halo(Ci-Ce)alkyl}, \text{halo(Ci-Ce)alkoxy}, \text{and (Ci-Ce)alkylthio};

- or, \( R^1 \) and \( R^2 \) together with the atoms to which they are attached, and a fragment selected from \(-\text{OCH}_2\text{O}-\), or \(-\text{OCH}_2\text{CH}_2\text{O}-\), form a ring.

- \( R^3 \) is chosen from hydrogen, \text{Ci-C}_8\text{hydrocarbon}, \text{heterocyclyl}, \text{aryl} and \text{hydroxyalkyl};

- \( R^4 \) is chosen from hydrogen, hydroxyl, amino, lower alkoxy, \text{Ci-C}_{20}\text{alkyl} and \text{Ci-C}_{20}\text{alkyl} substituted with hydroxyl or carbonyl;

- \( R^5 \) is lower alkyl;

- \( R^6 \) is lower alkyl;

- \( R^7 \) is chosen from hydrogen, \text{NR}^{10}\text{R}^{11} and \text{-OR}^{10}; or
together R\(^4\), R\(^5\), R\(^6\) and R\(^7\) may form from one, two, three, or four rings, said rings having optional additional substitution;

R\(^8\) and R\(^{8a}\) are both hydrogen or taken together R\(^8\) and R\(^{8a}\) are =0;

R\(^9\) is chosen from hydrogen and lower alkyl;

R\(^{10}\), R\(^{11}\), R\(^{12}\) and R\(^{13}\) are each independently hydrogen, optionally substituted lower alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted aryl, hydroxyl, -NR\(^{100}\)R\(^{101}\) or optionally substituted lower alkoxy, or R\(^{10}\) and R\(^{11}\), together with the nitrogen atom to which they are attached, form an optionally substituted fused carbocyclic or heterocyclic ring having from 5 to 7 ring members of which up to 3 can be heteroatoms selected from N, O and S; t is 0, 1, 2, 3, 4, 5, or 6;

R\(^{100}\) and R\(^{101}\) are each independently hydrogen, optionally substituted lower alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted aryl, hydroxyl, or optionally substituted lower alkoxy, or R\(^{100}\) and R\(^{101}\), together with the nitrogen atom to which they are attached, form an optionally substituted fused carbocyclic or heterocyclic ring having from 5 to 7 ring members of which up to 3 can be heteroatoms selected from N, O and S;

Y is a direct bond or -(C(R\(^{10}\))(R\(^{11}\)))\(^q\)-, wherein q is 0, 1, 2, 3, 4 or 5;

L is a direct bond or -(C(R\(^{10}\))(R\(^{13}\)))\(^q\)-; and

Cy is Ar\(^1\)-B-Ar\(^2\), wherein

Ar\(^1\) is absent, or an aryl or heteroaryl radical having from 1 to 4 N, O and/or S atoms, which may be unsubstituted or mono-, di- or trisubstituted by halogen, lower alkyl, alkenyl, alkynyl, cycloalkyl, -OR\(^{10}\), -NR\(^{10}\)R\(^{11}\), -CN, -COR\(^{10}\) or -COOR\(^{10}\);

B is a direct bond, -O-, -NR\(^{10}\), -S0\(^2\), or -(C(R\(^{10}\))(R\(^{11}\)))\(^s\)-, wherein s is 0, 1, 2, 3, 4 or 5; and

Ar\(^2\) is aryl or heteroaryl radical having from 1 to 4 N, O and/or S atoms, which may be unsubstituted or mono-, di- or trisubstituted by halogen, lower alkyl, alkenyl, alkynyl, cycloalkyl, -OR\(^{10}\), -NR\(^{10}\)R\(^{11}\), -CN, -COR\(^{10}\) or -COOR\(^{10}\), wherein when Cy is phenyl or biphenyl, Ri is other than -OCH\(^3\).

2. A compound of claim 1 wherein Cy is selected from:
wherein W is selected from \([C(R^9)]_2\), \(CR^8R^8\), \(O\), \(NR^9\), \(S\) and \(CR^9=CR^9\); and \(n\) is 1, 2, 3, 4 or 5.

3. A compound of claim 1 of formula III-VI:
Formula V

wherein, \( R^2_0 \), \( R^2_1 \) and \( R^2_2 \) are each chosen from hydrogen, hydroxyl, amino, lower alkoxy, \( \text{C}1-\text{C}20 \) alkyl and \( \text{C}1-\text{C}20 \) alkyl substituted with hydroxyl or carbonyl; or together, \( R^2_0 \), and \( R^2_1 \) with the carbon to which they are attached, form -CO, or -CS; or together, \( R^2_0 \), and \( R^2_1 \) with the carbon(s) to which they are attached, form a ring.

4. A compound according to claim 1 of formula:
5. A compound according to claim 1 selected from Table 1:

<table>
<thead>
<tr>
<th>No</th>
<th>Structure</th>
<th>No</th>
<th>Structure</th>
</tr>
</thead>
</table>
6. A compound according to claim 1 wherein Cy-R\(^1\)R\(^2\) is of formula

\[
\begin{align*}
\text{R}^1 & \text{Z} \text{Z} \text{Z} \text{Z} \text{Z} \text{Z} \text{Z} \text{Z} \text{Z} \\
\text{R}^2 & \text{Z} \text{Z} \text{Z} \text{Z} \text{Z} \text{Z} \text{Z} \text{Z} \text{Z} \\
\end{align*}
\]

wherein Z is CR\(^{10}\) or N, with the provisos that,

a) at the point of attachment of the distal ring to the proximal ring, Z must be C, and

b) at the points of attachment of R\(^1\) and R\(^2\), Z will be CR\(^1\) and CR\(^2\), respectively.

7. A compound according to claim 6 of formula wherein Cy-R\(^1\)R\(^2\) is of formula:

\[
\begin{align*}
\text{R}^1 & \text{Z} \text{Z} \text{Z} \text{Z} \\
\text{R}^2 & \text{Z} \text{Z} \\
\end{align*}
\]

8. A compound according to claim 7 wherein one of R\(^1\) and R\(^2\) is in the para position relative to B and the other of R\(^1\) and R\(^2\) is hydrogen.
9. A compound according to claim 1, wherein Ar\(^2\) is phenyl and one of R\(^1\) or R\(^2\) is in the para position relative to B.

10. A compound according to claim 9 wherein Cy-R\(^1\)R\(^2\) is of formula:

![Chemical Structure](image)

11. A pharmaceutical formulation comprising a compound according to any one of the other claims and a pharmaceutically acceptable carrier.

12. A method of preventing or treating a condition or disease associated with binding opioid receptors in a patient in need thereof, comprising the step of administering to said patient a composition comprising an effective amount of a compound according to any one of the other claims.

13. A method according to claim 12 wherein said disease or condition is chosen from the group consisting of pain, pruritis, diarrhea, irritable bowel syndrome, gastrointestinal motility disorder, obesity, respiratory depression, convulsions, coughing, hyperalgesia, inflammation, osteoarthritis and drug addiction.

14. A method according to claim 13 wherein said drug addiction is selected from heroin, cocaine, nicotine, amphetamine and alcohol addiction.

15. A method according to claim 13, wherein the condition is pain and the composition further comprises an effective amount of an opioid.
16. A method according to claim 13, wherein the condition is osteoarthritis and the composition further comprises an effective amount of an opioid.

17. A compound of formula la:

\[
\begin{align*}
R^1 & \quad \text{is chosen from hydrogen, Ci-Cg hydrocarbon, heterocyclyl, aryl and hydroxyalkyl;} \\
R^4 & \quad \text{is chosen from hydrogen, hydroxyl, amino, lower alkoxy, Ci-C_{20} alkyl and Ci-C_{20} alkyl substituted with hydroxyl or carbonyl;} \\
R^5 & \quad \text{is lower alkyl;} \\
R^6 & \quad \text{is lower alkyl;} \\
R^7 & \quad \text{is chosen from hydrogen, NR^{10}R^{11} and -OR^{10}; or together R^4, R^5, R^6 and R^7 may form from one to four rings, said rings having optional additional substitution;}
\end{align*}
\]

wherein

- \( R^1 \) and \( R^2 \) are each independently selected from hydrogen, halogen, -OH, -CN, -CHO, -OCH3, -OCH2CH3, -OCH(CH3)_2, heterocyclyl, optionally substituted lower alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted aryl, halo(Ci-Ce)alkyl, halo(Ci-Ce)alkoxy, (Ci-Ce)alkythio, -N0, -COR, -SO2R, -CONR^{10}, -CONR^{10}R^{11}, -C(=S)R^{10}, -C(=NO3)R^{10}, C(=NR^{10})R^{11} and -SO2NR^{10}R^{11};
- or, \( R^1 \) and \( R^2 \) together with the atoms to which they are attached, and a fragment selected from -OCH2O-, or -OCH2CH2O-, form a ring, with the proviso that \( R^1 \) and \( R^2 \) cannot both be hydrogen;
R^8 and R'^8 are both hydrogen or taken together R^8 and R'^8 are =0; 
R^9 is chosen from hydrogen and lower alkyl; 
R^10 and R'^11 are each independently hydrogen, optionally substituted lower alkyl,  
optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted 
aryl, hydroxyl, -NR^{100}R^{101} or optionally substituted lower alkoxy, or 
R^10 and R'^11, together with the nitrogen atom to which they are attached, form an  
only optionally substituted fused carbocyclic or heterocyclic ring having from 5 to 7 ring  
members of which up to 3 can be heteroatoms selected from N, O and S; 
R^{100} and R'^{101} are each independently hydrogen, optionally substituted lower alkyl,  
only optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted 
aryl, hydroxyl, or optionally substituted lower alkoxy, or 
R^{100} and R'^{101}, together with the nitrogen atom to which they are attached, form an  
only optionally substituted fused carbocyclic or heterocyclic ring having from 5 to 7 ring  
members of which up to 3 can be heteroatoms selected from N, O and S; 
Y is a direct bond or -(C(R^10)(R'^11))q-, wherein q is 0, 1, 2, 3, 4 or 5; and  
Cy is Ar^1-B-Ar^2, wherein  
Ar^1 is absent, or an aryl or heteroaryl radical having from 1 to 4 N, O and/or S  
atoms, which may be unsubstituted or mono-, di- or trisubstituted by halogen,  
lower alkyl, alkenyl, alkynyl, cycloalkyl, -OR^{10}, -NR^{10}R^{11}, -CN, -COR^{10} or -COOR^{10};  
B is a direct bond, -O-, -NR^{10}, -SO_{2}, or -(C(R^10)(R'^11))s-, wherein s is 0, 1, 2, 3,  
4 or 5; and  
Ar^2 is aryl or heteroaryl radical having from 1 to 4 N, O and/or S atoms, which  
may be unsubstituted or mono-, di- or trisubstituted by halogen, lower alkyl,  
alkenyl, alkynyl, cycloalkyl, -OR^{10}, -NR^{10}R^{11}, -CN, -COR^{10} or -COOR^{10},  
wherein when Cy is phenyl or biphenyl, Ri is other than -OCH_{3}. 

18. A compound of claim 17 wherein Cy is selected from:

![Chemical Structures](image_url)
wherein \( W \) is selected from \([C(R^9)]_{2n}\), CR\(^8\), O, NR\(^9\), S and CR\(^9\)=CR\(^9\); and \( n \) is 1, 2, 3, 4 or 5.

19. A compound of claim 18 wherein \( C_y \) is:

\[
\begin{array}{c}
\text{R}^2 \\
\text{N} \\
\text{R}^1
\end{array}
\]

20. A compound according to any one of claims 17-19 of formula:
21. A compound according to any one of claims 17-20 wherein Cy-R¹R² is of formula
wherein Z is CR\textsuperscript{10} or N, with the provisos that,

a) at the point of attachment of the distal ring to the proximal ring, Z must be C, and

b) at the points of attachment of R\textsuperscript{1} and R\textsuperscript{2}, Z will be CR\textsuperscript{1} and CR\textsuperscript{2}, respectively.

22. A compound according to claim 21 of formula

23. A compound according to claim 22 of formula

24. A compound according to any one of claims 17-23 wherein one of R\textsuperscript{1} and R\textsuperscript{2} is para to the point of attachment of the distal ring and the other of R\textsuperscript{1} and R\textsuperscript{2} is hydrogen.
25. A compound of any one of claims 17-24 wherein R is -CONH₂.

26. A compound of any of claims 17-25 wherein R₂ is -CONR¹⁰R¹¹.

27. A pharmaceutical formulation comprising a compound according to any one of the other claims and a pharmaceutically acceptable carrier.

28. A method of preventing or treating a condition or disease associated with binding opioid receptors in a patient in need thereof, comprising the step of administering to said patient a composition comprising an effective amount of a compound according to any one of the other claims.

29. A method according to claim 28 wherein said disease or condition is chosen from the group consisting of pain, pruritis, diarrhea, irritable bowel syndrome, gastrointestinal motility disorder, obesity, respiratory depression, convulsions, coughing, hyperalgesia, inflammation, osteoarthritis and drug addiction.

30. A method according to claim 29, wherein said drug addiction is selected from heroin, cocaine, nicotine, amphetamine and alcohol addiction.

31. A method according to claim 29, wherein the condition is pain and the composition further comprises an effective amount of an opioid.

32. A method according to claim 29, wherein the condition is osteoarthritis and the composition further comprises an effective amount of an opioid.

33. A compound or method according to any of the other claims wherein said R¹⁰ and R¹¹ are hydrogen.

34. A compound or method according to any of the other claims wherein R is -OH, -CHO, -CONH₂, -CON(H)CH₂CONH₂, -CON(H)CH₂CH₂CONH₂, -CON(H)CH₂COOH, or -CON(H)CH₂CH₂COOH; or R¹ and R² together with the atoms to which they are attached forms a -OCH₂O - fused ring.

35. A compound or method according to any of the other claims wherein R₂ is H.
36. A compound according to any of the other claims wherein \( R^1 \) is selected from -OH, -CN, -CHO, -OCH \(_3\), -OCH\(_2\)CH\(_3\), -OCH(CH\(_3\))\(_2\), -NO\(_2\), -COR\(^{10}\), -COOR\(^{10}\), -SO\(_2\)R\(^{10}\), -CONH\(_2\), -CSNH\(_2\), -CONR\(^{10}\)NR\(^{11}\)R\(_{12}\), -CONR\(^{10}\)OR\(^{11}\), -CONR\(^{10}\)((C(R^{12})(R^{13}))_i)CONR\(^{10}\)R\(_{11}\), -CONR\(^{10}\)((C(R^{12})(R^{13}))_i)COOR\(^{11}\), -C(=S)R\(^{10}\), -C(=NR\(^{11}\))R\(^{10}\), -C(=NR\(^{10}\))R\(^{11}\), and -SO\(_2\)NR\(^{10}\)R\(^{11}\); R\(_2\) is selected from -OH, -CN, -CHO, -OCH\(_3\), -OCH\(_2\)CH\(_3\), -OCH(CH\(_3\))\(_2\), -NO\(_2\), -COR\(^{10}\), -COOR\(^{10}\), -SO\(_2\)R\(^{10}\), -CONR\(^{10}\)R\(_{11}\), -CSNR\(^{10}\)R\(_{11}\), -CONR\(^{10}\)NR\(^{11}\)R\(_{12}\), -CONR\(^{10}\)OR\(_{11}\), -CONR\(^{10}\)((C(R^{12})X^{13}))_i)CONR\(^{10}\)R\(_{11}\), -CONR\(^{10}\)((C(R^{12})X^{13}))_i)COOR\(_{11}\), -C(=S)R\(_{10}\), -C(=NOR\(^{11}\))R\(_{10}\), C(=NR\(^{10}\))R\(_{11}\), -SO\(_2\)NR\(^{10}\)R\(_{11}\), heterocyclyl, optionally substituted lower alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted aryl, halo(Ci-Ce)alkyl, halo(Ci-Ce)alkoxy, and (Ci-c\(_6\))alkythio;

or, \( R^1 \) and \( R^2 \) together with the atoms to which they are attached, and a fragment selected from -OCH\(_2\)0-, or -OCH\(_2\)CH\(_2\)0-, form a ring.

37. A compound according to claim 3 wherein Cy-R\(^1\)R\(_2\) is of formula:

![Diagram](image)

wherein at the points of attachment of \( R^1 \) and \( R^2 \), \( Z \) will be CR\(^1\) and CR\(^2\), respectively.

38. A compound according to claim 37 wherein \( R^1 \) is in the para position relative to B and \( R^2 \) is hydrogen or methyl; or \( R^1 \) and \( R^2 \) together with the atoms to which they are attached, and a fragment selected from -OCH\(_2\)0- or -OCH\(_2\)CH\(_2\)0-, form a ring.