Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2957258 A1 2016/02/11

(21) 2 957 258

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) **Date de dépôt PCT/PCT Filing Date:** 2015/08/05
(87) **Date publication PCT/PCT Publication Date:** 2016/02/11
(85) **Entrée phase nationale/National Entry:** 2017/02/03
(86) **N° demande PCT/PCT Application No.:** IB 2015/055943
(87) **N° publication PCT/PCT Publication No.:** 2016/020856
(30) **Priorités/Priorities:** 2014/08/05 (US62/033,177); 2014/09/22 (US62/053,366); 2014/12/17 (US62/093,368)

(51) **Cl.Int./Int.Cl.** ***C07K 16/28*** (2006.01)

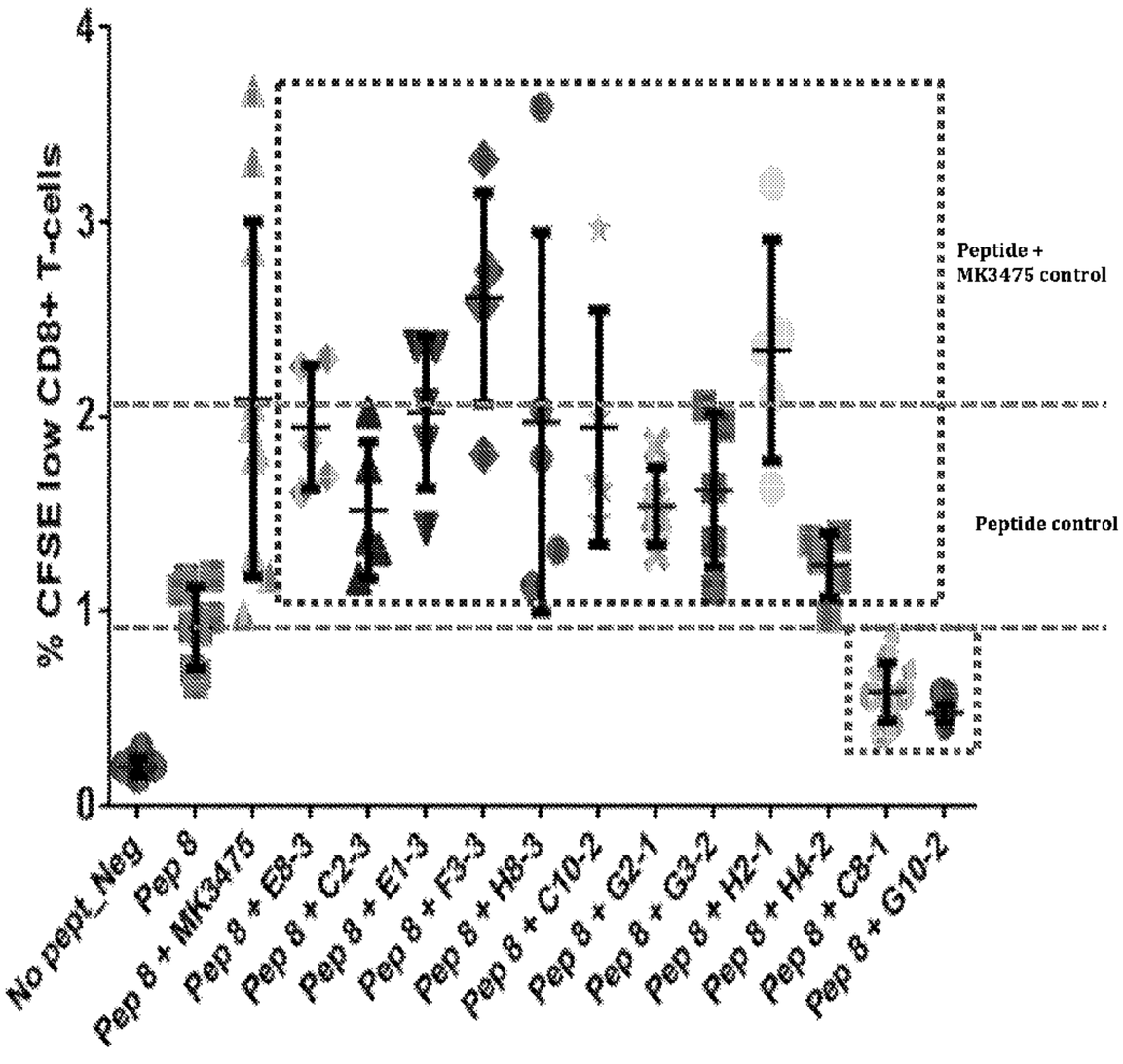
(71) **Demandeur/Applicant:**
MABQUEST SA, CH

(72) **Inventeurs/Inventors:**
PANTALEO, GIUSEPPE, CH;
FENWICK, CRAIG, CH

(74) **Agent:** SMART & BIGGAR

(54) **Titre : REACTIFS IMMUNOLOGIQUES**
(54) **Title: IMMUNOLOGICAL REAGENTS**

FIGURE 2



(57) **Abrégé/Abstract:**
This disclosure relates to binding agents with specificity for programmed cell death 1 (PD-1) and to methods for using the same to treat, prevent and / or ameliorate an infectious disease (e.g., human immunodeficiency virus (HIV)), cancer and / or autoimmunity.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 February 2016 (11.02.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/020856 A3

(51) International Patent Classification:
C07K 16/28 (2006.01)

(21) International Application Number:
PCT/IB2015/055943

(22) International Filing Date:
5 August 2015 (05.08.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

62/033,177	5 August 2014 (05.08.2014)	US
62/053,366	22 September 2014 (22.09.2014)	US
62/093,368	17 December 2014 (17.12.2014)	US

(71) Applicant: **MabQuest SA** [CH/CH]; Avenue General-Guisan 62, c/o Giuseppe Pantaleo, 1009 Pully (CH).

(72) Inventors: **PANTALEO, Giuseppe**; Avenue Général Guisan 62, CH-1009 Pully (CH). **FENWICK, Craig**; Av. Du Léman 36, CH-1005 Lausanne (CH).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

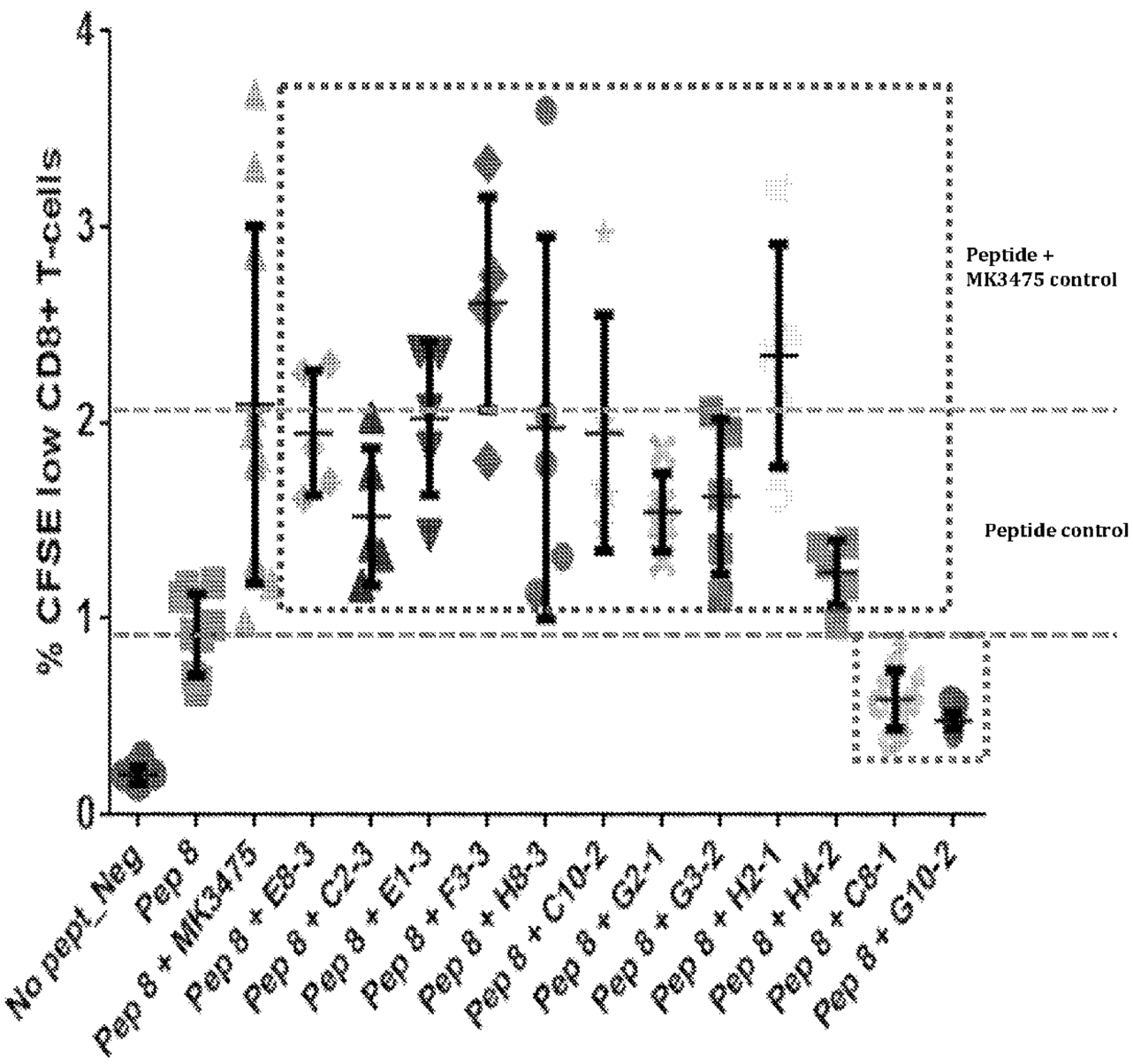
(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: IMMUNOLOGICAL REAGENTS BINDING TO PD-1

(57) Abstract: This disclosure relates to binding agents with specificity for programmed cell death 1 (PD-1) and to methods for using the same to treat, prevent and / or ameliorate an infectious disease (e.g., human immunodeficiency virus (HIV)), cancer and / or autoimmunity.

FIGURE 2



WO 2016/020856 A3

WO 2016/020856 A3

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) Date of publication of the international search report:
31 March 2016

IMMUNOLOGICAL REAGENTS

Related Applications

[001] This application claims priority to U.S. Ser. No. 62/033,177 filed August 5, 2014; U.S. Ser. No. 62/053,366 filed September 22, 2014; and U.S. Ser. No. 62/093,368 filed December 17, 2014; each of which being hereby incorporated into this disclosure in their entirety.

Field of the Disclosure

[002] This disclosure relates to binding agents with specificity for programmed cell death 1 (PD-1) (e.g., human PD-1) and to methods for using the same to treat and / or prevent infection (e.g., by human immunodeficiency virus (HIV)), cancer and / or autoimmunity.

Background of the Disclosure

[003] As we enter the fourth decade of the HIV epidemic, significant advances have been made in the understanding of HIV pathogenesis and in the development of potent and safe antiviral drugs. More than 30 antiviral drugs have been registered and the impact of combination antiretroviral therapy (ART) on both morbidity and mortality has been remarkable. However, despite the long-term suppression of HIV replication achieved in patients with optimal adherence to ART, HIV invariably rebounds after interruption of therapy. Furthermore, successful therapy does not induce or allow restoration/development of virus-specific immune responses capable of controlling HIV replication in the absence of ART. Thus, life-long ART is needed to control HIV replication and associated disease in the large majority of HIV infected subjects.

[004] A population of long-lived central memory CD4 T-cells latently infected with HIV has been identified in the blood as an important component of the HIV cell reservoir and as the primary cause of HIV persistence. The life-span of this latent cell reservoir is estimated to be approximately 70 years in the presence of full HIV suppression with ART. However, recent studies have demonstrated that two populations of CD4 T-cells resident in lymph nodes serve as the primary CD4 T-cell compartment for HIV infection, replication and production. These two CD4 T-cell populations are defined by the expression of PD-1 and CXCR5 and include the PD-1+CXCR5+, i.e. T follicular helper cells (Tfh) and PD-1+CXCR5- CD4 T-cell populations.

[005] A number of mechanisms responsible for the establishment and maintenance of the

HIV latent cell reservoir(s) have been proposed. One of the mechanisms is the persistent of minimal virus replication under ART which may replenish the HIV cell reservoir. Therefore, ART is unable to induce full suppression of HIV replication and the “natural” HIV-1 specific immune response under ART is also unable to totally suppress and eliminate ongoing residual virus replication. The failures of ART and of the HIV-specific immune response provide the rationale for investigating alternative interventions to target also the persistent HIV cell reservoir.

[006] A number of immunological interventions have been investigated in the past and currently being further developed with the goal to achieve HIV functional cure, wherein viral replication is suppressed without sustained antiviral therapy (9). Therapeutic vaccine strategies have been the primary intervention strategy investigated but the results have shown modest efficacy in experimental animal models and patients with the exception of a CMV-based vector HIV vaccine (50% efficacy in the NHP model;10). Recent studies have generated interesting results on the possibility of using anti-envelope broad neutralizing antibodies (bNabs) as therapeutic agents in HIV infection (11,12). Furthermore, antagonist PD-1 Abs have been shown to restore T-cell functions in HIV infected patients and the possibility to use these Abs as a therapeutic strategy to augment the potency of HIV-specific T-cell responses has been proposed (13,14).

[007] It is well established that infiltrating tumor-specific CD8 T-cells are dysfunctional with regard their ability to proliferate and to mediate cytotoxic activity. The large majority of infiltrating tumor-specific CD8 T-cells are in a so-called exhaustion functional state. The primary mechanism responsible for the exhaustion of infiltrating tumor-specific CD8 T-cells is the increased expression of a number of regulatory receptors and particularly PD-1 regulatory receptor. The observation that the blockade of the PD-1/PDL-1/2 (PD-1 ligands) is associated with the recovery of CD8 T-cells from exhaustion has provided the rationale for developing intervention strategies targeting the PD-1 molecule expressed by exhaustedCD8 T-cells. Recent studies have shown very promising results with the use of PD-1 antibodies with antagonist activity in patients with advanced cancer-associated disease. Studies have show substantial rates of response, ranging from 18 to 40%, in patients with advanced melanoma, non-small cell lung carcinoma and renal carcinoma. Anti-PD-1 antibodies in these studies have been used either alone or in combination with an anti-CTL-A4 antibody. After these initial studies, the current studies are being performed in patients with a variety of tumors

including also hematological tumors.

[008] There is a need in the art for additional reagents for targeting PD-1 and methods for using the same. This disclosure addresses those needs by providing reagents and methods that may be used to target PD-1 and cells and / or tissues expressing the same.

Brief Description of the Drawings

[009] Figure 1. **A.** Mouse PD-1. **B.** Human PD-1.

[0010] Figure 2. CFSE assay to evaluate the functional effect of anti-PD1 antibodies on the proliferation of HIV specific CD8 T cells.

[0011] Figure 3. Concentration response binding of anti-PD-1 antibodies to cell surface PD-1 on activated CD4 T-cells.

[0012] Figure 4. Antibody classes.

[0013] Figure 5a-f. Proliferation relative to controls (NEG and Peptide 8).

[0014] Figure 6a-b. Restoration of HIV peptide specific CD8 T-cell proliferation mediated by anti-PD-1 antibodies binding to different epitopes in a functional exhaustion recovery assay.

[0015] Figure 7. Enhanced restoration of HIV peptide specific CD8 T-cell proliferation mediated by the combination of anti-PD-1 antibodies binding to different PD-1 epitopes in a functional exhaustion recovery assay.

[0016] Figure 8. Synergy between a first binding agent that blocks the interaction of PD-1 and PD-L1 with a second binding agent that does not block the interaction of PD-1 and PD-L1.

Summary of the Disclosure

[0017] This disclosure relates to binding agents with specificity for programmed cell death 1 (PD-1) (e.g., human PD-1) and to methods for using the same such as to treat, prevent and / or ameliorate infection (e.g., by human immunodeficiency virus (HIV)), cancer and / or an autoimmune condition. Functional assays for identifying binding agents that interact with PD-1 are also provided. Combinations of binding agents, such as a first binding agent that blocks the interaction of PD-1 and PD-L1 with a second binding agent that does not block the interaction of PD-1 and PD-L1, are also provided that act synergistically to rescue T cells from exhaustion.

Detailed Description

[0018] This disclosure relates to binding agents that bind programmed cell death (PD-1) protein (e.g., SEQ ID NO:1, Fig. 1A, Fig. 1B of U.S. Pat. No. 5,698,520 (Honjo, et al.) which is hereby incorporated by reference in its entirety) (e.g., human PD-1) on the surface of cells *in vitro* and / or *in vivo*. The binding agents may also bind isolated PD-1 polypeptide (e.g., human PD-1) and / or fragments and / or derivatives thereof, typically *in vitro*. Also provided are methods for using such binding agents to diagnose, treat, prevent and / or ameliorate one or more diseases associated with the existence of cells expressing PD-1. For instance, the binding agents may be antibodies (e.g., monoclonal antibodies) that may react with and / or bind to the epitopes of PD-1. The "binding agents" described herein may include, for example, an agonist or an antagonist of PD-1. An agonist binding agent is one that is not typically capable of restoring T-cell function and / or expression of PD-1. An agonist PD-1 binding agent may be useful for treating autoimmune diseases and others in which PD-1 expressing cells are involved in disease progression. In contrast, an antagonist binding agent is one capable for restoring T-cell function and / or expression of PD-1. For instance, a PD-1 antagonist binding agent may be capable of restoring the function of PD-1 expressing T-cells from functional exhaustion as is known to occur in HIV infection and in a variety of tumors. Restoration of T cell function may be determined by, for instance, measuring proliferation, cytokine production, cytotoxic activity or other characteristics of such cells. Another use for the binding agents described herein is the selective targeting and elimination of HIV-infected CD4 T-cell populations containing replication competent HIV (e.g., in a latent and / or replication state). Such PD-1 expressing cells expressing PD-1 are known to serve as a major cell reservoir for replication competent HIV. A potential mechanism for the elimination of these CD4 T-cell populations is antibody-dependent cellular cytotoxicity (ADCC) using the binding agents described herein (e.g., mono- and / or bi-specific PD-1 antibodies). In some embodiments, one or more PD-1 antagonistic binding agents having, for instance, different specificities (e.g., recognizing different epitopes) may be combined to induce rescue of antigen-specific CD8 T-cells from functional exhaustion caused by PD-1 expression in those cells (e.g., restoring or improving proliferation, cytokine production and / or cytotoxic activity). In some embodiments, the binding agents described herein may also provide for the selective elimination and / or suppression of PD-1 expressing cells. In some embodiments, the PD-1 agonist binding agents described herein may be used to supress and / or eliminate PD-1 expressing cells to treat, for instance, infectious diseases (e.g., HIV), cancer, and / or, especially, autoimmune conditions. Other embodiments, uses and the like

are described below.

[0019] The binding agents may be antibodies such as monoclonal antibodies that may comprise, for instance, any one or more of the amino acid sequences shown in **Table 1** (and / or one or more fragments and / or derivatives thereof). This disclosure also provides for the use of such monoclonal antibodies to isolate, identify, and / or target cells expressing PD-1. In certain embodiments, these monoclonal antibodies may be reactive against PD-1 expressed on the surface of cells. The term "antibody" or “antibodies” may refer to whole or fragmented antibodies in unpurified or partially purified form (e.g., hybridoma supernatant, ascites, polyclonal antisera) or in purified form. The antibodies may be of any suitable origin or form including, for example, murine (e.g., produced by murine hybridoma cells), or expressed as humanized antibodies, chimeric antibodies, human antibodies, and the like. For instance, antibodies may be wholly or partially dervied from human (e.g., IgG (IgG1, IgG2, IgG2a, Ig2b, IgG3, IgG4), IgM, IgA (IgA1 and IgA2), IgD, and IgE), canine (e.g., IgGA, IgGB, IgGC, IgGD), chicken (e.g., IgA, IgD, IgE, IgG, IgM, IgY), goat (e.g., IgG), mouse (e.g., IgG, IgD, IgE, IgG, IgM), and / or pig (e.g., IgG, IgD, IgE, IgG, IgM), rat (e.g., IgG, IgD, IgE, IgG, IgM) antibodies, for instance. Methods of preparing, utilizing and storing various types of antibodies are well-known to those of skill in the art and would be suitable in practicing the present invention (see, for example, Harlow, et al. *Antibodies: A Laboratory Manual*, Cold Spring Harbor Laboratory, 1988; Harlow, et al. *Using Antibodies: A Laboratory Manual, Portable Protocol No. 1*, 1998; Kohler and Milstein, Nature, 256:495 (1975)); Jones et al. Nature, 321:522-525 (1986); Riechmann et al. Nature, 332:323-329 (1988); Presta (Curr. Op. Struct. Biol., 2:593-596 (1992); Verhoeyen et al. (Science, 239:1534-1536 (1988); Hoogenboom et al., J. Mol. Biol., 227:381 (1991); Marks et al., J. Mol. Biol., 222:581 (1991); Cole et al., Monoclonal Antibodies and Cancer Therapy, Alan R. Liss, p. 77 (1985); Boerner et al., J. Immunol., 147(1):86-95 (1991); Marks et al., Bio/Technology 10, 779-783 (1992); Lonberg et al., Nature 368 856-859 (1994); Morrison, Nature 368 812-13 (1994); Fishwild et al., Nature Biotechnology 14, 845-51 (1996); Neuberger, Nature Biotechnology 14, 826 (1996); Lonberg and Huszar, Intern. Rev. Immunol. 13 65-93 (1995); as well as U.S. Pat. Nos. 4,816,567; 5,545,807; 5,545,806; 5,569,825; 5,625,126; 5,633,425; and, 5,661,016). In certain applications, the antibodies may be contained within hybridoma supernatant or ascites and utilized either directly as such or following concentration using standard techniques. In other applications, the antibodies may be further purified using, for example, salt fractionation and ion exchange chromatography, or affinity chromatography using Protein

A, Protein G, Protein A/G, and / or Protein L ligands covalently coupled to a solid support such as agarose beads, or combinations of these techniques. The antibodies may be stored in any suitable format, including as a frozen preparation (e.g., -20°C or -70°C), in lyophilized form, or under normal refrigeration conditions (e.g., 4°C). When stored in liquid form, for instance, it is preferred that a suitable buffer such as Tris-buffered saline (TBS) or phosphate buffered saline (PBS) is utilized. In some embodiments, the binding agent may be prepared as an injectable preparation, such as in suspension in a non-toxic parenterally acceptable diluent or solvent. Suitable vehicles and solvents that may be utilized include water, Ringer's solution, and isotonic sodium chloride solution, TBS and / or PBS, among others. Such preparations may be suitable for use in vitro or in vivo may be prepared as is known in the art and the exact preparation may depend on the particular application.

[0020] However, the binding agents described are not in any way limited to antibodies. For example, the binding agent may be any compound exhibiting similar binding properties as another (e.g., a mimetic). For example, an exemplary binding agent may be one that binds PD-1 and / or can compete with binding agent having specificity therefor (e.g., a monoclonal antibody). In some embodiments, the mimetic may exhibit substantially the same affinity in binding assays as the binding agent (e.g., monoclonal antibody) to which it is being compared. The affinity a particular binding agent may be measured by any suitable assay including but not limited to FACS staining of endogenous cell surface PD-1 on activated CD4 T cells as described in the Examples. One binding agent may be said to have “substantially the same affinity” as another where the measurements (e.g., nm) are within about any of 1-20, 1-5, 5-10, 10-15, or 15-20 percent of one another. Exemplary mimetics may include, for example, organic compounds that specifically bind PD-1, or an affibody (Nygren, et al. FEBS J. 275 (11): 2668–76 (2008)), affilin (Ebersbach, et al. J. Mol. Biol. 372 (1): 172–85 (2007)), affitin (Krehenbrink, et al. J. Mol. Biol. 383 (5): 1058–68 (2008)), anticalin (Skerra, A. FEBS J. 275 (11): 2677–83 (2008)), avimer (Silverman, et al. Nat. Biotechnol. 23 (12): 1556–61 (2005)), DARPin (Stumpp, et al. Drug Discov. Today 13 (15–16): 695–701 (2008)), Fynomer (Grabulovski, et al. J. Biol. Chem. 282 (5): 3196–3204 (2007)), Kunitz domain peptide (Nixon, et al. Curr. Opin. Drug Discov. Devel. 9 (2): 261–8 (2006)), and / or a monobody (Koide, et al. Methods Mol. Biol. 352: 95–109 (2007)). Other mimetics may include, for example, a derivative of an antibody (of, for example, the monoclonal antibody 1E4, 1G10, and / or 1G1) such as, for example, an F_{ab}, F_{ab2}, Fab’ single chain antibody, F_v, single domain antibody, mono-specific antibody, bi-specific antibody, tri-specific antibody, multi-valent

antibody, chimeric antibody, canine-human chimeric antibody, canine-mouse chimeric antibody, antibody comprising a canine Fc, humanized antibody, human antibody, caninized, CDR-grafted antibody, shark antibody, nanobody, canelid antibody, microbody, and / or intrabody, or derivative thereof. Other binding agents are also provided herein as would be understood by one of ordinary skill in the art.

[0021] Any method known to those of ordinary skill in the art may be used to generate binding agents having specificity for (e.g., binding to) PD-1. For instance, to generate and isolate monoclonal antibodies an animal such as a mouse may be administered (e.g., immunized) with one or more PD-1 proteins (e.g., PD-1 Fc fusion protein and / or PD-1 His tag protein). Animals exhibiting serum reactivity to PD-1 expressed on activated human T lymphocytes (as determined by, for instance, flow cytometry and / or microscopy) may then be selected for generation of anti-PD-1 hybridoma cell lines. This may be repeated for multiple rounds. For instance, the primary criteria for the first round of binding agent selection may be include but are not limited to: i) level of staining of PD-1 on activated human T lymphocytes by flow cytometry; (ii) diversity of CDR VH and VL sequences as compared to those of the existing anti-PD-1 antibodies; and, (iii) epitope mapping performed by competitive binding studies with PD-1 conjugated Luminex beads pre-coupled with PD-L1 or one of several commercially available anti-PD-1 antibodies binding to different epitopes on PD-1. An exemplary first or second round of selection may also include, for instance, affinity binding (not a primary criteria since it may not correlate with the stimulatory potential of anti-PD-1 antibodies); and / or, functional characterization to identify the binding agent as an agonist or an antagonist.

[0022] As described in Example 1 herein, for instance, the Exhaustion Functional Recovery Assay (EFRA) may be used. In this assay, test binding agents may be assayed for the ability to rescue immune cells such as T cells from exhaustion. This may be determined by measuring the ability of a binding agent to restore proliferation to such cells in the presence of an antigen, such as a test peptide derived from a virus such as human immunodeficiency virus (HIV). Proliferation is measured in a CFSE assay in comparison to a control, such as the test peptide alone or a positive control anti-PD-1 antibody such as MK-3475 (pembrolizumab). In some embodiments, a binding agent is determined to restore proliferation where the comparison shows a signficant difference (such as a P value of <0.001) compared to either a peptide alone control or peptide with an isotype control mouse

IgG1 antibody. This assay may be used to identify binding agents (such as antibodies) that compete with other binding agents for binding to PD-1 (such as PD-L1 or PD-L2) and / or lead to the functional restoration of immune cells. Example 1 also describes two methods of epitope mapping the antibodies listed in Table 2 using Luminex-based assays. In one biochemical assay, a PD-1 Fc fusion protein is bound to beads and competitive binding studies are performed between the anti-PD-1 antibodies described in Table 2 and one of two different commercially available anti-PD-1 antibodies. Example 1 describes four classes of monoclonal antibodies binding to distinct epitopes on PD-1 that were: class 1 (competitive with a first monoclonal antibody that blocks the interaction of PD-1 with PD-L1), class 2 (competitive with a second monoclonal antibody that binds PD-1 but does not block the interaction of PD-1 with PD-L1), class 3 (competitive with both the first and second monoclonal antibodies), and class 4 (non-competitive with either the first or second antibodies). In a seperate assay, competition for binding to a recombinant PD-1 protein was evaluated for the anti-PD-1 antibodies listed in Table 2 and a biotinylated PD-L1 recombinant protein. Antibodies that induced proliferation in the EFRA were identified from all four binding classes that are proposed of binding to different epitopes on PD-1. Likewise, the EFRA allowed for the identification of anti-PD-1 antibodies that were either competitive, partially competitive or non-competitive with the PD-1 /PD-L1 interaction and specifically restored proliferative function to HIV specific CD8 T-cell.

[0023] Combinations of binding agents may also be identified, such as those described in Example 2. In some embodiments, the combinations may be identified to provide statistically significant differences from results obtained using only one or more of the binding agents and not others. In some embodiments, combinations exhibiting synergistic ability to restore immune cell function may be identified. In some embodiments, the combination may comprise a first binding agent that blocks the interaction of PD-1 and PD-L1 with a second binding agent that does not block the interaction of PD-1 and PD-L1. The first and second binding agents may be different entities such as two or more different monoclonal antibodies or derivatives thereof, or may be found on the same entity such as a bi-functional antibody (a single antibody or derivative thereof comprising multiple binding specificities). For instance, an exemplary bi-functional antibody may comprise a first binding region that blocks the interaction of PD-1 and PD-L1 and a second binding region that does not block the interaction of PD-1 and PD-L1. Also contemplated are combinations that provide multiple types of each binding agent. For instance, the combination may comprise multiple types of

binding agents that block the interaction of PD-1 and PD-L1 with one or more that does not block the interaction of PD-1 and PD-L1. In some embodiments, the combination may comprise one or more of binding agents that block the interaction of PD-1 and PD-L1 with multiple binding agents that do not block the interaction of PD-1 and PD-L1. In some embodiments, the combination may comprise multiple binding agents that block the interaction of PD-1 and PD-L1 with multiple binding agents that do not block the interaction of PD-1 and PD-L1. Such combinations as described herein may also be combined with one or more other agents that may effect immune cell function such as antibodies against CTLA-4 and the like. One of ordindary skill in the art would recognize that many such combinations may be suitable for use as descrbed herein.

[0024] Where the binding agent is an antibody, it may be identified with reference to the nucleotide and / or amino acid sequence corresponding to the variability and / or complementarity determining regions ("CDRs") thereof. The variable region / CDR sequences may be used in combination with one or more other variable region / CDR amino acid sequences. The variable region / CDR amino acid sequences may alternatively and / or also be adjoined to one or more types of constant region polypeptides of an antibody molecule. For instance, the CDR amino acid sequences shown in **Tables 1A** and **1B** may be adjoined to or associated with the constant regions of any antibody molecule of the same or a different species (e.g., human, goat, rat, sheep, chicken) and / or antibody subtype of that from which the CDR amino acid sequence was derived. For instance, an exemplary binding agent may be, or may be derived from, or may be related to the monoclonal antibody produced by the hybridomas listed in, and / or may have about the same affinity and / or proliferation effect, and / or exhibit the same binding class shown in **Table 2**, and / or may have any one or more of the amino acid sequences of SEQ ID NOS. 1-138 and / or as shown in **Tables 1A** and **1B**. The binding agent may comprise an antibody heavy and / or a light chain that each comprises one or more constant and / or variable regions. The variable regions typically comprise one or more CDRs that may determine the binding specificity of the antibody. The monoclonal antibodies may also be identified by analysis of the amino acid sequences of (e.g., which may be encoded by such nucleotide sequences) such variable regions. For instance, exemplary amino acid sequences of the heavy chain CDRs of binding agents that bind PD-1 may include any one or more of comprising at least one amino acid sequence selected from the group consisting of SEQ ID NOS. 1-138, and/or any other shown in **Tables 1A** and / or **1B**. Any of the amino acid sequences described herein, and / or any

fragments and / or derivatives thereof may also be combined with any other variable region and / or CDR in any order and / or combination to form hybrid and / or fusion binding agents and / or inserted into other heavy and / or light chain variable regions using standard techniques. Exemplary combinations of CDRs (e.g., combination of heavy and / or light chain CDR1, CDR2 and CDR3 amino acid sequences) that may be found in a PD-1 (e.g., human PD-1) binding agent of this disclosure may include, for instance, the embodiments shown in **Tables 1A** and / or **1B**.

Table 1A

	Heavy chain: Amino acids sequence		
Clone	**CDR1**	**CDR2**	**CDR3**
122F10	DDFLH (SEQ ID NO: 1)	RIDPANGESRYAPKFQD (SEQ ID NO: 24)	TDYRGYYYAMDY (SEQ ID NO: 47)
139D6	NYYIH (SEQ ID NO: 2)	SIYPNYGDTNYNQKVKD (SEQ ID NO: 25)	GYSYAMDY (SEQ ID NO: 48)
135D1	NYYIH (SEQ ID NO: 3)	SIYPNYGETNYNQEFKG (SEQ ID NO: 26)	GYSYAMDY (SEQ ID NO: 49)
134D2	SNWMH (SEQ ID NO: 4)	AVNPGNSDTTYNQKFKG (SEQ ID NO: 27)	GRSYDGSFDY (SEQ ID NO: 50)
121G1	RYWMH (SEQ ID NO: 5)	NIDPSDSTTHYNPKFRD (SEQ ID NO: 28)	DLDDFYVGSHEDFDY (SEQ ID NO: 51)
136B5	SNWMH (SEQ ID NO: 6)	AVYPGNSDTTYNQNFKG (SEQ ID NO: 29)	GRSYDGSFDY (SEQ ID NO: 52)
127C2	NSYIH (SEQ ID NO: 7)	WISPGDGSTNYNEKFKG (SEQ ID NO: 30)	EEYDYDNY (SEQ ID NO: 53)
137F2	NYWIG (SEQ ID NO: 8)	DIYPGGGYTNYNEKFKG (SEQ ID NO: 31)	GYDFVLDR (SEQ ID NO: 54)
138H5	SYAMS (SEQ ID NO: 9)	TISGGGADTYYLDNVKG (SEQ ID NO: 32)	QRGENLFAH (SEQ ID NO: 55)
140A1	SDYAWN (SEQ ID NO: 10)	YINYSGYTNYNPFLKS (SEQ ID NO: 33)	YGGSYPWNFDV (SEQ ID NO: 56)
135H12	SYWIN (SEQ ID NO: 11)	NIYPGSSSTDYNEKFKS (SEQ ID NO: 34)	GLYWYFDV (SEQ ID NO: 57)
131D11	SSYIH (SEQ ID NO: 12)	WIFPGDGKTNYNEKFRD (SEQ ID NO: 35)	NDFDRGVY (SEQ ID NO: 58)
132F7	NHGMS (SEQ ID NO: 13)	SINTGGYSTYYPDNVKG (SEQ ID NO: 36)	DDYNWFAY (SEQ ID NO: 59)
126E4	NYWIG (SEQ ID NO: 14)	DIYPGSEYENYNEKFKG (SEQ ID NO: 37)	GYDFVLDH (SEQ ID NO: 60)
135G1	DSYIH (SEQ ID NO: 15)	RIDPAHGNVIYASKFRD (SEQ ID NO: 38)	IYYDYGEGDF (SEQ ID NO: 61)
136E10	DTYIH (SEQ ID NO: 16)	RIDLANDDILYASKFQG (SEQ ID NO: 39)	IYYDYGEGDY (SEQ ID NO: 62)
135C12	NFYIH (SEQ ID NO: 17)	SIYPNYGDTAYNQKFKD (SEQ ID NO: 40)	GYSYAMDY (SEQ ID NO: 63)

136F4	DSYIH (SEQ ID NO: 18)	RIDPARDNIIYASKFRD (SEQ ID NO: 41)	IYYDYGEGDY (SEQ ID NO: 64)
136B4	DDFLH (SEQ ID NO: 19)	RIDPANGESRYAPQFQD (SEQ ID NO: 42)	TDYRGYYYAMDY (SEQ ID NO: 65)
135E10	SYFMS (SEQ ID NO: 20)	GISTGGADTYYADSMKG (SEQ ID NO: 43)	LSHYYDGIPLDC (SEQ ID NO: 66)
140G5	NHGMS (SEQ ID NO: 21)	SISGGGDNTYYPDNLKG (SEQ ID NO: 44)	VRQLGLHRAAMDY (SEQ ID NO: 67)
122H2	NYWIG (SEQ ID NO: 22)	DIYPGGDHKNYNEKFKD (SEQ ID NO: 45)	GFDFVLDY (SEQ ID NO: 68)
139F11	SFAMS (SEQ ID NO: 23)	TITGGGVNTYYPDTVKG (SEQ ID NO: 46)	QAIYDGHYVLDY (SEQ ID NO: 69)

Table 1B

	Light chain: Amino acids sequence		
Clone	**CDR1**	**CDR2**	**CDR3**
122F10	KSSQSVLYSSNQKNYLA (SEQ ID NO: 70)	WASTRES (SEQ ID NO: 93)	HQYLSSYT (SEQ ID NO: 116)
139D6	SASQGISDGLN (SEQ ID NO: 71)	HTSTLHS (SEQ ID NO: 94)	QQYSKFPLT (SEQ ID NO: 117)
135D1	SASQGISNGLN (SEQ ID NO: 72)	HTSTLHS (SEQ ID NO: 95)	QQYSKFPLT (SEQ ID NO: 118)
134D2	KASQDINKYIA (SEQ ID NO: 73)	YTSTLRP (SEQ ID NO: 96)	LQYDNLWT (SEQ ID NO: 119)
121G1	RSSQSIVYSNGNTYLE (SEQ ID NO: 74)	KVSHRFS (SEQ ID NO: 97)	FQGSHVPYT (SEQ ID NO: 120)
136B5	KASQDINKYMA (SEQ ID NO: 75)	YTSTLRP (SEQ ID NO: 98)	LQYDNLWT (SEQ ID NO: 121)
127C2	KASQNVGTNVG (SEQ ID NO: 76)	SASYRYN (SEQ ID NO: 99)	QQYNTYPWT (SEQ ID NO: 122)
137F2	KSSQSLFNSETQKNYLA (SEQ ID NO: 77)	WASTRES (SEQ ID NO: 100)	KQSYTLRT (SEQ ID NO: 123)
138H5	LASQTIGTWLA (SEQ ID NO: 78)	AATSLAD (SEQ ID NO: 101)	QQLYSTPWT (SEQ ID NO: 124)
140A1	RSSQTIVHNNGDTYLE (SEQ ID NO: 79)	KISNRFF (SEQ ID NO: 102)	FQGSHVPYT (SEQ ID NO: 125)
135H12	KSSQSLFNSGTRKNYLA (SEQ ID NO: 80)	WASTRDS (SEQ ID NO: 103)	KQSYNLYT (SEQ ID NO: 126)
131D11	KASQNVDTNVA (SEQ ID NO: 81)	SASYRYN (SEQ ID NO: 104)	QQYNNYPYT (SEQ ID NO: 127)
132F7	KSSQSLLNSGNQKNYLT (SEQ ID NO: 82)	WASTRES (SEQ ID NO: 105)	QSDYSYPLT (SEQ ID NO: 128)
126E4	KSSQSLFNSGTRKSYLA (SEQ ID NO: 83)	WASTRET (SEQ ID NO: 106)	MQSYNLRT (SEQ ID NO: 129)
135G1	HASQNINVWLS (SEQ ID NO: 84)	KASNLHT (SEQ ID NO: 107)	QQGQSWPLT (SEQ ID NO: 130)
136E10	HASQNINVWLS (SEQ ID NO: 85)	KASNLHT (SEQ ID NO: 108)	QQGQSYPLT (SEQ ID NO: 131)

135C12	SASQGISGDLN (SEQ ID NO: 86)	HTSSLHS (SEQ ID NO: 109)	QYYSKDLLT (SEQ ID NO: 132)
136F4	HASQNINVWLS (SEQ ID NO: 87)	KASNLHT (SEQ ID NO: 110)	QQGQSWPLT (SEQ ID NO: 133)
136B4	KSSQSVLYSSNQKNYLA (SEQ ID NO: 88)	WASTRES (SEQ ID NO: 111)	HQYLSSYT (SEQ ID NO: 134)
135E10	RASESVDNSGVSFLT (SEQ ID NO: 89)	AASNQGS (SEQ ID NO: 112)	QQTKEVPWT (SEQ ID NO: 135)
140G5	KASQSVSDDVS (SEQ ID NO: 90)	SAFFRYP (SEQ ID NO: 113)	QQDYSSPLT (SEQ ID NO: 136)
122H2	KSSQSLFNSGTRKNYLA (SEQ ID NO: 91)	WASTRES (SEQ ID NO: 114)	MQSFNLRT (SEQ ID NO: 137)
139F11	RTSGNIHNYLA (SEQ ID NO: 92)	NVKTLTD (SEQ ID NO: 115)	QQFWSIPWT (SEQ ID NO: 138)

In addition, any of SEQ ID NOS. 1-69 may be combined with any one or more of SEQ ID NOS. 70-138 into a binding agent. In preferred embodiments, the heavy chain CDRs of each clone are combined with their respective light chain CDRs into a binding agent. In some embodiments, the binding agent may comprise the heavy chain CDRs and light chain CDRs shown below:

122F10 (SEQ ID NOS. 1, 24, 47, 70, 93, and 116);
139D6 (SEQ ID NOS. 2, 25, 48, 71, 94, and 117);
135D1 (SEQ ID NOS. 3, 26, 49, 72, 95, and 118);
134D2 (SEQ ID NOS. 4, 27, 50, 73, 96, and 119);
121G1 (SEQ ID NOS. 5, 28, 51, 74, 97, and 120);
136B5 (SEQ ID NOS. 6, 29, 52, 75, 98, and 121);
127C2 (SEQ ID NOS. 7, 30, 53, 76, 99, and 122);
137F2 (SEQ ID NOS. 8, 31, 54, 77, 100, and 123);
138H5 (SEQ ID NOS. 9, 32, 55, 78, 101, and 124);
140A1 (SEQ ID NOS. 10, 33, 56, 79, 102, and 125);
135H12 (SEQ ID NOS. 11, 34, 57, 80, 103, and 126);
131D11 (SEQ ID NOS. 12, 35, 58, 81, 104, and 127);
132F7 (SEQ ID NOS. 13, 36, 59, 82, 105, and 128);
126E4 (SEQ ID NOS. 14, 37, 60, 83, 106, and 129);
135G1 (SEQ ID NOS. 15, 38, 61, 84, 107, and 130);
136E10 (SEQ ID NOS. 16, 39, 62, 85, 108, and 131);
135C12 (SEQ ID NOS. 17, 40, 63, 86, 109, and 132);
136F4 (SEQ ID NOS. 18, 41, 64, 87, 110, and 133);
136B4 (SEQ ID NOS. 19, 42, 65, 88, 111, and 134);
135E10 (SEQ ID NOS. 20, 43, 66, 89, 112, and 135);
140G5 (SEQ ID NOS. 21, 44, 67, 90, 113, and 136);
122H2 (SEQ ID NOS. 22, 45, 68, 91, 114, and 137); or
139F11 (SEQ ID NOS. 23, 46, 69, 92, 115, and 138).

Other combinations may also be useful as may ascertained by one of ordinary skill in the art.

[0025] Binding agents comprising the CDRs of **Tables 1A** and/or **1B**, or those of the immediately preceding paragraph, may also exhibit the following characteristics:

Table 2

Clone	Affinity* (nM)	Binding Class**	Antibody competition with the PD-1 / PD-L1 interaction***	EFRA %relative to peptide stimulation alone#
122F10	2.2	4	Non-competitive	146%
139D6	2.4	2	Partial competition	195%
135D1	6.5	2	Partial competition	187%
134D2	4.8	4	Competitive	205%
121G1	11.9	4	Non-competitive	120%
136B5	7.7	4	Competitive	200%
127C2	1.0	2	Non-competitive	100%
137F2	1.5	1	Competitive	250%
138H5	1.6	3	Competitive	210%
140A1	1.4	3	Competitive	160%
135H12	1.9	1	Competitive	190%
131D11	2.7	1	Competitive	180%
132F7	100	2	Non-competitive	210%
126E4	0.5	4	Competitive	130%
135G1	32	4	NA	138%
136E10	7.1	4	Non-competitive	148%
135C12	1.7	2	Partial competition	195%
136F4	8.3	4	Non-competitive	108%
136B4	1.4	2	Non-competitive	185%
135E10	1.5	3	Competitive	165%
140G5	1.6	1	Competitive	205%
122H2	4.3	1	Competitive	200%
139F11	3.1	1	Competitive	250%

* Binding affinity for the antibodies listed in Table 1 was evaluated by FACS staining of endogenous cell surface PD-1 on activated CD4 T cells.

** Binding class was determined by Luminex assay competitive binding studies. Binding class 1 mAb clones are competitive with the EH12.2H7 clone commercial antibody, class 2 mAb clones are competitive with the J116 clone commercial antibody, class 3 mAb clones are competitive with both EH12.2H7 and J116 antibodies and class 4 mAb clones bind in the presence of both EH12.2H7 and J116 antibodies.

*** Antibody competition with the PD-1 / PD-L1 interaction was determined in a second Luminex binding assay. In this assays, PD-1 Fc fusion protein coated beads were incubated in the absence or presence of an anti-PD-1 antibody from Table 2 at a concentration of 20 nM. A fixed concentration of 1.25 nM biotinylated PD-L1, approximately equivalent to the IC_{50} of

the PD-1 /PD-L1 interaction, was then incubated with the PD-1/antibody complex and PD-L1 binding was detected by fluorescence with phycoerythrin labeled streptavidin. Based on PD-L1 binding to the PD-1 /antibody complex, antibodies were defined as being competitive, partially competitive or non-competitive with the PD-1/PD-L1 interaction.

ǂ Proliferative effect is evaluated using a CFSE assay (an embodiment of the Exhaustion Functional Recovery Assay, "EFRA"). PBMCs isolated from a chronically infected HIV subject were stimulated with an HIV specific peptide in the presence and absence of an anti-PD-1 antibody. Following a 6 day incubation, proliferation of HIV specific CD8 T cells was evaluated in the anti-PD-1 treated samples relative to the peptide alone control.

NA=not available

[0026] Binding affinity may be determined by any technique available to those of ordinary skill in the art. The binding affinity data presented in **Table 2** was evaluated by flow cytometry staining of endogenous cell surface PD-1 on CD4 T cells that were stimulated for a period of 3 to 6 days with phytohaemagglutinin (PHA). Binding class may also be determined by any technique available to those of ordinary skill in the art. The binding class data presented in **Table 2** was determined by Luminex assay competitive binding studies. In **Table 2**, binding class 1 mAb antibodies are those determined to be competitive with the EH12.2H7 clone commercial antibody (available from BioLegend, San Diego, CA (e.g., Cat. No. 329905)); class 2 antibodies are those determined to be competitive with the J116 clone commercial antibody (available from Affymetrix eBioscience, San Diego, CA (e.g., Cat. No. 16-9989-80)); and class 3 antibodies are those determined to be competitive with both EH12.2H7 and J116 antibodies; and class 4 mAb clone antibodies are those determined to bind PD-1 in the presence of both EH12.2H7 and J116 antibodies.

[0027] Proliferative effect may be determined by any technique available to those of ordinary skill in the art. For instance, the EFRA system described above and used in Example 1 may be used. Such an assay was used to determine the proliferative effect data presented in **Table 2**. Briefly, a carboxyfluorescein succinimidyl ester (CFSE) assay in which peripheral blood mononuclear cells (PBMCs) were isolated from a chronically infected HIV subject and stimulated with an HIV-specific peptide in the presence and absence of an anti-PD-1 antibody. A control anti-PD1 antibody (the Merck antibody MK-3475) was also tested as a positive control. Following a six-day incubation, proliferation of HIV-specific CD8 T cells was evaluated in the anti-PD-1 treated samples relative to the peptide alone control and the result

expressed as a percentage above control ("Proliferation effect").

[0028] In some embodiments, the techniques used to identify and characterize PD-1 binding agents such as antibodies may be combined to provide a system for identifying and characterizing such binding agents. For instance, one or more candidate binding agents such one or more monoclonal antibodies may be assayed by EFRA or a similar assay to determine the ability of the candidate binding agent to restore function to immune cells as measured by, for instance, proliferation in the presence of an immunogenic peptide. In some embodiments, this type of assay may be used as an initial screen to ensure the candidate binding agents to be further studied are capable of restoring immune cell function. In some embodiments, these types of assays may be followed by one for determining the binding affinity to immune cells such as activated peripheral blood mononuclear cells (PBMCs). In some embodiments, this assay may use a technique such as fluorescence activated cell sorting (FACS). In some embodiments, the assay may include the presence or absence of non-specific binding and / or competitive binding studies using known binding reagents such as anti-PD1 antibody (e.g., the Merck antibody MK-3475, also know as pembrolizumab). These assays may then be followed by sequencing of the CDRs of the candidate binding agents such as provided in **Tables 1A** and/or **1B** above. Together, then, the EFRA, affinity determination, epitope mapping studies and CDR identification methods described herein provide a system with which a candidate binding agent may be identified.

[0029] Any of the amino acid sequences of **Tables 1A** and/or **1B** (and / or any one or more fragments and / or derivatives thereof) may be also substituted by any other amino acid as desired by one of ordinary skill in the art. For example, one of skill in the art may make conservative substitutions by replacing particular amino acids with others as shown in **Table 3** below. The specific amino acid substitution selected may depend on the location of the site selected. Such conservative amino acid substitutions may involve a substitution of a native amino acid residue with a non-native residue such that there is little or no effect on the size, polarity, charge, hydrophobicity, or hydrophilicity of the amino acid residue at that position and, in particular, does not result in decreased PD-1 binding.

Table 3

Original Amino Acid Residues in SEQ ID NOS. 1-138	Exemplary Conservative Substitutions of the Original Amino Acid Residues of SEQ ID NOS. 1-138	Preferred ConservativeSubstitution of the Original Amino Acid Residues of SEQ ID NOS. 1-138
Ala	Val, Leu, Ile	Val
Arg	Lys, Gln, Asn	Lys
Asn	Gln	Gln
Asp	Glu	Glu
Cys	Ser, Ala	Ser
Gln	Asn	Asn
Glu	Asp	Asp
Gly	Pro, Ala	Ala
His	Asn, Gln, Lys, Arg	Arg
Ile	Leu, Val, Met, Ala, Phe, Norleucine	Leu
Leu	Norleucine, Ile, Val, Met, Ala, Phe	Ile
Lys	Arg, 1,4 Diamino-butyric Acid, Gln, Asn	Arg
Met	Leu, Phe, Ile	Leu
Phe	Leu, Val, Ile, Ala, Tyr	Leu
Pro	Ala	Gly
Ser	Thr, Ala, Cys	Thr
Thr	Ser	Ser
Trp	Tyr, Phe	Tyr
Tyr	Trp, Phe, Thr, Ser	Phe
Val	Ile, Met, Leu, Phe, Ala, Norleucine	Leu

[0030] In some embodiments, this disclosure provides binding agents with multiple specificities such that PD-1 and at least one other secondary antigen (e.g., a cell surface protein) may be bound by a single binding agent. In some embodiments, the secondary antigen may be one expressed by cells infected by an infectious agent. For instance, an exemplary secondary antigen may be HIV Env antigen. Such binding agents may bind the secondary antigen and / or may serve to neutralize the infectious agent. In certain embodiments, such as for a bi-specific binding agent having dual specificity for PD-1 and an HIV antigen such as env and / or another antigen, for instance. The HIV immunogen may be derived from any of the subtypes described herein, or any other. In some embodiments, such binding agents may include: PD-1 agonist / Env binding; PD-1 agonist PD-1 / Env binding and neutralization; PD-1 antagonist / Env binding; and / or PD-1 antagonist / PD-1 / Env binding and neutralization. Given the prevelance of the various subtypes, it may be preferable to select antigens from HIV-1 subtypes B and / or C. It may also be desirable to include binding agents having specificity for antigens from multiple HIV subtypes (e.g., HIV-1 subtypes B and C, HIV-2 subtypes A and B, or a combination of HIV-1 and HIV-2 subtypes)

in a single composition. For treating a disease such as cancer, it may be beneficial to obtain binding agents with multiple PD-1 specificities (e.g., bi-specific PD-1a/PD1b antagonist PD-1 antibodies specific to two different epitopes) and / or specificity to both PD-1 and one or more tumor antigens (e.g., cancer-testis (CT) antigen (i.e., MAGE, NY-ESO-1); melanocyte differentiation antigen (i.e., Melan A/MART-1, tyrosinase, gp100); mutational antigen (i.e., MUM-1, p53, CDK-4); overexpressed 'self´ antigen (i.e., HER-2/neu, p53); and / or viral antigens (i.e., HPV, EBV)). The binding agents (e.g., monoclonal antibodies) may be generated as generally described above. The specificities of such binding agents may be recombined into a single binding agent using techniques that are widely available to those of ordinary skill in the art. In some embodiments, multiple single specifity binding agents may also be combined and used (e.g., administered) to provide an effective multiple specificity reagent.

[0031] In some embodiments, the binding agents described herein may be conjugated to active agents to target and inhibit the function of and /or eliminate cell populations expressing PD-1 (and / or another antigen in the case of binding agents with multiple specificities). For instance, $CD4^+$ T-cell populations containing replication competent HIV may be targeted and eliminated using binding agent / drug conjugates (e.g., antibody-drug conjugates (ADC)). Mono- and/or bi-specific candidate binding agents may be conjugated with one or more types of drugs (e.g., drugs damaging DNA, targeting microtubules). The binding agents described herein and/ or derivatives thereof may also be adjoined to and / or conjugated to functional agents for *in vitro* and / or *in vivo* use. For instance, the binding agent may be adjoined to and / or conjugated to functional moieties such as cytotoxic drugs or toxins, and / or active fragments thereof such as diphtheria A chain, exotoxin A chain, ricin A chain, abrin A chain, curcin, crotin, phenomycin, enomycin, among others. Suitable functional moieties may also include radiochemicals. Binding agents, such as antibodies, may be adjoined to and / or conjugated to the one or more functional agents using standard techniques in the art.

[0032] In some embodiments, the binding agents may be administered in conjunction with other agents such as anti-infective agents (e.g., antibiotics, anti-viral medications). For instance, the binding agents described herein may be combined with monoclonal antibodies and / or other reagents such as Nivolumab (also known as MDX-1106, BMS-936558 (Topalian, et al. N. Eng. J. Med. 2012; 366(26): 2443-2454), MDX-1106, ONO-4538, a fully human IgG4 mAb available from Bristol-Myers Squibb), Lambrolizumab (also known as MK-

3475 and SCH 900475, a humanized IgG4 monoclonal antibody available from Merck), Pidilizumab (a humanized IgG1 monoclonal antibody available from CureTech), AMP-224 (a B7-DC/IgG1 fusion protein available from GlaxoSmithKline / Amplimmune), and / or an antibody or other reagent or method described in any of U.S. Pat. No. 8,354,509B2 (Carven, et al), U.S. Pat. No. 8,008,449B2 (Korman, et al), WO 2012/135408A1 (Manoj, et al.), US 2010/026617 (Carven, et al.), WO 2011/110621A1 (Tyson, et al), U.S. Pat. No. 7,488,802B2 (Collins, et al.), WO 2010/029435A1 (Simon, et al.), WO 2010/089411A2 (Olive, D.), ,WO 2012/145493A1 (Langermann, et al.), WO 2013/0435569A1 (Rolland, et al.), WO 2011/159877A2 (Kuchroo, et al.), U.S. Pat. No. 7,563,869B2 (Ono Pharm.), U.S. Pat. No. 7,858,746B2 (Honjo, et al.), U.S. Pat. No. 8,728,474B2 (Ono Pharm.), U.S. Pat. No. 9,067,999 (Ono Pharm.), and/or U.S. Pat. No. 9,067,999, each of which is hereby incorporated in its entirety into this disclosure.

[0033] As mentioned above, the PD-1 binding agents described herein (e.g., a PD-1 antagonist) may be used to treat and / or prevent and / or ameliorate the symptoms of infection by HIV. As is well-known in the art, HIV isolates are now classified into discrete genetic subtypes. HIV-1 is known to comprise at least ten subtypes (A1, A2, A3, A4, B, C, D, E, F1, F2, G, H, J and K) (Taylor et al, NEJM, 359(18):1965-1966 (2008)). HIV-2 is known to include at least five subtypes (A, B, C, D, and E). Subtype B has been associated with the HIV epidemic in homosexual men and intravenous drug users worldwide. Most HIV-1 immunogens, laboratory adapted isolates, reagents and mapped epitopes belong to subtype B. In sub-Saharan Africa, India and China, areas where the incidence of new HIV infections is high, HIV-1 subtype B accounts for only a small minority of infections, and subtype HIV-1 C appears to be the most common infecting subtype. Any of these types of isolates may be addressed using the binding agents described herein. One or more binding agents may also be administered with or in conjunction with one or more agents used to prevent, treat and / or ameliorate HIV such as for example, a protease inhibitor, an HIV entry inhibitor, a reverse transcriptase inhibitor, and / or an anti- retroviral nucleoside analog. Suitable compounds include, for example, Agenerase (amprenavir), Combivir (Retrovir / Epivir), Crixivan (indinavir), Emtriva (emtricitabine), Epivir (3tc / lamivudine), Epzicom, Fortovase / Invirase (saquinavir), Fuzeon (enfuvirtide), Hivid (ddc / zalcitabine), Kaletra (lopinavir), Lexiva (Fosamprenavir), Norvir (ritonavir), Rescriptor (delavirdine), Retrovir / AZT (zidovudine), Reyatax (atazanavir, BMS-232632), Sustiva (efavirenz), Trizivir (abacavir / zidovudine / lamivudine), Truvada (Emtricitabine / Tenofovir DF), Videx (ddl / didanosine), Videx EC (ddl,

didanosine), Viracept (nevirapine), Viread (tenofovir disoproxil fumarate), Zerit (d4T / stavudine), and Ziagen (abacavir) may be utilized. Other suitable agents are known to those of skill in the art and may be suitable for use as described herein. Such agents may either be used prior to, during, or after administration of the binding agents and / or use of the methods described herein.

[0034] As mentioned above, the PD-1 binding agents described herein (e.g., a PD-1 antagonist) may be used to treat and / or prevent and / or ameliorate the symptoms of cancer. Exemplary cancers may include, for instance, any of the breast, blood, colon, stomach, rectum, skeletal tissue, skin (e.g., melanoma) brain, lung, bladder, kidney, ovary, and / or liver, among others. One or more of the binding agents may also be combined with and / or administered with or in conjunction with one or more agents used to prevent, treat and / or ameliorate cancer such as for example, an alkylating agent (e.g., any nitrogen mustard, nitrosourea, tetrazine, aziridine, cisplatin and / or derivative thereof), anti-metabolite (e.g., any of the methotrexates, pemetrexeds, fluoropyrimidines and / or derivative thereof), anti-microbtubule agent (e.g., vinca alkyloids, taxanes, podophyllotoxin and / or derivative thereof), topoisomerase I and / or II inhibitors (e.g., a camptothecin, irinotecan, topotecan, etoposide, doxorubicin, mitoxantrone, teniposide, novobiocin, merbarone, aclarubicin and / or derivative thereof) and / or cytotoxic antibiotic (e.g., any anthracyclines, actinomycin, bleomycin, plicamycin, and mitomycin and / or derivative thereof). The one or more binding agents may also, or alternatively, be combined with one or more other binding agents available to those of ordinary skill in the art for treating, preventing and / or ameliorating cancer such as, for example, Nivolumab, Lambrolizumab, Pidilizumab and / or other similar agents and / or derivatives thereof. Other suitable agents are known to those of skill in the art and may be suitable for use as described herein. Such agents may either be used prior to, during, or after administration of the binding agents and / or use of the methods described herein.

[0035] As mentioned above, the PD-1 binding agents described herein (e.g., a PD-1 agonist) may be used to treat and / or prevent and / or ameliorate the symptoms of autoimmunity. Exemplary autoimmune conditions may include, for instance, any in which PD-1 is involved in maintaining self-tolerance and / or one involving inflammatory T cells (e.g., autoreactive or self antigen-specific T cells) such as, for instance, systemic lupus erythematosus (SLE), type I diabetes, rheumatoid arthritis, glomerulonephritis, and multiple sclerosis. Such PD-1

binding agents may also be combined with other agents such as anti-CTLA-4 agents (e.g., ipilimumab). One or more of the binding agents may also be combined with and / or administered with or in conjunction with one or more agents used to prevent, treat and / or ameliorate autoimmunity such as, for example, glucocorticoids, cytostatics (e.g., alkylating agent, anti-metabolite, methotrexate, azathioprine, mercaptopurine, cytotoxic antibiotics (e.g., dactinomycin, anthracyclines, mitomycin C, bleomycin, mithramycin), antibodies (e.g., Atgam, Thymoglobuline, Simulect, Zenapax), drugs acting on immunophilins (e.g,. ciclosporin, tacrolimus, sirolimus), interferons, opioids, TNF-binding agents (e.g., Remicade, Enbrel, Humira), mycophenolate, fingolimod, myriocin, and / or derivatives thereof. Other suitable agents are known to those of skill in the art and may be suitable for use as described herein. Such agents may either be used prior to, during, or after administration of the binding agents and / or use of the methods described herein.

[0036] In some embodiments, the binding agents may be adjoined to and / or conjugated to one or more detectable labels. For instance, suitable detectable labels may include, for instance, fluorosceins (e.g., DyLight, Cy3, Cy5, FITC, HiLyte Fluor 555, HiLyte Fluor 647; 5-carboxy-2,7-dichlorofluorescein; 5-Carboxyfluorescein (5-FAM); 5-HAT (Hydroxy Tryptamine); 5-Hydroxy Tryptamine (HAT); 6-JOE; 6-carboxyfluorescein (6-FAM); FITC; 6-carboxy-1,4-dichloro-2',7'-dichlorofluorescein (TET); 6-carboxy-1,4-dichloro-2',4', 5', 7'-tetra-chlorofluorescein (HEX); 6-carboxy-4',5'-dichloro-2', 7'-dimethoxyfluorescein (JOE); Alexa fluors (e.g., 350, 405, 430, 488, 500, 514, 532, 546, 555, 568, 594, 610, 633, 635, 647, 660, 680, 700, 750); BODIPY fluorophores (e.g., 492/515, 493/503, 500/510, 505/515, 530/550, 542/563, 558/568, 564/570, 576/589, 581/591, 630/650-X, 650/665-X, 665/676, FL, FL ATP, Fl-Ceramide, R6G SE, TMR, TMR-X conjugate, TMR-X, SE, TR, TR ATP, TR-X SE)), rhodamines (e.g., 110, 123, B, B 200, BB, BG, B extra, 5-carboxytetramethylrhodamine (5-TAMRA), 5 GLD, 6-Carboxyrhodamine 6G, Lissamine, Lissamine Rhodamine B, Phallicidine, Phalloidine, Red, Rhod-2, ROX (6-carboxy-X-rhodamine), 5-ROX (carboxy-X-rhodamine), Sulphorhodamine B can C, Sulphorhodamine G Extra, TAMRA (6-carboxytetramethyl-rhodamine), Tetramethylrhodamine (TRITC), WT), Texas Red, and / or Texas Red-X. Other detectable labels known in the art may also be suitable for use. Binding agents, such as antibodies, may be adjoined to and / or conjugated to the one or more detectable labels using standard techniques in the art.

[0037] In certain embodiments, a nucleic acid molecule encoding one or more binding agents described herein may be inserted into one or more expression vectors, as discussed below in greater detail. In such embodiments, the binding agent may be encoded by nucleotides corresponding to the amino acid sequence. The particular combinations of nucleotides (codons) that encode the various amino acids (AA) are well known in the art, as described in various references used by those skilled in the art (e.g., Lewin, B. *Genes V*, Oxford University Press, 1994). The nucleotide sequences encoding the amino acids of said binding agents may be ascertained with reference to **Table 4**, for example. Nucleic acid variants may use any combination of nucleotides that encode the binding agent.

Table 4

Codons Encoding Amino Acids (AA) of SEQ ID NOS. 1-138 of Variants Thereof

AA	Codon	AA	Codons	AA	Codons	AA	Codons
Phe (F)	TTT	Ser (S)	TCT	Tyr (Y)	TAT	Cys (C)	TGT
	TTC		TCC		TAC		TGC
Leu (L)	TTA		TCA	TERM	TAA	TERM	TGA
	TTG		TCG		TAG	Trp (W)	TGG
	CTT	Pro (P)	CCT	His (H)	CAT	Arg (R)	CGT
	CTC		CCC		CAC		CGC
	CTA		CCA	Gln (Q)	CAA		CGA
	CTG		CCG		CAG		CGG
Ile (I)	ATT	Thr (T)	ACT	Asn (N)	AAT	Ser (S)	AGT
	ATC		ACC		AAC		AGC
	ATA		ACA	Lys (K)	AAA	Arg (R)	AGA
Met (M)	ATG		ACG		AAG		AGG
Val (V)	GTT	Ala (A)	GCT	Asp (D)	GAT	Gly (G)	GGT
	GTC		GCC		GAC		GGC
	GTA		GCA	Glu (E)	GAA		GGA
	GTG		GCG		GAG		GGG

Those of ordinary skill in the art understand that the nucleotide sequence encoding a particular amino acid sequence may be easily derived from the amino acid sequence and the information presented in **Table 4**. For instance, it may be deduced from the amino acid sequence DDFLH (SEQ ID NO.: 1) and the information presented in **Table 4** that the amino acid sequence may be encoded by the nucleotide sequence GAT GAT TTT TTA CAT (SEQ ID NO.:139). Those of ordinary skill in the art would understand that nucleotide sequences encoding SEQ ID NOS. 2-138 may be deduced in the same way, and such nucleotide sequences are contemplated herein. Where the binding agents are antibodies, nucleotide sequences encoding the variable regions thereof may also be isolated from the phage and / or hybridoma cells expressing the same cloned into expression vectors to produce certain

preparations (e.g., humanized antibodies). Methods for producing such preparations are well-known in the art.

[0038] To determine the amino acid sequences of the variable regions (e.g., CDRs) of interest, hybridoma cells from mice immunized with a PD-1 antigen / immunogen may be selected using the functional assays described herein and cloning techniques that are readily available to those of ordinary skill in the art. For instance, to isolate and sequence nucleic acids encoding the heavy and light chain variable regions of the selected hybridomas, total RNA may be extracted from fresh hybridoma cells using TRIzol reagent according to the manufacturer's protocol. cDNA may be synthesized from the RNA using isotype-specific anti-sense primers or universal primers using standard techniques (e.g., following the technical manual of PrimeScript™ 1st Strand cDNA Synthesis Kit). Polymerase chain reaction (PCR) may then be performed to amplify the nucleic acids encoding the variable regions (heavy and light chains) of the antibody produced by the selected hybridoma, which may then be cloned into a standard cloning vector separately and sequenced. Colony PCR screening may then be performed to identify clones with inserts of correct sizes. Preferably, no less than five single colonies with inserts of correct sizes are sequenced for each antibody variable region. Standard protocols may then be used for the expression and purification of the anti-PD-1 antibodies. For instance, hybridoma clones may be grown in serum-free medium and the cell culture broth centrifuged and then filtered. The filtered supernatant containing the antibody may then be loaded onto an affinity column (e.g., Protein A) column, washed and eluted with an appropriate buffer (e.g., Pierce IgG elute buffer). The eluted fractions may then be pooled and buffer-exchanged into PBS, pH 7.2. The purified antibody may then be analyzed by SDS-PAGE and Western blot by using standard protocols for molecular weight, yield and purity. Size exclusion chromatography HPLC may then be performed on an appropriate column (e.g., TSK GEL-G3000 SWXL column (Tosoh)) for biophysical characterization in order to ensure high antibody purity (generally >90%) with low presence of protein aggregates. These procedures were used in isolating and sequencing nucleic acids encoding SEQ ID NOS. 1-138 from selected hybridoma cells. These techniques, variations thereof, and/or other may also be of use for these purposes as would be understood by those of ordinary skill in the art.

[0039] Nucleic acid molecules encoding one or more PD-1 binding agents may be contained within a viral and / or a non-viral vector. In one embodiment, a DNA vector is utilized to deliver

nucleic acids encoding one or more PD-1 binding agents to the patient. In doing so, various strategies may be utilized to improve the efficiency of such mechanisms including, for example, the use of self-replicating viral replicons (Caley, et al. 1999. *Vaccine*, 17: 3124-2135; Dubensky, et al. 2000. *Mol. Med.* 6: 723-732; Leitner, et al. 2000. *Cancer Res.* 60: 51-55), codon optimization (Liu, et al. 2000. *Mol. Ther.*, 1: 497-500; Dubensky, *supra*; Huang, et al. 2001. *J. Virol.* 75: 4947-4951), *in vivo* electroporation (Widera, et al. 2000. *J. Immunol.* 164: 4635-3640), incorporation of nucleic acids encoding co-stimulatory molecules, cytokines and / or chemokines (Xiang, et al. 1995. *Immunity*, 2: 129-135; Kim, et al. 1998. *Eur. J. Immunol.*, 28: 1089-1103; Iwasaki, et al. 1997. *J. Immunol.* 158: 4591-3601; Sheerlinck, et al. 2001. *Vaccine*, 19: 2647-2656), incorporation of stimulatory motifs such as CpG (Gurunathan, *supra*; Leitner, *supra*), sequences for targeting of the endocytic or ubiquitin-processing pathways (Thomson, et al. 1998. *J. Virol.* 72: 2246-2252; Velders, et al. 2001. *J. Immunol.* 166: 5366-5373), prime-boost regimens (Gurunathan, *supra*; Sullivan, et al. 2000. *Nature*, 408: 605-609; Hanke, et al. 1998. *Vaccine*, 16: 439-445; Amara, et al. 2001. *Science*, 292: 69-74), proteasome-sensitive cleavage sites, and the use of mucosal delivery vectors such as *Salmonella* (Darji, et al. 1997. *Cell*, 91: 765-775; Woo, et al. 2001. *Vaccine*, 19: 2945-2954). Other methods are known in the art, some of which are described below. Various viral vectors that have been successfully utilized for introducing a nucleic acid to a host include retrovirus, adenovirus, adeno-associated virus (AAV), herpes virus, and poxvirus, among others. The vectors may be constructed using standard recombinant techniques widely available to one skilled in the art. Such techniques may be found in common molecular biology references such as *Molecular Cloning: A Laboratory Manual* (Sambrook, et al., 1989, Cold Spring Harbor Laboratory Press), *Gene Expression Technology* (Methods in Enzymology, Vol. 185, edited by D. Goeddel, 1991. Academic Press, San Diego, CA), and *PCR Protocols: A Guide to Methods and Applications* (Innis, et al. 1990. Academic Press, San Diego, ca). "Non-viral" plasmid vectors may also be suitable in certain embodiments. Preferred plasmid vectors are compatible with bacterial, insect, and / or mammalian host cells. Such vectors include, for example, PCR-ii, PCR3, and pcDNA3.1 (Invitrogen, San Diego, CA), pBSii (Stratagene, La Jolla, CA), pet15 (Novagen, Madison, WI), pGEX (Pharmacia Biotech, Piscataway, NJ), pEGFp-n2 (Clontech, Palo Alto, CA), pETI (Bluebacii, Invitrogen), pDSR-alpha (PCT pub. No. WO 90/14363) and pFASTBACdual (Gibco-BRL, Grand island, NY) as well as Bluescript® plasmid derivatives (a high copy number COLe1-based phagemid, Stratagene Cloning Systems, La Jolla, CA), PCR cloning plasmids designed for cloning TAQ-amplified PCR products (*e.g.*, TOPO™ TA cloning® kit, PCR2.1® plasmid derivatives, Invitrogen, Carlsbad,

CA). Bacterial vectors may also be used. These vectors include, for example, *Shigella, Salmonella, Vibrio cholerae, Lactobacillus, Bacille Calmette Guérin (BCG), and Streptococcus* (see for example, WO 88/6626; WO 90/0594; WO 91/13157; WO 92/1796; and WO 92/21376). Many other non-viral plasmid expression vectors and systems are known in the art and may be use. Other delivery techniques may also suffice including, for example, DNA-ligand complexes, adenovirus-ligand-DNA complexes, direct injection of DNA, $CaPO_4$ precipitation, gene gun techniques, electroporation, and colloidal dispersion systems. Colloidal dispersion systems include macromolecule complexes, nanocapsules, microspheres, beads, and lipid-based systems including oil-in-water emulsions, micelles, mixed micelles, and liposomes. The preferred colloidal system is a liposome, which are artificial membrane vesicles useful as delivery vehicles *in vitro* and *in vivo*. RNA, DNA and intact virions can be encapsulated within the aqueous interior and be delivered to cells in a biologically active form (Fraley, R., *et al.,* 1981, *Trends Biochem. Sci*., 6: 77). The composition of the liposome is usually a combination of phospholipids, particularly high-phase-transition-temperature phospholipids, usually in combination with steroids, especially cholesterol. Other phospholipids or other lipids may also be used. The physical characteristics of liposomes depend on pH, ionic strength, and the presence of divalent cations. Examples of lipids useful in liposome production include phosphatidyl compounds, such as phosphatidylglycerol, phosphatidylcholine, phosphatidylserine, phosphatidylethanolamine, sphingolipids, cerebrosides, and gangliosides. Particularly useful are diacylphosphatidylglycerols, where the lipid moiety contains from 14-18 carbon atoms, particularly from 16-18 carbon atoms, and is saturated. Illustrative phospholipids include egg phosphatidylcholine, dipalmitoylphosphatidylcholine and distearoylphosphatidylcholine.

[0040] A cultured cell comprising the vector is also provided. The cultured cell may be a cultured cell transfected with the vector or a progeny of the cell, wherein the cell expresses the immunogenic polypeptide. Suitable cell lines are known to those of skill in the art and are commercially available, for example, through the American Type Culture Collection (ATCC). The transfected cells can be used in a method of producing an immunogenic polypeptide. The method comprises culturing a cell comprising the vector under conditions that allow expression of the immunogenic polypeptide, optionally under the control of an expression sequence. The immunogenic polypeptide can be isolated from the cell or the culture medium using standard protein purification methods.

[0041] The skilled artisan has many suitable techniques for using the binding agents (e.g., antibodies) described herein to identify biological samples containing proteins that bind thereto. For instance, antibodies may be utilized to isolate PD-1 using, for example, immunoprecipitation or other capture-type assay. This well-known technique is performed by attaching the antibody to a solid support or chromatographic material (e.g., a bead coated with Protein A, Protein G and / or Protein L). The bound antibody is then introduced into a solution either containing or believed to contain the PD-1 (e.g., an HIV-infected T cell lysate). PD-1 may then bind to the antibody and non-binding materials are washed away under conditions in which the PD-1 remains bound to the antibody. The bound protein may then be separated from the antibody and analyzed as desired. Similar methods for isolating a protein using an antibody are well-known in the art. The binding agents (e.g., antibodies) may also be utilized to detect PD-1 within a biological sample. For instance, the antibodies may be used in assays such as, for example, flow cytometric analysis, ELISA, immunoblotting (e.g., western blot), *in situ* detection, immunocytochemistry, and / or immunhistochemistry. Methods of carrying out such assays are well-known in the art.

[0042] The binding agents described herein may be also be used to determine the presence of a disease state in a patient, to predict prognosis, or to determine the effectiveness of a chemotherapeutic or other treatment regimen. Expression profile assays, performed as described herein or as is otherwise known in the art, may be used to determine the relative level of expression of PD-1. The level of expression may then be correlated with base (e.g., control) levels to determine whether a particular disease is present within the patient, the patient's prognosis, or whether a particular treatment regimen is effective. For example, if the patient is being treated with a particular anti-infective regimen, an increased or decreased level of expression of PD-1 in the patient's tissues (e.g., in peripheral blood, breast tissue biopsy) may indicate the regimen is worsening or improving the load of the infectious agent in that host. The increase or decrease in expression may indicate the regimen is having or not having the desired effect and another therapeutic modality may therefore be selected.

[0043] It is also possible to use the binding agents described herein as reagents in drug screening assays to test, for example, new drug candidates. The reagents may be used to ascertain the effect of a drug candidate on the expression of the immunogenic target in a cell line, or a cell or tissue of a patient. The expression profiling technique may be combined with high throughput screening techniques to allow rapid identification of useful compounds and

monitor the effectiveness of treatment with a drug candidate (see, for example, Zlokarnik, et al., Science 279, 84-8 (1998)). Drug candidates may be chemical compounds, nucleic acids, proteins, antibodies, or derivatives therefrom, whether naturally occurring or synthetically derived. Drug candidates thus identified may be utilized, among other uses, as pharmaceutical compositions for administration to patients or for use in further screening assays.

[0044] In some embodiments, the binding agents are in purified form. A "purified" binding agent (e.g., antibody) may be one that is separated from at least about 50% of the proteins and / or other components with which it is initially found (e.g., as part of a hybridoma supernatant or ascites preparation in the case of a monoclonal antibody). A purified binding agent (e.g., antibody) may be one that is separated from at least about 50%, 60%, 75%, 90%, or 95% of the proteins and / or other components with which it is initially found.

[0045] The polypeptides and nucleic acids described herein may be combined with one or more pharmaceutically acceptable carriers prior to administration to a host. A pharmaceutically acceptable carrier is a material that is not biologically or otherwise undesirable, e.g., the material may be administered to a subject, without causing any undesirable biological effects or interacting in a deleterious manner with any of the other components of the pharmaceutical composition in which it is contained. The carrier would naturally be selected to minimize any degradation of the active ingredient and to minimize any adverse side effects in the subject, as would be well known to one of skill in the art. Suitable pharmaceutical carriers and their formulations are described in, for example, *Remington's: The Science and Practice of Pharmacy, 21st Edition*, David B. Troy, ed., Lippicott Williams & Wilkins (2005). Typically, an appropriate amount of a pharmaceutically-acceptable salt is used in the formulation to render the formulation isotonic. Examples of the pharmaceutically-acceptable carriers include, but are not limited to, sterile water, saline, buffered solutions like Ringer's solution, and dextrose solution. The pH of the solution is generally from about 5 to about 8 or from about 7 to about 7.5. Other carriers include sustained-release preparations such as semipermeable matrices of solid hydrophobic polymers containing polypeptides or fragments thereof. Matrices may be in the form of shaped articles, e.g., films, liposomes or microparticles. It will be apparent to those persons skilled in the art that certain carriers may be more preferable depending upon, for instance, the route of administration and concentration of composition being administered. Carriers

are those suitable for administration of polypeptides and / or fragments thereof to humans or other subjects. Pharmaceutical compositions may also include carriers, thickeners, diluents, buffers, preservatives, surface active agents, adjuvants, immunostimulants, in addition to the immunogenic polypeptide. Pharmaceutical compositions may also include one or more active ingredients such as antimicrobial agents, antiinflammatory agents and anesthetics. The pharmaceutical composition may be administered orally, parentally, by inhalation spray, rectally, intranodally, or topically in dosage unit formulations containing conventional pharmaceutically acceptable carriers, adjuvants, and vehicles. The term “pharmaceutically acceptable carrier” or “physiologically acceptable carrier” as used herein refers to one or more formulation materials suitable for accomplishing or enhancing the delivery of a nucleic acid, polypeptide, or peptide as a pharmaceutical composition. A “pharmaceutical composition” is a composition comprising a therapeutically effective amount of a nucleic acid or polypeptide. The terms “effective amount” and “therapeutically effective amount” each refer to the amount of a binding agent, nucleic acid or the like used to observe the desired therapeutic effect (e.g., restore T cell function).

[0046] Methods for treating one or more disease conditions (e.g., HIV or cancer) in a mammalian host comprising administering to the mammal at least one or more effective doses of one or more binding agents (and / or derivative(s) thereof) described herein are also provided. In some embodiments, the binding agent is a monoclonal antibody or fragment or derivative thereof comprising one or more of SEQ ID NOS. 1-138 and / or shown in **Tables 1A** and **1B**. The one or more binding agents may be administered in a dosage amount of about 1 to about 50 mg / kg, about 1 to about 30 mg / kg, or about 5 to about 30 mg / kg (e.g., about any of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 35, or 40 mg / kg). In certain embodiments, the one or more binding agents may be administered to the mammal (e.g., intradermally, intravenously, orally, rectally) at about 10 mg / kg one or more times. When multiple doses are administered, the doses may comprise about the same or different amount of binding agent in each dose. The doses may also be separated in time from one another by the same or different intervals. For instance, the doses may be separated by about any of 6, 12, 24, 36, 48, 60, 72, 84, or 96 hours, one week, two weeks, three weeks, one month, two months, three months, four months, five months, six months, seven months, eight months, nine months, 10 months, 11 months, 12 months, 1.5 years, 2 years, 3 years, 4 years, 5 years, or any time period before, after, and / or between any of these time periods. In some embodiments, the binding agents

may be administered in conjunction with other agents (e.g., anti-infective agents and/or chemotherapeutic agent). Such other agents may be administered about simultaneously with the binding agents, or at a different time and / or frequency. Other embodiments of such methods may also be appropriate as could be readily determined by one of ordinary skill in the art.

[0047] To assist the skilled artisan in using the antibodies described herein, the same may be provided in kit format. A kit including such antibodies and optionally other components necessary for using the antibodies to detect cells expressing PD-1 is provided. The antibodies of the kit may be provided in any suitable form, including frozen, lyophilized, or in a pharmaceutically acceptable buffer such as TBS or PBS. The kit may also include other reagents required for utilization of the antibodies in vitro or in vivo such as buffers (e.g., TBS, PBS), blocking agents (solutions including nonfat dry milk, normal sera, Tween-20 Detergent, BSA, or casein), and / or detection reagents (e.g., goat anti-mouse IgG biotin, streptavidin-HRP conjugates, allophycocyanin, B-phycoerythrin, R-phycoerythrin, peroxidase, detectable labels, and other labels and / or staining kits (e.g., ABC Staining Kit, Pierce)). The kits may also include other reagents and / or instructions for using the antibodies in commonly utilized assays described above such as, for example, flow cytometric analysis, ELISA, immunoblotting (e.g., western blot), *in situ* detection, immunocytochemistry, immunhistochemistry. In one embodiment, the kit provides a binding agent in purified form. In another embodiment, the binding agent may be provided in biotinylated form either alone or along with an avidin-conjugated detection reagent (e.g., antibody). In another embodiment, the kit includes a binding agents comprising one or more detectable labels that may be used to directly detect PD-1. Buffers and the like required for using any of these systems are well-known in the art and / or may be prepared by the end-user or provided as a component of the kit. The kit may also include a solid support containing positive- and negative-control protein and / or tissue samples. For example, kits for performing spotting or western blot-type assays may include control cell or tissue lysates for use in SDS-PAGE or nylon or other membranes containing pre-fixed control samples with additional space for experimental samples. Kits for visualization of PD-1 in cells on slides may include pre-formatted slides containing control cell or tissue samples with additional space for experimental samples. Other embodiments of kits are also contemplated herein as would be understood by those of ordinary skill in the art.

[0048] Thus, this disclosure provides a binding agent that binds PD-1 agonistically or antagonistically. In some embodiments, the binding agent is a polypeptide comprising at least one amino acid sequence selected from the group consisting of SEQ ID NOS. 1-138 and / or shown in **Tables 1A** and **1B**. In some embodiments, the binding agent is a polypeptide comprising one or more combinations of SEQ ID NOS. 1-138 (e.g., as shown in **Tables 1A** and/or **1B**). In some embodiments, the binding agent is an antibody. In some embodiments, the binding agent is a polypeptide such as an antibody comprising a heavy chain CDR1 amino acid sequence selected from the group consisting of SEQ ID NOS. 1-23. In some embodiments, the binding agent is a polypeptide such as an antibody comprising a heavy chain CDR2 amino acid sequence selected from the group consisting of SEQ ID NOS. 24-46. In some embodiments, the binding agent is a polypeptide such as an antibody comprising a heavy chain CDR3 amino acid sequence selected from the group consisting of 47-69. In some embodiments, the binding agent is a polypeptide such as an antibody comprising a light chain CDR1 amino acid sequence selected from the group consisting of SEQ ID NOS. 70-92. In some embodiments, the binding agent is a polypeptide such as an antibody comprising a heavy chain CDR2 amino acid sequence selected from the group consisting of SEQ ID NOS. 93-115. In some embodiments, the binding agent is a polypeptide such as an antibody comprising a heavy chain CDR3 amino acid sequence selected from the group consisting of 116-138. In some embodiments, the binding agent comprises the combinations of CDRs shown in **Tables 1A** and / or **1B** and/or has the properties described in **Table 2**. In some embodiments, the binding agent is derived from or related to (e.g., by sequence or derivation) a human antibody, human IgG, human IgG1, human IgG2, human IgG2a, human IgG2b, human IgG3, human IgG4, human IgM, human IgA, human IgA1, human IgA2, human IgD, human IgE, canine antibody, canine IgGA, canine IgGB, canine IgGC, canine IgGD, chicken antibody, chicken IgA, chicken IgD, chicken IgE, chicken IgG, chicken IgM, chicken IgY, goat antibody, goat IgG, mouse antibody, mouse IgG, pig antibody, and / or rat antibody, and / or a derivative thereof. In some embodiments, the derivative may be selected from the group consisting of an F_{ab}, F_{ab2}, Fab' single chain antibody, F_v, single chain, mono-specific antibody, bispecific antibody, trimeric antibody, multi-specific antibody, multivalent antibody, chimeric antibody, canine-human chimeric antibody, canine-mouse chimeric antibody, antibody comprising a canine Fc, humanized antibody, human antibody, caninized antibody, CDR-grafted antibody, shark antibody, nanobody, and / or canelid antibody. In some embodiments, the binding agent comprises at least a least a first and second specificity, the first being against PD-1 and the second being against a different antigen (e.g., an antigen of an

infectious agent such as HIV (e.g., env) and / or a tumor antigen). In some embodiments, the binding agent and / or derivative thereof may comprise a detectable label fixably attached thereto. In some embodiments, the binding agent of any one and / or derivative thereof comprises an effector moiety (e.g., a cytotoxic drug, toxin, diphtheria A chain, exotoxin A chain, ricin A chain, abrin A chain, curcin, crotin, phenomycin, enomycin, and radiochemical) fixably attached thereto. In some embodiments, polynucleotides encoding one or more binding agents are also provided (e.g.. as an expression vector). Host cells comprising and / or expressing the polypeptide products of such polynucleotides are also provided. In some embodiments, compositions comprising at least one binding agent or derivative; at least one isolated polynucleotide; at least one expression vector; and / or, at least one host cell; or a combination thereof; and, a pharmaceutically acceptable carrier are also provided.

[0049] This disclosure also provides methods for detecting PD-1 on a cell, the method comprising contacting a test biological sample with a binding agent or derivative described herein and detecting the binding agent bound to the biological sample or components thereof. Such methods may be an *in vivo* method or an *in vitro* method. In some embodiments, the method may comprise comparing the amount of binding to the test biological sample or components thereof to the amount of binding to a control biological sample or components thereof, wherein increased binding to the test biological sample or components thereof relative to the control biological sample or components thereof indicates the presence of a cell expressing PD-1 in the test biological sample (e.g., mammalian blood). In some embodiments, a system for identifying a PD-1 antibody binding agent by assaying the candidate binding agent by the exhaustion functional recovery assay (EFRA); determining the affinity of the candidate binding agent for PD-1; and, determining the nucleotide sequence of the CDR of the candidate binding agent is provided.

[0050] In some embodiments, a kit for detecting the expression of PD-1 in or on a cell, the kit comprising a binding agent or derivative thereof and instructions for use. In some embodiments, the binding agent and / or derivative thereof is in lyophilized form.

[0051] In some embodiments, this disclosure provides methods for treating, preventing and / or ameliorating an infectious disease, cancer and / or autoimmunity in a mammal comprising administering to the mammal at least one effective dose of a pharmaceutical composition comprising a binding agent or derivative thereof. In some embodiments, the infectious

disease is human immunodeficiency virus (HIV). In some embodiments, the binding agent and / or derivative thereof used to treat infectious disease and / or cancer is a PD-1 antagonist. In some embodiments, the binding agent and / or derivative thereof used to treat an autoimmune condition is a PD-1 agonist. In some embodiments, multiple doses are administered to the animal. In some embodiments, the binding agent and / or derivative thereof may be administered in a dosage amount of about 1 to 50 mg / kg.

[0052] This disclosure also provides combinations of PD-1 binding agents. In some embodiments, the combination comprises a first binding agent that blocks the interaction of PD-1 and PD-L1 and a second binding agent that does not block the interaction of PD-1 and PD-L1. Such combinations may be used for any use described herein or as may be otherwise ascertained by those of ordinary skill in the art. For instance, such combinations may be used in the methods for treating, preventing and / or ameliorating an infectious disease, cancer and / or autoimmunity in a mammal described herein.

[0053] This disclosure also provides methods for producing the binding agents described herein by expressing the binding agent in a cell and isolating the binding agent from the cell or a culture supernatant of the cell. In some embodiments, such methods may further comprise expressing a nucleic acid encoding such binding agent(s). In some embodiments, such methods may also include combining the binding agent(s) following isolation with one or more pharmaceutically acceptable excipients.

[0054] Methods for producing a combination(s) of binding agents, such as a first binding agent that blocks the interaction of PD-1 and PD-L1 and a second binding agent that does not block the interaction of PD-1 and PD-L1, are also provided by this disclosure. In some embodiments, the second binding agent binds PD-1. In some embodiments, the first and / or second binding agents are antibodies such monoclonal antibodies or fragments or derivatives thereof. In some embodiments, the second binding agent comprises the amino acid sequences SEQ ID NOS. 2, 25, 48, 71, 94 and 117; or SEQ ID NOS. 17, 40, 63, 86, 109, and 132. In some embodiments, these methods may further include the addition of a pharmaceutically acceptable excipient.

[0055] The terms “about”, “approximately”, and the like, when preceding a list of numerical values or range, refer to each individual value in the list or range independently as if each

individual value in the list or range was immediately preceded by that term. The terms mean that the values to which the same refer are exactly, close to, or similar thereto.

[0056] As used herein, a subject or a host is meant to be an individual. The subject can include domesticated animals, such as cats and dogs, livestock (e.g., cattle, horses, pigs, sheep, and goats), laboratory animals (e.g., mice, rabbits, rats, guinea pigs) and birds. In one aspect, the subject is a mammal such as a primate or a human.

[0057] Optional or optionally means that the subsequently described event or circumstance can or cannot occur, and that the description includes instances where the event or circumstance occurs and instances where it does not. For example, the phrase optionally the composition can comprise a combination means that the composition may comprise a combination of different molecules or may not include a combination such that the description includes both the combination and the absence of the combination (i.e., individual members of the combination).

[0058] Ranges may be expressed herein as from about one particular value, and/or to about another particular value. When such a range is expressed, another aspect includes from the one particular value and/or to the other particular value. Similarly, when values are expressed as approximations, by use of the antecedent about or approximately, it will be understood that the particular value forms another aspect. It will be further understood that the endpoints of each of the ranges are significant both in relation to the other endpoint, and independently of the other endpoint. Ranges (e.g., 90-100%) are meant to include the range *per se* as well as each independent value within the range as if each value was individually listed.

[0059] The term “combined” or “in combination” or “in conjunction” may refer to a physical combination of agents that are administered together or the use of two or more agents in a regimen (e.g., administered separately, physically and / or in time) for treating, preventing and / or ameliorating a particular disease.

[0060] When the terms treat, prevent, and / or ameliorate or derivatives thereof are used herein in connection with a given treatment for a given condition (e.g., preventing cancer infection by HIV), it is meant to convey that the treated patient either does not develop a

clinically observable level of the condition at all, or develops it more slowly and/or to a lesser degree than he/she would have absent the treatment. These terms are not limited solely to a situation in which the patient experiences no aspect of the condition whatsoever. For example, a treatment will be said to have prevented the condition if it is given during exposure of a patient to a stimulus that would have been expected to produce a given manifestation of the condition, and results in the patient's experiencing fewer and/or milder symptoms of the condition than otherwise expected. For instance, a treatment can “prevent” infection by resulting in the patient's displaying only mild overt symptoms of the infection; it does not imply that there must have been no penetration of any cell by the infecting microorganism.

[0061] Similarly, reduce, reducing, and reduction as used herein in connection with prevention, treatment and / or amelioration of a given condition by a particular treatment typically refers to a subject developing an infection more slowly or to a lesser degree as compared to a control or basal level of developing an infection in the absence of a treatment (e.g., administration of one or more PD-1 binding agents). A reduction in the risk of infection may result in the patient's displaying only mild overt symptoms of the infection or delayed symptoms of infection; it does not imply that there must have been no penetration of any cell by the infecting microorganism.

[0062] All references cited within this disclosure are hereby incorporated by reference in their entirety. Certain embodiments are further described in the following examples. These embodiments are provided as examples only and are not intended to limit the scope of the claims in any way.

EXAMPLES

Example 1

Generation and Characterization of PD-1 Binding Agents

[0063] Four mice strains (total of 16 mice) have been immunized with two PD-1 proteins, i.e. human PD-1 Fc fusion protein and a human PD-1 monomeric protein. Mice showing serum reactivity to PD-1 expressed on activated human T lymphocytes have been selected for generation of anti-PD-1 hybridoma cell lines. A total of 240 PD-1 hybridoma cell lines were selected for producing antibodies that bind to recombinant PD-1 protein. The primary criteria for the first round of antibodies selection were: i) staining of PD-1 on activated human T

lymphocytes by flow cytometry; ii) diversity of CDR VH and VL sequences as compared to those of the existing anti-PD-1 antibodies; and, iii) epitope mapping performed by competitive binding studies with PD-1 conjugated Luminex beads with two commercially available anti-PD-1 antibodies binding to different epitopes on PD-1. A second round of selection was then carried out by: iv) affinity binding assays (not a primary criteria as it does not correlate with the stimulatory potential of anti-PD-1 antibodies); v) evaluation of anti-PD-1 antibodies that bind PD-1 and are either competitive, partially competitive or non-competitive with the binding of PD-L1 in a Luminex biochemical assay; and, vi) functional characterization of antibodies as agonist (not able to restore T-cells from functional exhaustion) or antagonist (able to restore T-cells from functional exhaustion). In these studies, the antibodies were tested and differentiated based on their ability to rescue proliferation in HIV-specific exhausted CD8 T-cells.

[0064] In a primary screen of antibody supernatants from individual cell cultured hybridoma cell clones, the EFRA assay was carried out to evaluate the functional effect of anti-PD1 antibodies on the proliferation of HIV-specific CD8 T cells (**Figure 2**). Antibody clones in the upper box (E8-3, C2-3, E1-3, F3-3, H8-3, C10-2, G2-1, G3-2, H2-1, and H4-2) act as PD-1 antagonists and stimulate proliferation while antibody clones in the lower box (C8-1 and G10-2) are agonistic and promote the PD-1 negative regulatory effect. The level of proliferation induced by the peptide control (Pep 8) is indicated by the lower horizontal line (just below 1%) and the induced proliferation by the Merck MK-3475 anti-PD1 antibody is shown in the upper horizontal line (just above 2%). Antibodies of interest identified by these processes underwent a second round of subcloning and the resulting hybridoma clones were used for the production and purification of the antibodies in **Table 2**. Binding assays were carried out with the purified anti-PD-1 antibodies to ensure that the subclones retained their affinity for PD-1. The concentration response binding of anti-PD-1 antibodies to cell surface PD-1 was evaluated on activated CD4 T-cells (**Figure 3**).

[0065] The EFRA provides for the selection of binding agents that restore T-cells from functional exhaustion but are not necessarily antagonistic, meaning those binding agents that do not necessarily interfere with the interaction between PD-1 and its biological ligand(s) (e.g., PD-L1 or PD-L2). An embodiment of the EFRA was to identify such binding agents (antibodies) that bind PD-1. Epitope mapping of antibody binding to PD-1 was performed with two seperate biochemical assays. In one assay, competitive binding to PD-1 Fc fusion

protein labeled beads was evaluated between one of two commercial anti-PD-1 antibodies (BMS-5C4 and MK3475) and the anti-PD-1 antibodies listed (also described in **Table 2**). Four classes of monoclonal antibodies binding to distinct epitopes were identified based on this assay. These are: class 1 (competitive with the EH12.2H7 commercial monoclonal antibody clone that blocks the interaction of PD-1 with PD-L1), class 2 (competitive with the J116 commercial monoclonal antibody clone that binds PD-1 but does not effectively block the interaction of PD-1 with PD-L1), class 3 (competitive with both the EH12.2H7 and J116 commercial monoclonal antibodies), and class 4 (non-competitive with either the EH12.2H7 or J116 commercial antibodies). The relative binding of these antibodies for cell surface PD-1 is represented by the mean fluorescence intensity (MFI) relative to a control anti-PD-1 antibody in **Figure 4.** These results show that tight binding antibodies were identified from all four binding classes. A second Luminex binding assay was used to directly evaluate if an anti-PD-1 antibody blocks the interaction between PD-1 and PD-L1. This assay was carried out using PD-1 Fc fusion protein coated beads that were incubated in the absence or presence of different concentrations of the anti-PD-1 antibodies listed in **Table 2**. A fixed concentration of biotinylated PD-L1, approximately equivalent to the IC_{50} of the PD-1 /PD-L1 interaction, was then incubated with the PD-1/antibody complex and PD-L1 binding was detected using fluorescently labeled streptavidin (representative binding curves shown in **Figure 5a-c**). Using this biochemical assay, antibodies were defined as being competitive, partially competitive or non-competitive with the PD-1/PD-L1 interaction. The competitive, partially competitive and non-competitive antibodies were identified which bind distinct sites on PD-1 and exhibit high binding affinity (**Table 2**). Further evaluation of antibodies that bind PD-1 and are non-competitive or partially competitive with PD-L1 were performed by incubating PD-1 Fc fusion protein coated Luminex beads with 20 nM of an anti-PD-1 antibody from Table 2 followed by an incubation of the PD-1/antibody complex with different concentrations of biotinylated PD-L1. **Figure 5d-f** shows that a competive anti-PD-1 antibody competely blocks the interaction between PD-1 and PD-L1. Partially competitive and non-competitive anti-PD-1 antibodies listed in **Table 2** results in a shift in the binding affinity of PD-L1 for PD-1, but does not block the interaction when concentration of PD-L1 are increased. Some of these antibodies were also shown to exhibit statistically significant increases in proliferation relative to controls (peptide 8 alone control or the peptide and IgG1 isotype control antibody in **Figures 6a** and **6b**). Class 1 antibodies (competitive with the EH12.2H7 commercial monoclonal antibody that blocks the interaction of PD-1 with PD-L1) or competitive in the PD-1/PD-L1 intereaction assay were generally determined to provide

improved proliferative restoration. In combining the data from multiple EFRA experiments and using MK-3475 as the common comparator, **Figure 7** shows that select antibodies described in **Table 2** exhibited equivalent or statistically improved activity ($p < 0.007$) compared to the benchmark MK-3475 antibody.

Example 2

Antibody Combinations

[0066] Combinations of antibodies binding to different PD-1 epitopes were found to enhance restoration of HIV peptide specific CD8 T-cell proliferation in a functional exhaustion recovery assay (**Figure 8**). Synergy between antibody types was also observed. For instance, it was determined that class 1 (MK-3475 in **Figure 8**) and class 2 (139D6 in **Figure 8**) antibodies are able to simultaneously bind PD-1. While the maximum stimulation observed for MK-3475 is consistently about 200% relative to the HIV peptide, combinations of MK-3475 and 139D6 monoclonal antibodies at 5 µg/ml exhibited synergy with a 288% increase in HIV-specific CD8 T cell proliferation relative to the HIV peptide control alone or a 144% increased proliferation relative to MK-3475 or 139D6 added alone (**Figure 8**). This synergistic increase in proliferation was observed in several experimental tests with a statistically significant p value of 0.007. As a comparison, addition of 10 µg/ml of either MK-3475 or 139D6 alone did not result in an increased proliferation in the EFRA. Thus, the combination of a first binding agent that blocks the interaction of PD-1 and PD-L1 with a second binding agent that does not block the interaction of PD-1 and PD-L1 has been determined to act synergistically to rescue T cells from exhaustion.

[0067] While certain embodiments have been described in terms of the preferred embodiments, it is understood that variations and modifications will occur to those skilled in the art. Therefore, it is intended that the appended claims cover all such equivalent variations that come within the scope of the following claims.

REFERENCES

1. Chun TW et al. *Nature* **387**: 183-188, 1997
2. Chun TW et al. *Proc Natl Acad Sci USA* **94**: 13193-13197, 1997
3. Finzi D et al. *Science* **278**: 1295-1300, 1997
4. Chomont N et al. *Nat Med* **15**:893-900, 2009
5. Siliciano JD et al. *Nat Med* **9**:727-728, 203
6. Perreau M et al. *J Exp Med* **210**: 143-156, 2013
7. Rong L and Perelson A *J Theoret Biol* **260**:308-331, 2009
8. Sigal A et al. *Nature* **477**:95-98, 2011
9. Katlama C et al. *Lancet* **381**:2109-2117, 2013
10. Hansen SG et al. *Nature* **503**:100-106, 2013
11. Klein F et al. *Nature* **492**: 518.522, 2012
12. Barouch DH et al. *Nature* **503**:224-228, 2013
13. Trautmann L et al. *Nat Med* **12**:1198-1202, 2006
14. Day CL et al. *Nature* **443**:350-354, 2006
15. Archin NM et al. *Nature* **487**:482-485, 2012
16. Sievers EL and Senter PD *Annu Rev Med*. **64**:15-29, 2013
17. Zolot RS et al. *Nat Rev Drug Discov* **4**:259-260, 2013

CLAIMS

What is claimed is:

1. A binding agent that binds programmed cell death 1 (PD1) comprising at least one amino acid sequence selected from the group consisting of SEQ ID NOS. 1-138 and / or shown in Tables 1A and / or 1B.

2. The binding agent of claim 1 that is an isolated monoclonal antibody.

3. The binding agent of claim 1 or 2 comprising at least one heavy chain CDR1 amino acid sequence selected from the group consisting of SEQ ID NOS. 1-23.

4. The binding agent of any one of claims 1-3 comprising at least one heavy chain CDR2 amino acid sequence selected from the group consisting of SEQ ID NOS. 24-46.

5. The binding agent of any one of claims 1-4 comprising at lesat one heavy chain CDR3 amino acid sequence selected from the group consisting of SEQ ID NOS. 47-69.

6. The binding agent of any one of claims 1-5 comprising at lesat one light chain CDR1 amino acid sequence selected from the group consisting of SEQ ID NOS. 70-92.

7. The binding agent of any one of claims 1-6 comprising at lesat one light chain CDR2 amino acid sequence selected from the group consisting of SEQ ID NOS. 93-115.

8. The binding agent of any one of claims 1-7 comprising at lesat one light chain CDR3 amino acid sequence selected from the group consisting of SEQ ID NOS. 116-138.

9. The binding agent of any one of claims 1-8 comprising the amino acid sequences selected from the group consisting of:

DDFLH (SEQ ID NO: 1),	RIDPANGESRYAPKFQD (SEQ ID NO: 24),	TDYRGYYYAMDY (SEQ ID NO: 47),
NYYIH (SEQ ID NO: 2),	SIYPNYGDTNYNQKVKD (SEQ ID NO: 25),	GYSYAMDY (SEQ ID NO: 48),
NYYIH (SEQ ID NO: 3),	SIYPNYGETNYNQEFKG (SEQ ID NO: 26),	GYSYAMDY (SEQ ID NO: 49),

SNWMH (SEQ ID NO: 4),	AVNPGNSDTTYNQKFKG (SEQ ID NO: 27),	GRSYDGSFDY (SEQ ID NO: 50),
RYWMH (SEQ ID NO: 5),	NIDPSDSTTHYNPKFRD (SEQ ID NO: 28),	DLDDFYVGSHEDFDY (SEQ ID NO: 51),
SNWMH (SEQ ID NO: 6),	AVYPGNSDTTYNQNFKG (SEQ ID NO: 29),	GRSYDGSFDY (SEQ ID NO: 52),
NSYIH (SEQ ID NO: 7),	WISPGDGSTNYNEKFKG (SEQ ID NO: 30),	EEYDYDNY (SEQ ID NO: 53),
NYWIG (SEQ ID NO: 8),	DIYPGGGYTNYNEKFKG (SEQ ID NO: 31),	GYDFVLDR (SEQ ID NO: 54),
SYAMS (SEQ ID NO: 9),	TISGGGADTYYLDNVKG (SEQ ID NO: 32),	QRGENLFAH (SEQ ID NO: 55),
SDYAWN (SEQ ID NO: 10),	YINYSGYTNYNPFLKS (SEQ ID NO: 33),	YGGSYPWNFDV (SEQ ID NO: 56),
SYWIN (SEQ ID NO: 11),	NIYPGSSSTDYNEKFKS (SEQ ID NO: 34),	GLYWYFDV (SEQ ID NO: 57),
SSYIH (SEQ ID NO: 12),	WIFPGDGKTNYNEKFRD (SEQ ID NO: 35),	NDFDRGVY (SEQ ID NO: 58),
NHGMS (SEQ ID NO: 13),	SINTGGYSTYYPDNVKG (SEQ ID NO: 36),	DDYNWFAY (SEQ ID NO: 59),
NYWIG (SEQ ID NO: 14),	DIYPGSEYENYNEKFKG (SEQ ID NO: 37),	GYDFVLDH (SEQ ID NO: 60),
DSYIH (SEQ ID NO: 15),	RIDPAHGNVIYASKFRD (SEQ ID NO: 38),	IYYDYGEGDF (SEQ ID NO: 61),
DTYIH (SEQ ID NO: 16),	RIDLANDDILYASKFQG (SEQ ID NO: 39),	IYYDYGEGDY (SEQ ID NO: 62),
NFYIH (SEQ ID NO: 17),	SIYPNYGDTAYNQKFKD (SEQ ID NO: 40),	GYSYAMDY (SEQ ID NO: 63),
DSYIH (SEQ ID NO: 18),	RIDPARDNIIYASKFRD (SEQ ID NO: 41),	IYYDYGEGDY (SEQ ID NO: 64),
DDFLH (SEQ ID NO: 19),	RIDPANGESRYAPQFQD (SEQ ID NO: 42),	TDYRGYYYAMDY (SEQ ID NO: 65),
SYFMS (SEQ ID NO: 20),	GISTGGADTYYADSMKG (SEQ ID NO: 43),	LSHYYDGIPLDC (SEQ ID NO: 66),
NHGMS (SEQ ID NO: 21),	SISGGGDNTYYPDNLKG (SEQ ID NO: 44),	VRQLGLHRAAMDY (SEQ ID NO: 67),
NYWIG (SEQ ID NO: 22),	DIYPGGDHKNYNEKFKD (SEQ ID NO: 45),	GFDFVLDY (SEQ ID NO: 68),
SFAMS (SEQ ID NO: 23),	TITGGGVNTYYPDTVKG (SEQ ID NO: 46),	QAIYDGHYVLDY (SEQ ID NO: 69),

and/or, the amino acid sequences selected from the group consisting of:

KSSQSVLYSSNQKNYLA (SEQ ID NO: 70),	WASTRES (SEQ ID NO: 93),	HQYLSSYT (SEQ ID NO: 116),
SASQGISDGLN (SEQ ID NO: 71),	HTSTLHS (SEQ ID NO: 94),	QQYSKFPLT (SEQ ID NO: 117),
SASQGISNGLN (SEQ ID NO: 72),	HTSTLHS (SEQ ID NO: 95),	QQYSKFPLT (SEQ ID NO: 118),
KASQDINKYIA (SEQ ID NO: 73),	YTSTLRP (SEQ ID NO: 96),	LQYDNLWT (SEQ ID NO: 119),
RSSQSIVYSNGNTYLE (SEQ ID NO: 74),	KVSHRFS (SEQ ID NO: 97),	FQGSHVPYT (SEQ ID NO: 120),
KASQDINKYMA (SEQ ID NO: 75),	YTSTLRP (SEQ ID NO: 98),	LQYDNLWT (SEQ ID NO: 121),
KASQNVGTNVG (SEQ ID NO: 76),	SASYRYN (SEQ ID NO: 99),	QQYNTYPWT (SEQ ID NO: 122),
KSSQSLFNSETQKNYLA (SEQ ID NO: 77),	WASTRES (SEQ ID NO: 100),	KQSYTLRT (SEQ ID NO: 123),
LASQTIGTWLA (SEQ ID NO: 78),	AATSLAD (SEQ ID NO: 101),	QQLYSTPWT (SEQ ID NO: 124),
RSSQTIVHNNGDTYLE (SEQ ID NO: 79),	KISNRFF (SEQ ID NO: 102),	FQGSHVPYT (SEQ ID NO: 125),
KSSQSLFNSGTRKNYLA (SEQ ID NO: 80),	WASTRDS (SEQ ID NO: 103),	KQSYNLYT (SEQ ID NO: 126),
KASQNVDTNVA (SEQ ID NO: 81),	SASYRYN (SEQ ID NO: 104),	QQYNNYPYT (SEQ ID NO: 127),
KSSQSLLNSGNQKNYLT (SEQ ID NO: 82),	WASTRES (SEQ ID NO: 105),	QSDYSYPLT (SEQ ID NO: 128),
KSSQSLFNSGTRKSYLA (SEQ ID NO: 83),	WASTRET (SEQ ID NO: 106),	MQSYNLRT (SEQ ID NO: 129),
HASQNINVWLS (SEQ ID NO: 84),	KASNLHT (SEQ ID NO: 107),	QQGQSWPLT (SEQ ID NO: 130),
HASQNINVWLS (SEQ ID NO: 85),	KASNLHT (SEQ ID NO: 108),	QQGQSYPLT (SEQ ID NO: 131),
SASQGISGDLN (SEQ ID NO: 86),	HTSSLHS (SEQ ID NO: 109),	QYYSKDLLT (SEQ ID NO: 132),

HASQNINVWLS (SEQ ID NO: 87),	KASNLHT (SEQ ID NO: 110),	QQGQSWPLT (SEQ ID NO: 133),
KSSQSVLYSSNQKNYLA (SEQ ID NO: 88),	WASTRES (SEQ ID NO: 111),	HQYLSSYT (SEQ ID NO: 134),
RASESVDNSGVSFLT (SEQ ID NO: 89),	AASNQGS (SEQ ID NO: 112),	QQTKEVPWT (SEQ ID NO: 135),
KASQSVSDDVS (SEQ ID NO: 90),	SAFFRYP (SEQ ID NO: 113),	QQDYSSPLT (SEQ ID NO: 136),
KSSQSLFNSGTRKNYLA (SEQ ID NO: 91),	WASTRES (SEQ ID NO: 114),	MQSFNLRT (SEQ ID NO: 137),
RTSGNIHNYLA (SEQ ID NO: 92),	NVKTLTD (SEQ ID NO: 115),	QQFWSIPWT (SEQ ID NO: 138),

10. The binding agent of claim 9 comprising a combination of amino acid sequences, the combination being selected from the group consisting of:

SEQ ID NOS. 1, 24, 47, 70, 93, and 116;
SEQ ID NOS. 2, 25, 48, 71, 94, and 117;
SEQ ID NOS. 3, 26, 49, 72, 95, and 118;
SEQ ID NOS. 4, 27, 50, 73, 96, and 119;
SEQ ID NOS. 5, 28, 51, 74, 97, and 120;
SEQ ID NOS. 6, 29, 52, 75, 98, and 121;
SEQ ID NOS. 7, 30, 53, 76, 99, and 122;
SEQ ID NOS. 8, 31, 54, 77, 100, and 123;
SEQ ID NOS. 9, 32, 55, 78, 101, and 124;
SEQ ID NOS. 10, 33, 56, 79, 102, and 125;
SEQ ID NOS. 11, 34, 57, 80, 103, and 126;
SEQ ID NOS. 12, 35, 58, 81, 104, and 127;
SEQ ID NOS. 13, 36, 59, 82, 105, and 128;
SEQ ID NOS. 14, 37, 60, 83, 106, and 129;
SEQ ID NOS. 15, 38, 61, 84, 107, and 130;
SEQ ID NOS. 16, 39, 62, 85, 108, and 131;
SEQ ID NOS. 17, 40, 63, 86, 109, and 132;
SEQ ID NOS. 18, 41, 64, 87, 110, and 133;
SEQ ID NOS. 19, 42, 65, 88, 111, and 134;
SEQ ID NOS. 20, 43, 66, 89, 112, and 135;
SEQ ID NOS. 21, 44, 67, 90, 113, and 136;
SEQ ID NOS. 22, 45, 68, 91, 114, and 137; and,
SEQ ID NOS. 23, 46, 69, 92, 115, and 138.

11. The binding agent of any one of claims 1-10 derived from a human antibody, human IgG, human IgG1, human IgG2, human IgG2a, human IgG2b, human IgG3, human IgG4, human IgM, human IgA, human IgA1, human IgA2, human IgD, human IgE, canine antibody, canine IgGA, canine IgGB, canine IgGC, canine IgGD, chicken

antibody, chicken IgA, chicken IgD, chicken IgE, chicken IgG, chicken IgM, chicken IgY, goat antibody, goat IgG, mouse antibody, mouse IgG, pig antibody, and rat antibody.

12. A derivative of a binding agent of any one of claims 1-11.

13. The derivative of claim 12 selected from the group consisting of an F_{ab}, F_{ab2}, Fab' single chain antibody, F_v, single chain, mono-specific antibody, bispecific antibody, trimeric antibody, multi-specific antibody, multivalent antibody, chimeric antibody, canine-human chimeric antibody, canine-mouse chimeric antibody, antibody comprising a canine Fc, humanized antibody, human antibody, caninized antibody, CDR-grafted antibody, shark antibody, nanobody, and canelid antibody.

14. The binding agent or derivative of any one of claims 1-13, or the combination of any one of claims 38-40, comprising at least a least a first and second specificity, the first being against PD-1 and the second being against a different antigen.

15. The binding agent or derivative of of claim 14 wherein the second specificity is against an antigen of an infectious agent or a tumor antigen.

16. The binding agent or derivative of claim 15 wherein the infectious agent is human immunodeficiency virus (HIV).

17. The binding agent or derivative of claim 16 wherein the antigen is HIV env.

18. The binding agent of any one of claims 1-17 or derivative thereof comprising a detectable label fixably attached thereto.

19. The binding agent of claim 18 wherein the detectable label is selected from the group consisting of fluorescein, DyLight, Cy3, Cy5, FITC, HiLyte Fluor 555, HiLyte Fluor 647, 5-carboxy-2,7-dichlorofluorescein, 5-carboxyfluorescein, 5-FAM, hydroxy tryptamine, 5-hydroxy tryptamine (5-HAT), 6-carboxyfluorescein (6-FAM), FITC, 6-carboxy-1,4-dichloro-2',7'-dichlorofluorescein (TET), 6-carboxy-1,4-dichloro-2',4',5',7'-tetra-chlorofluorescein (HEX), 6-carboxy-4',5'-dichloro-2',7'-dimethoxyfluorescein (6-JOE),

an Alexa fluor, Alexa fluor 350, Alexa fluor 405, Alexa fluor 430, Alexa fluor 488, Alexa fluor 500, Alexa fluor 514, Alexa fluor 532, Alexa fluor 546, Alexa fluor 555, Alexa fluor 568, Alexa fluor 594, Alexa fluor 610, Alexa fluor 633, Alexa fluor 635, Alexa fluor 647, Alexa fluor 660, Alexa fluor 680, Alexa fluor 700, Alexa fluor 750, a BODIPY fluorophores, BODIPY 492/515, BODIPY 493/503, BODIPY 500/510, BODIPY 505/515, BODIPY 530/550, BODIPY 542/563, BODIPY 558/568, BODIPY 564/570, BODIPY 576/589, BODIPY 581/591, BODIPY 630/650-X, BODIPY 650/665-X, BODIPY 665/676, FL, FL ATP, FI-Ceramide, R6G SE, TMR, TMR-X conjugate, TMR-X, SE, TR, TR ATP, TR-X SE, a rhodamine, rhodamine 110, rhodamine 123, rhodamine B, rhodamine B 200, rhodamine BB, rhodamine BG, rhodamine B extra, 5-carboxytetramethylrhodamine (5-TAMRA), 5 GLD, 6-carboxyrhodamine 6G, Lissamine, Lissamine Rhodamine B, Phallicidine, Phalloidine, rhodamine red, Rhod-2, 6-carboxy-X-rhodamine (ROX), carboxy-X-rhodamine (5-ROX), Sulphorhodamine B can C, Sulphorhodamine G Extra, 6-carboxytetramethylrhodamine (TAMRA), tetramethylrhodamine (TRITC), rhodamine WT, Texas Red, and Texas Red-X.

20. The binding agent of any one of claims 1-19 or derivative thereof comprising an effector moiety fixably attached thereto.

21. The binding agent or derivative of claim 20 wherein the effector moiety is selected from the group consisting of a cytotoxic drug, toxin, diphtheria A chain, exotoxin A chain, ricin A chain, abrin A chain, curcin, crotin, phenomycin, enomycin, and radiochemical.

22. An isolated polynucleotide encoding a binding agent of any one of claims 1-17.

23. An expression vector comprising one or more polynucleotides of claim 22.

24. A host cell comprising the isolated polynucleotide of claim 22 and / or the expression vector of claim 23.

25. A composition comprising at least one binding agent or derivative of any one of claims 1-21; at least one isolated polynucleotide of claim 22; at least one expression vector of claim 23; and / or, at least one host cell of claim 24; or a combination thereof; and/or a combination of any one of claims 39-43; and, a pharmaceutically acceptable carrier.

26. A method for detecting PD-1 on a cell, the method comprising contacting a test biological sample with a binding agent or derivative of any one of claims 1-21, and/or a combination of any one of claims 39-43, and detecting the binding agent bound to the biological sample or components thereof.

27. The method of claim 26, further comprising comparing the amount of binding to the test biological sample or components thereof to the amount of binding to a control biological sample or components thereof, wherein increased binding to the test biological sample or components thereof relative to the control biological sample or components thereof indicates the presence of a cell expressing PD-1 in the test biological sample.

28. The method of claim 26 or 27 wherein the test biological sample is mammalian blood.

29. The method of any one of claims 26-28 wherein the method is an *in vivo* method.

30. The method of any one of claims 26-28 wherein the method is an *in vitro* method.

31. A method for treating, preventing and / or ameliorating an infectious disease, cancer and / or autoimmunity in a mammal comprising administering to the mammal at least one effective dose of a pharmaceutical composition comprising a binding agent or derivative of any one of claims 1-21, and/or a combination of any one of claims 39-43.

32. The method of claim 31 wherein the infectious disease is human immunodeficiency virus (HIV).

33. The method of claim 31or 32 wherein the binding agent and / or derivative thereof used to treat infectious disease, HIV and / or cancer is a PD-1 antagonist.

34. The method of claim 31 wherein the binding agent and / or derivative thereof used to treat an autoimmune condition is a PD-1 agonist.

35. The method of any one of claims 31-34 wherein multiple doses are administered to the animal.

36. The method of any one of claims 31-35 wherein the binding agent is administered in a dosage amount of about 1 to 50 mg / kg.

37. A kit for detecting the expression of PD-1 in or on a cell, the kit comprising a binding agent or derivative or combination of any one of claims 1-21 and instructions for use.

38. The kit of claim 37 wherein the binding agent, antibody, or derivative is in lyophilized form.

39. A combination of binding agents, the combination comprising a first binding agent that blocks the interaction of PD-1 and PD-L1 and a second binding agent that does not block the interaction of PD-1 and PD-L1.

40. The combination of claim 39 wherein the second binding agent binds PD-1.

41. The combination of claim 39 wherein the first and / or second binding agents are antibodies.

42. The combination of claim 40 wherein the binding agents are monoclonal antibodies.

43. The combination of claim 39 wherein the second binding agent comprises the amino acid sequences SEQ ID NOS. 2, 25, 48, 71, 94 and 117; or SEQ ID NOS. 17, 40, 63, 86, 109, and 132.

44. A method for producing a combination of any one of claims 39-43 comprising combining a first binding agent that blocks the interaction of PD-1 and PD-L1 and a second binding agent that does not block the interaction of PD-1 and PD-L1.

45. The method of claim 44 wherein the second binding agent binds PD-1.

46. The method of claim 44 wherein the first and / or second binding agents are antibodies.

47. The method of claim 44 wherein the binding agents are monoclonal antibodies.

48. The method of claim 44 wherein the second binding agent comprises the amino acid sequences SEQ ID NOS. 2, 25, 48, 71, 94 and 117; or SEQ ID NOS. 17, 40, 63, 86, 109, and 132.

49. The method of any one of claims 44-48 wherein further comprising the addition of a pharmaceutically acceptable excipient.

50. A method for inducing immune cell proliferation in the presence of an antigen by contacting the immune cell with the combination of any one of claims 39-43.

51. A method for identifying a PD-1 antibody binding agent, the method comprising:
a) assaying a candidate PD-1 binding agent by the exhaustion functional recovery assay (EFRA);
b) determining the affinity of the candidate binding agent for PD-1; and,
c) determining the nucleotide sequence of the complementarity determining region (CDR) of the candidate binding agent.

52. A method for producing a binding agent of any one of claims 1-11 comprising expressing the binding agent in a cell and isolating the binding agent from the cell or a culture supernatant of the cell.

53. The method of claim 52 further comprising expressing a nucleic acid encoding a binding agent of any one of claims 1-11 in a host cell.

54. The method of claim 52 or 53 further comprising combining the binding agent following isolation with a pharmaceutically acceptable excipient.

FIGURE 1

A. Mouse PD-1 (GenBank Accession No. CAA48113.1; Ishida, et al. EMBO J. 11(11): 3887-3895 (1992))

```
1   mwvrqvpwsf twavlqlswq sgwllevpng pwrsltfypa wltvsegana tftcslsnws
61  edlmlnwnrl spsnqtekqa afcnglsqpv qdarfqiiql pnrhdfhmni ldtrrndsgi
121 ylcgaislhp kakieespga elvvterile tstrypspsp kpegrfqgmv igimsalvgi
181 pvllllawal avfcstsmse argagskddt lkeepsaapv psvayeeldf qgrektpelp
241 tacvhteyat ivfteglgas amgrrgsadg lqgprppprhe dghcswpl
```

(SEQ ID NO.:140)

B. Human PD-1 (GenBank Accession No. AAC51773.1; Finger, et al. Gene 197(1-2): 177-187 (1997))

```
1   mqipqapwpv vwavlqlgwr pgwfldspdr pwnpptffpa llvvtegdna tftcsfsnts
61  esfvlnwyrm spsnqtdkla afpedrsqpg qdcrfrvtql pngrdfhmsv vrarrndsgt
121 ylcgaislap kaqikeslra elrvterrae vptahpspsp rpagqfqtlv vgvvggllgs
181 lvllvwvlav icsraargti garrtgqplk edpsavpvfs vdygeldfqw rektpeppvp
241 cvpeqteyat ivfpsgmgts sparrgsadg prsaqplrpe dghcswpl
```

(SEQ ID NO.:141)

FIGURE 2

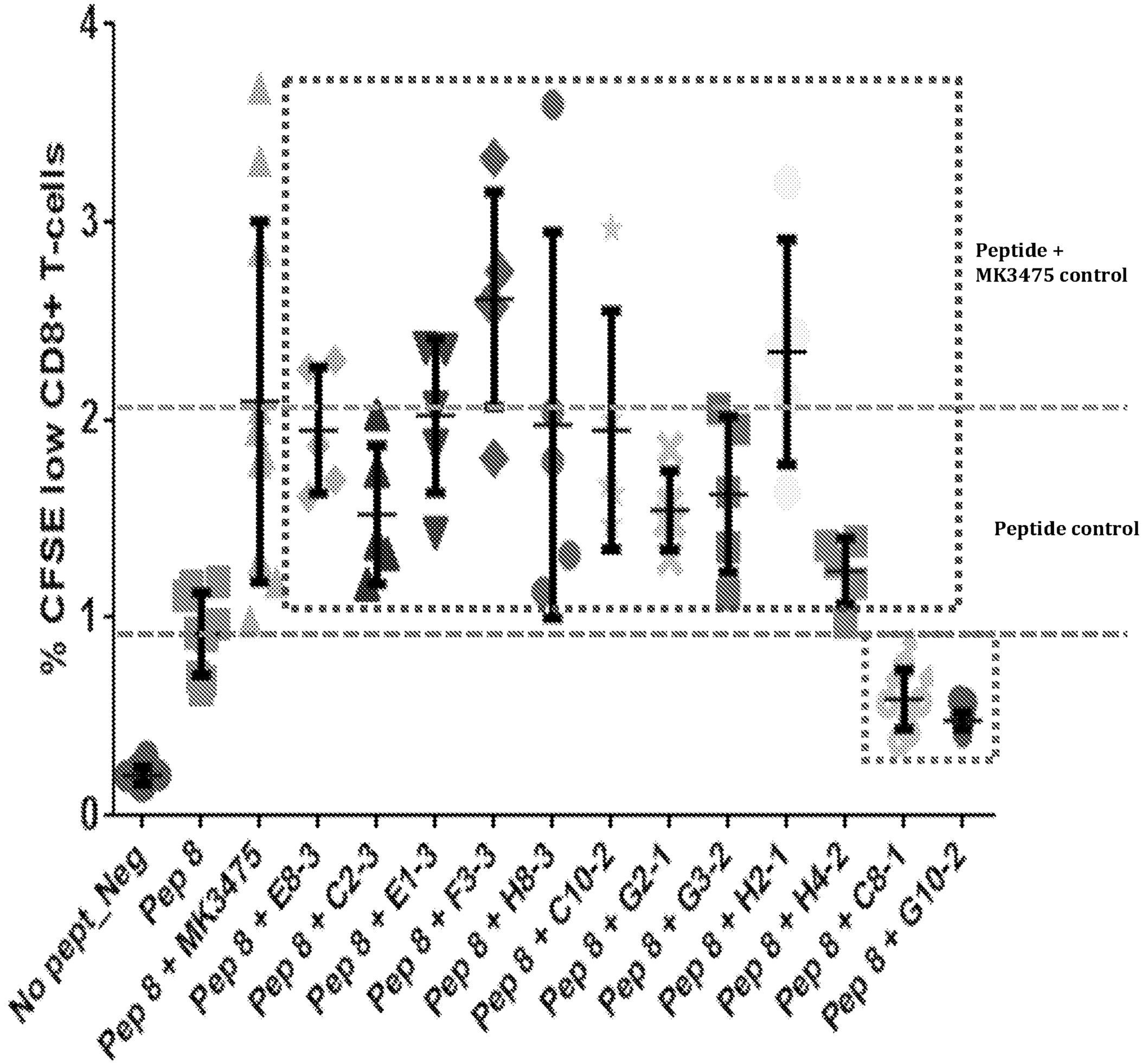

% CFSE low CD8+ T-cells
0
1
2
3
4
Peptide +
MK3475 control
Peptide control
No pept_Neg
Pep 8
Pep 8 + MK3475
Pep 8 + E8-3
Pep 8 + C2-3
Pep 8 + E1-3
Pep 8 + F3-3
Pep 8 + H8-3
Pep 8 + C10-2
Pep 8 + G2-1
Pep 8 + G3-2
Pep 8 + H2-1
Pep 8 + H4-2
Pep 8 + C8-1
Pep 8 + G10-2

FIGURE 3

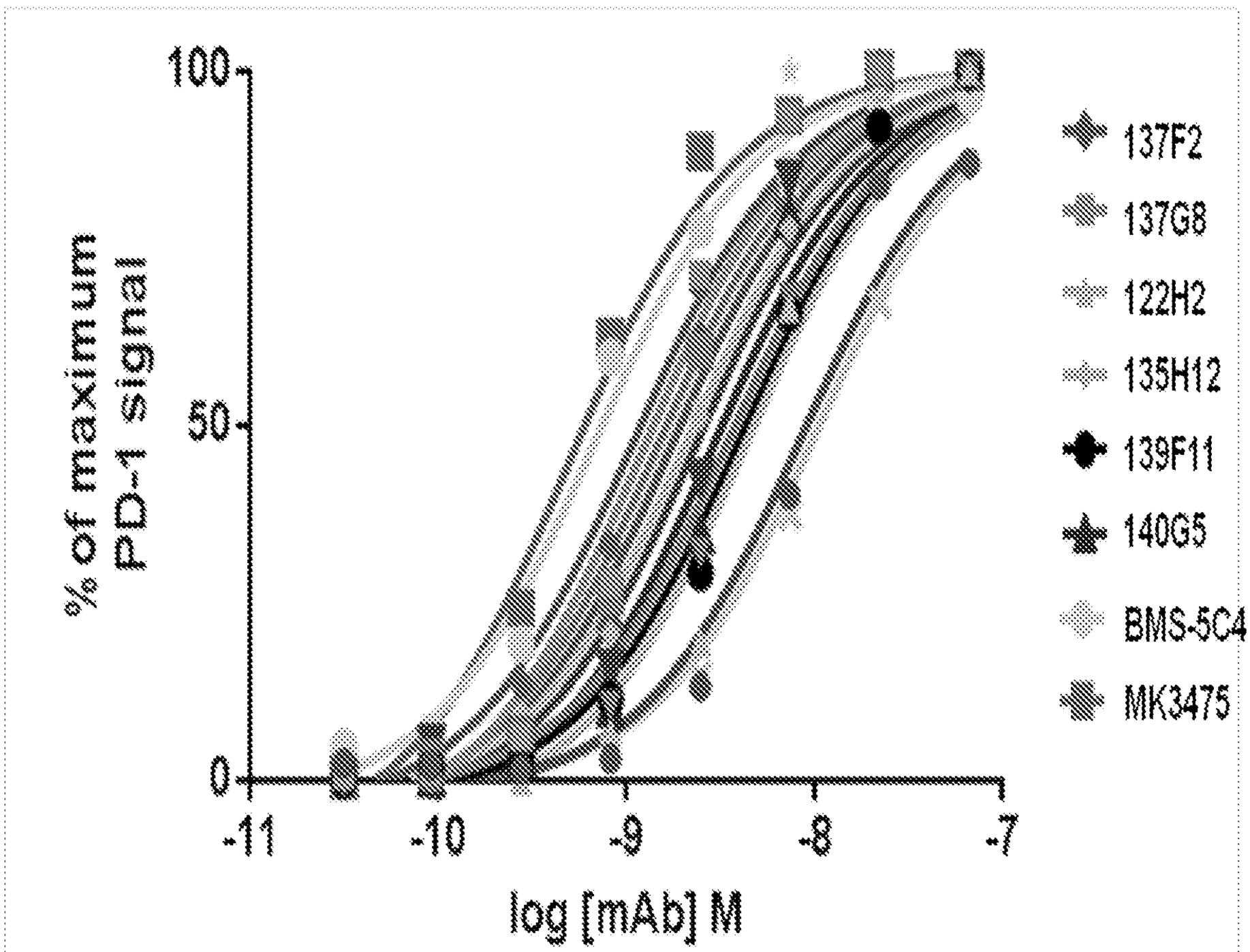

% of maximum PD-1 signal
100
50
0
-11
-10
-9
-8
-7
log [mAb] M
137F2
137G8
122H2
135H12
139F11
140G5
BMS-5C4
MK3475
139D6
135C12
140A1
135E10
131D11
122F10
138H5
136B5

FIGURE 4

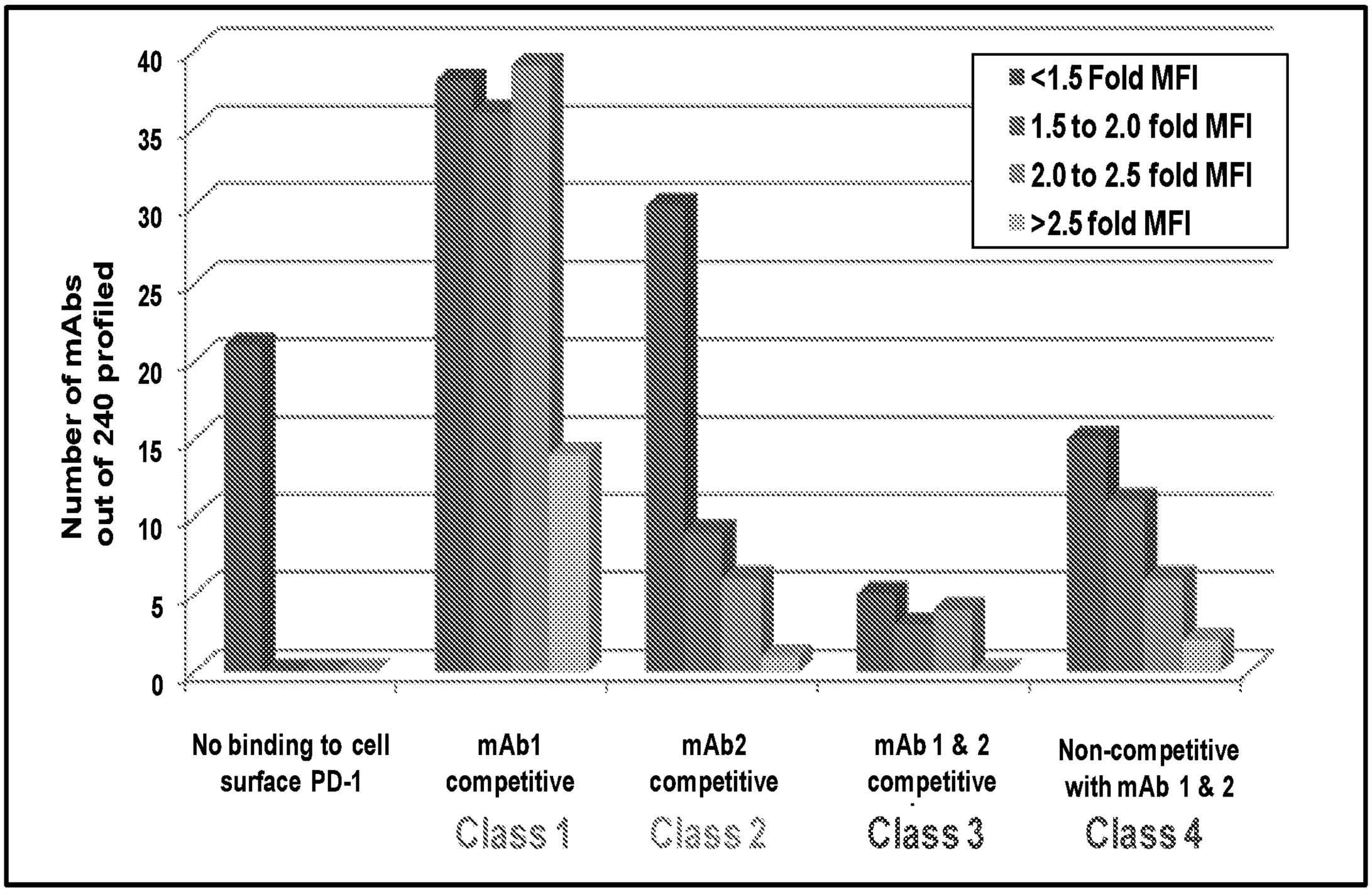
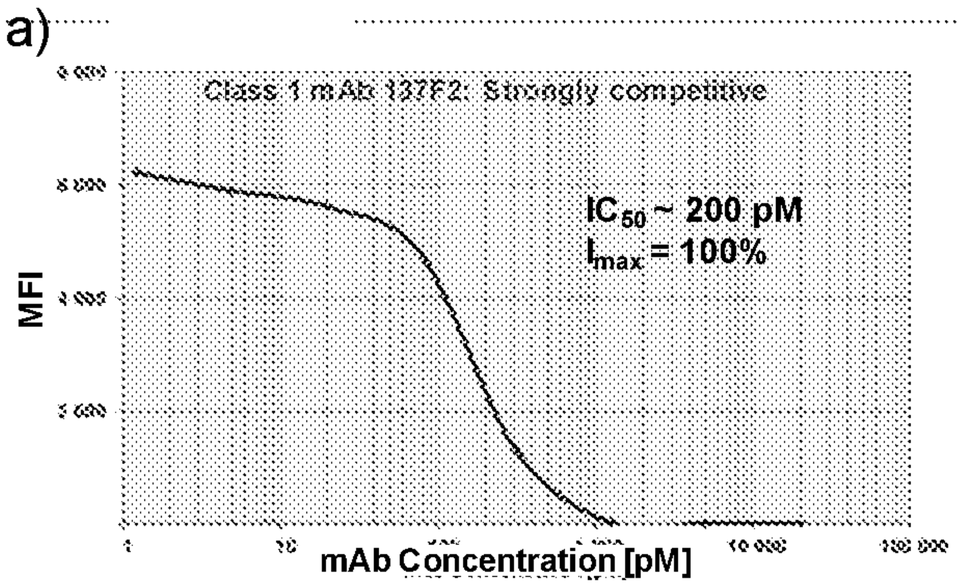
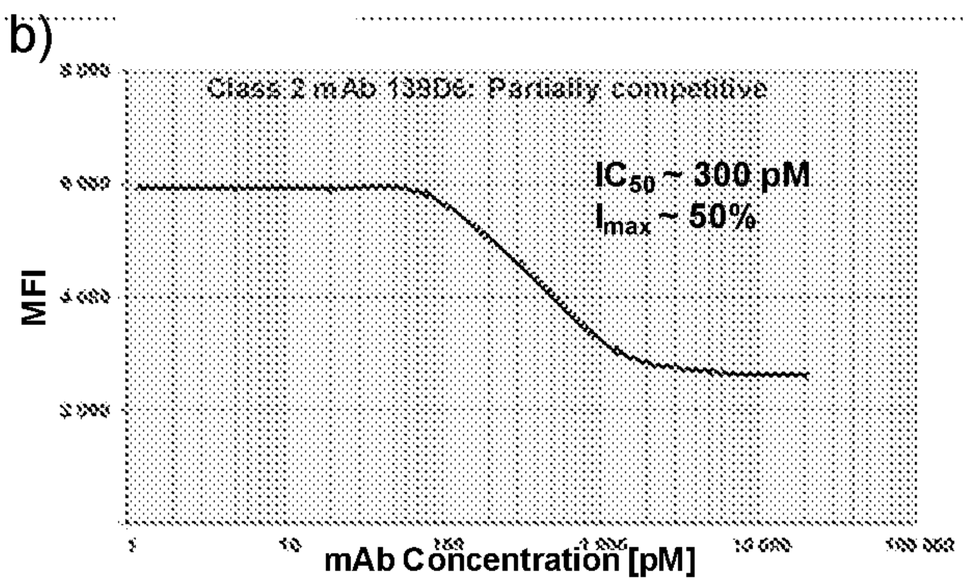
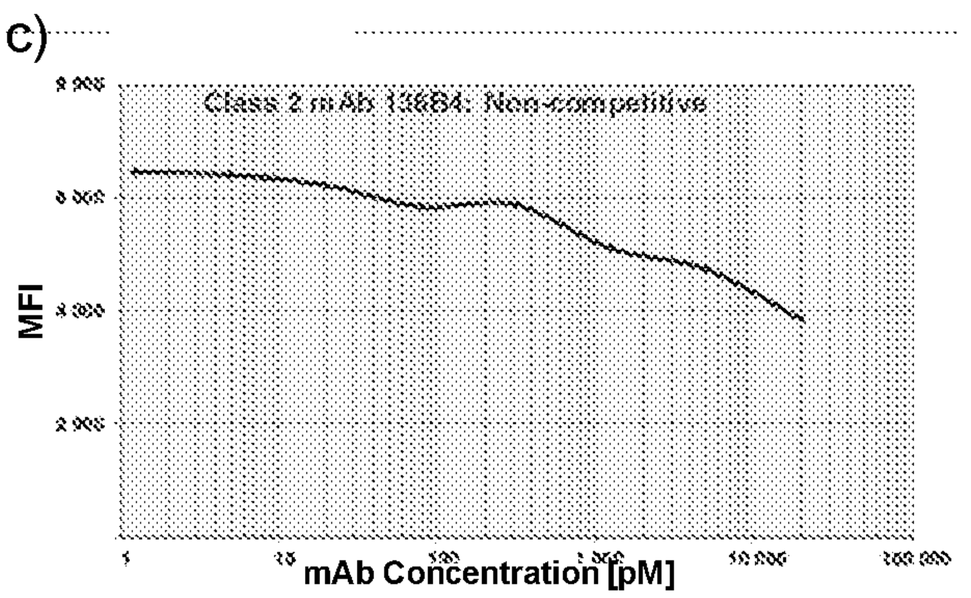

Number of mAbs out of 240 profiled
0
5
10
15
20
25
30
35
40
<1.5 Fold MFI
1.5 to 2.0 fold MFI
2.0 to 2.5 fold MFI
>2.5 fold MFI
No binding to cell surface PD-1
mAb1 competitive
Class 1
mAb2 competitive
Class 2
mAb 1 & 2 competitive
Class 3
Non-competitive with mAb 1 & 2
Class 4

FIGURE 5

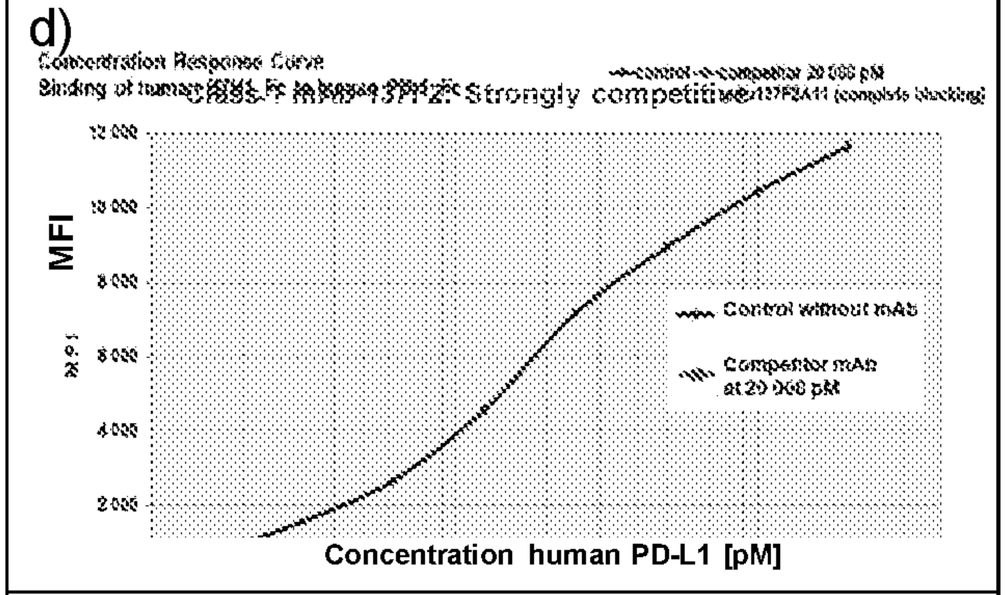
Antibody concentration response curves for the inhibition of PD-1 / PD-L1 interaction

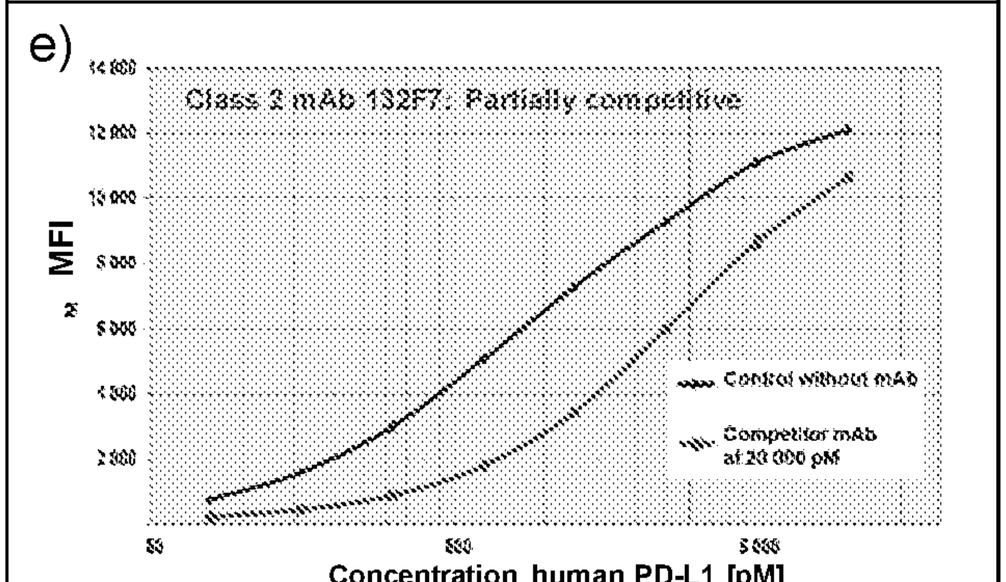






Concentration response curves Binding of human PD-L1 to human PD-1 Fc





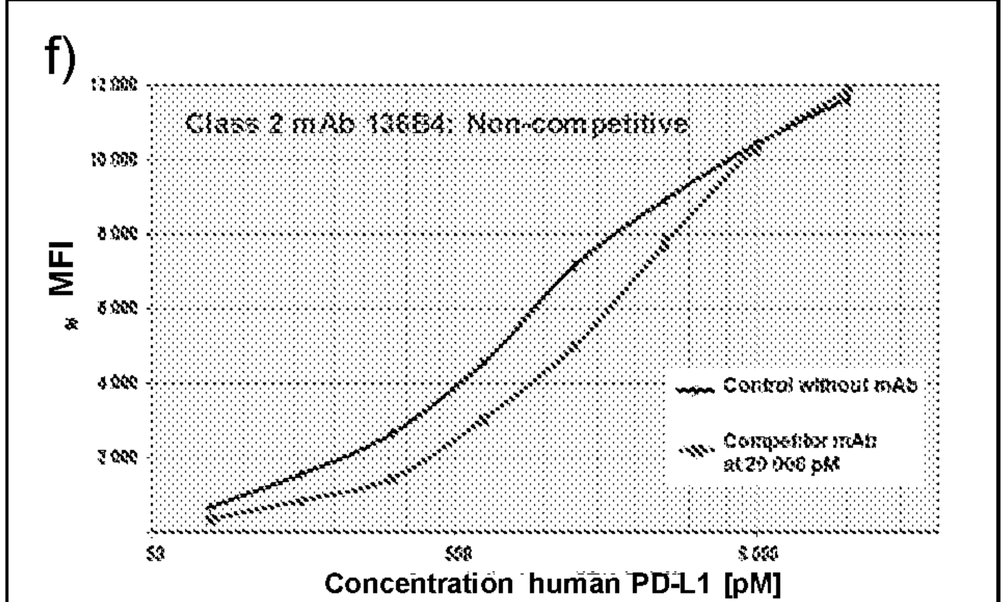


FIGURE 6a

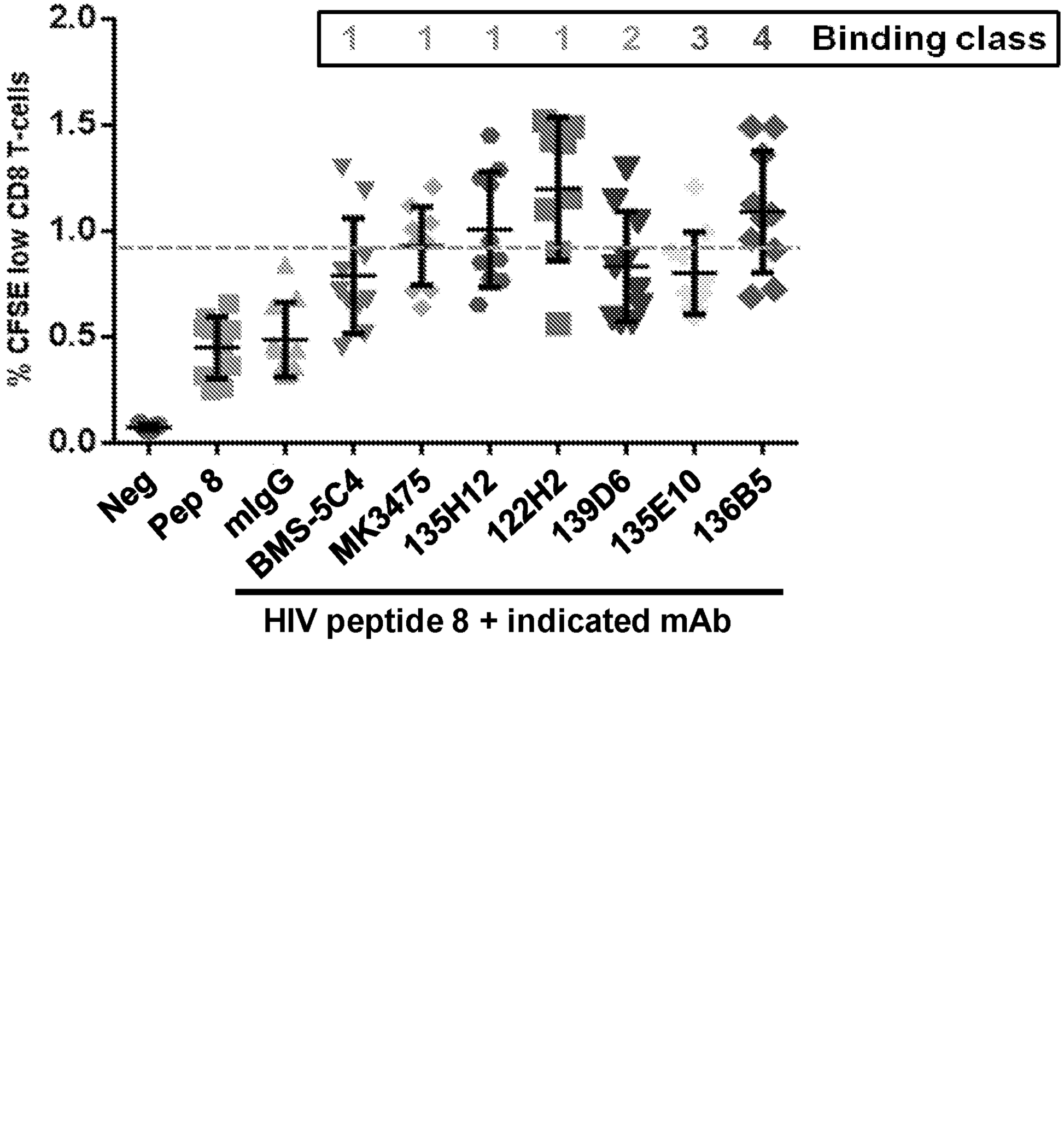

1 1 1 1 2 3 4 Binding class
% CFSE low CD8 T-cells
2.0
1.5
1.0
0.5
0.0
Neg
Pep 8
mIgG
BMS-5C4
MK3475
135H12
122H2
139D6
135E10
136B5
HIV peptide 8 + indicated mAb

FIGURE 6b

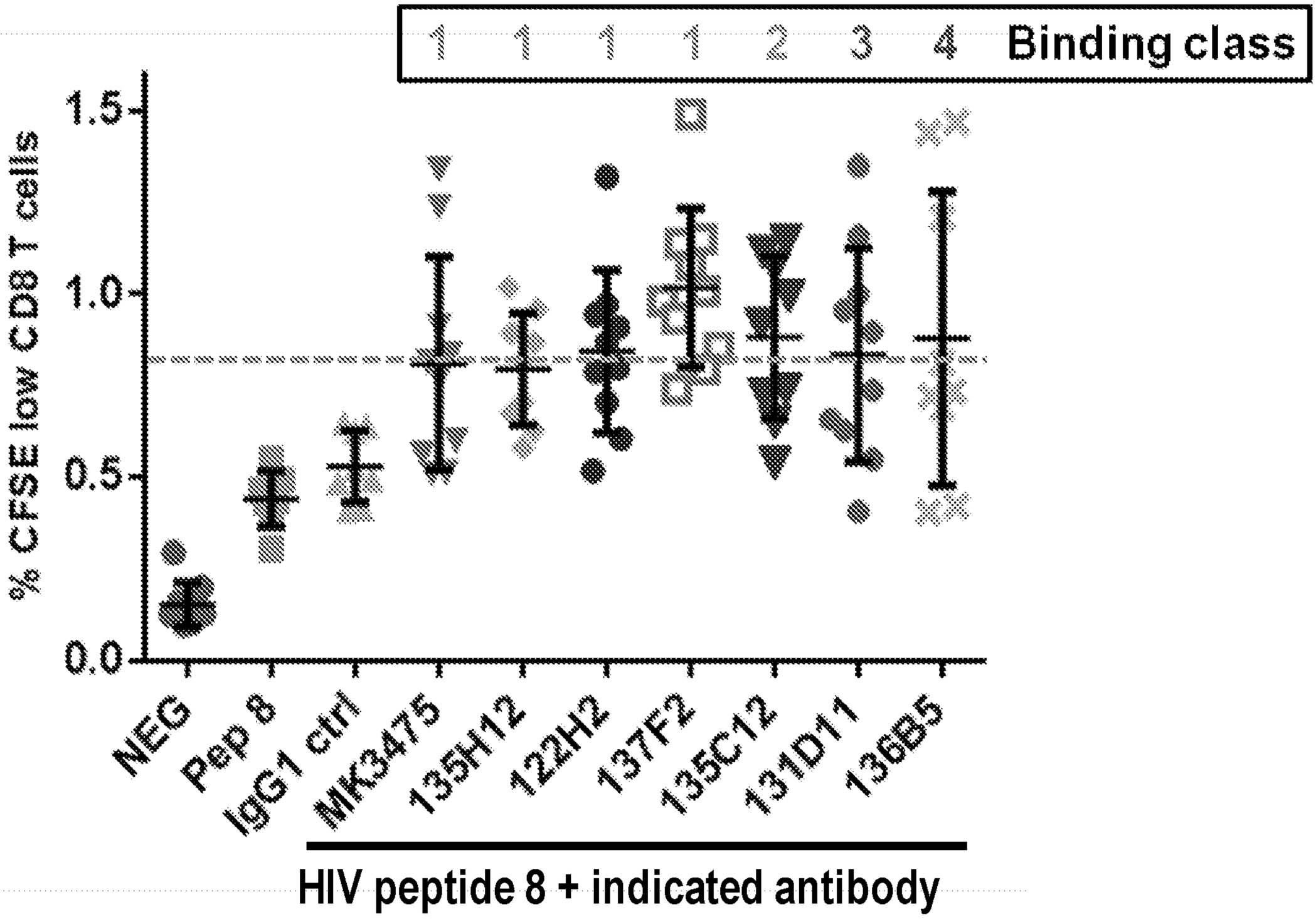

1 1 1 1 2 3 4 Binding class
% CFSE low CD8 T cells
0.0
0.5
1.0
1.5
NEG
Pep 8
IgG1 ctrl
MK3475
135H12
122H2
137F2
135C12
131D11
136B5
HIV peptide 8 + indicated antibody

FIGURE 7

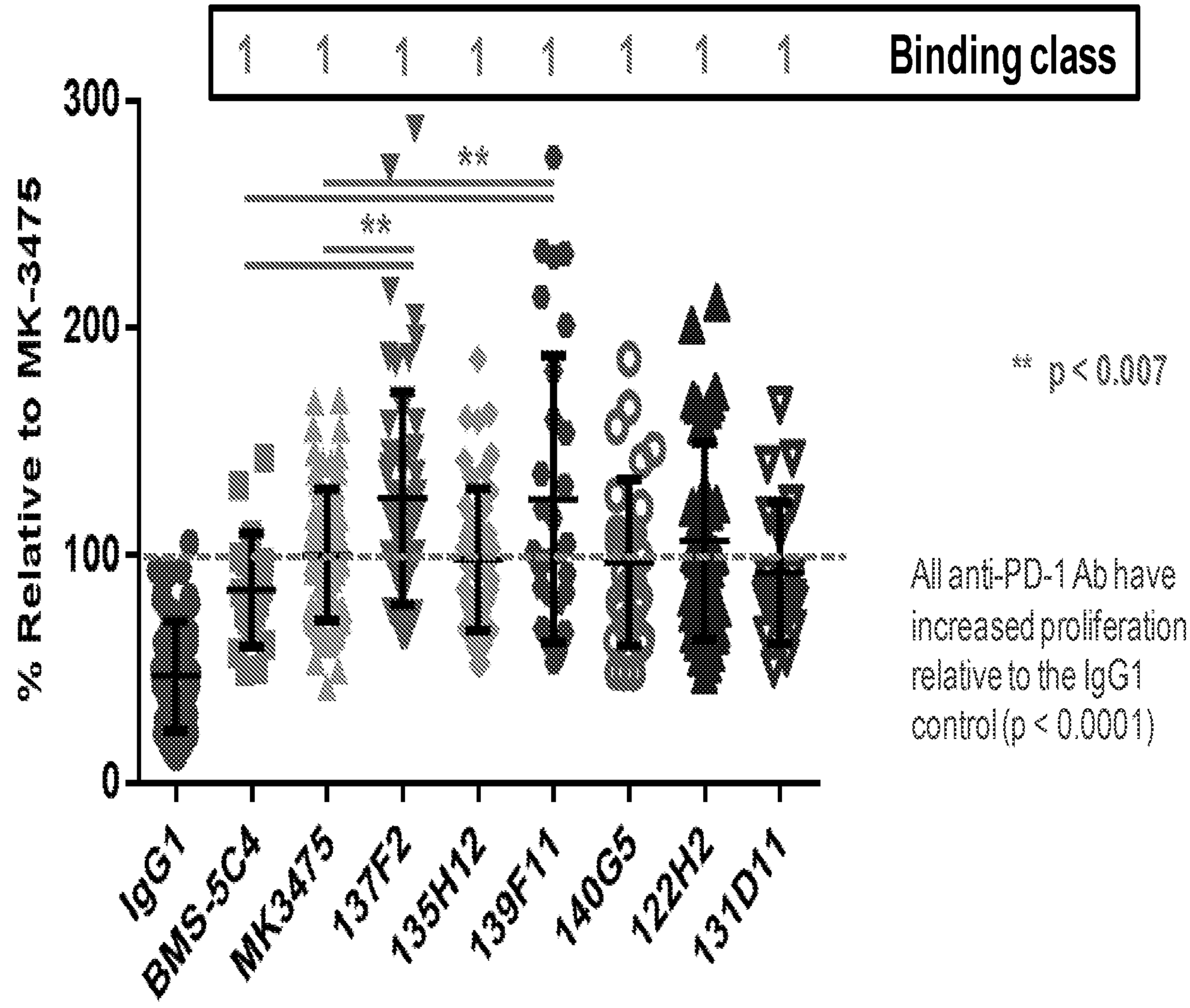

Binding class
% Relative to MK-3475
300
200
100
0
**
** p < 0.007
All anti-PD-1 Ab have increased proliferation relative to the IgG1 control (p < 0.0001)
IgG1
BMS-5C4
MK3475
137F2
135H12
139F11
140G5
122H2
131D11

FIGURE 8

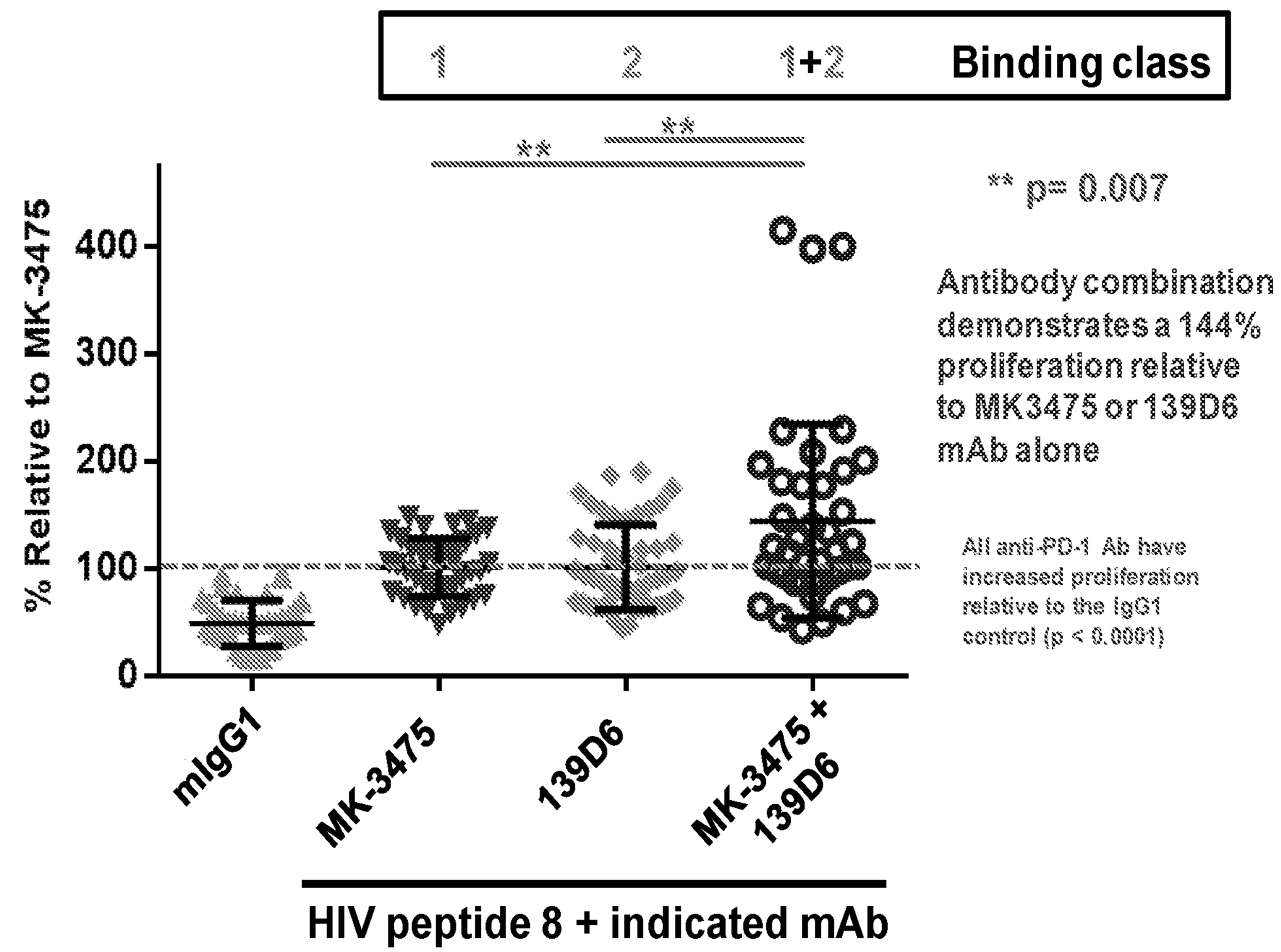
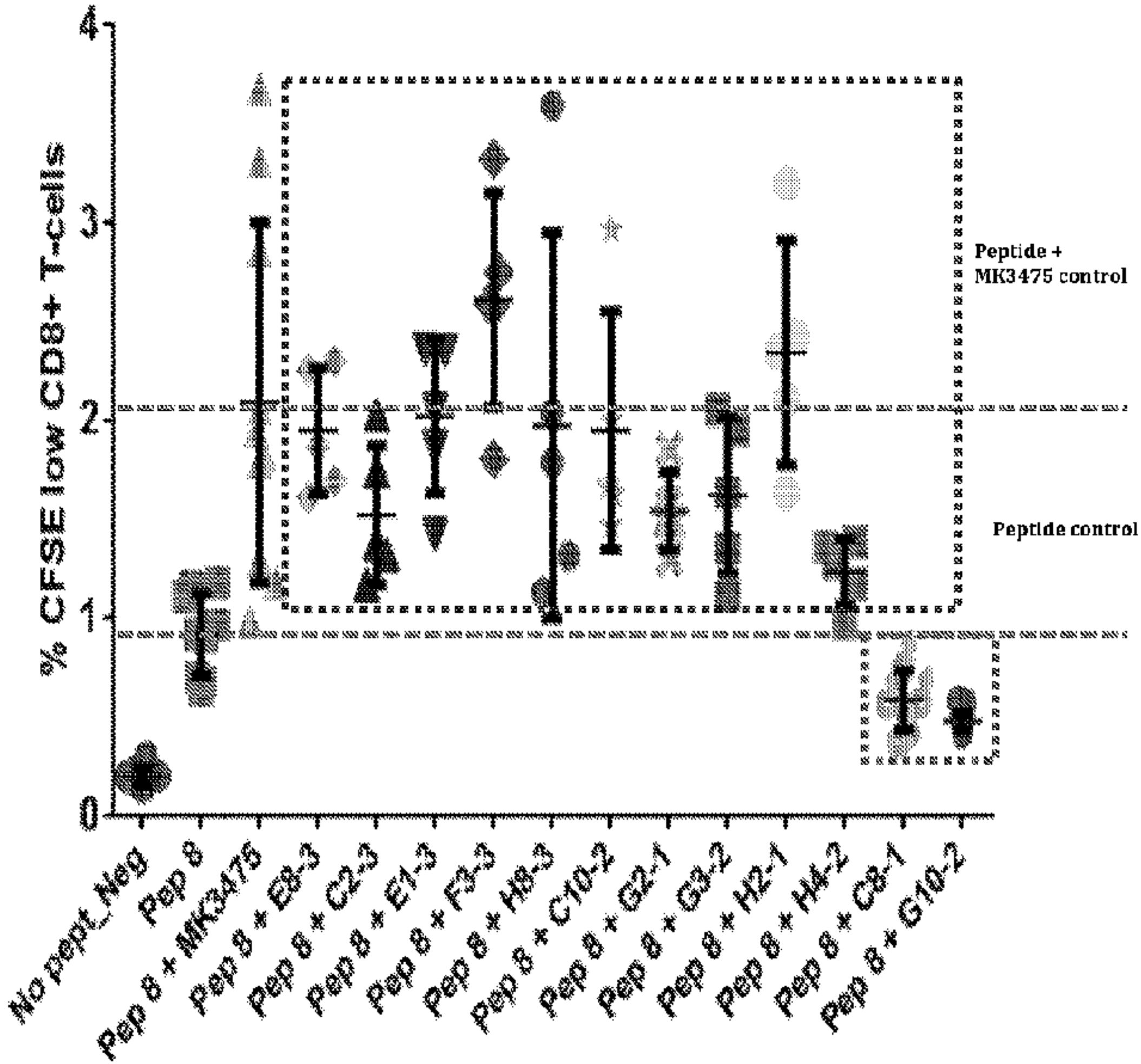

1
2
1+2
Binding class
**
**
% Relative to MK-3475
400
300
200
100
0
** p= 0.007
Antibody combination demonstrates a 144% proliferation relative to MK3475 or 139D6 mAb alone
All anti-PD-1 Ab have increased proliferation relative to the IgG1 control (p < 0.0001)
mIgG1
MK-3475
139D6
MK-3475 + 139D6
HIV peptide 8 + indicated mAb

FIGURE 2


% CFSE low CD8+ T-cells
4
3
2
1
0
Peptide + MK3475 control
Peptide control
No pept_Neg
Pep 8
Pep 8 + MK3475
Pep 8 * E8-3
Pep 8 * C2-3
Pep 8 * E1-3
Pep 8 * F3-3
Pep 8 * H8-3
Pep 8 * C10-2
Pep 8 * G2-1
Pep 8 * G3-2
Pep 8 * H2-1
Pep 8 * H4-2
Pep 8 * C8-1
Pep 8 * G10-2