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1 *Article*

2 Suppression of IFN-γ production in murine 3 splenocytes by histamine receptor antagonists

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15

16 **Abstract:** Accumulating evidence suggests that histamine synthesis induced in several types of
17 tumor tissues should modulate tumor immunity. We found that a transient histamine synthesis was
18 induced in CD11b$^+$Gr-1$^+$splenocytes derived from BALB/c mice transplanted with a syngeneic colon
19 carcinoma, CT-26, when they were co-cultured with CT-26 cells. Significant levels of IFN-γ were
20 produced under this co-culture condition. We explored the modulatory roles of histamine on IFN-γ
21 production and found that several histamine receptor antagonists, such as pyrilamine,
22 diphenhydramine, JNJ7777120, and thioperamide, could significantly suppress IFN-γ production.
23 However, suppression of IFN-γ production by these antagonists was also found when splenocytes
24 were derived from the *Hdc*$^{-/-}$ BALB/c mice. Suppressive effects of these antagonists were found on
25 IFN-γ production induced by concanavalin A or the combination of an anti-CD3 antibody and an
26 anti-CD28 antibody in a histamine-independent manner. Murine splenocytes were found to express
27 H_1 and H_2 receptors, but not H_3 and H_4 receptors. IFN-γ production in the *Hh1r*$^{-/-}$ splenocytes
28 induced by the combination of an anti-CD3 antibody and an anti-CD28 antibody was significantly
29 suppressed by these antagonists. These findings suggest that pyrilamine, diphenhydramine,
30 JNJ7777120, and thioperamide could suppress IFN-γ production in activated splenocytes in
31 histamine-independent manner.

32 **Keywords:** IFN-γ; histamine; splenocyte; histamine H_1 receptor, histidine decarboxylase
33

34 1. Introduction

35 Histamine has diverse physiological roles, which are mediated by four subtypes of its specific
36 receptors [1]. They are excellent and promising targets of therapeutic compounds for various
37 diseases, such as type I allergy, peptic ulcer, and sleep disorders. Histamine is formed through
38 decarboxylation of histidine by L-histidine decarboxylase (HDC), which is expressed in the limited
39 kinds of cells, such as mast cells, enterochromaffin-like cells, and histaminergic neuron.
40 Accumulating evidence suggests that HDC could be induced in some kinds of myeloid cells in
41 addition to mast cells [2-5]. Activated neutrophils have also been identified as the source of
42 histamine, which might be involved in lung and airway inflammation in response to mycoplasma
43 pneumonia infection [6, 7].

44 It has been controversial how histamine should modulate tumor immunity. Jutel et al.
45 demonstrated using the *Hh2r*$^{-/-}$ mice that H_2 receptor expressed in T cells should be involved in

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suppression of their cytokine production [8]. We previously raised the possibility that histamine should suppress tumor immunity through inhibition of the local expression of several cytokines that have potentials to antagonize tumor growth by acting on the H_2 receptors in a murine syngeneic tumor model [9,10]. Granulocytic myeloid cells expressing HDC were found to recruit FoxP3$^+$ cells in murine colon cancer [11]. These findings suggest that histamine should contribute to suppression of immune responses. On the other hand, Yang et al. demonstrated that the frequency of chemical carcinogenesis was increased in the *Hdc*$^{-/-}$ mice [12]. They hypothesized that histamine synthesis should induce maturation of CD11b$^+$Ly6G$^+$ cells in an autocrine manner, resulting in the impaired immunosuppressive functions. This concept has also been supported by the findings in a murine glioma model [13]. They suggested that suppression of the activity of the myeloid-derived suppressor cells (MDSC) by histamine might result in enhanced tumor immunity. However, it remains unknown how HDC should be induced in such myeloid cells and how HDC$^+$ MDSC could maintain in the tumor tissues.

It is of great significance to clarify how histamine should modulate tumor immunity because various histamine receptor ligands have been developed and some of them are approved for clinical use. We found that histamine synthesis was induced in murine splenocytes derived from the tumor-bearing mice when they were co-cultured with the tumor cells. We here determined the identity of histamine-forming cells in the splenocytes and investigated the roles of histamine using various histamine receptor antagonists.

2. Results

2.1. Induced histamine synthesis in the splenocytes derived the tumor-bearing mice

We previously demonstrated that histamine synthesis was induced in the tumor tissue in a murine syngenic tumor model, in which CT-26 cells were transplanted in the dorsal skin of male BALB/c mice [9]. We then asked whether splenocytes derived from the tumor-bearing mice could produce histamine in the presence of CT-26 cells *in vitro* to identify the population responsible for histamine synthesis in tumor immunity. Significant levels of HDC activity were observed in the splenocytes derived from the tumor-bearing mice when they were co-cultured with mitomycin c-treated CT-26 cells (Fig. 1a). Histmaine synthesis was detected neither in the splenocytes alone nor in the splenocytes derived from the control, tumor-free mice. We then investigated the effects of the conditioned medium obtained from the co-culture on histamine synthesis in the other freshly prepared splenocytes derived from the tumor bearing mice. The conditioned medium obtained from the co-culture of the splenocytes derived from the tumor-bearing mice and CT-26 cells was found to induce HDC in the splenocytes derived from the tumor-bearing mice, not in the control splenocytes (Fig. 1b). Flow cytometric analysis indicated that HDC was induced in CD11b$^+$Gr-1$^+$ populations (Fig. 1c). Very low levels of basal HDC expression were also found in the CD11b$^+$Gr-1^{low} population.

2.2 IFN-γ production mainly in spleen CD8+ T cells

IFN-γ production during the co-culture period was also measured. IFN-γ production was detected only when the splenocytes derived from the tumor-bearing mice were co-cultured with CT-26 cells as well as HDC (Fig. 2a). Significant levels of IFN-γ were released 12 hr after the onset of the co-culture and were abolished by depleting CD8$^+$ T cells (Fig. 2b and 2c).

2.3 Suppression of IFN-γ production during the co-culture period by several histamine receptor antagonists

Histamine receptors have been found to be involved in modulation of cytokine production from various immune cells including T cells [14]. We then investigated the effects of histamine produced by the splenocytes on IFN-γ production during the co-culture period. Relatively high concentrations

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of H_1 antagonists, pyrilamine and diphenhydramine, and H_4 antagonists, JNJ7777120 and thioperamide, significantly suppressed IFN-γ production during the co-culture period (Fig. 3a and 3b). An H_2 antagonist, cimetidine, had no effects on the IFN-γ production. We then asked whether these compounds suppressed IFN-γ production by antagonizing endogenous histamine by using the splenocytes derived from the tumor-bearing *HDC*$^{-/-}$ mice. Unexpectedly, these compounds suppressed IFN-γ production by the *HDC*$^{-/-}$ splenocytes in a similar fashion to that by the control splenocytes (Fig. 3c and 3d). The amounts of IFN-γ production during the co-culture periods were comparable between the wild type and *HDC*$^{-/-}$ splenocytes (Wild type; 980 ± 300 pg/ml, *HDC*$^{-/-}$; 1,400 ± 680 pg/ml, n=4).

2.4 Effects of histamine receptor ligands on IFN-γproduction in the activated splenocytes

We then asked whether suppressive effects of several histamine receptor antagonists should be specific for IFN-γ production induced in the immune responses against tumor expansion. Concanavalin A (Con A), which is a lectin with potentials to activate T cells, induced IFN-γ production in the wild type and *HDC*$^{-/-}$ splenocytes (Wild type; 830 ± 160 pg/ml, *HDC*$^{-/-}$; 900 ± 240 pg/ml, n=4). Pyrilamine, diphenhydramine, JNJ7777120, and thioperamide dose-dependently suppressed Con A-induced IFN-γ production in the splenocytes derived from the wild type and *HDC*$^{-/-}$ mice, whereas cimetidine had no effects on it (Fig. 4). Histamine exhibited partial suppressive effects on Con A-induced IFN-γ production, which reached to a plateau at 1 μM. We investigated using the antibodies raised against CD3 and CD28 whether IFN-γ production induced by T cell receptor activation should be also suppressed by these histamine receptor antagonists. Because previous studies demonstrated that H_1 receptor should be involved in augmented Th1 responses [8, 15], we investigated the effects of these compounds using the splenocytes derived from *Hh1r*$^{-/-}$ mice [16] in addition to *Hdc*$^{-/-}$ mice. Production of IFN-γ upon T cell receptor activation was significantly suppressed by pyrilamine, diphenhydramine, JNJ7777120, and thioperamide in the splenocytes derived from BALB/c, C57Bl6, *HDC*$^{-/-}$ (backcrossed to BALB/c), and *Hh1r*$^{-/-}$ strains (Fig. 5). The amounts of IFN-γ were comparable between the wild type and *HDC*$^{-/-}$ mice (BALB/c; 5,900 ± 3,800 pg/ml, *HDC*$^{-/-}$; 2,000 ± 400 pg/ml, n=4) whereas those were higher in *Hh1r*$^{-/-}$ mice than in the wild type mice (C57Bl6; 225 ± 53 pg/ml, *Hh1r*$^{-/-}$; 1,400 ± 45 pg/ml, n=3).

2.5 Effects of histamine receptor ligands on IL-2 prodcution in the activated splenocytes

We observed decreases in the number of aggregated splenocyte colonies in the presence of these histamine receptor antagonists, raising the possibility that they might suppress IL-2-mediated proliferation of T cells. We then investigated the effects of these compounds on IL-2 production in the activated splenocytes. Pyrilamine, diphenhydramine, and JNJ7777120 significantly suppressed IL-2 production in the splenocytes stimulated with Con A whereas cimetidine, thioperamide, and histamine did not affect IL-2 production (Fig. 6a). IL-2 production induced upon T cell receptor activation was found to be insensitive to these compounds except diphenhydramine (Fig. 6c). The absence of HDC did not affect the potencies of these compounds (Fig. 6b and 6d).

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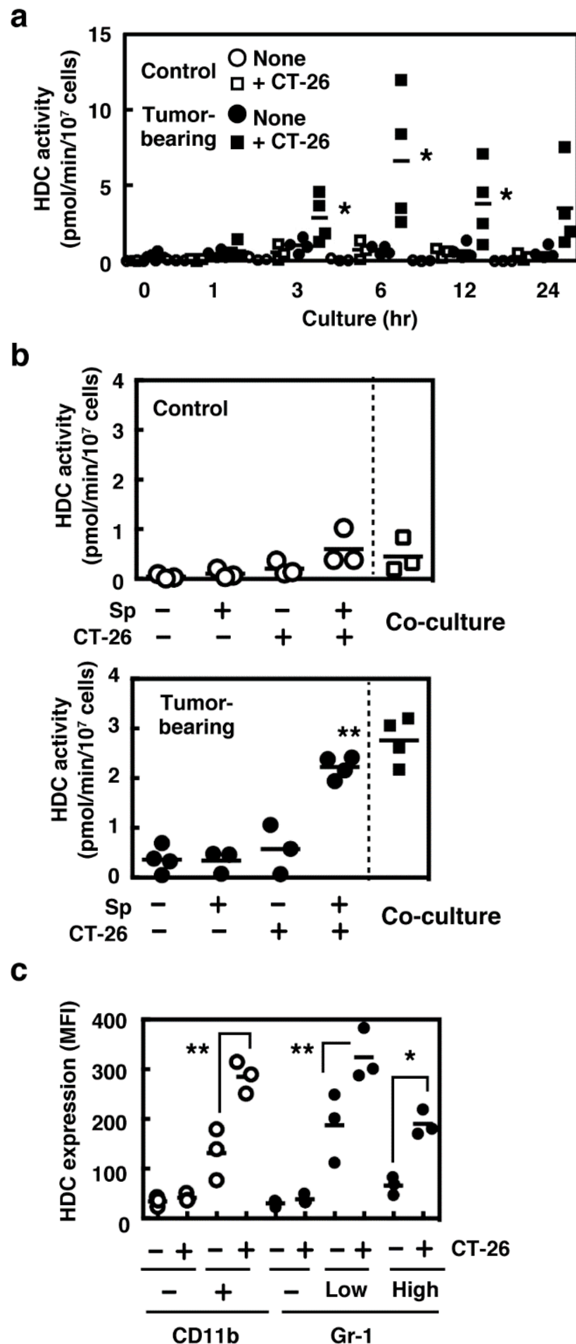

133 **Figure 1.** (a) Splenocytes were collected from the control (open symbols) and tumor-bearing mice
134 (closed symbols) and then cultured in the absence (circles) or presence of CT-26 cells (squares) for the
135 periods indicated. HDC activity was measured in the cultured splenocytes. (b) Culture of splenocytes
136 were performed under various conditions as described above for 6 hr and the conditioned media were
137 then collected. Splenocyes from the control (open symbols) and tumor-bearing mice (closed symbols)
138 were incubated in each conditioned medium for 6 hr and HDC activity was measured. HDC activity
139 in the splenocytes co-cultured with CT-26 cells was measured as the reference. (c) Expression levels
140 of HDC in the splenocytes derived from the tumor-bearing mice co-culture without or with CT-26
141 cells were measured using flow cytometry with the antibodies raised against CD11b, Gr-1, and HDC.
142 Expression of HDC was analyzed in the subpopulations of the splenocytes. Multiple comparisons
143 were performed using one-way ANOVA with the Tukey post test. Values with *$p<0.05$ and **$p<0.01$
144 are regarded as significant.

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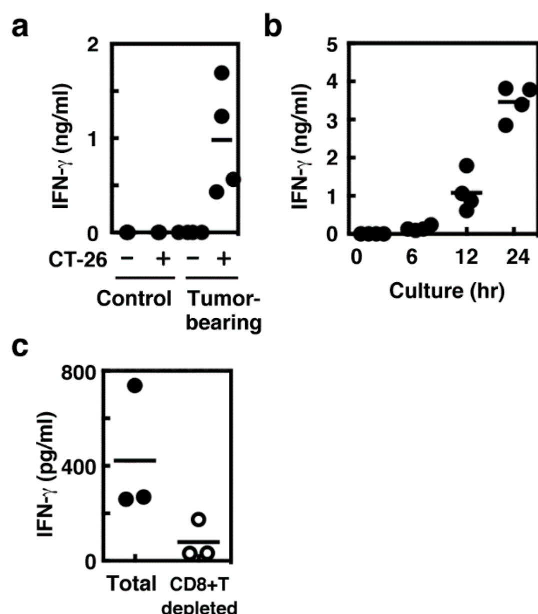
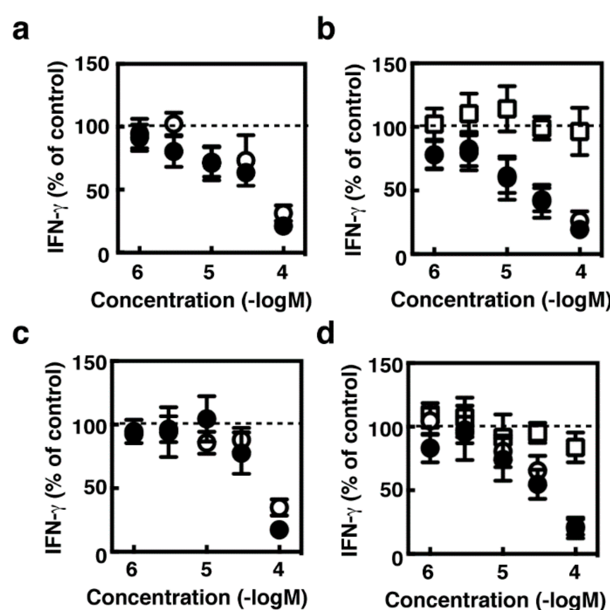


145 **Figure 2.** (a) Splenocytes were collected from the control and tumor-bearing mice and then cultured
146 in the absence or presence of CT-26 cells for 24 hr. The amounts of IFN-γ in the medium were
147 measured. (b) Splenocytes were collected from the tumor-bearing mice and co-cultured with CT-26
148 cells for the periods indicated. The amounts of IFN-γ in the medium were measured. (c) Total
149 splenocytes derived from tumor-bearing mice or those depleted with CD8^{+} T cells were co-cultured
150 with CT-26 cells for 24 hr. The amounts of IFN-γ in the medium were measured.



151 **Figure 3.** Splenocytes derived from the tumor-bearing wild type mice (a and b) and *HDC*$^{-/-}$ mice (c
152 and d) were co-cultured with CT-26 cells for 24 hr in the presence of the indicated concentrations of
153 pyrilamine (a, c, open circles), diphenhydramine (a, c, closed circles), cimetidine (b, d, open squares),
154 JNJ7777120 (b, d, open circles), and thioperamide (b, d, closed circles). The amounts of IFN-γ in the
155 medium are presented as the percentages of the control. Values are presented as the mean ± SEM
156 (n=3).

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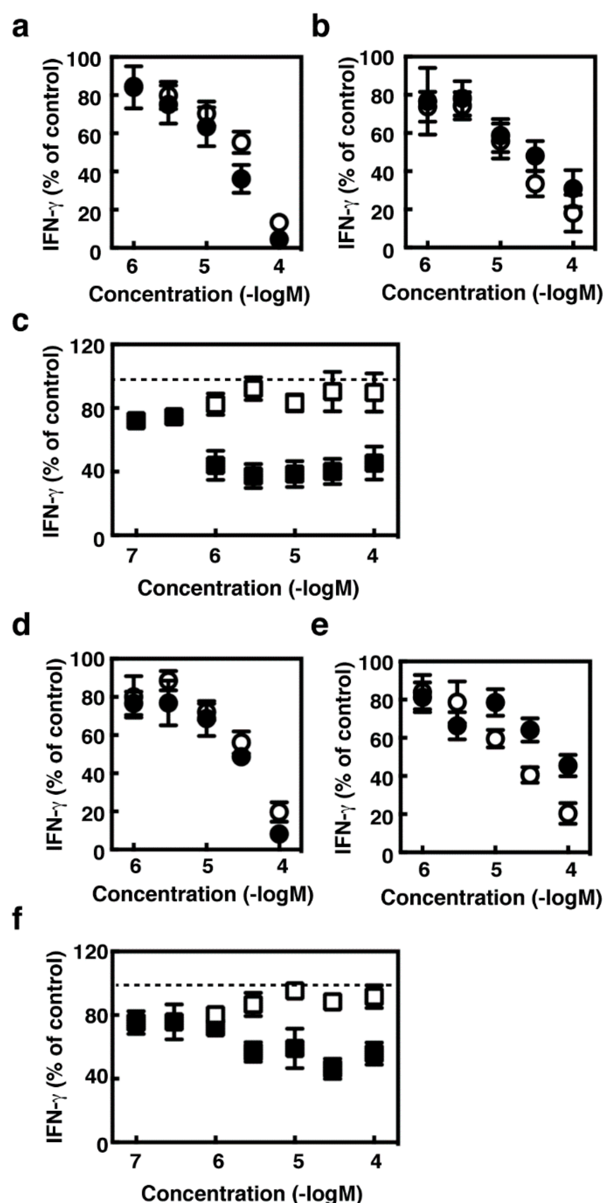

157 **Figure 4.** Splenocytes derived from the wild type mice (a, b, and c) and *HDC*$^{-/-}$ mice (d, e, and f) were
158 stimulated with concanavalin A (5 μg/ml) for 24 hr in the presence of the indicated concentrations of
159 pyrilamine (a, d, open circles), diphenhydramine (a, d, closed circles), cimetidine (c, f, open squares),
160 JNJ7777120 (b, e, open circles), thioperamide (b, e, closed circles), and histamine (c, f, closed squares).
161 The amounts of IFN-γ in the medium are presented as the percentages of the control. Values are
162 presented as the mean ± SEM (n=3).

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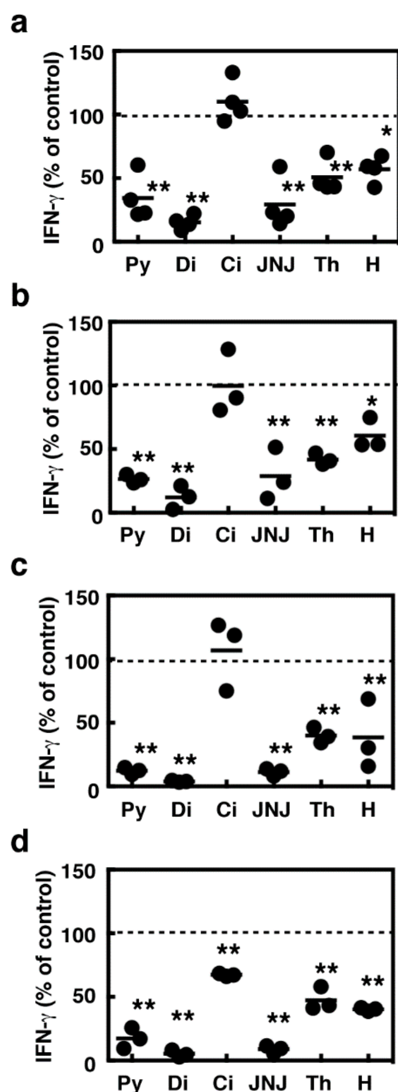

163 **Figure 5.** Splenocytes derived from the BALB/c mice (a), *HDC*$^{-/-}$ mice (b), C57Bl6 mice (c), and *Hh1r*$^{-/-}$
164 mice (d) were stimulated in the culture plates coated with an anti-CD3 antibody and an anti-CD28
165 antibody for 24 hr in the presence of 100 μM of pyrilamine (Py), diphenhydramine (Di), cimetidine
166 (Ci), JNJ7777120 (JNJ), thioperamide (Th), and histamine (H). The amounts of IFN-γ in the medium
167 are presented as the percentages of the control. Multiple comparisons were performed using one-way
168 ANOVA with the Tukey post test. Values with *p<0.05 and **p<0.01 are regarded as significant.

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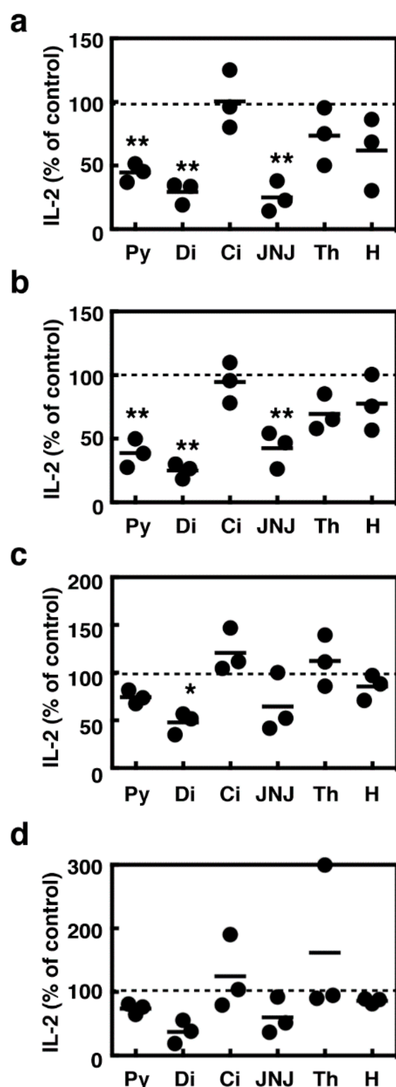

169 **Figure 6.** Splenocytes derived from the wild type mice (a and c) and *HDC*$^{-/-}$ mice (b and d) were
170 stimulated with concanavalin A (5 μg/ml, a and b) or in the culture plates coated with an anti-CD3
171 antibody and an anti-CD28 antibody (c and d) for 24 hr in the presence of 100 μM of pyrilamine (Py),
172 diphenhydramine (Di), cimetidine (Ci), JNJ7777120 (JNJ), thioperamide (Th), and histamine (H). The
173 amounts of IL-2 in the medium are presented as the percentages of the control. Multiple comparisons
174 were performed using one-way ANOVA with the Tukey post test. Values with *p<0.05 and **p<0.01
175 are regarded as significant.

176

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3. Discussion

Accumulating evidence suggests that MDSC should be the major source of histamine in the tumor tissues, although it remains to be clarified how HDC is induced. We reproduced here the process of induction of histamine synthesis by murine myeloid cells in the tumor tissues by establishing a system, in which splenocytes derived from the tumor-bearing mice were co-cultured with mitomycin c-treated tumor cells. HDC-expressing cells were found to be $CD11b^{+}Gr\text{-}1^{+}$ cells, raising the possibility that histamine synthesis was induced in MDSC in our model. Induction of histamine synthesis was limited in the situation, in which tumor immunity was established. It is likely that CT-26 cells triggered acquired immunity against themselves during the co-culture period, such as stimulated production of a wide variety of cytokines including IFN-γ. Because the conditioned medium could induce histamine synthesis in the splenocytes derived from the tumor-bearing mice, it is likely that soluble mediators, such as cytokines, induced upon tumor immunity should act on the surface receptors on the splenocytes to induce HDC. Previous studies demonstrated that several cytokines should be involved in induction of histamine synthesis. Interleukin-3 could induce histamine synthesis in murine bone marrow [17]. Injection of IL-1 into mice was found to induce histamine synthesis in various tissues, such as bone marrow, spleen, lung, and liver, as well as lipopolysaccharide (LPS) injection [18]. Several studies suggested that GM-CSF could also induce HDC in bone marrow-derived cells [6,19]. Although we could not identify the cytokines that should be responsible for induced histamine synthesis, our co-culture model will be useful for identifying the putative HDC-inducing factors.

We then tried to determine the roles of histamine produced by MDSC in our system. Among several histamine receptor antagonists, H_1 antagonists (pyrilamine and diphenhydramine) and H_4 antagonists (JNJ777120 and thioperamide) were found to suppress IFN-γ production, whereas an H_2 antagonist, cimetidine, had no effects on it. Unexpectedly, these inhibitory effects were also observed in the *Hdc*$^{-/-}$ splenocytes, indicating that the suppressive effects of these compounds should not be associated with their abilities to compete with histamine. Because no common target molecules of these compounds have been reported, it is rather difficult to identify their targets in addition to histamine receptors. These inhibitory effects were also observed when splenocytes derived from tumor-free, control mice were stimulated with concanavalin A or the combination of anti-CD3 and anti-CD28 antibodies. These results suggest that shared signaling pathways leading to IFN-γ production should be suppressed by these compounds, because $CD4^{+}$ T cells should also be involved in IFN-γ production under these conditions. Interestingly, clozapine, which could function as an H_4 agonist [20], was found to suppress IFN-γ production in activated human peripheral blood mononuclear cells through suppression of expression of T-bet, which is the master transcription factor of Th1 differentiation [21]. A recent study reported that some benzoxazole derivatives could suppress IFN-γ production in murine $CD4^{+}$ T cells in a similar manner to clozapine [22]. Accumulating evidence suggests that T-bet should be involved in IFN-γ production both in $CD4^{+}$ and $CD8^{+}$ T cells, although T-bet-independent IFN-γ production was reported in $CD8^{+}$ T cells [23-25]. The compounds with suppressive effects on IFN-γ production found here may also have potentials to modulate the expression levels and transcriptional activity of T-bet.

Among the compounds tested here, pyrilamine and diphenhydramine exhibited relatively strong effects. Because previous studies have indicated that several H_1 antagonists including pyrilamine could function as inverse agonists [26-29], we verified this possibility using the *Hh1r*$^{-/-}$ mice. Previous studies demonstrated that H_1 receptors should be involved in promotion of Th1 responses including IFN-γ production [8, 15]. We confirmed significant levels of H_1 and H_2 receptor mRNA in isolated splenocytes (data not shown). However, our results obtained using the *Hh1r*$^{-/-}$ splenocytes indicated that the H_1 receptor should be unrelated to the actions of pyrilamine and diphenhydramine. Regarding the expression levels of H_4 receptors, no or very low levels of mRNA expression were detected in the isolated splenocytes (data not shown), although the abundant levels of expression were confirmed in the bone marrow cells. Our finding might be inconsistent with the previous study demonstrating that murine H_4 receptors are distributed in the hematopoietic system including bone marrow and spleen [30]. We speculate that JNJ7777120 might suppress IFN-γ

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production in an H_4 receptor-independent manner whereas it should be clarified how the expression levels of H_4 receptors in splenocytes should be dynamically changed.

Suppressive effects of these histamine receptor antagonists on IFN-γ production were observed in relatively higher concentrations, indicating that a majority of the reported findings using these compounds should not be associated with suppressed IFN-γ production. This study will contribute in development of novel therapeutic compounds targeting IFN-γ, which plays critical roles in pathology of various diseases, such as autoimmune diseases and inflammatory bowel diseases [31,32].

4. Materials and Methods

4.1. Materials

4.2. Animals Specific-pathogen-free 5-10-week-old male BALB/c mice and C57BL/6 mice were obtained from Japan SLC (Hamamatsu, Japan). $Hdc^{-/-}$ mice [32] were backcrossed to BALB/c strain for more than 10 generations. $Hh1r^{-/-}$ mice [16] were backcrossed to C57BL/6 strain for more than 10 generations. These gene-targeted male mice were used at 8-10 week of age. All mice were kept in a specific-pathogen-free animal facility at Okayama University. This study was approved by the Committee on Animal Experiments of Okayama University.

4.3. Murine syngenic tumor model Male BALB/c mice (5 weeks of age) were transplanted with a syngenic colon tumor cell line, CT-26 (1×10^6 cells/mouse, at the dorsal skin) as previously described [9]. The spleen was collected 14 days after the transplantation, minsed, and filtered with nylon mesh to obtain the splenocytes.

4.4. Co-culture of splenocytes and CT-26 cells Suspended splenocytes were treated with ACK buffer (150 mM NH_4Cl containing 10 mM $KHCO_3$, 1 mM EDTA) to eliminate red blood cells. CT-26 cells were treated with 1 μg/ml mitomycin C for 3 hr in RPMI-1640 medium containing 10% heat-inactivated FBS, 100 U/ml penicillin, and 0.1 mg/ml streptomycin (complete RPMI medium) and then twice washed. Splenocytes suspended in the complete RPMI medium were seeded onto the monolayer of CT-26 cells.

4.5. Measurement of histamine Splenocytes were homogenized in the cell lysis buffer (10 mM potassium phosphate, pH 6.8 containing 10 mM KCl, 1.5 mM $MgCl_2$, 0.2 mM dithiothreitol, 0.01 mM pyridoxal phosphate, 1 mM EDTA, 1 mM EGTA, 0.2 mM phenylmethylsulfonyl fluoride, 0.1 mM benzamidine, 10 μg/ml aprotinin, 10 μg/ml leupeptin, 10 μg/ml E-64, 1 μg/ml pepstatin A, and 0.1% Triton X-100) and centrifuged at 10,000 x *g* for 15 min at 4˚C. The resultant supernatant was subjected to the enzymatic assay of HDC. The reaction was performed in 0.1 M potassium phosphate, pH 6.8 containing 0.2 mM dithiothreitol, 0.01 mM pyridoxal phosphate, 2% polyethylene glycol #300, 0.2 mM aminoguanidine, and 0.8 mM histidine, for 4 hr at 37˚C and then terminated by addition of perchlorolic acid (fin. 3%). Histamine was fluoremetrically measured by HPLC with a cation exchange column, WCX-1 (Shimadzu, Japan), after derivatization with *o*-phtalaldehyde [33].

4.6. Flow cytometry Cultured splenocytes were collected and incubated with the 2.4G2 antibody (BD Biosciences, NJ) to block Fc receptors at 4˚C for 15 min. The cells were then labeled with the antibodies raised against the surface antigens, CD11b or Gr-1. For intracellular staining, the cells were fixed with PBS containing 4% formaldehyde at 4˚C for 30 min and then permeabilized with PBS containing 0.1% saponin and 1% FBS at room temperature for 10 min. The permeabilized cells were incubated with an anti-HDC antibody (ab37291, Abcam, UK) at 4˚C for 30 min and visualized with a phycoerythrin-conjugated anti-rabbit IgG antibody. The cells were analyzed using FACSCalibur (BD Biosciences).

4.7. Measurement of cytokies The amounts of cytokines in the medium were measured using the ELISA kits (mouse IFN-γ ELISA Ready Set Go! And mouse IL-2 ELISA Ready Set Go!, Thermo Fisher Scientific, MA) according to the manufacture's instructions.

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277 *4.8. Depletion of CD8⁺ T cells* Depletion of $CD8^+$ T cells from total splenocytes was performed using
278 $CD8a^+$ T cell Isolation Kit II (Miltenyi Biotec, Germany) according to the manufacture's instruction.

279 *4.9. Stimulation of T cell receptors* Splenic T cells were activated in the antibody-coated culture wells.
280 Culture wells were coated with an anti-CD3 antibody (5 μg/ml, BD Biosciences) and an anti-CD28
281 antibody (1 μg/ml, BD Biosciences) at 4°C over night. In case of the splenocytes derived from the
282 *Hh1r*$^{-/-}$ mice and the control C57BL/6 mice, 2 μg/ml of an anti-CD3 antibody and 0.4 μg/ml an anti-
283 CD28 antibody were used for coating.

284 *4.10. Measurement of histamine receptor mRNAs* Total RNAs were extracted from the splenocytes
285 using NucleoSpin RNA Kit (TaKaRa Bio Inc., Japan) and reverse transcribed using PrimeScript™
286 RT Reagent Kit (TaKaRa Bio Inc.). First strand DNAs were subjected to quantitative PCR using
287 KOD SYBR qPCR Mix (TOYOBO, Japan) or SYBR Green PCR Master Mix (Thermo Fisher Scientific)
288 with the specific primer pairs as follows. *Hh1r*: 5′-TCA CTC CAG GCC TCA CAT GAC-3′, 5′-CAA
289 AGT TCT CAT CCC AAG TTT CCA-3′, *Hh2r*: 5′-CAG TCC TAA GCG ACC CGG TA-3′, 5′-GGC
290 ACT GCT GGA TGT ATC TTG A-3′, Hh3r: 5′-ATG ACC GAT TCC TGT CAG TCA CTC-3′, 5′-TTC
291 CGA ACA GCC CGT CTT G-3′, *Hh4r*: 5′-TAC TGG CAT CTT GCC ACC AG-3′, 5′-ACG TGA GGG
292 ATG TAC AGA GGA-3′, and *Gapdh*: 5′-TGT GTC CGT CGT GGA TCT GA-3′, 5′-TTG CTG TTG
293 AAG TCG CAG GAG-3′

294 *4.11. Statistics* Statistical significance for comparison between two groups was determined by
295 unpaired Student's *t*-test. Statistical significance for comparisons among multiple groups was
296 determined using one-way ANOVA. Additional comparisons were made with Dunnett multiple
297 comparison test for comparison with the control groups or Tukey-Kramer multiple comparison test
298 for all pairs of column comparison.

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304 **Abbreviations**

ANOVA	Analysis of variance
Con A	Concanavalin A
FBS	Fetal bovine serum
GM-CSF	Granulocyte-macrophage colony-stimulating factor
HDC	L-Histidine decarboxylase
IFN	Interferon
MDSC	Myeloid-derived suppressor cells
PBS	Phosphate buffered saline
PCR	Polymerase chain reaction
T-bet	T box-containing protein expressed in T cells

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