Reconstitution of the Functional Receptors for Murine and Human Interleukin 5

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Summary

The murine interleukin 5 receptor (mIL-5R) is composed of two distinct subunits, α and β. The α subunit (mIL-5Rα) specifically binds IL-5 with low affinity. The β subunit (mIL-5Rβ) does not bind IL-5 by itself, but forms the high-affinity receptor with mIL-5Rα. mIL-5Rβ has been revealed to be the mIL-3R-like protein, AIC2B which is shared with receptors for IL-3 and granulocyte/macrophage colony–stimulating factor. We demonstrated here the reconstitution of the functional receptors for murine and human IL-5 on the mouse IL-2–dependent cell line, CTLL-2. CTLL-2 was transfected with the cDNAs for mIL-5Rα and/or AIC2B. Only CTLL-2 transfectant expressing both mIL-5Rα and AIC2B expressed the high-affinity receptor and proliferated in response to murine IL-5. Then CTLL-2 was transfected with the cDNAs for hIL-5Rα and/or KH97 (β_c), the human homologue of AIC2B. Though β_c did not contribute much to binding affinity of hIL-5R, only CTLL-2 transfectant expressing both hIL-5Rα and β_c proliferated in response to human IL-5. These results showed that the β subunit is indispensable in IL-5 signal transduction. We further investigated the function of IL-5–specific α subunit in transmitting IL-5 signals. Mutant mIL-5Rα, which lacks its whole cytoplasmic domain, was transfected into mouse IL-3–dependent cell line, FDC-P1 expressing AIC2B intrinsically. The resulting transfectant did not respond to IL-5, though the transfectant expressed the high-affinity IL-5R, indicating that the cytoplasmic portion of the α subunit also has some important role in IL-5–mediated signal transduction.

IL-5 is a glycoprotein produced by activated T cells and mast cells. IL-5 was originally identified as a cytokine that stimulates proliferation and differentiation of murine (m)[1] activated B cells, and proved to regulate the production and function of some other hematopoietic cells, such as CD5$^+$ B cells, eosinophils, and basophils (1). In humans, IL-5 acts mainly on eosinophils. IL-5 induces the production of eosinophils from bone marrow progenitors and works for survival and priming of eosinophils in vitro. IL-5 expression was observed in many diseases with eosinophilia, suggesting that IL-5 plays important roles in promoting production and function of eosinophils in vivo (2).

From the series of binding and crosslinking studies, we have shown that mIL-5 binds to a specific cell surface receptor (mIL-5R) with both high (K_d = 10–150 pM) and low affinity (K_d = 2–10 nM) and that two distinct membrane proteins, α and β, comprise the functional mIL-5R (3). The cloning of mIL-5Rα cDNA discloses molecular constitutions of mIL-5R (4). The mIL-5Rα alone binds IL-5 with low affinity. The mIL-5Rβ does not bind IL-5 by itself, however, it forms the high-affinity IL-5R in combination with the mIL-5Rα (4, 5). The mIL-5Rβ was then identified as AIC2B (6), the homologous protein of the low-affinity mIL-3R (AIC2A[7])(8, 9). The high-affinity mIL-5R is reconstituted on L cell transfectant coexpressing mIL-5Rα and AIC2B. Because the L cell transfectant does not respond to mIL-5 in DNA synthesis, it remains, however, unclear whether the reconstituted high-affinity mIL-5R transduces the IL-5–mediated signal into cell interior.

In contrast to mIL-5R, there are controversial reports about human (h)IL-5R. In many cases, only a single class of hIL-5R with high affinity is detected on hIL-5–responsive cells, but its binding affinity to hIL-5 has been reported as various values (10–13). There is one report describing two kinds of hIL-5Rs on human erythroleukemic cell line, TF-1 (14). Some

[1] *Abbreviations used in this paper:* h, human; m, murine; R, receptor.

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reports show that hIL-5R is specific for hIL-5 (10–13), however, others show that binding of hIL-5 is competed by hIL-3 or hGM-CSF at 4°C (cross-competition) (15). We isolated hIL-5Rα by cross-species hybridization (16). The hIL-5Rα resembles mIL-5Rα in its primary structure. It is, therefore, very likely that functional hIL-5R requires the β subunits, and that is the human homologue of AIC2 proteins, KH97, the common β subunit (β_c) of hGM-CSF (receptor) R and hIL-3R (17, 18). Recent cloning of cDNAs for mIL-3Rα and mGM-CSFRα show that AIC2B is the common β subunit of the receptors for mIL-3 and mGM-CSF (and that AIC2A is mIL-3Rβ) (19, 20). However, COS7 cells transfected with hIL-5Rα cDNA binds hIL-5 with almost the same affinity compared to normal eosinophils (16). It remains an unsolved issue how putative hIL-5Rβ contributes to the binding of hIL-5 and transmitting signals.

In this report, we demonstrate the reconstitution of the functional receptors for m and hIL-5 on a mouse IL-2–dependent cell line, CTLL-2. In both mouse and humans, the functional IL-5R complex contains two different membrane proteins, α and β. hIL-5Rβ is revealed to be the common molecule that is shared with hIL-3R and hGM-CSFR, and does not contribute much to increasing the binding affinity of hIL-5 in contrast to the mIL-5R system. In addition, using mutant mIL-5α which lacks the whole cytoplasmic domain, we showed that the α subunit has an important role not only in determining the binding specificity, but also in transmitting the growth signal of IL-5.

Materials and Methods

Cells and Reagents. A mouse IL-2–dependent CTLL-2 cell line was maintained in RPMI 1640 medium supplemented with 10% FCS and 50 μM 2-ME and 5% conditioned medium from Con A–stimulated rat spleen cells. A mouse IL-3–dependent FDC-P1 cell line was maintained in RPMI 1640 medium supplemented with 5% FCS, 50 μM 2-ME, and 5 U/ml of mIL-3. mIL-5 was prepared and purified using anti-mIL-5 mAb–coupled beads (3). Purified hIL-5 was obtained from DNAX Research Institute.

Plasmid Construction. The cDNA fragments were inserted downstream of the SRα promoter in the expression vector, pME18, the derivative of pCEV4 (7) (Maruyama, K., and A. Miyajima, unpublished results). Either neomycin or hygromycin-resistant selection maker was added to the vectors. To construct the plasmid that expresses the truncated mutant mIL-5Rα, an XhoI-PstI fragment of mIL-5Rα cDNA corresponding mostly to the extracellular and transmembrane portion was excised, and then ligated into the XhoI and NotI armed pME18 vector, to which the hygromycin-resistant gene had been added, by the use of asymmetric adopters (5'GAGTGTGTTAGC and 5'GGCCGCTAACACACTCTGCA) that generate a new stop codon. Resulting plasmid-encoded mutant mIL-5Rα terminated to the end of transmembrane domain (Cys, position 361 in mIL-5Rα [4]).

Transfection. Cells were washed twice and resuspended in Hepes buffered saline (pH 7.2). 10^7 cells per 800 μl were then transfected with 50 μg of linearized plasmid DNA by electroporation by 350 V and 960 μF in a 0.4-cm gap cuvette using Gene Pulser (Bio-Rad Laboratories, Richmond, CA). Transfectants were selected in the medium containing either 400 μg/ml of G418 (geneticin; Sigma Chemical Co., St. Louis, MO) or 200–400 μg/ml of hygromycin (Wako Pure Chemical Industries, Osaka, Japan), depending on the selection marker on the plasmid DNA. The expression of the cDNA products was examined by flow cytometry analysis using mAbs against mIL-5Rα (H7) (21), AIC2A or AIC2B (anti-Aic-2) (22), and KH97 (CRS-1) (23), except for the hIL-5Rα transfectants. The expression of hIL-5Rα was verified by binding assay using ^{125}I-hIL-5.

IL-5 Binding Assay. Purified hIL-5 was iodo labeled using IODO-GEN® (Pierce Chemical Co., Rockford, IL). mIL-5 were biosynthetically ^{35}S-methionine labeled, as previously described (3). Specific activities of ^{125}I-labeled hIL-5 and ^{35}S-labeled mIL-5 were 5.5×10^6 cpm/pmol and 4.7×10^6 cpm/pmol, respectively. For binding assay, $5–10 \times 10^5$ cells were incubated in the binding medium (RPMI 1640 medium containing 25 mM Hepes, pH 7.2 and 0.1% BSA) with increased concentrations of radiolabeled IL-5 at 4°C for 2 h. Cell-associated radioactivity was separated from free ligand by centrifugation through 3:2 dibutyl/dioctyl phthalates and counted. Specific binding was defined as the difference between total and nonspecific binding obtained in the presence of 100-fold molar excess of unlabeled IL-5. Binding data were analyzed by Scatchard analysis using the EBDA and LIGAND computer programs (Elsevier-BIOSOFT, Cambridge, UK).

Chemical Crosslinking. Crosslinking experiments using mIL-5R transfectants were performed according to the method described previously (3). In brief, 5×10^6 cells were incubated with radiolabeled IL-5, collected, and resuspended in 500 μl of HBSS containing 1 mM disuccinimidyl tartarate (DST; Pierce Chemical Co.). After incubation at 4°C for 30 min, cells were solubilized with lysis buffer (PBS containing 1% Triton X-100 and protease inhibitors). After removing insoluble fraction by centrifugation, cell lysates were subjected to SDS-PAGE (7.5% polyacrylamide) under reducing condition. Gel was fixed and dried, then analyzed by Fijix BAS2000 Bioimaging Analyzer (Fuji Photo Film, Tokyo, Japan). For hIL-5R transfectants, crosslinking was performed in PBS containing 200 μM disuccinimidyl suberate (DSS; Pierce Chemical Co.), instead of 1 mM DST (14).

Proliferation Assay. Transfectants were harvested and washed with HBSS, then inoculated into a 96-well microtiter plate at a concentration of 10^4/200 μl per well with various concentrations of m or hIL-5. The cells were pulse labeled with [^{3}H]thymidine (0.2 μCi/well) during the last 6 h of a 48-h culture period, and incorporated [^{3}H]thymidine was measured by a liquid scintillation counter.

Results

Reconstitution of the Functional mIL-5R in IL-2–dependent CTLL-2 Cells. In a previous report, we reconstituted the high-affinity mIL-5R on fibroblastic L cells by coexpressing mIL-5Rα and AIC2B, however, the transfectant does not respond to mIL-5 in DNA synthesis (8). To test the signal-transducing ability of recombinant mIL-5Rs, we introduced cDNAs of the mIL-5Rα and/or AIC2B into mIL-2–dependent CTLL-2 cell line. The stable CTLL-2 transfectants expressing mIL-5Rα alone (CTLL-m5Rα) or coexpressing mIL-5Rα and AIC2A (CTLL-m5Rα-2A) bound mIL-5 with low affinity (K_d = 2–5 nM). Only the transfectant coexpressing mIL-5Rα and AIC2B (CTLL-m5Rα-2B) bound mIL-5 not only with low but also with high affinity (K_d = 10–60 pM) (data not shown). These results were consistent with our previous observation obtained using L cell transfectants (8). Responsiveness of these CTLL-2 transfectants to mIL-5

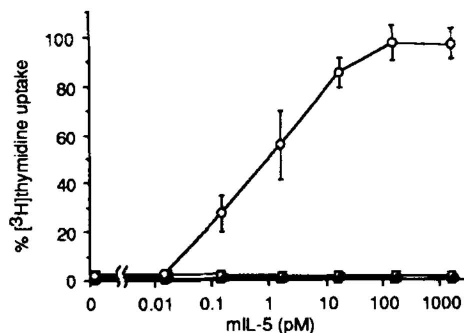

Figure 1. IL-5-responsiveness of the CTLL-2 transfectants expressing mIL-5Rα, AIC2B, and AIC2A. Cells were incubated for 48 h in the presence of various concentrations of mIL-5 and incorporated [3H]thymidine was measured. The results are expressed as the percentage of incorporation of [3H]thymidine in the same cells incubated with 100 U/ml of hIL-2. Data are shown in mean ± SD of three independent transfectant clones. (●) CTLL-m5Rα (expressing mIL-5Rα), (□) CTLL-2B (expressing AIC2B), (■) CTLL-m5Rα-2A (expressing mIL-5Rα and AIC2A), and (○) CTLL-m5Rα-2B (expressing mIL-5Rα and AIC2B).

was then examined. As shown in Fig. 1, only CTLL-m5Rα-2B which expressed the high-affinity mIL-5R responded to mIL-5 in DNA synthesis. mIL-5 induced a similar magnitude of proliferative response to that induced by IL-2. CTLL-m5Rα-2B could be maintained by mIL-5 in the absence of IL-2 for long periods of time (data not shown).

Binding Characteristics of the hIL-5R Transfectants. Next, we established the stable CTLL-2 transfectants expressing either hIL-5Rα and/or KH97 (β_c). First, the hIL-5 binding characteristics of resulting transfectants were examined. CTLL-2 expressing hIL-5Rα alone (CTLL-h5Rα) bound hIL-5 with almost similar affinity (K_d = 650–720 pM) to that of normal eosinophils (Fig. 2, ○) as we previously showed using COS7 cells (16). Transfectants expressing β_c (CTLL-β_c) did not bind hIL-5 (see Fig. 3, lanes *3* and *4*).

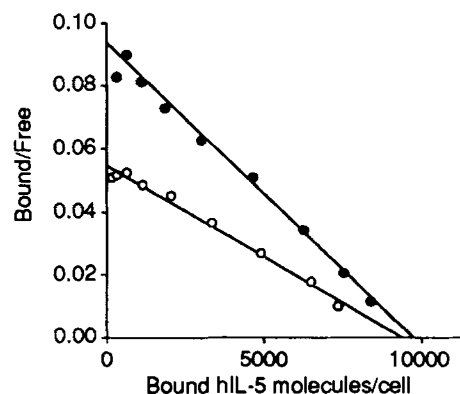

Figure 2. Scatchard plot analysis of 125I-hIL-5 binding to CTLL-2 transfectants. (○) CTLL-h5Rα (expressing hIL-5Rα) and (●) CTLL-h5Rα-β_c (expressing hIL-5Rα and β_c). Two independent clones of CTLL-h5Rα and three clones of CTLL-h5Rα-β_c were analyzed. The K_d values are 650 and 720 pM for CTLL-h5Rα, and 310–450 pM for CTLL-h5Rα-β_c transfectants. The representative results were presented.

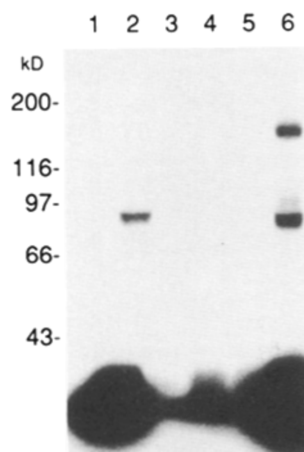

Figure 3. Chemical crosslinking of 125I-hIL-5 to CTLL-2 transfectants. (Lanes *1* and *2*) CTLL-h5Rα (expressing hIL-5Rα); (lanes *3* and *4*) CTLL-β_c (expressing β_c); and (lanes *5* and *6*) CTLL-h5Rα-β_c (expressing hIL-5Rα and β_c). Cells were incubated with 4 nM 125I-hIL-5 at 4°C for 2 h in the presence (lanes *1*, *3*, and *5*) or absence of (lanes *2*, *4*, and *6*) large molar excess of unlabeled IL-5, and were crosslinked with DSS. The cell lysates were subjected to SDS-PAGE under reducing conditions, and were analyzed by a BAS2000 Bioimaging Analyzer (Fuji Photo Film).

The value of binding affinity of a transfectant coexpressing hIL-5Rα and β_c (CTLL-h5Rα-β_c) did not differ so much, but was slightly higher (K_d = 310–450 pM) (Fig. 2, ●) than that of CTLL-h5Rα. However, the interaction of β_c with hIL-5Rα was confirmed by chemical crosslinking experiments. When CTLL-h5Rα was incubated with 125I-IL-5 and crosslinked with DSS, an ~80-kD band corresponding to the complex of hIL-5Rα and hIL-5 was detected (Fig. 3, lane *2*). In contrast, when CTLL-h5Rα-β_c was crosslinked with 125I-IL-5, a ~140-kD band corresponding to the complex of β_c and hIL-5 was detected in addition to 80-kD band (Fig. 3, lane *6*). Though β_c did not greatly change the binding affinity of hIL-5Rα and hIL-5, it indeed existed in close proximity to hIL-5 when hIL-5Rα was expressed. It is highly suggestive that β_c interacts with hIL-5Rα in binding to hIL-5.

Reconstitution of the Functional hIL-5R. To clarify whether β_c is necessary for the signal transduction through IL-5R, the responsiveness of the transfectants was examined. As shown in Fig. 4, neither CTLL-h5Rα nor CTLL-β_c respond to hIL-5. Only CTLL-h5Rα-β_c responded to hIL-5 in DNA synthesis. Moreover, CTLL-h5Rα-β_c acquired the ability to proliferate in response to hIL-5 without IL-2 for more than 2 mo (data not shown). From these results, it was confirmed that β_c is indispensable for the functional hIL-5R. In murine IL-2–dependent cells, reconstituted hIL-5R could associate to murine cytoplasmic proteins that transduce growth signals.

Consequences of the Deletion of the Cytoplasmic Domain of α Subunit. From these transfection experiments, it was confirmed that the common β subunit shared among receptors for IL-5, IL-3, and GM-CSF, AIC2B in mice and β_c (KH97) in humans, is indispensable to construct functional IL-5Rs.

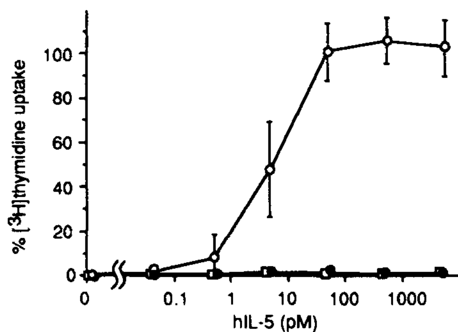

Figure 4. IL-5–dependent proliferation of CTLL-2 transfectants expressing hIL-5Rs. Cells were incubated for 48 h in the presence of increasing concentrations of hIL-5, and incorporated [^{3}H]thymidine was measured. The results are expressed as the percentage of incorporation of [^{3}H]thymidine in the same cells incubated with 100 Units/ml of hIL-2. Data are shown as mean ± SD of three independent transfectant clones. (●) CTLL-h5Rα (expressing hIL-5Rα), (□) CTLL-β_c (expressing β_c), and (O) CTLL-h5Rα-β_c (expressing hIL-5Rα and β_c).

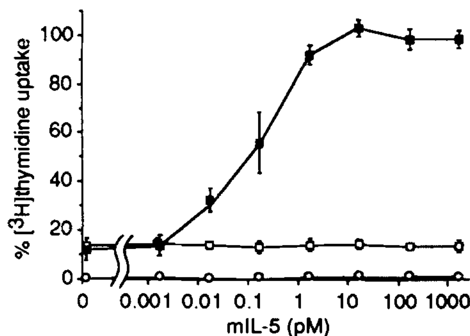

Figure 6. IL-5–induced proliferation of FDC-P1 transfectants expressing wild-type (■) or mutant mIL-5Rα (□), and CTLL-2 transfectants coexpressing mutant mIL-5Rα and AIC2B (O). Cells were incubated for 48 h in the presence of various concentrations of mIL-5 and incorporated [^{3}H]thymidine was measured. The results are expressed as the percentage of incorporation of [^{3}H]thymidine in the same cells incubated with 100 U/ml of mIL-3 for FDC-P1 transfectants or 100 U/ml of hIL-2 for CTLL-2 transfectant. Data are shown as mean ± SD of three independent transfectant clones.

Sharing of the signal-transducing molecule explains many overlapping biological activities of these cytokines, particularly on eosinophils. However, IL-5, IL-3, and GM-CSF induce different responses depending on cell types. We hypothesized that the signals specific for respective cytokines may exist and be mediated by the relevant α subunit, specific components to respective receptors. To examine the mIL-5Rα function, we constructed the mutant cDNA which lacks the whole cytoplasmic domain (Fig. 5 *A*), and transfected into mouse IL-3–dependent FDC-P1 cells endogenously expressing AIC2B. First, we examined interaction of mutant α subunit and AIC2B. As shown in Fig. 5 *B*, the high (K_d = 10 pM) and low-affinity (K_d = 2 nM) mIL-5Rs were reconstituted on FDC-P1 transfectants. The high-affinity receptor was detected on FDC-P1 transfectants not only at 4°C but also at 37°C (data not shown), indicating that mutant mIL-5Rα molecules were retained on cell surface and interacted with AIC2B. Though the number of high-affinity mIL-5R on mutant mIL-5Rα transfectants was smaller than that on intact mIL-5Rα transfectants, it was indicated that the cytoplasmic portion of mIL-5Rα is not indispensable to interact with AIC2B. This interaction was also confirmed by crosslinking experiment (Fig. 5 *C*). The ∼75-kD complex of mutant mIL-5Rα and radio-labeled IL-5 and the ∼150-kD complex of AIC2B and IL-5 were detected on the FDC-P1 transfectants expressing the mutant α subunit. We next investigated the IL-5 responsiveness of mutant mIL-5Rα transfectants (Fig. 6, □). FDC-P1 transfected with wild-type mIL-5Rα prolifer-

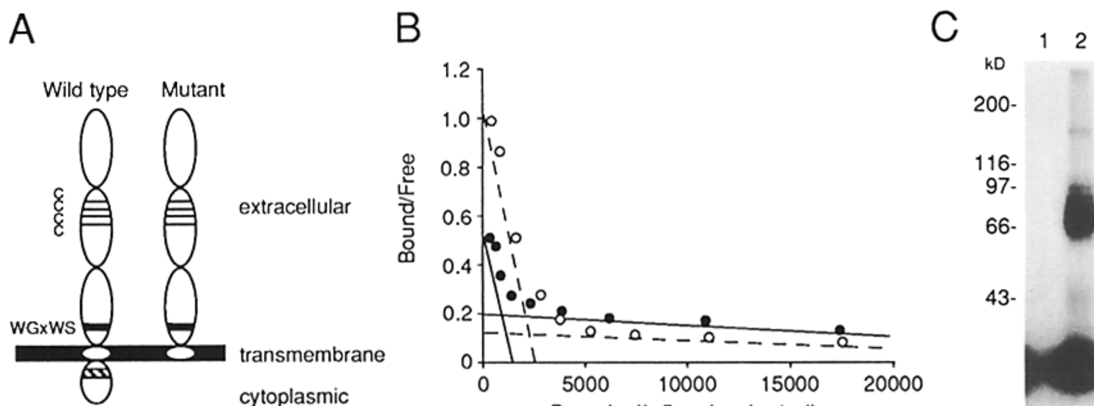

Figure 5. (*A*) Schematic representation of wild-type (*left*) and mutant mIL-5Rα (*right*). The extracellular portion of the mIL-5Rα is divided into three fibronectin-like domains (16). (*Hatched box*, cytoplasmic domain) Region (RLFPP^I/$_V$Pxxx^K/$_R$xx^L/$_I$xD) conserved among each α subunit of IL-5R, IL-3R, and GM-CSFR. Stop codon was generated just below the transmembrane domain, and the resulting mutant mIL-5Rα lacks the whole cytoplasmic domain. (*B*) Scatchard plot analysis of binding of ^{35}S-mIL-5 to FDC-P1 transfectants. (●) FDC-P1 transfectant expressing mutant mIL-5Rα; and (O) FDC-PI transfectant expressing wild-type mIL-5Rα. (*C*) Crosslinking of radiolabeled mIL-5 to the transfectant expressing mutant mIL-5Rα. Chemical crosslinking was performed in the presence (lane *1*) or absence (lane *2*) of 100-fold molar excess of unlabeled IL-5. The cell lysates were subjected to SDS-PAGE under reducing conditions, and were analyzed by BAS2000 Bioimaging Analyzer (Fuji Photo Film).

ated in response to mIL-5 as previously shown (4). In contrast, FDC-P1 transfectants expressing mutant mIL-5Rα did not respond to mIL-5. We obtained essentially the same result with CTLL-2 transfectants. CTLL-2 transfectants coexpressing mutant mIL-5Rα and AIC2B did not respond to mIL-5 (Fig. 6, O). The IL-5–mediated growth signal was never transmitted through the high-affinity IL-5R that consisted of mutant α and wild-type β subunit, indicating that the cytoplasmic domain of IL-5Rα has some important roles in transmitting IL-5 signals.

Discussion

We showed that both the α and β subunits are indispensable to form the functional IL-5R. hIL-5Rβ was revealed to be the same molecule to the common β subunit (β_c) of receptors for hGM-CSF and hIL-3. In contrast to mIL-5R, or to receptors for hIL-3 and hGM-CSF, β_c did not contribute much to hIL-5 binding affinity. We observed the same result using L cell or COS7 cell transfectants (data not shown), indicating that the same affinity of the reconstituted hIL-5R is independent of the nature of the parental cell line used for transfection. In other words, the hIL-5 binding is fully reconstituted by coexpressing hIL-5Rα and β_c. Tavenier et al. (24) have also reported that β_c is hIL-5Rβ. They isolated cDNAs encoding the soluble form of hIL-5Rα, and reported that COS cells expressing chimeric human–mouse IL-5Rα bind hIL-5 with low affinity (K_d = 1 nM) by itself, and that cotransfection of β_c with the chimeric IL-5Rα leads to a fourfold increase (K_d = 250 pM) in binding affinity (24). The usage of the chimeric IL-5Rα may lead to somewhat different results from ours presented in this report. Recently, Tavernier et al. (25) reported that hIL-5 binding affinity of COS cells coexpressing the full-length hIL-5Rα and β_c is only twofold higher than that of COS cells expressing hIL-5Rα alone. However, it is still not clear how the cross-competition of hIL-5 binding by hIL-3 or hGM-CSF occurs. It is supposed that binding of hIL-5 is irrelevant to the existence of β_c, as the binding affinity of α alone does not differ so much from that of α/β complex in contrast to hIL-3R and hGM-CSFR systems. The establishment of transfectant coexpressing β_c and α subunits of hIL-5R, hIL-3R, and hGM-CSFR will answer this confusing question.

In addition to receptors for IL-5, IL-3, and GM-CSF, sharing of signal-transducing component has been demonstrated in receptors for IL-6, leukemia inhibitory factor (LIF), ciliary neurotropic factor (CNTF), and oncostatin M (26). In the IL-6R system, the cytoplasmic and transmembrane domains of the ligand binding subunit (p80 IL-6R) are not required to transduce the growth signal, since the complex of the soluble form of p80 IL-6R and IL-6 associates with the signal-transducing subunit, gp130. There exist some differences between the IL-5R and receptor systems that use gp130 as a signal transducer. First, not only extracellular but also transmembrane regions of IL-5Rα are necessary to interact with β subunit. The anchoring of IL-5Rα is necessary for interacting with the β subunit, since the soluble form of mIL-5Rα inhibits binding of mIL-5 to IL-5–dependent cells (27) and does not induce proliferation of FDC-P1 even in the presence of IL-5 (Kikuchi, Y., S. Takaki, and K. Takatsu, unpublished data). Second, the cytoplasmic domain of IL-5Rα plays an important role in transducing the IL-5 signal. Mutant IL-5Rα, which lacks the whole cytoplasmic domain, did not transduce the IL-5–mediated growth signal, though the interaction to AIC2B was not completely impaired (Figs. 5 and 6). It is not clear at this time, how the α subunit functions in signal transduction. Each α subunit of IL-5R, IL-3R, and GM-CSFR has conserved region ($RLFPP^{I}/_{V}Pxxx^{K}/_{R}xx^{L}/_{I}xD$) just underneath the transmembrane domain (4, 18). This region may be important to interact with the cytoplasmic domain of the common β subunit or with a certain common signal-transducing molecule. The elements of the COOH-terminal region of the respective α subunit diversified relatively from one another. The specific function of respective cytokine may depend on the structure of the distal part of the cytoplasmic portion of the α subunits. Or, each α subunit may simply support the function of the common β subunit by inducing conformational change or dimerization of the β subunit. CTLL-2 cells transfected with the chimeric receptor that consists of the extracellular domain of erythropoietin receptor (EPO-R) and the cytoplasmic domain of AIC2A, become responsive to EPO (28). Recent studies showed that EPO-R may be activated by homodimerization (29). If that is the case, homodimerization of the cytoplasmic domain of AIC2A may be sufficient to transmit the IL-3–mediated signal. From a high degree of homology between AIC2A and AIC2B (6), it is supposed that similar dimerization mechanism may be involved in IL-5–mediated signal transduction. However, this may only be the case in the signal transduction for cell growth. In other cases, such as signals for B cells to induce differentiation for Ig-secreting cells, the cytoplasmic domain of the α subunit may have some important roles in transmitting IL-5–specific signal. It is possible that there are several signal-transducing machineries that connect with the membrane receptors to the intracellular device, and that some machineries function only in a limited cell type.

A recent study (30) showed that the cytoplasmic region of β_c has critical function in transducing growth signal. In addition, it was shown that the cytoplasmic region of hGM-CSFRα also has some roles in transmitting hGM-CSF–mediated signal (30). The transfectant of mIL-3–dependent Ba/F3 or mIL-2–dependent CTLL-2 expressing mutant hGM-CSFRα and β_c does not respond to hGM-CSF at the beginning of culture, but adapts to response to hGM-CSF several days later (30). In the case of mIL-5Rα, the cytoplasmic domain was indispensable for transmitting signal, because the FCD-P1 transfectant expressing mutant IL-5Rα and the CTLL-2 transfectant coexpressing mutant IL-5Rα and AIC2B never became responsive to mIL-5. Even when the transfectants were cultured for several weeks in the presence of mIL-5, no IL-5–responsive transfectant grew up (data not shown). This discrepancy between hGM-CSFR and mIL-5R may suggest the functional difference of each α subunit. In addition, CTLL-2 transfectants expressing hIL-3Rα became responsive to hIL-3 because of the induction of the intrinsic AIC2B expression, whereas the transfectant expressing hGM-CSFRα

expression, whereas the transfectant expressing hGM-CSFRα did not induce any AIC2B expression (31). There is an interesting report (32) showing that IL-3 and GM-CSF induce self-renewal and differentiation activity, respectively, in different proportions in FDC-mix cells. These results may reflect the difference of signal-transmitting ability of each α subunit. Further studies using mutant receptors and reconstitution experiments in a variety of cell types will be required to dissolve the function of the common β subunit and ligand-specific α subunits in signal transduction.

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