

## SUCCESSFUL TREATMENT OF AUTOIMMUNITY IN NZB/NZW F<sub>1</sub> MICE WITH MONOCLONAL ANTIBODY TO L3T4

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The advent of hybridoma technology has rekindled hopes of using antibodies as specific therapeutic agents (1-4). Several reports have focused attention on the potential use of monoclonal antibodies (mAb)<sup>1</sup> either as antitumor agents (4-15) or as immunosuppressive agents designed to facilitate organ transplantation (16-21). Early therapeutic trials in humans have demonstrated that certain mAb can be used to retard the progression of lymphoid malignancy (10, 11) or to reverse renal allograft rejection (17, 18). However, in most cases, the beneficial effects of treatment have been transient (4, 12-17) due in part to the development of host immunity to the administered mAb (4, 9, 16, 17).

Recently, (22) we treated three murine models for systemic lupus erythematosus (SLE) with biweekly injections of rat anti-T cell (anti-Thy-1.2) mAb in order to examine the role of T cells in the pathogenesis of murine lupus and to explore the possibility of using antilymphocyte mAb to treat autoimmunity. Treatment with anti-Thy-1.2 substantially reduced circulating T cells in all three strains (MRL/lpr, NZB/NZW F<sub>1</sub>, BXSB), despite development of antibodies to rat Ig. Therapy was beneficial in MRL/lpr mice. It reduced autoantibody production, retarded renal disease, and markedly prolonged life. In contrast, treatment did not reduce autoimmunity in NZB/NZW F<sub>1</sub> (B/W) mice, and it caused fatal anaphylaxis in BXSB mice. These findings demonstrate that antilymphocyte mAb can serve as specific probes to examine the cells that contribute to autoimmunity. The results in MRL/lpr mice illustrate the potential therapeutic value of antilymphocyte mAb when a pathogenic cell subset can be identified. However, the results in BXSB mice emphasize equally the potential hazards of the host immune response to treatment with mAb.

The development of a new rat mAb (GK1.5) reactive with mouse helper T cells provides an opportunity for a more selective approach to the study of T cell regulation of autoimmunity in murine lupus. This antibody recognizes a glycoprotein antigen, designated L3T4, that is the mouse homologue for the human T cell antigen termed Leu-3 or T4 (23). Like Leu-3/T4 in humans, L3T4

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<sup>1</sup>Abbreviations used in this paper: BGG, bovine gamma globulin; BSA, bovine serum albumin; BUN, blood urea nitrogen; ELISA, enzyme-linked immunosorbent assay; mAb, monoclonal antibody; MHA II, class II major histocompatibility antigens; SLE, systemic lupus erythematosus; TLI, total lymphoid irradiation.

participates in the T cell response to class II major histocompatibility antigens (MHA II) on antigen-presenting cells (24–28). Antibody to L3T4 inhibits most MHA II-dependent T cell responses in vitro (25–27). Therefore, administration of mAb against L3T4 might alter immune responses in vivo and thereby influence the course of autoimmune disease. To test this hypothesis, we treated B/W female mice with weekly injections of GK1.5 (anti-L3T4) beginning at age 4 mo. Treatment produced a sustained reduction in circulating T cells expressing L3T4. It also dramatically reduced autoantibody concentrations, retarded renal disease, and prolonged life. Mice treated with rat anti-L3T4 mAb developed little or no antibody to the administered rat Ig. In contrast, control mice treated with purified nonimmune rat IgG developed high titers of antibody to rat Ig. These findings establish that autoimmune disease in B/W mice is T cell-dependent. They further demonstrate that: (a) mAb directed against helper T cells can significantly improve autoimmune disease in B/W mice; and (b) the beneficial effects of treatment with anti-L3T4 may not be complicated by the development of a host immune response to therapy.

### Materials and Methods

*Mice.* B/W mice were bred in our colony at the San Francisco Veterans Administration Medical Center from NZB females, purchased from The Jackson Laboratory, Bar Harbor, ME, and NZW males purchased from Simonsen Laboratory, Gilroy, CA.

*Treatment Regimen.* 10 mice were treated with a rat IgG2b mAb against L3T4, designated GK1.5 (23). The hybridoma used to produce GK1.5 was generously provided by Dr. Frank W. Fitch, University of Chicago. Antibody to L3T4 was harvested as ascites from sublethally irradiated BALB/c mice, partially purified by ammonium sulfate precipitation, dialyzed against phosphate-buffered saline, and quantified by protein electrophoresis and measurement of optical density. Treatment consisted of an initial intravenous injection of 2 mg of anti-L3T4, followed by weekly intraperitoneal injections (2 mg per mouse). In preliminary studies, we determined that an intravenous injection of 2 mg of anti-L3T4 produces saturation binding of circulating and splenic target cells, and substantial, though incomplete, binding of L3T4<sup>+</sup> lymph node cells and thymocytes (unpublished data). Two control groups were also studied: one group (10 mice) received weekly 2-mg injections of chromatographically purified rat IgG (Cappel Laboratories, Cochranville, PA); the other group (11 mice) received saline.

*Fluorescence Analysis of Lymphocyte Subpopulations.* Peripheral blood was obtained from individual mice by retroorbital bleeding into heparinized pipettes. Mononuclear cells were separated by centrifugation over Lympholyte-M (Cedarlane Laboratories, Ontario, Canada), and quantified using a Coulter ZBI cell counter (Coulter Electronics, Inc., Hialeah, FL). Mononuclear cell subsets were identified by staining with fluorescein-conjugated mAb, as described previously (29). The antibodies used for analysis included: anti-Thy-1.2 (30-H12) to identify all T cells, anti-L3T4 (GK1.5) and anti-Lyt-2 (53-6) to identify the major T cell subsets, and anti-ThB (53-9) to identify B cells. Fluorescein-conjugated mouse anti-rat kappa chain mAb (MAR 18.5; B-D FACS Systems, Sunnyvale, CA) was used to detect anti-L3T4 on target cell surfaces. Except as noted, fluorescence analysis was always performed immediately before treatment, i.e., 1 wk after the previous injection.

*Assessment of Renal Disease.* Blood urea nitrogen (BUN) was determined on samples from individual mice using a Centrifichem System 400 (Union Carbide, Danbury, CT). Proteinuria was measured colorimetrically by the use of Albustix (Miles Laboratories Inc., Elkhart, IN). This produces an approximation of proteinuria as follows: trace, 10 mg/dl; 1+, 30 mg/dl; 2+, 100 mg/dl; 3+, 300 mg/dl; 4+, 1,000 mg/dl. All measurements of proteinuria were performed by an observer who had no knowledge of the given treatment.

*Measurement of Serum Antibodies to Double-stranded DNA.* Anti-DNA antibody concentrations were assessed by a solid phase enzyme-linked immunosorbent assay (ELISA)

derived from the method of Fish and Ziff (30). Immulon II polyvinyl microtitration trays were coated sequentially with a 50 µg/ml solution of poly-L-lysine (Sigma Chemical Co., St. Louis, MO) in 0.1 M Tris-HCl buffer, pH 7.3 (75 µg/well), a 20 µg/ml solution of poly(dA-dT) (Sigma Chemical Co.) in Tris buffer (75 µl/well), and a 2% solution of bovine serum albumin (BSA) (Sigma Chemical Co.) in Tris buffer (250 µl/well). Serum samples that had been serially diluted in Tris buffer containing 1% BSA and 2% bovine gamma globulin (BGG) (Sigma Chemical Co.) were then incubated at 75 µl/well for 1.5 h at room temperature. The wells were then washed five times and incubated with peroxidase-conjugated goat anti-mouse Ig that had been extensively absorbed with rat Ig (0.3 µg/well; Cappel Laboratories). After incubation at room temperature for 1 h, the wells were washed five times and treated in the dark for 10 min with *o*-phenylenediamine (100 µl/well). The enzymatic reaction was stopped with 2 N H<sub>2</sub>SO<sub>4</sub> (200 µl/well), and absorbance was measured at 490 nm. Serum from adult MRL/lpr and C57BL/6 mice served as positive and negative controls, respectively. The specificity of the assay was demonstrated using wells that had not been coated with poly(dA-dT).

*Measurement of Serum Antibodies to Rat Ig.* Antibodies to rat Ig were measured by an ELISA technique similar to the one described above. Briefly, Immulon II polyvinyl microtitration trays were coated with rat Ig mAb (0.5 µg 30-H12/well) followed by 2% BSA in 0.1 M Tris-HCl buffer. Serum samples were serially diluted in Tris buffer containing 1% BSA and 2% BGG, then incubated at 75 µl/well for 1.5 h at room temperature. The wells were then washed, incubated with peroxidase-conjugated goat anti-mouse Ig that had been absorbed with rat Ig, washed again, and then treated in the dark with *o*-phenylenediamine exactly as described above. Mouse anti-rat kappa chain mAb (MAR 18.5) and normal mouse serum served as positive and negative controls, respectively.

*Measurement of Serum IgM and IgG Levels.* Serum concentrations of mouse IgM and IgG were measured by ELISA. Immulon II polyvinyl microtitration trays were coated with a 10 µg/ml solution of either goat anti-mouse IgG or goat anti-mouse IgM (both, Cappel Laboratories), followed by 2% BSA in 0.1 M Tris-HCl buffer. Serum samples were serially diluted in Tris buffer containing 1% BSA and 2% BGG, then incubated at 75 µl/well for 1.5 h at room temperature. The wells were then washed, incubated with peroxidase-conjugated goat anti-mouse Ig that had been absorbed with rat Ig, washed again, and then treated in the dark with *o*-phenylenediamine, as described above. Purified mouse IgM and IgG (Miles Laboratories) were used to generate standard curves and document the specificity of the assay.

## Results

*Effect of Age on Circulating Lymphocyte Subpopulations in Untreated B/W Mice.* In control B/W mice treated with saline, there was a spontaneous age-dependent reduction in circulating T lymphocytes (Fig. 1, A and B). The number of circulating B lymphocytes remained relatively constant (Fig. 1C). Although T cell counts fell by ~50% between 4 and 8 mo of age, L3T4<sup>+</sup> cells and Lyt-2<sup>+</sup> cells were comparably affected and, therefore, the L3T4/Lyt-2 (helper/suppressor) ratio remained constant (Fig. 1D). Treatment with weekly injections of nonimmune rat IgG did not affect the spontaneous progressive changes in circulating lymphocyte subpopulations in B/W mice.

*Effect of Treatment With Anti-L3T4 mAb on Circulating Lymphocyte Subpopulations.* Treatment of B/W mice with weekly injections of anti-L3T4 mAb produced a dramatic and sustained reduction in circulating L3T4<sup>+</sup> lymphocytes (Fig. 1A). Circulating L3T4<sup>+</sup> cells were reduced by 30% 24 h after the first injection, by 90% 1 wk later, and by 95% thereafter. Fluorescence analysis of circulating lymphocytes using mouse anti-rat kappa chain mAb demonstrated persistence of administered antibody on the few remaining target cells 7 d after

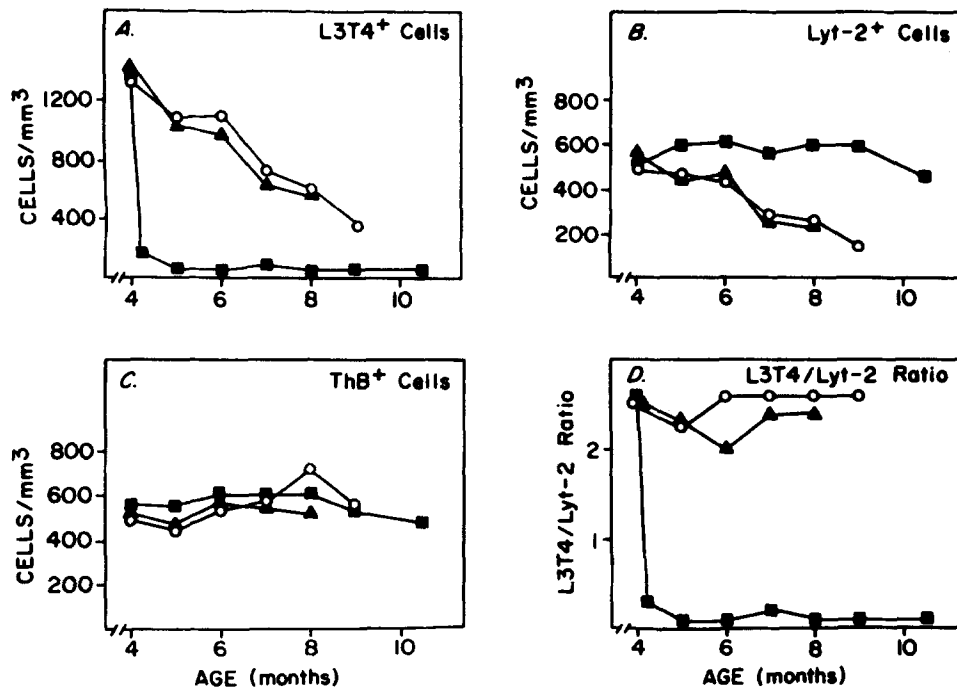


FIGURE 1. Circulating lymphocyte subpopulations in B/W mice treated with weekly injections of saline (○), nonimmune rat IgG (▲), or anti-L3T4 mAb (■) beginning at age 4 mo. Helper T cells, suppressor/cytotoxic T cells, and B cells were identified using fluorescein-conjugated anti-L3T4 mAb (A), anti-Lyt-2 (B), and anti-Thy B (C), respectively. The relative proportion of L3T4<sup>+</sup> and Lyt-2<sup>+</sup> T cells is shown in D.

injection. Staining with fluorescein-conjugated anti-Thy-1.2 mAb and anti-Lyt-2 established that, after 1 wk of therapy, >90% of circulating T cells in treated mice expressed Lyt-2, indicating that the reduction in L3T4<sup>+</sup> T cells reflected target cell depletion rather than antigen modulation. The effect of treatment with anti-L3T4 was specific. The number of circulating B cells and Lyt-2<sup>+</sup> T cells remained stable in treated mice (Fig. 1, B and C). The mean L3T4/Lyt-2 ratio in treated mice was 0.1:1, compared with 2.6:1, in untreated mice.

**Host Immune Response to Treatment.** Control mice treated with nonimmune rat IgG all developed high titers of antibody to rat Ig (Fig. 2). Host antibodies were detectable 7 d after the first injection of rat IgG and rapidly rose to a peak mean titer of 1:4,500. In contrast, only 3 of 10 mice treated with rat anti-L3T4 mAb developed antibodies to rat Ig. In these mice, antibodies to rat Ig first appeared after 2–3 mo of therapy and were present only in relatively low titer (<1:400). 7 of the 10 treated mice never developed detectable antibody to rat Ig. This is in striking contrast to our previous observation that B/W mice treated with rat anti-Thy-1.2 mAb of the same isotype as anti-L3T4 all develop high titers of anti-rat Ig (22).

**Anti-L3T4 Reduces Autoimmunity.** Treatment of B/W mice with anti-L3T4 mAb prevented development of high titers of antibody to double-stranded DNA (Fig. 3). Although small amounts of anti-DNA antibody appeared within the first

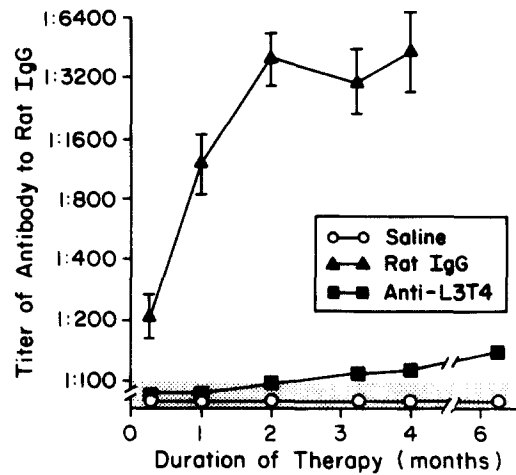


FIGURE 2. Geometric mean titer ( $\times$  SEM) of antibodies to rat Ig in B/W mice treated with saline (○), nonimmune rat IgG (▲), or anti-L3T4 mAb (■). The shaded area indicates assay results using normal mouse sera as negative controls.

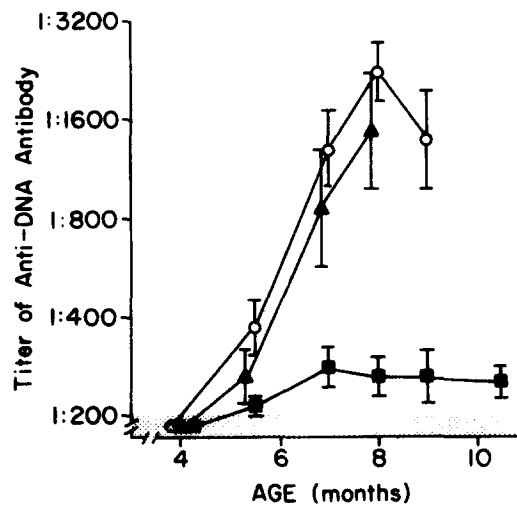


FIGURE 3. Geometric mean titer ( $\times$  SEM) of antibody to double-stranded DNA in B/W mice treated with saline (○), nonimmune rat IgG (▲), or anti-L3T4 mAb (■). The shaded area indicates the titer of anti-DNA antibody ( $<1:200$ ) in normal (C57BL/6) mice.

2 mo of therapy with anti-L3T4, the titers of anti-DNA antibody were markedly lower in treated mice than in control mice, and the titers remained low throughout the duration of therapy. At age 8 mo, the geometric mean titer of anti-DNA antibody was  $1:2,200 \pm 1.2$  in mice treated with saline,  $1:1,500 \pm 1.5$  in mice treated with nonimmune rat IgG, and  $1:270 \pm 1.1$  in mice treated with anti-L3T4 ( $P < 0.0005$  compared with either control group; Student's  $t$  test). The reduction in anti-DNA antibody did not reflect a generalized reduction in total Ig levels in treated mice (Table I). After 4 mo of treatment, there was a slight reduction in the mean IgG concentration in treated mice that was not statistically significant.

TABLE I  
Effect of Treatment on Ig Concentration

Treatment	IgM*		IgG*	
	4-mo-old	8-mo-old	4-mo-old	8-mo-old
Saline	9.5 ± 0.2	9.2 ± 0.2	15.5 ± 0.2	15.7 ± 0.2
Rat IgG	9.6 ± 0.2	9.6 ± 0.2	15.7 ± 0.3	15.5 ± 0.6
Anti-L3T4	9.6 ± 0.2	10.3 ± 0.2 <sup>‡</sup>	15.5 ± 0.3	15.2 ± 0.3

\* Log<sub>2</sub> titer ( $\bar{x} \pm \text{SEM}$ ) as measured by ELISA.

<sup>‡</sup>  $P < 0.05$  compared to pretreatment IgM levels and to IgM levels in both control groups.

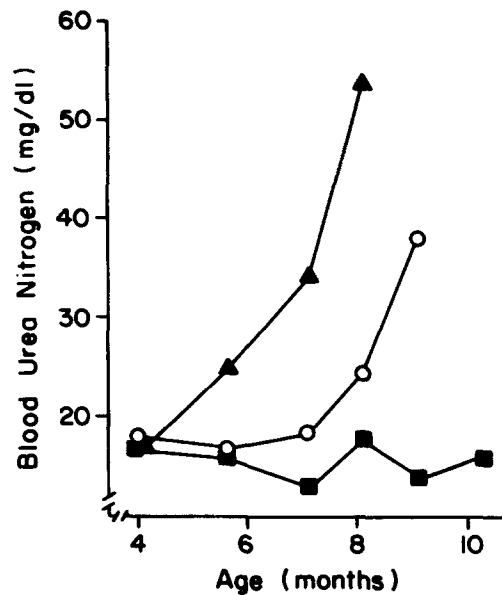


FIGURE 4. Mean BUN in B/W mice treated with saline (○), nonimmune rat IgG (▲) or anti-L3T4 mAb (■).

However, there was a significant increase in the mean IgM concentration in treated mice compared with pretreatment levels, and with IgM levels in control mice. Increased plasma IgM has been reported previously (31) in association with successful treatment of B/W mice.

**Anti-L3T4 Reduces Renal Disease.** The reduction in anti-DNA antibody concentration in mice treated with anti-L3T4 was associated with a significant reduction in renal disease. Renal function, as assessed by BUN, deteriorated steadily in both control groups, but was preserved in mice treated with anti-L3T4 (Fig. 4). Renal insufficiency occurred earliest in mice treated with nonimmune rat IgG, perhaps as a consequence of the host immune response to rat Ig. At age 7 mo, the mean BUN in mice treated with rat IgG was  $34.2 \pm 12.1$  mg/dl, compared to  $18.5 \pm 2.7$  mg/dl in mice treated with saline ( $P < 0.05$ ; Mann-Whitney  $U$  test) and  $13.1 \pm 0.8$  mg/dl in mice treated with anti-L3T4 ( $P < 0.01$  compared with rat IgG treatment;  $P < 0.05$  compared with saline treatment). By 9 mo, the mean BUN in mice treated with saline rose to  $38.0 \pm 11.6$  mg/dl, compared with  $14.3 \pm 0.9$  mg/dl in mice treated with anti-L3T4 ( $P$

< 0.01). Severe proteinuria ( $\geq 3+$ ) developed in 50–60% of mice in each control group, but in none of the mice treated with anti-L3T4 ( $P < 0.05$ ; chi-square analysis) (Fig. 5). Moderate proteinuria ( $2+$ ) developed in 16 of 21 control mice but in only 2 of 10 treated mice ( $P < 0.05$ ). These two mice were among the three treated mice that developed low titers of antibody to rat Ig, suggesting that the immune response to rat Ig may have contributed to the development of proteinuria.

*Anti-L3T4 Prolongs Survival.* Treatment with anti-L3T4 mAb dramatically prolonged life (Fig. 6). Median survival was 9.3 mo in mice treated with saline and 7.6 mo in mice treated with rat IgG. In contrast, all of the mice treated with anti-L3T4 are still alive at 10 mo. The difference in 10-mo survival between

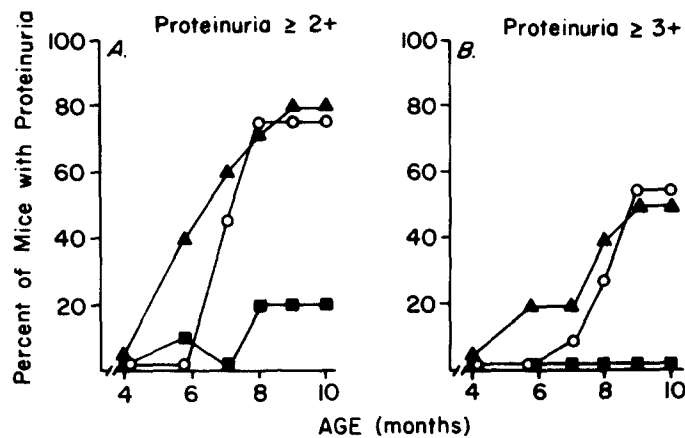


FIGURE 5. Frequency of significant proteinuria in B/W mice treated with saline (○), nonimmune rat IgG (▲), or anti-L3T4 mAb (■). (A) Percent of mice with proteinuria  $\geq 2+$  (100 mg/dl). (B) Percent of mice with proteinuria  $\geq 3+$  (300 mg/dl). To reflect accurately the development of renal disease in all mice, each point reflects the current level of proteinuria in surviving mice, as well as the last measurement of proteinuria in deceased mice.

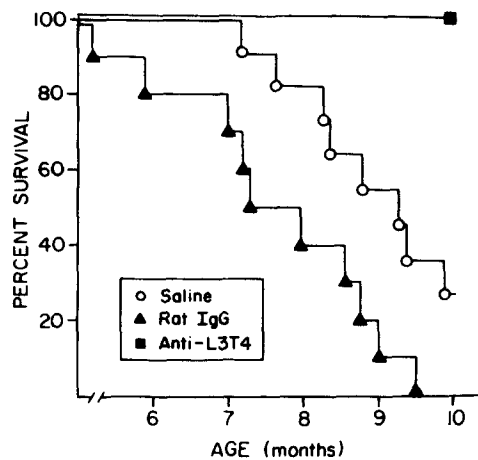


FIGURE 6. Survival in B/W mice treated with saline (○), nonimmune rat IgG (▲), or anti-L3T4 mAb (■).

mice treated with anti-L3T4 and control mice is strongly significant ( $P < 0.001$  compared with the saline control group;  $P < 0.00001$  compared with the rat IgG control group; chi-square analysis). The difference in mean survival between the two control groups is also statistically significant ( $P < 0.05$ ;  $t$  test), i.e., treatment with nonimmune rat Ig accelerated mortality.

### Discussion

To clarify the role of helper T cells in the pathogenesis of autoimmune disease in the B/W model for SLE, we treated female B/W mice with repeated injections of a rat mAb directed against the mouse helper T cell antigen, L3T4. Treatment depleted circulating target cells, reduced autoantibody production, retarded renal disease, and prolonged life. Moreover, treated mice produced little or no host antibodies to the administered rat mAb. These findings provide the first clear demonstration that autoimmune disease in B/W mice is T cell dependent. They further suggest that mAb directed against specific helper T cell antigens may be effective in the treatment of certain autoimmune diseases, and that the therapeutic benefit may be achieved without provoking an undesirable, and potentially hazardous, immune response to the mAb.

For two decades, the B/W strain has been studied (32, 33) as a model for SLE in humans. Early studies (34–37) focused attention on T cell abnormalities in B/W mice, emphasizing defects in suppressor T cell number and function. Recent studies, however, have cast doubt on the significance of these T cell abnormalities. For example, neonatal thymectomy has little effect on the course of autoimmunity in B/W mice (38), but elimination of a specific subset of B cells prevents autoimmune disease (39). Other studies, demonstrating B cell abnormalities, and indicating that B cell abnormalities may precede demonstrable T cell abnormalities in B/W mice, have suggested that autoimmunity in these mice may reflect a primary B cell defect, and that T cell defects may be secondary phenomena (40–43). Our results demonstrate conclusively that T cells, specifically helper T cells, play an important role in the pathogenesis of autoimmune disease in B/W mice. If primary defects occur in other cell types, particularly B lymphocytes, these cells nonetheless require helper T cells for the expression of disease.

It has been postulated that autoimmunity in B/W mice might reflect selective loss of suppressor T cells (36, 37), perhaps as a consequence of the action of natural thymocytotoxic antibodies (44, 45). Our findings in untreated B/W mice show that, although progressive T lymphocytopenia occurs, there is no selective effect on suppressor (Lyt-2<sup>+</sup>) T cells. Rather, both major T cell subsets are comparably reduced, and the L3T4/Lyt-2 ratio is unchanged. There is, thus, no numerical imbalance between helper and suppressor/cytotoxic T cells, although functional differences cannot be excluded.

The L3T4 molecule is expressed on a distinct subpopulation of T cells previously referred to descriptively as helper T cells. More precisely, L3T4 identifies T cells that respond to MHA II on antigen-presenting cells (24–27). The functional importance of the L3T4 molecule is demonstrated by the observation that mAb against L3T4 blocks in vitro T cell responses to MHA II (25–27). The beneficial effects of anti-L3T4 in B/W mice may, therefore, be due not only to target cell depletion, but also to direct inhibition of T cell responses that



are dependent on the recognition of MHA II. The latter mechanism would imply that autoimmunity, like immunity to foreign antigens, requires a T cell response to MHA II. Our results are compatible with this possibility, but they do not prove it. We previously (22) treated B/W mice with mAb against Thy-1.2, an antigen expressed on all T cells. Although treatment reduced circulating L3T4<sup>+</sup> T cells by 75%, there was a comparable reduction in Lyt-2<sup>+</sup> T cells, and no improvement in autoimmunity. The failure of anti-Thy-1.2 to improve autoimmunity despite depletion of L3T4<sup>+</sup> cells suggests either that: (a) regulation of autoimmunity in B/W mice involves a balance between L3T4<sup>+</sup> cells and Lyt-2<sup>+</sup> cells that is not disturbed by treatment with anti-Thy-1.2; or (b) successful treatment with anti-L3T4 requires functional impairment of the L3T4 molecule.

An important observation in our present studies was the relative lack of host immunity to the anti-L3T4 antibody. Previous attempts to use mAb as therapeutic agents in humans and in mice have been complicated by the development of a host immune response to the mAb (4, 9, 16, 17, 22). In B/W mice treated with rat anti-Thy-1.2 mAb (subclass IgG2b), the development of antibody to rat Ig was associated with accelerated mortality, even though autoimmunity was not affected (22). In autoimmune BXSB mice, treatment with anti-Thy-1.2 caused fatal anaphylaxis (22). The current study reemphasizes the potential hazards of treatment with foreign Ig, because administration of purified nonimmune rat IgG significantly reduced survival. In this context, the weak host immune response to rat anti-L3T4 mAb (subclass IgG2b) takes on added significance. The ability to administer anti-L3T4 without generating high titers of host antibody to rat Ig may not only maximize the therapeutic effect of anti-L3T4, it may also minimize the risks associated with the host immune response to foreign protein.

The lack of host immunity to repeated injections of anti-L3T4 is the first demonstration that anti-L3T4 can interrupt the immune response *in vivo*. It remains to be determined if anti-L3T4 will block the *in vivo* response to foreign antigens other than itself, although it has been demonstrated (25) that anti-L3T4 can block *in vitro* responses to foreign antigens that are presented in association with MHA II. Immune recognition of MHA II can also be blocked both *in vitro* and *in vivo* by mAb against MHA II (46–49). One group of researchers (50–52) have treated murine models for several autoimmune diseases with mAb against MHA II. This treatment was effective in experimental autoimmune encephalitis (50) and experimentally induced myasthenia gravis (51). It also increased survival in B/W mice, even though it did not reduce autoantibody production (52). In mice, MHA II are expressed on macrophages, B cells, and activated T cells (53), but it is not known whether successful treatment with mAb against MHA II is associated with depletion of these cell types. In humans, MHA II are expressed not only on certain lymphoid cells, but also on blood vessel endothelial cells (54). This may account for the severe toxicity of mAb against MHA II in monkeys (55), which may complicate the use of anti-MHA II in humans. Unlike MHA II, L3T4 appears to be restricted in its expression to a distinct subpopulation of T lymphocytes and T lymphocyte precursors (24). Therefore, anti-L3T4 mAb may provide an alternative to the use of anti-MHA II mAb that would be more selective in its effect on the immune system. The human homologue for the

L3T4 antigen has been identified (23), and mAb against this antigen have already been used to prolong renal allograft survival in nonhuman primates (19).

Treatment of B/W mice with anti-L3T4 had profound effects on the immune system that raise questions about the immune competence of treated mice. The reduction in L3T4<sup>+</sup> T cells creates an imbalance between T cell subpopulations that resembles the distribution of T cell subsets in acquired immunodeficiency syndrome (AIDS) in people (56). The beneficial reduction in antibodies to double-stranded DNA and antibodies to rat Ig may reflect a more generalized impairment of humoral immunity. Our studies do not establish the significance of these alterations in cellular and humoral immunity, but they do provide some preliminary insight. Despite a 10-fold reduction in autoantibody concentration, treatment with anti-L3T4 did not significantly depress Ig levels. Moreover, treated mice did not develop infectious complications, even though they were housed without special precautions in our main animal colony. Studies are currently in progress in our laboratory to determine the precise effects of treatment with anti-L3T4 on immune competence in normal and autoimmune mice.

The immunologic abnormalities in B/W mice closely parallel the immunologic abnormalities underlying SLE in humans. T lymphocytopenia, impaired suppressor T cell function, reduced lymphokine production, and B cell hyperactivity all occur in humans with SLE as well as in B/W mice, but the significance of these abnormalities remains controversial (32, 57–60). There is no fixed abnormality in the relative proportion of circulating T cell subsets in either B/W mice or humans with SLE (61), but our results make it clear that this does not exclude the possibility that T cells regulate autoimmunity in SLE. The similarities between SLE in humans and SLE in B/W mice suggest that they may share common pathogenetic mechanisms. Our findings in B/W mice therefore support the hypothesis that autoimmunity in people with SLE is regulated by T cells. This hypothesis is consistent with recent studies indicating that total lymphoid irradiation (TLI) improves lupus nephritis in humans (62–64). Although the effect of TLI on lymphocyte subsets in SLE has not yet been determined, TLI causes prolonged depletion and impaired function of Leu-3/T4<sup>+</sup> cells in people with rheumatoid arthritis (65–67). These observations add weight to the possibility that treatment with mAb against Leu-3/T4 would favorably influence the course of autoimmune disease in people with SLE. However, we believe that such treatment would be premature until the effects of anti-L3T4 on normal immune function have been thoroughly investigated.

### Summary

Autoimmune NZB/NZW mice were treated with weekly injections of monoclonal antibody (mAb) to L3T4, an antigen expressed on a distinct subpopulation of T cells that respond to class II major histocompatibility antigens. Treatment with anti-L3T4 depleted circulating target cells, reduced autoantibody production, retarded renal disease, and prolonged life relative to control mice treated either with saline or with purified nonimmune rat IgG. These findings establish that autoimmune disease in NZB/NZW mice is regulated by T cells. In contrast to mice treated with nonimmune rat IgG, mice treated with rat anti-L3T4 mAb

developed little or no antibody to rat Ig. Thus, the benefits of treatment with anti-L3T4 were achieved while minimizing the risks associated with a host immune response to therapy. This study raises the possibility that treatment with mAb against Leu-3/T4, the human homologue for L3T4, might be effective in the treatment of certain autoimmune diseases in people.

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