

REPLACED SHEETS	SG
☐ Description : paged to paged	
☒ Claim(s) : paged <u>38</u> to paged <u>42</u>	
☐ Drawing(s) : paged to paged	
☐ Abstract : paged to paged	
DATE OF RECEIPT	

- 1 -

**CYTOKINE SYNTHESIS INHIBITORY FACTOR. ANTAGONISTS
THEREOF. AND METHODS OF USING SAME**

Field of the Invention

5 The invention relates generally to methods and compositions
for treating diseases associated with immune system imbalances,
particularly imbalances involving humoral and cell-mediated immune
responses. The invention also includes proteins and antagonists thereof
capable of modulating the synthesis of certain cytokines involved in
10 immune system to achieve therapeutic effects.

BACKGROUND

Immune responses to antigen are classified as being
predominantly either *cell-mediated*, exemplified by the phenomena of
delayed-type hypersensitivity (DTH), or *humoral*, exemplified by the
15 production of antibodies. Cell-mediated immunity is of paramount
importance for the rejection of tumors and for recovery from many viral,
bacterial, protozoan, and fungal infections. In contrast, a humoral immune
response is the most effective form of immunity for eliminating toxins and
invading organisms from circulation. It has been observed that for
20 different antigens one or the other of these two responses often
predominates in a mutually exclusive fashion, and that the severity of some
diseases, e.g. leprosy, leishmaniasis, and some types of autoimmunity, may
be due the inappropriate dominance of one class of response over the other,
Mosmann et al, Immunol. Today, Vol 8, pgs. 223-227 (1987); Mosmann et al,

Ann. Rev. Immunol., Vol. 7, pgs. 145-173 (1989); Parish, Transplant. Rev, Vol. 13, pgs. 35-66 (1972); and Liew, Immunol. Today, Vol. 10, pgs. 40-45 (1989). It has further been observed that sets of cytokines are separately associated with DTH reactions and humoral immune responses, Cher et al, J. Immunol.,
5 Vol. 138, pgs. 3688-3694 (1987); and Mosmann et al (1987 and 1989, cited above), and it is thought that diseases associated with these classes of response are caused by the inappropriate production of the associated sets of cytokines.

For example, a large body of evidence suggests that excessive
10 production of gamma interferon (IFN- γ) is responsible for major histocompatibility complex (MHC) associated autoimmune diseases: Hooks et al, New England J. Med., Vol. 301, pgs. 5-8 (1979) (elevated serum levels of IFN- γ correlated with autoimmunity); Basham et al, J. Immunol., Vol. 130, pgs. 1492-1494 (1983) (IFN- γ can increase MHC gene product expression);
15 Battazzo et al, Lancet, pgs. 1115-1119 (11/12/83) (aberrant MHC gene product expression correlated with some forms of autoimmunity); Hooks et al, Ann. N.Y. Acad. Sci., Vol. 301, pgs. 21-32 (1980) (higher IFN- γ levels correlated to greater severity of disease in SLE patients, and histamine-release enhancing activity of interferon can be inhibited by anti-interferon sera); and Iwatani
20 et al, J. Clin. Endocrin. and Metabol., Vol. 63, pgs. 695-708 (1986) (anti-IFN- γ monoclonal antibody eliminated the ability of leucoagglutinin-stimulated T cells to induce HLA-DR expression). It is hypothesized that excess IFN- γ causes the inappropriate expression of MHC gene products which, in turn, causes autoimmune reactions against the tissues whose cells are
25 inappropriately expressing the MHC products and displaying autoantigens in the context of the products.

In the area of clinical parasitology, it has recently been observed that the levels of IFN- γ and IL-2 are important factors in the progression and/or resolution of the protozoan infection, leishmaniasis. In
30 particular, the presence of adequate levels of IFN- γ appears to be essential for the activation of infected macrophages to eliminate intracellular amastigotes, Mauel and Behin, in Cohen et al, eds., Immunology of Parasitic Infections (Blackwell, London, 1982). And, in murine models of the disease, it has been shown that high levels of IFN- γ and low levels of IL-4 are
35 associated with resolution, whereas low levels of IFN- γ and high levels of

IL-4 are associated with progression of leishmaniasis, Heinz et al, J. Exp. Med., Vol. 169, pgs. 59-72 (1989).

In view of the above, it would be advantageous to have available agents that could shift the dominance of one class of immune response to the other, and in particular that could suppress or increase the synthesis of IFN- γ and/or other cytokines, respectively, as required for therapy. Such agents would be highly advantageous for treatment of diseases associated with inappropriate or inadequate immune responses, such as tissue rejection, leishmaniasis and other parasitic diseases, and MHC associated immune disorders including rheumatoid arthritis, systemic lupus erythematosus (SLE), myasthenia gravis, insulin-dependent diabetes mellitus, thyroiditis, and the like.

SUMMARY OF THE INVENTION

The present invention is directed to mammalian cytokine synthesis inhibitory factor (CSIF), CSIF analogs, CSIF peptides, and CSIF antagonists. It includes nucleic acids coding for polypeptides exhibiting CSIF activity, as well as the polypeptides themselves, their agonistic and/or antagonistic analogs, methods for their production, and methods of using them to treat disorders associated with cytokine imbalances, particularly those leading to an inappropriate class of immune response. The invention also includes the use of CSIF or its antagonists, alone or as vaccine adjuvants, to selectively induce a predominantly cell-mediated immune response or a predominantly humoral immune response, respectively. Preferably, antagonists of CSIF are derived from monoclonal antibodies capable of blocking the biological activity of CSIF. The nucleic acids of the invention are defined (1) by their homology to, or their ability to form detectable hybrids with, the cloned complementary DNA (cDNA) sequences disclosed herein, and (2) by functional assays for CSIF activity applied to the polypeptides encoded by the nucleic acids. As used herein, the term "CSIF activity" in reference to a protein or a polypeptide means that the protein or polypeptide is capable of inhibiting or substantially reducing the level of production of at least one of the following cytokines in the assays described below: IFN- γ , interleukin-2 (IL-2), lymphotoxin, interleukin-3 (IL-3), or granulocyte-macrophage colony stimulating factor (GM-CSF).

A preferred embodiment of the invention is a mature human CSIF of the open reading frame defined by the following amino acid sequence:

5 MHSSALLCCL VLLTGVRASP GQGTQSENSC THFPGNLPNM
LRDLRDAFSR VKTFFQMKDQ LDNLLLKESL LEDFKGYLGC
QALSEMIQFY LEEVMPQAEN QDPDIKAHVN SLGENLKT
LRLRRCHRFL PCENKSKAVE QVKNAFNKLQ EKGITYKAMSE
FDIFINYIEA YMTMKIRN ,

wherein the standard one-letter symbols (see below) for L-amino acids are listed left to right starting from the N-terminal methionine. More preferably, the mature human CSIF is defined by the following amino acid sequence:

15 SPGQGTQSEN SCTHFPNLP NMLRDLRDAF SRVKTFFQMK
DQLDNLLLKE SLLEDFKGYL GCQALSEMIQ FYLEEVMPQA
ENQDPDIKAH VNSLGENLKT LRLRLRRCHR FLPCENKSKA
VEQVKNAFNK LQEKGIYKAM SEFDIFINYI EAYMTMKIR N .

In these sequences, the spaces are only for the convenience of the reader. The standard single-letter code is used here for the amino acids:

	A	Ala	Alanine	M	Met	Methionine
	C	Cys	Cysteine	N	Asn	Asparagine
20	D	Asp	Aspartic acid	P	Pro	Proline
	E	Glu	Glutamic acid	Q	Gln	Glutamine
	F	Phe	Phenylalanine	R	Arg	Arginine
	G	Gly	Glycine	S	Ser	Serine
	H	His	Histidine	T	Thr	Threonine
25	I	Ile	Isoleucine	V	Val	Valine
	K	Lys	Lysine	W	Trp	Tryptophane
	L	Leu	Leucine	Y	Tyr	Tyrosine.

The invention is based in part on the discovery and cloning of cDNAs which are capable of expressing proteins having CSIF activity.

30 Accordingly, several such clones designated pcD(SR α)-F115 (carrying a mouse CSIF gene), and pH5C and pH15C (each carrying a human CSIF gene) have been deposited with the American Type Culture Collection (ATCC),

Rockville, MD under the accession numbers 68027, 68191, and 68192, respectively.

Brief Description of the Figures

5 Figure 1 illustrates a dose-response relationship for the degree of IFN- γ synthesis inhibition in several mouse T cell clones treated with different amounts of CSIF.

 Figure 2 is a diagram illustrating the major features of the mammalian expression vectors pH5C and pH15C.

10 Figure 3 illustrates the RBS-ATG-polylinker region of plasmid TAC-RBS-hCSIF.

 Figure 4 illustrates the nucleotide sequence of the cDNA insert of pH15C.

DETAILED DESCRIPTION OF THE INVENTION

15 The invention includes mature polypeptides, or proteins, of the largest open reading frames of the cDNA inserts of pH5C, pH15C, pcD(SR α)-F115, and effectively homologous cDNAs, as well as antagonists thereof. For secreted proteins, an open reading frame usually encodes a polypeptide that consists of a mature or secreted product covalently linked at
20 its N-terminus to a signal peptide. The signal peptide is cleaved prior to secretion of the mature, or active, polypeptide. The cleavage site can be predicted with a high degree of accuracy from empirical rules, e.g. von Heijne, Nucleic Acids Research, Vol. 14, pgs. 4683-4690 (1986), and the precise amino acid composition of the signal peptide does not appear to be
25 critical to its function, e.g. Randall et al, Science, Vol. 243, pgs. 1156-1159 (1989); Kaiser et al, Science, Vol. 235, pgs. 312-317 (1987). Consequently, mature proteins are readily expressed by vectors encoding signal peptides quite different than that encoded by the open reading frame defined by the cDNA inserts of pH5C, pH15C, and pcD(SR α)-F115.

30

I. Obtaining and Expressing CSIF cDNAs

 The term "effectively homologous" as used herein means that the nucleotide sequence is capable of being detected by a hybridization probe derived from a cDNA clone of the invention. The exact numerical measure of

homology necessary to detect nucleic acids coding for CSIF activity depends on several factors including (1) the homology of the probe to non-CSIF coding sequences associated with the target nucleic acids, (2) the stringency of the hybridization conditions, (3) whether single stranded or double stranded probes are employed, (4) whether RNA or DNA probes are employed, (5) the measures taken to reduce nonspecific binding of the probe, (6) the nature of the method used to label the probe, (7) the fraction of guanidine and cytosine bases in the probe, (8) the distribution of mismatches between probe and target, (9) the size of the probe, and the like. Preferably, an effectively homologous nucleic acid sequence is at least ninety percent (90%) homologous to the cDNA of the invention. Most particularly, an effectively homologous nucleic acid sequence is one whose cDNA can be isolated by a probe constructed from a cDNA insert of pcD(SRa)-F115, pH5C, pH15C, or an equivalent thereof, using the hybridization protocol described in the examples with no more than a few false positive signals, e.g. fewer than a hundred. There is an extensive literature that provides guidance in selecting conditions for such hybridizations, e.g. Hames et al, *Nucleic Acid Hybridization: A Practical Approach* (IRL Press, Washington, D.C., 1985); Gray et al, *Proc. Natl. Acad. Sci.*, Vol. 80, pgs. 5842-5846 (1983); Kafatos et al, *Nucleic Acids Research*, Vol. 7, pgs. 1541-1552 (1979); Sambrook et al, *Molecular Cloning: A Laboratory Manual*, 2nd Ed. (Cold Spring Harbor Laboratory, New York, 1989); and Beltz et al, *Meth. in Enzymol.*, Vol. 100, pgs. 266-285 (1983), to name a few.

Homology as the term is used herein is a measure of similarity between two nucleotide (or amino acid) sequences. Homology is expressed as the fraction or percentage of matching bases (or amino acids) after two sequences (possibly of unequal length) have been aligned. The term alignment is used in the sense defined by Sankoff and Kruskal in chapter one of *Time Warps, String Edits, and Macromolecules: The Theory and Practice of Sequence Comparison* (Addison-Wesley, Reading, MA, 1983). Roughly, two sequences are aligned by maximizing the number of matching bases (or amino acids) between the two sequences with the insertion of a minimal number of "blank" or "null" bases into either sequence to bring about the maximum overlap. Given two sequences, algorithms are available for computing their homology, e.g. Needleham and Wunsch, *J. Mol. Biol.*, Vol.

48, pgs. 443-453 (1970); and Sankoff and Kruskal (cited above) pgs. 23-29. Also, commercial services and software packages are available for performing such comparisons, e.g. Intelligenetics, Inc. (Palo Alto, CA); and University of Wisconsin Genetics Computer Group (Madison, Wisconsin).

5 Restriction endonuclease fragments of the vectors carrying the cDNAs of the invention are used to construct probes (using standard techniques such as nick-translation, e.g. see Sambrook et al., cited above) for screening at low hybridization stringencies genomic or cDNA libraries (again, constructed by standard techniques) of a cell type suspected of
10 producing CSIF. Standard screening procedures are employed, e.g. Grunstein et al., Proc. Natl. Acad. Sci., Vol. 72, pgs. 3961-3965 (1975); or Benton et al., Science, Vol. 196, pgs. 180-183 (1977) or Woo, Methods in Enzymology, Vol. 68, pgs. 389-396 (1979). Alternatively, libraries can be screened with labeled oligonucleotide probes whose sequences are
15 determined from the nucleotide sequences of the cDNA inserts of pcD(SR α)-F115, pH5C, and pH15C. Such probes can be synthesized on commercially available DNA synthesizers, e.g. Applied Biosystems model 381A, using standard techniques, e.g. Gait, Oligonucleotide Synthesis: A Practical Approach, (IRL Press, Washington D.C., 1984). In either case, it is preferable
20 that the probe be at least 18-30 bases long. More preferably, the probe is at least 50-200 bases long. Hybridization probes can also be used to screen candidate sources of CSIF mRNA prior to library construction.

 A wide range of single-cell and multicellular expression systems (i.e. host-expression vector combinations) can be used to produce the proteins of
25 the invention. Possible types of host cells include, but are not limited to, bacterial, yeast, insect, mammalian, and the like. Many reviews are available which provide guidance for making choices and/or modifications of specific expression systems, e.g. to name a few, de Boer and Shepard, "Strategies for Optimizing Foreign Gene Expression in Escherichia coli," pgs.
30 205-247, in Kroon, ed. Genes: Structure and Expression (John Wiley & Sons, New York, 1983), review several E. coli expression systems; Kucherlapati et al., Critical Reviews in Biochemistry, Vol. 16, Issue 4, pgs. 349-379 (1984), and Banerji et al., Genetic Engineering, Vol. 5, pgs. 19-31 (1983) review methods for transfecting and transforming mammalian cells; Reznikoff and Gold,
35 eds., Maximizing Gene Expression (Butterworths, Boston, 1986) review

selected topics in gene expression in *E. coli*, yeast, and mammalian cells; and Thilly, *Mammalian Cell Technology* (Butterworths, Boston, 1986) reviews mammalian expression systems. Likewise, many reviews are available which describe techniques and conditions for linking and/or manipulating
5 specific cDNAs and expression control sequences to create and/or modify expression vectors suitable for use with the present invention, e.g. Sambrook et al (cited above).

An *E. coli* expression system is disclosed by Riggs in U.S. Patent 4,431,739, which is incorporated by reference. A particularly useful
10 prokaryotic promoter for high expression in *E. coli* is the *tac* promoter, disclosed by de Boer in U.S. Patent 4,551,433, which is incorporated herein by reference. Secretion expression vectors are also available for *E. coli* hosts. Particularly useful are the pIN-III-ompA vectors, disclosed by Ghrayeb et al., in *EMBO J.*, Vol. 3, pgs. 2437-2442 (1984), in which the cDNA to be transcribed
15 is fused to the portion of the *E. coli* OmpA gene encoding the signal peptide of the ompA protein which, in turn, causes the mature protein to be secreted into the periplasmic space of the bacteria. U.S. Patents 4,336,336 and 4,338,397 also disclose secretion expression vectors for prokaryotes. Accordingly, these references are incorporated by reference.

20 Numerous strains of bacteria are suitable hosts for prokaryotic expression vectors including strains of *E. coli*, such as W3110 (ATCC No. 27325), JA221, C600, ED767, DH1, LE392, HB101, X1776 (ATCC No. 31244), X2282, RR1 (ATCC No. 31343) MRCI; strains of *Bacillus subtilis*; and other enterobacteriaceae such as *Salmonella typhimurium* or *Serratia marcescens*,
25 and various species of *Pseudomonas*. General methods for deriving bacterial strains, such as *E. coli* K12 X1776, useful in the expression of eukaryotic proteins is disclosed by Curtis III in U.S. Patent 4,190,495. Accordingly this patent is incorporated by reference.

In addition to prokaryotic and eukaryotic microorganisms, expression
30 systems comprising cells derived from multicellular organism may also be used to produce proteins of the invention. Of particular interest are mammalian expression systems because their posttranslational processing machinery is more likely to produce biologically active mammalian proteins. Several DNA tumor viruses have been used as vectors for
35 mammalian hosts. Particularly important are the numerous vectors which comprise SV40 replication, transcription, and/or translation control

sequences coupled to bacterial replication control sequences, e.g. the pcD vectors developed by Okayama and Berg, disclosed in Mol. Cell. Biol., Vol. 2, pgs. 161-170 (1982) and Mol. Cell. Biol., Vol. 3, pgs. 280-289 (1983), and improved by Takebe et al, Mol. Cell. Biol., Vol. 8, pgs. 466-472 (1988).

5 Accordingly, these references are incorporated herein by reference. Other SV40-based mammalian expression vectors include those disclosed by Kaufman and Sharp, in Mol. Cell. Biol., Vol. 2, pgs. 1304-1319 (1982), and Clark et al., in U.S. patent 4,675,285, both of which are incorporated herein by reference. Monkey cells are usually the preferred hosts for the above
10 vectors. Such vectors containing the SV40 ori sequences and an intact A gene can replicate autonomously in monkey cells (to give higher copy numbers and/or more stable copy numbers than nonautonomously replicating plasmids). Moreover, vectors containing the SV40 ori sequences without an intact A gene can replicate autonomously to high copy numbers
15 (but not stably) in COS7 monkey cells, described by Gluzman, Cell, Vol. 23, pgs. 175-182 (1981) and available from the ATCC (accession no. CRL 1651). The above SV40-based vectors are also capable of transforming other mammalian cells, such as mouse L cells, by integration into the host cell DNA.

20 Multicellular organisms can also serve as hosts for the production of CSIF, e.g. insect larvae, Maeda et al, Nature, Vol. 315, pgs. 592-594 (1985) and Ann. Rev. Entomol., pgs. 351-372 (1989); and transgenic animals, Jaenisch, Science, Vol. 240, pgs. 1468-1474 (1988).

25 II. In vitro Assays for CSIF

CSIF activity is the property of inhibiting the synthesis of at least one cytokine in the group consisting of IFN- γ , lymphotoxin, IL-2, IL-3, and GM-CSF in a population of T helper cells induced to synthesize one or more of these cytokines by exposure to syngeneic antigen presenting cells (APCs)
30 and antigen. Preferably, the APCs are treated so that they are incapable of replication, but that their antigen processing machinery remains functional. This is conveniently accomplished by irradiating the APCs, e.g. with about 1500-3000 R (gamma or X-radiation) before mixing with the T cells.

35 Alternatively, cytokine inhibition may be assayed in primary or, preferably, secondary mixed lymphocyte reactions (MLR), in which case

syngeneic APCs need not be used. MLRs are well known in the art, e.g. Bradley, pgs. 162-166, in Mishell et al, eds. Selected Methods in Cellular Immunology (Freeman, San Francisco, 1980); and Battisto et al, Meth. in Enzymol., Vol. 150, pgs. 83-91 (1987). Briefly, two populations of allogenic lymphoid cells are mixed, one of the populations having been treated prior to mixing to prevent proliferation, e.g. by irradiation. Preferably, the cell populations are prepared at a concentration of about 2×10^6 cells/ml in supplemented medium, e.g. RPMI 1640 with 10% fetal calf serum. For both controls and test cultures, mix 0.5 ml of each population for the assay. For a secondary MLR, the cells remaining after 7 days in the primary MLR are re-stimulated by freshly prepared, irradiated stimulator cells. The sample suspected of containing CSIF may be added to the test cultures at the time of mixing, and both controls and test cultures may be assayed for cytokine production from 1 to 3 days after mixing.

Obtaining T cell populations and/or APC populations for CSIF assays employs techniques well known in the art which are fully described in DiSabato et al, eds., Meth. in Enzymol., Vol. 108 (1984). APCs for the preferred CSIF assay are peripheral blood monocytes. These are obtained using standard techniques, e.g. as described by Boyum, Meth. in Enzymol., Vol. 108, pgs. 88-102 (1984); Mage, Meth. in Enzymol., Vol. 108, pgs. 118-132 (1984); Litvin et al., Meth. in Enzymol., Vol. 108, pgs. 298-302 (1984); Stevenson, Meth. in Enzymol., Vol. 108, pgs. 242-249 (1989); and Romain et al, Meth. in Enzymol., Vol. 108, pgs. 148-153 (1984), which references are incorporated by reference. Preferably, helper T cells are used in the CSIF assays, which are obtained by first separating lymphocytes from the peripheral blood then selecting, e.g. by panning or flow cytometry, helper cells using a commercially available anti-CD4 antibody, e.g. OKT4 described in U.S. patent 4,381,295 and available from Ortho Pharmaceutical Corp. The requisite techniques are fully disclosed in Boyum, Scand. J. Clin. Lab. Invest., Vol. 21 (Suppl. 97), pg. 77 (1968); Meth. in Enzymol., Vol. 108 (cited above), and in Bram et al, Meth. in Enzymol., Vol. 121, pgs. 737-748 (1986). Generally, PBLs are obtained from fresh blood by Ficoll-Hypaque density gradient centrifugation.

A variety of antigens can be employed in the assay, e.g. Keyhole limpet hemocyanin (KLH), fowl γ -globulin, or the like. More preferably, in

place of antigen, helper T cells are stimulated with anti-CD3 monoclonal antibody, e.g. OKT3 disclosed in U.S. patent 4,361,549, in the assay.

Cytokine concentrations in control and test samples are measured by standard biological and/or immunochemical assays. Construction of
5 immunochemical assays for specific cytokines is well known in the art when the purified cytokine is available, e. g. Campbell, Monoclonal Antibody Technology (Elsevier, Amsterdam, 1984); Tijssen, Practice and Theory of Enzyme Immunoassays (Elsevier, Amsterdam, 1985); and U.S. patent 4,486,530 are exemplary of the extensive literature on the subject. ELISA kits for
10 human IL-2, human IL-3, and human GM-CSF are commercially available from Genzyme Corp. (Boston, MA); and an ELISA kit for human IFN- γ is commercially available from Endogen, Inc. (Boston, MA). Polyclonal antibodies specific for human lymphotoxin are available from Genzyme Corp. which can be used in a radioimmunoassay for human lymphotoxin, e.g.
15 Chard, An Introduction to Radioimmunoassay and Related Techniques (Elsevier, Amsterdam, 1982).

Biological assays of the cytokines listed above can also be used to determine CSIF activity. A biological assay for human lymphotoxin is disclosed in Aggarwal, Meth. in Enzymol., Vol. 116, pgs. 441-447 (1985), and
20 Matthews et al, pgs. 221-225, in Clemens et al, eds., Lymphokines and Interferons: A Practical Approach (IRL Press, Washington, D.C., 1987). Human IL-2 and GM-CSF can be assayed with factor dependent cell lines CTLL-2 and KG-1, available from the ATCC under accession numbers TIB 214 and CCL 246, respectively. Human IL-3 can be assayed by its ability to
25 stimulate the formation of a wide range of hematopoietic cell colonies in soft agar cultures, e.g. as described by Metcalf, The Hemopoietic Colony Stimulating Factors (Elsevier, Amsterdam, 1984). INF- γ can be quantified with anti-viral assays, e.g. Meager, pgs. 129-147, in Clemens et al, eds. (cited above).

30 Cytokine production can also be determined by mRNA analysis. Cytokine mRNAs can be measured by cytoplasmic dot hybridization as described by White et al., J. Biol. Chem., Vol. 257, pgs. 8569-8572 (1982) and Gillespie et al., U.S. patent 4,483,920. Accordingly, these references are incorporated by reference. Other approaches include dot blotting using
35 purified RNA, e.g. chapter 6, in Hames et al., eds., Nucleic Acid Hybridization A Practical Approach (IRL Press, Washington, D.C., 1985). Generally,

cytoplasmic dot hybridization involves anchoring mRNA from a cell or tissue sample onto a solid phase support, e.g. nitrocellulose, hybridizing a DNA probe to the anchored mRNA, and removing probe sequences nonspecifically bound to the solid phase support or forming mismatched hybrids with the mRNA. so that only probe sequences forming substantially perfect hybrids with target mRNAs remain. The amount of DNA probe remaining is a measure of the number of target mRNA anchored to the solid phase support. The amount of DNA probe remaining is determined by the signal generated by its label. Several standard techniques are available for labeling single and double stranded nucleic acid fragments. They include incorporation of radioactive labels, e.g. Harper et al., *Chromosoma*, Vol. 83, pgs. 431-439 (1984); direct attachment of fluorescent labels, e.g. Smith et al., *Nucleic Acids Research*, Vol. 13, pgs. 2399-2412 (1985), and Connolly et al., *Nucleic Acids Research*, Vol. 13, pgs. 4485-4502 (1985); and various chemical modifications of the nucleic acid fragments that render them detectable immunochemically or by other affinity reactions, e.g. Tchen et al., *Proc. Natl. Acad. Sci.*, Vol. 81, pgs. 3466-3470 (1984); Richardson et al., *Nucleic Acids Research*, Vol. 11, pgs. 6167-6184 (1983); Langer et al., *Proc. Natl. Acad. Sci.*, Vol. 78, pgs. 6633-6637 (1981); Brigati et al., *Virology*, Vol. 126, pgs. 32-50 (1983); Broker et al., *Nucleic Acids Research*, Vol. 5, pgs. 363-384 (1978); and Bayer et al., *Methods of Biochemical Analysis*, Vol. 26, pgs. 1-45 (1980).

Preferably mRNA from T cells is anchored for hybridization to the probe by the following protocol. Isolated T cells are lysed by suspending in a lysis buffer (0.14 M NaCl, 1.5 mM MgCl₂, 10 mM Tris-HCl pH 8.6, 0.5% Nonidet P-40 (a nonionic detergent, e.g. from Sigma)) at 4°C at a final concentration of 1×10^8 cells/ml. The suspension is vortexed for 10 sec and the nuclei are pelleted (13,000 g, 2.5 min). The resulting cytoplasmic lysates are then transferred to a sterile 1.5 ml tube containing 0.3 volumes of 20x SSC (1x SSC=0.15 M NaCl, 0.015 M trisodium citrate (standard saline citrate)) and 0.2 volumes of 37% (w/w) formaldehyde. The mixture is then incubated at 60°C for 15 min and stored in aliquots at -70°C. For analysis, 15 ml of each sample is titrated by serial three fold dilutions in 15x SSC into a 96-well flat-bottomed microtiter plate (Falcon, Becton Dickinson, Oxnard, CA) in 0.1 ml. Each dilution is applied with suction to a sheet of Nytran (a modified nylon support available from Schleicher and Schuell, Keene, NH; 0.45 mm pore

size) supported on a filter paper (Whatman 3mmChr, Whatman Inc., Clifton, NJ) utilizing a 96 hold Minifold apparatus (Schleicher and Schuell). The Nytran paper is then baked (80°C, 2 H) and treated with a prehybridization solution consisting of 50% formamide (BRL, Gaithersburg, MD) 6x SSC, 50
5 mg/ml E. coli tRNA (Sigma), 0.2% (w/v) each of ficoll (MW=400,000), polyvinylpyrrolidone, and bovine serum albumin (BSA). The probe is applied to the Nytran support at a concentrate of about 50 ng probe/ml of prehybridization solution. Following hybridization, the support is washed two times for 15 min each at room temperature in 2x SSC, then twice for 30
10 min each at 60°C in 2x SSC/0.5% SDS. The support is then exposed to film using an intensifying screen and quantitated by scanning with a laser densitometer (e.g. Ultrosan XL, LKB Instruments Inc., Gaithersburg, MD). If cytoplasmic dot hybridization lacks sufficient sensitivity, preferably the RNA is first extracted from the PBLs prior to blotting. For example, RNA may
15 be extracted by the guanidinium thiocyanate method disclosed by Chirgwin et al., in Biochemistry, Vol. 18, pgs. 5294-5299 (1979).

In some cases, samples to be tested for CSIF activity must be pretreated to remove predetermined cytokines that might interfere with the assay. For example, IL-2 increases the production of IFN- γ in some cells. Thus
20 depending on the helper T cells used in the assay, IL-2 may have to be removed from the sample being tested. Such removals are conveniently accomplished by passing the sample over a standard anti-cytokine affinity column.

25 III. Monoclonal Antibodies and Antagonists Specific for CSIF

Preferably, antagonists of the invention are derived from antibodies specific for human CSIF. More preferably, the antagonists of the invention comprise fragments or binding compositions specific for human CSIF. Antibodies comprise an assembly of polypeptide chains linked together by
30 disulfide bridges. Two major polypeptide chains, referred to as the light chain and the heavy chain, make up all major structural classes (isotypes) of antibody. Both heavy chains and light chains are further divided into subregions referred to as variable regions and constant regions. Heavy chains comprise a single variable region and three different constant
35 regions, and light chains comprise a single variable region (different from that of the heavy chain) and a single constant region (different from those

of the heavy chain). The variable regions of the heavy chain and light chain are responsible for the antibody's binding specificity.

As used herein, the term "heavy chain variable region" means a polypeptide (1) which is from 110 to 125 amino acids in length, and (2) whose amino acid sequence corresponds to that of a heavy chain of a monoclonal antibody of the invention, starting from the heavy chain's N-terminal amino acid. Likewise, the term "light chain variable region" means a polypeptide (1) which is from 95 to 115 amino acids in length, and (2) whose amino acid sequence corresponds to that of a light chain of a monoclonal antibody of the invention, starting from the light chain's N-terminal amino acid.

As used herein the term "monoclonal antibody" refers to homogeneous populations of immunoglobulins which are capable of specifically binding to human CSIF.

As used herein the term "binding composition" means a composition comprising two polypeptide chains (1) which, when operationally associated, assume a conformation having high binding affinity for human CSIF, and (2) which are derived from a hybridoma producing monoclonal antibodies specific for human CSIF. The term "operationally associated" is meant to indicate that the two polypeptide chains can be positioned relative to one another for binding by a variety of means, including by association in a native antibody fragment, such as Fab or Fv, or by way of genetically engineered cysteine-containing peptide linkers at the carboxyl termini. Normally, the two polypeptide chains correspond to the light chain variable region and heavy chain variable region of a monoclonal antibody specific for human CSIF. Preferably, antagonists of the invention are derived from monoclonal antibodies specific for human CSIF. Monoclonal antibodies capable of blocking, or neutralizing, CSIF are selected by their ability to inhibit CSIF-induced effects in standard CSIF bioassays, e.g. inhibition of IFN- γ synthesis.

Hybridomas of the invention are produced by well known techniques. Usually, the process involves the fusion of an immortalizing cell line with a B-lymphocyte which produces the desired antibody. Alternatively, non-fusion techniques for generating an immortal antibody producing cell lines are possible, and come within the purview of the present invention, e.g. virally induced transformation: Casali et al., "Human Monoclonals from

Antigen-Specific Selection of B Lymphocytes and Transformation by EBV," Science, Vol. 234, pgs. 476-479 (1986). Immortalizing cell lines are usually transformed mammalian cells, particularly myeloma cells of rodent, bovine, and human origin. Most frequently, rat or mouse myeloma cell lines are employed as a matter of convenience and availability. Techniques for obtaining the appropriate lymphocytes from mammals injected with the target antigen are well known. Generally, either peripheral blood lymphocytes (PBLs) are used if cells of human origin are desired, or spleen cells or lymph node cells are used if non-human mammalian sources are desired. A host mammal is injected with repeated dosages of the purified antigen, and the mammal is permitted to generate the desired antibody producing cells before these are harvested for fusion with the immortalizing cell line. Techniques for fusion are also well known in the art, and in general, involve mixing the cells with a fusing agent, such as polyethylene glycol. Hybridomas are selected by standard procedures, such as HAT selection. From among these hybridomas, those secreting the desired antibody, i.e. specific for human CSIF, are selected by assaying their culture medium by standard immunoassays, such as Western blotting, ELISA, RIA, CSIF neutralizing capability, or the like. Antibodies are recovered from the medium using standard protein purification techniques, e.g. Tijssen, Practice and Theory of Enzyme Immunoassays (Elsevier, Amsterdam, 1985). Many references are available for guidance in applying any of the above techniques, e.g. Kohler et al., Hybridoma Techniques (Cold Spring Harbor Laboratory, New York, 1980); Tijssen, Practice and Theory of Enzyme Immunoassays (Elsevier, Amsterdam, 1985); Campbell, Monoclonal Antibody Technology (Elsevier, Amsterdam, 1984); Hurrell, Monoclonal Hybridoma Antibodies: Techniques and Applications (CRC Press, Boca Raton, FL, 1982); and the like. Hybridomas producing monoclonal antibodies specific for human CSIF are then subjected to a second screen using the CSIF assays described above to select ones capable of blocking, or neutralizing, the biological activity of CSIF.

The use and generation of fragments of antibodies is also well known, e.g. Fab fragments: Tijssen, Practice and Theory of Enzyme Immunoassays (Elsevier, Amsterdam, 1985); and Fv fragments: Hochman et al. Biochemistry, Vol. 12, pgs. 1130-1135 (1973), Sharon et al., Biochemistry, Vol.

15, pgs. 1591-1594 (1976) and Ehrlich et al., U.S. Patent 4,355,023; and antibody half molecules: Auditore-Hargreaves, U.S. Patent 4,470,925.

Antibodies and antibody fragments characteristic of hybridomas of the invention can also be produced by recombinant means by extracting
5 messenger RNA, constructing a cDNA library, and selecting clones which encode segments of the antibody molecule, e.g. Wall et al., Nucleic Acids Research, Vol. 5, pgs. 3113-3128 (1978); Zakut et al., Nucleic Acids Research, Vol. 8, pgs. 3591-3601 (1980); Cabilly et al., Proc. Natl. Acad. Sci., Vol. 81, pgs. 3273-3277 (1984); Boss et al., Nucleic Acids Research, Vol. 12, pgs. 3791-3806
10 (1984); Amster et al., Nucleic Acids Research, Vol. 8, pgs. 2055-2065 (1980); Moore et al., U.S. Patent 4,642,334; Skerra et al., Science, Vol. 240, pgs. 1038-1041(1988); and Huse et al., Science, Vol. 246, pgs. 1275-1281 (1989). In particular, such techniques can be used to produce interspecific monoclonal antibodies, wherein the binding region of one species is combined with
15 non-binding region of the antibody of another species to reduce immunogenicity, e.g. Liu et al., Proc. Natl. Acad. Sci., Vol. 84, pgs. 3439-3443 (1987).

IV. Purification and Pharmaceutical Compositions

20 When polypeptides of the present invention are expressed in soluble form, for example as a secreted product of transformed yeast or mammalian cells, they can be purified according to standard procedures of the art, including steps of ammonium sulfate precipitation, ion exchange chromatography, gel filtration, electrophoresis, affinity chromatography,
25 and/or the like, e.g. "Enzyme Purification and Related Techniques," Methods in Enzymology, 22:233-577 (1977), and Scopes, R., Protein Purification: Principles and Practice (Springer-Verlag, New York, 1982) provide guidance in such purifications. Likewise, when polypeptides of the invention are expressed in insoluble form, for example as aggregates, inclusion bodies, or
30 the like, they can be purified by standard procedures in the art, including separating the inclusion bodies from disrupted host cells by centrifugation, solubilizing the inclusion bodies with chaotropic and reducing agents, diluting the solubilized mixture, and lowering the concentration of chaotropic agent and reducing agent so that the polypeptide takes on a
35 biologically active conformation. The latter procedures are disclosed in the following references, which are incorporated by reference: Winkler et al,

Biochemistry, 25: 4041-4045 (1986); Winkler et al, Biotechnology, 3: 992-998 (1985); Koths et al, U.S. patent 4,569,790; and European patent applications 86306917.5 and 86306353.3.

As used herein "effective amount" means an amount sufficient to
5 ameliorate a symptom of an autoimmune condition. The effective amount for
a particular patient may vary depending on such factors as the state of the
autoimmune condition being treated, the overall health of the patient,
method of administration, the severity of side-effects, and the like.
Generally, CSIF is administered as a pharmaceutical composition comprising
10 an effective amount of CSIF and a pharmaceutical carrier. A pharmaceutical
carrier can be any compatible, non-toxic substance suitable for delivering
the compositions of the invention to a patient. Generally, compositions
useful for parenteral administration of such drugs are well known, e.g.
Remington's Pharmaceutical Science, 15th Ed. (Mack Publishing Company,
15 Easton, PA 1980). Alternatively, compositions of the invention may be
introduced into a patient's body by implantable or injectable drug delivery
system, e.g. Urquhart et al., Ann. Rev. Pharmacol. Toxicol., Vol. 24, pgs. 199-
236 (1984); Lewis, ed. Controlled Release of Pesticides and Pharmaceuticals
(Plenum Press, New York, 1981); U.S. patent 3,773,919; U.S. patent 3,270,960;
20 and the like.

When administered parenterally, the CSIF is formulated in a unit
dosage injectable form (solution, suspension, emulsion) in association with a
pharmaceutical carrier. Examples of such carriers are normal saline,
Ringer's solution, dextrose solution, and Hank's solution. Nonaqueous
25 carriers such as fixed oils and ethyl oleate may also be used. A preferred
carrier is 5% dextrose/saline. The carrier may contain minor amounts of
additives such as substances that enhance isotonicity and chemical stability,
e.g., buffers and preservatives. The CSIF is preferably formulated in
purified form substantially free of aggregates and other proteins at a
30 concentration in the range of about 5 to 20 $\mu\text{g/ml}$. Preferably, CSIF is
administered by continuous infusion so that an amount in the range of about
50-800 μg is delivered per day (i.e. about 1-16 $\mu\text{g/kg/day}$). The daily infusion
rate may be varied based on monitoring of side effects and blood cell counts.

CSIF can be purified from culture supernatants of mammalian cells
35 transiently transfected or stably transformed by an expression vector
carrying an CSIF gene. Preferably, CSIF is purified from culture

supernatants of COS 7 cells transiently transfected by the pcD expression vector. Transfection of COS 7 cells with pcD proceeds as follows: One day prior to transfection, approximately 10^6 COS 7 monkey cells are seeded onto individual 100 mm plates in Dulbecco's modified Eagle medium (DME) containing 10% fetal calf serum and 2 mM glutamine. To perform the transfection, the medium is aspirated from each plate and replaced with 4 ml of DME containing 50 mM Tris.HCl pH 7.4, 400 mg/ml DEAE-Dextran and 50 μ g of plasmid DNA. The plates are incubated for four hours at 37°C, then the DNA-containing medium is removed, and the plates are washed twice with 5 ml of serum-free DME. DME is added back to the plates which are then incubated for an additional 3 hrs at 37°C. The plates are washed once with DME, after which DME containing 4% fetal calf serum, 2 mM glutamine, penicillin (100 U/L) and streptomycin (100 μ g/L) at standard concentrations is added. The cells are then incubated for 72 hrs at 37°C, after which the growth medium is collected for purification of CSIF. Alternatively, transfection can be accomplished by electroporation as described in the examples. Plasmid DNA for the transfections is obtained by growing pcD(SR α) containing the CSIF cDNA insert in *E. coli* MC1061, described by Casadaban and Cohen, *J. Mol. Biol.*, Vol. 138, pgs. 179-207 (1980), or like organism. The plasmid DNA is isolated from the cultures by standard techniques, e.g. Maniatis et al., *Molecular Cloning: A Laboratory Manual* (Cold Spring Harbor Laboratory, New York, 1982).

When the antagonists of the invention are derived from antibodies, they are normally administered parenterally, preferably intravenously. Since such protein or peptide antagonists may be immunogenic they are preferably administered slowly, either by a conventional IV administration set or from a subcutaneous depot, e.g. as taught by Tomasi et al, U.S. patent 4,732,863. When administered parenterally, the antibodies and/or fragments are formulated in a unit dosage injectable form in association with a pharmaceutical carrier, as described above. The antibody is preferably formulated in purified form substantially free of aggregates, other proteins, endotoxins, and the like, at concentrations of about 5 to 30 mg/ml, preferably 10 to 20 mg/ml. Preferably, the endotoxin levels are less than 2.5 EU/ml.

Selecting an administration regimen for an antagonist depends on several factors, including the serum turnover rate of the antagonist, the

serum level of CSIF associated with the disorder being treated, the immunogenicity of the antagonist, the accessibility of the target CSIF (e.g. if non-serum CSIF is to be blocked), the relative affinity of CSIF to its receptor(s) versus CSIF to the antagonist, and the like. Preferably, an administration regimen maximizes the amount of antagonist delivered to the patient consistent with an acceptable level of side effects. Accordingly, the amount of antagonist delivered depends in part on the particular antagonist and the severity of the condition being treated. Guidance in selecting appropriate doses is found in the literature on therapeutic uses of antibodies, e.g. Bach et al., chapter 22, in Ferrone et al., eds., Handbook of Monoclonal Antibodies (Noges Publications, Park Ridge, NJ, 1985); and Russell, pgs. 303-357, and Smith et al., pgs. 365-389, in Haber et al., eds. Antibodies in Human Diagnosis and Therapy (Raven Press, New York, 1977). Preferably, whenever the antagonist comprises monoclonal antibodies or Fab-sized fragments thereof (including binding compositions), the dose is in the range of about 1-20 mg/kg per day. More preferably the dose is in the range of about 1-10 mg/kg per day.

V. Genetically Engineered Mutant CSIFs

Once nucleic acid sequence and/or amino acid sequence information is available for a native protein a variety of techniques become available for producing virtually any mutation in the native sequence, e.g. Shortle, in Science, Vol. 229, pgs. 1193-1201 (1985); Zoller and Smith, Methods in Enzymology, Vol. 100, pgs. 468-500 (1983); Mark et al., U.S. Patent 4,518,584; Wells et al., in Gene, Vol. 34, pgs. 315-323 (1985); Estell et al., Science, Vol. 233, pgs. 659-663 (1986); Mullenbach et al., J. Biol. Chem., Vol. 261, pgs. 719-722 (1986), and Feretti et al., Proc. Natl. Acad. Sci., Vol. 83, pgs. 597-603 (1986). Accordingly, these references are incorporated by reference.

Mutants of the natural polypeptide may be desirable in a variety of circumstances. For example, undesirable side effects might be reduced by certain mutants, particularly if the side effect activity is associated with a different part of the polypeptide from that of the desired activity. In some expression systems, the native polypeptide may be susceptible to degradation by proteases. In such cases, selected substitutions and/or deletions of amino acids which change the susceptible sequences can significantly enhance yields, e.g. British patent application 2173-804-A where Arg at position 275 of

human tissue plasminogen activator is replaced by Gly or Glu. Muteins may also increase yields in purification procedures and/or increase shelf lives of proteins by eliminating amino acids susceptible to oxidation, acylation, alkylation, or other chemical modifications. For example, methionines
5 readily undergo oxidation to form sulfoxides, which in many proteins is associated with loss of biological activity, e.g. Brot and Weissbach, Arch. Biochem. Biophys., Vol. 223, pg. 271 (1983). Often methionines can be replaced by more inert amino acids with little or no loss of biological activity, e.g. Australian patent application AU-A-52451/86. In bacterial
10 expression systems, yields can sometimes be increased by eliminating or replacing conformationally inessential cysteine residues, e.g. Mark et al., U.S. Patent 4,518,584.

Preferably cassette mutagenesis is employed to generate mutant proteins. A synthetic gene is constructed with a sequence of restriction
15 endonuclease sites spaced approximately uniformly along the gene; these restriction endonuclease sites are chosen to remain unique even when the gene is inserted in an appropriate vector. The unique restriction sites allow segments of the gene to be conveniently excised and replaced with synthetic oligonucleotides (i.e. "cassettes") which code for desired mutations.
20 Determination of the number and distribution of unique restriction sites entails the consideration of several factors including (1) preexisting restriction sites in the vector to be employed in expression, (2) whether species-specific or genera-specific codon usage is desired, (3) the number of different non-vector-cutting restriction endonucleases available (and their
25 multiplicities within the synthetic gene), and (4) the convenience and reliability of synthesizing and/or sequencing the segments between the unique restriction sites.

The above technique is a convenient way to effect conservative amino acid substitutions, and the like, in the native protein sequence.
30 "Conservative" as used herein means (i) that the alterations are as conformationally neutral as possible, that is, designed to produce minimal changes in the tertiary structure of the mutant polypeptides as compared to the native protein, and (ii) that the alterations are as antigenically neutral as possible, that is, designed to produce minimal changes in the antigenic
35 determinants of the mutant polypeptides as compared to the native protein. Conformational neutrality is desirable for preserving biological activity,

and antigenic neutrality is desirable for avoiding the triggering of immunogenic responses in patients or animals treated with the compounds of the invention. Although it is difficult to select with absolute certainty which alternatives will be conformationally and antigenically neutral, rules exist which can guide those skilled in the art to make alterations that have high probabilities of being conformationally and antigenically neutral, e.g. Anfisen (cited above); Berzofsky, Science, Vol. 229, pgs. 932-940 (1985); and Bowie et al, Science, Vol. 247, pgs. 1306-1310 (1990). Some of the more important rules include (1) replacement of hydrophobic residues is less likely to produce changes in antigenicity because they are likely to be located in the protein's interior, e.g. Berzofsky (cited above) and Bowie et al (cited above); (2) replacement of physiochemically similar, i.e. synonymous, residues are less likely to produce conformational changes because the replacing amino acid can play the same structural role as the replaced amino acid; and (3) alteration of evolutionarily conserved sequences is likely to produce deleterious conformational effects because evolutionary conservation suggests sequences may be functionally important. In addition to such basic rules for selecting mutein sequences, assays are available to confirm the biological activity and conformation of the engineered molecules. Biological assays for the polypeptides of the invention are described more fully above. Changes in conformation can be tested by at least two well known assays: the microcomplement fixation method, e.g. Wasserman et al., J. Immunol., Vol. 87, pgs. 290-295 (1961), or Levine et al. Methods in Enzymology, Vol. 11, pgs. 928-936 (1967) used widely in evolutionary studies of the tertiary structures of proteins; and affinities to sets of conformation-specific monoclonal antibodies, e.g. Lewis et al., Biochemistry, Vol. 22, pgs. 948-954 (1983).

VI. Human CSIF Peptide Antibodies

The invention includes peptides derived from human CSIF, and immunogens comprising conjugates between carriers and peptides of the invention. The term immunogen as used herein refers to a substance which is capable of causing an immune response. The term carrier as used herein refers to any substance which when chemically conjugated to a peptide of the invention permits a host organism immunized with the resulting conjugate to generate antibodies specific for the conjugated peptide.

Carriers include red blood cells, bacteriophages, proteins, and synthetic particles such as agarose beads. Preferably, carriers are proteins, such as serum albumin, gamma-globulin, keyhole limpet hemocyanin, thyroglobulin, ovalbumin, fibrinogen, or the like.

- 5 Peptides of the invention are synthesized by standard techniques, e.g. Stewart and Young, *Solid Phase Peptide Synthesis*, 2nd Ed. (Pierce Chemical Company, Rockford, IL, 1984). Preferably, a commercial peptide synthesizer is used, e.g. model 430A of Applied Biosystems, Inc. (Foster City, CA). Peptides of the invention are assembled by solid phase synthesis on a cross-linked
10 polystyrene support starting from the carboxyl terminal residue and adding amino acids in a stepwise fashion until the entire peptide has been formed. The following references are guides to the chemistry employed during synthesis: Merrifield, J. Amer. Chem. Soc., Vol. 85, pg. 2149 (1963); Kent et al., pg 185, in *Peptides 1984*, Ragnarsson, Ed. (Almqvist and Weksell, Stockholm,
15 1984); Kent et al., pg. 217 in *Peptide Chemistry 84*, Izumiya, Ed. (Protein Research Foundation, B.H. Osaka, 1985); Merrifield, *Science*, Vol. 232, pgs. 341-347 (1986); Kent, *Ann. Rev. Biochem.*, Vol. 57, pgs. 957-989 (1988), and references cited in these last two references.

- In solid state synthesis it is most important to eliminate synthesis
20 by-products, which are primarily termination, deletion, or modification peptides. Most side reactions can be eliminated or minimized by use of clean, well characterized resins, clean amino acid derivatives, clean solvents, and the selection of proper coupling and cleavage methods and reaction conditions, e.g. Barany and Merrifield, *The Peptides*, Cross and Meienhofer,
25 Eds., Vol. 2, pgs 1-284 (Academic Press, New York, 1979). It is important to monitor coupling reactions to determine that they proceed to completion so that deletion peptides missing one or more residues will be avoided. The quantitative ninhydrin reaction is useful for that purpose: Sarin et al. *Anal. Biochem.*, Vol. 117, pg 147 (1981). Na-t-butyloxycarbonyl (t-Boc) - amino
30 acids are used with appropriate side chain protecting groups stable to the conditions of chain assembly but labile to strong acids. After assembly of the protected peptide chain, the protecting groups are removed and the peptide anchoring bond is cleaved by the use of low then high concentrations of anhydrous hydrogen fluoride in the presence of a
35 thioester scavenger: Tam et al., J. Amer. Chem. Soc., Vol. 105, pg. 6442 (1983). Suitable side chain protecting groups that can be used are indicated by the

three-letter abbreviation for the amino acid in question, followed by the protecting group in parentheses: Asp(OBzl), Glu(OBzl), Ser(Bzl), Thr(Bzl), Lys(Cl-Z), Tyr(Br-Z), Arg(NGTos), Cys(4-MeBzl), and His(ImDNP). (Bzl = benzyloxy; Tos = toluene sulfoxyl; DNP = dinitrophenyl; Im = imidazole; Z = benzyloxycarbonyl). The remaining amino acids have no side chain protecting groups. For each cycle the (t-Boc Na)-protected peptide-resin is exposed to 65 percent trifluoroacetic acid (from Eastman Kodak) (distilled before use) in dichloromethane (DCM), (Mallenckrodt): first for 1 minute then for 13 minutes to remove the Na-protecting group. The peptide-resin is washed in DCM and neutralized twice with 10 percent diisopropylethylamine (DIEA) (Aldrich) in dimethylformamide (DMF) (Applied Biosystems), for 1 minute each time. Neutralization is followed by washing with DMF. Coupling is performed with the symmetric anhydride of the amino acid in DMF for 16 minutes. The symmetric anhydride is prepared on the synthesizer by dissolving 2 mmol of amino acid in 6 ml of DCM and adding 1 mmol of dicyclohexylcarbodiimide (Aldrich) in 2 ml of DCM. After 5 minutes, the activated amino acid is transferred to a separate vessel and the DCM is evaporated by purging with a continuous stream of nitrogen gas. The DCM is replaced by DMF (6 ml total) at various stages during the purging. After the first coupling, the peptide-resin is washed with DCM, 10 percent DIEA in DCM, and then with DCM. For recoupling, the same amino acid and the activating agent, dicyclohexylcarbodiimide, are transferred sequentially to the reaction vessel. After activation in situ and coupling for 10 minutes, sufficient DMF is added to make a 50 percent DMF-DCM mixture, and the coupling is continued for 15 minutes. Arginine is coupled as a hydroxybenzotriazole (Aldrich) ester in DMF for 60 minutes and then recoupled in the same manner as the other amino acids. Asparagine and glutamine are coupled twice as hydroxybenzotriazole esters in DMF, 40 minutes for each coupling. For all residues, the resin is washed after the second coupling and a sample is automatically taken for monitoring residual uncoupled α -amine by quantitative ninhydrin reaction, Sarin et al. (cited above).

The general technique of linking synthetic peptides to a carrier is described in several references, e.g. Walter and Doolittle, "Antibodies Against Synthetic Peptides," in Setlow et al., eds., Genetic Engineering, Vol. 5, pgs. 61-91 (Plenum Press, N.Y., 1983); Green et al. Cell, Vol. 28, pgs. 477-487

(1982); Lerner et al., Proc. Natl. Acad. Sci., Vol. 78, pgs. 3403-3407 (1981); Shimizu et al., U.S. Patent 4,474,754; and Ganfield et al., U.S. Patent 4,311,639. Accordingly, these references are incorporated by reference. Also, techniques employed to link haptens to carriers are essentially the same as the above-referenced techniques, e.g. chapter 20 in Tijssseu's Practice and Theory of Enzyme Immunoassays (Elsevier, New York, 1985). The four most commonly used schemes for attaching a peptide to a carrier are (1) glutaraldehyde for amino coupling, e.g. as disclosed by Kagan and Glick, in Jaffe and Behrman, eds. Methods of Hormone Radioimmunoassay, pgs. 328-329 (Academic Press, N.Y., 1979), and Walter et al. Proc. Natl. Acad. Sci., Vol. 77, pgs. 5197-5200 (1980); (2) water-soluble carbodiimides for carboxyl to amino coupling, e.g. as disclosed by Hoare et al., J. Biol. Chem., Vol. 242, pgs. 2447-2453 (1967); (3) bis-diazobenzidine (BDB) for tyrosine to tyrosine sidechain coupling, e.g. as disclosed by Bassiri, et al., pgs. 46-47, in Jaffe and Behrman, eds. (cited above), and Walter et al. (cited above); and (4) maleimidobenzoyl-N-hydroxysuccinimide ester (MBS) for coupling cysteine (or other sulfhydryls) to amino groups, e.g. as disclosed by Kitagawa et al., J. Biochem. (Tokyo), Vol. 79, pgs. 233-239 (1976), and Lerner et al. (cited above). A general rule for selecting an appropriate method for coupling a given peptide to a protein carrier can be stated as follows: the group involved in attachment should occur only once in the sequence, preferably at the appropriate end of the segment. For example, BDB should not be used if a tyrosine residue occurs in the main part of a sequence chosen for its potentially antigenic character. Similarly, centrally located lysines rule out the glutaraldehyde method, and the occurrences of aspartic and glutamic acids frequently exclude the carbodiimide approach. On the other hand, suitable residues can be positioned at either end of chosen sequence segment as attachment sites, whether or not they occur in the "native" protein sequence. Internal segments, unlike the amino and carboxy termini, will differ significantly at the "unattached end" from the same sequence as it is found in the native protein where the polypeptide backbone is continuous. The problem can be remedied, to a degree, by acetylating the α -amino group and then attaching the peptide by way of its carboxy terminus. The coupling efficiency to the carrier protein is conveniently measured by using a radioactively labeled peptide, prepared either by using a radioactive amino acid for one step of the synthesis or by labeling the completed peptide

by the iodination of a tyrosine residue. The presence of tyrosine in the peptide also allows one to set up a sensitive radioimmune assay, if desirable. Therefore, tyrosine can be introduced as a terminal residue if it is not part of the peptide sequence defined by the native polypeptide.

5 Preferred carriers are proteins, and preferred protein carriers include bovine serum albumin, myoglobin, ovalbumin (OVA), keyhole limpet hemocyanin (KLH), and the like. Peptides can be linked to KLH through cysteines by MBS as disclosed by Liu et al., *Biochemistry*, Vol. 18, pgs. 690-697 (1979). The peptides are dissolved in phosphate-buffered saline
10 (pH 7.5), 0.1 M sodium borate buffer (pH 9.0) or 1.0 M sodium acetate buffer (pH 4.0). The pH for the dissolution of the peptide is chosen to optimize peptide solubility. The content of free cysteine for soluble peptides is determined by Ellman's method, Ellman, *Arch. Biochem. Biophys.*, Vol. 82, pg. 7077 (1959). For each peptide, 4 mg KLH in 0.25 ml of 10 mM sodium
15 phosphate buffer (pH 7.2) is reacted with 0.7 mg MBS (dissolved in dimethyl formamide) and stirred for 30 min at room temperature. The MBS is added dropwise to ensure that the local concentration of formamide is not too high, since KLH is insoluble in >30% formamide. The reaction product, KLH-MBS, is then passed through Sephadex G-25 equilibrated with 50 mM sodium
20 phosphate buffer (pH 6.0) to remove free MBS. KLH recovery from peak fractions of the column eluate (monitored by OD280) is estimated to be approximately 80%. KLH-MBS is then reacted with 5 mg peptide dissolved 25 in 1 ml of the chosen buffer. The pH is adjusted to 7-7.5 and the reaction is stirred for 3 hr at room temperature. Coupling efficiency is monitored with
25 radioactive peptide by dialysis of a sample of the conjugate against phosphate-buffered saline, and ranged from 8% to 60%. Once the peptide-carrier conjugate is available, polyclonal or monoclonal antibodies are produced by standard techniques, e.g. as disclosed by Campbell, *Monoclonal Antibody Technology* (Elsevier, New York, 1984); Hurrell, ed. *Monoclonal Hybridoma Antibodies: Techniques and Applications* (CRC Press, Boca Raton, FL, 1982); Schreier et al. *Hybridoma Techniques* (Cold Spring Harbor Laboratory, New York, 1980); U.S. Patent 4,562,003; or the like. In particular, U.S. Patent 4,562,003 is incorporated by reference.

Both polyclonal and monoclonal antibodies can be screened by ELISA.
35 As in other solid phase immunoassays, the test is based on the tendency of macromolecules to adsorb nonspecifically to plastic. The irreversibility of

this reaction, without loss of immunological activity, allows the formation of antigen-antibody complexes with a simple separation of such complexes from unbound material. To titrate anti-peptide serum, peptide conjugated to a carrier different from that used in immunization is adsorbed to the wells of a 96-well microtiter plate. The adsorbed antigen is then allowed to react in the wells with dilutions of anti-peptide serum. Unbound antibody is washed away, and the remaining antigen-antibody complexes are allowed to react with antibody specific for the IgG of the immunized animal. This second antibody is conjugated to an enzyme such as alkaline phosphatase. A visible colored reaction product produced when the enzyme substrate is added indicates which wells have bound anti-peptide antibodies. The use of spectrophotometer readings allows better quantification of the amount of peptide-specific antibody bound. High-titer antisera yield a linear titration curve between 10^{-3} and 10^{-5} dilutions.

EXAMPLES

The following examples serve to illustrate the present invention. Selection of vectors and hosts as well as the concentration of reagents, temperatures, and the values of other variables are only to exemplify application of the present invention and are not to be considered limitations thereof.

Example I. Biological Activities of Mouse CSIF

Mouse CSIF-containing supernatants from the several T cell clones were obtained by incubating the T cell clones (5×10^6 cells/ml) in serum free medium (RPMI 1640 lacking phenol red and containing 0.05 mM 2-mercaptoethanol and 20 mM HEPES) and concanavalin A (5 μ g/ml) for 24 hours. The clones included cell lines, D9 described in U.S. patent 4,613,459, D10 (described below), MB2-1 described in Mosmann et al, J. Immunol., Vol. 136, pgs. 2348-2357 (1986), CDC25 and CDC35 described in Tony et al, J. Exp. Med., Vol. 161, pg. 223 (1985), and M411-2 and M411-6. The T cell supernatants were assayed for their ability to suppress IFN- γ synthesis in the cell line HDK-1, described in Cherwinski, et al, J. Exp. Med., Vol. 166, pgs. 1229-1244 (1987). Serial twofold dilutions of samples from each T cell clone were prepared in 96-well flat-bottomed microtiter trays in a volume of 0.05

ml. HDK-1 cells (5×10^4 cells per well) along with irradiated (2500 R) syngeneic APCs (spleen cells at 5×10^5 cells per well) and antigen (keyhole limpet hemocyanin at 150 $\mu\text{g/ml}$) were added in a volume of 0.15 ml. 11B11 anti-IL-4 antibody (10 $\mu\text{g/ml}$), described in Ohara et, Nature, Vol. 315, pgs.333-336 (1985), was added to samples suspected of containing IL-4. After incubation at 37°C for 24 h, supernatants were collected and kept at 4°C for periods of less than a week, or at -80°C for longer periods. Levels of IFN- γ were assayed by two site sandwich ELISA using a rat anti-mouse IFN- γ monoclonal antibody, XMG1.2, and affinity-purified rabbit anti-mouse IFN- γ antibody. Figure 1 shows the degree of inhibition of IFN- γ synthesis as percentage of control levels.

CSIF produced by D10 cells was partially purified and applied to two different T cell clones to examine the degree of cytokine synthesis inhibition as a function of CSIF concentration. The partially purified CSIF was prepared as follows: 1-2.5 L batches of concanavalin A-induced D10 supernatant were concentrated approximately 10-fold using Amicon YM-5 membranes (Amicon Corp. , Danvers, MA), passed through a 5-ml mannose-conjugated agarose column (E-Y Laboratories, San Mateo, CA), then further concentrated another 3- to 5-fold, for a total concentration of 30-50 fold. This material was then further purified by two steps of high performance liquid chromatography: first over a hydroxylapatite-based column (Bio-Gel HPHT, Bio-Rad Laboratories, Richmond, CA) and then over a gel filtration column (TSK-G 3000 SW, 60 cm length, LKB Instruments, Gaithersburg, MD). One such batch of partially purified CSIF was kept in aliquots at -80°C and used as a standard of CSIF activity. When initially assayed, this preparation caused approximately 50% inhibition of IFN- γ production at a dilution of 1/200 in an assay volume of 0.2 ml, and so a standard unit was defined by assigning a value of 1000 U/ml to the standard CSIF preparation. In each assay below, the CSIF activity in unknown samples was quantitated by comparing levels of inhibition of IFN- γ synthesis by the unknown to that of the standard. The T cell clones that were assayed for inhibition of cytokine synthesis were HDK-1 (described above) and MD13-10, described in Cell. Immunol., Vol. 97, pg. 357 (1986). For the assay of IL-3 and GM-CSF levels the partially purified CSIF was further treated by passing it over anti-IL-3 and anti-GM-CSF affinity columns. Antibodies in 0.1 M NaCl, 0.1 M HEPES, and 0.08 M CaCl_2 were coupled to Affi-Gel 10 (Bio-Rad) at 4°C with gentle mixing

for 4 hours. Each 1-2 ml column contained approximately 10 to 20 mg of coupled antibody.

As shown in the Table below, IFN- γ production was inhibited in both clones. The synthesis of the other cytokines, IL-2, lymphotoxin, IL-3, and GM-CSF was inhibited to a lesser degree or not at all in MD13-10 cells.

TABLE

Cell line	Cytokine	% of Control Synthesis Level		
		14 U/ml	42 U/ml	125 U/ml
10 HDK-1	IFN- γ	47.6	29.1	18.6
	IL-2	71.7	59.6	40.4
	lymphotoxin	41.9	45.1	42.8
	IL-3	63.9	52.6	38.4
	GM-CSF	86.9	79.1	66.8
15 MD13-10	IFN- γ	36.0	27.5	23.2
	IL-2	88.2	109.3	96.0
	IL-3	60.2	63.0	51.0
	GM-CSF	109.0	119.9	97.6

20

**Example II. Construction of cDNA library from D10 cells and
Isolation of clone pcD(SR α)-F115**

A cDNA library was constructed in the pcD(SR α) vector from mRNA extracted from D10 cells, described in Kaye et al, J. Exp. Med., Vol. 158, pg. 836 (1983), in accordance with the method of Okayama and Berg, Mol. Cell. Biol. 2: 161-170 (1982) and 3: 280-289 (1983), also disclosed in U.S. patent 4,695,542, which is incorporated by reference. The pcD(SR α) vectors carrying cDNA inserts were amplified in E. coli. Plasmid DNA was extracted from pools of these randomly picked clones and used to transfect COS 7 monkey cells as described below. The supernatants of the COS 7 cultures were then tested for CSIF activity. COS cells were transfected as follows: One day prior to transfection, approximately 1.5×10^6 COS 7 monkey cells were seeded onto individual 100 mm plates in Dulbecco's modified Eagle medium (DME) containing 5% fetal calf serum (FCS) and 2 mM glutamine. To perform the

30

transfection, COS 7 cells were removed from the dishes by incubation with trypsin, washed twice in serum-free DME, and suspended to 10^7 cells/ml in serum-free DME. A 0.75 ml aliquot was mixed with 20 μ g DNA and transferred to a sterile 0.4 cm electroporation cuvette. After 10 minutes, the cells were
5 pulsed at 200 volts, 960 μ F in a BioRad Gene Pulser unit. After another 10 minutes, the cells were removed from the cuvette and added to 20 ml of DME containing 5% FCS, 2mM glutamine, penicillin, streptomycin, and gentamycin. The mixture was aliquoted to four 100 mm tissue culture dishes. After 12-24 hours at 37°C, 5% CO₂, the medium was replaced with similar
10 medium containing only 1% FCS and the incubation continued for an additional 72 hours at 37°C, 5% CO₂, after which the medium was collected and assayed for CSIF activity. Subsequently, the sequence of the largest open reading frame of the cDNA insert of pcD(SR α)-F115 was determined as follows:

15

```
5'- ATGCTGGCT  CAGCACTGCT  ATGCTGCTG  CTCCTACTGA  CTGGCATGAG
    GATCAGCAGG  GGCCAGTACA  GCGGGAAGA  CAATAACTGC  AOCCTTCC
    CAGTGGCCA  GAGCCACATG  CTCTAGAGC  TGCGGACTGC  CTCAGCCAG
    GTGAAGACTT  TCTTTCAAAC  AAAGGACCAG  CTGGACAACA  TACTGCTAAC
20  CGACTCCTTA  ATGCAGGACT  TTAAGGGTGA  CTGGGGTTC  CAAGCCTTAT
    CGGAAATGAT  CCAGTTTAC  CTGGTAGAAG  TGATGCCCCA  GGCAGAGAAG
    CATGGCCAG  AAATCAAGGA  GCATTGGAAT  TCCCTGGGTG  AGAAGCTGAA
    GACCTCAGG  ATGCGGCTGA  GCGGCTGTC  TCGATTTCCT  CCTGTGAAA
    ATAAGAGCAA  GGCAGTGGAG  CAGGTGAAGA  GTGATTTTAA  TAAGCTCCAA
25  GACCAAGGTG  TCTACAAGGC  CATGAATGAA  TTTGACATCT  TCATCAACTG
    CATAGAAGCA  TACATGATGA  TCAAAATGAA  AAGCTAA    -3' ;
```

and the amino acid sequence of the mature mouse CSIF protein determined by the Heijne algorithm is as follows:

30

```
QYSREDNNCT HFPVGQSHML LELRTAFSQV KTFQTKDQL
DNILLTDSLM QDFKGYLGCQ ALSEMIQFYL VEVMPQAEKH
GPEIKEHLNS LGEKLKTLRM RLRRCHRFLP CENKSKAVEQ
VKSDFNKLQD QGVYKAMNEF DIFINCIEAY MMIKMKS .
```

35

Example III. Screening cDNA libraries for human CSIF using probes derived from pcD(SR α)-F115: Isolation of pH5C and pH15C

A cDNA library constructed in pcD(SR α) from mRNA extracted from a human T cell clone was screened with a collection of 70-mer oligonucleotides whose sequences were complementary to the coding and noncoding strands of the fragment of the mouse CSIF gene encoding mature CSIF. Standard hybridization protocols were used, e.g. bacterial colonies grown on 150 mm petri dishes were transferred to GeneScreen membranes, treated with the radioactively labeled oligonucleotide probes, washed, then exposed to X-ray film. The probes were hybridized under low stringency conditions for the length of the probes: prehybridization consisted of incubation of the target nucleic acids in 5X SET (20X SET is 3 M NaCl + 0.4 Tris-Cl (pH 7.8) + 20 mM EDTA) at 60°C, followed by hybridization under the same conditions, and washing in 5X SET at 50°C. Two clones carrying plasmids pH5C and pH15C were identified. Both plasmids expressed proteins in COS 7 cells that were capable of inhibiting IFN- γ synthesis in PHA-stimulated human PBLs. The cDNA insert of pH15C is illustrated in Figure 4, and the nucleotide sequence of its largest open reading frame is given below:

20	5'-	ATGCACAGCT	CAGCACTGCT	CTGTTGCGTG	GTCCTCTGA	CTGGGGTGAG
		GGCCAGCCCA	GGCCAGGGCA	CCCAGTCTGA	GAACAGCTGC	ACCCACTTCC
		CAGGCACTT	GCCTAACATG	CTTCGAGATC	TCCGAGATGC	CTTCAGCAGA
		GTGAAGACTT	TCTTTCAAAT	GAAGGATCAG	CTGGACAAC	TGTTGTATAA
		GGAGTCTTG	CTGGAGGACT	TTAAGGGTTA	CTGGGGTTC	CAAGCCTTGT
25		CTGAGATGAT	CCAGTTTAC	CTGGAGGAGG	TGATGCCCCA	AGCTGAGAAC
		CAAGACCCAG	ACATCAAGGC	GCATGTGAAC	TCCCTGGGGG	AGAACCTGAA
		GACCTCAGG	CTGAGGCTAC	GGCGCTGTCA	TGATTTCTT	CCCTGTGAAA
		ACAAGAGCAA	GGCGTGGAG	CAGGTGAAGA	ATGCCTTTAA	TAAGCTCCAA
		GAGAAAGGCA	TCTACAAAGC	CATGAGTGAG	TTGACATCT	TCATCAACTA
30		CATAGAAGCC	TACATGACAA	TGAAGATACG	AAACTGA	-3'.

Example IV. Monoclonal Antibodies Specific for CSIF

A male Lewis rat is immunized with semi-purified preparations of human CSIF expressed in COS7 cells. The rat is first immunized with approximately 50 μ g of human CSIF in Freund's Complete Adjuvant, and boosted twice with the same amount of material in Freund's Incomplete

Adjuvant. Test bleeds are taken. The animal is given a final boost of 25 µg in phosphate-buffered saline, and four days later the spleen is obtained for fusion.

Approximately 3×10^8 rat splenocytes are fused with an equal number of P3X63-AG8.653 mouse myeloma cells (available from the ATCC under accession number CRL 1580). 3840 microtiter plate wells are seeded at 5.7×10^4 parental myeloma cells per well. Standard protocols for the fusion and subsequent culturing of hybrids are followed, e.g. as described by Chretien et al, J. Immunol. Meth., Vol. 117, pgs. 67-81 (1989). 12 days after fusion supernatants are harvested and screened by indirect ELISA on PVC plates coated with human produced in CSIF COS7 cells. Hybridoma JES3-19F1 was identified in this manner and deposited with the American Type Culture Collection.

Hybridomas producing blocking antibodies are selected from the initially screened hybridomas by their ability to produce antibodies that counteract the CSIF-induced inhibition of IFN-γ synthesis in PHA-stimulated human PBLs.

Example V. Expression of human CSIF in a bacterial host

A synthetic human CSIF gene is assembled from a plurality of chemically synthesized double stranded DNA fragments to form an expression vector designated TAC-RBS-hCSIF. Cloning and expression are carried out in a standard bacterial system, for example E. coli K-12 strain JM101, JM103, or the like, described by Viera and Messing, in Gene, Vol. 19, pgs. 259-268 (1982). Restriction endonuclease digestions and ligase reactions are performed using standard protocols, e.g. Maniatis et al., Molecular Cloning: A Laboratory Manual (Cold Spring Harbor Laboratory, New York, 1982).

The alkaline method (Maniatis et al., cited above) is used for small scale plasmid preparations. For large scale preparations a modification of the alkaline method is used in which an equal volume of isopropanol is used to precipitate nucleic acids from the cleared lysate. Precipitation with cold 2.5 M ammonium acetate is used to remove RNA prior to cesium chloride equilibrium density centrifugation and detection with ethidium bromide.

For filter hybridizations Whatman 540 filter circles are used to lift colonies which are then lysed and fixed by successive treatments with 0.5M

NaOH, 1.5M NaCl; 1M Tris.HCl pH8.0, 1.5M NaCl (2 min each); and heating at 80°C (30 min). Hybridizations are in 6xSSPE, 20% formamide, 0.1% sodium dodecylsulphate (SDS), 100 mg/ml E. coli tRNA, 100 mg/ml Coomassie Brilliant Blue G-250 (Bio-Rad) at 42°C for 6 hrs using ³²P-labelled (kinased) synthetic
5 DNAs. (20xSSPE is prepared by dissolving 174 g of NaCl, 7.4 g of EDTA, and 27.6 g of NaH₂PO₄.9H₂O in 800 ml of water; the pH is adjusted to 7.4 with NaOH, volume is adjusted to 1 liter, and the solution is sterilized by autoclaving). Filters are washed twice (15 min, room temperature) with 1xSSPE, 0.1% SDS. After autoradiography (Fuji RX film), positive colonies are located by
10 aligning the regrown colonies with the blue-stained colonies on the filters. DNA is sequenced by the dideoxy method, Sanger et al. Proc. Natl. Acad. Sci., Vol. 74, pg. 5463 (1977). Templates for the dideoxy reactions are either single-stranded DNAs of relevant regions recloned into M13mp vectors, e.g. Messing et al. Nucleic Acids Res., Vol. 9, pg. 309 (1981), or double-stranded
15 DNA prepared by the minialkaline method and denatured with 0.2M NaOH (5 min, room temperature) and precipitated from 0.2M NaOH, 1.43M ammonium acetate by the addition of 2 volumes of ethanol. DNA is synthesized by phosphoramidite chemistry using Applied Biosystems 380A synthesizers. Synthesis, deprotection, cleavage and purification (7M urea PAGE, elution,
20 DEAE-cellulose chromatography) are done as described in the 380A synthesizer manual.

Complementary strands of synthetic DNAs to be cloned (400ng each) are mixed and phosphorylated with polynucleotide kinase in a reaction volume of 50 ml. This DNA is ligated with 1 mg of vector DNA digested with
25 appropriate restriction enzymes, and ligations are in a volume of 50 ml at room temperature for 4 to 12 hours. Conditions for phosphorylation, restriction enzyme digestions, polymerase reactions, and ligation have been described (Maniatis et al., cited above). Colonies are scored for lacZ+ (when desired) by plating on L agar supplemented with ampicillin, isopropyl-1-
30 thio-beta-D-galactoside (IPTG) (0.4 mM) and 5-bromo-4-chloro-3-indolyl-beta-D-galactopyranoside (x-gal) (40 mg/ml).

The TAC-RBS vector is constructed by filling-in with DNA polymerase the single BamHI site of the tacP-bearing plasmid pDR540 (Pharmacia). This is then ligated to unphosphorylated synthetic oligonucleotides (Pharmacia)
35 which form a double-stranded fragment encoding a consensus ribosome binding site (RBS, GTAAGGAGGTTTAAC). After ligation, the mixture is

phosphorylated and religated with the SstI linker ATGAGCTCAT. This complex was then cleaved with SstI and EcoRI, and the 173 bp fragment isolated by polyacrylamide gel electrophoresis (PAGE) and cloned into EcoRI-SstI-restricted pUC19 (Pharmacia) (as described below). The sequence of the RBS-ATG-polylinker regions of the final construction (called TAC-RBS) is shown in Figure 3.

The synthetic CSIF gene is assembled into a pUC19 plasmid in eight steps. At each step inserts free of deletions and/or inserts can be detected after cloning by maintaining the lacZ(α) gene of pUC19 in frame with the ATG start codon inserted in step 1. Clones containing deletion and/or insertion changes can be filtered out by scoring for blue colonies on L-ampicillin plates containing x-gal and IPTG. Alternatively, at each step sequences of inserts can be readily confirmed using a universal sequencing primer on small scale plasmid DNA preparations, e.g. available from Boehringer Mannheim.

In step 1 the TAC-RBS vector is digested with SstI, treated with T4 DNA polymerase (whose 3'-exonuclease activity digests the 3'-protruding strands of the SstI cuts to form blunt-end fragments), and after deactivation of T4 DNA polymerase, treated with EcoRI to form a 173 bp fragment containing the TAC-RBS region and having a blunt end at the ATG start codon and the EcoRI cut at the opposite end. Finally, the 173 bp TAC-RBS fragment is isolated.

In step 2 the isolated TAC-RBS fragment of step 1 is mixed with EcoRI/KpnI-digested plasmid pUC19 and synthetic fragment 1A/B which, as shown below, has a blunt end at its upstream terminus and a staggered end corresponding to a KpnI cut at its downstream terminus. This KpnI end is adjacent to and downstream of a BstEII site. The fragments are ligated to form the pUC19 of step 2.

In step 3 synthetic fragment 2A/B and 3A/B (shown below) are mixed with BstEII/SmaI-digested pUC19 of step 2 (after amplification and purification) and ligated to form pUC19 of step 3. Note that the downstream terminus of fragment 3A/B contains extra bases which form the SmaI blunt end. These extra bases are cleaved in step 4. Also fragments 2A/B and 3A/B have complementary 9-residue single-stranded ends which anneal upon mixture, leaving the upstream BstEII cut of 2A/B and the downstream blunt end of 3A/B to ligate to the pUC19.

In step 4 AflIII/XbaI-digested pUC19 of step 3 (after amplification and purification) is repurified, mixed with synthetic fragment 4A/B (shown below), and ligated to form pUC19 of step 4.

In step 5 XbaI/SalI-digested pUC19 of step 4 (after amplification and purification) is mixed with synthetic fragment 5A/B (shown below) and ligated to form the pUC19 of step 5. Note that the SalI staggered end of fragment 5A/B is eliminated by digestion with HpaI in step 6.

In step 6 HpaI/PstI-digested pUC19 of step 5 (after amplification and purification) is mixed with synthetic fragment 6A/B (shown below) and ligated to form the pUC19 of step 6.

In step 7 ClaI/SphI-digested pUC19 of step 6 (after amplification and purification) is mixed with synthetic fragment 7A/B (shown below) and ligated to form the pUC19 of step 7.

In step 8 MluI/HindIII-digested pUC19 of step 7 (after amplification and purification) is mixed with synthetic fragments 8A/B and 9A/B and ligated to form the final construction. The final construction is inserted into E. coli K-12 strain JM101, e.g. available from the ATCC under accession number 33876, by standard techniques. After culturing, protein is extracted from the JM101 cells and dilutions of the extracts are tested for biological activity.

AGCCCAGGCC	AGGGCACCCA	GTCTGAGAAC	AGCTGCACCC	ACTTC-
TCGGGTCCGG	TCCCGTGGGT	CAGACTCTTG	TCGACGTGGG	TGAAG-
CCAGGtAACC	ggtac			
GGTCCaTTGG	c			

25 Fragment 1A/B

GtAACCTGCC	TAACATGCTT	CGAGATCTCC	GAGATGCCTT	CAGCA-
GACGG	ATTGTACGAA	GCTCTAGAGG	CTCTACGGAA	GTCGT-
GAGTGAAGAC	TTTCTTT			
CTCACTTC				

30 Fragment 2A/B

TGAAAGAAA	CAAATGAAGG	ATCAGCTGGA	CAACTTGTTc	TtAAG
	GTTTACTTCC	TAGTCGACCT	GTTGAACAAg	AaTTC

Fragment 3A/B

GAGTCCTTGC	TGGAGGACTT	TAAGGGTTAC	CTGGGTGACC	AAGCC-
CTCAGGAACG	ACCTCCTGAA	ATTCCCAATG	GACCCAACGG	TTCGG-
TTGTCTGAGA	TGATCCAGTT	TTAt		
AACAGACTCT	ACTAGGTCAA	AATaGAtC		

5

Fragment 4A/B

CTaGAGGAGG	TGATGCCCCA	AGCTGAGAAC	CAAGACCCAG	ACATC-
GAtCTCCTCC	ACTACGGGGT	TCGACTCTTG	GTTCTGGGTC	TGTAG-
AAGGCGCATG	TtAACg			
TTCCGCGTAC	AaTTGcagct			

10

Fragment 5A/B

AACTCCCTGG	GGGAGAACCT	GAAGACCCTC	AGGCTGAGGC	TACGG-
TTGAGGGACC	CCCTCTTGGA	CTTCTGGGAG	TCCGACTCCG	ATGCC-
CGCTGTCATC	GATctgca			
GCGACAGTAG	CTAg			

15

Fragment 6A/B

CGATTTCTTC	CCTGTCAAAA	CAAGAGCAAG	GCCGTGGAGC	AGGTG-
TAAAGAAG	GGACAGTTTT	GTTCTCGTTC	CGGCACCTCG	TCCAC-
AAGAAcGCgT	gcatg			
TTCTTgCGcA	c			

20

Fragment 7A/B

CGCGTTTAAT	AATAAGCTCC	AAGACAAAGG	CATCTACAAA	GCCAT-
AAATTA	TTATTCGAGG	TTCTGTTTCC	GTAGATGTTT	CGGTA-
GAGTGAGTTT	GAC			
CTCA				

25

Fragment 8A/B

CTCAAACTG	ATCTTCATCA	ACTACATAGA	AGCCTACATG	ACAAT-
	TAGAAGTAGT	TGATGTATCT	TCGGATGTAC	TGTTA-
GAAGATACGA	AACTGA			
CTTCTATGCT	TTGACTtcga			

30

Fragment 9A/B

(Lower case letters indicate that a base differs from that of the native sequence at the same site)

Example VI. Antibodies Specific for the CENKSKAVE-Peptide

50 mg of ovalbumin (OVA) and 50 mg of myoglobin (MYO) (e.g. available from Sigma) are each dissolved in 10 ml of 0.1 M sodium bicarbonate, and reacted with 1 ml of 0.12 iodoacetamide solution (88 mg of iodoacetamide dissolved in 4 ml 0.1 M sodium bicarbonate) for 1 hour at room temperature in a 15 ml Falcon tube (Falcon Plastics, Oxnard, CA), or the like. Each reaction mixture is dialyzed overnight against 4 liters of 0.1 M sodium bicarbonate at 4RC. Separately, 10 mg of CENKSKAVE is dissolved in 2 ml of 0.1 M DTT (dithiothreitol) solution (containing 50 mM Tris and 2.5 mM EDTA at pH8) in a 4 ml tube, incubated at 37°C overnight; and then applied to a GF05 gel-filtration column (1.5 x 26.5 cm) (LKB, Bromma, Sweden) and eluted with a peptide elution buffer consisting of 0.015 M acetic acid and 0.005 M beta-mercaptoethanol. Three fractions of about 3.5 ml each which contained the reduced peptide are identified by optical density at 206 nm, collected, pooled, frozen in dry ice, and lyophilized overnight. Meanwhile OVA and MYO are recovered from dialysis, and clarified by filtration through 0.45 micrometer filters. OVA and MYO are activated by mixing each with 380 microliters of N-hydroxysuccinimide ester of iodoacetic acid (NHIA) (disclosed by Rector et al., in J. Immunol. Meth., Vol. 24, pg. 321 (1978)) dissolved in tetrahydrofuran (THF) (5 mg/ml), stirring for 30 minutes at room temperature, and dialyzing overnight against 4 liters PBS (1.8 g NaH₂PO₄·H₂O, 7.2 g Na₂HPO₄·H₂O; and 34g NaCl in 4 liters H₂O). Separately the lyophilized peptide is resuspended in 5 ml of borate reduction buffer (2 g Na₂B₄O₇·10H₂O, 17.4 g NaCl, and 336 mg EDTA-Na₂ in one liter H₂O with pH adjusted to 8.5 with concentrated HCl, deoxygenated under nitrogen for 15 minutes, after which 178 mg ascorbate is added). The dialyzed iodoacetylated OVA and MYO are recovered, separately mixed with equal volumes (preferably 2 ml) of borate reduction buffer containing the peptide, and incubated overnight at room temperature. The resulting conjugates are analyzed by SDS-PAGE (12.5% gel). The conjugate containing solution is diluted with PBS to 1 mg/ml, sterile filtered, and aliquotted to convenient volumes (e.g. 500 microliters) for immunizations, and/or stored at 4°C. Polyclonal anti-sera against the MYO conjugate is produced in both rats and rabbits (New Zealand White). The immunization schedule for rabbits is as follows: Initially (week 0) a 10 ml sample of serum is extracted as a control. One week later (week 1) 0.5 ml of peptide-carrier conjugate is mixed with 0.5 ml Freund's Complete Adjuvant and injected I.P. Three weeks later (week 4) a booster is given consisting of 0.5 ml

peptide-carrier conjugate mixed with 0.5 ml Freund's Incomplete Adjuvant. The following week (week 5) an additional booster is given, again consisting of 0.5 ml peptide-carrier conjugate mixed with 0.5 ml Freund's Incomplete Adjuvant, followed by yet another identical booster the next week (week 6). On
5 week 7, 20 ml of serum is bled from the animal. After separating out the cellular fraction the serum assayed for positive anti-CENKSKAVE titer by ELISA. Rat immunization proceeded similarly except that the initial injection consists of 0.15 ml PBS and 0.1 ml peptide-carrier conjugate mixed with 0.75 ml Freund's Complete Adjuvant, boosters consisted of 0.15 ml PBS and 0.1 ml peptide-carrier
10 conjugate mixed with 0.75 ml Freund's Incomplete Adjuvant, and only 2-3 ml of serum is bled from the rat. Again, a positive anti-CENKSKAVE reaction is detected by ELISA.

The descriptions of the foregoing embodiments of the invention have been presented for purpose of illustration and description. They are not
15 intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teaching. The embodiments were chosen and described in order to best explain the principles of the invention to thereby enable others skilled in the art to best utilize the invention in various embodiments and with various
20 modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto.

Applicants have separately deposited E. coli MC1061 carrying pcD(SR α)-F115, pH5C, and pH15C with the American Type Culture Collection, Rockville, MD, USA (ATCC), under accession numbers 68027, 68191, and 68192,
25 respectively. These deposits were made under conditions as provided under ATCC's agreement for Culture Deposit for Patent Purposes, which assures that the deposits will be made available to the US Commissioner of Patents and Trademarks pursuant to 35 USC 122 and 37 CFR 1.14, and will be made available to the public upon issue of a U.S. patent, which requires that the deposits be
30 maintained. Availability of the deposited strain is not to be construed as a license to practice the invention in contravention of the rights granted under the authority of any government in accordance with its patent laws.

The deposits have been modified to conform to the requirements of the Budapest Treaty on the Deposition of Microorganisms.



- 38 -

CLAIMS:

1. Mammalian cytokine synthesis inhibitory factor substantially free from any other mammalian proteins.

2. The compound of claim 1 wherein said mammalian cytokine synthesis inhibitory factor is human cytokine synthesis inhibitory factor substantially free from any other human proteins.

3. The compound of claim 2 wherein said human cytokine synthesis inhibitory factor is selected from the group of mature polypeptides of the open reading frame defined by the amino acid sequence:

10

MHSSALLCCL VLLTGVRASP GQGTQSENSC THFPGNLPNM
LRDLRDAFSR VKTFFQMKDQ LDNLLLKESL LEDFKGYLGC
QALSEMIQFY LEEVMPQAEN QDPDIKAHVN SLGENLKT LR
LRLRRCHRFL PCENKSKAVE QVKNAFNKLQ EKG IYKAMSE
FDIFINYIEA YMTMKIRN.

15

4. The compound of claim 3 wherein said human cytokine synthesis inhibitory factor is defined by the amino acid sequence:

20

SPGQGTQSEN SCTHFPGNLP NMLRDLRDAF SRVKTFFQMK
DQLDNLLLKE SLLEDFKGYL GCQALSEMIQ FYEEVMPQA
ENQDPDIKAH VNSLGENLKT LRLRLRRCHR FLPCENKSKA
VEQVKNAFNK LQEKGIYKAM SEFDIFINYI EAYMTMKIRN.

5. The compound of claim 1 wherein said mammalian cytokine synthesis inhibitory factor is mouse cytokine synthesis inhibitory factor substantially free from any other mouse proteins.

6. The compound of claim 5 wherein said mouse cytokine synthesis inhibitory factor is defined by the amino acid sequence:

30

QYSREDNNCT HFPVGQSHML LELRTAFSQV KTFQTKDQL
DNILLTDSLM QDFKGYLGCQ ALSEMIQFYL VEVMPQAEKH



* C L M S *



- 39 -

GPEIKEHLNSL GEKLKTLRMR LRRCHRFLPC ENKSKAVEQV
KSDFNKLQDQ GVIYKAMNEFD IFINCIEAYM MIKMKS.

7. An isolated gene encoding cytokine synthesis inhibitory factor.
8. The compound of claim 7 wherein said cytokine synthesis inhibitory
5 factor is human cytokine synthesis inhibitory factor.
9. The compound of claim 8 wherein said isolated gene encodes a mature polypeptide of the open reading frame defined by the amino acid sequence:

MHSSALLCCL VLLTGVRASP GQGTQSENSC THFPGNLPNM
LRDLRDAFSR VKTFFQMKDQ LDNLLLKESL LEDFKGYLGC
10 QALSEMIQFY LEEVMPQAEN QDPDIKAHVN SLGENLKTLR
LRLRCHRFL PCENKSKAVE QVKNAFNKLQ EKGIIYKAMSE
FDIFINYIEA YMTMKIRN.

10. A nucleic acid capable of encoding with a continuous nucleotide
15 sequence a polypeptide exhibiting cytokine synthesis inhibitory factor activity, said nucleic acid capable of forming a detectable hybrid with one or more probes derived from the cDNA inserts of pcD(SR α)-F115, pH5C, or pH15C, in the presence of 5X SET at 60°C, or equivalent conditions.
11. The nucleic acid of claim 10 that is at least ninety percent homologous
20 to the coding region for a mature polypeptide of the largest open reading frame of a cDNA insert of a vector selected from the group consisting of pcD(SR α)-F115, pH5C, and pH15C.
12. The nucleic acid of claim 10 being derived from a mammalian cell source.
13. A method of producing a polypeptide exhibiting human cytokine
25 synthesis inhibitory factor activity, the method comprising the steps of:
constructing a vector comprising a nucleotide sequence coding for said polypeptide, wherein the nucleotide sequence is capable of being expressed by a host containing the vector and wherein the nucleotide
30 sequence is selected from a group encoding mature polypeptides of the open reading frame defined by the amino acid sequence:



* C L N S *



MHSSALLCCL VLLTGVRASP GQGTQSENSC THFPGNLPNM
LRDLRDAFSR VKTFFQMKDQ LDNLLLKESL LEDFKGYLGC
QALSEMIQFY LEEVMPQAEN QDPDIKAHVN SLGENLKTLR
LRLRRCHRFL PCENKSKAVE QVKNAFNKLQ EKGITYKAMSE
FDIFINYIEA YMTMKIRN;

5

incorporating the vector into the host; and
maintaining the host in a culture medium under conditions suitable
for expression of the nucleotide sequence into said polypeptide.

10 14. The method of claim 13 further including the step of separating said
polypeptide from said culture medium and said host.

15 15. A method of treating a patient to control a disease associated with an
MHC-linked immune response, the method comprising administering an
effective amount of human cytokine synthesis inhibitory factor.

16 16. The method of claim 15 wherein said step of administering includes
intravenous delivery of an amount of said human cytokine synthesis
inhibitory factor in the range of about 1-10 μ g/kg body weight of said
individual per day.

17 17. A method of suppressing a cell-mediated immune response in a
20 patient, the method comprising administering an effective amount of
human cytokine synthesis inhibitory factor.

18 18. A method of suppressing a humoral immune response in an
individual, the method comprising administering an effective amount of an
antagonist to human cytokine synthesis inhibitory factor.

25

19. An expression vector capable of expressing a cytokine synthesis
inhibitory factor protein in a host.

20. The expression vector of claim 19 wherein said host is mammalian.

21. The expression vector of claim 20 wherein said cytokine synthesis
30 inhibitory factor is human cytokine synthesis inhibitory factor.





- 41 -

22. The expression vector of claim 21 selected from the group consisting of pH5C and pH15C.
23. The expression vector of claim 19 wherein said host is bacterial.
24. The expression vector of claim 23 wherein said cytokine synthesis
5 inhibitory factor is human cytokine synthesis inhibitory factor.
25. The expression vector of claim 24 consisting of TAC-RBS-hCSIF.
26. A monoclonal antibody which specifically binds to human cytokine synthesis inhibitory factor.
27. The monoclonal antibody of claim 26 wherein said human cytokine
10 synthesis inhibitory factor is defined by the amino acid sequence:

15 SPGQGTQSEN SCTHFPGNLP NMLRDLRDAF SRVKTFQMK
DQLDNLLLKE SLLEDFKGYL GCQALSEMIQ FYLEEVMPQA
ENQDPDIKAH VNSLGENLKT LRLRLRCHR FLPCENSKA
VEQVKNAFNK LQEKGIYKAM SEFDIFINYI EAYMTMKIRN.

28. The monoclonal antibody of claim 26 capable of inhibiting the biological activity of human synthesis inhibitory factor.
29. Human cytokine synthesis inhibitory factor defined by the amino
20 acid sequence:

SPGQGTQSEN SCTHFPGNLP NMLRDLRDAF SRVKTFQMK
DQLDNLLLKE SLLEDFKGYL GCQALSEMIQ FYLEEVMPQA
ENQDPDIKAH VNSLGENLKT LRLRLRCHR FLPCENSKA
VEQVKNAFNK LQEKGIYKAM SEFDIFINYI EAYMTMKIRN.

- 25 30. A peptide consisting of 6 to 30 amino acids whose sequence is identical to a subsequence of a mature human cytokine synthesis inhibitory factor defined by the formula:





SPGQGTQSEN SCTHFPGNLP NMLRDLRDAF SRVKTFFQMK
 DQLDNLLLKE SLLEDFKGYL GCQALSEMIQ FYLEEVMPQA
 ENQDPDIKAH VNSLGENLKT LRLRLRCHR FLPCENKSKA
 VEQVKNAFNK LQEKGIYKAM SEFDIFINYI EAYMTMKIRN.

- 5 31. The peptide of claim 30 consisting of 6 to 12 amino acids wherein said subsequence occurs in a portion of said mature human cytokine synthesis inhibitory factor defined by the formula:

SPGQGTQSEN SCTHFPGNLP NMLRDLRDAF SRVKTFFQMK.

32. The peptide of claim 31 defined by the amino acid sequence RDLRDA.

- 10 33. The peptide of claim 30 consisting of 6 to 12 amino acids wherein said subsequence occurs in a portion of said mature human cytokine synthesis inhibitory factor defined by the formula:

LEEVMPPQAEN QDPDIKAHVN SLGEN.

34. The peptide of claim 34 defined by the amino acid sequence ENQDPD.

- 15 35. The peptide of claim 30 consisting of 6 to 12 amino acids wherein said subsequence occurs in a portion of said mature human cytokine synthesis inhibitory factor defined by the formula:

CHRFLPCENK SKAVEQVKNA FNK.

36. The peptide of claim 35 defined by the amino acid sequence ENKSKA.

