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<p>(21) International Application Number: PCT/US99/14163</p> <p>(22) International Filing Date: 23 July 1999 (23.07.99)</p> <p>(30) Priority Data: 60/094,238 27 July 1998 (27.07.98) US</p> <p>(71) Applicant (for all designated States except US): PHARMACIA &amp; UPIJOHN COMPANY [US/US]; 301 Henrietta Street, Kalamazoo, MI 49001 (US).</p> <p>(72) Inventors; and (75) Inventors/Applicants (for US only): HEINRIKSON, Robert, Leroy [US/US]; 81 South Lake Doster Drive, Plainwell, MI 49080 (US). TOMASSELLI, Alfredo, Giuseppe [IT/US]; 2503 Cuttysark Drive, Kalamazoo, MI 49009 (US). KOEPLINGER, Kenneth, A. [US/US]; 2717 Fleetwood Drive, Portage, MI 49024 (US).</p> <p>(74) Agent: KERBER, Lori, K.; Intellectual Property Legal Services, Pharmacia &amp; Upjohn Company, 301 Henrietta Street, Kalamazoo, MI 49001 (US).</p>		<p>(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> <i>Without international search report and to be republished upon receipt of that report.</i></p>
<p>(54) Title: METHOD FOR AUTOACTIVATION OF PROCASPASE 8</p>		
<p>(57) Abstract</p> <p>A novel recombinant procaspase 8 protein lacking the death effector domains and a method for converting said novel procaspase protein to full active human caspase 8 by concentration of the procaspase 8 on a collection device.</p>		

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**METHOD FOR AUTOACTIVATION OF PROCASPASE 8****Background of Invention**Field of Invention:

5           The present invention is a method for converting recombinant procaspase 8 protein to active human caspase 8 enzyme and a method of producing the recombinant protein.

Related Art:

          The caspases are a family of related cysteinyl proteinases which play important intracellular roles in inflammation and apoptosis. See, for example, D. W. Nicholson et al.,  
10   TIBS **22**: 299-306 (1997). Members of this proteinase family share a number of features in common. They all employ a conserved cysteine residue as the nucleophile for attack on peptide bonds, and the sites of cleavage all show Asp in the P<sub>1</sub> position of the peptide substrates (A. C. Chinnayan et al., *Current Biol.* **6**, 555-562 (1996)). The catalytic domain of the caspases has a mass of roughly 30 kDa and comprises two polypeptide chains, a 20  
15   kDa N-terminal  $\alpha$  fragment which contains the active site Cys, and a 10 kDa C-terminal  $\beta$  peptide which contributes to the formation of the active site. These chains arise by internal cleavage of a single-chain zymogen precursor, and are tightly associated in an  $\alpha\beta$  heterodimer. Proteolytic processing which gives rise to these component polypeptides may be autocatalytic (H. R. Stennicke et al., *J. Biol. Chem.* **272**, 25719-25723 (1997)), or can be  
20   mediated by other caspases or by enzymes of similar specificity, for example, granzyme B, a lymphocyte enzyme with a specificity for P<sub>1</sub> Asp similar to that of the caspases (C.J. Froelich et al., *Nature Medicine* **3**: 954-55 (1997)).

          As with nearly all proteolytic enzymes, the caspases exist as inactive precursors, or proenzymes. The length of the N-terminal prodomains of the caspases vary considerably  
25   depending on how activation is regulated. Our present invention focuses on caspase 8 which is involved in apoptosis. The structure of the proenzyme, or zymogen form of this protein is illustrated schematically in Figures 1A, 1B and 1C. The N-terminal prosegment in caspase 8, contains two death-effector domains (DED). Immunoprecipitation experiments of activated death-initiation signaling complexes (DISC) show that procaspase 8 is a  
30   component of the activated receptor complexes (M. Muzio et al., *J. Biol. Chem.* **273**, 2926-2930 (1996)). Because of sequence homology between the death effector domains of procaspase 8 and the death domains (DD) of FADD and TRADD, the death domain proteins associated with TNF and Fas receptors (J. P. Medema et al., *EMBO Journal* **16**,

2794-2804 (1997)), the regions of homology are thought to result in the selective association or recruitment of procaspase 8 to the activated receptors. As a component of activated DISC, procaspase 8 plays a key role in the direct line of signal transduction, and activation of the Fas or TNF receptors with Fas ligand or TNF results in its autocatalytic, intermolecular activation. Activated caspase 8 is then thought to activate other, downstream caspases, like caspase 3, which have prosegments that are shorter and whose intracellular concentrations are not high enough to support their autocatalytic processing and activation. Thus, caspase 8 has been suggested to sit at the apex of the Fas or TNF mediated apoptotic cascade and likely serves as the prime mover for activation of the "executioners" of apoptosis whose function is to destroy critical cellular proteins (D. W. Nicholson et al., see above).

Because of its initiating role in Fas or TNF mediated apoptosis, caspase 8 is believed to be a viable target in blockade of the undesirable cell death which occurs in a variety of neurological disorders. See, for example, M. P. Mattson et al., *J. Neurochem.* **70**, 1-14 (1998). In view of the biological significant role of caspase 8 in the apoptotic process and the need to further elucidate the role and mechanism of action of this protein in the cell death process the need for a reproducible method for the production of active protein has become very important.

The current belief that the death-effector domains provide the mechanism for recruitment of procaspase 8 to the cell membrane is consistent with our finding that given a sufficiently high concentration of the catalytic domain of the protein in solution, it is possible to affect autoactivation of a truncated procaspase 8 construct missing the DED.

#### Information Disclosure

References relating to caspase 8: M. Muzio et al., *J. Biol. Chem.* **272**, 2952-2956 (1997); H.R. Stennicke et al., *J. Biol. Chem.* **272**, 25719-25723 (1997); Q. Zhou et al., *J. Biol. Chem.* **272**, 7797-7800 (1997); D. A. Martin et al., *J. Biol. Chem.* **273**, 4345-4349 (1998); and M. Muzio et al., *J. Biol. Chem.* **273**, 2926-2930 (1998).

Other caspase references: J. Sun et al., *Biochem. Biophys. Res. Comm.* **238**, 920-924 (1997); D. K. Miller et al., *J. Cell. Biochem.* **64**, 2-10 (1997); N. Margolin et al., *J. Biol. Chem.* **272**, 7223-7228 (1997); R. V. Talanian et al., *J. Biol. Chem.* **272**, 9677-9682 (1997); N. A. Thornberry et al., *J. Biol. Chem.* **272**, 17907-17911 (1997); K. Orth et al., *J. Biol. Chem.* **271**, 20977-20980 (1996); and T. Fernandes-Alnemri et al., *Cancer Res.* **55**, 2737-2742 (1995).

### Summary of Invention

The present invention provides a novel recombinant procaspase 8 protein molecule the amino acid sequence of which is shown in Figure 2 and more specifically in SEQ ID NO:

- 5 1. The cDNA construct (SEQ ID NO: 2) used to express the novel recombinant procaspase 8 protein is also a part of the present invention.

The present invention also provides a method for the quantitative and reproducible conversion of the recombinant procaspase 8 protein to active human caspase 8, with a recovery of 50 to 75%. In the method of the present invention a buffered solution, pH 8, of  
10 the recombinant procaspase 8 protein is passed through a matrix thereby concentrating the protein on the matrix surface to create an environment favorable to autoactivation of the protein. In a preferred embodiment of the present invention the matrix is an ultrafiltration membrane.

### Description of Figures:

15 Figures 1A, 1B, and 1C depict schematic representations of different procaspases. Figure 1A depicts native full length procaspase 3. Figure 1B depicts native full length procaspase 8. Figure 1C depicts the recombinant procaspase 8 of the present invention lacking the death effector domains (the recombinant (His)<sub>6</sub> procaspase 8 construct). Sites of autocatalytic processing are indicated by arrows.

20 Figure 2 depicts the complete amino acid sequence of the recombinant procaspase 8 of the present invention.

Figures 3A and 3B are SDS-PAGE gels. Figure 3A shows the effect of concentration of the buffered (His)<sub>6</sub> procaspase 8 solution on autoprocessing and autoactivation. Figure 3B shows the ultimate total processing of (His)<sub>6</sub> procaspase 8 under  
25 conditions of drying.

Figure 4 is a graphic representation of the effect of concentration of the buffered (His)<sub>6</sub> procaspase 8 solution on enzyme activity wherein the lines 1 to 10 correspond to lanes 1 to 9 of Figure 3A, and lane 10 of Figure 3B.

30 Figure 5 shows the reversed phase HPLC separation of the 10 and 20 kDa subunits of activated caspase 8. The conditions used were as follows: Vydac protein C<sub>4</sub> 0.46 x 25 cm column, flow rate: 0.8 ml/min., mobile phase 25-50% B in 45 min. (A: 0.15% TFA in water; B: 100% acetonitrile); detection wavelength: 220 nm.

Detailed Description of Invention:

The present invention provides a procaspase 8 polypeptide construct lacking the death effector domain (DED) prodomain. Hereinafter, references to a "procaspase 8 construct" will be understood to refer to procaspase 8 polypeptide lacking the DED  
5 prodomain.

The invention also provides a method for the quantitative, reproducible conversion of the recombinant procaspase 8 protein construct to highly active human caspase 8. In our method, activation is achieved by concentration of the protein onto a matrix surface. Non-specific aggregation of our procaspase 8 construct, without the DED prodomain, at a matrix  
10 surface results in substantially complete activation of the proenzyme. We propose that this "matrix-assisted" activation of the proenzyme mirrors the mode of intracellular activation of procaspase 8. Because our proenzyme lacks the long N-terminal prodomain present in natural procaspase 8, yet is fully activable by surface aggregation, the prodomain present in native procaspase 8 may serve only to bring the catalytic prodomains into close proximity  
15 via binding of their death-effector regions to sites on activated membrane receptor complexes.

The complete amino acid sequence of the procaspase 8 protein construct is shown in Figure 2 and SEQ ID NO: 1, and numbering of residues shown here will be used throughout the report in reference to particular amino acids in the construct.

The present invention also provides isolated nucleic acid molecules having a polynucleotide sequence encoding the procaspase 8 polypeptide lacking the DED prodomain polypeptides of the invention. Thus, the isolated nucleic acid molecules provided by the present invention may differ, and yet encode identical amino acid sequences, due to the degeneracy of the genetic code. Isolated nucleic acid molecules comprising a nucleotide  
25 sequence encoding fragments of any of the above-mentioned polypeptides are also included herein.

As used herein, an "isolated" nucleic acid molecule refers to a nucleic acid molecule (DNA or RNA) that has been removed from its native environment. Examples of isolated nucleic acid molecules include, but are not limited to, recombinant DNA molecules contained in a vector, recombinant DNA molecules maintained in a heterologous host cell,  
30 partially or substantially purified nucleic acid molecules, and synthetic DNA or RNA molecules.

The DNA molecules encoding procaspase 8 polypeptide lacking the DED prodomain of the present invention include cDNA, chemically synthesized DNA, DNA isolated by PCR, genomic DNA, and combinations thereof.

In a preferred embodiment, the isolated nucleic acid molecule of the invention  
5 comprises a polynucleotide having the complete nucleotide sequence given in SEQ ID NO 2.

The materials and certain art recognized procedures utilized in achieving the present invention are the following. Restriction enzymes, T4 DNA Ligase, and cell culture media/antibiotics were from Life Technologies (Gaithersburg, MD). Pfu cloned DNA polymerase was from Stratagene (La Jolla, CA). Oligonucleotide primers were synthesized  
10 by Genosys (The Woodlands, TX). Expression vectors, *E. coli* cells and DNA purification reagents were from Quagen (Chatsworth, CA). The DNA sequencing was done with the Sequenase Version 2.0 Kit from U.S.B. (Cleveland, Ohio). Guanidine hydrochloride, 7-amino-4-methyl-coumarin, 4-nitroaniline, Trizma base, Trizma hydrochloride, ethylenediaminetetraacetic acid tetrasodium salt, 2-mercaptoethanol, and dithiothrietol (99  
15 +%) were obtained from the Sigma Chemical Company. Mono and dibasic sodium phosphate were obtained from J.T. Baker. The caspase substrates Ac-DEVD-pNA, Ac-IETD-pNA, and Ac-IETD-AMC were obtained from California Peptide Research, Inc. (Napa, CA). The caspase substrates Ac-DEVD-AMC, Ac-YVAD-AMC and aldehyde inhibitors Ac-YVAD-H, Ac-DEVD-H and Ac-IETD-H were obtained from Peptide  
20 Institute, Inc. (Osaka, Japan; distributed in the US by Peptides International, Louisville, KY).

The cDNA coding for our procaspase 8 construct was amplified from Incyte clone T14775 by procedures known in the art (See, for example, K. Orth et al., *J. Biol. Chem.* **271**, 20977-20980 (1996); S. M. Srinivasula et al., *Proc. Natl. Acad. Sci. U.S.A.* **93**, 14486-  
25 14491 (1996); M. Muzio et al., *J. Biol. Chem.* **272**, 2952-2956 (1997) and cloned into the BamHI site of vector pGEX2T (Pharmacia) for expression. The insert was amplified by polymerase chain reaction (PCR), introducing a HindIII site at the 3' end for directional cloning into the BamHI-HindIII sites of vector pQE30 (Qiagen). The primers used for PCR were 5'-ggg ctg gca agc cac gtt tgg tg (pGEX vector 5' sequencing primer) (SEQ ID NO: 3)  
30 and 5' ccg act caa get tca atc aga agg gaa gac (SEQ ID NO: 4). Approximately 10 ng of the pGEX2T construct DNA was used under the following conditions: 5 minutes denaturation at 90°C followed by 30 cycles of 30 seconds at 90°C, 30 seconds at 48°C and 30 seconds at 72°C, and one cycle with a 5 minutes 70°C extension. The PCR products were fractionated

by agarose gel electrophoresis and purified by GeneClean (Bio101, Vista, CA). After digestion with BamHI and HindIII followed by agarose gel/GeneClean purification, the product was ligated into the corresponding sites of the pQE30 vector. The ligated DNA was used to transform *E. coli* M15 (pREP4) and DNA from potential positive colonies isolated using Qiaprep columns (Qiagen). Insert containing clones were identified by restriction digests and both DNA strands were sequenced.

The sequence of the new construct (pQE30-FLICE) is shown in SEQ ID NO: 2. The caspase 8 protease domain begins with *Met*<sub>13</sub> and terminates at *Asp*<sub>286</sub>. A prosegment, consisting of the first 12 amino acids precedes the protease sequence and contains a (His)<sub>6</sub>-tag for purification by Ni-chelate column chromatography.

The media used for plasmid propagation and expression was LB Broth with 100 µg/ml Ampicillin and 25 µg/ml Kanamycin, at 37°C. An overnight culture was diluted 1:100 and incubated with vigorous shaking to A<sub>550</sub>=0.7-0.8. Expression was induced by the addition of IPTG to a final concentration of 1mM. Cells were incubated for an additional 1, 1, and 3 hours and overnight. Harvesting of the bacteria was done by centrifugation at 5000xg for 10 min at 4°C. The cell pellets were resuspended in TE (10 mM Tris HCl pH8.0, 1mM EDTA) and frozen at -70°C for protein purification.

The protein was obtained by resuspending the cells and disrupting them by sonication on ice using a Branson sonifier. The insoluble protein fraction was separated from the soluble proteins and most of the cell debris by low speed centrifugation (3000 RPM, SS34 Sorvall rotor) for 30 min. Fractions were analyzed by SDS-PAGE. The presence of inclusion bodies was determined by light microscopy.

Quantitation of the protein was carried out by amino acid analysis. Samples were hydrolyzed in 6M HCl containing 1% phenol for 24 h at 110 C in evacuated sealed tubes. Dried hydrolysates were dissolved in buffer at pH 2.2 (NaS; Beckman) prior to automated ion-exchange chromatography on a Beckman Model 6300 amino acid analyzer. As a secondary method of quantitation, protein was estimated using the Coomassie Plus™ protein assay (Pierce Chemical Co) against caspase 8 standards the concentration of which was determined accurately by quantitative amino acid analysis.

To analyze the protein sequence PTH-amino acid sequencing was performed using a Perkin Elmer/Applied Biosystems Procise™ sequencer. A MacIntosh Quadra 650 computer with PE/Applied Bisystems Procise™ Model 610A version 2.1 software was employed for data acquisition and processing.

The masses of major procaspase processing fragments and intermediates were determined with electrospray ionization on a Micromass Quattro II MS and MALDI ionization on a Perseptive Biosystems Voyager Elite time-of-flight MS. The masses, N-terminal sequence data and known amino sequence of the procaspase construct were used to confirm the sites of autocatalytic cleavage and thus the complete amino acid sequence of the fragments.

Processed caspase 8 was analyzed by reversed-phase HPLC on a Vydac protein C<sub>4</sub> column (0.46 x 25 cm), flow rate: 0.8 ml/min, mobile phase 25-50% B in 45 minutes (A: 0.15% TFA in water B: 0.15% TFA in acetonitrile) using a Perkin Elmer Series 410 bioLCpump and PE 235C diode-array detector. Detection wavelengths were 220 and 280 nm. Data were acquired, archived and analyzed on a Shimadzu Class-VP chromatography data system. The results are shown in Fig. 5.

Sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) was carried out using Novex 16 % Tris-glycine or 10% NuPage Bis-Tris (with MES running buffer) precast mini-gels and a Novex Xcell II mini-cell apparatus. Samples were reduced and denatured by boiling in loading buffer containing 5% 2-mercaptoethanol prior to loading. Electrophoresis was carried out at constant voltage. Protein was visualized with Coomassie staining. Protein for N-terminal sequence analysis was electroblotted to PVDF (Amersham Hybond P) using the Novex Xcell II blot module. The results are shown in Fig. 3.

Enzyme activity of caspase 8 preparations was monitored using the chromogenic substrates Ac-DEVD-pNA or Ac-IETD-pNA or the fluorogenic substrates Ac-DEVD-AMC or Ac-IETD-AMC. For the chromogenic substrates, kinetic release of para-nitroaniline (pNA) was followed at 405 nm using either a Lambda 6 spectrophotometer or in a microtitre plate format using a Molecular Devices Thermomax plate reader with 405 nm wavelength filter. Kinetic enzyme assays monitoring the release of 7-amino-4-methylcoumarin from the fluorogenic substrates were conducted using a Molecular Devices fmax plate reader with Ex= 355 nm and Em= 460 nm.

Unless otherwise indicated, all specific enzyme activity measurements described herein were made using the Ac-DEVD-pNA substrate. Measurements were carried out at a substrate concentration of 400  $\mu$ M ( $K_m$ = 167  $\mu$ M) in 100 mM sodium phosphate/10 mM Tris/ 100 mM DTT, pH 7.50 at 37 °C. Initial rates were determined as follows: 100  $\mu$ l of 1M DTT, 790  $\mu$ l 100 mM sodium phosphate/10 mM Tris, pH 7.50, and 10  $\mu$ l of caspase 8 sample solution (for protein concentrations near 0.5 mg/ml) were added to a quartz semi-

micro cuvette. The solution was heated at 37 °C for 3 minutes after which time the reaction was started with the addition of 100 µl of 4 mM Ac-DEVD-pNA in 100 mM sodium phosphate/10 mM Tris, pH 7.50. Absorbance at 405 nm was followed for 15-30 using a Perkin Elmer Lambda 6 spectrophotometer with temperature controlled cuvette holder and auxillary circulating water bath equilibrated to 37 °C. Standards of paranitroaniline (pNA) were prepared to calibrate the molar extinction of the pNA product. Initial rate of pNA formation was calculated and specific activity (µmol pNA formed/min/mg) was calculated based on the protein concentration in each incubation mixture.

With the present invention we observed that upon dilution of the protein into 1.0 M Tris buffer, pH 8.0, the procaspase 8 gave a single, clean band on SDS-PAGE as shown in Figures 3A and 3B. The procaspase 8 at a concentration of about 25 µg/ml in 1.0 M Tris, pH 8.0/ 5 mM DTT, was concentrated under nitrogen pressure in an Amicon ultrafiltration cell, utilizing a regenerated cellulose 10000 MWCO membrane. Although we used an Amicon ultrafiltration cell which is cellulose based, other matrix surfaces may be used in practicing the present invention. During the course of concentration, samples were removed at various times and subjected to SDS-PAGE. Autoprocessing of the procaspase 8 to the characteristic 19 kDa and 11 kDa fragments of the active enzyme was not observed until a 100-fold concentration had been achieved (> 2 mg/ml). Upon standing for up to 4 h at this concentration only minor levels of the 19 and 11 kDa bands were observed to form as can be seen in Figures 3A and 3B. Nevertheless, this low degree of processing was accompanied by generation of a corresponding low level of active enzyme, as seen by the hydrolysis of the chromogenic substrates Ac-Asp-Glu-Val-Asp-paranitroanilide or Ac-Ile-Glu-Thr-Asp-paranitroanilide depicted in Figure 4. To our surprise, rinses of the ultrafiltration membranes used for concentrating the protein showed low levels of caspase 8 of high specific enzyme activity. Consequently, concentration of the protein solution to near dryness was carried out, leaving a moist membrane. The ultrafiltration cell was then disassembled, and the membrane washed with 1M Tris/5mM DTT, pH 8.0 buffer. All the protein was completely processed to the 19 and 11 kDa polypeptides as was shown by SDS-PAGE (see Figures 3A and 3B) and reversed phase HPLC (see Figure 5). The yield of protein from this procedure was nearly quantitative. The overall yield from starting inclusion body protein was 50-75 %, and it was reproducible. Complete conversion of our recombinant procaspase 8 protein to the highly active caspase 8 occurred consistently upon concentration of protein to near-dryness on ultrafiltration membranes. The completely

processed enzyme showed a corresponding high level of activity (Figure 4) with specific enzyme activities of 5-8  $\mu\text{mol}/\text{min}/\text{mg}$  (Ac-DEVD-pNA) or 8.4  $\mu\text{mol}/\text{min}/\text{mg}$  (Ac-IETD-pNA).

N-terminal sequence and sizes based upon mass spectral data for the two major 10 and 20 kDa autocatalytic processing fragments of our procaspase construct are annotated in 5 Figures 3A and 3B. The minor ca 20 kD bands migrating above the major p19 band on the gel contain the N-terminal His tag leader sequence. Sequence analysis of these and other minor bands observed after protein was electroblotted to PVDF and visualized with Coomassie staining showed that they all derived from the p33 precursor and are not 10 unrelated impurities. The full-length p33 precursor is indicated by the sequence: M<sup>1</sup> RGS(H)<sub>6</sub>...LVFPSD<sup>286</sup>; residue number indications are as derived from the sequence of the whole construct given in Figure 2. Prominent bands in lane 10 of Figure 3B correspond to the major products of processing to give the 19 kDa peptide (S<sup>18</sup>PREQD...IPVETD<sup>181</sup>) and the 11 kDa chain (L<sup>192</sup>SSPQ...LVFPSD<sup>286</sup>). Minor bands designated in Figures 3A and 3B 15 correspond to incompletely cleaved intermediate fragments (M<sup>1</sup>RGS(H)<sub>6</sub>...YLEMD<sup>191</sup>, MRGS(H)<sub>6</sub>...IPVETD<sup>181</sup>). Another site of alternate cleavage that was observed, but not shown in Figures 3A and 3B is that represented by S<sup>24</sup>ESQTLD.....IPVETD<sup>181</sup>. The sites of autocatalytic activation that we observed were identical to those reported for full length procaspase 8 (S. M. Srinvasula, 1996, see above).

20 Our autocatalytically processed caspase 8 preparations readily cleaved the chromogenic caspase substrates Ac-DEVD-pNA or Ac-IETD-pNA, as well as the fluorogenic substrates Ac-DEVD-AMC or Ac-IETD-AMC. Concentrated, but unprocessed, protein had no measurable activity against the same substrates.

Specific Example 1, set forth below, provides details of the isolation and refolding of 25 the recombinant protein, and it will be recognized by those skilled in the pertinent art that modifications to the procedure could be implemented. In the refolding process we maintained the pH of the solution at 8.0 using sodium hydroxide, however, other buffers having a pK in the range of 7 to 9 could be used. For example, phosphate, MOPS, HEPES are illustrative of suitable buffers which could be used. Also, in the solubilization of the 30 recombinant protein formic acid could be used in place of glacial acetic acid, however, we prefer the use of glacial acetic acid. It is highly important to maintain the recombinant protein in the reduced state. The step of concentrating the recombinant protein on a matrix results in high yields (50-75%) of recombinant human caspase 8 enzyme having high specific activity.

The highly active human caspase 8 produced by the procedures of the present invention can be used for biochemical studies and x-ray crystallographic analysis. Active caspase 8 is an  $\alpha_2\beta_2$  heterodimer, suggesting that therapeutic intervention in blocking the activity of this enzyme could derive from strategies geared both to blocking of the catalytic site, and to disruption of the dimer:dimer interaction.

The following specific example illustrates in detail the procedure for isolating the recombinant procaspase 8 protein from inclusion bodies, refolding the protein and concentrating the protein to obtain active human caspase 8 protein.

#### **Example 1a: Refolding Protocol**

*E. coli* expressing the construct as inclusion bodies were resuspended in 10 mM Tris, 1mM EDTA, pH 8.0 buffer to a cell density yielding OD<sub>550</sub> between 20-40. Cell aggregates were broken by brief (1-2 min) homogenization of the cell suspension using a polytron. A volume of 500 ml was passed through a Rannie high pressure homogenizer with a pressure differential of 10,000 psi to break up the cells. Inclusion bodies were sedimented by centrifugation at 1074 x g for 30 min at 4 °C. Inclusion body pellets were washed three times by resuspension in 10 mM Tris, 1 mM EDTA, pH 8.0 buffer, and resedimentation by centrifugation at 1074 x g. Inclusion bodies were then dissolved in 6M guanidine HCl, 0.1 M Tris, 5 mM DTT, pH 8.0 (2.5 ml per every 10 ml of TE buffer that was used for original *E. coli* suspension). The inclusion bodies were allowed to dissolve with magnetic stirring on ice for 1 hour followed by centrifugation at 27,491 x g for 15 min at 4 °C to sediment undissolved solid.

A volume of 20 ml of glacial acetic acid was added to 20 ml of the 6M guanidine solubilized inclusion bodies (procaspase 8 protein concentration of 1.6 mg/ml by quantitative amino acid analysis). The chaotrope was removed by dialysis (12-14,000 MWCO) overnight against 2 l of 50 % acetic acid followed by dilution into 360 ml of Milli-Q purified water. This solution was rapidly diluted into 1600 ml of 1M Tris, 5 mM DTT, pH 8.0. The pH of the solution was adjusted to 8.0 with 2N sodium hydroxide. The solution, 2450 ml, was transferred to an Amicon Model 2000 stirred ultrafiltration cell with a MilliPore PLGC 10,000 MWCO regenerated cellulose, low protein binding 150 mm diameter membrane. The solution was concentrated with stirring under a nitrogen pressure of 40 psi. Specific activity measurements and SDS-PAGE analysis were performed as a function of concentration of the 32 kD proenzyme construct. The solution was concentrated from 2450 ml to near dryness, leaving a moist membrane. Protein was then resolubilized with the

addition of 40.0 ml of fresh 1M Tris/5 mM DTT pH 8.0 buffer. Undissolved material was removed by centrifugation and protein measured by quantitative amino acid analysis.

**Example 1b: Size Exclusion Chromatography**

Recombinant activated human caspase 8 (0.5 mg/ml) was analyzed by size exclusion chromatography (injected volume = 20  $\mu$ l) at 25 °C on a Toyopearl G2000SW column (300 x 8 mm;Toso Haas) with Dulbecco's phosphate buffered saline, pH 7.1 as the running buffer (Gibco BRL, without  $MgCl_2$  and  $CaCl_2$ ) at a flow rate of 0.5 ml/min. Chromatography was carried out on a Waters 625 HPLC system with Waters 484 variable wavelength detector (UV@220 nm). Data were acquired, archived and analyzed on a Shimadzu Class-VP chromatography data system. Fractions (100  $\mu$ l each) eluting from the gel filtration column were collected manually. The fractions were assayed immediately following collection for enzyme activity in the following manner: 50  $\mu$ l of each column fraction was added to separate wells of a 96-well microtitre plate, 20  $\mu$ l of 1M DTT, and 125  $\mu$ l of 100 mM sodium phosphate, pH 7.2 buffer was added. The plate was preincubated at 37 °C for 3 min and then 5  $\mu$ l of 4 mM Ac-IETD-pNA substrate stock in buffer was added to each well to start the reactions. The initial rates of reaction were followed by monitoring absorbance change at 405 nm. Molecular weight calibration was performed using the following standards obtained from Sigma: BSA (66,000), ovalbumin (45,000), chymotrypsinogen A (25,000), cytochrome c (12,500).

Samples of activated caspase 8 in 1M Tris, pH 8.0 containing 5, 25, and 100 mM DTT were allowed to stand on ice for up to 48 h. Aliquots were analyzed by size exclusion chromatography and enzyme activity (as above).

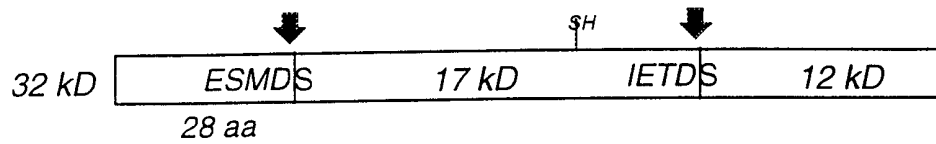
*What is claimed is:*

1. An isolated nucleic acid molecule comprising a polynucleotide having a nucleotide sequence selected from the group consisting of:
  - (a) a nucleotide sequence encoding a human procaspase 8 polypeptide lacking the DED and having the complete amino acid sequence of SEQ ID NO:1; and
  - (b) a nucleotide sequence that is complementary to the nucleotide sequence of (a).
2. The nucleic acid molecule of claim 1, wherein the polynucleotide molecule of 1(a) comprises the complete nucleotide sequence of SEQ ID NO:2.
3. An isolated nucleic acid molecule comprising a polynucleotide having a sequence at least 95% identical to a polynucleotide having the nucleotide sequence in (a) or (b) of claim 1.
4. A vector comprising the nucleic acid molecule of claim 1.
5. The vector of claim 4, wherein said nucleic acid molecule of claim 1 is operably linked to a promoter for the expression of a human procaspase 8 polypeptide lacking the DED.
6. A host cell comprising the vector of claim 5.
7. The host cell of claim 6, wherein said host is *E. coli*.
8. A method of obtaining a human procaspase 8 polypeptide lacking the DED comprising culturing the host cell of claim 7 and isolating said polypeptide.
9. A human procaspase 8 polypeptide lacking the DED produced by the method of claim 8.
10. An isolated human procaspase 8 polypeptide lacking the DED comprising the amino acid sequence of SEQ ID NO:1.
11. A method for converting recombinant procaspase 8 protein lacking the DED to active human caspase 8 enzyme which comprises passing a solution of said protein through a matrix capable of concentrating said protein to affect auto-activation thereof to give active human caspase 8 enzyme.

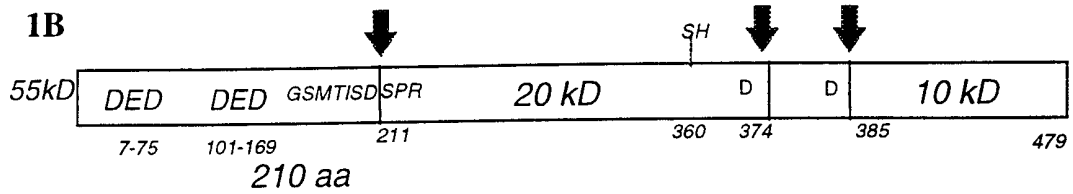
12. The method of claim 11 wherein the procaspase 8 protein lacking the DED comprises the amino acid sequence of SEQ ID NO:1.
- 5 13. The method of claim 11 wherein the matrix is an ultrafiltration membrane.
14. The method of claim 11 wherein the matrix is a Ni chelate column.
15. The method of claim 11 wherein the matrix is an anion exchange column.
- 10 16. The method of claim 13 wherein the membrane is comprised of cellulose.
17. The method of claim 16 wherein the procaspase 8 protein lacking the DED comprises the amino acid sequence of SEQ ID NO:1.
- 15

Figures 1A - 1C

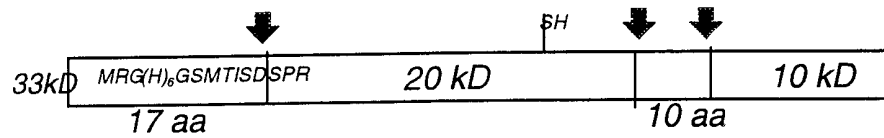
1A



1B



1C



**Figure 2**

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Figures 3A and 3B

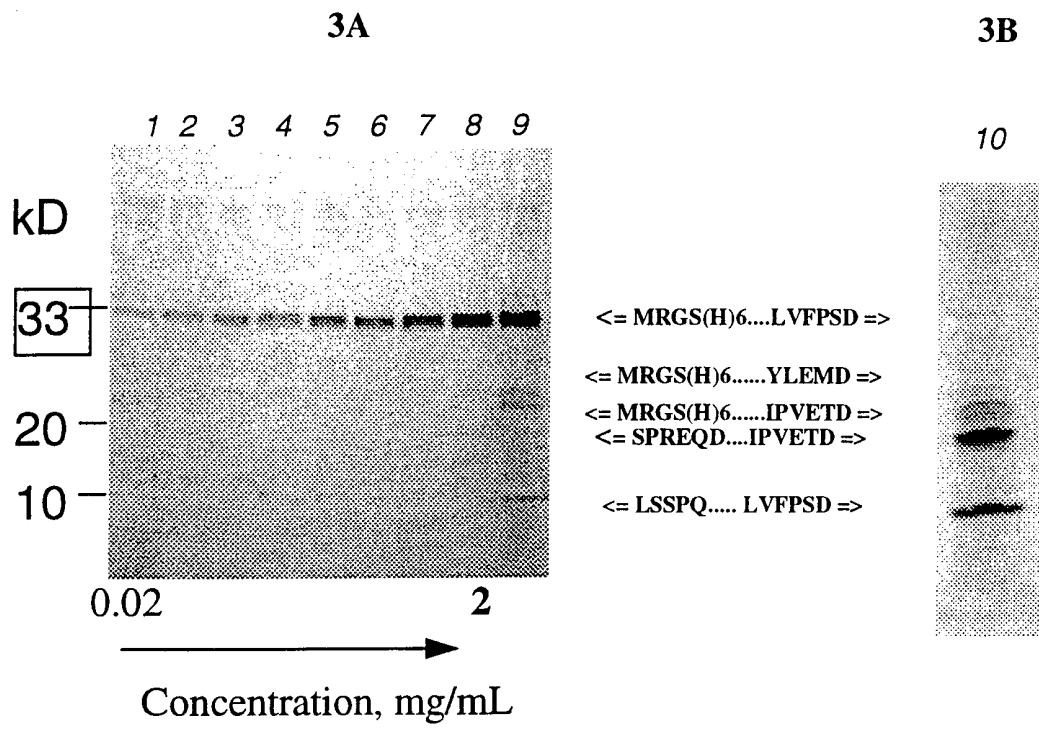


Figure 4

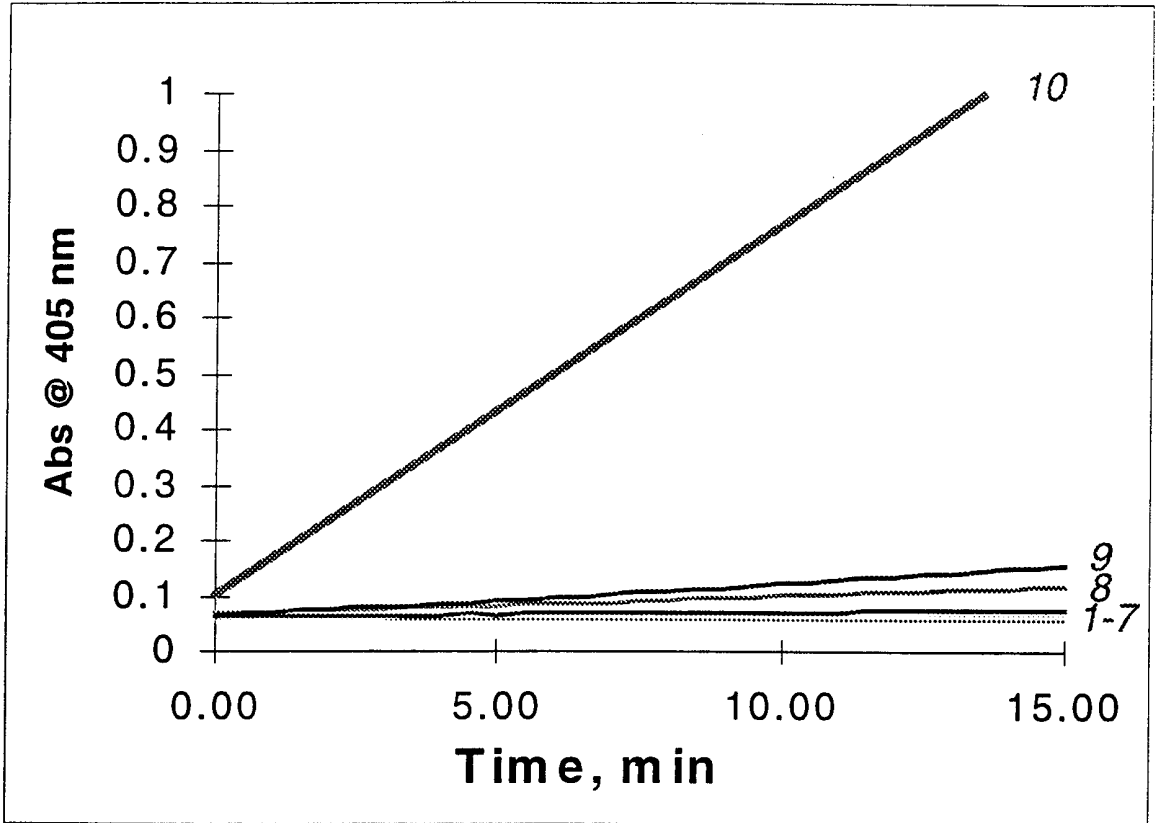
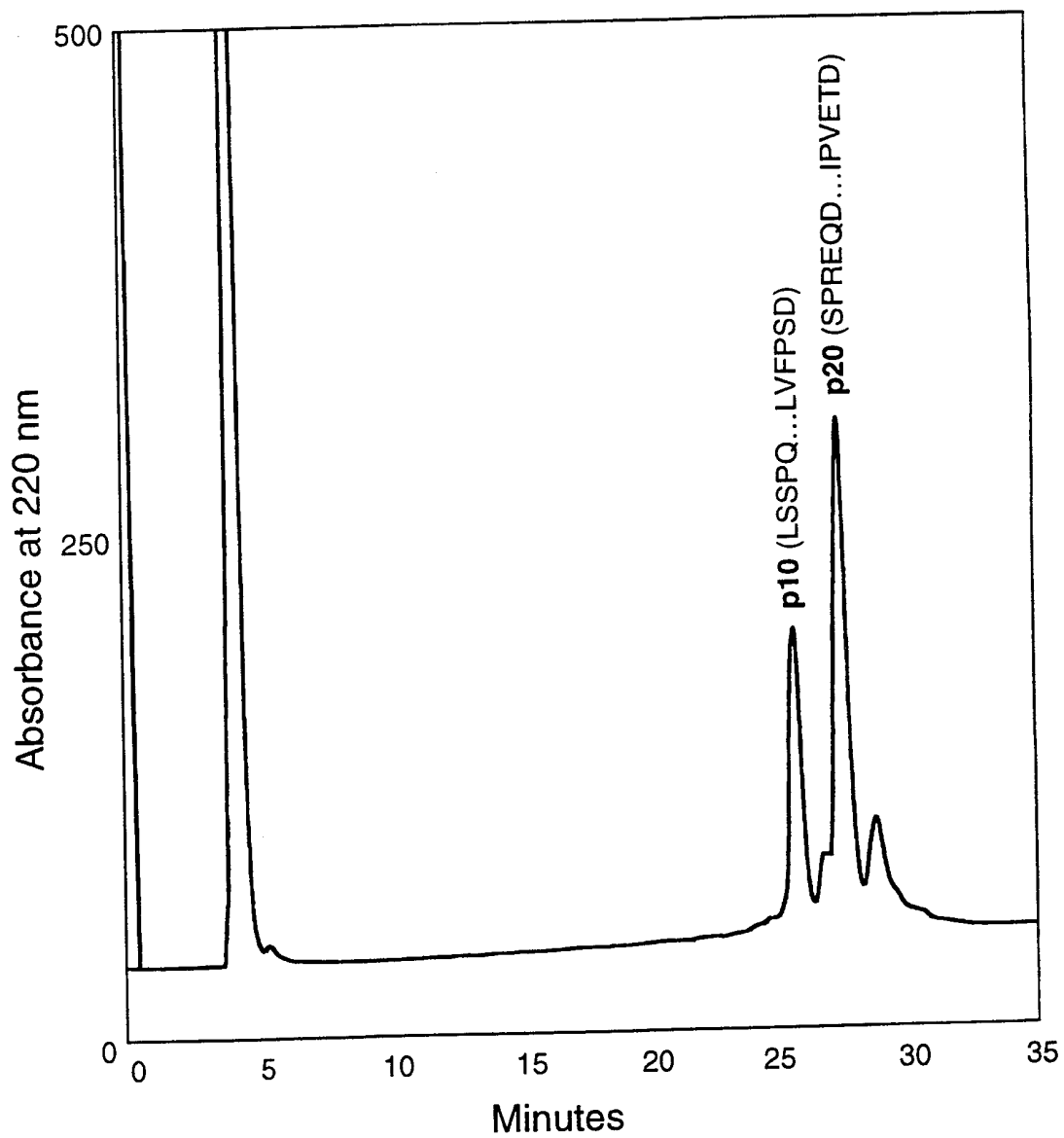


Figure 5



## SEQUENCE LISTING

<110> Heinrikson, Robert I.

Tomasselli, Alfredo G.

Koeplinger, Kenneth A.

<120> Method for Autoactivation of Procaspase 8

<130> Docket No. 6172.P CP

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