GLYCOPROTEOMICS IN NEURODEGENERATIVE DISEASES

Hyejin Hwang,[1] Jianpeng Zhang,[1] Kathryn A. Chung,[2] James B. Leverenz,[3,4] Cyrus P. Zabetian,[4] Elaine R. Peskind,[3,4] Joseph Jankovic,[5] Zhen Su,[1] Aneeka M. Hancock,[1] Catherine Pan,[1] Thomas J. Montine,[1] Sheng Pan,[1] John Nutt,[2] Roger Albin,[6] Marla Gearing,[7] Richard P. Beyer,[8] Min Shi,[1] and Jing Zhang[1]*

[1]*Department of Pathology, University of Washington, Seattle, WA*
[2]*Department of Neurology, Oregon Health and Science University, Portland, OR*
[3]*Department of Psychiatry and Behavioral Sciences, University of Washington School of Medicine, Seattle, WA*
[4]*Department of Neurology, University of Washington School of Medicine, Seattle, WA*
[5]*Department of Neurology, Baylor College of Medicine, Houston, TX*
[6]*Ann Arbor VAMC GRECC and Department of Neurology, University of Michigan, Ann Arbor, MI*
[7]*Department of Pathology and Laboratory Medicine, Emory University, Atlanta, GA*
[8]*Department of Environmental & Occupational Health Sciences, University of Washington School of Medicine, Seattle, WA*

Received 23 October 2008; accepted 29 December 2008

Published online 8 April 2009 in Wiley InterScience (www.interscience.wiley.com) DOI 10.1002/mas.20221

Protein glycosylation regulates protein function and cellular distribution. Additionally, aberrant protein glycosylations have been recognized to play major roles in human disorders, including neurodegenerative diseases. Glycoproteomics, a branch of proteomics that catalogs and quantifies glycoproteins, provides a powerful means to systematically profile the glycopeptides or glycoproteins of a complex mixture that are highly enriched in body fluids, and therefore, carry great potential to be diagnostic and/or prognostic markers. Application of this mass spectrometry-based technology to the study of neurodegenerative disorders (e.g., Alzheimer's disease and Parkinson's disease) is relatively new, and is expected to provide insight into the biochemical pathogenesis of neurodegeneration, as well as biomarker discovery. In this review, we have summarized the current understanding of glycoproteins in biology and neurodegenerative disease, and have discussed existing proteomic technologies that are utilized to characterize glycoproteins. Some of the ongoing studies, where glycoproteins isolated from cerebrospinal fluid and human brain are being characterized in Parkinson's disease at different stages versus controls, are presented, along with future applications of targeted validation of brain specific glycoproteins in body fluids. © 2009 Wiley Periodicals, Inc., Mass Spec Rev 29:79–125, 2010

Keywords: *glycoproteomics; mass spectrometry; Alzheimer's diseases; Parkinson's disease; biomarkers; cerebrospinal fluids*

I. INTRODUCTION

Advances in proteomic concepts and technologies, particularly unbiased techniques, have stimulated a great interest in application of mass spectrometry (MS) to explore neurodegenerative disorders, for example, Alzheimer's disease (AD), Parkinson's disease (PD), and amyotrophic lateral sclerosis (ALS)—one of the most important groups of diseases in our rapidly aging population in developing and industrialized countries (Chiang, Lam, & Luo, 2008). Application of these techniques to neurodegenerative disorders is especially advantageous because, despite decades of ''mechanism''- or ''pathway'' -based pursuits, the pathogenesis of most of these diseases remains largely unknown (Cookson, 2005; Moore et al., 2005; Thomas & Beal, 2007; Arakawa, Kita, & Niikura, 2008; Siddique & Siddique, 2008). Indeed, in the past several years, proteomic investigations that use different platforms with samples collected from AD and PD patients have already revealed quite a few novel proteins that are potentially critical, not only to the understanding of the mechanisms of the diseases but also to new avenues to diagnose these diseases and to monitor disease progression (Castegna et al., 2002; Butterfield et al., 2003; Jin et al., 2006; Finehout et al., 2007; Leverenz et al., 2007; Osorio et al., 2007; Simonsen et al., 2007).

Defining protein biomarkers unique to a disease diagnosis or progression in body fluids, particularly cerebrospinal fluid (CSF), is currently one of the most exciting areas of research in neurodegenerative disorders (Yuan & Desiderio, 2003, 2005; Rite et al., 2007; Simonsen et al., 2007; Tumani et al., 2008; Yang et al., 2008). CSF, which originates within the ventricles and surrounds the brain and spinal cord, is an ideal source for biomarker discovery for diseases of the central nervous system (CNS) like AD and PD. The reasons include (Abdi et al., 2006;

Contract grant sponsor: NIH; Contract grant numbers: ES012703, NS057567, AG025327, AG033398, NS060252, AG05136, AG08671.
**Correspondence to:* Jing Zhang, Department of Pathology, University of Washington School of Medicine, HMC Box 359635, Seattle, WA 98104. E-mail: zhangj@u.washington.edu

Zhang, 2007; Srivastava, Murphy, & Jeffery, 2008): (1) CSF is the only body fluid that directly interchanges with the extracellular fluid of the CNS, and therefore reflects pathological changes in the CNS most directly, and (2) multiple CSF taps can be obtained with minimal risk to make possible a longitudinal analysis of biomarkers in a given cohort. That said, among thousands of proteins identified by proteomics in human CSF thus far (Pan et al., 2007b; Zougman et al., 2008), only a small portion are related to the CNS structurally or functionally. This deficit in identifying CNS-specific proteins is mainly due to the fact that most of the CNS-specific proteins are low in abundance, and all current proteomic techniques are biased towards abundant proteins in a sample with a large dynamic range (Gulcicek et al., 2005). One of the approaches to get around this difficulty is to focus on a subproteome(s) that can be isolated readily (e.g., proteins with glycosylation, phosphorylation, or oxidation) before proteomic profiling, thereby effectively reducing the dynamic range of a given complex sample (Korolainen et al., 2002; Bahl et al., 2008; Kubota et al., 2008). To this end, characterizing glycoproteins is especially appealing because they are intimately related to the health of cells, and in addition, are relatively enriched in body fluids like CSF and plasma (Ohtsubo & Marth, 2006).

In this report, we will begin by summarizing the current understanding of glycoproteins in biology and neurodegenerative disease, followed by an introduction of existing proteomic technologies used to characterize glycoproteins. Next, we will present some of the ongoing studies where glycoproteins isolated from human CSF and brain tissue are characterized in PD at different stages and in controls. Future applications of targeted proteomics—to identify unique proteins in the CNS first, followed by confirmation/validation of known proteins in CSF or plasma—also will be addressed briefly.

II. GLYCOPROTEINS IN HEATH AND NEURODEGENERATIVE DISEASE

A. Glycosylation in Health and Disease

Post-translational modifications (PTMs) play a key role to modulate the activities and functions of most proteins in biological systems (Hann, 2006). Among various PTMs, glycosylation represents the most common and complicated form. It is estimated that 50–60% of proteins in the human body are modified by glycosylation (Apweiler, Hermjakob, & Sharon, 1999; Hagglund et al., 2004; Kameyama et al., 2006). A glycoprotein often contains more than one oligosaccharide attachment site, and each glycosylation site can be modified with multiple oligosaccharide chains. Additionally, on a single glycoprotein, the structure of oligosaccharides at each site can be significantly different. Various glycosylated proteins are synthesized mainly in the endoplasmic reticulum and Golgi *via* reactions that involve sugar nucleotide synthases, transporters, glycosyltransferases, glycosidases, and other sugar-modifying enzymes. In addition, the structures of glycans can be easily altered by changes of the physiological condition of the cells (Lowe & Marth, 2003; Haltiwanger & Lowe, 2004). It should be noted that, although it is beyond a review focused on glycoproteins, a mass spectrometric study of glycans is itself an active area of current research (Morelle & Michalski, 2005; Zaia, 2008).

The amino acids known to be involved in glycosylation are asparagine, arginine, serine, threonine, proline, hydroxyproline, tryptophan, and tyrosine (Spiro, 2002). Typically, protein glycosylation is categorized as either O-linked or N-linked. The N-linked glycosylation, characterized by the attachment of the glycan to an asparagine side chain of the protein, is by far the most common (Nalivaeva & Turner, 2001). The consensus sequence for N-glycosylation is Asn-Xaa-Ser/Thr, where Xaa is any amino acid other than proline (Johansen, Marshall, & Neuberger, 1961). The asparagine is linked to N-acetylglucosamine (GlcNAc) residues. Additional sugar residues in the glycan depend on whether the glycosylation is the high-mannose hybrid or complex type (Suzuki et al., 1995). In O-linked glycosylation, on the other hand, the glycan is attached to the serine/threonine side chain (Spiro, 1973). O-linked glycosylation usually starts with an N-acetylgalactosamine (GalNAc) linked to serine/threonine and, unlike N-linked glycosylation, no consensus sequence that defines an O-linked glycosylation site exists (Spiro, 1964, 1973, 2002; Tanaka, Bertolini, & Pigman, 1964). This type of glycosylation is observed most abundantly in mucin-like glycoproteins that form part of epithelial secretions in, for example, the gut, cervix, and lungs (Gendler & Spicer, 1995; Hanisch, 2001). Another variation of O-linked glycans is the Ser/Thr-O-GlcNAc sequence, which is abundant in nucleocytosolic proteins that aid in signal transduction (Spiro, 2002).

One of the initial functions of glycosylation of a given protein is to direct the protein to the appropriate subcellular location; for example, many lysosomal proteins contain a mannose-6-phosphate moiety, a signaling molecule for lysosome (Kaplan, Achord, & Sly, 1977; Varki & Kornfeld, 1980). Additionally, glycosylation has been implicated in numerous biological processes, including cell growth and developmental biology, immune response, tumor growth, metastasis, anti-coagulation, cell-to-cell communication, and microbial pathogenesis (Liu et al., 2002; Sasisekharan et al., 2002; Hwang et al., 2003; Inatani et al., 2003; Lowe & Marth, 2003; Casu, Guerrini, & Torri, 2004; Collins & Paulson, 2004; Guo et al., 2004; Lin, 2004; Dube & Bertozzi, 2005; Kinjo et al., 2005; Miller, Ernst, & Bader, 2005). Aberrant protein glycosylations could also contribute to human disorders, including neurodegenerative diseases (Liu et al., 2002; Saez-Valero et al., 2003).

B. Glycosylation Alterations in Human Neurodegenerative Disorders

Alterations in protein glycosylation have been related to human neurodegenerative disease states, such as Creutzfeldt-Jakob disease (CJD), AD, and PD (Saez-Valero et al., 2003; Silveyra et al., 2006). Although the structural elucidation of glycoproteins is a challenge because of their inherent complexity and heterogeneity in biological systems, advances have been made to identify a few proteins where glycosylation appears to be important in the disease processes of AD and PD (Sihlbom et al.,

2004). A few key proteins involved in AD and PD pathogenesis are discussed below.

Acetylcholinesterase (AChE), one of the critical enzymes targeted in the current clinical management of AD, hydrolyzes the neurotransmitter acetylcholine at cholinergic synapses, and is widely distributed in brain regions. The glycosylation of AChE is altered in the *post-mortem* brain and CSF of AD patients (Saez-Valero et al., 1999, 2000). Additionally, the change in glycosylation of AChE appears to be specific for AD because it is not seen in other neurological diseases. More recently, the glycosylation of a related enzyme, butyrylcholinesterase (BuChE), also appears to be altered in AD CSF (Saez-Valero & Small, 2001). Unfortunately, the sensitivity of diagnosing AD with AChE and BuChE in the CSF is lower than that considered necessary for a satisfactory biomarker (Saez-Valero et al., 2003).

Microtubule-associated protein (MAP) tau, another essential protein involved in AD pathogenesis and related tauopathies, undergoes several PTMs, and aggregates into paired helical filaments. Known modifications of tau include hyperphosphorylation, glycosylation, ubiquitination, glycation, polyamination, nitration, and proteolysis. Glycosylation of tau is an early abnormality that might facilitate the hyperphosphorylation of tau, a pathological hallmark, in an AD brain (Liu et al., 2002). Robertson, Moya, and Breen (2004) observed a significant decrease in the glycosylated tau (O-linked) in AD *post-mortem* brain samples compared with control; that decrease suggested an inverse relationship between the two PTMs (i.e., glycosylation vs. hyperphosphorylation). Furthermore, cells transfected with the cDNA coding for O-GlcNAc transferase displayed altered tau phosphorylation patterns as compared with control cells; these alterations again suggested that changes in tau glycosylation might influence its phosphorylation state. However, glycosylation of tau as a biomarker for AD has not been reported.

Until recently, very little has been known about the role of glycosylated proteins in PD. Farrer et al. (2001) noted a potential connection between the dysfunction of parkin, an E3 ubiquitin ligase involved in the ubiquitination of protein substrates that targets them for degradation by the proteasomal complex, and the formation of α-synuclein inclusions. It turned out that the mechanism that underlies this process could be the parkin-mediated ubiquitination of an O-linked glycosylated form of α-synuclein (Shimura et al., 2001). It should be emphasized that mutations of parkin and α-synuclein result in the development of autosomal recessive and dominant familial PD, respectively (Tan & Skipper, 2007; Wakabayashi et al., 2007), and that changes in the total amount of α-synuclein in CSF have been tested as potential biomarkers of PD (also see later discussion).

From what has been discussed above, it is obvious that glycosylation and glycoproteins play critical roles not only in normal physiological conditions but perhaps also in neurodegenerative disorders like in AD and PD. On the other hand, aside from two earlier reports of CSF glycoproteins (Sihlbom et al., 2004; Pan et al., 2006), there is no systematic analysis of glycoproteins in human tissue or CSF for any disease or even in control subjects. Thus, in this report, we will present the glycoproteins identified in human brain in addition to CSF after an introduction of the current proteomic techniques used for characterization of glycoproteins.

III. CHARACTERIZATION OF GLYCOPROTEINS BY MASS SPECTROMETRY-BASED PROTEOMICS

A. Enrichment of Glycoproteins

As discussed above, the glycoproteome represents one of the most important sub-proteomes in tissues and body fluids. However, many glycoproteins might be low in abundance in their glycosylated forms, even though the parent proteins are abundant in CSF or plasma. Consequently, numerous attempts have been made to develop methods to enrich glycoproteins present in complex biological samples prior to mass spectrometric analysis.

1. Enrichment by Lectin Column

Lectins are widely distributed in nature and can recognize carbohydrates on the surface of proteins. To isolate glycoproteins or glycopeptides by affinity chromatography, various lectins can be used (Cummings & Kornfeld, 1982; Hirabayashi, 2004). Concanavalin A (ConA) is a lectin that binds mannosyl and glucosyl residues that contain unmodified hydroxyl groups at positions C3, C4, and C6, and can be utilized for the targeted binding of certain oligosaccharide structures of N-glycosylated proteins (Goldstein, Hollerman, & Smith, 1965; Yahara & Edelman, 1972; Kamra & Gupta, 1987). The use of wheat germ agglutinin (WGA) isolates glycostructures with N-acetylglucosamine and sialic acids (Nagata & Burger, 1974). *Arachis hypogaea* agglutinin (PNA) is specific to glycans that contain β-Gal, whereas *Datura stramonium* agglutinin (DSA) is specific to glycans that contain GlcNAc residues (Novogrodsky et al., 1975; Yamashita et al., 1987). Due to their ability to specifically recognize distinct oligosaccharide epitopes (Sharon & Lis, 1989), lectins bound to appropriate matrices like agarose, membranes, or magnetic beads, can be used to isolate, fractionate, and characterize glycoproteins on the basis of their different glycan structures (Wiener & van Hoek, 1996; Bundy & Fenselau, 2001). In this regard, affinity chromatography with lectins is a useful and powerful technique to fractionate and isolate glycans and glycopeptides. The combination of lectin chromatography and MS analysis provides high-sensitive detection and useful information on glycan structures, and enables further biological approaches. However, because individual lectins display unique binding specificities, separation with a particular lectin will isolate only a fraction of glycoproteins or glycopeptides that bind to that lectin with high affinity (Xiong, Andrews, & Regnier, 2003; Bunkenborg et al., 2004; Ghosh et al., 2004). To overcome the limitation of selective capture of a subset of glycoproteins for a given lectin, a technique has been introduced for glycoprotein/peptide isolation and enrichment from complex mixtures that involves double lectin chromatography prior to identification with liquid chromatograph (LC)-electrospray ionization (ESI) MS (Bunkenborg et al., 2004). Recently, a more elegant method has been established with a multi-lectin column, which allows for an almost complete enrichment of glycoproteins from biological fluids (Yang & Hancock, 2004; Wang, Wu, & Hancock, 2006). In a similar manner, lectin arrays have been developed that contain more than 35 different lectins that allow a qualitative and quantitative

profiling of glycoprotein glycan patterns in a rapid and sensitive high-throughput manner (Kuno et al., 2005). Finally, lectin microcolumns have also been generated that are applicable to high-pressure analytical schemes, and thus, can be directly coupled on-line to ESI-MS to enable a highly sensitive semi-automated profiling of glycoproteins (Madera, Mechref, & Novotny, 2005; Madera et al., 2006, 2007).

2. Enrichment with Hydrazide

Hydrazide chemistry has been used to selectively isolate, identify, and quantify N-linked glycopeptides in a much more specific and efficient manner (Zhang et al., 2003). This method is based on the conjugation of glycoproteins to a solid support with hydrazide chemistry after periodate-mediated oxidation of the carbohydrate. Peptide moieties of the covalently captured glycopeptides are released with PNGase F treatment to allow the peptide and glycosylation site to be identified. Recently, Sun et al. (2007) reported a novel chemical capture approach that focuses on a more efficient glycopeptide enrichment. In this approach, glycopeptides derived from glycoproteins are enriched by selective capture onto a solid support with hydrazide chemistry followed by enzymatic release of the peptides and subsequent analysis by tandem MS. Digestion of proteins into peptides improves the solubility of large membrane proteins, and exposes all of the glycosylation sites (at least in theory) to ensure an equal accessibility to external capture reagents. Notably, whereas the specificity has been increased by capturing N-linked glycopeptides/glycoproteins with the hydrazide chemistry, this method is restricted to N-glycopeptides and, in addition, information on the carbohydrate structures is lost due to the destruction and removal of the glycan moieties.

3. Other Methods for Enriching Glycoproteins

Besides lectins and hydrazide, a few other techniques, including treatment with boronic acids, have also been employed to facilitate enrichment of glycoproteins. Because boronic acids enhance the capture of the more heterogeneous group of O-linked oligosaccharides, this method has been incorporated into lectin methodology; for example, a boronic acid-lectin affinity chromatography column has been used to isolate glycoproteins with selective and/or combined elution (Monzo, Bonn, & Guttman, 2007).

B. Mass Spectrometric Analysis of Glycoproteins/Peptides

Modern MS has greatly facilitated the characterization of glycoproteins because it provides glycosylation site-specific information by conducting glycopeptide-based analysis, wherein the glycan and its attachment site to the protein can be elucidated in the same experiment; at least in theory. This glycosylation site-specific information is useful to elucidate functional properties of the glycoprotein. Typically, glycopeptide-based MS analysis entails an enzymatic cleavage of glycoproteins with an endoprotease, followed by a separation technique and mass analysis.

1. Desalting

When analyzing glycopeptides and glycoproteins, it is necessary to desalt the sample and remove organic contaminants to avoid the formation of salt adducts, thereby obtaining more-informative MS spectra. Cation and anion exchange materials have been used commonly for desalting (Lattard et al., 2006). One of the efficient methods is to use a microcolumn in a GELoader tip (Eppendorf) into which a mixed bed resin column of AG-3 (to remove anions), AG-50 (to remove cations), and C18 (to remove organic materials) are packed (Kussmann et al., 1997). Hydrophilic interaction liquid chromatography (HILIC) (Hagglund et al., 2004) and graphite columns (Larsen, Cordwell, & Roepstorff, 2002) are also useful for desalting.

2. Identification of Glycoproteins by Mass Spectrometric Technologies

Most of the large-scale glycoprotein identification studies have used a shotgun proteomics approach, in which glycoproteins are typically trypsin-digested and de-glycosylated so that glycosylated peptides can be sequenced in their deglycosylated forms with MS/MS. For glycopeptides with N-linked glycosylation site(s), most of the glycans can be removed with PNGase F. The enzyme cleavage of a glycan group converts asparagine to aspartic acid in a peptide, to introduce a mass difference of 0.984 Da and a negative charge. This phenomenon was used to map the N-linked glycosylation site(s) using MS (Zhou, Aebersold, & Zhang, 2007). In the past few years, several studies have used MS to profile N-linked glycoproteins in human body fluids. Liu et al. (2005) applied immunoaffinity subtraction and hydrazide chemistry to enrich glycoproteins from human plasma. The captured plasma glycoproteins were subjected to two-dimensional (2D) LC separation (strong cation exchange [SCX] and reverse-phase capillary LC) followed by tandem MS or MS/MS analysis with a Fourier transform ion cyclotron resonance mass spectrometer. A detection sensitivity at low ng/mL was achieved. A total of 2,053 different N-glycopeptides, representing 303 non-redundant glycoproteins, were identified, including many low-abundance glycoproteins. Other studies applied a lectin affinity-based approach to characterize serum and plasma N-linked glycoproteins, and have added significant numbers of glycoproteins to the blood glycoproteome database (Zhang et al., 2003; Yang & Hancock, 2004). Related to the study of neurodegenerative diseases, the CSF glycoproteome has been investigated in an experiment, where lectin affinity and hydrazide chemistry enrichment methods were both applied to reveal 216 glycoproteins (Pan et al., 2006).

Different approaches have characterized O-glycosylation with tandem mass spectrometry. A very sensitive technique to identify O-glycosylated sites employs the use of ammonia or ethylamine for the specific release of O-linked glycan chains. The integrity of the peptide backbone was retained and ammonia or ethylamine was incorporated into the amino acid residue(s) to

which the glycan(s) had been attached. Thus, the former glycosylation site was labeled, and thus, can be identified by the mass alteration of −1 Da and +27 Da for ammonia and ethylamine, respectively (Rademaker et al., 1998; Hanisch, Jovanovic, & Peter-Katalinic, 2001). The limitations of collision-induced dissociation (CID) ESI-MS/MS for glycosylation site analysis (i.e., the dominating fragmentation of the glycan chains) can be overcome with different tandem MS techniques. Haynes and Aebersold (2000) demonstrated a technique that provided simultaneous detection and identification of O-GlcNAc-modified peptides with low-energy collisions in tandem MS. The differential between the energy required to remove the O-GlcNAc group versus the energy required to fragment the peptide chain allows the O-GlcNAc group to be detected and the peptide sequence, and therefore the protein, to be identified. More recently, ''soft'' collision techniques, such as electron capture dissociation (ECD) and electron transfer dissociation (ETD) (Mormann, Paulsen, & Peter-Katalinic, 2005; Catalina et al., 2007), have led to a preferential cleavage of the peptide backbone and to leaving glycan structures intact, to thus allow an unambiguous assignment of the glycosylation site in N- and O-glycopeptides (Hakansson et al., 2001; Hogan et al., 2005). To enhance the specificity of O-glycosylation analysis, Durham et al. applied a serial lectin affinity chromatography that combine ConA and Jacalin to enhance the identification of O-glycosylated sites on proteins from the human blood proteome (Durham & Regnier, 2006). The enriched O-glycopeptides were deglycosylated with oxidative elimination and analyzed with ESI and MALDI (matrix-assisted laser desorption/ionization) tandem MS to identify over thirty O-glycosylated glycoproteins from human serum.

MALDI-based mass spectrometric analysis usually produces singly charged glycopeptide ions that can be analyzed off-line with high sensitivity after deposition of nano-LC-derived glycopeptide fractions onto the MALDI-target (Lochnit & Geyer, 2004). This technique is complementary to ESI technology, because ESI mass spectra are sometimes too complicated to fully assign oligosaccharide structures due to the formation of many multiply charged ions. With a MALDI-TOF/TOF-instrument, glycopeptides can be further analyzed *via* characteristic fragment ions that can sequence the glycan and the peptide simultaneously (Krokhin et al., 2004; Kurogochi & Nishimura, 2004; Stephens et al., 2004; Wuhrer, Hokke, & Deelder, 2004). Nonetheless, a more systematic assessment of O- or N-glycosylation sites on glycoproteins might require the use of mass spectrometers with higher mass accuracies; for example, ESI or MALDI with Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR) (Irungu et al., 2008). FT-ICR MS provides the high mass accuracy needed to improve the specificity for protein database search results, and enhances the prediction of glycoforms. Sihlbom's group applied FT-ICR MS and infrared multi-photon dissociation (IRMPD) to determine the glycosylation states of isoforms of CSF proteins from individual AD patients compared to controls (Sihlbom et al., 2004). In that study, they reported that the sub-femtomole sensitivities of FT-ICR MS analyzed 2D gel-separated complex human protein mixtures. An additional advantage to IRMPD is that it selectively dissociates the glycosidic bonds of N-linked glycans (amino acid consensus sequence N–X–S/T/C, in which X cannot be P).

3. *Isotope Labeling for Quantification of Glycoproteins*

Characterizing glycoproteins as extensively as possible is just the first step to define biomarkers unique to a disease or disease progression. A more important process is to quantify the changes associated with a disease or a disease stage. Additionally, quantitative glycoproteomics can help to characterize the regulatory pathways and complex system networks by providing protein concentration information that corresponds to different cellular states. Although label-free techniques have been developed by numerous investigators (Levin et al., 2007), most published studies with human samples largely rely on various isotope-labeling techniques for quantification, particularly when large-scale profiling is the main focus. Examples include the use of chemical reactions to introduce isotopic tags at specific functional groups on peptides or proteins, such as ICAT (isotope-coded affinity tags) (Gygi et al., 1999; Haqqani, Kelly, & Stanimirovic, 2008) and iTRAQ (isobaric tags for relative and absolute quantitation) (Aggarwal, Choe, & Lee, 2006) as well as the methods that introduce stable-isotope tags *via* enzymatic reaction, such as enzymatic ^{18}O incorporation (Kaji et al., 2003, 2006; Zhang et al., 2003).

ICAT labels the side chains of cysteinyl residues in two reduced protein samples with the isotopic light or heavy reagent, respectively, and generates the mass signatures that identify sample origin and serve as the basis for accurate quantification, to thus afford simultaneous comparison of two proteomes. However, ICAT selectively targets cysteine residues, and therefore approximately 3% of mammalian proteins that lack cysteine residues cannot be analyzed (Colangelo & Williams, 2006). In addition, some cysteines are blocked or are inaccessible to the labeling reagent. More recently, iTRAQ technology, which labels lysines and N-termini, has been used for quantitative proteomics in human body fluid and tissue (Martin et al., 2008; Song et al., 2008). The iTRAQ technology has a significant advantage over other methods due to its capability to multiplex up to eight samples in a single experiment (D'Ascenzo, Choe, & Lee, 2008). Another positive aspect includes unbiased peptide labeling, because iTRAQ isobaric tags theoretically label lysine side groups and all free amino-terminal groups of the peptides present in a sample. The iTRAQ tags consist of a reporter group, a balance group, and a peptide reactive group that covalently binds to the peptides. The tandem mass spectra include contributions from each sample, and the individual contributions of each sample can be measured by the intensity of the reporter ion peaks. Moreover, a chemical approach for the N-glycosylation identification (i.e., hydrazide chemistry capture) can be incorporated with the iTRAQ quantification method because an iTRAQ-labeled peptide is chemically stable in other buffer systems.

Notably, in addition to quantification, isotope-labeling methods might also increase the certainty of glycoproteome assignments and enable quantitative comparisons of glycosylated

samples. For example, several groups have used isotope-coded glycosylation-site-specific tagging (IGOT) for the large-scale identification of N-glycosylated proteins from a complex biological sample (Kaji et al., 2003, 2006). The IGOT approach is based on the lectin column-mediated affinity capture of a set of glycopeptides generated by tryptic digestion of protein mixtures, followed by peptide-N-glycosidase-mediated incorporation of a stable isotope tag, ^{18}O, specifically into the N-glycosylation site. The ^{18}O-tagged peptides are identified with multi-dimensional LC-MS-based technology. The application of this method to characterize N-linked high-mannose and/or hybrid-type glycoproteins from an extract of *Caenorhabditis elegans* proteins identified 250 glycoproteins, including 83 putative transmembrane proteins, with the simultaneous determination of 400 unique N-glycosylation sites. A similar approach was later used to identify and quantify N-linked glycoproteins in serum (Zhang et al., 2003). In this study, the N-linked glycopeptides were oxidized and captured directly on a hydrazide column; the quantitation was achieved by comparing two samples that were tagged differentially with ^{18}O- or ^{16}O-labeled water.

IV. CHARACTERIZATION OF GLYCOPROTEINS ASSOCIATED WITH PARKINSON'S DISEASE AND DISEASE PROGRESSION

In the next few sections, we will use one of the ongoing projects focused on PD to illustrate a strategy that identifies and quantifies CNS-specific glycoproteins at the same time. However, only identification data will be shown in this report.

A. Parkinson's Disease and Its Progression

PD is traditionally considered a movement disorder that results from a relatively selective loss of neurons in the brainstem, including dopaminergic (DAergic) neurons in the *substantia nigra pars compacta* (SNpc), with subsequent loss of striatal dopamine and accompanied by the formation of intraneuronal inclusions called Lewy bodies that contain α-synuclein as one of the major proteins (Lowe, Graham, & Leigh, 1997; Jankovic, 2001). More recently, however, it has become increasingly clear that neurodegeneration in PD is widespread with associated presentation of multiple ''non-motor'' symptoms, including cognitive impairment, particularly as the disease advances. Cognitive impairment in PD, ranging from mild dysfunction to severe dementia, has major clinical consequences, because it has been associated with a reduced quality of life (Schrag, Jahanshahi, & Quinn, 2000), shortened survival (Nussbaum et al., 1998), and increased caregiver distress compared to PD without cognitive impairment (Aarsland et al., 1999). It should be emphasized that the risk of developing dementia in PD patients is several-fold higher than for community-dwelling controls (Marder et al., 1995; Aarsland et al., 2001, 2003). Furthermore, in more recent studies, when PD patients are tested more rigorously, it has been estimated that 36% of patients newly diagnosed with PD had mild cognitive impairment (MCI)—a prodrome of PD dementia (Foltynie et al., 2004; Levin & Katzen, 2005), and that 57% of patients with newly diagnosed PD will develop MCI within 3–5 years (Williams-Gray et al., 2007).

Numerous clinicopathological studies have sought to identify the structural basis of cognitive impairment in patients with PD dementia (PDD). Though remaining to be investigated, it appears that, in a significant portion of PD patients, PD progression is characterized pathologically by the spreading of aggregated α-synuclein deposits from the brainstem to other parts of the brain (Braak et al., 2002, 2003). A staging procedure for the PD-related inclusion body pathology (i.e., Lewy neurites and Lewy bodies) in the brain proposes that the pathological process begins at two sites (the medulla oblongata and olfactory bulb) and progresses in a topographically predictable sequence in six stages. During stages 1–2, the inclusion body pathology remains confined to the medulla oblongata, pontine tegmentum, and anterior olfactory structures. In stages 3–4, the basal midbrain, including SNpc, and forebrain become the foci of the pathology, and the illness reaches its symptomatic phase (motor symptoms). In the final stages 5–6, the pathological process is seen in the association areas and primary fields of the neocortex. The basic concept is diagramed in Figure 1.

B. Biomarkers for Parkinson's Disease and Parkinson's Disease Progression

Two approaches, protein-specific, for example, α-synuclein (Jakowec et al., 1998; Borghi et al., 2000; Verbeek, De Jong, & Kremer, 2003; El-Agnaf et al., 2006; Tokuda et al., 2006) and DJ-1 (Waragai et al., 2006; Hirotani et al., 2008), and unbiased profiling (Abdi et al., 2006) have been undertaken to define protein biomarkers unique to PD diagnosis. Profiling is advantageous because it provides an unbiased view of a disease or stage of a disease whose pathogenesis is largely unknown. In addition, multiple markers can be generated for a given disease when a profiling approach is taken, and generally speaking, a combination of multiple markers offers better sensitivity and specificity than a single protein alone for disease diagnosis (Zhang et al., 2008). There are no known markers that can predict PD progression, whether related to motor symptoms or cognitive impairment; that concept has been emphasized more recently. To resolve this issue, in the last few years, with unbiased proteomics, we have compared the proteome of brain tissue associated with Lewy body progression as PD advances, with the goal of identifying proteins before Lewy body formation in the neocortex (Fig. 1). However, in an earlier analysis, among ~1,500 proteins identified in CSF only 9% were present in the proteins identified in human brain tissue (Pan et al., 2007a,b). It has been hypothesized that there are at least two limitations associated with the previous approaches: (1) the cellular fractionation technique is biased against extracellular proteins, because most of them are discarded along with cell debris (Jin et al., 2006; Pan et al., 2007a), and (2) the large dynamic range of the CSF proteome makes it very challenging to identify proteins of low abundance [albumin and immunoglobulins constitute more than 75% of CSF proteins (Srivastava, Murphy, & Jeffery, 2008)]. Indeed, both limitations are the major problems that must be dealt with not only in diseases related to the CNS but also in the biomarker discovery field in general (Aebersold et al., 2005; Qian

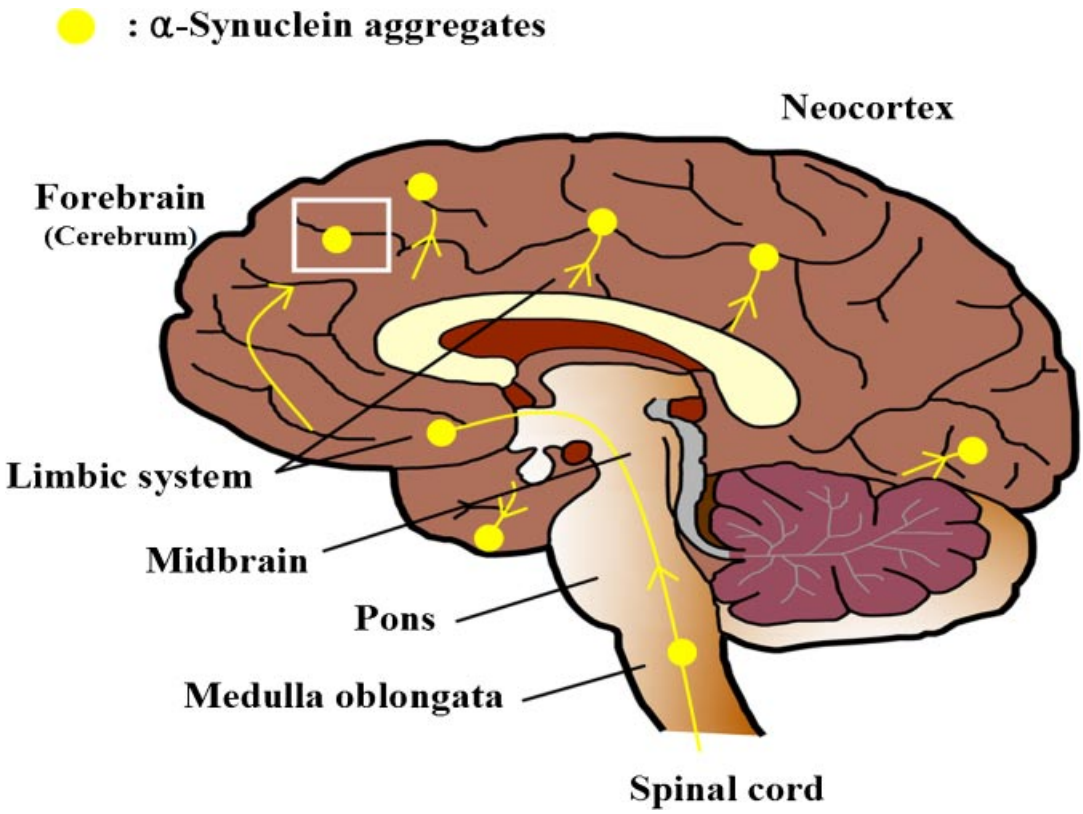

FIGURE 1. Cognitive impairment associated with PD progression is characterized pathologically by the spreading of α-synuclein aggregates, the main component of Lewy bodies, from brainstem to limbic system and eventually to the neocortex (Braak et al., 2003). The boxed area, the middle frontal gyrus, is the tissue source for a recent non-biased profiling (Pan et al., 2007a; Shi et al., 2008) as well as characterization of glycoproteins to reveal proteins unique to PD and/or PD progression, particularly development of dementia. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

et al., 2006). To increase the likelihood of identifying proteins that are accessible clinically, most investigators have turned their attention either to removing high-abundance proteins before profiling or to a specific sub-proteome with a unique PTM; for example, proteins with glycosylation. As mentioned earlier, protein glycosylation, and in particular N-linked glycosylation, is prevalent in proteins destined for extracellular environments (Roth, 2002).

C. Glycoprotein/Peptide in Human Cerebrospinal Fluid and Brain Tissue

1. Glycoproteins in Human Cerebrospinal Fluid

This investigation consisted of four groups: control subjects, AD, and PD patients at two different stages. More specifically, the control group consisted of 29 individuals aged 70 ± 6 years, 18 men and 11 women, with no history, symptoms, or signs of psychiatric or neurological disease. The AD group consisted of 51 patients aged 69 ± 9 years, 28 men and 23 women, all of whom underwent a comprehensive clinical examination, and were diagnosed with AD according to NINCDS ADRDA criteria (Jobst, Barnetson, & Shepstone, 1997). The early stage PD group consisted of 11 patients aged 61 ± 8 years, 9 men and 2 women, all of whom underwent a comprehensive clinical examination and were diagnosed with PD at a Hoehn and Yahr stage of 1.5 or less. The late stage PD group consisted of 11 patients aged 66 ± 7 years, 7 men and 4 women, all of whom underwent a comprehensive clinical examination and were diagnosed with PD at a Hoehn and Yahr stage of 3 or greater. All CSF samples have been controlled for blood contamination before pooling samples into four groups (Abdi et al., 2006). The pooled CSF samples were mixed with a protease inhibitor cocktail, and stored at -80°C before use. To perform quantitative analysis of glycoproteins unique to PD and PD progression, samples were digested with trypsin, followed with iTRAQ labeling, before hydrazide bead capture. Of note, quantitative data are still being evaluated currently and will be published separately at a later time. The glycopeptides derived from glycoproteins in human CSF were

enriched by hydrazide bead capture followed by enzymatic release of the N-linked glycosylated peptides. Peptides from each sample were dissolved in 0.5% trifluoroacetic acid (TFA), and separated with reverse phase (RP) chromatography. MS/MS analysis used the 4800 Proteomics Analyzer with TOF/TOF Optics™ (Applied Biosystems, Foster City, CA, USA). The MS/MS spectra were extracted and searched against the International Protein Index (IPI) human protein database (version 3.42 from the European Bioinformatics Institute [EBI]) with ProteinPilot™ software (version 2.0.1, revision 33087, Applied Biosystems) with the Paragon™ method. The raw peptide identification results from the Paragon™ Algorithm (Applied Biosystems) searches were further processed with the Pro Group™ Algorithm (Applied Biosystems) within the ProteinPilot™ software before final display. The Pro Group Algorithm uses the peptide identification results to determine the minimal set of proteins that can be reported for a given protein confidence threshold. For each protein, Pro Group Algorithm reports two types of scores for each protein: unused ProtScore and total ProtScore. The total ProtScore is a measurement of all the peptide evidence for a protein, and is analogous to protein scores reported by other protein identification software. The unused ProtScore, however, is a measurement of all the peptide evidence for a protein that is not better explained by a higher ranking protein. In other words, the unused ProtScore is calculated with the unique peptides (peptides that are not used by the higher ranking protein), and it is a clearer indicator of protein evidence and assists in singling out members of a multiprotein family. All reported data were based on 95% confidence for protein identification as determined by ProteinPilot (ProtScore $\geq$1.3). Identified glycoproteins were checked against the UniProtKB/Swiss-Prot database and the Institute for Systems Biology (ISB) database as glycoproteins with known glycosylation sites or probable/potential glycosylation sites.

The MALDI-TOF-TOF analysis revealed a total of 283 non-redundant glycoproteins in human CSF (Appendix I). In comparison with the existing publicly accessible database, 243 of these proteins were annotated in UniProtKB/Swiss-Prot and the ISB database as glycoproteins with known glycosylation sites or probable/potential glycosylation sites. The specificity of this approach was approximately 86% (243/283). When this dataset is compared with what has been published earlier, where lectin affinity purification and hydrazide chemistry were both used to characterize CSF glycoproteins with an ion trap mass spectrometer (LCQ) (Pan et al., 2006), 87 were observed in both datasets; that is, a 36% overlap of 243 glycoproteins. This overlap is considered reasonable, given that a different database and different technology (LCQ vs. MALDI-TOF-TOF as well as hydrazide chemistry + lectin affinity vs. hydrazide chemistry alone) were used to characterize glycoproteins in two different studies.

2. Glycoproteins in Brain Tissue

An alternative approach to increase the chances to identify proteins of low abundance is to perform targeted proteomics; that is, identify proteins unique to a disease or disease progression in tissue, followed by confirmation and validation in a body fluid. This concept will be discussed further in a later section (targeted proteomics). To characterize tissue glycoproteins associated with PD and PD progression, particularly those related to development of PD dementia, the advantage of well-characterized PD brains obtained at autopsy was taken. In this study, all PD cases had been given a clinical diagnosis of PD initially, which meant that dementia with Lewy body disease (DLB) cases, a disease overlapping with PD with dementia (PDD) cases pathologically, were excluded from the study. The brain region of interest was the middle frontal gyrus (Fig. 1), and the four groups of cases (five per group with matching age, gender, and *post-mortem* interval) were investigated: normal age-matched control (78.6 ± 4.0; male/female [M/F] ratio = 3:2), PD with brainstem Lewy bodies only (77.2 ± 11.3; M/F = 3:2), PD with brainstem and limbic Lewy bodies (78.8 ± 8.3; M/F = 3:2), and PD with Lewy bodies in neocortex plus brainstem and limbic system (77.0 ± 1.9; M/F = 3:2). Glycoproteins were isolated with methods identical to those described for CSF above after iTRAQ labeling. Again, the quantitative data will be published in a separate manuscript that is under preparation.

This investigation revealed 394 non-redundant glycoproteins (Appendix II). In comparison with the existing database, 343 of these proteins were annotated in the UniProtKB/Swiss-Prot and ISB databases as glycoproteins with known glycosylation sites or probable/potential glycosylation sites. The specificity was approximately 87% (343/394). It should be emphasized that this dataset represents the first systematic analysis of glycoproteins in human brain in normal and diseased settings.

3. Gene Ontology Analysis

Over the last few years, a Gene Ontology (GO) method has been used to study datasets generated by proteomic analysis (Pan et al., 2007a,b; Kitsou et al., 2008; Shi et al., 2008) to provide insight into the underlying biology (Alexa, Rahnenfuhrer, & Lengauer, 2006). GO analysis, either based on cellular components (CC) or biological processes (BP), detects over-represented GO categories (Alexa, Rahnenfuhrer, & Lengauer, 2006). When the glycoproteins identified in human CSF and tissues were classified by GO analysis, it was apparent that a majority of the proteins belong to either the extracellular compartment or are associated with the plasma membrane (Fig. 2). This is entirely consistent with the claim that most membrane proteins are glycosylated, and that a significant portion of glycoproteins are designated for secretion into the extracellular fluid and thereby enter blood or CSF (Yang et al., 2005).

4. A Brief Discussion of Overlapped Proteins

As indicated earlier, one of the major goals to isolate glycoproteins is to reveal CNS-specific proteins that are low in abundance in body fluids with the potential to serve as biomarkers for disease diagnosis or disease progression. To this end, there are a few features of the data presented above that must be stressed: (1) isolation of glycoproteins significantly increased the portion of proteins related to CNS function and/or structure (a partial list

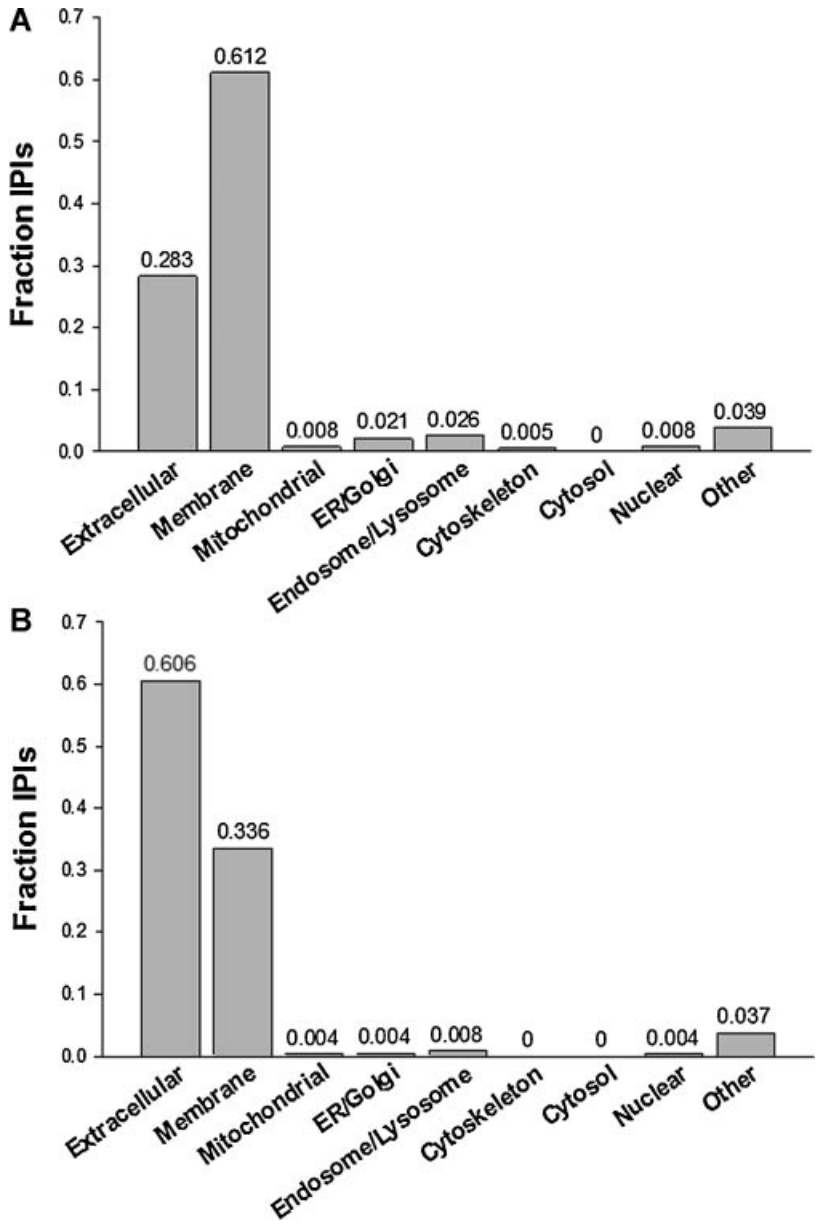

FIGURE 2. GO analysis of glycoproteins identified in human brain (**A**) and CSF (**B**), to clearly emphasize the fact that a majority of the proteins are distributed to extracellular and membrane compartments.

of those proteins is shown in Table 1), (2) the overlap between the CSF and tissue proteomes is also improved significantly over the general profiling, where only 140 proteins were found in tissue and CSF general profiles that account for 9% of ~1,500 identified CSF proteins. When glycoproteins were analyzed, 98 proteins were seen in brain tissue (a total of 343 proteins) and CSF (a total of 243 proteins) to account for 43% of CSF glycoproteins. Furthermore, several of the overlapping proteins identified with glycoprotein isolation are likely related to PD pathogenesis. For example, ceruloplasmin and transferrin, both regulate iron metabolism, were reported to be dysregulated in PD patients (Dexter et al., 1989; Riederer et al., 1989).

Besides the proteins known to be important to PD pathogenesis, others such as neuroserpin, neural cell adhesion molecule, and neuronal pentraxin II are critical to CNS function, and some have been linked to other neurodegenerative diseases. For example, one of the overlapping proteins, neuroserpin, is a member of the serpin family of serine protease inhibitors. Tissue-distribution analysis reveals a predominantly neuronal expression during the late stages of neurogenesis and, in the adult brain,

TABLE 1. A partial list of overlapped glycoproteins between human CSF and brain tissue

Protein IPI	Description	Comments (source: UniPortKB/Swiss-Prot database)
IPI00002714.1	Dickkopf-related protein 3 precursor	Inhibitor of Wnt signaling pathway (Potential). Highest expression in heart, brain, and spinal cord
IPI00003813.5	Isoform 1 of cell adhesion molecule 1 precursor	May act as a synaptic cell adhesion molecule that drives synapse assembly. May be involved in neuronal migration, axon growth, pathfinding, and fasciculation on the axons of differentiating neurons.
IPI00009997.1	N-acetyllactosaminide beta-1,3-N-acetylglucosaminyltransferase	Can initiate the synthesis or the elongation of the linear poly-*N*-acetyllactosaminoglycans. In the adult, highly expressed in heart, brain, skeletal muscle and kidney
IPI00011732.2	Isoform 1 of GDNF family receptor alpha-2 precursor	Receptor for neurturin. Mediates the NRTN-induced autophosphorylation and activation of the RET receptor. Also able to mediate GDNF signaling through the RET tyrosine kinase receptor. Isoform 1 is found in brain and placenta
IPI00013303.2	Limbic system-associated membrane protein precursor	Mediates selective neuronal growth and axon targeting. Contributes to the guidance of developing axons and remodeling of mature circuits in the limbic system. Essential for normal growth of the hippocampal mossy fiber projection (By similarity)
IPI00017601.1	Ceruloplasmin precursor	Defects in CP are the cause of aceruloplasminemia. It is an autosomal recessive disorder of iron metabolism characterized by iron accumulation in the brain/visceral organs.
IPI00020557.1	Prolow-density lipoprotein receptor-related protein 1 precursor	May modulate cellular events, such as APP metabolism, kinase-dependent intracellular signaling, neuronal calcium signaling as well as neurotransmission
IPI00024035.1	Isoform 1 of cadherin-6 precursor	Cadherins are calcium dependent cell adhesion proteins. They preferentially interact with themselves in a homophilic manner in connecting cells; cadherins may thus contribute to the sorting of heterogeneous cell types.
IPI00024966.1	Contactin-2 precursor	Attached to the neuronal membrane by a GPI-anchor and is also released from neurons. May play a role in the initial growth and guidance of axons. May be involved in cell adhesion
IPI00026946.2	Neuronal pentraxin-2 precursor	Likely to play role in the modification of cellular properties that underlie long-term plasticity. Binds to agar matrix in a calcium-dependent manner
IPI00030887.1	Tyrosine-protein kinase Receptor TYRO3 precursor	May be involved in cell adhesion processes, particularly in the central nervous system
IPI00031121.2	Carboxypeptidase E precursor	Removes residual C-terminal Arg or Lys remaining after initial endoprotease cleavage during prohormone processing. Processes proinsulin. Neuropeptide signaling pathway

TABLE 1. (*Continued*)

Protein IPI	Description	Comments (source: UniPortKB/Swiss-Prot database)
IPI00064667.4	Beta-Ala-His dipeptidase p recursor	Preferential hydrolysis of the beta-Ala-|-His dipeptide (carnosine), and also anserine, Xaa-|-His dipeptides and other dipeptides including homocarnosine.
IPI00159927.2	Neurocan core protein precursor	May modulate neuronal adhesion and neurite growth during development by binding to neural cell adhesion molecules (NG-CAM and N-CAM). Chondroitin sulfate proteoglycan; binds to hyaluronic acid
IPI00160552.3	Isoform 1 of tenascin-R precursor	Neural extracellular matrix (ECM) protein involved in interactions with different cells and matrix components
IPI00171473.2	Spondin-1 precursor	Cell adhesion protein that promotes the attachment of spinal cord and sensory neuron cells and the outgrowth of neurites in vitro. May contribute to the growth and guidance of axons in both the spinal cord and the PNS (By similarity). Major factor for vascular smooth muscle cell
IPI00176427.1	Cell adhesion molecule 4 precursor	Involved in the cell-cell adhesion. Has calcium- and magnesium-independent cell-cell adhesion activity. May have tumor- suppressor activity.
IPI00216641.1	Isoform 2 of contactin-1 precursor	Contactins mediate cell surface interactions during nervous system development. Interaction with TNR induces a repulsion of neurons and an inhibition of neurite outgrowth
IPI00217882.3	Sortilin precursor	Promotes neuronal apoptosis by mediating endocytosis of the proapoptotic precursor forms of BDNF (proBDNF) and NGFB (proNGFB). Also acts as a receptor for neurotensin.
IPI00295832.1	Oligodendrocyte-myelin glycoprotein precursor	Cell adhesion molecule contributing to the interactive process required for myelination in the central nervous system.
IPI00301512.3	Isoform DPPX-L of Dipeptidyl aminopeptidase-like protein 6	May be involved in the physiological processes of brain function. Has no dipeptidyl aminopeptidase activity. May modulate the cell surface expression and the activity of the potassium channel KCND2.
IPI00303210.3	Isoform 2 of ectonucleotide pyrophosphatase/phosphodiest erase family member 2 precursor	Involved in several motility- related processes such as angiogenesis and neurite outgrowth
IPI00332887.5	signal-regulatory protein alpha precursor	Supports adhesion of cerebellar neurons, neurite outgrowth and glial cell attachment.
IPI00376427.3	Neural cell adhesion molecule 2 precursor	May play important roles in selective fasciculation and zone-to-zone projection of the primary olfactory axons
IPI00413696.5	41 kDa protein	Plays an important role in memory formation and synaptic plasticity in the hippocampus
IPI00456623.2	Isoform 1 of brevican core protein precursor	May play a role in the terminally differentiating and the adult nervous system during postnatal development. Could stabilize interactions between hyaluronan (HA) and brain proteoglycans.

(*Continued*)

TABLE 1. (*Continued*)

Protein IPI	Description	Comments (source: UniPortKB/Swiss-Prot database)
IPI00470696.1	Isoform 1 of netrin receptor UNC5D precursor	Receptor for netrin. May be involved in axon guidance by mediating axon repulsion of neuronal growth cones in the developing nervous system upon ligand binding.
IPI00479514.1	Voltage-dependent calcium channel subunit alpha-2/ delta-1 precursor	The alpha-2/delta subunit of voltage-dependent calcium channels regulates calcium current density and activation/inactivation kinetics of the calcium channel. Plays an important role in excitation-contraction coupling
IPI00513964.1	Isoform 2 of semaphorin-4B precursor	Inhibits axonal extension by providing local signals to specify territories inaccessible for growing axons
IPI00552450.1	Opioid binding protein/cell adhesion molecule-like isoform b preproprotein	Binds opioids in the presence of acidic lipids; probably involved in cell contact
IPI00554760.1	Isoform 2 of tenascin-R precursor	Neural extracellular matrix (ECM) protein involved in interactions with different cells and matrix components. These interactions can influence cellular behavior by either evoking a stable adhesion and differentiation, or repulsion and inhibition of neurite growth
IPI00655702.3	Isoform 5 of neurofascin precursor	Cell adhesion, ankyrin-binding protein which may be involved in neurite extension, axonal guidance, synaptogenesis, myelination and neuron-glial cell interactions
IPI00783390.1	Isoform 1 of neural cell adhesion molecule L1-like protein precursor	Extracellular matrix and cell adhesion protein that plays a role in nervous system development and in synaptic plasticity.
IPI00797025.1	Major prion protein	PrP is found in high quantity in the brain of humans and animals infected with neurodegenerative diseases known as transmissible spongiform encephalopathies or prion diseases, like: Creutzfeldt-Jakob disease
IPI00807403.1	Isoform 2 of CD166 antigen precursor	Cell adhesion molecule that binds to CD6. Involved in neurite extension by neurons via heterophilic and homophilic interactions. May play a role in the binding of T- and B-cells to activated leukocytes, as well as in interactions between cells of the nervous system.
IPI00855821.1	Isoform 2 of neurexin-1-alpha precursor	Neuronal cell surface protein that may be involved in cell recognition and cell adhesion. May mediate intracellular signaling.
IPI00873446.1	Isoform 5 of neuronal cell adhesion molecule precursor	Cell adhesion, ankyrin-binding protein involved in neuron-neuron adhesion. May play a role in the molecular assembly of the nodes of Ranvier

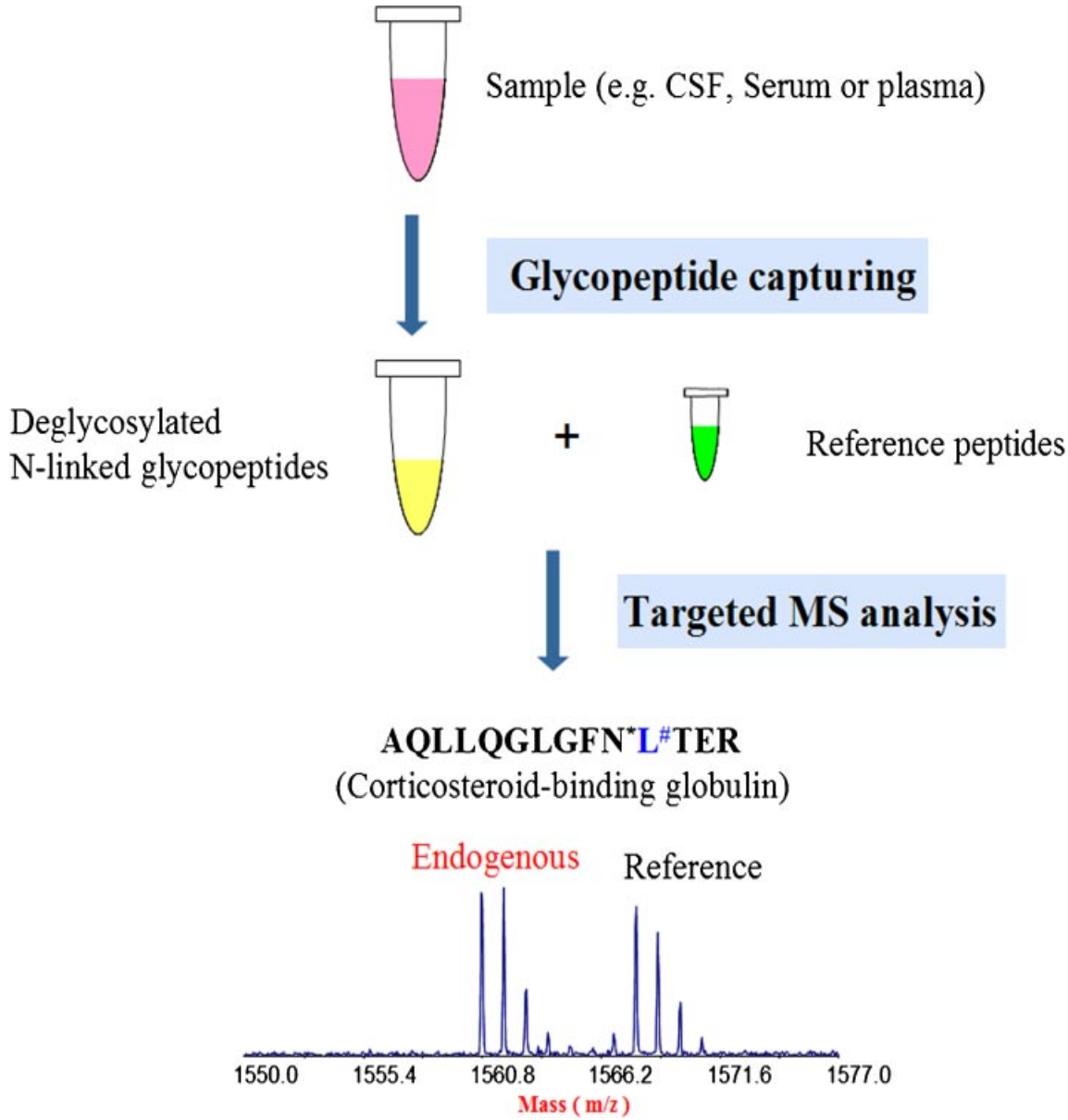

FIGURE 3. The illustration of mass spectrometry-based targeted quantitative analysis to detect N-linked glycopeptides in body fluids. Synthetic peptides with stable isotope labeling are used as internal standards for the quantification of endogenous glycopeptides. As an example, N-linked glycopeptide AQLLQGLGFN*L#TER (Corticosteroid-binding globulin) was extracted from human serum with hydrazide chemistry-based solid-phase extraction and detected with an LC MALDI TOF/TOF platform with targeted approach. (Note: # indicates the amino acid that was stable isotope labeled (^{13}C and ^{15}N) in reference peptides; * indicates enzyme-catalyzed conversion of asparagines to aspartic acid at the site of carbohydrate attachment.) [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

in areas where synaptic changes are associated with learning and memory (synaptic plasticity). To this end, it should be mentioned that synaptic dysfunction appears to be one of the major early signs of PD progression in human cortex (Pisani et al., 2005). Another example, neural cell adhesion molecule, is involved in signal transduction (Niethammer et al., 2002), and promotes neurite outgrowth and fasciculation (Rutishauser & Edelman, 1980). In the SNpc of PD patients, polysialated-neural

cell-adhesion molecule-positive immature neurons were detected. The polysialated neural cell adhesion molecule is a marker of immature, migrating neuroblasts (Yoshimi et al., 2005). The third example, neuronal pentraxin II, was recently reported to be highly up-regulated in PD and is a novel component of Lewy bodies (Moran et al., 2008). Neuronal pentraxin II is also known as the neuronal activity-regulated protein, which is secreted and involved in long-term neuronal plasticity (Hsu & Perin, 1995).

V. FUTURE PERSPECTIVES

From the analysis of glycoproteins of human CSF and brain tissue, it is obvious that even a focused analysis of glycoproteins remains inadequate for an extensive characterization of CNS-specific proteins. When comparing glycoproteins identified in brain tissue (Appendix II) with those identified in CSF (Appendix I), we found, as expected, that proteins related to the CNS structurally and/or functionally are more frequently identified/quantified in tissue. Because of dynamic issues and a common technical caveat associated with MS-based proteomics, absence of a protein only means that it is not detected, but not necessarily absent, in a particular analysis. We believe that it is critical to examine the tissue proteins unique to a disease process (PD diagnosis and progression in this case) in body fluid by targeted analysis. In our opinion, this approach is critical to the CNS-based disease, given that the CNS is highly organized and specialized with each neurodegenerative disorder that involves selective brain regions. For example, AD predominantly affects the cerebral cortex and hippocampus, whereas PD usually damages brainstem structures, particularly during the early stages of the diseases before other brain regions are involved (Braak et al., 2000; Wenk, 2003; Sudo et al., 2005). Therefore, the pathology-specific proteins could be so diluted in CSF that they are difficult to detect even when glycoproteins are isolated first.

Targeted analysis of proteomics—first identify unique proteins in the CNS, followed by confirmation/validation of known proteins in CSF or plasma in this case—indicates a progression away from unbiased profiling toward a multi-phase technology that allows key elements that uniquely represent a specific biological condition to be analyzed (Aebersold, 2003; Pan et al., 2005). The technology uses isotope dilution followed by MS analysis (Gerber et al., 2003; Anderson et al., 2004; Anderson, 2005; Pan et al., 2005; Anderson & Hunter, 2006), in which test-samples are supplemented (spiked) with synthetic peptides that serve as the signature markers to identify and quantify native peptides (target) within each sample. To date, few investigations have been reported that use the concept of candidate-based targeted quantitative proteomics to study selected peptides/proteins for biomarker verification/validation *via* ESI or MALDI based platforms. For the ESI approach, a hybrid triple-quadrupole/ion trap mass spectrometer was used to identify and quantify a selected group of targeted proteins within human plasma (Anderson & Hunter, 2006). Alternatively, an off-line LC MALDI-TOF/TOF platform was established to monitor a panel of targeted glycopeptides/glycoproteins in human serum, in conjunction with a sample preparation strategy that extracted deglycosylated N-linked glycopeptides from human serum (Pan et al., 2005). These early investigations have demonstrated the feasibility and advantages of the MS-based targeted quantitative proteomics to simultaneously identify and quantify a panel of selected peptides/proteins in a complex milieu, and consequently could be applied for biomarker verification/validation of AD and PD. Figure 3 demonstrates the basic concepts and work flow to validate a protein of interest in an LC-MALDI format. In fact, we have recently applied this technology to confirm/validate a subset of proteins identified in a previous non-biased proteomics profiling (Abdi et al., 2006) unique to AD and PD, respectively, in CSF (Pan et al., 2008). A project is also underway to use this platform to cross-examine the proteins identified in brain tissue with CSF (and *vice versa*), and eventually in human plasma.

VI. CONCLUDING REMARKS

The development of technologies from gel electrophoresis-based approaches to high-resolution MS-based approaches for protein identification and quantification has revolutionized protein biomarker discovery critical to disease diagnosis and disease progression monitoring, as well as greatly facilitated studies to reveal the molecular events that underlie neurodegenerative diseases. Among these studies, protein glycosylation and glycoproteomics are growing fields of interest due to the relationship between glycosylation degree/type and the health status of cells. The discovery and identification of glycosylated peptides and proteins and the analyses of their glyco-structures are increasingly important in diagnosis and treatment of neurodegenerative diseases. However, it is obvious that the complete characterization of glycoproteins remains a major challenge in the years to come, largely because of the enormous dynamic range of typical human samples as well as the heterogeneity of human beings. Thus, effective and in-depth protein identification of glycoproteins involved in neurodegenerative disorders requires a concerted approach, including improved glycoprotein enrichment, extensive separation of proteins/peptides, high-resolution tandem mass spectrometric analysis, at profiling and targeted modes, and state-of-the-art bioinformatics.

ACKNOWLEDGMENTS

The proteomics analysis of human CSF and brain tissue is supported by NIH grants (ES012703; NS057567; AG025327; AG033398; NS060252; AG05136; AG08671), an award by Michael J. Fox Foundation as well as the Chen-Mei Shaw and the Nancy and Buster Alvord Endowments.

(*Continued on page 43.*)

VII. APPENDIX I: GLYCOPEPTIDES IDENTIFIED IN HUMAN CEREBROSPINAL FLUID

Accessions	Names	Sequence-our	EBI		ISB	
			Identified	Potential	Identified	Potential
IPI00000877.1	HYOU1 Hypoxia up-regulated protein 1 precursor	VI*N*ETWAWK	Y			Y
IPI00001662.1	OPCML Opioid-binding protein/cell adhesion molecule precursor	DYG*N*YTCVATNK		Y		Y
IPI00001662.1	OPCML Opioid-binding protein/cell adhesion molecule precursor	MSTLTFF*N*VSEK		Y	Y	
IPI00002714.1	DKK3 Dickkopf-related protein 3 precursor	ASSEVNLANLPPSYH*N*ETNTDTK		Y		Y
IPI00002714.1	DKK3 Dickkopf-related protein 3 precursor	ITN*N*QTGQMVFSETVITSVGDEEGR		Y	Y	
IPI00002714.1	DKK3 Dickkopf-related protein 3 precursor	VG*N*NTIHVHR		Y	Y	
IPI00003813.5	CADM1 Isoform 1 of Cell adhesion molecule 1 precursor	FQLL*N*FSSSELK	Y		Y	
IPI00003813.5	CADM1 Isoform 1 of Cell adhesion molecule 1 precursor	VSLT*N*VSISDEGR	Y		Y	
IPI00003919.1	QPCT Glutaminyl-peptide cyclotransferase precursor	NYHQPAIL*N*SSALR		Y	Y	
IPI00004413.1	TNFRSF21 Tumor necrosis factor receptor superfamily member 21 precursor	VLSSIQEGTVPD*N*TSSAR		Y	Y	
IPI00005517.1	EFNA5 Ephrin-A5 precursor	YAVYW*N*SSNPR	Y		Y	
IPI00005794.2	PGCP 60 kDa protein	IVVYNQPYI*N*YSR			Y	
IPI00006114.4	SERPINF1 Pigment epithelium-derived factor precursor	VTQ*N*LTLIEESLTSEFIHDIDR	Y		Y	
IPI00006601.5	CHGB Secretogranin-1 precursor	GHPQEESEES*N*VSMASLGEK			Y	
IPI00006662.1	APOD Apolipoprotein D precursor	ADGTVNQIEGEATPV*N*LT	Y			
IPI00006662.1	APOD Apolipoprotein D precursor	ADGTVNQIEGEATPV*N*LTEPAK	Y		Y	
IPI00006662.1	APOD Apolipoprotein D precursor	ADGTVNQIEGEATPV*N*LTEPAKL	Y			
IPI00006662.1	APOD Apolipoprotein D precursor	ADGTVNQIEGEATPV*N*LTEPAKLEVK	Y		Y	
IPI00006662.1	APOD Apolipoprotein D precursor	CIQA*N*YSLMENGK	Y		Y	
IPI00006662.1	APOD Apolipoprotein D precursor	CIQA*N*YSLME*N*GKI	Y		Y	
IPI00006662.1	APOD Apolipoprotein D precursor	QANYSLME*N*GK			Y	
IPI00006662.1	APOD Apolipoprotein D precursor	EATPV*N*LTEPAK	Y		Y	
IPI00006662.1	APOD Apolipoprotein D precursor	EATPV*N*LTEPAKLEVK	Y		Y	
IPI00006662.1	APOD Apolipoprotein D precursor	GTVNQIEGEATPV*N*LTEPAK	Y		Y	
IPI00006662.1	APOD Apolipoprotein D precursor	PV*N*LTEPAK	Y		Y	
IPI00006662.1	APOD Apolipoprotein D precursor	QANYSLME*N*GK	Y		Y	
IPI00006662.1	APOD Apolipoprotein D precursor	QIEGEATPV*N*LTEPAK	Y		Y	
IPI00006662.1	APOD Apolipoprotein D precursor	QIEGEATPV*N*LTEPAKLEVK	Y		Y	
IPI00006662.1	APOD Apolipoprotein D precursor	TVNQIEGEATPV*N*LTEPAK	Y		Y	
IPI00007199.4	SERPINA10 Protein Z-dependent protease inhibitor precursor	ETFF*N*LSK	Y		Y	
IPI00007221.1	SERPINA5 Plasma serine protease inhibitor precursor	VVGVPYQG*N*ATALFILPSEGK	Y		Y	
IPI00007709.2	ADAM28 Isoform 1 of ADAM 28 precursor	NLLAPGYTETYY*N*STGK				Y
IPI00009997.1	B3GNT1 N-acetyllactosaminide beta-1,3-N-acetylglucosaminyltransferase	VAQPGINYALGT*N*VSYPNNLLR		Y		
IPI00011218.1	CSF1R Macrophage colony-stimulating factor 1 receptor precursor	HT*N*YSFSPWHGFTIHR		Y	Y	
IPI00011218.1	CSF1R Macrophage colony-stimulating factor 1 receptor precursor	VTVQSLLTVETLEH*N*QTYECR		Y		Y
IPI00011229.1	CTSD Cathepsin D precursor	GSLSYL*N*VTR	Y		Y	
IPI00011732.2	GFRA2 Isoform 1 of GDNF family receptor alpha-2 precursor	NAIQAFG*N*GTDVNVSPK		Y	Y	
IPI00012102.1	GNS N-acetylglucosamine-6-sulfatase precursor	YY*N*YTLSINGK	Y		Y	
IPI00012440.7	FUCA2 Plasma alpha-L-fucosidase precursor	SQ*N*DTVTPDVWYTSKPK		Y		Y
IPI00012887.1	CTSL1 Cathepsin L1 precursor	YSVA*N*DTGFVDIPK	Y		Y	
IPI00012887.1	CTSL1 Cathepsin L1 precursor	YSVA*N*DTGFVDIPKQEK	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	FSAGLAS*N*SSWLR	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	GL*N*LTSTFLR	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	KSVVAPATDGGL*N*LTSTFLR	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	SAGLAS*N*SSWLR	Y		Y	

(*Continued*)

APPENDIX I: (Continued)

IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	SVVAPATDGGL*N*	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	SVVAPATDGGL*N*LT	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	SVVAPATDGGL*N*LTSTF	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	SVVAPATDGGL*N*LTSTFL	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	SVVAPATDGGL*N*LTSTFLR	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	SVVAPATDGGL*N*LTSTFLRK	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	VVAPATDGGL*N*LTSTFLR	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	WFSAGLAS*N*	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	WFSAGLAS*N*S	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	WFSAGLAS*N*SS	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	WFSAGLAS*N*SSW	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	WFSAGLAS*N*SSWL	Y		Y	
IPI00013179.1	PTGDS Prostaglandin-H2 D-isomerase precursor	WFSAGLAS*N*SSWLR	Y		Y	
IPI00013303.2	LSAMP Limbic system-associated membrane protein precursor	LGVT*N*ASLVLFRPGSVR		Y	Y	
IPI00014048.1	RNASE1 Ribonuclease pancreatic precursor	S*N*SSMHITDCR	Y			Y
IPI00016150.1	SERPINI1 Neuroserpin precursor	DA*N*LTGLSDNK		Y	Y	
IPI00016150.1	SERPINI1 Neuroserpin precursor	WVE*N*NTNNLVK		Y	Y	
IPI00017601.1	CP Ceruloplasmin precursor	EHEGAIYPD*N*TTDFQR	Y		Y	
IPI00017601.1	CP Ceruloplasmin precursor	ELHHLQEQ*N*VSNAFLDK	Y		Y	
IPI00017601.1	CP Ceruloplasmin precursor	ELHHLQEQ*N*VSNAFLDKGEFYIGSK	Y		Y	
IPI00017601.1	CP Ceruloplasmin precursor	E*N*LTAPGSDSAVFFEQGTTR	Y		Y	
IPI00019568.1	F2 Prothrombin precursor (Fragment)	GHV*N*ITR	Y		Y	
IPI00019568.1	F2 Prothrombin precursor (Fragment)	YPHKPEI*N*STTHPGADLQENFCR	Y		Y	
IPI00019943.1	AFM Afamin precursor	DIENF*N*STQK	Y		Y	
IPI00019943.1	AFM Afamin precursor	H*N*FSHCCSK		Y	Y	
IPI00019943.1	AFM Afamin precursor	YAEDKF*N*ETTEK	Y		Y	
IPI00020091.1	ORM2 Alpha-1-acid glycoprotein 2 precursor	CANLVPVPIT*N*ATLDR	Y		Y	
IPI00020091.1	ORM2 Alpha-1-acid glycoprotein 2 precursor	LVPVPIT*N*ATLDR	Y		Y	
IPI00020091.1	ORM2 Alpha-1-acid glycoprotein 2 precursor	PLCANLVPVPIT*N*ATLDR	Y		Y	
IPI00020091.1	ORM2 Alpha-1-acid glycoprotein 2 precursor	QNQCFY*N*SSYLNVQR	Y		Y	
IPI00020557.1	LRP1 Prolow-density lipoprotein receptor-related protein 1 precursor	F*N*STEYQVVTR	Y		Y	
IPI00020986.2	LUM Lumican precursor	KLHINHN*N*LTESVGPLPK		Y	Y	
IPI00020986.2	LUM Lumican precursor	LGSFEGLV*N*LTFIHLQHNR	Y		Y	
IPI00020986.2	LUM Lumican precursor	LHINHN*N*LTESVGPLPK		Y	Y	
IPI00022371.1	HRG Histidine-rich glycoprotein precursor	IADAHLDRVE*N*TTVY	Y		Y	
IPI00022371.1	HRG Histidine-rich glycoprotein precursor	VIDF*N*CTTSSVSSALANTK	Y		Y	
IPI00022395.1	C9 Complement component C9 precursor	AV*N*ITSENLIDDVVSLIR	Y		Y	
IPI00022395.1	C9 Complement component C9 precursor	FSYSK*N*ETYQLFLSYSSK	Y		Y	
IPI00022417.4	LRG1 Leucine-rich alpha-2-glycoprotein precursor	KLPPGLLA*N*FTLLR	Y		Y	
IPI00022429.3	ORM1 Alpha-1-acid glycoprotein 1 precursor	ANLVPVPIT*N*ATLDQITGK	Y		Y	
IPI00022429.3	ORM1 Alpha-1-acid glycoprotein 1 precursor	CANLVPVPIT*N*ATLDQITGK	Y		Y	
IPI00022429.3	ORM1 Alpha-1-acid glycoprotein 1 precursor	IY*N*TTYLNVQR	Y		Y	
IPI00022429.3	ORM1 Alpha-1-acid glycoprotein 1 precursor	LVPVPIT*N*ATLDQITGK	Y		Y	
IPI00022429.3	ORM1 Alpha-1-acid glycoprotein 1 precursor	PIT*N*ATLDQITGK	Y		Y	

APPENDIX I: (Continued)

IPI00022429.3	ORM1 Alpha-1-acid glycoprotein 1 precursor	PLCANLVPVPITNATLDQITGK	Y		Y	
IPI00022429.3	ORM1 Alpha-1-acid glycoprotein 1 precursor	QDQCIYNTTYLN	Y			Y
IPI00022429.3	ORM1 Alpha-1-acid glycoprotein 1 precursor	QDQCIYNTTYLNVQR	Y			Y
IPI00022429.3	ORM1 Alpha-1-acid glycoprotein 1 precursor	QIPLCANLVPVPITNATLDQITGK	Y		Y	
IPI00022431.1	AHSG Alpha-2-HS-glycoprotein precursor	AALAAFNAQNNGSNFQLEEISR	Y		Y	
IPI00022431.1	AHSG Alpha-2-HS-glycoprotein precursor	AQNNGSNFQLEEISR	Y		Y	
IPI00022431.1	AHSG Alpha-2-HS-glycoprotein precursor	KVCQDCPLLAPLNDTR	Y		Y	
IPI00022431.1	AHSG Alpha-2-HS-glycoprotein precursor	NAQNNGSNFQLEEISR	Y		Y	
IPI00022431.1	AHSG Alpha-2-HS-glycoprotein precursor	NGSNFQLEEISR	Y		Y	
IPI00022431.1	AHSG Alpha-2-HS-glycoprotein precursor	VCQDCPLLAPLNDTR	Y		Y	
IPI00022488.1	HPX Hemopexin precursor	ALPQPQNVTSLL	Y		Y	
IPI00022488.1	HPX Hemopexin precursor	ALPQPQNVTSLLG	Y		Y	
IPI00022488.1	HPX Hemopexin precursor	ALPQPQNVTSLLGCT	Y		Y	
IPI00022488.1	HPX Hemopexin precursor	ALPQPQNVTSLLGCTH	Y		Y	
IPI00022488.1	HPX Hemopexin precursor	CSDGWSFDATTLDDNGTMLFFK	Y		Y	
IPI00022488.1	HPX Hemopexin precursor	SWPAVGNCSSALR	Y		Y	
IPI00023019.1	SHBG Isoform 1 of Sex hormone-binding globulin precursor	LDVDQALNR	Y		Y	
IPI00023648.6	ISLR Immunoglobulin superfamily containing leucine-rich repeat protein precursor	DLESVPPGFPANVTTLSLSANR			Y	
IPI00023648.6	ISLR Immunoglobulin superfamily containing leucine-rich repeat protein precursor	FQAFANGSLLIPDFGK			Y	
IPI00023673.1	LGALS3BP Galectin-3-binding protein precursor	AAIPSALDTNSSK	Y		Y	
IPI00023673.1	LGALS3BP Galectin-3-binding protein precursor	ALGFENATQALGR	Y		Y	
IPI00023673.1	LGALS3BP Galectin-3-binding protein precursor	DAGVVCTNETR	Y		Y	
IPI00023673.1	LGALS3BP Galectin-3-binding protein precursor	GLNLTEDTYKPR	Y		Y	
IPI00023673.1	LGALS3BP Galectin-3-binding protein precursor	TVIRPFYLTNSSGVD	Y		Y	
IPI00023673.1	LGALS3BP Galectin-3-binding protein precursor	YKGLNLTEDTYKPR	Y		Y	
IPI00023814.2	NEO1 Isoform 1 of Neogenin precursor	LPSGMLVISNATEGDGGLYR	Y		Y	
IPI00023814.2	NEO1 Isoform 1 of Neogenin precursor	TLSDVPSAAPQNLSLEVR		Y	Y	
IPI00023845.1	KLK6 Kallikrein-6 precursor	DCSANTTSCHILGWGK		Y	Y	
IPI00024035.1	CDH6 Isoform 1 of Cadherin-6 precursor	EDAQINTTIGSVTAQDPDAAR	Y		Y	
IPI00024572.3	ASPH aspartate beta-hydroxylase isoform e	YNLSEVLQGK			Y	
IPI00024621.3	OLFML3 Isoform 1 of Olfactomedin-like protein 3 precursor	IYVLDGTQNDTAFVFPR		Y	Y	
IPI00024966.1	CNTN2 Contactin-2 precursor	ANSTGILSVR		Y		Y
IPI00024966.1	CNTN2 Contactin-2 precursor	GTEILVNSSR		Y	Y	
IPI00024966.1	CNTN2 Contactin-2 precursor	VPGADAQYFVYSNESVRPYTPFEVK			Y	
IPI00025257.1	SEMA7A Semaphorin-7A precursor	EDNPDKNPEAPLNVSR		Y	Y	
IPI00025465.1	OGN Mimecan precursor	CKANDTSYIR		Y	Y	
IPI00026104.1	IDS Isoform Long of Iduronate 2-sulfatase precursor	EDVQALNISVPYGPIPVDFQR		Y	Y	
IPI00026104.1	IDS Isoform Long of Iduronate 2-sulfatase precursor	VHAGNFSTIPQYFK		Y	Y	
IPI00026946.2	NPTX2 Neuronal pentraxin-2 precursor	ANVSNAGLPGDFR		Y	Y	
IPI00027235.1	ATRN Isoform 1 of Attractin precursor	IDSTGNVTNELR	Y		Y	
IPI00027235.1	ATRN Isoform 1 of Attractin precursor	NHSCSEGQISIFR	Y		Y	
IPI00027482.1	SERPINA6 Corticosteroid-binding globulin precursor	AQLLQGLGFNLTER	Y		Y	
IPI00027827.2	SOD3 Extracellular superoxide dismutase [Cu-Zn] precursor	AKLDAFFALEGFPTEPNSSSR	Y		Y	
IPI00027827.2	SOD3 Extracellular superoxide dismutase [Cu-Zn] precursor	LDAFFALEGFPTEPNSSSR	Y		Y	
IPI00027851.1	HEXA Beta-hexosaminidase alpha chain precursor	SAEGTFFINK		Y	Y	
IPI00029260.2	CD14 Monocyte differentiation antigen CD14 precursor	NVSWATGR	Y		Y	

(*Continued*)

APPENDIX I: (Continued)

IPI00029723.1	FSTL1 Follistatin-related protein 1 precursor	FVEQ*N*ETAINITTYPDQENNK			Y	
IPI00029723.1	FSTL1 Follistatin-related protein 1 precursor	GS*N*YSEILDK		Y		Y
IPI00029739.5	CFH Isoform 1 of Complement factor H precursor	IPCSQPPQIEHGTI*N*SSR	Y		Y	
IPI00029739.5	CFH Isoform 1 of Complement factor H precursor	ISEE*N*ETTCYMGK	Y		Y	
IPI00029739.5	CFH Isoform 1 of Complement factor H precursor	L*N*DTLDYECH	Y		Y	
IPI00029751.1	CNTN1 Isoform 1 of Contactin-1 precursor	A*N*STGTLVITDPTR	Y		Y	
IPI00029751.1	CNTN1 Isoform 1 of Contactin-1 precursor	GKA*N*STGTLVITDPTR	Y		Y	
IPI00029751.1	CNTN1 Isoform 1 of Contactin-1 precursor	G*N*YSCFVSSPSITK		Y	Y	
IPI00029751.1	CNTN1 Isoform 1 of Contactin-1 precursor	YIITWDHVVALS*N*ESTVTGYK		Y		Y
IPI00030887.1	TYRO3 Tyrosine-protein kinase receptor TYRO3 precursor	DLVPAT*N*YSLR		Y		Y
IPI00031121.2	CPE Carboxypeptidase E precursor	DLQGNPIA*N*ATISVEGIDHDVTSAK		Y	Y	
IPI00031121.2	CPE Carboxypeptidase E precursor	G*N*ETIVNLIHSTR		Y	Y	
IPI00032179.2	SERPINC1 Antithrombin III variant	LGAC*N*DTLQQLMEVFK	Y		Y	
IPI00032179.2	SERPINC1 Antithrombin III variant	SLTF*N*ETYQDISELVYGAK	Y		Y	
IPI00032179.2	SERPINC1 Antithrombin III variant	WVS*N*KTEGR	Y		Y	
IPI00032220.3	AGT Angiotensinogen precursor	HLVIH*N*EST	Y		Y	
IPI00032220.3	AGT Angiotensinogen precursor	HLVIH*N*ESTCEQLAK	Y		Y	
IPI00032220.3	AGT Angiotensinogen precursor	LQAILGVPWKDK*N*CTSR	Y		Y	
IPI00032220.3	AGT Angiotensinogen precursor	VIH*N*ESTCEQLAK	Y		Y	
IPI00032220.3	AGT Angiotensinogen precursor	VYIHPFHLVIH*N*EST	Y		Y	
IPI00032220.3	AGT Angiotensinogen precursor	VYIHPFHLVIH*N*ESTCEQLAK	Y		Y	
IPI00032292.1	TIMP1 Metalloproteinase inhibitor 1 precursor	FVGTPEV*N*QTTLYQR	Y		Y	
IPI00032292.1	TIMP1 Metalloproteinase inhibitor 1 precursor	SH*N*RSEEFLIAGK	Y		Y	
IPI00032328.2	KNG1 Isoform HMW of Kininogen-1 precursor	HGIQYFN*N*NTQHSSLFMLNEVK	Y		Y	
IPI00032328.2	KNG1 Isoform HMW of Kininogen-1 precursor	ITYSIVQT*N*CSK	Y		Y	
IPI00032328.2	KNG1 Isoform HMW of Kininogen-1 precursor	LNAEN*N*ATFYFK	Y		Y	
IPI00060310.4	PLD4 Phospholipase D4	ELGAVIY*N*CSHLAQDLEK				Y
IPI00060310.4	PLD4 Phospholipase D4	SLQALSNPAA*N*VSVDVK			Y	
IPI00060310.4	PLD4 Phospholipase D4	TWPQ*N*FSSHFNR				Y
IPI00060310.4	PLD4 Phospholipase D4	VFIVPVG*N*HSNIPFSR				Y
IPI00064667.4	CNDP1 Beta-Ala-His dipeptidase precursor	AIHLDLEEYR*N*SSR	Y		Y	
IPI00064667.4	CNDP1 Beta-Ala-His dipeptidase precursor	AIHLDLEEYR*N*SSRVEK	Y		Y	
IPI00064667.4	CNDP1 Beta-Ala-His dipeptidase precursor	LVPHM*N*VSAVEK	Y		Y	
IPI00073777.1	PLXDC2 Isoform 2 of Plexin domain-containing protein 2 precursor	V*N*LSFDFPFYGHFLR		Y	Y	
IPI00152789.4	SNED1 67 kDa protein	AY*N*ISVFSVK		Y	Y	
IPI00159927.2	NCAN Neurocan core protein precursor	A*N*ATLLLGPLR		Y	Y	
IPI00160552.3	TNR Isoform 1 of Tenascin-R precursor	QSVEEEGGIANY*N*TSSK		Y	Y	
IPI00163207.1	PGLYRP2 Isoform 1 of N-acetylmuramoyl-L-alanine amidase precursor	GFGVAIVG*N*YTAALPTEAALR	Y		Y	
IPI00166392.1	CADM1 Immunoglobulin superfamily member 4	FQLL*N*FSSSELK	Y		Y	
IPI00166392.1	CADM1 Immunoglobulin superfamily member 4	VSLT*N*VSISDEGR	Y		Y	
IPI00166729.4	AZGP1 alpha-2-glycoprotein 1, zinc	DIVEYY*N*DS*N*GSHVLQGR	Y1,Y2		Y1,Y2	
IPI00166729.4	AZGP1 alpha-2-glycoprotein 1, zinc	FGCEIEN*N*R	Y		Y	
IPI00167093.4	CFHR1 complement factor H-related 1	LQNNEN*N*ISCVER	Y			
IPI00168728.1	IGHM FLJ00385 protein (Fragment)	EEQF*N*STFR			Y	
IPI00168728.1	IGHM FLJ00385 protein (Fragment)	KPREEQF*N*STFR			Y	
IPI00168728.1	IGHM FLJ00385 protein (Fragment)	TKPREEQF*N*STFR			Y	
IPI00171411.4	GOLM1 Golgi membrane protein 1	AVLVN*N*ITTGER			Y	
IPI00171473.2	SPON1 Spondin-1 precursor	LTFYG*N*WSEK		Y	Y	
IPI00176427.1	CADM4 Cell adhesion molecule 4 precursor	QTLFF*N*GTR		Y	Y	
IPI00178926.2	IGJ immunoglobulin J chain	IIVPLNNRE*N*ISDPTSPLR	Y		Y	
IPI00215894.1	KNG1 Isoform LMW of Kininogen-1 precursor	HGIQYFN*N*NTQHSSLFMLNEVK	Y		Y	
IPI00215894.1	KNG1 Isoform LMW of Kininogen-1	HGIQYFN*N*NTQHSSLFMLNEVKR	Y		Y	

APPENDIX I: (Continued)

	precursor					
IPI00215894.1	KNG1 Isoform LMW of Kininogen-1 precursor	ITYSIVQT*N*CSK	Y		Y	
IPI00215894.1	KNG1 Isoform LMW of Kininogen-1 precursor	ITYSIVQT*N*CSKENFLFLTPDCK	Y		Y	
IPI00215894.1	KNG1 Isoform LMW of Kininogen-1 precursor	KY*N*SQNQSNNQFVLYR	Y			
IPI00215894.1	KNG1 Isoform LMW of Kininogen-1 precursor	LNAEN*N*ATFYFK	Y		Y	
IPI00216250.5	CNTNAP4 Cell recognition protein CASPR4	T*N*ETQTYWGGSSPDLQK		Y		Y
IPI00216641.1	CNTN1 Isoform 2 of Contactin-1 precursor	A*N*STGTLVITDPTR	Y		Y	
IPI00216641.1	CNTN1 Isoform 2 of Contactin-1 precursor	GKA*N*STGTLVITDPTR	Y		Y	
IPI00216641.1	CNTN1 Isoform 2 of Contactin-1 precursor	G*N*YSCFVSSPSITK		Y	Y	
IPI00216641.1	CNTN1 Isoform 2 of Contactin-1 precursor	YIITWDHVVALS*N*ESTVTGYK		Y		Y
IPI00217376.1	SCN4B Isoform 1 of Sodium channel subunit beta-4 precursor	WTY*N*SSDAFK		Y	Y	
IPI00217882.3	SORT1 Sortilin precursor	DITDLI*N*NTFIR	Y		Y	
IPI00217882.3	SORT1 Sortilin precursor	HLYTTTGGETDFT*N*VTSLR		Y	Y	
IPI00218192.2	ITIH4 Isoform 2 of Inter-alpha-trypsin inhibitor heavy chain H4 precursor	LPTQ*N*ITFQTESSVAEQEAEFQSPK	Y		Y	
IPI00218732.3	PON1 Serum paraoxonase/arylesterase 1	HA*N*WTLTPLK	Y		Y	
IPI00218732.3	PON1 Serum paraoxonase/arylesterase 1	VTQVYAE*N*GTVLQGSTVASVYK	Y		Y	
IPI00242956.4	FCGBP IgGFc-binding protein precursor	VITVQVA*N*FTLR			Y	
IPI00242956.4	FCGBP IgGFc-binding protein precursor	YLPV*N*SSLLTSDCSER			Y	
IPI00290856.4	LYVE1 Lymphatic vessel endothelial hyaluronic acid receptor 1 precursor	KANQQL*N*FTEAK	Y		Y	
IPI00291136.4	COL6A1 Collagen alpha-1(VI) chain precursor	GEDGPAG*N*GTEGFPGFPGYPGNR		Y	Y	
IPI00291136.4	COL6A1 Collagen alpha-1(VI) chain precursor	*N*VTAQICIDK		Y	Y	
IPI00291867.3	CFI Complement factor I precursor	FLN*N*GTCTAEGK	Y		Y	
IPI00292071.6	SCG3 Secretogranin-3 precursor	NKLEK*N*ATDNISK			Y	
IPI00292071.6	SCG3 Secretogranin-3 precursor	TYPPENKPGQS*N*YSFVDNLNLLK			Y	
IPI00292732.3	FMOD fibromodulin precursor	LYLDHN*N*LTR	Y		Y	
IPI00292946.1	SERPINA7 Thyroxine-binding globulin precursor	TLYETEVFSTDFS*N*ISAAK	Y		Y	
IPI00294193.4	ITIH4 Isoform 1 of Inter-alpha-trypsin inhibitor heavy chain H4 precursor	LPTQ*N*ITFQTESSVAEQEAEFQSPK	Y		Y	
IPI00294395.1	C8B Complement component C8 beta chain precursor	EYESYSDFER*N*VTEK	Y		Y	
IPI00294650.5	FRZB Secreted frizzled-related protein 3 precursor	SLPW*N*MTK		Y		Y
IPI00294776.3	RELN Isoform 1 of Reelin precursor	APS*N*VSTIIHILYLPEDAK		Y	Y	
IPI00294776.3	RELN Isoform 1 of Reelin precursor	HDYILLPEDALT*N*TTR		Y	Y	
IPI00295832.1	OMG Oligodendrocyte-myelin glycoprotein precursor	Q*N*ITYLLK		Y		Y
IPI00295832.1	OMG Oligodendrocyte-myelin glycoprotein precursor	SLEVI*N*LSSNK		Y	Y	
IPI00295832.1	OMG Oligodendrocyte-myelin glycoprotein precursor	SLW*N*MSAANNNIK		Y	Y	
IPI00296165.5	C1R;ACYP1;C17orf13 Complement C1r subcomponent precursor	EHEAQS*N*ASLDVFLGHTNVEELMK	Y		Y	
IPI00296534.1	FBLN1 Isoform D of Fibulin-1 precursor	CATPHGD*N*ASLEATFVK		Y	Y	
IPI00296608.6	C7 Complement component C7 precursor	INNDFNYEFY*N*STWSYVK	Y		Y	
IPI00296608.6	C7 Complement component C7 precursor	*N*YTLTGR	Y		Y	
IPI00297124.1	IL6ST Isoform 1 of Interleukin-6 receptor subunit beta precursor	EQYTII*N*R	Y			Y
IPI00297124.1	IL6ST Isoform 1 of Interleukin-6 receptor subunit beta precursor	ETHLET*N*FTLK	Y		Y	
IPI00297124.1	IL6ST Isoform 1 of Interleukin-6 receptor subunit beta precursor	LTV*N*LTNDR				Y
IPI00297124.1	IL6ST Isoform 1 of Interleukin-6 receptor subunit beta precursor	*N*YTIFYR	Y			Y
IPI00297263.6	HEG1 Isoform 1 of Protein HEG homolog 1 precursor	SHAASDAPE*N*LTLLAETADAR	Y		Y	
IPI00297646.4	COL1A1 Collagen alpha-1(I) chain precursor	LMSTEASQ*N*ITYHCK	Y		Y	
IPI00298828.3	APOH Beta-2-glycoprotein 1 precursor	LG*N*WSAMPSCK	Y		Y	

(*Continued*)

APPENDIX I: (Continued)

IPI00298828.3	APOH Beta-2-glycoprotein 1 precursor	VYKPSAG*N*NSLYR	Y		Y	
IPI00298971.1	VTN Vitronectin precursor	*N*GSLFAFR	Y		Y	
IPI00298971.1	VTN Vitronectin precursor	*N*ISDGFDGIPDNVDAALALPAHSYSGR	Y		Y	
IPI00298971.1	VTN Vitronectin precursor	N*N*ATVHEQVGGPSLTSDLQAQSK	Y		Y	
IPI00301395.4	CPVL Probable serine carboxypeptidase CPVL precursor	QAIHVG*N*QTFNDGTIVEK		Y	Y	
IPI00301395.4	CPVL Probable serine carboxypeptidase CPVL precursor	SYAGFLTV*N*K		Y	Y	
IPI00301512.3	DPP6 Isoform DPPX-L of Dipeptidyl aminopeptidase-like protein 6	LAYAAI*N*DSR	Y			Y
IPI00301579.3	NPC2 Epididymal secretory protein E1 precursor	GQSYSV*N*VTFTSNIQSK		Y	Y	
IPI00302641.1	FAT2 Protocadherin Fat 2 precursor	ASEYTVSIQS*N*VSK		Y	Y	
IPI00302641.1	FAT2 Protocadherin Fat 2 precursor	VPE*N*ITLYTPILHTQAR		Y	Y	
IPI00303210.3	ENPP2 Isoform 2 of Ectonucleotide pyrophosphatase/phosphodiesterase family member 2 precursor	AEGWEEGPPTVLSDSPWT*N*ISGSCK		Y		Y
IPI00303210.3	ENPP2 Isoform 2 of Ectonucleotide pyrophosphatase/phosphodiesterase family member 2 precursor	AIIA*N*LTCK		Y	Y	
IPI00303963.1	C2 Complement C2 precursor (Fragment)	QSVPAHFVAL*N*GSK	Y		Y	
IPI00307276.1	ADAMTS4 ADAMTS-4 precursor	EEEIVFPEKL*N*GSVLPGSGAPAR				Y
IPI00328609.3	SERPINA4 Kallistatin precursor	DFYVDE*N*TTVR	Y		Y	
IPI00328609.3	SERPINA4 Kallistatin precursor	FL*N*DTMAVYEAK	Y		Y	
IPI00328609.3	SERPINA4 Kallistatin precursor	SQILEGLGF*N*LTELSESDVHR	Y		Y	
IPI00328609.3	SERPINA4 Kallistatin precursor	TTPKDFYVDE*N*TTVR	Y		Y	
IPI00329775.7	CPB2 Isoform 1 of Carboxypeptidase B2 precursor	KQVHFFV*N*ASDVDNVK	Y		Y	
IPI00329775.7	CPB2 Isoform 1 of Carboxypeptidase B2 precursor	QVHFFV*N*ASDVDNVK	Y		Y	
IPI00332273.2	PTPRS Isoform PTPS-MEC of Receptor-type tyrosine-protein phosphatase S precursor	KVEAEAL*N*ATAIR	Y		Y	
IPI00332887.5	SIRPA signal-regulatory protein alpha precursor	AENQV*N*VTCQVR		Y	Y	
IPI00332887.5	SIRPA signal-regulatory protein alpha precursor	GTA*N*LSETIR	Y		Y	
IPI00332887.5	SIRPA signal-regulatory protein alpha precursor	IG*N*ITPADAGTYYCVK			Y	
IPI00333140.8	DNER Delta and Notch-like epidermal growth factor-related receptor precursor	LVSFEVPQ*N*TSVK	Y		Y	
IPI00333140.8	DNER Delta and Notch-like epidermal growth factor-related receptor precursor	WDQVEVIPDIACG*N*ASS*N*SSAGGR				Y1,Y2
IPI00333776.5	NRCAM Isoform 1 of Neuronal cell adhesion molecule precursor	DGDDEWTSVVVA*N*VSK		Y	Y	
IPI00333776.5	NRCAM Isoform 1 of Neuronal cell adhesion molecule precursor	ERPPTFLTPEG*N*ASNK	Y		Y	
IPI00333776.5	NRCAM Isoform 1 of Neuronal cell adhesion molecule precursor	ERPPTFLTPEG*N*ASNKEELR	Y		Y	
IPI00333776.5	NRCAM Isoform 1 of Neuronal cell adhesion molecule precursor	F*N*HTQTIQQK		Y	Y	
IPI00333776.5	NRCAM Isoform 1 of Neuronal cell adhesion molecule precursor	GSALHEDIYVLHE*N*GTLEIPVAQK		Y	Y	
IPI00333776.5	NRCAM Isoform 1 of Neuronal cell adhesion molecule precursor	LSPYV*N*YSFR		Y	Y	
IPI00333776.5	NRCAM Isoform 1 of Neuronal cell adhesion molecule precursor	QKDGDDEWTSVVVA*N*VSK		Y	Y	
IPI00333776.5	NRCAM Isoform 1 of Neuronal cell adhesion molecule precursor	VISVDEL*N*DTIAANLSDTEFYGAK		Y	Y	
IPI00333776.5	NRCAM Isoform 1 of Neuronal cell adhesion molecule precursor	VNVV*N*STLAEVHWDPVPLK		Y	Y	
IPI00333776.5	NRCAM Isoform 1 of Neuronal cell adhesion molecule precursor	YQPI*N*STHELGPLVDLK		Y	Y	
IPI00376427.3	NCAM2 Neural cell adhesion molecule 2 precursor	DKLVLPAK*N*TTNLK			Y	
IPI00376427.3	NCAM2 Neural cell adhesion molecule 2 precursor	LVLPAK*N*TTNLK			Y	
IPI00377015.5	EFNA1 Isoform 2 of Ephrin-A1 precursor	HTVFW*N*SSNPK		Y	Y	
IPI00382750.1	GNPTG Similar to protein kinase C	YEFCPFH*N*VTQHEQTFR		Y	Y	

APPENDIX I: (Continued)

	substrate					
IPI00384938.1	IGHG1 Putative uncharacterized protein DKFZp686N02209	TVLHQDWL*N*GK	Y			
IPI00394992.1	PGLYRP2 Isoform 2 of N-acetylmuramoyl-L-alanine amidase precursor	GFGVAIVG*N*YTAALPTEAALR	Y		Y	
IPI00395488.2	VASN Vasorin precursor	LHEIT*N*ETFR	Y		Y	
IPI00399307.2	PRCP prolylcarboxypeptidase isoform 2 preproprotein	*N*YSVLYFQQK		Y	Y	
IPI00400826.1	CLU clusterin isoform 1	ELPGVC*N*ETMMALWEECKPCLK	Y		Y	
IPI00400826.1	CLU clusterin isoform 1	KEDAL*N*ETR	Y		Y	
IPI00400826.1	CLU clusterin isoform 1	KKEDAL*N*ETR	Y		Y	
IPI00400826.1	CLU clusterin isoform 1	LA*N*LTQGEDQYYLR	Y		Y	
IPI00400826.1	CLU clusterin isoform 1	ML*N*TSSLLEQLNEQFNWVSR	Y		Y	
IPI00400826.1	CLU clusterin isoform 1	QLEEFL*N*QSSPFYFWMNGDR	Y		Y	
IPI00413016.4	CADM2 Isoform 1 of Cell adhesion molecule 2 precursor	ELNILFL*N*K				Y
IPI00413696.5	CD47 41 kDa protein	SDAVSHTG*N*YTCEVTELTR	Y		Y	
IPI00418183.4	SGCE sarcoglycan, epsilon isoform 2	LNAI*N*ITSALDR		Y	Y	
IPI00418531.4	GLDN Isoform 1 of Gliomedin	TFSVVQHV*N*TTYPK		Y		
IPI00419724.2	SEMA4B semaphorin 4B precursor	FEAEHIS*N*YTALLLSR	Y			
IPI00431645.1	HP HP protein	MVSHH*N*LTTGATLINEQWLLTTAK	Y		Y	
IPI00431645.1	HP HP protein	NLFL*N*HSE*N*ATAK	Y1,Y2		Y1,Y2	
IPI00431645.1	HP HP protein	VSHH*N*LTTGATLINEQWLLTTAK	Y		Y	
IPI00431645.1	HP HP protein	VVLHP*N*YSQVDIGLIK	Y		Y	
IPI00431645.1	HP HP protein	VVLHP*N*YSQVDIGLIKL	Y		Y	
IPI00433478.3	ASPH ASPH protein	Y*N*LSEVLQGK				Y
IPI00441498.1	FOLR1 Folate receptor alpha precursor	GW*N*WTSGFNK		Y		Y
IPI00456623.2	BCAN Isoform 1 of Brevican core protein precursor	TLFLFP*N*QTGFPNK		Y	Y	
IPI00456623.2	BCAN Isoform 1 of Brevican core protein precursor	VALPAYPASLTDVSLALSELRP*N*DSGIYR		Y	Y	
IPI00470388.2	CADM2 Isoform 2 of Cell adhesion molecule 2 precursor	ELNILFL*N*K				Y
IPI00470696.1	UNC5D Isoform 1 of Netrin receptor UNC5D precursor	EVFI*N*VTR		Y		Y
IPI00472011.1	NEO1 154 kDa protein	TLSDVPSAAPQ*N*LSLEVR		Y	Y	
IPI00478003.1	A2M Alpha-2-macroglobulin precursor	GNEANYYS*N*ATTDEHGLVQF	Y		Y	
IPI00478003.1	A2M Alpha-2-macroglobulin precursor	IYVLDYL*N*ETQQLTPEVK	Y		Y	
IPI00478003.1	A2M Alpha-2-macroglobulin precursor	SLGNV*N*FTVSAEALESQELCGTEVPSVPEHG R	Y		Y	
IPI00478003.1	A2M Alpha-2-macroglobulin precursor	VS*N*QTLSLFF	Y		Y	
IPI00478003.1	A2M Alpha-2-macroglobulin precursor	VS*N*QTLSLFFTVLQDVPVR	Y		Y	
IPI00478809.3	F5 Coagulation factor V precursor	TNI*N*SSRDPDNIAAWYLR	Y		Y	
IPI00479514.1	CACNA2D1 Voltage-dependent calcium channel subunit alpha-2/delta-1 precursor	IDVNSWIE*N*FTK			Y	
IPI00479514.1	CACNA2D1 Voltage-dependent calcium channel subunit alpha-2/delta-1 precursor	ISD*N*NTEFLLNFNEFIDR	Y		Y	
IPI00479514.1	CACNA2D1 Voltage-dependent calcium channel subunit alpha-2/delta-1 precursor	SFSGVLDCG*N*CSR			Y	
IPI00479514.1	CACNA2D1 Voltage-dependent calcium channel subunit alpha-2/delta-1 precursor	VLKDAVN*N*ITAK	Y		Y	
IPI00513705.1	NFASC Isoform 1 of Neurofascin precursor	QIVENFSP*N*QTK		Y		Y
IPI00513705.1	NFASC Isoform 1 of Neurofascin precursor	WA*N*ITWK				Y
IPI00513705.1	NFASC Isoform 1 of Neurofascin precursor	YVAF*N*GTK		Y		Y
IPI00513964.1	SEMA4B Isoform 2 of Semaphorin-4B precursor	FEAEHIS*N*YTALLLSR			Y	
IPI00514397.1	APOM Apolipoprotein M	TELFSSSCPGGIML*N*ETGQGYQR	Y		Y	
IPI00549291.4	IGHM IGHM protein	GLTFQQ*N*ASSMCVPDQDTAIR	Y			
IPI00552450.1	OPCML opioid binding protein/cell adhesion molecule-like isoform b preproprotein	DYG*N*YTCVATNK		Y		Y
IPI00552450.1	OPCML opioid binding protein/cell adhesion molecule-like isoform b preproprotein	MSTLTFF*N*VSEK		Y	Y	
IPI00553177.1	SERPINA1 Isoform 1 of Alpha-1-antitrypsin precursor	ADTHDEILEGLNF*N*LT	Y		Y	
IPI00553177.1	SERPINA1 Isoform 1 of Alpha-1-antitrypsin precursor	ADTHDEILEGLNF*N*LTEIPEAQIHEGFQELLR	Y		Y	
IPI00553177.1	SERPINA1 Isoform 1 of Alpha-1-	F*N*LTEIPEAQIHEGFQELLR	Y		Y	

(*Continued*)

APPENDIX I: (Continued)

	antitrypsin precursor					
IPI00553177.1	SERPINA1 Isoform 1 of Alpha-1-antitrypsin precursor	G*N*ATAIFFLPDEGK	Y		Y	
IPI00553177.1	SERPINA1 Isoform 1 of Alpha-1-antitrypsin precursor	LG*N*ATAIFFLPDEGK	Y		Y	
IPI00553177.1	SERPINA1 Isoform 1 of Alpha-1-antitrypsin precursor	QLAHQS*N*STNIF	Y		Y	
IPI00553177.1	SERPINA1 Isoform 1 of Alpha-1-antitrypsin precursor	QLAHQS*N*STNIFFSPV	Y		Y	
IPI00553177.1	SERPINA1 Isoform 1 of Alpha-1-antitrypsin precursor	QLAHQS*N*STNIFFSPVSIATA	Y		Y	
IPI00553177.1	SERPINA1 Isoform 1 of Alpha-1-antitrypsin precursor	QLAHQS*N*STNIFFSPVSIATAF	Y		Y	
IPI00553177.1	SERPINA1 Isoform 1 of Alpha-1-antitrypsin precursor	QLAHQS*N*STNIFFSPVSIATAFAM	Y		Y	
IPI00553177.1	SERPINA1 Isoform 1 of Alpha-1-antitrypsin precursor	QLAHQSNST*M*IFFSPVSIATAFAMLSLGTK	Y			
IPI00553177.1	SERPINA1 Isoform 1 of Alpha-1-antitrypsin precursor	YLG*N*ATAIF	Y		Y	
IPI00553177.1	SERPINA1 Isoform 1 of Alpha-1-antitrypsin precursor	YLG*N*ATAIFF	Y		Y	
IPI00553177.1	SERPINA1 Isoform 1 of Alpha-1-antitrypsin precursor	YLG*N*ATAIFFLPDEGK	Y		Y	
IPI00554518.1	IL6ST IL6ST nirs variant 4	ETHLET*N*FTLK	Y		Y	
IPI00554518.1	IL6ST IL6ST nirs variant 4	*N*YTIFYR	Y			Y
IPI00554538.3	TPP1 60 kDa protein	FLSSSPHLPPSSYF*N*ASGR			Y	
IPI00554760.1	TNR Isoform 2 of Tenascin-R precursor	QSVEEEGGIANY*N*TSSK		Y	Y	
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	DEGTYTCALHHSGHSPPISSQ*N*VTVLR	Y		Y	
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	HE*N*TSSSPIQYEF	Y		Y	
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	HE*N*TSSSPIQYEFSLTR	Y		Y	
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	LDCRHE*N*TSSSPIQYEFSLTR	Y		Y	
IPI00555628.1	NCAM1 Neural cell adhesion molecule 1, 120 kDa isoform variant (Fragment)	DGQLLPSS*N*YSNIK			Y	
IPI00555628.1	NCAM1 Neural cell adhesion molecule 1, 120 kDa isoform variant (Fragment)	IYNTPSASYLEVTPDSENDFGNY*N*CTAVNR			Y	
IPI00556575.1	FGFR3 Fibroblast growth factor receptor 3 isoform 1 variant (Fragment)	LQVL*N*ASHEDSGAYSCR		Y		Y
IPI00607580.2	MEGF8 multiple EGF-like-domains 8	ALLT*N*VSSVALGSR	Y			
IPI00607600.1	APLP1 amyloid precursor-like protein 1 isoform 1 precursor	KV*N*ASVPR		Y	Y	
IPI00607600.1	APLP1 amyloid precursor-like protein 1 isoform 1 precursor	V*N*QSLGLLDQN		Y	Y	
IPI00607600.1	APLP1 amyloid precursor-like protein 1 isoform 1 precursor	V*N*QSLGLLDQNPHLAQELR		Y	Y	
IPI00607648.1	NRXN1 Isoform 2 of Neurexin-1-alpha precursor	*N*TTLFIDQVEAK		Y	Y	
IPI00607648.1	NRXN1 Isoform 2 of Neurexin-1-alpha precursor	V*N*SSQVLPVDSGEVK		Y	Y	
IPI00607652.1	OLFML3 Isoform 2 of Olfactomedin-like protein 3 precursor	IYVLDGTQ*N*DTAFVFPR		Y		
IPI00639937.1	CFB Complement factor B	SPYY*N*VSDEISFH	Y			
IPI00639937.1	CFB Complement factor B	SPYY*N*VSDEISFHCYDGYTLR	Y			
IPI00641737.1	HP Haptoglobin precursor	MVSHH*N*LTTGATLINEQWLLTTAK	Y		Y	
IPI00641737.1	HP Haptoglobin precursor	NLFL*N*HSE*N*ATAK	Y1,Y2		Y1,Y2	
IPI00641737.1	HP Haptoglobin precursor	VVLHP*N*YSQVDIGLIK	Y		Y	
IPI00641940.1	PCDH9 Protocadherin 9	IVASDSGKPSL*N*QTALVR		Y	Y	
IPI00642017.1	IGHA2 Putative uncharacterized protein DKFZp686C02218 (Fragment)	LAGKPTHV*N*VSVVMAEVDGTC	Y		Y	
IPI00642017.1	IGHA2 Putative uncharacterized protein DKFZp686C02218 (Fragment)	LSLHRPALEDLLLGSEA*N*LTCTLTGLR	Y		Y	
IPI00642017.1	IGHA2 Putative uncharacterized protein DKFZp686C02218 (Fragment)	TPLTA*N*ITK	Y		Y	
IPI00643034.2	PLTP Isoform 1 of Phospholipid transfer protein precursor	EGHFYY*N*ISEVK	Y		Y	
IPI00643034.2	PLTP Isoform 1 of Phospholipid transfer	GAFFPLTER*N*WSLPNR	Y		Y	

APPENDIX I: (Continued)

	protein precursor					
IPI00643034.2	PLTP Isoform 1 of Phospholipid transfer protein precursor	GKEGHFYY*N*ISEVK			Y	
IPI00643034.2	PLTP Isoform 1 of Phospholipid transfer protein precursor	IYS*N*HSALESLALIPLQAPLK			Y	
IPI00643034.2	PLTP Isoform 1 of Phospholipid transfer protein precursor	*N*WSLPNR			Y	
IPI00643034.2	PLTP Isoform 1 of Phospholipid transfer protein precursor	RGKEGHFYY*N*ISEVK			Y	
IPI00643034.2	PLTP Isoform 1 of Phospholipid transfer protein precursor	VS*N*VSCQASVSR			Y	
IPI00643506.3	C2 Complement component 2	QSVPAHFVAL*N*GSK			Y	
IPI00643506.3	C2 Complement component 2	TMFP*N*LTDVR				Y
IPI00643525.1	C4A Complement component 4A	FSDGLES*N*SSTQFEVK	Y		Y	
IPI00643525.1	C4A Complement component 4A	FSDGLES*N*SSTQFEVKK	Y		Y	
IPI00643525.1	C4A Complement component 4A	GL*N*VTLSSTGR	Y		Y	
IPI00643525.1	C4A Complement component 4A	GL*N*VTLSSTGRNGFK	Y		Y	
IPI00643525.1	C4A Complement component 4A	*N*TTCQDLQIEVTVK	Y		Y	
IPI00643663.1	PCSK2 Proprotein convertase subtilisin/kexin type 2	YLEHVQAVITV*N*ATR		Y	Y	
IPI00644276.3	CNTNAP4 cell recognition protein CASPR4 isoform 2	T*N*ETQTYWGGSSPDLQK		Y		
IPI00645038.1	ITIH2 Inter-alpha (Globulin) inhibitor H2	GAFIS*N*FSMTVDGK	Y		Y	
IPI00654888.4	KLKB1 Plasma kallikrein precursor	GVNF*N*VSK	Y		Y	
IPI00654888.4	KLKB1 Plasma kallikrein precursor	IYPGVDFGGEEL*N*VTFVK	Y		Y	
IPI00655702.3	NFASC Isoform 5 of Neurofascin precursor	WA*N*ITWK				Y
IPI00655927.1	PRG4 Isoform B of Proteoglycan-4 precursor	*N*GTLVAFR	Y		Y	
IPI00656113.2	SIRPA Signal-regulatory protein alpha	AENQV*N*VTCQVR		Y		
IPI00656113.2	SIRPA Signal-regulatory protein alpha	GTA*N*LSETIR	Y			
IPI00656113.2	SIRPA Signal-regulatory protein alpha	LQLTWLENG*N*VSR		Y		
IPI00739477.1	PILRA Isoform 2 of Paired immunoglobulin-like type 2 receptor alpha precursor	LFL*N*WTEGQK		Y		Y
IPI00739827.1	LAMP2 Isoform LAMP-2B of Lysosome-associated membrane glycoprotein 2 precursor	IAVQFGPGFSWIA*N*FTK	Y		Y	
IPI00739827.1	LAMP2 Isoform LAMP-2B of Lysosome-associated membrane glycoprotein 2 precursor	VASVININP*N*TTHSTGSCR	Y		Y	
IPI00739827.1	LAMP2 Isoform LAMP-2B of Lysosome-associated membrane glycoprotein 2 precursor	VQPF*N*VTQGK	Y		Y	
IPI00743766.2	FETUB Fetuin-B precursor	GC*N*DSDVLAVAGFALR	Y		Y	
IPI00743766.2	FETUB Fetuin-B precursor	VLYLAAY*N*CTLRPVSK	Y		Y	
IPI00744685.2	BTD Uncharacterized protein BTD (Fragment)	DVQIIVFPEDGIHGF*N*FTR			Y	
IPI00744685.2	BTD Uncharacterized protein BTD (Fragment)	F*N*DTEVLQR			Y	
IPI00744685.2	BTD Uncharacterized protein BTD (Fragment)	NPVGLIGAE*N*ATGETDPSHSK			Y	
IPI00744685.2	BTD Uncharacterized protein BTD (Fragment)	WNPCLEPHRF*N*DTEVLQR			Y	
IPI00744685.2	BTD Uncharacterized protein BTD (Fragment)	YQFNTNVVFSN*N*GTLVDR			Y	
IPI00745089.2	A1BG alpha 1B-glycoprotein precursor	EGDHEFLEVPEAQEDVEATFPVHQPG*N*YSCS YR	Y		Y	
IPI00745207.1	B3GNT2 45 kDa protein	DTFF*N*LSLK		Y		
IPI00748395.2	SEZ6 seizure related 6 homolog isoform 2	EGETVTVEGLGGPDPLPLA*N*QSFLLR			Y	
IPI00783390.1	CHL1 Isoform 1 of Neural cell adhesion molecule L1-like protein precursor	DGEAFEI*N*GTEDGR	Y		Y	
IPI00783390.1	CHL1 Isoform 1 of Neural cell adhesion molecule L1-like protein precursor	IIPS*N*NSGTFR			Y	
IPI00783390.1	CHL1 Isoform 1 of Neural cell adhesion molecule L1-like protein precursor	ISGV*N*LTQK	Y			Y
IPI00783390.1	CHL1 Isoform 1 of Neural cell adhesion molecule L1-like protein precursor	LTWEAGADHNS*N*ISEYIVEFEGNKEEPGR			Y	
IPI00783390.1	CHL1 Isoform 1 of Neural cell adhesion molecule L1-like protein precursor	VTWKPQGAPVEWEEETVT*N*HTLR	Y		Y	

(*Continued*)

APPENDIX I: (Continued)

IPI00783390.1	CHL1 Isoform 1 of Neural cell adhesion molecule L1-like protein precursor	YHIYE*N*GTLQI*N*R	Y1,Y2		Y1,Y2	
IPI00783987.2	C3 Complement C3 precursor (Fragment)	TVLTPATNHMG*N*VTF	Y		Y	
IPI00783987.2	C3 Complement C3 precursor (Fragment)	TVLTPATNHMG*N*VTFTIPANR	Y		Y	
IPI00784119.1	ATP6AP1 Vacuolar ATP synthase subunit S1 precursor	L*N*ASLPALLLIR		Y	Y	
IPI00784169.1	CD55 Decay-accelerating factor splicing variant 1	GSQWSDIEEFC*N*R		Y		
IPI00784432.1	CBX6 53 kDa protein	V*N*LSAAPAPVSAVPTGLHSK			Y	
IPI00784807.1	IGHG2 Putative uncharacterized protein	EEQF*N*STFR	Y		Y	
IPI00784807.1	IGHG2 Putative uncharacterized protein	TKPREEQF*N*STFR	Y		Y	
IPI00787050.1	NPTX1 similar to neuronal pentraxin 1 precursor	L*N*SSSQTNSLKDLLQSK			Y	
IPI00788159.1	DPP7 similar to Dipeptidyl-peptidase 2 precursor	ALAGLVY*N*ASGSEHCYDIYR			Y	
IPI00789795.1	ADAM22 98 kDa protein	LFEFSLDDLPSEFQQV*N*ITPSK			Y	
IPI00790218.1	ICOSLG Uncharacterized protein ICOSLG	LF*N*VTPQDEQK	Y			
IPI00790218.1	ICOSLG Uncharacterized protein ICOSLG	TVVTYHIPQ*N*SSLENVDSR	Y			
IPI00790784.2	SERPINA1 Isoform 2 of Alpha-1-antitrypsin precursor	ADTHDEILEGLNF*N*LT	Y		Y	
IPI00790784.2	SERPINA1 Isoform 2 of Alpha-1-antitrypsin precursor	ADTHDEILEGLNF*N*LTEIPEAQIH	Y		Y	
IPI00790784.2	SERPINA1 Isoform 2 of Alpha-1-antitrypsin precursor	ADTHDEILEGLNF*N*LTEIPEAQIHEGFQELLR	Y		Y	
IPI00790784.2	SERPINA1 Isoform 2 of Alpha-1-antitrypsin precursor	F*N*LTEIPEAQIHEGFQELLR	Y		Y	
IPI00790784.2	SERPINA1 Isoform 2 of Alpha-1-antitrypsin precursor	G*N*ATAIFFLPDEGK	Y		Y	
IPI00790784.2	SERPINA1 Isoform 2 of Alpha-1-antitrypsin precursor	QLAHQS*N*STNIF	Y		Y	
IPI00790784.2	SERPINA1 Isoform 2 of Alpha-1-antitrypsin precursor	QLAHQS*N*STNIFFSPVSIATA	Y		Y	
IPI00790784.2	SERPINA1 Isoform 2 of Alpha-1-antitrypsin precursor	QLAHQS*N*STNIFFSPVSIATAF	Y		Y	
IPI00790784.2	SERPINA1 Isoform 2 of Alpha-1-antitrypsin precursor	QLAHQS*N*STNIFFSPVSIATAFAMLSLGTK	Y		Y	
IPI00790784.2	SERPINA1 Isoform 2 of Alpha-1-antitrypsin precursor	YLG*N*ATAI	Y		Y	
IPI00790784.2	SERPINA1 Isoform 2 of Alpha-1-antitrypsin precursor	YLG*N*ATAIF	Y		Y	
IPI00790784.2	SERPINA1 Isoform 2 of Alpha-1-antitrypsin precursor	YLG*N*ATAIFF	Y		Y	
IPI00790784.2	SERPINA1 Isoform 2 of Alpha-1-antitrypsin precursor	YLG*N*ATAIFFLPDEGK	Y		Y	
IPI00790784.2	SERPINA1 Isoform 2 of Alpha-1-antitrypsin precursor	YLG*N*ATAIFFLPDEGKL	Y		Y	
IPI00790784.2	SERPINA1 Isoform 2 of Alpha-1-antitrypsin precursor	YLG*N*ATAIFFLPDEGKLQHLENELTHDIITK	Y		Y	
IPI00793751.1	MFAP4 Uncharacterized protein MFAP4	F*N*GSVSFFR			Y	
IPI00793751.1	MFAP4 Uncharacterized protein MFAP4	VDLEDFE*N*NTAYAK			Y	
IPI00793848.1	CLU 54 kDa protein	A*N*LTQGEDQYYLR	Y		Y	
IPI00793848.1	CLU 54 kDa protein	EDAL*N*ETR	Y		Y	
IPI00793848.1	CLU 54 kDa protein	EDAL*N*ETRESETK	Y		Y	
IPI00793848.1	CLU 54 kDa protein	EIRH*N*STGCLR	Y		Y	
IPI00793848.1	CLU 54 kDa protein	ELPGVC*N*ETMMALWEECKPCLK	Y		Y	
IPI00793848.1	CLU 54 kDa protein	H*N*STGCLR	Y		Y	
IPI00793848.1	CLU 54 kDa protein	KEDAL*N*ETR	Y		Y	
IPI00793848.1	CLU 54 kDa protein	KEDAL*N*ETRESETK	Y		Y	
IPI00793848.1	CLU 54 kDa protein	KKEDAL*N*ETR	Y		Y	
IPI00793848.1	CLU 54 kDa protein	KKEDAL*N*ETRESETK	Y		Y	
IPI00793848.1	CLU 54 kDa protein	KKKEDAL*N*ETR	Y		Y	
IPI00793848.1	CLU 54 kDa protein	KKKEDAL*N*ETRESETK	Y		Y	
IPI00793848.1	CLU 54 kDa protein	LA*N*LTQGEDQYYLR	Y		Y	
IPI00793848.1	CLU 54 kDa protein	LKELPGVC*N*ETMMALWEECKPCLK	Y		Y	
IPI00793848.1	CLU 54 kDa protein	ML*N*TSSLLEQLN	Y		Y	
IPI00793848.1	CLU 54 kDa protein	ML*N*TSSLLEQLNEQFNWVSR	Y		Y	
IPI00793848.1	CLU 54 kDa protein	QLEEFL*N*QS	Y		Y	
IPI00793848.1	CLU 54 kDa protein	QLEEFL*N*QSSPF	Y		Y	
IPI00793848.1	CLU 54 kDa protein	QLEEFL*N*QSSPFYF	Y		Y	

APPENDIX I: (Continued)

IPI00793848.1	CLU 54 kDa protein	QLEEFLNQSSPFYFWMNGDR	Y		Y	
IPI00794403.1	LUM 23 kDa protein	AFENVTDLQWLILDHNLLENSK	Y		Y	
IPI00794403.1	LUM 23 kDa protein	KLHINHNNLTESVGPLPK		Y	Y	
IPI00794403.1	LUM 23 kDa protein	LGSFEGLVNLTFIHLQHNR	Y		Y	
IPI00794403.1	LUM 23 kDa protein	LHINHNNLTESVGPLPK		Y	Y	
IPI00795624.1	NELL2 Cerebral protein-12	QVPGLHNGTK		Y		Y
IPI00795801.1	CD109 Isoform 4 of CD109 antigen precursor	INYTVPQSGTFK	Y		Y	
IPI00795801.1	CD109 Isoform 4 of CD109 antigen precursor	TQDEILFSNSTR	Y		Y	
IPI00795918.1	NCAM1 neural cell adhesion molecule 1 isoform 2	DGQLLPSSNYSNIK	Y		Y	
IPI00795918.1	NCAM1 neural cell adhesion molecule 1 isoform 2	IYNTPSASYLEVTPDSENDFGNYNCTAVNR		Y	Y	
IPI00796279.1	SERPINF1 25 kDa protein	VTQNLTLIEESLTSEFIHDIDR	Y		Y	
IPI00796279.1	SERPINF1 25 kDa protein	VTQNLTLIEESLTSEFIHDIDRELK	Y		Y	
IPI00797025.1	PRNP Major prion protein	GENFTETDVK	Y		Y	
IPI00797025.1	PRNP Major prion protein	QHTVTTTTKGENFTETDVK	Y		Y	
IPI00797539.1	NELL2 80 kDa protein	QVPGLHNGTK		Y		Y
IPI00798167.1	PON1 32 kDa protein	HANWTLTPLK			Y	
IPI00798167.1	PON1 32 kDa protein	VTQVYAENGTVLQGSTVASVYK			Y	
IPI00798430.1	TF Transferrin variant (Fragment)	CGLVPVLAENYNK			Y	
IPI00798430.1	TF Transferrin variant (Fragment)	CGLVPVLAENYNKSDN			Y	
IPI00798430.1	TF Transferrin variant (Fragment)	CGLVPVLAENYNKSDNCEDTPEAGYFAVAV VK			Y	
IPI00798430.1	TF Transferrin variant (Fragment)	GLVPVLAENYNK			Y	
IPI00798430.1	TF Transferrin variant (Fragment)	LVPVLAENYNK			Y	
IPI00798430.1	TF Transferrin variant (Fragment)	PVLAENYNK			Y	
IPI00798430.1	TF Transferrin variant (Fragment)	QQQHLFGSNVTD			Y	
IPI00798430.1	TF Transferrin variant (Fragment)	QQQHLFGSNVTDC			Y	
IPI00798430.1	TF Transferrin variant (Fragment)	QQQHLFGSNVTDCSGN			Y	
IPI00798430.1	TF Transferrin variant (Fragment)	QQQHLFGSNVTDCSGNF			Y	
IPI00798430.1	TF Transferrin variant (Fragment)	QQQHLFGSNVTDCSGNFC			Y	
IPI00798430.1	TF Transferrin variant (Fragment)	QQQHLFGSNVTDCSGNFCLF			Y	
IPI00798430.1	TF Transferrin variant (Fragment)	QQQHLFGSNVTDCSGNFCLFR			Y	
IPI00798430.1	TF Transferrin variant (Fragment)	VPVLAENYNK			Y	
IPI00807403.1	ALCAM Isoform 2 of CD166 antigen precursor	LNLSENYTLSISNAR	Y		Y	
IPI00807403.1	ALCAM Isoform 2 of CD166 antigen precursor	NATVVWMK		Y	Y	
IPI00815926.1	IGHG1 IGHG1 protein	TKPREEQYNSTYR	Y		Y	
IPI00829683.1	FGFR1 fibroblast growth factor receptor 1 isoform 9 precursor	SPHRPILQAGLPANK		Y		Y
IPI00829767.1	IGHG2 Uncharacterized protein IGHG2 (Fragment)	EEQFNSTFR	Y		Y	
IPI00829767.1	IGHG2 Uncharacterized protein IGHG2 (Fragment)	TKPREEQFNSTFR	Y		Y	
IPI00847381.1	SEPP1 selenoprotein P isoform 2	EGYSNISYIVVNHQGISSR	Y		Y	
IPI00847589.2	RELN reelin isoform b	APSNVSTIIHILYLPEDAK		Y	Y	
IPI00847589.2	RELN reelin isoform b	HDYILLPEDALTNTTR		Y	Y	
IPI00847635.1	SERPINA3 Isoform 1 of Alpha-1-antichymotrypsin precursor	FNLTETSEAEIHQSFQH	Y			
IPI00847635.1	SERPINA3 Isoform 1 of Alpha-1-antichymotrypsin precursor	FNLTETSEAEIHQSFQHLLR	Y			
IPI00847635.1	SERPINA3 Isoform 1 of Alpha-1-antichymotrypsin precursor	GAHNTTLTEILK	Y		Y	
IPI00847635.1	SERPINA3 Isoform 1 of Alpha-1-antichymotrypsin precursor	GLKFNLTETSEAEIHQSFQHLLR	Y			
IPI00847635.1	SERPINA3 Isoform 1 of Alpha-1-antichymotrypsin precursor	LSLGAHNTTLTEILK	Y		Y	
IPI00847635.1	SERPINA3 Isoform 1 of Alpha-1-antichymotrypsin precursor	TLNQSSDELQLSMGN	Y			
IPI00847635.1	SERPINA3 Isoform 1 of Alpha-1-antichymotrypsin precursor	TLNQSSDELQLSMGNAMFVK	Y			
IPI00847635.1	SERPINA3 Isoform 1 of Alpha-1-antichymotrypsin precursor	YTGNASALFILPDQDK	Y		Y	
IPI00848309.1	SIRPA Isoform 2 of Tyrosine-protein phosphatase non-receptor type substrate 1 precursor	AENQVNVTCQVR		Y		

(*Continued*)

APPENDIX I: (Continued)

IPI00848309.1	SIRPA Isoform 2 of Tyrosine-protein phosphatase non-receptor type substrate 1 precursor	GTA*N*LSETIR	Y			
IPI00848309.1	SIRPA Isoform 2 of Tyrosine-protein phosphatase non-receptor type substrate 1 precursor	LQLTWLENG*N*VSR		Y		
IPI00852617.1	NBL1 neuroblastoma, suppression of tumorigenicity 1 1	*N*ITQIVGH			Y	
IPI00852617.1	NBL1 neuroblastoma, suppression of tumorigenicity 1 1	*N*ITQIVGHSGCEAK			Y	
IPI00852846.1	NBL1 Neuroblastoma, suppression of tumorigenicity 1	*N*ITQIVGHSGCEAK			Y	
IPI00853369.1	PLXNB2 Plexin-B2 precursor	TEAGAFEYVPDPTFE*N*FTGGVK		Y	Y	
IPI00853455.1	CTSD Protein	GSLSYL*N*VTR	Y		Y	
IPI00853589.1	SGCE sarcoglycan, epsilon isoform 3	LNAI*N*ITSALDR		Y	Y	
IPI00855785.1	FN1 Isoform 15 of Fibronectin precursor	DQCIVDDITYNV*N*DTFHK	Y		Y	
IPI00855785.1	FN1 Isoform 15 of Fibronectin precursor	LDAPTNLQFV*N*ETDSTVLVR	Y		Y	
IPI00855785.1	FN1 Isoform 15 of Fibronectin precursor	WTPL*N*SSTIIGYR			Y	
IPI00855821.1	NRXN1-alpha	*N*TTLFIDQVEAK		Y	Y	
IPI00855821.1	NRXN1-alpha	SGG*N*ATLQVDSWPVIER		Y		Y
IPI00855821.1	NRXN1-alpha	V*N*SSQVLPVDSGEVK		Y	Y	
IPI00855835.1	Insulin-like growth factor binding protein 3 isoform b	GLCV*N*ASAVSR			Y	
IPI00855880.2	SNED1 Isoform 4 of Sushi, nidogen and EGF-like domain-containing protein 1 precursor	AY*N*ISVFSVK		Y		
IPI00855916.1	Transthyretin	ALGISPFHEHAEVVFTA*N*DSGPR			Y	
IPI00867588.1	FN1 Isoform 13 of Fibronectin precursor	DQCIVDDITYNV*N*DTFHK	Y		Y	
IPI00867588.1	FN1 Isoform 13 of Fibronectin precursor	LDAPTNLQFV*N*ETDSTVLVR	Y		Y	
IPI00871267.1	L1CAM 140 kDa protein	GY*N*VTYWR		Y		Y
IPI00871467.1	L1CAM cDNA FLJ76744, highly similar to Homo sapiens L1 cell adhesion molecule (L1CAM), transcript variant 1, mRNA	FFPYA*N*GTLGIR		Y	Y	
IPI00871467.1	L1CAM cDNA FLJ76744, highly similar to Homo sapiens L1 cell adhesion molecule (L1CAM), transcript variant 1, mRNA	GY*N*VTYWR		Y		Y
IPI00871467.1	L1CAM cDNA FLJ76744, highly similar to Homo sapiens L1 cell adhesion molecule (L1CAM), transcript variant 1, mRNA	TH*N*LTDLSPHLR		Y	Y	
IPI00871792.1	PTPRZ1 265 kDa protein	ESFLQT*N*YTEIR		Y	Y	
IPI00871792.1	PTPRZ1 265 kDa protein	TVEI*N*LTNDYR	Y		Y	
IPI00872117.1	NTRK2 Tyrosine-protein kinase receptor (Fragment)	LEPNSVDPE*N*ITEIFIANQK			Y	
IPI00872117.1	NTRK2 Tyrosine-protein kinase receptor (Fragment)	*N*LTIVDSGLK			Y	
IPI00872117.1	NTRK2 Tyrosine-protein kinase receptor (Fragment)	NSNLQHI*N*FTR			Y	
IPI00872117.1	NTRK2 Tyrosine-protein kinase receptor (Fragment)	SSPDTQDLYCL*N*ESSK			Y	
IPI00872555.2	CFI cDNA FLJ76262, highly similar to Homo sapiens I factor (complement) (IF), mRNA	FLN*N*GTCTAEGK			Y	
IPI00872555.2	CFI cDNA FLJ76262, highly similar to Homo sapiens I factor (complement) (IF), mRNA	LIS*N*CSK			Y	
IPI00872573.1	C1RL 48 kDa protein	GFLALYQTVAV*N*YSQPISEASR	Y		Y	
IPI00873020.1	PSAP Prosaposin variant	*N*STKQEILAALEK	Y		Y	
IPI00873020.1	PSAP Prosaposin variant	T*N*STFVQALVEHVK	Y		Y	
IPI00873201.1	PSAP Isoform Sap-mu-6 of Proactivator polypeptide precursor	NLEK*N*STKQEILAALEK	Y		Y	
IPI00873201.1	PSAP Isoform Sap-mu-6 of Proactivator polypeptide precursor	*N*STKQEILAALEK	Y		Y	
IPI00873201.1	PSAP Isoform Sap-mu-6 of Proactivator polypeptide precursor	T*N*STFVQALVEHVKEECDR	Y		Y	
IPI00873341.1	PTPRG Uncharacterized protein PTPRG	VEFHWGHS*N*GSAGSEHSINGR		Y	Y	
IPI00873446.1	NRCAM Isoform 5 of Neuronal cell adhesion molecule precursor	DGDDEWTSVVVA*N*VSK		Y	Y	
IPI00873446.1	NRCAM Isoform 5 of Neuronal cell adhesion molecule precursor	ERPPTFLTPEG*N*ASNK	Y		Y	

APPENDIX I: (Continued)

IPI00873446.1	NRCAM Isoform 5 of Neuronal cell adhesion molecule precursor	ERPPTFLTPEG*N*ASNKEELR	Y		Y	
IPI00873446.1	NRCAM Isoform 5 of Neuronal cell adhesion molecule precursor	F*N*HTQTIQQK		Y	Y	
IPI00873446.1	NRCAM Isoform 5 of Neuronal cell adhesion molecule precursor	GSALHEDIYVLHE*N*GTLEIPVAQK		Y	Y	
IPI00873446.1	NRCAM Isoform 5 of Neuronal cell adhesion molecule precursor	QKDGDDEWTSVVVA*N*VSK		Y	Y	
IPI00873446.1	NRCAM Isoform 5 of Neuronal cell adhesion molecule precursor	VISVDEL*N*DTIAA*N*LSDTEFYGAK	Y1,Y2		Y1,Y2	
IPI00873446.1	NRCAM Isoform 5 of Neuronal cell adhesion molecule precursor	YQPI*N*STHELGPLVDLK		Y	Y	
IPI00877792.1	FGG 50 kDa protein	VDKDLQSLEDILHQVE*N*K	Y		Y	
IPI00877967.1	F2 36 kDa protein	YPHKPEI*N*STTHPGADLQENFCR	Y		Y	
IPI00879573.1	SERPIND1 Heparin cofactor 2 precursor	*N*LSMPLLPADFHK	Y		Y	
IPI00879665.1	SEZ6L Seizure related 6 homolog (Mouse)-like	DPYW*N*DTEPLCR		Y	Y	
IPI00879665.1	SEZ6L Seizure related 6 homolog (Mouse)-like	SV*N*LSDGELLSIR		Y	Y	
IPI00879709.2	C6 complement component 6 precursor	VL*N*FTTK			Y	
IPI00879931.1	SERPING1 cDNA FLJ78023, highly similar to Homo sapiens serine (or cysteine) proteinase inhibitor, clade G (C1inhibitor), member 1, (angioedema, hereditary) (SERPING1), mRNA	DTFV*N*ASR	Y		Y	
IPI00879931.1	SERPING1 cDNA FLJ78023, highly similar to Homo sapiens serine (or cysteine) proteinase inhibitor, clade G (C1inhibitor), member 1, (angioedema, hereditary) (SERPING1), mRNA	GVTSVSQIFHSPDLAIRDTFV*N*ASR	Y		Y	
IPI00879931.1	SERPING1 cDNA FLJ78023, highly similar to Homo sapiens serine (or cysteine) proteinase inhibitor, clade G (C1inhibitor), member 1, (angioedema, hereditary) (SERPING1), mRNA	VGQLQLSH*N*LSLVILVPQNLK	Y		Y	
IPI00879931.1	SERPING1 cDNA FLJ78023, highly similar to Homo sapiens serine (or cysteine) proteinase inhibitor, clade G (C1inhibitor), member 1, (angioedema, hereditary) (SERPING1), mRNA	VLS*N*NSDANLELINTWVAK	Y		Y	
IPI00884105.1	LAMP1 Lysosome-associated membrane glycoprotein 1 precursor	GHTLTL*N*FTR	Y		Y	
IPI00884913.1	Sex hormone binding globulin (Fragment)	LDVDQAL*N*R			Y	
IPI00884988.1	APLP2 Isoform 4 of Amyloid-like protein 2 precursor	R*N*QSLSLLYK				Y
IPI00887154.2	LOC100134219 Complement component 4B	FSDGLES*N*SSTQFEVK			Y	
IPI00887154.2	LOC100134219 Complement component 4B	GL*N*VTLSSTGR			Y	
IPI00889714.1	Fibulin 1 (Fragment)	CATPHGD*N*ASLEATFVK		Y		
IPI00889723.1	C4A;C4B complement component 4B preproprotein	FSDGLES*N*SSTQFEVK	Y		Y	
IPI00889740.1	Fibulin 1	CATPHGD*N*ASLEATFVK		Y		

EBI, European Bioinformatics Institute; ISB, Institute for Systems Biology; N, N-glycosylated site.

VIII. APPENDIX II: GLYCOPEPTIDES IDENTIFIED IN HUMAN BRAIN TISSUE

Accessions	Names	Sequence-our	EBI		ISB	
			Identified	Potential	Identified	Potential
IPI00000265.2	C10orf38 UPF0560 protein C10orf38 precursor	LPE*N*TSYSDLTAFLTAASSPSEVDSFPYLR				Y
IPI00000877.1	HYOU1 Hypoxia up-regulated protein 1 precursor	LSALDNLL*N*HSSMFLK	Y		Y	
IPI00000877.1	HYOU1 Hypoxia up-regulated protein 1 precursor	VFGSQ*N*LTTVK	Y		Y	
IPI00000877.1	HYOU1 Hypoxia up-regulated protein 1 precursor	VI*N*ETWAWK	Y		Y	
IPI00002230.4	AADACL1 arylacetamide deacetylase-like 1	L*N*WTSLLPASFTK		Y	Y	
IPI00002714.1	DKK3 Dickkopf-related protein 3 precursor	ITN*N*QTGQMVFSETVITSVGDEEGR	Y		Y	
IPI00002790.3	SELIL Isoform 1 of Protein sel-1 homolog 1 precursor	MYSEGSDIVPQS*N*ETALHYFK	Y		Y	
IPI00002897.3	GABRA3 Gamma-aminobutyric acid receptor subunit alpha-3 precursor	HAPDIPDDSTD*N*ITIFTR		Y		Y
IPI00003467.3	GABRB3 Isoform 1 of Gamma-aminobutyric acid receptor subunit beta-3 precursor	LAYSGIPL*N*LTLDNR		Y		Y
IPI00003813.5	CADM1 Isoform 1 of Cell adhesion molecule 1 precursor	FQLL*N*FSSSELK	Y		Y	
IPI00003813.5	CADM1 Isoform 1 of Cell adhesion molecule 1 precursor	VSLT*N*VSISDEGR	Y		Y	
IPI00004440.1	PTPRN Receptor-type tyrosine-protein phosphatase-like N precursor	HNEQ*N*LSLADVTQQAGLVK		Y	Y	
IPI00005126.1	EFNB2 Ephrin-B2 precursor	SIVLEPIYW*N*SSNSK		Y		Y
IPI00006071.4	CD38 Isoform 1 of ADP-ribosyl cyclase 1	HPC*N*ITEEDYQPLMK		Y	Y	
IPI00006071.4	CD38 Isoform 1 of ADP-ribosyl cyclase 1	IFDK*N*STFGSVEVHNLQPEK		Y	Y	
IPI00006121.1	IDS Isoform Short of Iduronate 2-sulfatase precursor	EDVQAL*N*ISVPYGPIPVDFQR		Y	Y	
IPI00006121.1	IDS Isoform Short of Iduronate 2-sulfatase precursor	VHAG*N*FSTIPQYFK		Y	Y	
IPI00006631.6	SV2B Synaptic vesicle glycoprotein 2B	FI*N*STFLEQK		Y	Y	
IPI00006631.6	SV2B Synaptic vesicle glycoprotein 2B	*N*CTIESTIFYNTDLYEHK		Y		Y
IPI00006631.6	SV2B Synaptic vesicle glycoprotein 2B	VFFGEHVYGATI*N*FTMENQIHQHGK		Y		Y
IPI00006662.1	APOD Apolipoprotein D precursor	ADGTVNQIEGEATPV*N*LTEPAK	Y		Y	
IPI00006662.1	APOD Apolipoprotein D precursor	ADGTVNQIEGEATPV*N*LTEPAKLEVK	Y		Y	
IPI00006662.1	APOD Apolipoprotein D precursor	CIQA*N*YSLMENGK	Y		Y	
IPI00006967.3	PCDH9 Protocadherin-9 precursor	NADIVYQLGP*N*ASFFDLDR		Y	Y	
IPI00006967.3	PCDH9 Protocadherin-9 precursor	YIISPI*N*GTVYLSEKDPVNTK		Y	Y	
IPI00007664.5	PGCP Plasma glutamate carboxypeptidase precursor	IVVYNQPYI*N*YSR	Y		Y	
IPI00008600.1	FUT9 Alpha-(1,3)-fucosyltransferase	SGIEHLF*N*LTLTYR		Y		Y
IPI00009111.1	TPBG Trophoblast glycoprotein precursor	*N*LTEVPTDLPAYVR		Y	Y	
IPI00009111.1	TPBG Trophoblast glycoprotein precursor	VLH*N*GTLAELQGLPHIR		Y	Y	
IPI00009890.1	SERPINE2 Glia-derived nexin precursor	*N*ASEIEVPFVTR		Y		Y
IPI00009997.1	B3GNT1 N-acetyllactosaminide beta-1,3-N-acetylglucosaminyltransferase	VAQPGINYALGT*N*VSYPNNLLR		Y	Y	
IPI00010279.4	GDE1 Glycerophosphodiester phosphodiesterase 1	EAVAECLNH*N*LTIFFDVK		Y		Y
IPI00010949.3	SIAE Isoform 1 of Sialate O-acetylesterase precursor	GLL*N*LTYYQQIQVQK		Y	Y	
IPI00011454.1	GANAB Isoform 2 of Neutral alpha-glucosidase AB precursor	V*N*LTLGSIWDK				Y
IPI00011732.2	GFRA2 Isoform 1 of GDNF family receptor alpha-2 precursor	NAIQAFG*N*GTDVNVSPK		Y	Y	
IPI00012102.1	GNS N-acetylglucosamine-6-sulfatase precursor	YY*N*YTLSINGK	Y		Y	
IPI00012887.1	CTSL1 Cathepsin L1 precursor	YSVA*N*DTGFVDIPK	Y		Y	
IPI00013303.2	LSAMP Limbic system-associated membrane protein precursor	LGVT*N*ASLVLFRPGSVR		Y	Y	
IPI00013744.1	ITGA2 Integrin alpha-2 precursor	YFF*N*VSDEAALLEK	Y		Y	
IPI00013897.1	ADAM10 ADAM 10 precursor	I*N*TTADEKDPTNPFR	Y		Y	

APPENDIX II: (Continued)

IPI00013897.1	ADAM10 ADAM 10 precursor	*N*ISQVLEK		Y	Y	
IPI00015688.1	GPC1 Glypican-1 precursor	SFDDHFQHLL*N*DSER		Y	Y	
IPI00015872.3	TSPAN8 Tetraspanin-8	IV*N*ETLYENTK		Y		Y
IPI00016848.1	C20orf103 Uncharacterized protein C20orf103 precursor	E*N*GTTCLMAEFAAK		Y		Y
IPI00017601.1	CP Ceruloplasmin precursor	EHEGAIYPD*N*TTDFQR	Y		Y	
IPI00017601.1	CP Ceruloplasmin precursor	ELHHLQEQ*N*VSNAFLDK	Y		Y	
IPI00017601.1	CP Ceruloplasmin precursor	E*N*LTAPGSDSAVFFEQGTTR	Y		Y	
IPI00018274.1	EGFR Isoform 1 of Epidermal growth factor receptor precursor	DSLSI*N*ATNIK	Y		Y	
IPI00019988.1	SGSH N-sulphoglucosamine sulphohydrolase precursor	DAGVL*N*DTLVIFTSDNGIPFPSGR	Y		Y	
IPI00020091.1	ORM2 Alpha-1-acid glycoprotein 2 precursor	CANLVPVPIT*N*ATLDR	Y		Y	
IPI00020091.1	ORM2 Alpha-1-acid glycoprotein 2 precursor	LVPVPIT*N*ATLDR	Y		Y	
IPI00020091.1	ORM2 Alpha-1-acid glycoprotein 2 precursor	PLCANLVPVPIT*N*ATLDR	Y		Y	
IPI00020557.1	LRP1 Prolow-density lipoprotein receptor-related protein 1 precursor	D*N*TTCYEFK		Y		Y
IPI00020557.1	LRP1 Prolow-density lipoprotein receptor-related protein 1 precursor	F*N*STEYQVVTR	Y		Y	
IPI00020557.1	LRP1 Prolow-density lipoprotein receptor-related protein 1 precursor	GVTHL*N*ISGLK		Y		Y
IPI00020557.1	LRP1 Prolow-density lipoprotein receptor-related protein 1 precursor	IETILL*N*GTDR	Y		Y	
IPI00020557.1	LRP1 Prolow-density lipoprotein receptor-related protein 1 precursor	KLNLDGS*N*YTLLK	Y		Y	
IPI00020557.1	LRP1 Prolow-density lipoprotein receptor-related protein 1 precursor	LNLDGS*N*YTLLK	Y		Y	
IPI00020557.1	LRP1 Prolow-density lipoprotein receptor-related protein 1 precursor	LTSCAT*N*ASICGDEAR		Y	Y	
IPI00020557.1	LRP1 Prolow-density lipoprotein receptor-related protein 1 precursor	TVPDID*N*VTVLDYDAR		Y		Y
IPI00020557.1	LRP1 Prolow-density lipoprotein receptor-related protein 1 precursor	WTGH*N*VTVVQR		Y		Y
IPI00020747.1	SCN3B Sodium channel subunit beta-3 precursor	LQW*N*GSK		Y		Y
IPI00020987.1	PRELP Prolargin precursor	IHYLYLQNNFITELPVESFQ*N*ATGLR		Y	Y	
IPI00020987.1	PRELP Prolargin precursor	I*N*GTQICPNDLVAFHDFSSDLENVPHLR		Y		Y
IPI00020987.1	PRELP Prolargin precursor	NSF*N*ISNLLVLHLSHNR		Y	Y	
IPI00021091.1	LGI1 Isoform 1 of Leucine-rich glioma-inactivated protein 1 precursor	ATQLFT*N*QTDIPNMEDVYAVK		Y		Y
IPI00021807.2	GBA Isoform Long of Glucosylceramidase precursor	DLGPTLA*N*STHHNVR	Y		Y	
IPI00021983.1	NCSTN Isoform 1 of Nicastrin precursor	A*N*NSWFQSILR		Y		Y
IPI00021983.1	NCSTN Isoform 1 of Nicastrin precursor	DLYEYSWVQGPLHS*N*ETDR		Y	Y	
IPI00021983.1	NCSTN Isoform 1 of Nicastrin precursor	*N*ISGVVLADHSGAFHNK		Y		Y
IPI00022229.1	APOB Apolipoprotein B-100 precursor	FEVDSPVY*N*ATWSASLK	Y		Y	
IPI00022371.1	HRG Histidine-rich glycoprotein precursor	VIDF*N*CTTSSVSSALANTK	Y		Y	
IPI00022395.1	C9 Complement component C9 precursor	AV*N*ITSENLIDDVVSLIR	Y		Y	
IPI00022417.4	LRG1 Leucine-rich alpha-2-glycoprotein precursor	KLPPGLLA*N*FTLLR		Y	Y	
IPI00022429.3	ORM1 Alpha-1-acid glycoprotein 1 precursor	LVPVPIT*N*ATLDQITGK	Y		Y	
IPI00022429.3	ORM1 Alpha-1-acid glycoprotein 1 precursor	QDQCIY*N*TTYLNVQR	Y		Y	
IPI00022431.1	AHSG Alpha-2-HS-glycoprotein precursor	AALAAFNAQN*N*GSNFQLEEISR	Y		Y	
IPI00022488.1	HPX Hemopexin precursor	ALPQPQ*N*VTSLLGCTH	Y		Y	
IPI00022488.1	HPX Hemopexin precursor	SWPAVG*N*CSSALR	Y		Y	
IPI00022608.1	SORL1 Sortilin-related receptor precursor	LTIV*N*SSVLDRPR		Y	Y	
IPI00023542.6	TMED9 transmembrane emp24 protein transport domain containing 9	FTFTSHTPGEHQICLHS*N*STK	Y		Y	
IPI00023601.1	HAPLN1 Hyaluronan and proteoglycan link protein 1 precursor	GG*N*VTLPCK		Y		Y
IPI00023648.6	ISLR Immunoglobulin superfamily containing leucine-rich repeat protein precursor	FQAFA*N*GSLLIPDFGK			Y	

(*Continued*)

APPENDIX II: (Continued)

IPI00023673.1	LGALS3BP Galectin-3-binding protein precursor	ALGFE*N*ATQALGR	Y		Y	
IPI00023673.1	LGALS3BP Galectin-3-binding protein precursor	GL*N*LTEDTYKPR	Y		Y	
IPI00023807.3	SEMA4D Semaphorin-4D precursor	AA*N*YTSSLNLPDK		Y	Y	
IPI00023807.3	SEMA4D Semaphorin-4D precursor	DV*N*YTQIVVDR	Y		Y	
IPI00023807.3	SEMA4D Semaphorin-4D precursor	EAVFAVNAL*N*ISEK		Y	Y	
IPI00023807.3	SEMA4D Semaphorin-4D precursor	KDV*N*YTQIVVDR	Y		Y	
IPI00024035.1	CDH6 Isoform 1 of Cadherin-6 precursor	EDAQL*N*TTIGSVTAQDPDAAR	Y		Y	
IPI00024036.1	CDH8 Cadherin-8 precursor	ELSVWH*N*ITTIATEIR		Y		Y
IPI00024046.1	CDH13 Cadherin-13 precursor	ANYNLPIMVTDSGKPPMT*N*ITDLR		Y	Y	
IPI00024046.1	CDH13 Cadherin-13 precursor	DPAGWLNINPL*N*GTVDTTAVLDR		Y		Y
IPI00024046.1	CDH13 Cadherin-13 precursor	I*N*NTHALVSLLQNLNK	Y		Y	
IPI00024046.1	CDH13 Cadherin-13 precursor	*N*LSVVILGASDK		Y		Y
IPI00024046.1	CDH13 Cadherin-13 precursor	*N*LSVVILGASDKDLHPNTDPFK		Y		Y
IPI00024046.1	CDH13 Cadherin-13 precursor	QEDLSVGSVLLTV*N*ATDPDSLQHQTIR	Y		Y	
IPI00024284.4	HSPG2 Basement membrane-specific heparan sulfate proteoglycan core protein precursor	ALV*N*FTR		Y		Y
IPI00024284.4	HSPG2 Basement membrane-specific heparan sulfate proteoglycan core protein precursor	SLTQGSLIVGDLAPV*N*GTSQGK		Y	Y	
IPI00024572.3	ASPH aspartate beta-hydroxylase isoform e	Y*N*LSEVLQGK				Y
IPI00024766.1	PLXNC1 Plexin-C1 precursor	SNVIVTGA*N*FTR				Y
IPI00024966.1	CNTN2 Contactin-2 precursor	A*N*STGILSVR		Y		Y
IPI00024966.1	CNTN2 Contactin-2 precursor	VPGADAQYFVYS*N*ESVRPYTPFEVK		Y	Y	
IPI00024966.1	CNTN2 Contactin-2 precursor	WDPVVPFR*N*ESAVTGYK		Y		Y
IPI00025297.2	ENTPD3 Ectonucleoside triphosphate diphosphohydrolase 3	LQ*N*ETAANEVLESIQSYFK		Y		Y
IPI00026237.1	MAG Myelin-associated glycoprotein precursor	LGCQASFP*N*TTLQFEGYASMDVK	Y			Y
IPI00026237.1	MAG Myelin-associated glycoprotein precursor	*N*CTLLLSNVSPELGGK	Y		Y	
IPI00026237.1	MAG Myelin-associated glycoprotein precursor	SNPEPSVAFELPSR*N*VTVNESER	Y			Y
IPI00026270.1	CPM Carboxypeptidase M precursor	NFPDAFEYN*N*VSR		Y	Y	
IPI00026946.2	NPTX2 Neuronal pentraxin-2 precursor	A*N*VSNAGLPGDFR		Y	Y	
IPI00027078.3	CPD Carboxypeptidase D precursor	SEGAIQV*N*FTLVR		Y		Y
IPI00027230.3	HSP90B1 Endoplasmin precursor	EEEAIQLDGL*N*ASQIR		Y	Y	
IPI00027230.3	HSP90B1 Endoplasmin precursor	HN*N*DTQHIWESDSNEFSVIADPR	Y		Y	
IPI00027230.3	HSP90B1 Endoplasmin precursor	TDDEVVQREEEAIQLDGL*N*ASQIR		Y	Y	
IPI00027232.3	IGF1R Insulin-like growth factor 1 receptor precursor	WNPPSLPNG*N*LSYYIVR		Y		Y
IPI00027250.1	GABBR2 Gamma-aminobutyric acid type B receptor subunit 2 precursor	IQDF*N*YTDHTLGR		Y		Y
IPI00027482.1	SERPINA6 Corticosteroid-binding globulin precursor	AQLLQGLGF*N*LTER	Y		Y	
IPI00027505.2	ITGAV Isoform 1 of Integrin alpha-V precursor	A*N*TTQPGIVEGGQVLK		Y	Y	
IPI00027505.2	ITGAV Isoform 1 of Integrin alpha-V precursor	TAADTTGLQPILNQFTPA*N*ISR	Y		Y	
IPI00027851.1	HEXA Beta-hexosaminidase alpha chain precursor	SAEGTFFI*N*K	Y		Y	
IPI00029343.2	CNTNAP2 Isoform 1 of Contactin-associated protein-like 2 precursor	GCMESINYNGV*N*ITDLAR		Y	Y	
IPI00029343.2	CNTNAP2 Isoform 1 of Contactin-associated protein-like 2 precursor	KPGSFA*N*VSIDMCAIIDR		Y		Y
IPI00029343.2	CNTNAP2 Isoform 1 of Contactin-associated protein-like 2 precursor	SI*N*LTLDR		Y		Y
IPI00029343.2	CNTNAP2 Isoform 1 of Contactin-associated protein-like 2 precursor	TVPVFF*N*ATSYLEVPGR		Y		Y
IPI00029343.2	CNTNAP2 Isoform 1 of Contactin-associated protein-like 2 precursor	VGVHI*N*ITQTK		Y	Y	
IPI00029533.1	ITGB8 Integrin beta-8 precursor	NYAIIKPIGF*N*ETAK		Y		Y
IPI00029739.5	CFH Isoform 1 of Complement factor H precursor	IPCSQPPQIEHGTI*N*SSR	Y		Y	
IPI00029768.1	GRIN2A Glutamate [NMDA] receptor subunit epsilon-1 precursor	WE*N*HTLSLR		Y		Y

APPENDIX II: (Continued)

IPI00030880.2	GRIA1 Isoform Flop of Glutamate receptor 1 precursor	ESGA*N*VTGFQLV*N*YTDTIPAK		Y1,Y2		Y1,Y2
IPI00030887.1	TYRO3 Tyrosine-protein kinase receptor TYRO3 precursor	DLVPAT*N*YSLR		Y		Y
IPI00031121.2	CPE Carboxypeptidase E precursor	DLQGNPIA*N*ATISVEGIDHDVTSAK		Y	Y	
IPI00031121.2	CPE Carboxypeptidase E precursor	G*N*ETIVNLIHSTR		Y	Y	
IPI00032063.6	LRP1B Similar to Candidate tumor suppressor protein	AFI*N*GTGLETVISR		Y		Y
IPI00032179.2	SERPINC1 Antithrombin III variant	SLTF*N*ETYQDISELVYGAK	Y		Y	
IPI00032220.3	AGT Angiotensinogen precursor	HLVIH*N*ESTCEQLAK	Y		Y	
IPI00032220.3	AGT Angiotensinogen precursor	VYIHPFHLVIH*N*ESTCEQLAK	Y		Y	
IPI00044823.2	SLC2A13 Proton myo-inositol cotransporter	ITFKPIAPSGQ*N*ATCTR		Y		Y
IPI00045906.3	BSCL2 Isoform 3 of Seipin	TDCDSSTTSLCSFPVA*N*VSLTK	Y			Y
IPI00045928.1	SLC9A7 Sodium/hydrogen exchanger 7	AFSTLLV*N*VSGK				Y
IPI00047169.5	SYNPR Synaptoporin	LSVDCV*N*K		Y		Y
IPI00047169.5	SYNPR Synaptoporin	TES*N*LSIDIAFAYPFR		Y		Y
IPI00062679.4	TMEM30A Isoform 2 of Cell cycle control protein 50A	YSL*N*VTYNYPVHYFDGR		Y	Y	
IPI00064667.4	CNDP1 Beta-Ala-His dipeptidase precursor	LVPHM*N*VSAVEK	Y		Y	
IPI00072918.2	COL6A3 alpha 3 type VI collagen isoform 4 precursor	GPPGV*N*GTQGFQGCPGQR		Y		Y
IPI00152850.2	JAM3 junctional adhesion molecule 3 precursor	IW*N*VTR		Y		Y
IPI00152850.2	JAM3 junctional adhesion molecule 3 precursor	*N*SSFHLNSETGTLVFTAVHK		Y	Y	
IPI00159927.2	NCAN Neurocan core protein precursor	A*N*ATLLLGPLR		Y	Y	
IPI00159927.2	NCAN Neurocan core protein precursor	GTVLCGPPPAVE*N*ASLIGAR		Y		Y
IPI00160552.3	TNR Isoform 1 of Tenascin-R precursor	CA*N*GTCLCEEGYVGEDCGQR		Y		Y
IPI00163207.1	PGLYRP2 Isoform 1 of N-acetylmuramoyl-L-alanine amidase precursor	GFGVAIVG*N*YTAALPTEAALR	Y		Y	
IPI00165931.7	PLXNA4 Isoform 1 of Plexin-A4 precursor	SPSYIVC*N*TTSSDEVLEMK	Y			Y
IPI00166048.3	CADM3 Isoform 1 of Cell adhesion molecule 3 precursor	MTQESALIFPFL*N*K			Y	
IPI00166048.3	CADM3 Isoform 1 of Cell adhesion molecule 3 precursor	TQESALIFPFL*N*K			Y	
IPI00167215.6	HEPACAM Isoform 1 of Hepatocyte cell adhesion molecule precursor	DGKPLL*N*DSR		Y		Y
IPI00167215.6	HEPACAM Isoform 1 of Hepatocyte cell adhesion molecule precursor	TI*N*LTVDVPISR		Y		Y
IPI00167619.2	LRTM2 Leucine-rich repeat and transmembrane domain-containing protein 2 precursor	LSALPSWAFA*N*LSSLQR		Y		Y
IPI00167619.2	LRTM2 Leucine-rich repeat and transmembrane domain-containing protein 2 precursor	SIFGDLT*N*LTELQLR		Y		Y
IPI00168878.1	TOR1AIP2 Torsin-1A-interacting protein 2	HL*N*ASNPTEPATIIFTAAR				Y
IPI00169285.5	P76 Putative phospholipase B-like 2 precursor	HPDAVAWA*N*LTNAIR	Y		Y	
IPI00169285.5	P76 Putative phospholipase B-like 2 precursor	SDLNPA*N*GSYPFKALR	Y		Y	
IPI00171385.3	C3orf39 Uncharacterized glycosyltransferase AGO61 precursor	L*N*VSHTGVPLGEEYILVFSR		Y		Y
IPI00171473.2	SPON1 Spondin-1 precursor	LTFYG*N*WSEK		Y	Y	
IPI00173947.1	SV2C Synaptic vesicle glycoprotein 2C	*N*CTFIDTVFDNTDFEPYK		Y		Y
IPI00176221.7	NEGR1 Neuronal growth regulator 1 precursor	GAWL*N*R		Y	Y	
IPI00176221.7	NEGR1 Neuronal growth regulator 1 precursor	KLFNGQQGIIIQ*N*FSTR		Y	Y	
IPI00176221.7	NEGR1 Neuronal growth regulator 1 precursor	LFNGQQGIIIQ*N*FSTR		Y	Y	
IPI00176221.7	NEGR1 Neuronal growth regulator 1 precursor	SILTVT*N*VTQEHFG*N*YT		Y1,Y2	Y1,Y2	
IPI00176221.7	NEGR1 Neuronal growth regulator 1 precursor	SILTVT*N*VTQEHFG*N*YTCVAANK		Y1,Y2	Y1,Y2	
IPI00176427.1	CADM4 Cell adhesion molecule 4 precursor	AEAVGETLTLPGLVSAD*N*GTYTCEASNK		Y	Y	
IPI00176427.1	CADM4 Cell adhesion molecule 4 precursor	QTLFF*N*GTR		Y	Y	
IPI00182126.3	FKBP9 FK506-binding protein 9 precursor	YHY*N*GTLLDGTLFDSSYSR	Y		Y	Y
IPI00182194.7	ODZ2 Teneurin-2	*N*VTSILELR		Y		Y
IPI00186736.3	IGSF8 Isoform 3 of Immunoglobulin superfamily	GETASLLC*N*ISVR			Y	

(*Continued*)

APPENDIX II: (Continued)

	member 8 precursor					
IPI00186736.3	IGSF8 Isoform 3 of Immunoglobulin superfamily member 8 precursor	IGPGEPLELLC*N*VSGALPPAGR		Y	Y	
IPI00215631.1	VCAN Isoform Vint of Versican core protein precursor	FE*N*QTGFPPPDSR	Y		Y	
IPI00215844.1	ASAHL Isoform 2 of N-acylethanolamine-hydrolyzing acid amidase precursor	F*N*VSLDSVPELR		Y		
IPI00216224.1	ITGA6 Isoform Alpha-6X2B of Integrin alpha-6 precursor	LW*N*STFLEEYSK		Y	Y	
IPI00216394.1	GABRB2 Isoform Long of Gamma-aminobutyric acid receptor subunit beta-2 precursor	LSYNVIPL*N*LTLDNR		Y	Y	
IPI00216489.3	ACAN Isoform 2 of Aggrecan core protein precursor	TVYLYP*N*QTGLPDPLSR	Y		Y	
IPI00216489.3	ACAN Isoform 2 of Aggrecan core protein precursor	TVYVHA*N*QTGYPDPSSR	Y			Y
IPI00216641.1	CNTN1 Isoform 2 of Contactin-1 precursor	A*N*STGTLVITDPTR	Y		Y	
IPI00216641.1	CNTN1 Isoform 2 of Contactin-1 precursor	DVYALMGQ*N*VTLECF		Y	Y	
IPI00216641.1	CNTN1 Isoform 2 of Contactin-1 precursor	DVYALMGQ*N*VTLECFALGNPVPDIR		Y	Y	
IPI00216641.1	CNTN1 Isoform 2 of Contactin-1 precursor	GKA*N*STGTLVITDPTR	Y		Y	
IPI00216641.1	CNTN1 Isoform 2 of Contactin-1 precursor	G*N*YSCFVSSPSITK		Y	Y	
IPI00216641.1	CNTN1 Isoform 2 of Contactin-1 precursor	GTEWLV*N*SSR		Y	Y	
IPI00216641.1	CNTN1 Isoform 2 of Contactin-1 precursor	ILIWEDGSLEIN*N*ITR		Y		Y
IPI00216641.1	CNTN1 Isoform 2 of Contactin-1 precursor	TIVD*N*SSASADLVVR		Y	Y	
IPI00216641.1	CNTN1 Isoform 2 of Contactin-1 precursor	YIITWDHVVALS*N*ESTVTGYK		Y		Y
IPI00216641.1	CNTN1 Isoform 2 of Contactin-1 precursor	YTCTAQTIVD*N*SSASADLVVR		Y	Y	
IPI00216762.1	ECE1 Isoform D of Endothelin-converting enzyme 1	FF*N*FSWR		Y	Y	
IPI00216910.1	FOLH1 Isoform PSMA' of Glutamate carboxypeptidase 2	VPYNVGPGFTG*N*FSTQK	Y		Y	
IPI00217146.1	SLITRK4 SLIT and NTRK-like protein 4 precursor	GDVFH*N*LTNLR				Y
IPI00217766.3	SCARB2 Lysosome membrane protein 2	ANIQFGD*N*GTTISAVSNK		Y	Y	
IPI00217766.3	SCARB2 Lysosome membrane protein 2	CNMI*N*GTDGDSFHPLITK	Y			Y
IPI00217766.3	SCARB2 Lysosome membrane protein 2	FF*N*VTNPEEILR		Y	Y	
IPI00217766.3	SCARB2 Lysosome membrane protein 2	*N*GTNDGDYVFLTGEDSYL*N*FTK		Y1,Y2	Y1,Y2	
IPI00217766.3	SCARB2 Lysosome membrane protein 2	TMVFPVMYL*N*ESVHIDK	Y		Y	
IPI00217766.3	SCARB2 Lysosome membrane protein 2	YFF*N*VTNPEEILR		Y	Y	
IPI00217882.3	SORT1 Sortilin precursor	DITDLI*N*NTFIR	Y		Y	
IPI00217882.3	SORT1 Sortilin precursor	HLYTTTGGETDFT*N*VTSLR		Y	Y	
IPI00217882.3	SORT1 Sortilin precursor	LA*N*NTHQHVFDDLR		Y	Y	
IPI00217987.8	ITGAM Integrin alpha-M precursor	EF*N*VTVTVR		Y		Y
IPI00217987.8	ITGAM Integrin alpha-M precursor	ELF*N*ITNGAR		Y		Y
IPI00218192.2	ITIH4 Isoform 2 of Inter-alpha-trypsin inhibitor heavy chain H4 precursor	LPTQ*N*ITFQTESSVAEQEAEFQSPK	Y		Y	
IPI00218646.3	CYBB Cytochrome b-245 heavy chain	GQTAESLAVH*N*ITVCEQK		Y		Y
IPI00218725.3	LAMA2 laminin alpha 2 subunit isoform b precursor	YMQ*N*LTVEQPIEVK		Y	Y	
IPI00218887.1	PVRL1 Isoform Alpha of Poliovirus receptor-related protein 1 precursor	ADANPPATEYHWTTL*N*GSLPK		Y	Y	
IPI00218887.1	PVRL1 Isoform Alpha of Poliovirus receptor-related protein 1 precursor	ESQL*N*LTVMAK		Y	Y	
IPI00219124.2	GRIA1 Isoform Flip of Glutamate receptor 1 precursor	T*N*YTLHVIEMK		Y		Y
IPI00219249.4	CNTNAP1 Contactin-associated protein 1 precursor	A*N*HSLDVSFYFR		Y		Y
IPI00219249.4	CNTNAP1 Contactin-associated protein 1 precursor	DV*N*FTLDGYVQR		Y		Y
IPI00219249.4	CNTNAP1 Contactin-associated protein 1 precursor	GH*N*STFFGNV*N*ESAVVR		Y1,Y2		Y1,Y2
IPI00219249.4	CNTNAP1 Contactin-associated protein 1 precursor	TSG*N*FTIDPDGSGPLKPF		Y		Y
IPI00219249.4	CNTNAP1 Contactin-associated protein 1 precursor	VDGQLV*N*LTLVEGR		Y		Y

APPENDIX II: (Continued)

IPI00219249.4	CNTNAP1 Contactin-associated protein 1 precursor	WDCHS*N*QTAF		Y		Y
IPI00220213.1	TNC Isoform 4 of Tenascin precursor	LLETVEY*N*ISGAER		Y		Y
IPI00220213.1	TNC Isoform 4 of Tenascin precursor	L*N*YSLPTGQWVGVQLPR		Y	Y	
IPI00220213.1	TNC Isoform 4 of Tenascin precursor	*N*LTVPGSLR		Y		Y
IPI00220213.1	TNC Isoform 4 of Tenascin precursor	QSGV*N*ATLPEENQPVVFNHVYNIK		Y		Y
IPI00220213.1	TNC Isoform 4 of Tenascin precursor	VEAAQ*N*LTLPGSLR		Y		Y
IPI00220277.2	GRM5 Isoform 2 of Metabotropic glutamate receptor 5 precursor	T*N*FTGVSGDTILFDENGDSPGR		Y		Y
IPI00221224.6	ANPEP Aminopeptidase N	AEF*N*ITLIHPK	Y		Y	
IPI00236554.1	MPO Isoform H14 of Myeloperoxidase precursor	ALLPFDNLHDDPCLLT*N*R	Y		Y	
IPI00289329.2	EPHB3 Ephrin type-B receptor 3 precursor	YAAV*N*ITTNQAAPSEVPTLR		Y	Y	
IPI00289849.6	ELFN2 Leucine-rich repeat and fibronectin type-III domain-containing protein 6 precursor	FG*N*LTDL*N*LTK		Y1,Y2		Y1,Y2
IPI00289870.3	PCDH7 Isoform C of Protocadherin-7 precursor	ID*N*LTGELSTSER		Y		Y
IPI00290456.3	ICAM5 Intercellular adhesion molecule 5 precursor	AELDLRPHGLGLFE*N*SSAPR		Y	Y	
IPI00290456.3	ICAM5 Intercellular adhesion molecule 5 precursor	FEEPSCPS*N*WTWVEGSGR		Y		Y
IPI00290456.3	ICAM5 Intercellular adhesion molecule 5 precursor	GGSLWL*N*CSTNCPRPER		Y		Y
IPI00290456.3	ICAM5 Intercellular adhesion molecule 5 precursor	GLGLFE*N*SSAPR		Y	Y	
IPI00290456.3	ICAM5 Intercellular adhesion molecule 5 precursor	QLVC*N*VTLGGENR		Y		Y
IPI00290456.3	ICAM5 Intercellular adhesion molecule 5 precursor	VLAPGIYVC*N*ATNR		Y	Y	
IPI00291136.4	COL6A1 Collagen alpha-1(VI) chain precursor	GEDGPAG*N*GTEGFPGFPGYPGNR		Y		Y
IPI00291136.4	COL6A1 Collagen alpha-1(VI) chain precursor	*N*VTAQICIDK		Y	Y	
IPI00291792.2	ITGB2 Integrin beta-2 precursor	L*N*FTGPGDPDSIR		Y	Y	
IPI00292732.3	FMOD fibromodulin precursor	LYLDHN*N*LTR	Y		Y	
IPI00293033.5	NID2 NID2 protein	DYSLTFGAI*N*QTWSYR		Y	Y	
IPI00293033.5	NID2 NID2 protein	IHQ*N*ITYQVCR		Y	Y	
IPI00293074.5	SLC44A2 Isoform 2 of Choline transporter-like protein 2	GVLMVG*N*ETTYEDGHGSR		Y	Y	
IPI00293074.5	SLC44A2 Isoform 2 of Choline transporter-like protein 2	K*N*ITDLVEGAK		Y	Y	
IPI00293074.5	SLC44A2 Isoform 2 of Choline transporter-like protein 2	*N*ITDLVEGAK		Y	Y	
IPI00293088.5	GAA Lysosomal alpha-glucosidase precursor	GVFIT*N*ETGQPLIGK	Y		Y	
IPI00293088.5	GAA Lysosomal alpha-glucosidase precursor	LE*N*LSSSEMGYTATLTR	Y		Y	
IPI00293088.5	GAA Lysosomal alpha-glucosidase precursor	*N*NTIVNELVR	Y			Y
IPI00293328.3	P2RX7 P2X purinoceptor 7	LDDKTT*N*VSLYPGYNFR		Y		Y
IPI00293328.3	P2RX7 P2X purinoceptor 7	NILPGL*N*ITCTFHK		Y		Y
IPI00293328.3	P2RX7 P2X purinoceptor 7	NIDFPGH*N*YTTR		Y		Y
IPI00293328.3	P2RX7 P2X purinoceptor 7	PALLNSAE*N*FTVLIK		Y		Y
IPI00293588.4	TMEFF1 Isoform 1 of Tomoregulin-1 precursor	SI*N*CSELNVR				Y
IPI00293971.3	ATP1B2 Sodium/potassium-transporting ATPase subunit beta-2	FHV*N*YTQPL		Y		Y
IPI00293971.3	ATP1B2 Sodium/potassium-transporting ATPase subunit beta-2	FHV*N*YTQPLVAVK		Y		Y
IPI00293971.3	ATP1B2 Sodium/potassium-transporting ATPase subunit beta-2	FLEPY*N*DSIQAQK		Y		Y
IPI00293971.3	ATP1B2 Sodium/potassium-transporting ATPase subunit beta-2	FL*N*VTPNVEVNVECR				Y
IPI00293971.3	ATP1B2 Sodium/potassium-transporting ATPase subunit beta-2	HV*N*YTQPLVAVK		Y		Y
IPI00293971.3	ATP1B2 Sodium/potassium-transporting ATPase subunit beta-2	KFHV*N*YTQPLVAVK		Y		Y
IPI00293971.3	ATP1B2 Sodium/potassium-transporting ATPase subunit beta-2	TENLDVIV*N*VSDTESWDQHVQK		Y		Y
IPI00293971.3	ATP1B2 Sodium/potassium-transporting ATPase subunit beta-2	TQLG*N*CSGIGDSTHYGY		Y		Y
IPI00293971.3	ATP1B2 Sodium/potassium-transporting ATPase subunit beta-2	TQLG*N*CSGIGDSTHYGYSTGQPCVF		Y		Y

(*Continued*)

APPENDIX II: (Continued)

IPI00293971.3	ATP1B2 Sodium/potassium-transporting ATPase subunit beta-2	TQLG*N*CSGIGDSTHYGYSTGQPCVFIK		Y		Y
IPI00293971.3	ATP1B2 Sodium/potassium-transporting ATPase subunit beta-2	VINFYAGA*N*QSM*N*VTCAGK		Y1,Y2	Y1,Y2	
IPI00294455.1	UGT8 2-hydroxyacylsphingosine 1-beta-galactosyltransferase precursor	YPGIF*N*STTSDAFLQSK		Y		Y
IPI00294834.6	ASPH Aspartyl/asparaginyl beta-hydroxylase	LVQLFP*N*DTSLK		Y		Y
IPI00295399.4	CDH10 Cadherin-10 precursor	ELSQWH*N*LTVIAAEINNPK		Y	Y	
IPI00295494.1	CCDC39 Coiled-coil domain-containing protein 39	ATV*N*RTSSDLEALRK				Y
IPI00295832.1	OMG Oligodendrocyte-myelin glycoprotein precursor	Q*N*ITYLLK		Y		Y
IPI00295832.1	OMG Oligodendrocyte-myelin glycoprotein precursor	SLEVL*N*LSSNK		Y	Y	
IPI00295832.1	OMG Oligodendrocyte-myelin glycoprotein precursor	SLEVL*N*LSSNKL		Y	Y	
IPI00295832.1	OMG Oligodendrocyte-myelin glycoprotein precursor	SLW*N*MSAANNNIK		Y	Y	
IPI00295832.1	OMG Oligodendrocyte-myelin glycoprotein precursor	WSCDHKQ*N*ITYLLK		Y		Y
IPI00296373.3	GABBR1 Isoform 1C of Gamma-aminobutyric acid type B receptor subunit 1 precursor	AM*N*SSSFEGVSGHVVFDASGSR		Y		Y
IPI00296373.3	GABBR1 Isoform 1C of Gamma-aminobutyric acid type B receptor subunit 1 precursor	LEDFNYN*N*QTITDQIYR		Y		Y
IPI00296373.3	GABBR1 Isoform 1C of Gamma-aminobutyric acid type B receptor subunit 1 precursor	SIS*N*MTSQEFVEK		Y		Y
IPI00297933.1	GRIN2B Glutamate [NMDA] receptor subunit epsilon-2 precursor	YLI*N*VTFEGR		Y		Y
IPI00298237.7	TPP1 Isoform 1 of Tripeptidyl-peptidase 1 precursor	FLSSSPHLPPSSYF*N*ASGR	Y		Y	
IPI00298281.3	LAMC1 Laminin subunit gamma-1 precursor	KIPAI*N*QTITEANEK	Y		Y	
IPI00298281.3	LAMC1 Laminin subunit gamma-1 precursor	LLN*N*LTSIK	Y		Y	
IPI00298281.3	LAMC1 Laminin subunit gamma-1 precursor	QVLSYGQ*N*LSFSFR		Y	Y	
IPI00298281.3	LAMC1 Laminin subunit gamma-1 precursor	TA*N*DTSTEAYNLLLR		Y	Y	
IPI00298281.3	LAMC1 Laminin subunit gamma-1 precursor	TLAGE*N*QTAFEIEELNR	Y		Y	
IPI00298971.1	VTN Vitronectin precursor	*N*ISDGFDGIPDNVDAALALPAHSYSGR	Y		Y	
IPI00299063.1	STIM1 Stromal interaction molecule 1 precursor	LAVT*N*TTMTGTVLK	Y		Y	
IPI00299299.3	STCH Stress 70 protein chaperone microsome-associated 60 kDa protein precursor	*N*STIEAANLAGLK				Y
IPI00299652.2	ADAM11 Isoform Long of ADAM 11 precursor	CLPASAF*N*FSTCPGSGER		Y		Y
IPI00301395.4	CPVL Probable serine carboxypeptidase CPVL precursor	QAIHVG*N*QTFNDGTIVEK		Y	Y	
IPI00301512.3	DPP6 Isoform DPPX-L of Dipeptidyl aminopeptidase-like protein 6	A*N*YSLQIYPDESHYFTSSSLK	Y			Y
IPI00301512.3	DPP6 Isoform DPPX-L of Dipeptidyl aminopeptidase-like protein 6	LAYAAI*N*DSR	Y			Y
IPI00301512.3	DPP6 Isoform DPPX-L of Dipeptidyl aminopeptidase-like protein 6	LWNVET*N*TSTVLIEGK	Y			Y
IPI00303210.3	ENPP2 Isoform 2 of Ectonucleotide pyrophosphatase/phosphodiesterase family member 2 precursor	AIIA*N*LTCK		Y	Y	
IPI00304227.4	CDH11 Isoform 1 of Cadherin-11 precursor	FIFSLPPEIIHNP*N*FTVR		Y		Y
IPI00304840.4	COL6A2 Isoform 2C2 of Collagen alpha-2(VI) chain precursor	GTFTDCALA*N*MTEQIR		Y	Y	
IPI00304840.4	COL6A2 Isoform 2C2 of Collagen alpha-2(VI) chain precursor	*N*MTLFSDLVAEK		Y		Y
IPI00307433.3	STS Steryl-sulfatase precursor	NYEIIQQPMSYD*N*LTQR	Y			Y
IPI00307612.4	CDH20 Cadherin-20 precursor	NGQHFYYSLAPEAANNP*N*FTIR		Y		Y
IPI00328113.2	FBN1 Fibrillin-1 precursor	*N*CTDIDECR		Y	Y	
IPI00328113.2	FBN1 Fibrillin-1 precursor	VLPV*N*VTDYCQLVR		Y	Y	
IPI00328719.2	SLC15A2 Oligopeptide transporter, kidney isoform	YH*N*LSLYTEHSVQEK		Y		Y
IPI00328829.4	ITIH5 inter-alpha trypsin inhibitor heavy chain precursor 5 isoform 1	TLFPNYF*N*GSEIIIAGK		Y		Y
IPI00329573.9	COL12A1 Isoform 1 of Collagen alpha-1(XII) chain precursor	EAG*N*TTDGYEILGK		Y	Y	
IPI00329573.9	COL12A1 Isoform 1 of Collagen alpha-1(XII) chain precursor	MLEAY*N*LTEK		Y	Y	

APPENDIX II: (Continued)

IPI00332887.5	SIRPA signal-regulatory protein alpha precursor	AENQV*N*VTCQVR		Y	Y	
IPI00332887.5	SIRPA signal-regulatory protein alpha precursor	GTA*N*LSETIR	Y		Y	
IPI00332887.5	SIRPA signal-regulatory protein alpha precursor	IG*N*ITPADAGTYYCVK			Y	
IPI00332887.5	SIRPA signal-regulatory protein alpha precursor	LQLTWLENG*N*VSR		Y	Y	
IPI00333777.5	NRCAM Isoform 2 of Neuronal cell adhesion molecule precursor	DGDDEWTSVVVA*N*VSK		Y	Y	
IPI00333777.5	NRCAM Isoform 2 of Neuronal cell adhesion molecule precursor	ERPPTFLTPEG*N*ASNK	Y		Y	
IPI00333777.5	NRCAM Isoform 2 of Neuronal cell adhesion molecule precursor	ERPPTFLTPEG*N*ASNKEELR	Y		Y	
IPI00333777.5	NRCAM Isoform 2 of Neuronal cell adhesion molecule precursor	GSALHEDIYVLHE*N*GTLEIPVAQK		Y	Y	
IPI00333777.5	NRCAM Isoform 2 of Neuronal cell adhesion molecule precursor	NL*N*FSTR		Y	Y	
IPI00333777.5	NRCAM Isoform 2 of Neuronal cell adhesion molecule precursor	QKDGDDEWTSVVVA*N*VSK		Y	Y	
IPI00333777.5	NRCAM Isoform 2 of Neuronal cell adhesion molecule precursor	VNVV*N*STLAEVHWDPVPLK		Y	Y	
IPI00333777.5	NRCAM Isoform 2 of Neuronal cell adhesion molecule precursor	YQPI*N*STHELGPLVDLK		Y	Y	
IPI00335355.3	SLC6A17 Orphan sodium- and chloride-dependent neurotransmitter transporter NTT4	DLIPPHV*N*FSHLTTK		Y		Y
IPI00337351.3	MDGA2 MAM domain-containing glycosylphosphatidylinositol anchor protein 2 precursor	FQDSSVF*N*ETLR		Y		
IPI00339364.1	GGT7 65 kDa protein	AAAVAQDGF*N*VTHDLAR		Y		Y
IPI00339364.1	GGT7 65 kDa protein	R*N*ESHLIDFR		Y		Y
IPI00375253.2	MAG myelin associated glycoprotein isoform b precursor	ATAF*N*LSVEFAPVLLLESH	Y		Y	
IPI00375253.2	MAG myelin associated glycoprotein isoform b precursor	ATAF*N*LSVEFAPVLLLESHCAAAR	Y		Y	
IPI00375879.6	KIAA1467 Uncharacterized protein KIAA1467	APDS*N*CSNLLITTR				Y
IPI00376427.3	NCAM2 Neural cell adhesion molecule 2 precursor	DKLVLPAK*N*TTNLK	Y		Y	
IPI00376427.3	NCAM2 Neural cell adhesion molecule 2 precursor	LAMLANNNLQILNI*N*K		Y	Y	
IPI00376427.3	NCAM2 Neural cell adhesion molecule 2 precursor	LVLPAK*N*TTNLK	Y		Y	
IPI00376427.3	NCAM2 Neural cell adhesion molecule 2 precursor	PI*N*ISCDVK		Y		Y
IPI00376427.3	NCAM2 Neural cell adhesion molecule 2 precursor	Y*N*CTATNHIGTR		Y	Y	
IPI00376986.2	NTRK3 Isoform D of NT-3 growth factor receptor precursor	NPLGTA*N*QTINGHFLK		Y		Y
IPI00382672.4	ENTPD1 Isoform Vascular of Ectonucleoside triphosphate diphosphohydrolase 1	VV*N*VSDLYK		Y		Y
IPI00384280.5	PCYOX1 Prenylcysteine oxidase 1 precursor	GEL*N*TSIFSSR	Y		Y	
IPI00384280.5	PCYOX1 Prenylcysteine oxidase 1 precursor	GEL*N*TSIFSSRPIDK	Y		Y	
IPI00384454.1	F3 Tissue factor	*N*NTFLSLR		Y		Y
IPI00384454.1	F3 Tissue factor	SGTTNTVAAY*N*LTWK		Y		Y
IPI00384484.1	GPM6B glycoprotein M6B isoform 2	SPQT*N*GTTGVEQICVDIR		Y		Y
IPI00385291.2	CD82 CD82 antigen isoform 2	DY*N*SSREDSLQDAWDYVQAQVK			Y	
IPI00394770.2	CSMD2 CSMD2 protein	GF*N*ITFTTFR		Y		Y
IPI00394820.3	OLFML1 Olfactomedin-like protein 1 precursor	*N*NTVWEFANIR		Y		Y
IPI00395428.1	SCN1B sodium channel, voltage-gated, type I, beta isoform b	LLFFENYEH*N*TSVVK		Y		Y
IPI00395903.1	TMEM106B Transmembrane protein 106B	LN*N*ITIIGPLDMK				Y
IPI00396134.3	P2RX7 P2X purinoceptor	TT*N*VSLYPGYNFR		Y		Y
IPI00396411.4	CLPTM1 Isoform 1 of Cleft lip and palate transmembrane protein 1	DYYPI*N*ESLASLPLR	Y		Y	
IPI00401212.3	GPM6A glycoprotein M6A isoform 3	*N*TTLVEGANLCLDLR		Y		Y
IPI00409626.2	PCDH9 protocadherin 9 isoform 1 precursor	ATVTL*N*VTDVNDNPPNIDLR		Y	Y	
IPI00409626.2	PCDH9 protocadherin 9 isoform 1 precursor	IDPVTG*N*TLEEKPAPTDVGLHR		Y	Y	
IPI00409626.2	PCDH9 protocadherin 9 isoform 1 precursor	IVASDSGKPSL*N*QTALVR		Y	Y	
IPI00409626.2	PCDH9 protocadherin 9 isoform 1 precursor	LFAL*NN*TTGLITVQR		Y1,Y2	Y1	Y2

(*Continued*)

APPENDIX II: (Continued)

IPI00409626.2	PCDH9 protocadherin 9 isoform 1 precursor	LVV*N*ISDLGYPK		Y		Y
IPI00409667.1	PCDHGC3 Isoform 3 of Protocadherin gamma-C3 precursor	ETVPEY*N*LSITAR		Y	Y	
IPI00409667.1	PCDHGC3 Isoform 3 of Protocadherin gamma-C3 precursor	VLDANDNAPVF*N*QSLYR		Y		Y
IPI00410210.1	LPHN1 Isoform 2 of Latrophilin-1 precursor	GPDLS*N*CTSPWVNQVAQK		Y		Y
IPI00412541.2	GPR158 Probable G-protein coupled receptor 158 precursor	ILLQDLSSSAPHLA*N*ATLETEWFHGLR		Y		Y
IPI00413690.2	ARSB arylsulfatase B isoform 2 precursor	CTLIDAL*N*VTR		Y		Y
IPI00413696.5	CD47 41 kDa protein	DIYTFDGAL*N*K	Y		Y	
IPI00413696.5	CD47 41 kDa protein	FVTNMEAQ*N*TTEVYVK		Y	Y	
IPI00413696.5	CD47 41 kDa protein	GRDIYTFDGAL*N*K	Y		Y	
IPI00413696.5	CD47 41 kDa protein	SDAVSHTG*N*YTCEVTELTR	Y		Y	
IPI00418446.4	ASAH1 N-acylsphingosine amidohydrolase (acid ceramidase) 1 isoform b	TVLE*N*STSYEEAK	Y		Y	
IPI00418446.4	ASAH1 N-acylsphingosine amidohydrolase (acid ceramidase) 1 isoform b	ILAPAYFILGG*N*QSGEGCVITR	Y		Y	
IPI00418446.4	ASAH1 N-acylsphingosine amidohydrolase (acid ceramidase) 1 isoform b	ILGG*N*QSGEGCVITR	Y		Y	
IPI00437751.1	ACE Isoform Somatic-1 of Angiotensin-converting enzyme, somatic isoform precursor	KFDVNQLQ*N*TTIK	Y		Y	
IPI00449669.2	SSR1 Isoform 2 of Translocon-associated protein subunit alpha precursor	YPQDYQFYIQ*N*FTALPLNTVVPPQR	Y		Y	
IPI00456623.2	BCAN Isoform 1 of Brevican core protein precursor	LFLFP*N*QTGFPNK		Y	Y	
IPI00456623.2	BCAN Isoform 1 of Brevican core protein precursor	TLFLFP*N*QTGFPNK		Y	Y	
IPI00456623.2	BCAN Isoform 1 of Brevican core protein precursor	VALPAYPASLTDVSLALSELRP*N*DSGIYR		Y	Y	
IPI00465308.3	PIGS Isoform 1 of GPI transamidase component PIG-S	TY*N*ASVLPVR		Y	Y	
IPI00470388.2	CADM2 Isoform 2 of Cell adhesion molecule 2 precursor	ELNILFL*N*K				Y
IPI00470388.2	CADM2 Isoform 2 of Cell adhesion molecule 2 precursor	ELNILFL*N*KTD*N*GTYR		Y2		Y1,Y2
IPI00470388.2	CADM2 Isoform 2 of Cell adhesion molecule 2 precursor	GSQGQFPLTQ*N*VTVVEGGTAIL		Y		Y
IPI00470388.2	CADM2 Isoform 2 of Cell adhesion molecule 2 precursor	GSQGQFPLTQ*N*VTVVEGGTAILTCR		Y		Y
IPI00470388.2	CADM2 Isoform 2 of Cell adhesion molecule 2 precursor	VDQND*N*TSLQWSNPAQQTLYFDDK		Y		Y
IPI00470388.2	CADM2 Isoform 2 of Cell adhesion molecule 2 precursor	VDQND*N*TSLQWSNPAQQTLYFDDKK		Y		Y
IPI00470529.3	GPNMB Isoform 1 of Transmembrane glycoprotein NMB precursor	VSVNTA*N*VTLGPQLMEVTVYR		Y	Y	
IPI00470696.1	UNC5D Isoform 1 of Netrin receptor UNC5D precursor	EVFI*N*VTR		Y		Y
IPI00472011.1	NEO1 154 kDa protein	TLSDVPSAAPQ*N*LSLEVR		Y	Y	
IPI00472139.1	PLXND1 Isoform 2 of Plexin-D1 precursor	A*N*FTIYDCSR		Y		Y
IPI00478003.1	A2M Alpha-2-macroglobulin precursor	GCVLLSYL*N*ETVTVSASLESVR	Y		Y	
IPI00478003.1	A2M Alpha-2-macroglobulin precursor	IYVLDYL*N*ETQQLTPEVK	Y			Y
IPI00478003.1	A2M Alpha-2-macroglobulin precursor	SLGNV*N*FTVSAEALESQELCGTEVPSVPEHGR	Y		Y	
IPI00478003.1	A2M Alpha-2-macroglobulin precursor	VS*N*QTLSLFFTVLQDVPVR	Y		Y	
IPI00478483.3	LAMC3 Laminin, gamma 3	LLA*N*LTSLR		Y		Y
IPI00479514.1	CACNA2D1 Voltage-dependent calcium channel subunit alpha-2/delta-1 precursor	GFSFAFEQLLNY*N*VSR		Y	Y	
IPI00479514.1	CACNA2D1 Voltage-dependent calcium channel subunit alpha-2/delta-1 precursor	HLV*N*ISVYAF*N*K		Y1	Y1,Y2	
IPI00479514.1	CACNA2D1 Voltage-dependent calcium channel subunit alpha-2/delta-1 precursor	IDVNSWIE*N*FTK			Y	
IPI00479514.1	CACNA2D1 Voltage-dependent calcium channel subunit alpha-2/delta-1 precursor	ISD*N*NTEFLLNFNEFIDR	Y		Y	
IPI00479514.1	CACNA2D1 Voltage-dependent calcium channel subunit alpha-2/delta-1 precursor	QSCITEQTQYFFD*N*DSK				Y
IPI00479514.1	CACNA2D1 Voltage-dependent calcium channel subunit alpha-2/delta-1 precursor	SFSGVLDCG*N*CSR			Y	
IPI00479514.1	CACNA2D1 Voltage-dependent calcium channel subunit alpha-2/delta-1 precursor	SLDNDNYVFTAPYF*N*K			Y	

APPENDIX II: (Continued)

IPI00513767.2	PTGDS Prostaglandin D2 synthase 21kDa	SVVAPATDGGL*N*LTSTFLR	Y		Y	
IPI00513767.2	PTGDS Prostaglandin D2 synthase 21kDa	WFSAGLAS*N*SSWLR	Y		Y	
IPI00513964.1	SEMA4B Isoform 2 of Semaphorin-4B precursor	FEAEHIS*N*YTALLLSR	Y		Y	
IPI00514424.2	PPT1 Palmitoyl-protein thioesterase 1	FL*N*DSIVDPVDSEWFGFYR	Y		Y	
IPI00514424.2	PPT1 Palmitoyl-protein thioesterase 1	*N*HSIFLADINQER		Y	Y	
IPI00514804.1	SCN4B Isoform 2 of Sodium channel subunit beta-4 precursor	WTY*N*SSDAFK		Y		Y
IPI00550145.3	OLFM1 NOELIN1_V2	LDPVSLQTLQTW*N*TSYPK	Y		Y	
IPI00550145.3	OLFM1 NOELIN1_V2	VQ*N*MSQSIEVLDR	Y		Y	
IPI00550918.2	COL14A1 Isoform 2 of Collagen alpha-1(XIV) chain precursor	SFMV*N*WTHAPGNVEK		Y	Y	
IPI00552302.3	NT5E 5'-nucleotidase, ecto	GNVISSHGNPILL*N*SSIPEDPSIK		Y	Y	
IPI00552450.1	OPCML opioid binding protein/cell adhesion molecule-like isoform b preproprotein	DYG*N*YTCVATNK		Y		Y
IPI00552450.1	OPCML opioid binding protein/cell adhesion molecule-like isoform b preproprotein	DYG*N*YTCVATNKL		Y		Y
IPI00552450.1	OPCML opioid binding protein/cell adhesion molecule-like isoform b preproprotein	MSTLTFF*N*VSEK		Y	Y	
IPI00552671.2	PLXNA1 Plexin-A1 precursor	LSG*N*LTLLR		Y		Y
IPI00552671.2	PLXNA1 Plexin-A1 precursor	Y*N*YTEDPTILR		Y		Y
IPI00554518.1	IL6ST IL6ST nirs variant 4	ETHLET*N*FTLK	Y		Y	
IPI00554722.1	LOC442497;SLC3A2 solute carrier family 3 (activators of dibasic and neutral amino acid transport), member 2 isoform e	DASSFLAEWQ*N*ITK	Y		Y	
IPI00554722.1	LOC442497;SLC3A2 solute carrier family 3 (activators of dibasic and neutral amino acid transport), member 2 isoform e	LLIAGT*N*SSDLQQILSLLESNK	Y		Y	
IPI00554722.1	LOC442497;SLC3A2 solute carrier family 3 (activators of dibasic and neutral amino acid transport), member 2 isoform e	SLVTQYL*N*ATGNR	Y		Y	
IPI00554760.1	TNR Isoform 2 of Tenascin-R precursor	PPKDITIS*N*VTK		Y		Y
IPI00554760.1	TNR Isoform 2 of Tenascin-R precursor	DITIS*N*VTK		Y		Y
IPI00554760.1	TNR Isoform 2 of Tenascin-R precursor	GT*N*ESDSATTQFTTEIDAPK		Y	Y	
IPI00554760.1	TNR Isoform 2 of Tenascin-R precursor	IGSY*N*GTAGDSLSYHQGR		Y		Y
IPI00554760.1	TNR Isoform 2 of Tenascin-R precursor	IGSY*N*GTAGDSLSYHQGRPF		Y		Y
IPI00554760.1	TNR Isoform 2 of Tenascin-R precursor	*N*CSEPYCPLGCSSR		Y		Y
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	ALHHSGHSPPISSQ*N*VTVLR	Y		Y	
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	DEGTYTCALHHSGHSPPISSQ*N*VTVLR	Y		Y	
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	HE*N*TSSSPIQY	Y		Y	
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	HE*N*TSSSPIQYE	Y		Y	
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	HE*N*TSSSPIQYEF	Y		Y	
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	HE*N*TSSSPIQYEFSLTR	Y		Y	
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	HSGHSPPISSQ*N*VTVLR	Y		Y	
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	LDCRHE*N*TSSSPIQYEFSLTR	Y		Y	
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	SGHSPPISSQ*N*VTVLR	Y		Y	
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	SPPISSQ*N*VTVLR	Y		Y	
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	TCALHHSGHSPPISSQ*N*VTVLR	Y		Y	
IPI00555577.1	THY1 Thy-1 cell surface antigen variant (Fragment)	T*N*FTSK		Y		Y
IPI00555628.1	NCAM1 Neural cell adhesion molecule 1, 120 kDa isoform variant (Fragment)	DGQLLPSS*N*YSNIK	Y		Y	
IPI00555628.1	NCAM1 Neural cell adhesion molecule 1, 120 kDa isoform variant (Fragment)	IYNTPSASYLEVTPDSENDFGNY*N*CTAVNR		Y	Y	
IPI00555628.1	NCAM1 Neural cell adhesion molecule 1, 120 kDa isoform variant (Fragment)	PSS*N*YSNIK	Y		Y	

(*Continued*)

APPENDIX II: (Continued)

IPI00555628.1	NCAM1 Neural cell adhesion molecule 1, 120 kDa isoform variant (Fragment)	RDGQLLPSS*N*YSNIK	Y		Y	
IPI00604442.2	SSR2 Putative uncharacterized protein DKFZp686F19123	IAPAS*N*VSHTVVLRPLK	Y		Y	
IPI00607580.2	MEGF8 multiple EGF-like-domains 8	ALLT*N*VSSVALGSR	Y		Y	
IPI00607652.1	OLFML3 Isoform 2 of Olfactomedin-like protein 3 precursor	IYVLDGTQ*N*DTAFVFPR		Y	Y	
IPI00607732.1	NCLN Isoform 2 of Nicalin precursor	VIY*N*LTEK		Y	Y	
IPI00619903.3	UGCGL1 UDP-glucose:glycoprotein glucosyltransferase 1 precursor	GTEV*N*TTVIGENDPIDEVQGFLFGK			Y	
IPI00641150.2	LAMA1 similar to laminin, alpha 1 precursor	DVAGLSQELL*N*TSASLSR		Y		Y
IPI00641524.2	BTN2A1 Isoform 1 of Butyrophilin subfamily 2 member A1 precursor	GSVALVIH*N*ITAQENGTYR		Y	Y	
IPI00641737.1	HP Haptoglobin precursor	MVSHH*N*LTTGATLINEQWLLTTAK	Y		Y	
IPI00641737.1	HP Haptoglobin precursor	NLFL*N*HSENATAK	Y		Y	
IPI00641737.1	HP Haptoglobin precursor	VVLHP*N*YSQVDIGLIK	Y		Y	
IPI00642378.2	LASS2 cDNA FLJ75329, highly similar to Homo sapiens LAG1 longevity assurance homolog 2 (S. cerevisiae), transcript variant 2, mRNA	LWLPV*N*LTWADLEDRDGR	Y			Y
IPI00642425.1	ICAM1 Cell surface glycoprotein	A*N*LTVVLLR	Y		Y	
IPI00643034.2	PLTP Isoform 1 of Phospholipid transfer protein precursor	EGHFYY*N*ISEVK	Y		Y	
IPI00643384.2	BGN Uncharacterized protein BGN	LLQVVYLHSN*N*ITK		Y		Y
IPI00643663.1	PCSK2 Proprotein convertase subtilisin/kexin type 2	NPEAGVATTDLYG*N*CTLR		Y		Y
IPI00643663.1	PCSK2 Proprotein convertase subtilisin/kexin type 2	YLEHVQAVITV*N*ATR		Y	Y	
IPI00644458.1	TM9SF3 SM-11044 binding protein	IVDV*N*LTSEGK		Y	Y	
IPI00644480.1	LPHN2 Latrophilin 2	SLGQFLSTE*N*ATIK		Y		Y
IPI00645060.1	PBXIP1 Isoform 2 of Pre-B-cell leukemia transcription factor-interacting protein 1	LQGLENWGQDPGVSA*N*ASK				Y
IPI00645194.1	ITGB1 integrin beta 1 isoform 1A precursor	DTCTQECSYF*N*ITK		Y	Y	
IPI00645484.1	SV2A Isoform 2 of Synaptic vesicle glycoprotein 2A	LI*N*STFLHNK		Y	Y	
IPI00645484.1	SV2A Isoform 2 of Synaptic vesicle glycoprotein 2A	*N*CTFINTVFYNTDLFEYK		Y		Y
IPI00645484.1	SV2A Isoform 2 of Synaptic vesicle glycoprotein 2A	VEHVTF*N*FTLENQIHR		Y		Y
IPI00646891.2	GRIN1 Glutamate receptor, ionotropic, N-methyl D-aspartate 1	LVQVGIY*N*GTHVIPNDR		Y	Y	
IPI00646891.2	GRIN1 Glutamate receptor, ionotropic, N-methyl D-aspartate 1	*N*VTALLMEAK		Y		Y
IPI00646891.2	GRIN1 Glutamate receptor, ionotropic, N-methyl D-aspartate 1	Q*N*VSLSILK		Y		Y
IPI00647704.1	IGHA1;IGHV3OR16-13 cDNA FLJ41552 fis, clone COLON2004478, highly similar to Protein Tro alpha1 H,myeloma	LAGKPTHV*N*VSVVMAEVDGTCY	Y		Y	
IPI00647704.1	IGHA1;IGHV3OR16-13 cDNA FLJ41552 fis, clone COLON2004478, highly similar to Protein Tro alpha1 H,myeloma	LSLHRPALEDLLLGSEA*N*LTCTLTGLR	Y		Y	
IPI00647704.1	IGHA1;IGHV3OR16-13 cDNA FLJ41552 fis, clone COLON2004478, highly similar to Protein Tro alpha1 H,myeloma	PALEDLLLGSEA*N*LTCTLTGLR	Y		Y	
IPI00654584.5	NPTN Isoform 4 of Neuroplastin precursor	A*N*ATIEVK		Y	Y	
IPI00654584.5	NPTN Isoform 4 of Neuroplastin precursor	DSPVLPVTLQC*N*LTSSSH		Y		Y
IPI00655702.3	NFASC Isoform 5 of Neurofascin precursor	HNFGPGTDFVVEYIDS*N*HTK		Y	Y	
IPI00655702.3	NFASC Isoform 5 of Neurofascin precursor	IHESAPDEQSIW*N*VTVLPNSK		Y		Y
IPI00655702.3	NFASC Isoform 5 of Neurofascin precursor	WA*N*ITWK		Y		Y
IPI00656113.2	SIRPA Signal-regulatory protein alpha	LLV*N*VSAHR		Y		Y
IPI00658202.1	CDH2 Uncharacterized protein CDH2	S*N*ISILR		Y		Y
IPI00735310.1	LAMA4 Isoform 2 of Laminin subunit alpha-4 precursor	*N*LTEVVPQLLDQLR		Y	Y	
IPI00737429.3	ODZ4 Teneurin-4	IFPSG*N*VTNILELR		Y		
IPI00737429.3	ODZ4 Teneurin-4	LT*N*VTFPTGQVSSFR		Y		

APPENDIX II: (Continued)

IPI00739827.1	LAMP2 Isoform LAMP-2B of Lysosome-associated membrane glycoprotein 2 precursor	IAVQFGPGFSWIA*N*FTK	Y		Y	
IPI00739827.1	LAMP2 Isoform LAMP-2B of Lysosome-associated membrane glycoprotein 2 precursor	VASVININP*N*TTHSTGSCR	Y		Y	
IPI00739827.1	LAMP2 Isoform LAMP-2B of Lysosome-associated membrane glycoprotein 2 precursor	VQPF*N*VTQGK	Y		Y	
IPI00739827.1	LAMP2 Isoform LAMP-2B of Lysosome-associated membrane glycoprotein 2 precursor	WQM*N*FTVR	Y		Y	
IPI00743064.1	LCN2 Uncharacterized protein LCN2	SY*N*VTSVLFR	Y		Y	
IPI00743104.2	ITGA1 Integrin alpha-1 precursor	VYVYAL*N*QTR	Y		Y	
IPI00743203.2	LAMB2 Similar to S-laminin	LAL*N*LTLR		Y		Y
IPI00743203.2	LAMB2 Similar to S-laminin	*N*TSAASTAQLVEATEELR		Y		Y
IPI00743302.2	ICAM5 intercellular adhesion molecule 5 precursor	VELMPLPPWQPVGE*N*FTLSCR		Y		Y
IPI00743517.1	PTPRS protein tyrosine phosphatase, receptor type, sigma isoform 2 precursor	KVEAEAL*N*ATAIR	Y		Y	
IPI00744685.2	BTD Uncharacterized protein BTD (Fragment)	DVQIIVFPEDGIHGF*N*FTR	Y		Y	
IPI00744835.1	PSAP Isoform Sap-mu-9 of Proactivator polypeptide precursor	D*N*ATEEEILVYLEK	Y		Y	
IPI00744835.1	PSAP Isoform Sap-mu-9 of Proactivator polypeptide precursor	NLEK*N*STKQEILAALEK	Y		Y	
IPI00744835.1	PSAP Isoform Sap-mu-9 of Proactivator polypeptide precursor	*N*STKQEILAALEK	Y		Y	
IPI00745954.2	GRM7 Isoform 3 of Metabotropic glutamate receptor 7 precursor	YDIFQYQTT*N*TSNPGYR		Y		Y
IPI00746595.3	MOG Uncharacterized protein MOG	*N*ATGMEVGWYRPPFSR		Y		Y
IPI00747849.2	ATP1B1 Isoform 1 of Sodium/potassium-transporting ATPase subunit beta-1	LG*N*CSGLNDETYGYK	Y		Y	
IPI00759642.1	CD163 Isoform 2 of Scavenger receptor cysteine-rich type 1 protein M130 precursor	EDAAV*N*CTDISVQK			Y	
IPI00783390.1	CHL1 Isoform 1 of Neural cell adhesion molecule L1-like protein precursor	IIPS*N*NSGTFR			Y	
IPI00783390.1	CHL1 Isoform 1 of Neural cell adhesion molecule L1-like protein precursor	VTWKPQGAPVEWEEETVT*N*HTLR	Y		Y	
IPI00783390.1	CHL1 Isoform 1 of Neural cell adhesion molecule L1-like protein precursor	YHIYE*N*GTLQINR	Y		Y	
IPI00783665.2	LAMA5 Laminin subunit alpha-5 precursor	D*N*ATLQATLHAAR		Y	Y	
IPI00783665.2	LAMA5 Laminin subunit alpha-5 precursor	GVH*N*ASLALSASIGR		Y	Y	
IPI00783665.2	LAMA5 Laminin subunit alpha-5 precursor	L*N*ASIADLQSQLR		Y	Y	
IPI00783698.4	TMEM87A Isoform 1 of Transmembrane protein 87A precursor	LFQ*N*CSELFK		Y	Y	
IPI00783987.2	C3 Complement C3 precursor (Fragment)	TVLTPATNHMG*N*VTFTIPANR	Y		Y	
IPI00784119.1	ATP6AP1 Vacuolar ATP synthase subunit S1 precursor	ILFWAQ*N*FSVAYK		Y		Y
IPI00784119.1	ATP6AP1 Vacuolar ATP synthase subunit S1 precursor	L*N*ASLPALLLIR		Y	Y	
IPI00784119.1	ATP6AP1 Vacuolar ATP synthase subunit S1 precursor	QKQPVSPVIHPPVSY*N*DTAPR		Y	Y	
IPI00784119.1	ATP6AP1 Vacuolar ATP synthase subunit S1 precursor	QPVSPVIHPPVSY*N*DTAPR		Y	Y	
IPI00784119.1	ATP6AP1 Vacuolar ATP synthase subunit S1 precursor	SPVIHPPVSY*N*DTAPR		Y	Y	
IPI00784147.1	NPTXR;CBX6 Uncharacterized protein NPTXR	V*N*LSAAPAPVSAVPTGLHSK		Y	Y	
IPI00784169.1	CD55 Decay-accelerating factor splicing variant 1	GSQWSDIEEFC*N*R		Y	Y	
IPI00784543.1	KIAA0090 Isoform 2 of Uncharacterized protein KIAA0090 precursor	FINY*N*QTVSR		Y	Y	
IPI00787965.2	ATP1B3 similar to Sodium/potassium-transporting ATPase subunit beta-3	*N*LTVCPDGALFEQK		Y	Y	
IPI00788159.1	DPP7 similar to Dipeptidyl-peptidase 2 precursor	ALAGLVY*N*ASGSEHCYDIYR		Y	Y	
IPI00788189.1	FCGBP similar to Fc fragment of IgG binding protein	VITVQVA*N*FTLR	Y		Y	
IPI00789795.1	ADAM22 98 kDa protein; ADAM22 Isoform 5 of ADAM 22 precursor	TL*N*CSGGHVK		Y		Y
IPI00789973.1	GRIN1 Glutamate receptor, ionotropic, N-methyl D-aspartate 1	KLVQVGIY*N*GTHVIPNDR		Y	Y	
IPI00789973.1	GRIN1 Glutamate receptor, ionotropic, N-methyl D-aspartate 1	TM*N*FTYEVHLVADGK		Y	Y	
IPI00791304.1	C20orf3 Chromosome 20 open reading frame 3	AGP*N*GTLFVADAYK	Y		Y	

(*Continued*)

APPENDIX II: (Continued)

IPI00791304.1	C20orf3 Chromosome 20 open reading frame 3	NMSFVNDLTVTQDGR	Y		Y	
IPI00791516.1	CD59 13 kDa protein	TAVNCSSDFDACLITK	Y		Y	
IPI00793495.1	C6orf27 G7c protein	TFVNPSFSLTSNLSR				Y
IPI00793688.1	CD276 60 kDa protein	TALFPDLLAQGNASLR		Y	Y	
IPI00793751.1	MFAP4 Uncharacterized protein MFAP4	VDLEDFENNTAYAK	Y		Y	
IPI00793751.1	MFAP4 Uncharacterized protein MFAP4	FNGSVSFFR		Y	Y	
IPI00793829.1	GRM3 99 kDa protein	INFTAPFNPNK		Y		Y
IPI00794214.1	BCAM Lutheran glycoprotein	TQNFTLLVQGSPELK	Y			
IPI00794423.1	SLC1A2 Solute carrier family 1	VLVAPPPDEEANATSAVVSLLNETVTEVPEETK		Y1,Y2	Y1,Y2	
IPI00795030.1	LASS6 LASS6 protein	FWLPHNVTWADLK		Y		
IPI00795150.1	BSG 46 kDa protein(IPI00019906)	ILLTCSLNDSATEVTGHR	Y		Y	
IPI00795326.1	LINGO1 Isoform 2 of Leucine-rich repeat and immunoglobulin-like domain-containing nogo receptor-interacting protein 1 precursor	LIPLGVFTGLSNLTK	Y		Y	
IPI00795504.1	ALCAM 62 kDa protein	KLGDCISEDSYPDGNITWYR	Y		Y	
IPI00795504.1	ALCAM 62 kDa protein	TVNSLNVSAISIPEHDEADEISDENR	Y		Y	
IPI00795633.1	CLU CLU	LANLTQGEDQYYLR	Y		Y	
IPI00795633.1	CLU CLU	QLEEFLNQSSPF	Y		Y	
IPI00795720.1	CD63 13 kDa protein	NNHTASILDR	Y		Y	
IPI00795801.1	CD109 Isoform 4 of CD109 antigen precursor	TQDEILFSNSTR	Y		Y	
IPI00795830.1	AHSG 29 kDa protein	VCQDCPLLAPLNDTR	Y		Y	
IPI00796279.1	SERPINF1 25 kDa protein	VTQNLTLIEESLTSEFIHDIDR	Y		Y	
IPI00797025.1	PRNP Major prion protein	GENFTETDVK	Y		Y	
IPI00797503.1	ITGA7 106 kDa protein	LWNSTFLEEYSAVK		Y		Y
IPI00798430.1	TF Transferrin variant (Fragment)	CGLVPVLAENYNK	Y		Y	
IPI00798430.1	TF Transferrin variant (Fragment)	QQQHLFGSNVTDCSGNF	Y		Y	
IPI00798430.1	TF Transferrin variant (Fragment)	QQQHLFGSNVTDCSGNFCLFR	Y		Y	
IPI00807403.1	ALCAM Isoform 2 of CD166 antigen precursor	IIISPEENVTLTCTAENQLER	Y		Y	
IPI00807403.1	ALCAM Isoform 2 of CD166 antigen precursor	LGDCISEDSYPDGNITWYR	Y		Y	
IPI00807403.1	ALCAM Isoform 2 of CD166 antigen precursor	LNLSENYTLSISNAR	Y		Y	
IPI00807403.1	ALCAM Isoform 2 of CD166 antigen precursor	NATVVWMK		Y	Y	
IPI00828205.1	IGHM IGHM protein	GLTFQQNASSMCVPDQDTAIR	Y		Y	
IPI00829767.1	IGHG2 Uncharacterized protein IGHG2 (Fragment)	EEQFNSTFR	Y			Y
IPI00829867.1	GBA GBA protein	TYTYADTPDDFQLHNFSLPEEDTK	Y		Y	
IPI00844079.1	PTPRC Isoform 1 of Leukocyte common antigen precursor	YANITVDYLYNK		Y	Y	
IPI00844348.1	PON2 39 kDa protein	HTNMNLTQLK		Y		Y
IPI00845399.1	KIAA1946 Isoform 2 of UPF0560 protein KIAA1946 precursor	QYLSQAVVEVFVNYTK		Y		Y
IPI00847414.1	DPP10 dipeptidyl peptidase 10 isoform short	WINDTDVVYK		Y		Y
IPI00847635.1	SERPINA3 Isoform 1 of Alpha-1-antichymotrypsin precursor	FNLTETSEAEIHQSFQHLLR	Y			
IPI00847635.1	SERPINA3 Isoform 1 of Alpha-1-antichymotrypsin precursor	LSLGAHNTTLTEILK	Y		Y	
IPI00847635.1	SERPINA3 Isoform 1 of Alpha-1-antichymotrypsin precursor	TLNQSSDELQLSMGNAMFVK	Y			
IPI00847635.1	SERPINA3 Isoform 1 of Alpha-1-antichymotrypsin precursor	YTGNASALFILPDQDK	Y		Y	
IPI00853369.1	PLXNB2 Plexin-B2 precursor	ALSNISLR		Y	Y	
IPI00853369.1	PLXNB2 Plexin-B2 precursor	SINVTGQGFSLIQR		Y	Y	
IPI00853369.1	PLXNB2 Plexin-B2 precursor	TEAGAFEYVPDPTFENFTGGVK		Y	Y	
IPI00853589.1	SGCE sarcoglycan, epsilon isoform 3	LNAINITSALDR		Y	Y	
IPI00854766.1	TXNDC15 Isoform 2 of Thioredoxin domain-containing protein 15 precursor	IFIFNQTGIEAK			Y	

APPENDIX II: (Continued)

IPI00855821.1	NRXN1-alpha	SGG*N*ATLQVDSWPVIER		Y		Y
IPI00869004.1	SERPINA1 Isoform 3 of Alpha-1-antitrypsin precursor	ADTHDEILEGLNF*N*LTEIPEAQIHEGFQELLR	Y		Y	
IPI00869004.1	SERPINA1 Isoform 3 of Alpha-1-antitrypsin precursor	QLAHQS*N*STNIFFSPVSIA	Y		Y	
IPI00869004.1	SERPINA1 Isoform 3 of Alpha-1-antitrypsin precursor	QLAHQS*N*STNIFFSPVSIATAF	Y		Y	
IPI00869004.1	SERPINA1 Isoform 3 of Alpha-1-antitrypsin precursor	YLG*N*ATAIF	Y		Y	
IPI00869004.1	SERPINA1 Isoform 3 of Alpha-1-antitrypsin precursor	YLG*N*ATAIFFLPDEGK	Y		Y	
IPI00871221.1	ATP1B1 Isoform 2 of Sodium/potassium-transporting ATPase subunit beta-1	FKLEWLG*N*CSGLNDETYGYK	Y		Y	
IPI00871221.1	ATP1B1 Isoform 2 of Sodium/potassium-transporting ATPase subunit beta-1	LAVQFT*N*LTMDTEIR	Y		Y	
IPI00871221.1	ATP1B1 Isoform 2 of Sodium/potassium-transporting ATPase subunit beta-1	LEWLG*N*CSGL	Y		Y	
IPI00871221.1	ATP1B1 Isoform 2 of Sodium/potassium-transporting ATPase subunit beta-1	LEWLG*N*CSGLN	Y		Y	
IPI00871221.1	ATP1B1 Isoform 2 of Sodium/potassium-transporting ATPase subunit beta-1	LEWLG*N*CSGLNDETYGYK	Y		Y	
IPI00871221.1	ATP1B1 Isoform 2 of Sodium/potassium-transporting ATPase subunit beta-1	VLGFKPKPPK*N*ESLETYPVMK	Y		Y	
IPI00871221.1	ATP1B1 Isoform 2 of Sodium/potassium-transporting ATPase subunit beta-1	YLQPLLAVQFT*N*LTMDTEIR	Y		Y	
IPI00871253.1	PTPRK Mutant receptor type protein tyrosine phosphatase K	GPLANPIW*N*VTGFTGR		Y	Y	
IPI00871253.1	PTPRK Mutant receptor type protein tyrosine phosphatase K	IAVDWESLGY*N*ITR		Y	Y	
IPI00871326.1	PLXNA1 plexin A1	V*N*VSEDCPQILPSTQIYVPVGVVKPITLAAR		Y		Y
IPI00871339.1	CACNA2D2 129 kDa protein	AAEDWTENPEPF*N*ASFYR				Y
IPI00871339.1	CACNA2D2 129 kDa protein	AGFEYAFDQLQNS*N*ITR				Y
IPI00871339.1	CACNA2D2 129 kDa protein	*N*YTWVPIR				Y
IPI00871467.1	L1CAM cDNA FLJ76744, highly similar to Homo sapiens L1 cell adhesion molecule (L1CAM), transcript variant 1, mRNA	GPWQEQIVSDPFLVVS*N*TSTFVPYEIK		Y		Y
IPI00871467.1	L1CAM cDNA FLJ76744, highly similar to Homo sapiens L1 cell adhesion molecule (L1CAM), transcript variant 1, mRNA	DHVVVPA*N*TTSVILSGLR		Y	Y	
IPI00871467.1	L1CAM cDNA FLJ76744, highly similar to Homo sapiens L1 cell adhesion molecule (L1CAM), transcript variant 1, mRNA	DHVVVPA*N*TTSVILSGLRPY		Y	Y	
IPI00871467.1	L1CAM cDNA FLJ76744, highly similar to Homo sapiens L1 cell adhesion molecule (L1CAM), transcript variant 1, mRNA	FFPYA*N*GTLGIR		Y	Y	
IPI00871467.1	L1CAM cDNA FLJ76744, highly similar to Homo sapiens L1 cell adhesion molecule (L1CAM), transcript variant 1, mRNA	GY*N*VTYWR		Y		Y
IPI00871467.1	L1CAM cDNA FLJ76744, highly similar to Homo sapiens L1 cell adhesion molecule (L1CAM), transcript variant 1, mRNA	TH*N*LTDLSPHLR		Y	Y	
IPI00871501.1	SLC44A1 Uncharacterized protein SLC44A1	CAPV*N*ISCYAK				Y
IPI00871501.1	SLC44A1 Uncharacterized protein SLC44A1	FAEI*N*GSALCSYNLKPSEYTTSPK				Y
IPI00871510.1	GRIA2 Isoform 3 of Glutamate receptor 2 precursor	I*N*YTINIMELK		Y		Y
IPI00871510.1	GRIA2 Isoform 3 of Glutamate receptor 2 precursor	IQFGGA*N*VSGFQIVDYDDSLVSK		Y		Y
IPI00871570.1	SIDT1 SID1 transmembrane family member 1 precursor	VYV*N*SSSENLNYPVLVVVR		Y		Y
IPI00871792.1	PTPRZ1 265 kDa protein	ESFLQT*N*YTEIR		Y	Y	
IPI00871792.1	PTPRZ1 265 kDa protein	TVEI*N*LTNDYR	Y		Y	
IPI00871938.1	PTGFRN 103 kDa protein	ELDLTC*N*ITTDR		Y	Y	
IPI00872117.1	NTRK2 Tyrosine-protein kinase receptor (Fragment)	LEPNSVDPE*N*ITEIFIANQK	Y		Y	
IPI00872117.1	NTRK2 Tyrosine-protein kinase receptor (Fragment)	*N*LTIVDSGLK		Y	Y	
IPI00872117.1	NTRK2 Tyrosine-protein kinase receptor (Fragment)	NSNLQHI*N*FTR	Y		Y	
IPI00872117.1	NTRK2 Tyrosine-protein kinase receptor (Fragment)	SSPDTQDLYCL*N*ESSK		Y	Y	

(*Continued*)

APPENDIX II: (Continued)

IPI00872343.1	SLC2A3 54 kDa protein	IIKEFI*N*K		Y		Y
IPI00872375.2	SLC2A1 Uncharacterized protein SLC2A1 (Fragment)	VIEEFY*N*QTWVHR	Y		Y	
IPI00872579.1	PCDH1 Isoform 2 of Protocadherin-1 precursor	A*N*DSDQGANAEIEYTFHQAPEVVR		Y		Y
IPI00872579.1	PCDH1 Isoform 2 of Protocadherin-1 precursor	YGTALVHLYV*N*ETLANR		Y	Y	
IPI00872773.1	ERO1L Uncharacterized protein ERO1L	WGH*N*ITEFQQR		Y	Y	
IPI00872795.1	PPAP2A 42 kDa protein	I*N*CSDGYIEYYICR		Y		Y
IPI00873151.1	ABCA2 270 kDa protein	LHPEAL*N*LSLDELPPALR		Y		Y
IPI00873201.1	PSAP Isoform Sap-mu-6 of Proactivator polypeptide precursor	T*N*STFVQALVEHVK	Y		Y	
IPI00873210.1	FN1 263 kDa protein	LDAPTNLQFV*N*ETDSTVLVR	Y		Y	
IPI00873446.1	NRCAM Isoform 5 of Neuronal cell adhesion molecule precursor	VISVDEL*N*DTIAA*N*LSDTEFYGAK		Y1,Y2	Y1,Y2	
IPI00873846.1	DPP10 Isoform 1 of Inactive dipeptidyl peptidase 10	AGV*N*YTMQVYPDEGHNVSEK		Y		Y
IPI00873846.1	DPP10 Isoform 1 of Inactive dipeptidyl peptidase 10	LNIET*N*ATTLLLE*N*TTFVTFK		Y1,Y2		Y1,Y2
IPI00873889.1	LAMA2 Uncharacterized protein LAMA2	VSQAESHAAQL*N*DSSAVLDGILDEAK		Y	Y	
IPI00874147.1	CXADR Uncharacterized protein CXADR (Fragment)	SGDASI*N*VTNLQLSDIGTYQCK		Y	Y	
IPI00874212.1	CREG1 27 kDa protein	IVTPEEYY*N*VT		Y		
IPI00874212.1	CREG1 27 kDa protein	L*N*ITNIWVLDYFGGPK		Y		
IPI00876857.1	TTYH3 Isoform 2 of Protein tweety homolog 3	VWDTAVGL*N*HTAEPSLQTLER		Y	Y	
IPI00877100.1	ACE Isoform Somatic-2 of Angiotensin-converting enzyme, somatic isoform precursor	ELYEPIWQ*N*FTDPQLR		Y	Y	
IPI00877110.1	SLC12A5 Isoform 1 of Solute carrier family 12 member 5	FL*N*ATCDEYFTR				Y
IPI00877110.1	SLC12A5 Isoform 1 of Solute carrier family 12 member 5	N*N*VTEIQGIPGAASGLIK				Y
IPI00877115.1	SLC39A12 Isoform 4 of Zinc transporter ZIP12	QDEDSSFLSQ*N*ETEDILAFTR				Y
IPI00877792.1	FGG 50 kDa protein	VDKDLQSLEDILHQVE*N*K		Y	Y	
IPI00878568.1	RTN4R Protein	DLG*N*LTHLFLHGNR	Y		Y	
IPI00879665.1	SEZ6L Seizure related 6 homolog (Mouse)-like	DPYW*N*DTEPLCR		Y	Y	
IPI00879883.1	RNF13 15 kDa protein	DILAYNFE*N*ASQTFDDLPAR				Y
IPI00879883.1	RNF13 15 kDa protein	D*N*SSGTFIVLIR				Y
IPI00879931.1	SERPING1 cDNA FLJ78023, highly similar to Homo sapiens serine (or cysteine) proteinase inhibitor, clade G (C1inhibitor), member 1, (angioedema, hereditary) (SERPING1), mRNA	VLS*N*NSDANLELINTWVAK	Y		Y	
IPI00880178.1	C19orf63 Isoform 3 of UPF0510 protein C19orf63 precursor	GHEVEDVDLELF*N*TSVQLQPPTTAPGPETAAFIER				Y
IPI00884105.1	LAMP1 Lysosome-associated membrane glycoprotein 1 precursor	E*N*TSDPSLVIAFGR	Y		Y	
IPI00884105.1	LAMP1 Lysosome-associated membrane glycoprotein 1 precursor	GHTLTL*N*FTR	Y		Y	
IPI00884105.1	LAMP1 Lysosome-associated membrane glycoprotein 1 precursor	SSCGKE*N*TSDPSLVIAFGR	Y		Y	
IPI00889518.1	MOG Myelin oligodendrocyte glycoprotein isoform alpha1 variant (Fragment)	ISPGK*N*ATGMEVGWYRPPFSR		Y		Y
IPI00889723.1	C4A;C4B complement component 4B preproprotein	FSDGLES*N*SSTQFEVK	Y		Y	
IPI00889723.1	C4A;C4B complement component 4B preproprotein	GL*N*VTLSSTGR	Y		Y	

EBI, European Bioinformatics Institute; ISB, Institute for Systems Biology; N, N-glycosylated site.

REFERENCES

Aarsland D, Larsen JP, Karlsen K, Lim NG, Tandberg E. 1999. Mental symptoms in Parkinson's disease are important contributors to caregiver distress. Int J Geriatr Psychiatry 14:866–874.

Aarsland D, Andersen K, Larsen JP, Lolk A, Nielsen H, Kragh-Sorensen P. 2001. Risk of dementia in Parkinson's disease: A community-based, prospective study. Neurology 56:730–736.

Aarsland D, Andersen K, Larsen JP, Lolk A, Kragh-Sorensen P. 2003. Prevalence and characteristics of dementia in Parkinson disease: An 8-year prospective study. Arch Neurol 60:387–392.

Abdi F, Quinn JF, Jankovic J, McIntosh M, Leverenz JB, Peskind E, Nixon R, Nutt J, Chung K, Zabetian C, Samii A, Lin M, Hattan S, Pan C, Wang Y, Jin J, Zhu D, Li GJ, Liu Y, Waichunas D, Montine TJ, Zhang J. 2006. Detection of biomarkers with a multiplex quantitative proteomic platform in cerebrospinal fluid of patients with neurodegenerative disorders. J Alzheimers Dis 9:293–348.

Aebersold R. 2003. Constellations in a cellular universe. Nature 422:115–116.

Aebersold R, Anderson L, Caprioli R, Druker B, Hartwell L, Smith R. 2005. Perspective: A program to improve protein biomarker discovery for cancer. J Proteome Res 4:1104–1109.

Aggarwal K, Choe LH, Lee KH. 2006. Shotgun proteomics using the iTRAQ isobaric tags. Brief Funct Genomic Proteomic 5:112–120.

Alexa A, Rahnenfuhrer J, Lengauer T. 2006. Improved scoring of functional groups from gene expression data by decorrelating GO graph structure. Bioinformatics 22:1600–1607.

Anderson L. 2005. Candidate-based proteomics in the search for biomarkers of cardiovascular disease. J Physiol 563:23–60.

Anderson L, Hunter CL. 2006. Quantitative mass spectrometric multiple reaction monitoring assays for major plasma proteins. Mol Cell Proteomics 5:573–588.

Anderson NL, Anderson NG, Haines LR, Hardie DB, Olafson RW, Pearson TW. 2004. Mass spectrometric quantitation of peptides and proteins using Stable Isotope Standards and Capture by Anti-Peptide Antibodies (SISCAPA). J Proteome Res 3:235–244.

Apweiler R, Hermjakob H, Sharon N. 1999. On the frequency of protein glycosylation, as deduced from analysis of the SWISS-PROT database. Biochim Biophys Acta 1473:4–8.

Arakawa T, Kita Y, Niikura T. 2008. A rescue factor for Alzheimer's diseases: Discovery, activity, structure, and mechanism. Curr Med Chem 15:2086–2098.

Bahl JM, Jensen SS, Larsen MR, Heegaard NH. 2008. Characterization of the human cerebrospinal fluid phosphoproteome by titanium dioxide affinity chromatography and mass spectrometry. Anal Chem 80:6308–6316.

Borghi R, Marchese R, Negro A, Marinelli L, Forloni G, Zaccheo D, Abbruzzese G, Tabaton M. 2000. Full length alpha-synuclein is present in cerebrospinal fluid from Parkinson's disease and normal subjects. Neurosci Lett 287:65–67.

Braak H, Rub U, Sandmann-Keil D, Gai WP, de Vos RA, Jansen Steur EN, Arai K, Braak E. 2000. Parkinson's disease: Affection of brain stem nuclei controlling premotor and motor neurons of the somatomotor system. Acta Neuropathol 99:489–495.

Braak H, Del Tredici K, Bratzke H, Hamm-Clement J, Sandmann-Keil D, Rub U. 2002. Staging of the intracerebral inclusion body pathology associated with idiopathic Parkinson's disease (preclinical and clinical stages). J Neurol 249III:1–5.

Braak H, Del Tredici K, Rub U, de Vos RA, Jansen Steur EN, Braak E. 2003. Staging of brain pathology related to sporadic Parkinson's disease. Neurobiol Aging 24:197–211.

Bundy JL, Fenselau C. 2001. Lectin and carbohydrate affinity capture surfaces for mass spectrometric analysis of microorganisms. Anal Chem 73:751–757.

Bunkenborg J, Pilch BJ, Podtelejnikov AV, Wisniewski JR. 2004. Screening for N-glycosylated proteins by liquid chromatography mass spectrometry. Proteomics 4:454–465.

Butterfield DA, Castegna A, Thongboonkerd V, Klein JB, Lynn B, Markesbery WR, Tsuji T, Shiozaki A, Kohno R, Yoshizato K, Shimohama S, Aksenov M, Pierce WM, Booze R. 2003. Proteomic analysis of oxidatively modified proteins in Alzheimer's disease brain: Insights into neurodegeneration. Cell Mol Biol (Noisy-le-grand) 49:747–751.

Castegna A, Aksenov M, Thongboonkerd V, Klein JB, Pierce WM, Booze R, Markesbery WR, Butterfield DA. 2002. Proteomic identification of oxidatively modified proteins in Alzheimer's disease brain. Part II: Dihydropyrimidinase-related protein 2, alpha-enolase and heat shock cognate 71. J Neurochem 82:1524–1532.

Casu B, Guerrini M, Torri G. 2004. Structural and conformational aspects of the anticoagulant and anti-thrombotic activity of heparin and dermatan sulfate. Curr Pharm Des 10:939–949.

Catalina MI, Koeleman CA, Deelder AM, Wuhrer M. 2007. Electron transfer dissociation of N-glycopeptides: Loss of the entire N-glycosylated asparagine side chain. Rapid Commun Mass Spectrom 21:1053–1061.

Chiang PK, Lam MA, Luo Y. 2008. The many faces of amyloid beta in Alzheimer's disease. Curr Mol Med 8:580–584.

Colangelo CM, Williams KR. 2006. Isotope-coded affinity tags for protein quantification. Methods Mol Biol 328:151–158.

Collins BE, Paulson JC. 2004. Cell surface biology mediated by low affinity multivalent protein-glycan interactions. Curr Opin Chem Biol 8:617–625.

Cookson MR. 2005. The biochemistry of Parkinson's disease. Annu Rev Biochem 74:29–52.

Cummings RD, Kornfeld S. 1982. Fractionation of asparagine-linked oligosaccharides by serial lectin-Agarose affinity chromatography. A rapid, sensitive, and specific technique. J Biol Chem 257:11235–11240.

D'Ascenzo M, Choe L, Lee KH. 2008. iTRAQPak: An R based analysis and visualization package for 8-plex isobaric protein expression data. Brief Funct Genomic Proteomic 7:127–135.

Dexter DT, Wells FR, Lees AJ, Agid F, Agid Y, Jenner P, Marsden CD. 1989. Increased nigral iron content and alterations in other metal ions occurring in brain in Parkinson's disease. J Neurochem 52:1830–1836.

Dube DH, Bertozzi CR. 2005. Glycans in cancer and inflammation—Potential for therapeutics and diagnostics. Nat Rev Drug Discov 4:477–488.

Durham M, Regnier FE. 2006. Targeted glycoproteomics: Serial lectin affinity chromatography in the selection of O-glycosylation sites on proteins from the human blood proteome. J Chromatogr A 1132:165–173.

El-Agnaf OM, Salem SA, Paleologou KE, Curran MD, Gibson MJ, Court JA, Schlossmacher MG, Allsop D. 2006. Detection of oligomeric forms of alpha-synuclein protein in human plasma as a potential biomarker for Parkinson's disease. FASEB J 20:419–425.

Farrer M, Chan P, Chen R, Tan L, Lincoln S, Hernandez D, Forno L, Gwinn-Hardy K, Petrucelli L, Hussey J, Singleton A, Tanner C, Hardy J, Langston JW. 2001. Lewy bodies and parkinsonism in families with parkin mutations. Ann Neurol 50:293–300.

Finehout EJ, Franck Z, Choe LH, Relkin N, Lee KH. 2007. Cerebrospinal fluid proteomic biomarkers for Alzheimer's disease. Ann Neurol 61:120–129.

Foltynie T, Brayne CE, Robbins TW, Barker RA. 2004. The cognitive ability of an incident cohort of Parkinson's patients in the UK. The CamPaIGN study. Brain 127:550–560.

Gendler SJ, Spicer AP. 1995. Epithelial mucin genes. Annu Rev Physiol 57:607–634.

Gerber SA, Rush J, Stemman O, Kirschner MW, Gygi SP. 2003. Absolute quantification of proteins and phosphoproteins from cell lysates by tandem MS. Proc Natl Acad Sci USA 100:6940–6945.

Ghosh D, Krokhin O, Antonovici M, Ens W, Standing KG, Beavis RC, Wilkins JA. 2004. Lectin affinity as an approach to the proteomic analysis of membrane glycoproteins. J Proteome Res 3:841–850.

Goldstein IJ, Hollerman CE, Smith EE. 1965. Protein-carbohydrate interaction. II. Inhibition studies on the interaction of concanavalin a with polysaccharides. Biochemistry 4:876–883.

Gulcicek EE, Colangelo CM, McMurray W, Stone K, Williams K, Wu T, Zhao H, Spratt H, Kurosky A, Wu B. 2005. Proteomics and the analysis of proteomic data: An overview of current protein-profiling technologies. Curr Protoc Bioinformatics Chapter 13:Unit 13.1.

Guo Y, Feinberg H, Conroy E, Mitchell DA, Alvarez R, Blixt O, Taylor ME, Weis WI, Drickamer K. 2004. Structural basis for distinct ligand-binding and targeting properties of the receptors DC-SIGN and DC-SIGNR. Nat Struct Mol Biol 11:591–598.

Gygi SP, Rist B, Gerber SA, Turecek F, Gelb MH, Aebersold R. 1999. Quantitative analysis of complex protein mixtures using isotope-coded affinity tags. Nat Biotechnol 17:994–999.

Hagglund P, Bunkenborg J, Elortza F, Jensen ON, Roepstorff P. 2004. A new strategy for identification of N-glycosylated proteins and unambiguous assignment of their glycosylation sites using HILIC enrichment and partial deglycosylation. J Proteome Res 3:556–566.

Hakansson K, Cooper HJ, Emmett MR, Costello CE, Marshall AG, Nilsson CL. 2001. Electron capture dissociation and infrared multiphoton dissociation MS/MS of an N-glycosylated tryptic peptic to yield complementary sequence information. Anal Chem 73:4530–4536.

Haltiwanger RS, Lowe JB. 2004. Role of glycosylation in development. Annu Rev Biochem 73:491–537.

Hanisch FG. 2001. O-glycosylation of the mucin type. Biol Chem 382:143–149.

Hanisch FG, Jovanovic M, Peter-Katalinic J. 2001. Glycoprotein identification and localization of O-glycosylation sites by mass spectrometric analysis of deglycosylated/alkylaminylated peptide fragments. Anal Biochem 290:47–59.

Hann SR. 2006. Role of post-translational modifications in regulating c-Myc proteolysis, transcriptional activity and biological function. Semin Cancer Biol 16:288–302.

Haqqani AS, Kelly JF, Stanimirovic DB. 2008. Quantitative protein profiling by mass spectrometry using isotope-coded affinity tags. Methods Mol Biol 439:225–240.

Haynes PA, Aebersold R. 2000. Simultaneous detection and identification of O-GlcNAc-modified glycoproteins using liquid chromatography-tandem mass spectrometry. Anal Chem 72:5402–5410.

Hirabayashi J. 2004. Lectin-based structural glycomics: Glycoproteomics and glycan profiling. Glycoconj J 21:35–40.

Hirotani M, Maita C, Niino M, Iguchi-Ariga S, Hamada S, Ariga H, Sasaki H. 2008. Correlation between DJ-1 levels in the cerebrospinal fluid and the progression of disabilities in multiple sclerosis patients. Mult Scler 14:1056–1060.

Hogan JM, Pitteri SJ, Chrisman PA, McLuckey SA. 2005. Complementary structural information from a tryptic N-linked glycopeptide via electron transfer ion/ion reactions and collision-induced dissociation. J Proteome Res 4:628–632.

Hsu YC, Perin MS. 1995. Human neuronal pentraxin II (NPTX2): Conservation, genomic structure, and chromosomal localization. Genomics 28:220–227.

Hwang HY, Olson SK, Esko JD, Horvitz HR. 2003. Caenorhabditis elegans early embryogenesis and vulval morphogenesis require chondroitin biosynthesis. Nature 423:439–443.

Inatani M, Irie F, Plump AS, Tessier-Lavigne M, Yamaguchi Y. 2003. Mammalian brain morphogenesis and midline axon guidance require heparan sulfate. Science 302:1044–1046.

Irungu J, Go EP, Zhang Y, Dalpathado DS, Liao HX, Haynes BF, Desaire H. 2008. Comparison of HPLC/ESI-FTICR MS versus MALDI-TOF/TOF MS for glycopeptide analysis of a highly glycosylated HIV envelope glycoprotein. J Am Soc Mass Spectrom 19:1209–1220.

Jakowec MW, Petzinger GM, Sastry S, Donaldson DM, McCormack A, Langston JW. 1998. The native form of alpha-synuclein is not found in the cerebrospinal fluid of patients with Parkinson's disease or normal controls. Neurosci Lett 253:13–16.

Jankovic J. 2001. Parkinson's disease. A half century of progress. Neurology 57:S1–S3.

Jin J, Hulette C, Wang Y, Zhang T, Pan C, Wadhwa R, Zhang J. 2006. Proteomic identification of a stress protein, mortalin/mthsp70/GRP75: Relevance to Parkinson disease. Mol Cell Proteomics 5:1193–1204.

Jobst KA, Barnetson LP, Shepstone BJ. 1997. Accurate prediction of histologically confirmed Alzheimer's disease and the differential diagnosis of dementia: The use of NINCDS-ADRDA and DSM-III-R criteria, SPECT, X-ray CT, and APO E4 medial temporal lobe dementias. The Oxford Project to Investigate Memory and Aging. Int Psychogeriatr 9 (Suppl 1):191–222; discussion 247–252.

Johansen PG, Marshall RD, Neuberger A. 1961. Carbohydrates in protein. 3. The preparation and some of the properties of a glycopeptide from hen's-egg albumin. Biochem J 78:518–527.

Kaji H, Saito H, Yamauchi Y, Shinkawa T, Taoka M, Hirabayashi J, Kasai K, Takahashi N, Isobe T. 2003. Lectin affinity capture, isotope-coded tagging and mass spectrometry to identify N-linked glycoproteins. Nat Biotechnol 21:667–672.

Kaji H, Yamauchi Y, Takahashi N, Isobe T. 2006. Mass spectrometric identification of N-linked glycopeptides using lectin-mediated affinity capture and glycosylation site-specific stable isotope tagging. Nat Protoc 1:3019–3027.

Kameyama A, Nakaya S, Ito H, Kikuchi N, Angata T, Nakamura M, Ishida HK, Narimatsu H. 2006. Strategy for simulation of CID spectra of N-linked oligosaccharides toward glycomics. J Proteome Res 5:808–814.

Kamra A, Gupta MN. 1987. Crosslinked concanavalin A-O-(diethylaminoethyl)-cellulose–an affinity medium for concanavalin A-interacting glycoproteins. Anal Biochem 164:405–410.

Kaplan A, Achord DT, Sly WS. 1977. Phosphohexosyl components of a lysosomal enzyme are recognized by pinocytosis receptors on human fibroblasts. Proc Natl Acad Sci USA 74:2026–2030.

Kinjo Y, Wu D, Kim G, Xing GW, Poles MA, Ho DD, Tsuji M, Kawahara K, Wong CH, Kronenberg M. 2005. Recognition of bacterial glycosphingolipids by natural killer T cells. Nature 434:520–525.

Kitsou E, Pan S, Zhang J, Shi M, Zabeti A, Dickson D, Albin R, Gearing M, Kashima D, Wang Y, Beyer R, Zhou Y, Pan C, Caudle W, Zhang J. 2008. Identification of proteins in human substantia nigra. Proteomics Clin Appl 2:776–782.

Korolainen MA, Goldsteins G, Alafuzoff I, Koistinaho J, Pirttila T. 2002. Proteomic analysis of protein oxidation in Alzheimer's disease brain. Electrophoresis 23:3428–3433.

Krokhin O, Ens W, Standing KG, Wilkins J, Perreault H. 2004. Site-specific N-glycosylation analysis: Matrix-assisted laser desorption/ionization quadrupole-quadrupole time-of-flight tandem mass spectral signatures for recognition and identification of glycopeptides. Rapid Commun Mass Spectrom 18:2020–2030.

Kubota K, Sato Y, Suzuki Y, Goto-Inoue N, Toda T, Suzuki M, Hisanaga S, Suzuki A, Endo T. 2008. Analysis of glycopeptides using lectin affinity chromatography with MALDI-TOF mass spectrometry. Anal Chem 80:3693–3698.

Kuno A, Uchiyama N, Koseki-Kuno S, Ebe Y, Takashima S, Yamada M, Hirabayashi J. 2005. Evanescent-field fluorescence-assisted lectin microarray: A new strategy for glycan profiling. Nat Methods 2:851–856.

Kurogochi M, Nishimura S. 2004. Structural characterization of N-glycopeptides by matrix-dependent selective fragmentation of MALDI-TOF/TOF tandem mass spectrometry. Anal Chem 76:6097–6101.

Kussmann M, Lassing U, Sturmer CA, Przybylski M, Roepstorff P. 1997. Matrix-assisted laser desorption/ionization mass spectrometric peptide mapping of the neural cell adhesion protein neurolin purified by sodium dodecyl sulfate polyacrylamide gel electrophoresis or acidic precipitation. J Mass Spectrom 32:483–493.

Larsen MR, Cordwell SJ, Roepstorff P. 2002. Graphite powder as an alternative or supplement to reversed-phase material for desalting and concentration of peptide mixtures prior to matrix-assisted laser desorption/ionization-mass spectrometry. Proteomics 2:1277–1287.

Lattard V, Fondeur-Gelinotte M, Gulberti S, Jacquinet JC, Boudrant J, Netter P, Magdalou J, Ouzzine M, Fournel-Gigleux S. 2006. Purification and characterization of a soluble form of the recombinant human galactose-beta1,3-glucuronosyltransferase I expressed in the yeast Pichia pastoris. Protein Expr Purif 47:137–143.

Leverenz JB, Umar I, Wang Q, Montine TJ, McMillan PJ, Tsuang DW, Jin J, Pan C, Shin J, Zhu D, Zhang J. 2007. Proteomic identification of novel proteins in cortical Lewy bodies. Brain Pathol 17:139–145.

Levin BE, Katzen HL. 2005. Early cognitive changes and nondementing behavioral abnormalities in Parkinson's disease. Adv Neurol 96:84–94.

Levin Y, Schwarz E, Wang L, Leweke FM, Bahn S. 2007. Label-free LC-MS/MS quantitative proteomics for large-scale biomarker discovery in complex samples. J Sep Sci 30:2198–2203.

Lin X. 2004. Functions of heparan sulfate proteoglycans in cell signaling during development. Development 131:6009–6021.

Liu F, Zaidi T, Iqbal K, Grundke-Iqbal I, Merkle RK, Gong CX. 2002. Role of glycosylation in hyperphosphorylation of tau in Alzheimer's disease. FEBS Lett 512:101–106.

Liu T, Qian WJ, Gritsenko MA, Camp DG II, Monroe ME, Moore RJ, Smith RD. 2005. Human plasma N-glycoproteome analysis by immunoaffinity subtraction, hydrazide chemistry, and mass spectrometry. J Proteome Res 4:2070–2080.

Lochnit G, Geyer R. 2004. An optimized protocol for nano-LC-MALDI-TOF-MS coupling for the analysis of proteolytic digests of glycoproteins. Biomed Chromatogr 18:841–848.

Lowe JB, Marth JD. 2003. A genetic approach to Mammalian glycan function. Annu Rev Biochem 72:643–691.

Lowe J, Graham L, Leigh PN. 1997. Disorders of movement and system degeneration. In: Graham DI, Lantos PL, editors. Greenfield's neuropathology. London: Arnold. pp. 281–366.

Madera M, Mechref Y, Novotny MV. 2005. Combining lectin microcolumns with high-resolution separation techniques for enrichment of glycoproteins and glycopeptides. Anal Chem 77:4081–4090.

Madera M, Mechref Y, Klouckova I, Novotny MV. 2006. Semiautomated high-sensitivity profiling of human blood serum glycoproteins through lectin preconcentration and multidimensional chromatography/tandem mass spectrometry. J Proteome Res 5:2348–2363.

Madera M, Mechref Y, Klouckova I, Novotny MV. 2007. High-sensitivity profiling of glycoproteins from human blood serum through multiple-lectin affinity chromatography and liquid chromatography/tandem mass spectrometry. J Chromatogr B Analyt Technol Biomed Life Sci 845:121–137.

Marder K, Tang MX, Cote L, Stern Y, Mayeux R. 1995. The frequency and associated risk factors for dementia in patients with Parkinson's disease. Arch Neurol 52:695–701.

Martin B, Brenneman R, Becker KG, Gucek M, Cole RN, Maudsley S. 2008. iTRAQ analysis of complex proteome alterations in 3xTgAD Alzheimer's mice: Understanding the interface between physiology and disease. PLoS ONE 3:. 2750.

Miller SI, Ernst RK, Bader MW. 2005. LPS, TLR4 and infectious disease diversity. Nat Rev Microbiol 3:36–46.

Monzo A, Bonn GK, Guttman A. 2007. Boronic acid-lectin affinity chromatography. 1. Simultaneous glycoprotein binding with selective or combined elution. Anal Bioanal Chem 389:2097–2102.

Moore DJ, West AB, Dawson VL, Dawson TM. 2005. Molecular pathophysiology of Parkinson's disease. Annu Rev Neurosci 28:57–87.

Moran LB, Hickey L, Michael GJ, Derkacs M, Christian LM, Kalaitzakis ME, Pearce RK, Graeber MB. 2008. Neuronal pentraxin II is highly upregulated in Parkinson's disease and a novel component of Lewy bodies. Acta Neuropathol 115:471–478.

Morelle W, Michalski JC. 2005. Glycomics and mass spectrometry. Curr Pharm Des 11:2615–2645.

Mormann M, Paulsen H, Peter-Katalinic J. 2005. Electron capture dissociation of O-glycosylated peptides: Radical site-induced fragmentation of glycosidic bonds. Eur J Mass Spectrom (Chichester, England) 11:497–511.

Nagata Y, Burger MM. 1974. Wheat germ agglutinin. Molecular characteristics and specificity for sugar binding. J Biol Chem 249:3116–3122.

Nalivaeva NN, Turner AJ. 2001. Post-translational modifications of proteins: Acetylcholinesterase as a model system. Proteomics 1:735–747.

Niethammer P, Delling M, Sytnyk V, Dityatev A, Fukami K, Schachner M. 2002. Cosignaling of NCAM via lipid rafts and the FGF receptor is required for neuritogenesis. J Cell Biol 157:521–532.

Novogrodsky A, Lotan R, Ravid A, Sharon N. 1975. Peanut agglutinin, a new mitogen that binds to galactosyl sites exposed after neuraminidase treatment. J Immunol 115:1243–1248.

Nussbaum M, Treves TA, Inzelberg R, Rabey JM, Korczyn AD. 1998. Survival in Parkinson's disease: The effect of dementia. Parkinsonism Relat Disord 4:179–181.

Ohtsubo K, Marth JD. 2006. Glycosylation in cellular mechanisms of health and disease. Cell 126:855–867.

Osorio C, Sullivan PM, He DN, Mace BE, Ervin JF, Strittmatter WJ, Alzate O. 2007. Mortalin is regulated by APOE in hippocampus of AD patients and by human APOE in TR mice. Neurobiol Aging 28:1853–1862.

Pan S, Zhang H, Rush J, Eng J, Zhang N, Patterson D, Comb MJ, Aebersold R. 2005. High throughput proteome screening for biomarker detection. Mol Cell Proteomics 4:182–190.

Pan S, Wang Y, Quinn JF, Peskind ER, Waichunas D, Wimberger JT, Jin J, Li JG, Zhu D, Pan C, Zhang J. 2006. Identification of glycoproteins in human cerebrospinal fluid with a complementary proteomic approach. J Proteome Res 5:2769–2779.

Pan S, Shi M, Jin J, Albin RL, Lieberman A, Gearing M, Lin B, Pan C, Yan X, Kashima DT, Zhang J. 2007a. Proteomics identification of proteins in human cortex using multidimensional separations and MALDI tandem mass spectrometer. Mol Cell Proteomics 6:1818–1823.

Pan S, Zhu D, Quinn JF, Peskind ER, Montine TJ, Lin B, Goodlett DR, Taylor G, Eng J, Zhang J. 2007b. A combined dataset of human cerebrospinal fluid proteins identified by multi-dimensional chromatography and tandem mass spectrometry. Proteomics 7:469–473.

Pan S, Rush J, Peskind ER, Galasko D, Chung K, Quinn J, Jankovic J, Leverenz JB, Zabetian C, Pan C, Wang Y, Oh JH, Gao J, Zhang J, Montine T, Zhang J. 2008. Application of targeted quantitative proteomics analysis in human cerebrospinal fluid using a liquid chromatography matrix-assisted laser desorption/ionization time-of-flight tandem mass spectrometer (LC MALDI TOF/TOF) platform. J Proteome Res 7:720–730.

Pisani A, Centonze D, Bernardi G, Calabresi P. 2005. Striatal synaptic plasticity: Implications for motor learning and Parkinson's disease. Mov Disord 20:395–402.

Qian WJ, Jacobs JM, Liu T, Camp DG II, Smith RD. 2006. Advances and challenges in liquid chromatography-mass spectrometry-based proteomics profiling for clinical applications. Mol Cell Proteomics 5:1727–1744.

Rademaker GJ, Pergantis SA, Blok-Tip L, Langridge JI, Kleen A, Thomas-Oates JE. 1998. Mass spectrometric determination of the sites of O-glycan attachment with low picomolar sensitivity. Anal Biochem 257:149–160.

Riederer P, Sofic E, Rausch WD, Schmidt B, Reynolds GP, Jellinger K, Youdim MB. 1989. Transition metals, ferritin, glutathione, and ascorbic acid in parkinsonian brains. J Neurochem 52:515–520.

Rite I, Arguelles S, Venero JL, Garcia-Rodriguez S, Ayala A, Cano J, Machado A. 2007. Proteomic identification of biomarkers in the cerebrospinal fluid in a rat model of nigrostriatal dopaminergic degeneration. J Neurosci Res 85:3607–3618.

Robertson LA, Moya KL, Breen KC. 2004. The potential role of tau protein O-glycosylation in Alzheimer's disease. J Alzheimers Dis 6:489–495.

Roth J. 2002. Protein N-glycosylation along the secretory pathway: Relationship to organelle topography and function, protein quality control, and cell interactions. Chem Rev 102:285–303.

Rutishauser U, Edelman GM. 1980. Effects of fasciculation on the outgrowth of neurites from spinal ganglia in culture. J Cell Biol 87:370–378.

Saez-Valero J, Small DH. 2001. Acetylcholinesterase and butyrylcholinesterase glycoforms are biomarkers of Alzheimer's disease. J Alzheimers Dis 3:323–328.

Saez-Valero J, Sberna G, McLean CA, Small DH. 1999. Molecular isoform distribution and glycosylation of acetylcholinesterase are altered in brain and cerebrospinal fluid of patients with Alzheimer's disease. J Neurochem 72:1600–1608.

Saez-Valero J, Barquero MS, Marcos A, McLean CA, Small DH. 2000. Altered glycosylation of acetylcholinesterase in lumbar cerebrospinal fluid of patients with Alzheimer's disease. J Neurol Neurosurg Psychiatry 69:664–667.

Saez-Valero J, Fodero LR, Sjogren M, Andreasen N, Amici S, Gallai V, Vanderstichele H, Vanmechelen E, Parnetti L, Blennow K, Small DH. 2003. Glycosylation of acetylcholinesterase and butyrylcholinesterase changes as a function of the duration of Alzheimer's disease. J Neurosci Res 72:520–526.

Sasisekharan R, Shriver Z, Venkataraman G, Narayanasami U. 2002. Roles of heparan-sulphate glycosaminoglycans in cancer. Nat Rev Cancer 2:521–528.

Schrag A, Jahanshahi M, Quinn N. 2000. How does Parkinson's disease affect quality of life? A comparison with quality of life in the general population. Mov Disord 15:1112–1118.

Sharon N, Lis H. 1989. Lectins as cell recognition molecules. Science 246:227–234.

Shi M, Jin J, Wang Y, Beyer RP, Kitsou E, Albin RL, Gearing M, Pan C, Zhang J. 2008. Mortalin: A protein associated with progression of Parkinson disease? J Neuropathol Exp Neurol 67:117–124.

Shimura H, Schlossmacher MG, Hattori N, Frosch MP, Trockenbacher A, Schneider R, Mizuno Y, Kosik KS, Selkoe DJ. 2001. Ubiquitination of a new form of alpha-synuclein by parkin from human brain: Implications for Parkinson's disease. Science 293:263–269.

Siddique N, Siddique T. 2008. Genetics of amyotrophic lateral sclerosis. Phys Med Rehabil Clin N Am 19:429–439, vii.

Sihlbom C, Davidsson P, Emmett MR, Marshall AG, Nilsson CL. 2004. Glycoproteomics of cerebrospinal fluid in neurodegenerative disease. Int J Mass Spectrom 234:145–152.

Silveyra MX, Cuadrado-Corrales N, Marcos A, Barquero MS, Rabano A, Calero M, Saez-Valero J. 2006. Altered glycosylation of acetylcholinesterase in Creutzfeldt-Jakob disease. J Neurochem 96:97–104.

Simonsen AH, McGuire J, Podust VN, Hagnelius NO, Nilsson TK, Kapaki E, Vassilopoulos D, Waldemar G. 2007. A novel panel of cerebrospinal fluid biomarkers for the differential diagnosis of Alzheimer's disease versus normal aging and frontotemporal dementia. Dement Geriatr Cogn Disord 24:434–440.

Song X, Bandow J, Sherman J, Baker JD, Brown PW, McDowell MT, Molloy MP. 2008. iTRAQ experimental design for plasma biomarker discovery. J Proteome Res 7:2952–2958.

Spiro RG. 1964. Periodate oxidation of the glycoprotein fetuin. J Biol Chem 239:567–573.

Spiro RG. 1973. Glycoproteins. Adv Protein Chem 27:349–467.

Spiro RG. 2002. Protein glycosylation: Nature, distribution, enzymatic formation, and disease implications of glycopeptide bonds. Glycobiology 12:43R–56R.

Srivastava R, Murphy MJ, Jeffery J. 2008. Cerebrospinal fluid: The role of biochemical analysis. Br J Hosp Med (Lond) 69:218–221.

Stephens E, Sugars J, Maslen SL, Williams DH, Packman LC, Ellar DJ. 2004. The N-linked oligosaccharides of aminopeptidase N from Manduca sexta: Site localization and identification of novel N-glycan structures. Eur J Biochem 271:4241–4258.

Sudo S, Shiozawa M, Cairns NJ, Wada Y. 2005. Aberrant accentuation of neurofibrillary degeneration in the hippocampus of Alzheimer's disease with amyloid precursor protein 717 and presenilin-1 gene mutations. J Neurol Sci 234:55–65.

Sun B, Ranish JA, Utleg AG, White JT, Yan X, Lin B, Hood L. 2007. Shotgun glycopeptide capture approach coupled with mass spectrometry for comprehensive glycoproteomics. Mol Cell Proteomics 6:141–149.

Suzuki T, Kitajima K, Inoue S, Inoue Y. 1995. N-glycosylation/deglycosylation as a mechanism for the post-translational modification/remodification of proteins. Glycoconj J 12:183–193.

Tan EK, Skipper LM. 2007. Pathogenic mutations in Parkinson disease. Hum Mutat 28:641–653.

Tanaka K, Bertolini M, Pigman W. 1964 Serine and threonine glycosidic linkages in bovine submaxillary mucin. Biochem Biophys Res Commun 16:404–409.

Thomas B, Beal MF. 2007. Parkinson's disease. Hum Mol Genet 16: (2):R183–R194.

Tokuda T, Salem SA, Allsop D, Mizuno T, Nakagawa M, Qureshi MM, Locascio JJ, Schlossmacher MG, El-Agnaf OM. 2006. Decreased alpha-synuclein in cerebrospinal fluid of aged individuals and subjects with Parkinson's disease. Biochem Biophys Res Commun 349:162–166.

Tumani H, Teunissen C, Sussmuth S, Otto M, Ludolph AC, Brettschneider J. 2008. Cerebrospinal fluid biomarkers of neurodegeneration in chronic neurological diseases. Expert Rev Mol Diagn 8:479–494.

Varki A, Kornfeld S. 1980. Structural studies of phosphorylated high mannose-type oligosaccharides. J Biol Chem 255:10847–10858.

Verbeek MM, De Jong D, Kremer HP. 2003. Brain-specific proteins in cerebrospinal fluid for the diagnosis of neurodegenerative diseases. Ann Clin Biochem 40:25–40.

Wakabayashi K, Tanji K, Mori F, Takahashi H. 2007. The Lewy body in Parkinson's disease: Molecules implicated in the formation and degradation of alpha-synuclein aggregates. Neuropathology 27:494–506.

Wang Y, Wu SL, Hancock WS. 2006. Approaches to the study of N-linked glycoproteins in human plasma using lectin affinity chromatography and nano-HPLC coupled to electrospray linear ion trap—Fourier transform mass spectrometry. Glycobiology 16:514–523.

Waragai M, Wei J, Fujita M, Nakai M, Ho GJ, Masliah E, Akatsu H, Yamada T, Hashimoto M. 2006. Increased level of DJ-1 in the cerebrospinal fluids of sporadic Parkinson's disease. Biochem Biophys Res Commun 345:967–972.

Wenk GL. 2003. Neuropathologic changes in Alzheimer's disease. J Clin Psychiatry 64 (Suppl 9):7–10.

Wiener MC, van Hoek AN. 1996. A lectin screening method for membrane glycoproteins: Application to the human CHIP28 water channel (AQP-1). Anal Biochem 241:267–268.

Williams-Gray CH, Foltynie T, Brayne CE, Robbins TW, Barker RA. 2007. Evolution of cognitive dysfunction in an incident Parkinson's disease cohort. Brain 130:1787–1798.

Wuhrer M, Hokke CH, Deelder AM. 2004. Glycopeptide analysis by matrix-assisted laser desorption/ionization tandem time-of-flight mass spec-

trometry reveals novel features of horseradish peroxidase glycosylation. Rapid Commun Mass Spectrom 18:1741–1748.

Xiong L, Andrews D, Regnier F. 2003. Comparative proteomics of glycoproteins based on lectin selection and isotope coding. J Proteome Res 2:618–625.

Yahara I, Edelman GM. 1972. Restriction of the mobility of lymphocyte immunoglobulin receptors by concanavalin A. Proc Natl Acad Sci USA 69:608–612.

Yamashita K, Totani K, Ohkura T, Takasaki S, Goldstein IJ, Kobata A. 1987. Carbohydrate binding properties of complex-type oligosaccharides on immobilized Datura stramonium lectin. J Biol Chem 262:1602–1607.

Yang Z, Hancock WS. 2004. Approach to the comprehensive analysis of glycoproteins isolated from human serum using a multi-lectin affinity column. J Chromatogr A 1053:79–88.

Yang Z, Hancock WS, Chew TR, Bonilla L. 2005. A study of glycoproteins in human serum and plasma reference standards (HUPO) using multilectin affinity chromatography coupled with RPLC-MS/MS. Proteomics 5: 3353–3366.

Yang YR, Liu SL, Qin ZY, Liu FJ, Qin YJ, Bai SM, Chen ZY. 2008. Comparative proteomics analysis of cerebrospinal fluid of patients with Guillain-Barre syndrome. Cell Mol Neurobiol 28:737–744.

Yoshimi K, Ren YR, Seki T, Yamada M, Ooizumi H, Onodera M, Saito Y, Murayama S, Okano H, Mizuno Y, Mochizuki H. 2005. Possibility for neurogenesis in substantia nigra of parkinsonian brain. Ann Neurol 58:31–40.

Yuan X, Desiderio DM. 2003. Proteomics analysis of phosphotyrosyl-proteins in human lumbar cerebrospinal fluid. J Proteome Res 2:476–487.

Yuan X, Desiderio DM. 2005. Human cerebrospinal fluid peptidomics. J Mass Spectrom 40:176–181.

Zaia J. 2008. Mass spectrometry and the emerging field of glycomics. Chem Biol 15:881–892.

Zhang J. 2007. Proteomics of human cerebrospinal fluid—The good, the bad, and the ugly. Proteomics Clin Appl 1:805–819.

Zhang H, Li XJ, Martin DB, Aebersold R. 2003. Identification and quantification of N-linked glycoproteins using hydrazide chemistry, stable isotope labeling and mass spectrometry. Nat Biotechnol 21:660–666.

Zhang J, Sokal I, Peskind ER, Quinn JF, Jankovic J, Kenney C, Chung KA, Millard SP, Nutt JG, Montine TJ. 2008. CSF multianalyte profile distinguishes Alzheimer and Parkinson diseases. Am J Clin Pathol 129: 526–529.

Zhou Y, Aebersold R, Zhang H. 2007. Isolation of N-linked glycopeptides from plasma. Anal Chem 79:5826–5837.

Zougman A, Pilch B, Podtelejnikov A, Kiehntopf M, Schnabel C, Kumar C, Mann M. 2008. Integrated analysis of the cerebrospinal fluid peptidome and proteome. J Proteome Res 7:386–399.