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# Proteome database of hepatocellular carcinoma.

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Review

# Proteome database of hepatocellular carcinoma

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### Abstract

Hepatocellular carcinoma (HCC or hepatoma) is the most common primary cancer of the liver. Persistent viral infection by the hepatic B or C virus is probably the most important cause of HCC worldwide. It is responsible for approximately one million deaths each year, predominantly in the underdeveloped and developing countries, but its incidence is also on the rise in the developed countries. For most patients suffering from HCC, long-term survival is rare, as they are presented late and are often unsuitable for curative treatment. Thus there is great interest to identify novel HCC diagnostic markers for early detection of the disease, and tumour specific associated proteins as potential therapeutic targets in the treatment of HCC. Proteome analyses of HCC cell lines and liver tumour tissues should facilitate the screening and discovery of these HCC proteins. The creation of a comprehensive HCC proteome database would be an important first step towards achieving this goal. This review presents an update of the two-dimensional electrophoresis proteome database of the cell line, HCC-M, which is also now freely accessible through the World Wide Web at http://proteome.btc.nus.edu.sg/hccm/. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Reviews; Proteomics; Hepatocellular carcinoma

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### 1. Introduction

Proteomics refers to the study of the proteome, which is the total protein complement of a genome. There are two major proteomic approaches: one of which is concerned with the global analysis of the total cellular proteins in a given cell type or tissue (protein expression proteomics), while the other seeks to define protein-protein interactions to understand gene function (functional or cell mapping proteomics) [1]. Thus, it has recently been hailed as the next frontier in biology in the postgenomic era. There are numerous applications in proteomics, but the one that is most well established is in the clinical and biomedical fields [2,3]. For example, using protein expression proteomics, disease specific/associated proteins can be identified by comparing the protein profiles of normal versus diseased tissues or biological fluids. Since these proteins are potential diagnostic tools or leads for drugs, proteomics also has great potential in the modern drug discovery process [4]. The disease that has received the greatest attention by proteomics studies is cancer. Several excellent reviews have been published on this subject recently [1,5,6]. In this review, we present an update on the results of the proteome analysis of the hepatocellular carcinoma (HCC or hepatoma) cell line, HCC-M, that would also now be made available the on world wide web http:/ at /proteome.btc.nus.edu.sg/hccm/.

## 2. Hepatocellular carcinoma

### 2.1. Epidemiology and aetiology

HCC is the most common primary cancer in liver, and is responsible for about 1 million deaths per year [7]. For most patients suffering from HCC, long-term survival is rare as they usually die within a year of diagnosis. HCC has been a malignancy of the underdeveloped and developing countries but its incidence is also on the rise in the developed countries. Depending on geographical location, HCC is four to eight times more common in males than in females, and its occurrence also increases progressively with age [7].

Persistent viral infection is probably the most important cause of HCC. Two viruses, hepatitis B virus (HBV) and hepatitis C virus (HCV), cause almost all these tumours. For example, the risk of HCC in a chronic HBV carrier is increased 100-fold as compared to a non-infected individual [8]. HBV infection leads to chronic liver injury, and this includes inflammation, liver regeneration, liver fibrosis and cirrhosis. In fact, it has been shown that more than 80% of patients with HCC have a cirrhotic liver [7]. Other aetiological factors of HCC include exposure to aflatoxins, excessive alcohol consumption, haematochromatosis, tyrosinaemia, and Wilson's disease [7,8].

## 2.2. Treatment

The treatment options available to patients with HCC are surgery, systemic chemotherapy, loco-regional treatment, and symptomatic relief [8]. Of these, only surgery has the potential to cure. However, at presentation, liver resection is only feasible for 10-15% of patients. The reasons for this low resectability rate include extensive local disease, presence of extra-hepatic disease, and poor functional liver reserve precluding any form of liver resection. In the light of this, there is a need to develop better methods to detect HCC at an early stage to allow the performance of curative surgery. By analysing the proteome of HCC, one hopes to identify novel diagnostic markers and specific disease associated proteins that are potential therapeutic targets in the treatment of HCC [8].

# 3. Proteome analysis of hepatocellular carcinoma

Several hepatoma cell lines [9-11] have been used for proteome analyses with the view to better understand the underlying process of hepatocarcinogenesis. Cell lines were chosen as they were more homogeneous in comparison to liver tumour tissues. Moreover, cell lines derived from human tumours have been used extensively as in vitro models of various diseases. For example, in an earlier publication, Wirth et al. [9], on the basis of 60 commonly expressed human liver proteins, reported that the proteins present in the nontransformed cell lines, Chang and WRL-68, were similar to those found in normal human liver. However, proteins expressed in the human hepatoma derived cell lines, HepG2, FOCUS, Huh-7 and SK-Hep1 were markedly different from those found in normal liver [9]. In a more recent study, Yu et al. [11] also reported differences in the proteins expressed between a human hepatoma derived (BEL-7404) and normal (L-02) liver cell line using two-dimensional electrophoresis (2-DE) and liquid chromatography-ion-trap mass spectrometry.

The most comprehensive proteome analysis of a hepatoma cell line, HCC-M, was carried out recently

by Seow et al. [12], Ou et al. [13], and Choong et al. [14]. An integrated approach consisting of 2-DE, matrix-assisted laser desorption/ionisation time-offlight mass spectrometry (MALDI-TOF MS), nanoelectrospray ionisation tandem MS (nESI-MS– MS), bioinformatics, and molecular biology techniques was employed to separate, identify and characterise the expressed proteins of this cell line. These proteins have now been organised into an interactive protein database that integrates the spots with the 2-DE map, and will be posted on the world wide web.

We present below the brief experimental protocols used in this proteomics project, with emphasis on some of the newer techniques, such as sample loading and fluorescent staining with SYPRO Ruby, that were used since our original publication [12] and an update [13]. The results on these newer experiments and the web database will be presented and discussed.

### 3.1. Cell culture and sample preparation

The HCC-M cell line was cultured as described previously [12], in Dulbelcco's modified Eagle medium (DMEM) supplemented with 10% foetal calf serum (FCS), and harvested once a monolayer culture was attained. During harvesting, the cells were rinsed with DMEM without FCS, and the harvested cells were stored at -80 °C. The harvested HCC-M cells were disrupted with a cocktail of 7 Mthiourea. 4% 3-[(3-cholamidopurea. 2 M ropyl)dimethylammonio]-1-propanesulphonate (CH-APS), 40 mM Tris, 1 mM phenylmethylsulphonyl fluoride (PMSF), 50 µg/ml DNase I, and 50 µg/ml RNase A.

# 3.2. Isoelectric focusing

The first dimensional isoelectric focusing (IEF) experiment was carried out on precast 18 cm (or 13 cm) immobilised pH gradient (IPG) strips at 20 °C with a maximum current setting of 50  $\mu$ A/strip in an IPGphor electrophoretic unit (Amersham Biosciences, Uppsala, Sweden). Two types of ceramic strip holders were used for IEF: the regular strip holders, and the newer cup-loading strip holders.

#### 3.2.1. Regular strip holder

The strips were rehydrated at 30 V for 6 h and 60 V for a further 6 h in the regular strip holders in 350  $\mu$ l (250  $\mu$ l for 13 cm strips) of sample containing 7 *M* urea, 2 *M* thiourea, 4% CHAPS, 20 m*M* dithiothreitol (DTT), and 0.5% IPG buffer. The amount of protein loaded was ~120  $\mu$ g. After rehydration, IEF was carried out according to the following conditions: (i) 200 V, 200 Vh; (ii) 500 V, 500 Vh; (iii) 1000 V, 500 Vh; (iv) 1000–8000 V gradient, 2250 Vh; and (v) 8000 V, 32 000 Vh (24 000 Vh for 13 cm strips). Voltage increases for (i–iii) were performed on a step-wise basis, while the increase for (iv) was on a linear gradient.

#### 3.2.2. Cup-loading strip holder

The strips were rehydrated overnight in 340  $\mu$ l of 7 *M* urea, 2 *M* thiourea, 4% CHAPS, 20 m*M* DTT, and 0.5% IPG buffer. After rehydration, 10  $\mu$ l of sample was loaded onto the anodic end of the IPG strip using a loading cup. The amount of protein loaded was ~120  $\mu$ g. IEF was performed according to the following regiment: (i) 200 V, 100 Vh; (ii) 500 V, 250 Vh; (iii) 1000 V, 500 Vh; (iv) 1000–8000 V gradient, 2250 Vh; and (v) 8000 V, 32 000 Vh. Again, voltage increases for (i–iii) were performed on a step-wise basis, while the increase for (iv) was on a linear gradient.

# 3.3. Sodium dodecyl sulphate-polyacrylamide gel electrophoresis

Before carrying out the second-dimensional sodium dodecyl sulphate-polyacrylamide gel electrophoresis (SDS-PAGE), the strips were subjected to a two-step equilibration process: the first being reduction with DTT, followed by a second alkylation step with iodoacetamide (IAA), as described previously [12]. SDS-PAGE was performed on 1.0 mm thick 10% polyacrylamide gels at 10 °C, either at a constant voltage of 110 V in an ISO-DALT (for both 13and 18-cm strips) apparatus (Amersham Biosciences), or at a constant current of 30 mA per gel in a PROTEAN II xi Cell IPG Conversion (for 18-cm strips) or a PROTEAN II xi Cell (for 13-cm strips) unit (Bio-Rad, Hercules, CA, USA).

### 3.4. Visualisation

The protein spots on the 2-DE gels were visualised using two different staining methods: silver staining, and fluorescent staining.

### 3.4.1. Silver staining

Silver staining of the gels was performed as described previously [12]. Briefly, the gels were fixed in 50% methanol, 5% acetic acid in water for 30 min followed by washing in 50% methanol in water for 10 min. The gels were then washed again with water for 60 min and sensitised with 0.02% sodium thiosulphate for 2 min. After the gels were rinsed twice with water for 1 min each, they were incubated in chilled 0.1% silver nitrate for 40 min at 4 °C. After rinsing with two changes of water for 1 min each, the gels were developed in 0.04% formalin in 2% sodium carbonate. When the desired intensity was attained, the development was stopped with 1.5% EDTA for 10 min. The staining procedure was completed by three rinses with water for 5 min each.

## 3.4.2. Fluorescent staining

Fluorescent staining was carried using the preprepared SYPRO Ruby fluorescent dye from Molecular Probes (Eugene, OR, USA), according to the manufacturer's instruction. The 2-DE gels were fixed in 10% methanol, 7% acetic acid in water for 30 min, before being incubated in the dark with the SYPRO Ruby dye for at least 3 h. The gels were rinsed twice with water for 5 min each, before being scanned on the Typhoon 8600 Imager (Amersham Biosciences).

### 3.5. Reduction and alkylation

After the protein spots were excised manually as described previously [12], they were subjected to a reduction and alkylation step before proteolysis. In essence, each excised spot was soaked with 150  $\mu$ l of washing solution consisting of 2.5 m*M* ammonium bicarbonate in 50% aqueous acetonitrile (ACN), and stored at 4 °C for at least 24 h. A fresh aliquot of washing solution was replaced and each spot was incubated for 20 min at 37 °C, followed by drying in a centrifugal concentrator. The spots were then subjected to reduction and alkylation as de-

scribed [15]. Briefly, 20  $\mu$ l of 10 m*M* DTT in 100 m*M* ammonium bicarbonate was added to each gel spot and incubated at 56 °C for 1 h. After cooling to room temperature, each spot was then incubated with 20  $\mu$ l of 55 mM IAA in 100 m*M* ammonium bicarbonate in the dark at ambient temperature for 45 min. After washing each spot with 100  $\mu$ l of 100 m*M* ammonium bicarbonate for 10 min, the gel spots were dehydrated with 100  $\mu$ l of ACN for 10 min. The washing and dehydration steps were repeated, before the spots were dried in a centrifugal concentrator.

### 3.6. Enzymatic digestion

Enzymatic digestion was performed with the addition of 10  $\mu$ l of 0.02  $\mu$ g/ $\mu$ l modified trypsin in 25 m*M* ammonium bicarbonate to each gel spot, and incubated at 37 °C for 16 h with shaking. To enhance peptide extraction, 10  $\mu$ l of 0.1% trifluoroacetic acid (TFA) in 50% aqueous ACN was added to each spot after the tryptic digestion, and sonicated for 20 min.

# 3.7. Matrix-assisted laser desorption/ionisation time-of-flight mass spectrometry

MALDI-TOF MS analyses were performed as described previously [12]. Essentially, 1 µl of the extracted sample from each of the gel spots was dispensed onto the MALDI sample plate with 1 µl of matrix solution (10 mg/ml  $\alpha$ -cyano-4-hydroxycinnamic acid, 0.1% TFA, 50% ACN), and allowed to dry under ambient conditions. The acquisition of spectra for each sample was performed using the delayed extraction and reflector mode as described [12]. Spectra were automatically calibrated upon acquisition using a two-point calibration with residual porcine trypsin autolytic fragments (842.51 and 2210.10 [M+H<sup>+</sup>] ions). Assignment of peaks and protein identification were performed automatically using the AutoMS-Fit software, which is part of the Proteomics Solution 1 system (Applied Biosystems, Foster City, CA, USA). Searches were queried against the swiss-prot and NCBI non-redundant databases, using parameters described previously [12].

# 3.8. Nanoelectrospray ionisation tandem mass spectrometry

Samples that did not return any confident matches from the MALDI-TOF MS database searches were subjected to nESI-MS-MS analysis as described [13]. Briefly, the remaining tryptic digested protein samples were each passed through a C<sub>18</sub> ZipTip (Millipore, Bedford, MA, USA), and eluted with 2 µl of 1% formic acid in 60% methanol. Each eluted sample was loaded into a spray capillary needle and the spray was initiated by applying a potential of 850 V. Data acquisition, spectra processing, and database searches were performed using the Analyst QS software (Applied Biosystems). The searches were performed either manually against the SWISS-PROT and NCBI non-redundant databases, or automatically using the Mascot search engine (Matrix Science, London, UK) [16].

#### 3.9. Two-dimensional electrophoresis maps

With the advent of high-resolution and reproducible 2-DE using IPG strips in the first dimension, it is now feasible to obtain high quality 2-DE maps of tissues and cells with reasonable speed for proteome analyses. We present here the 2-DE maps of seven hepatoma derived cell lines, HCC-M, Hep3B, HepG2, SK-Hep1, Huh-4, Huh-7, and PLC/PRF/5, and a non-transformed cell line, Chang liver (Fig. 1). It is apparent that these 2-DE maps exhibited differences in the protein profiles when compared with each other, and hence can be used as a basis to classify or differentiate the various hepatoma cell lines. This result is consistent with the recent gene expression profile studies of Kawai et al. [17], who showed that the  $\alpha$ -fetoprotein producing cell lines, HepG2, Huh-7, Hep3B, PLC/PRF/5 and Huh-6 have common gene-expression profiles when compared with HLE and SK-Hep1, which are α-fetoprotein negative hepatoma cell lines, and cancer cell lines of non-hepatocyte origin (HeLa and KMBC). In addition, HepG2, Huh-7, and Hep3B which had higher expressions of  $\alpha$ -fetoprotein shared a common gene expression profile when compared with the other  $\alpha$ -fetoprotein producing cells (Huh-6 and PLC/ PRF/5).



Fig. 1. 2-DE maps of human HCC cell lines. Cell lysate proteins were first separated on 13 cm Immobiline DryStrips pH 3-10 NL, using regular strip holders. The proteins were then separated using 10%T SDS-polyacrylamide gels using either the ISO-DALT or PROTEAN II xi cell electrophoretic tanks at 110 V and 30 mA/gel, respectively. The gels were silver stained. Protein loading was ~120 µg/gel.

3.10. Cup-loading versus in-gel rehydration sample application

It is a well-known fact that using the in-gel rehydration method for sample application on IPG



A. Regular strip holder, silver stained



C. Regular strip holder, SYPRO Ruby stained

strips, the separation of alkaline proteins was not satisfactory. The result is the presence of horizontal streaks in the SDS-polyacrylamide gel towards the basic end of the IPG strip, and there are a number of reasons for this phenomenon [18]. We have found



**B**. Cup-loading strip holder, silver stained



D. Cup-loading strip holder, SYPRO Ruby stained

Fig. 2. Comparison of in-gel rehydration versus cup-loading, and silver versus fluorescence staining of HCC-M proteins. HCC-M cell lysate proteins were first separated in 18 cm Immobiline DryStrips pH 3–10 NL, using regular (A and C) and cup-loading strip holders (B and D). The proteins were then separated using 10%T SDS–PAGE gels in a PROTEAN II xi Cell IPG Conversion unit, at 30 mA/gel. The gels were silver stained (A and B) and SYPRO Ruby stained (C and D). Protein loading was ~120  $\mu$ g/gel.

that sample application using the cup-loading method on the anode end of the IPG strips seemed to reduce the horizontal streaks to a certain extent (Fig. 2). This method was greatly facilitated by the recent release of the Universal strip holder for use on the IPGphor electrophoretic unit (Amersham Biosciences).

### 3.11. Fluorescent dyes versus silver staining

Silver staining is very sensitive (as low as 0.1 ng of protein per spot can be detected), but it is a multistep procedure with a very limited linear dynamic range. In addition it often leads to the formation of hollow spots or result in a doughnut effect which can complicate image analyses. On the other hand, staining with fluorescent dyes such as SYPRO Ruby is relatively sensitive, simple, and reproducible. In addition, it also has a broader linear dynamic range. We had compared the two staining methods for the 2-DE maps of HCC-M, and found SYPRO Ruby to be considerably less sensitive than silver staining (Fig. 2). Moreover, it was also found that some protein spots stained better with SYPRO Ruby than with silver nitrate, and the reverse was true as well. This observation is in full agreement with the report by Gorg et al. [18] who showed that the patterns obtained with silver staining and SYPRO Ruby staining were similar, but not identical. Finally, to facilitate the excision of the protein spots from 2-DE gels following SYPRO Ruby staining and image analysis, we have also developed a protocol to restain the gel with silver nitrate (results not shown).

# 3.12. Two-dimensional electrophoresis proteome database of HCC-M

### 3.12.1. Protein categorisation

We have earlier reported that, from a total of 408 unique spots excised from the 2-DE gel of HCC-M, 272 and 29 spots were identified by MALDI-TOF MS and nESI-MS-MS respectively [12,13]. This result represented the most comprehensive 2-DE protein database for any HCC cell line reported thus far. In this review, we have reorganised the database by grouping the proteins into different functional categories under (a) cell cycle, (b) chaperone/stress response, (c) cytoskeleton/mobility, (d) DNA repli-

cation/gene regulation, (e) immunological response, (f) ion channels, (g) membrane proteins, (h) metabolism, (i) oncogenes/tumour suppressor genes, (j) protection and detoxification, (k) protein synthesis and degradation, (1) signal transduction, (m) transport/binding proteins, (n) tumour associated proteins, and (o) unannotated/function inferred (Table 1). In addition, we have further grouped the proteins that have been shown to be implicated in HCC and other types of cancers into a separate list from the different categories of HCC-M proteins (see Table 2). We believe that such a categorisation and grouping of HCC-M proteins will simplify the 2DE protein database of HCC proteins, which in turn will facilitate the rapid identification and discovery of novel proteins that are involved in hepatocarcinogenesis.

# 3.12.2. HCC-M two-dimensional electrophoresis proteome web site

Finally, in line with our wish to allow the scientific community to access our extensive work on the identity of the proteins on the HCC-M 2-DE map, we have created an on-line database that provides an interactive way to query the HCC-M protein database. The data from our earlier publications [12,13] were first converted to MySQL database for data manipulation and retrieval. We are running an Apache web server and using Java servlets and applets technology to process and display the data.

There are two options to query the HCC-M database (Fig. 3).

Option 1: protein search by NCBI/SWISS-PROT Accession Number, Protein Name (full and partial name) and Protein ID (ID as published in our papers);

Option 2: interactive protein spots query on the original 2-DE image maps.

A query using Option 1 will retrieve a row or a list of proteins (if there are more than one match in the database) for selection as shown in Fig. 4. A click on the Sno column will display the protein identity page (Fig. 5) which includes information on the theoretical MW and pI, experimental MW and pI, a link to NCBI/SWISS-PROT information page, protein description, peptides matched from MALDI, subcellular location, method of identification and remarks. The location of the protein on the 2-DE map can also be

Table 1									
Categorisation	of	identified	proteins	from	the	HCC-M	cell	line <sup>a</sup>	

Accession no. <sup>b</sup>	Protein name(s) <sup>c</sup>
Cell cycle	
P34991	Cyclin A/CDK2-associated protein p19 (RNA polymerase II
	elongation factor-like protein) (organ of Corti protein 2)
	(OCP-II protein) (OCP-2) (transcription elongation factor B) (SIII)
Chaperone/stress re	sponse
3273383	TRAPI
4758484	Glutathione-S-transferase like (glutathione transferase $\omega$ )
P04792	Heat shock 27 kDa protein (HSP 27) (stress-responsive protein 27)
	(SRP27) (oestrogen-regulated 24 kDa protein) (28 kDa heat shock protein)
P07900	Heat shock protein HSP 90-α (HSP 86)
P08107	Heat shock 70 kDa protein 1 (HSP70.1) (HSP70-1/HSP70-2)
P08238	Heat shock protein HSP 90-β (HSP 84) (HSP 90)
P10809	60 kDa Heat shock protein, mitochondrial precursor (Hsp60)
	(60 kDa chaperonin) (CPN60) (heat shock protein 60) (HSP-60)
	(mitochondrial matrix protein P1) (P60 lymphocyte protein) (HuCHA60)
P11021	78 kDa glucose-regulated protein precursor (GRP 78)
	(immunoglobulin heavy chain binding protein) (BIP) (endoplasmic
	reticulum lumenal $Ca^{2+}$ binding protein grp78)
P11142	Heat shock cognate 71 kDa protein
P14625	Endoplasmin precursor (94 kDa glucose-regulated protein)
	(GRP94) (GP96 homolog) (tumour rejection antigen 1)
P30101	Protein disulphide isomerase A3 precursor (EC 5.3.4.1)
	(disulphide isomerase ER-60) (ERp60) (58 kDa microsomal
	protein) (P58) (ERp57)
P31948	Stress-induced-phosphoprotein 1 (STI1) (Hsp70/Hsp90-organizing
	protein) (transformation-sensitive protein IEF SSP 3521)
Cytoskeleton/mobilit	ty
4502561	Capping protein (actin filament), gelsolin-like
P02545	Lamin A/C (70 kDa lamin)
P02570	Actin, cytoplasmic 1 (β-actin)
P02571	Actin, cytoplasmic 2 (y-actin)
P04264	Keratin, type II cytoskeletal 1 (cytokeratin 1) (K1)
	(CK 1) (67 kDa cytokeratin) (hair $\alpha$ protein)
P07226	Tropomyosin, fibroblast non-muscle type
	(tropomyosin 4) (TM30-PL)
P08670	Vimentin
P08729	Keratin, type II cytoskeletal 7 (cytokeratin 7) (K7) (CK 7)
P09494	Tropomyosin $\alpha$ chain, fibroblast isoform TM3
	(tropomyosin 1, fibroblast isoform TM3)
P12324	Tropomyosin, cytoskeletal type (tropomyosin 3,
D10505	cytoskeletal) (TM30-NM)
P13797	T-Plastin
P32391	Actin-like protein 3 (actin-related protein 3) (actin-2)
P37802	Transgelin 2 (SM22- $\alpha$ homolog)
P40121	Macrophage capping protein (actin-regulatory protein CAP-G)
P42024	$\alpha$ -centractin (centractin) (centrosome-associated actin
D47755	nomolog) (actin-KPV) (AKPI) E actin appring protein a: 2 suburit (CAPZ a: 2)
r4//33 D47756	F-actin capping protein α-2 subunit (CAPZ α-2) E actin complex protein 0 subunit (CAPZ α)
r4//30 D52565	r-acuit capping protein $\beta$ subunit (CAPZ $\beta$ ) The CDR discontinuit inhibitor 1 (the CDL 1) (the CDL 1)
r32303 D52007	KIIO UDP-ulssociation innibitor 1 (mo UDI 1) (mo-UDI $\alpha$ )
г <i>32</i> 907	r-actin capping protein $\alpha$ -1 subunit (CAPZ $\alpha$ -1)

Table 1. Continued

Accession no. <sup>b</sup>	Protein name(s) <sup>c</sup>
Q07960	Rho-GTPase-activating protein 1 (GTPase-activating protein
	rhoOGAP) (rho-related small GTPase protein activator)
	(CDC42 GTPase-activating protein) (P50-rhoGAP)
Q16658	Fascin (singed-like protein) (55 kDa actin bundling protein) (p55)
DNA replication/gene reg	ulation
542991	Ran-specific GTPase-activating protein
4504865	KH-type splicing regulatory protein (FUSE binding protein 2)
P09429	High mobility group protein HMG1 (HMG-1)
P12004	Proliferating cell nuclear antigen (PCNA) (cyclin)
P13010	ATP-dependent DNA helicase II, 80 kDa subunit
	(lupus Ku autoantigen protein p86) (Ku86) (Ku80)
	(86 kDa subunit of Ku antigen) (thyroid-lupus autoantigen)
	(TLAA) (CTC box binding factor 85 kDa subunit) (CTCBF)
	(CTC85) (nuclear factor IV) (DNA-repair protein XRCC5)
P15927	Replication protein A 32 kDa subunit (RP-A) (RF-A)
	(replication factor-A protein 2)
P35232	Prohibitin
P35250	Activator 1 40 kDa subunit (replication factor C 40 kDa
	subunit) (A1 40 kDa subunit) (RF-C 40 kDa subunit) (RFC40)
Q09028	Chromatin assembly factor 1 subunit C (CAF-1 subunit C)
	(chromatin assembly factor I p48 subunit) (CAF-I 48 kDa subunit)
	(CAF-Ip48) (retinoblastoma binding protein p48) (retinoblastoma-
	binding protein 4) (RBBP-4) (MSI1 protein homolog)
Q16576	Histone acetyltransferase type B subunit 2 (retinoblastoma binding
	protein P46) (retinoblastoma-binding protein 7) (RBBP-7)
Immunological response	
P09960	Leukotriene A-4 hydrolase (EC 3.3.2.6) (LTA-4 hydrolase)
	(leukotriene A(4) hydrolase)
P12815	Programmed cell death protein 6 (probable calcium-binding
	protein ALG-2) (PMP41) (ALG-257)
P17693	HLA class I histocompatibility antigen, $\alpha$ chain G precursor
	(HLA G antigen)
P30740	Leukocyte elastase inhibitor (LEI) (monocyte/neutrophil elastase
	inhibitor) (M/NEI) (EI)
Ion channels	
O00299	Chloride intracellular channel protein 1 (nuclear chloride ion
	channel 27) (NCC27) (P64 CLCP) (chloride channel ABP)
P21796	Voltage-dependent anion-selective channel protein 1
	(VDAC-1) (hVDAC1) (outer mitochondrial membrane protein
	porin 1) (plasmalemmal porin) (porin 31HL) (porin 31HM)
P45880	Voltage-dependent anion-selective channel protein 2 (VDAC-2)
	(hVDAC2) (outer mitochondrial membrane protein porin 2)
Membrane proteins	
5174723	Mitochondrial outer membrane protein TOM40 (mitochondrial
0111120	outer membrane protein)
Metabolism—amino acids	
2674062	3-Phosphoglycerate dehydrogenase
P00367	Glutamate dehydrogenase 1, mitochondrial precursor (EC 1.4.1.3) (GDH)
P00966	Argininosuccinate synthase (EC 6.3.4.5) (citrulline-aspartate ligase)
P12277	Creatine kinase, B chain (EC 2.7.3.2) (B-CK)
P19623	Spermidine synthase (EC 2.5.1.16) (putrescine aminopropyltransferase) (SPDSY)
P23526	Adenosylhomocysteinase (EC 3.3.1.1) (S-adenosyl-L-homocysteine hydrolase) (AdoHcyase)
P32322	Pyrroline-5-carboxylate reductase (EC 1.5.1.2) (P5CR) (P5C reductase)
P41250	Glycyl-tRNA synthetase (EC 6.1.1.14) (glycine-tRNA ligase) (GlyRS) <sup>d</sup>

Accession no. <sup>b</sup>	Protein name(s) <sup>c</sup>
P48507	Glutamate-cysteine ligase regulatory subunit (EC 6.3.2.2)
	(γ-glutamylcysteine synthetase) (γ-ECS) (GCS light chain)
	(glutamate-cysteine ligase modifier subunit)
P48637	Glutathione synthetase (EC 6.3.2.3) (glutathione synthase)
	(GSH synthetase) (GSH-S)
P49419	Antiquitin (EC 1.2.1)
P49903	Selenide, water dikinase 1 (EC 2.7.9.3) (selenophosphate synthetase 1)
	(selenium donor protein 1)
Q13126	5'-Methylthioadenosine phosphorylase (EC 2.4.2.28)
	(MTA phosphorylase) (MTAPASE)
Metabolism—carboh	vdrate
5174471	Isocitrate dehydrogenase 1 (NADP <sup>+</sup> ), soluble <sup>d</sup>
6694937	Nudix hydrolase NUDT5
9507063	N-acetylneuraminic acid phosphate synthase, sialic acid synthase
P00338	L-Lactate dehydrogenase A chain (EC 1.1.1.27) (LDH-A)
	(LDH muscle subunit) (LDH-M) <sup>d</sup>
P00558	Phosphoglycerate kinase 1 (EC 2.7.2.3) (primer recognition
	protein 2) (PRP 2) <sup>d</sup>
P00938	Triosephosphate isomerase (EC 5.3.1.1) (TIM)
P04075	Fructose-bisphosphate aldolase A (EC 4.1.2.13) (muscle-type
	aldolase) (lung cancer antigen NY-LU-1) <sup>d</sup>
P04406	Glyceraldehyde 3-phosphate dehydrogenase, liver (EC 1.2.1.12) <sup>d</sup>
P06733	$\alpha$ -Enolase (EC 4.2.1.11) (2-phospho-b-glycerate hydrolyase)
	(NON-neural enolase) (NNE) (Phosphopyruvate hydratase) <sup>d</sup>
P07195	L-Lactate dehydrogenase B chain (EC 1.1.1.27) (LDH-B)
	(LDH heart subunit) $(LDH-H)^{4}$
P07954	Fumarate hydratase, mitochondrial precursor (EC 4.2.1.2) (fumarase) <sup><math>d</math></sup>
P09329	Ribose-phosphate pyrophosphokinase I (EC 2.7.6.1) (phosphoribosyl
	pyrophosphate synthetase I) (PPRibP) (PRS-I) <sup>d</sup>
P11413	Glucose-6-phosphate 1-dehydrogenase (EC 1.1.1.49) (G6PD)
P11908	Ribose-phosphate pyrophosphokinase II (EC 2.7.6.1)
	(phosphoribosyl pyrophosphate synthetase II) (PPRibP) (PRS-II) <sup>d</sup>
P13929	$\beta$ -Enolase (EC 4.2.1.11) (2-phospho-d-glycerate hydrolyase)
	(skeletal muscle enolase) (MSE) <sup>d</sup>
P14550	Alcohol dehydrogenase $[NADP^+]$ (EC 1.1.1.2) (aldehyde reductase) <sup>d</sup>
P14618	Pyruvate kinase, M1 isozyme (EC 2.7.1.40) (pyruvate kinase
	muscle isozyme) (cytosolic thyroid hormone-binding protein)
	(CTHBP) (THBP1) <sup>d</sup>
P14786	Pyruvate kinase, M2 isozyme (EC 2.7.1.40) <sup>d</sup>
P18669	Phosphoglycerate mutase, brain form (EC 5.4.2.1) (PGAM-B) (EC 5.4.2.4) (EC 3.1.3.13) (BPG-dependent PGAM)
P29401	Transketolase (EC 2.2.1.1) (TK) <sup>d</sup>
P37837	Transaldolase (EC 2.2.1.2)
P40925	Malate dehydrogenase, cytoplasmic (EC 1.1.1.37) <sup>d</sup>
P50213	Isocitrate dehydrogenase [NAD] subunit $\alpha$ , mitochondrial precursor
	(EC 1.1.1.41) (isocitric dehydrogenase) (NAD <sup>+</sup> -specific ICDH)
P51570	Galactokinase (EC 2.7.1.6) (galactose kinase)
Q04760	Lactoylglutathione lyase (EC 4.4.1.5) (methylglyoxalase)
	(aldoketomutase) (glyoxalase I) (Glx I) (ketone-aldehyde
	mutase) (S-D-lactoylglutathione methylglyoxal lyase)
Q99798	Aconitate hydratase, mitochondrial precursor (EC 4.2.1.3)
	(citrate hydrolyase) (aconitase) <sup>a</sup>
Metabolism—cofacto	ors and vitamins
O00764	Pyridoxine kinase (EC 2.7.1.35) (pyridoxal kinase)

Accession no. <sup>b</sup>	Protein name(s) <sup>c</sup>
P30043	Flavin reductase (EC 1.6.99.1) (FR) (NADPH-dependent
	diaphorase) (NADPH-flavin reductase) (FLR) (biliverdin
	reductase B) (EC 1.3.1.24) (BVR-B) (biliverdin-IX β-reductase)
	(green haem binding protein) (GHBP)
Metabolism-energy	
P06576	ATP synthase $\beta$ chain, mitochondrial precursor (EC 3.6.3.14)
P13804	Electron transfer flavoprotein $\alpha$ -subunit, mitochondrial precursor ( $\alpha$ -ETF)
P22695	Ubiquinol-cytochrome C reductase complex core protein 2,
	mitochondrial precursor (EC 1.10.2.2) (complex III subunit II)
Q15181	Inorganic pyrophosphatase (EC 3.6.1.1) (pyrophosphate
	phospho-hydrolase) (PPase)
Metabolism—lipid	
5174389	Acetyl-coenzyme A acetyltransferase 2 (acetoacetyl coenzyme A
	thiolase) (acetoacetyl coenzyme A thiolase) <sup>d</sup>
O00154	Cytosolic acyl coenzyme A thioester hydrolase (EC 3.1.2.2)
	(long chain acyl-CoA thioester hydrolase) (CTE-II)
	(brain acyl-CoA hydrolase) (BACH)
P02647	Apolipoprotein A-I precursor (Apo-AI)
P42126	3,2-trans-enoyl-CoA isomerase, mitochondrial precursor
	(EC 5.3.3.8) (dodecenoyl-CoA δ-isomerase)
P54619	5'-AMP-activated protein kinase, $\gamma$ -1 subunit (AMPK $\gamma$ -1 chain) (AMPKg)
P55809	Succinyl-CoA:3-ketoacid-coenzyme A transferase, mitochondrial
	precursor (EC 2.8.3.5) (succinyl CoA:3-oxoacid CoA-transferase) <sup>d</sup>
Q99714	3-Hydroxyacyl-CoA dehydrogenase type II (EC 1.1.1.35)
	(Type II HADH) (endoplasmic reticulum-associated amyloid β-peptide
	binding protein) (short-chain type dehydrogenase/reductase XH98G2) <sup>d</sup>
Metabolism—nucleotide	
P00491	Purine nucleoside phosphorylase (EC 2.4.2.1) (inosine phosphorylase) (PNP) <sup>d</sup>
P00568	Adenylate kinase isoenzyme 1 (EC 2.7.4.3) (ATP-AMP
	transphosphorylase) (AK1) (myokinase)
P07741	Adenine phosphoribosyltransferase (EC 2.4.2.7) (APRT)
P12268	Inosine-5'-monophosphate dehydrogenase 2 (EC 1.1.1.205)
	(IMP dehydrogenase 2) (IMPDH-II) (IMPD 2)
P15531	Nucleoside diphosphate kinase A (EC 2.7.4.6) (NDK A)
	(NDP kinase A) (tumour metastatic process-associated protein)
	(metastasis inhibition factor nm23) (nm23-H1)
P49915	GMP synthase [glutamine-hydrolyzing] (EC 6.3.5.2)
	(glutamine amidotransferase) (GMP synthetase) <sup>d</sup>
P55263	Adenosine kinase (EC 2.7.1.20) (AK) (adenosine 5'-phosphotransferase)
Oncogenes/tumour sup	pressor genes
4503801	Far upstream element-binding protein (far upstream element
	binding protein) (FUSE-binding protein)
6005749	RNA-binding protein regulatory subunit
9910460	Nit protein 2
P36952	Maspin precursor (protease inhibitor 5)
Protection and detoxific	ation
2135069	Probable thioredoxin peroxidase (EC 1.11.1)
4507149	Superoxide dismutase 1, soluble [amyotrophic lateral sclerosis 1
	(adult)] (Cu/Zn superoxide dismutase)
P00441	Superoxide dismutase [Cu–Zn]
P04179	Superoxide dismutase [Mn], mitochondrial precursor (EC 1.15.1.1)

Accession no <sup>b</sup>	Protein name(c) <sup>c</sup>	
Recession no.		
P08758	Annexin V (lipocortin V) (endonexin II) (calphobindin I) (CBP-I)	
	(placental anticoagulant protein I) (PAP-I) (PP4) (thromboplastin	
D00011	inhibitor) (vascular anticoagulant-a) (VAC-a) (anchorin CII)	
P09211	Glutathione S-transferase P (EC 2.5.1.18) (GST class-PI) (GSTP1-1)	
P30041	Antioxidant protein 2 (1-Cys peroxiredoxin) (1-Cys PRX)	
	(acidic calcium-independent phospholipase A2) (EC 3.1.1) (aiPLA2)	
	(non-selenium glutathione peroxidase) (EC 1.11.1.7) (NSGPx)	
<b>D2</b> 00.40	(24 kDa protein) (liver 2D PAGE spot 40) (red blood cells PAGE spot 12)	
P30048	Thioredoxin-dependent peroxide reductase, mitochondrial precursor	
	(peroxiredoxin 3) (antioxidant protein 1) (AOP-1) (MER5 protein	
	homolog) (HBC189) (PRX III)	
P32119	Peroxinedoxin 2 (thioredoxin peroxidase 1) (thioredoxin-dependent	
	peroxide reductase 1) (thiol-specific antioxidant protein) (TSA) (PRP)	
	(natural killer cell enhancing factor B) (NKEF-B)	
P38646	Stress-70 protein, mitochondrial precursor (75 kDa glucose	
	regulated protein) (GRP 75) (peptide-binding protein 74) (PBP74) (mortalin) (MOT)	
Q06830	Peroxiredoxin 1 (thioredoxin peroxidase 2) (thioredoxin-dependent peroxide	
	reductase 2) (proliferation-associated protein PAG) (natural killer	
	cell enhancing factor A) (NKEF-A)	
Protein synthesis an	d degradation	
542852	hnRNP protein E1	
3986482	Translation initiation factor eIF3 p40 subunit (eIF3p40)	
4468218	unr-interacting protein	
4503519	Eukaryotic translation initiation factor 3, subunit 5 ( $\epsilon$ , 47 kDa)	
4506195	Proteasome (prosome, macropain) subunit, $\beta$ type, 2	
	(proteasome subunit, $\beta$ type, 2)	
4506217	Proteasome (prosome, macropain) 26S subunit, non-ATPase, 10	
4506223	Proteasome (prosome, macropain) 26S subunit, non-ATPase,	
	13 (hypothetical protein) (26S proteasome subunit p40.5)	
4506237	Proteasome activator HPA28 subunit $\beta$	
4506753	TATA binding protein interacting protein 49 kDa	
5031981	26S proteasome-associated pad1 homolog	
5031997	Proteasome (prosome, macropain) activator subunit 3	
	(PA28 γ, Ki) (Ki nuclear autoantigen)	
5174731	Translin-associated factor X	
P04632	Calcium-dependent protease, small subunit (calpain	
	regulatory subunit) (calcium-activated neutral proteinase) (CANP)	
P04720	Elongation factor 1- $\alpha$ 1 (EF-1- $\alpha$ -1) (elongation factor 1 A-1)	
	(eEF1A-1) (elongation factor Tu) (EF-Tu)	
P05198	Eukaryotic translation initiation factor 2 subunit 1 (eukaryotic	
	translation initiation factor 2 $\alpha$ subunit) (eIF-2 $\alpha$ ) (EIF-2 $\alpha$ ) (EIF-2A)	
P07237	Protein disulphide isomerase precursor (PDI) (EC 5.3.4.1)	
	(prolyl 4-hydroxylase $\beta$ subunit) (cellular thyroid hormone binding protein) (P55)	
P07602	Proactivator polypeptide precursor [Contains: saposin A (protein A); saposin B	
	(sphingolipid activator protein 1) (SAP-1) (cerebroside sulphate activator) (CSAct)	
	(dispersin) (sulphatide/GM1 activator); saposin C (Co-β-glucosidase) (A1 activator)	
	(glucosylceramidase activator) (sphingolipid activator protein 2) (SAP-2); saposin D	
	(protein C) (component C)]	
P08865	40S ribosomal protein SA (P40) (34/67 kDa laminin receptor)	
	(colon carcinoma laminin-binding protein) (NEM/1CHD4)	

Ta	ble	e 1.	C	on	ti	n	ue	ed
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Accession no. <sup>b</sup>	Protein name(s) <sup>c</sup>
P09651	Heterogeneous nuclear ribonucleoprotein A1 (helix-destabilizing
	protein) (single-strand binding protein) (hnRNP core protein A1)
P12081	Histidyl-tRNA synthetase (EC 6.1.1.21) (histidine-tRNA ligase) (HisRS)
P13639	Elongation factor 2 (EF-2)
P13798	Acylamino-acid-releasing enzyme (EC 3.4.19.1) (acyl-peptide
	hydrolase) (APH) (acylaminoacyl-peptidase) (DNF15S2 protein)
P14866	Heterogeneous nuclear ribonucleoprotein L (hnRNP L)
P15374	Ubiquitin carboxyl-terminal hydrolase isozyme L3 (EC 3.4.19.12)
	(UCH-L3) (ubiquitin thiolesterase L3)
P17987	T-complex protein 1, $\alpha$ subunit (TCP-1- $\alpha$ ) (CCT- $\alpha$ )
P22061	Protein-L-isoaspartate(D-aspartate) O-methyltransferase (EC 2.1.1.77)
	(protein-β-aspartate methyltransferase) (PIMT) (protein L-isoaspartyl/
	D-aspartyl methyltransferase) (L-isoaspartyl protein carboxyl methyltransferase)
P22626	Heterogeneous nuclear ribonucleoproteins A2/B1 (hnRNP A2/hnRNP B1)
P25786	Proteasome subunit $\alpha$ type 1 (EC 3.4.25.1) (proteasome component C2)
	(macropain subunit C2) (multicatalytic endopeptidase complex subunit C2)
	(proteasome $\nu$ chain) (30 kDa prosomal protein) (PROS-30)
P25787	Proteasome subunit alpha type 2 (EC 3.4.25.1) (proteasome component C3)
	(macropain subunit C3) (multicatalytic endopeptidase complex subunit C3)
P25789	Proteasome subunit alpha type 4 (EC 3.4.25.1)(proteasome component C9)
	(macropain subunit C9) (multicatalytic endopeptidase complex subunit C9)
	(proteasome subunit L)
P27924	Ubiquitin-conjugating enzyme E2-25 kDa (EC 6.3.2.19) (ubiquitin-protein
	ligase) (ubiquitin carrier protein) (Huntington interacting protein) (HIP-2)
P28070	proteasome subunit $\beta$ type 4 precursor (EC 3.4.25.1) (proteasome $\beta$ -chain)
	(macropain $\beta$ chain) (multicatalytic endopeptidase complex $\beta$ -chain)
	(proteasome chain 3) (HSN3) (HsBPROS26)
P28072	Proteasome subunit $\beta$ type 6 precursor (EC 3.4.25.1)
	(proteasome $\delta$ -chain) (macropain $\delta$ chain) (multicatalytic endopeptidase
	complex δ chain) (proteasome subunit Y)
P30040	Endoplasmic reticulum protein ERp29 precursor (ERp31) (ERp28)
P31943	Heterogeneous nuclear ribonucleoprotein H (hnRNP H)
P33240	Cleavage stimulation factor, 64 kDa subunit (CSTF 64 kDa
	subunit) (CF-1 64 kDa subunit)
P34062	Proteasome subunit $\alpha$ type 6 (EC 3.4.25.1) (proteasome $\iota$ chain)
	(macropain ι chain) (multicatalytic endopeptidase complex ι chain)
	(27 kDa prosonal protein) (PROS-27) (p27K)
P35237	Placental thrombin inhibitor (cytoplasmic antiproteinase) (CAP)
	(protease inhibitor 6)
P35998	26S protease regulatory subunit 7 (MSS1 protein)
P40227	T-complex protein 1, $\zeta$ subunit (TCP-1- $\zeta$ ) (CCT- $\zeta$ ) (CCT- $\zeta$ -1) (Tcp20) (HTR3)
P48643	T-complex protein 1, $\epsilon$ subunit (TCP-1- $\epsilon$ ) (CCT- $\epsilon$ )
P49368	T-complex protein 1, $\gamma$ subunit (TCP-1- $\gamma$ ) (CCT- $\gamma$ )
P49411	Elongation factor Tu, mitochondrial precursor (P43)
P49720	Proteasome subunit $\beta$ type 3 (EC 3.4.25.1) (proteasome $\theta$ chain)
	(proteasome chain 13) (proteasome component C10-II)
P50990	T-complex protein 1, $\theta$ subunit (TCP-1- $\theta$ ) (CCT- $\theta$ )
P50991	T-complex protein 1, $\delta$ subunit (TCP-1- $\delta$ ) (CCT- $\delta$ )
	(stimulator of TAR RNA binding)
P55795	Heterogeneous nuclear ribonucleoprotein H' (hnRNP H') (FTP-3)

Q06323         Proteasome activator complex subunit 1 (proteasome activator 28-α subunit () (PA28a) (activator of multicatalytic protease subunit 1) (11S regulator complex a subunit) (RE6-a) (interferon γ upregulated 1-5111 protein) (IGUP 1-5111)           Q07244         Hetrogeneous nuclear infonucio/oprotein (K (InRN* K) (DC-stretch binding protein) (CISNP) (transformation upregulated nuclear protein) (TUSNP)           Q13347         Eakaryotic translation initiation factor 3 subunit 2 (efF-3 β) (efF 3 p56) (TGF-β receptor interacting protein 1) (TRP-1)           Q1744         Intersequenci (EG 3.4.12.9) (endopediates Clp)           Q07843         T-complex protein 1, n subunit (TCP-1-η) (CTT-η) (HIV-1 Nef interacting protein)           Q0852         T-complex protein 1, n subunit (TCP-1-η) (CTT-η) (HIV-1 Nef interacting protein)           Q2893         Phosphotyrosyl phosphatase activator PTPA 1244400           Q487056         WD repeat-containing protein 1, isoform 2           P04083         Annexin 1 (inpocortin 1) (calpactin 11) (chrounobindin 9) (P35) (phospholipace 2) inbitotry protein)           P04083         Annexin 1 (inpocortin 10)(calpactin 1 heavy chain) (chromobindin 8/07/60)(rocf) protein GU/G(GS)(GT) g subunit 1 (transductin g cotein μ2 subunit)           P1016         Guanine nucleotide-binding protein GU/G(GS)(GT) g subunit 2 (transductin g cotein μ2 subunit)           P23312         14-3-3 Protein (2/6 protein finduage cotein μ2 subunit)           P2334         Grawine nucleotide-binding protein 62 subunit)           P23	Accession no. <sup>b</sup>	Protein name(s) <sup>c</sup>
28-cx subuni) (PA280) (FA280) (activator of multicallytic protease subuni) (PA280) (FA280) (activator of multicallytic protease subuni) (PA280) (FA280) (activator of multicallytic protease (Interferon y upregulated Interferon Subuni) (CBP1) (Interferon y upregulated nuclear protein) (CISP) (transformation upregulated nuclear protein) (CISP) (transformation (GP3 protein Subuni) (CISP) (transformation upregulated nuclear protein) (CISP) (transformation (GP3 protein Subuni) (CIGP-β receptor interacting protein 1) (TRIP-1)         (11347)       Eukaryotic translation initiation factor 3 subuni 2 (cIF-3 β) (cIF-3 p50) (TGF-β receptor interacting protein 1) (TRIP-1)         (11347)       Eukaryotic translation initiation factor 3 subuni 2 (cIF-3 β) (cIF-3 p50) (TGF-β receptor interacting protein 1) (TRIP-1)         (11347)       Eukaryotic translation mitochondrial precursor (EC 3.421.92) (endopeptidase CIp)         (11540)       Interacting protein)         (11540)       Nef interacting protein)         (11540)       ICCT-1) (CCT-1) (CCT-1) (HIV-1)         Nef interacting protein 0       CIP         (11540)       ICCT-30 (CGT-3)	Q06323	Proteasome activator complex subunit 1 (proteasome activator
submit 1) (11S regulator complex a submit) (REG-a)           (interferor γ upregulated 15111 protein) (GUP F101)           Q07244         Heterogeneous nuclear ribonucleoprotein K (hnRNP K)           (DC-stretch binding protein) (CSBP) (transformation upregulated nuclear protein) (CSBP)         (EIF3 β)           Q13347         Eukaryotic translation initiation factor 3 submit 2 (eIF3 β)           Q16740         Patative ATP-dependent Clp protease proteolytic submit, mitochondrial precusion (CE 3.4.2.12) (endopendiase Clp)           Q99882         T-complex protein 1. η submit (TCP-1-η) (CTC-η) (HIV-1 Nef interacting protein)           Signal transduction         Net interacting protein)           1082693         Phosphotyrosyl phosphatase activator PTPA           1244400         hCKMP-2           3309170         COP9 complex submit 4           4757834         BCL-associated atmanogene 2 (BAG-family molecular chaperone regulator.2)           4827056         WD repeat-containing protein 11, isoform 2           P04083         Annexh 1 (Lipacotti 1D) (calpaciti 1D) (chromobindin 9) (P355) (chromobindin 8)(P36)(protein 1D) (clacental anticoagulant protein TV)(PAP-IV)           P11016         Guanine nucleotide-binding protein (GU/GS)/GCT) β submit 2 (transducin β chain 1)           P25388         Guanine nucleotide-binding protein (GU/GS)/GCT) (creeptor of activated protein khaase C 1) (RACK1)) (receptor of activated protein khaase C 1) (RACK1)           (RCD+		28- $\alpha$ subunit) (PA28 $\alpha$ ) (PA28a) (activator of multicatalytic protease
quick         (interferon'' querginated 1-5111)           Q07244         Heterogeneous nuclear rinonucleoprotein K (hnRNP K )           (DC-stretch binding protein) (CSBP) (transformation         upregulated nuclear protein) (TUNP)           (eIT3 p56) (TGT-β receptor interacting protein 1) (TRIP-1)         (Harden CL) protease proteolytic subunit, mitochondrial precursor (EC 3.42.192) (endopeptidase Clp)           (g99832         T-complex protein 1, n subunit (TCP-1-η) (CCT-η) (HIV-1)           Nef interacting protein)         Nef interacting protein           Signal transduction         1082693           1082693         Phosphotyrosyl phosphatase activator PTPA           124400         hCRMP-2           3009170         COP oomplex subunit 4           47757834         BCL2-associated athanogene 2 (BAG-family molecular chaperone regulator-2)           4827056         WD repeat-containing protein 1 isoform 2           P04083         Annexin 1 (ipocortin 1) (calpactin 11) (chromobindin 9)           (P35) (phospholipase 42 inhibitory protein           P04091         Guanine mucleotide-binding protein G(I)/G(S)/G(T)           β subunit 1 (transductin β chain 2) (G protein β 2 subuni)           P11016         Guanine nucleotide-binding protein 612/3           (P255)         Capetor of activated protein Kinase C 1 (RACK1)           (receptor for activated protein kinase C 1 (RACK1)     <		subunit 1) (11S regulator complex $\alpha$ subunit) (REG- $\alpha$ )
Q07244         Heterogeneous nuclear ribonucleoprotein K (hnRNP K) (DC-stretch binding protein) (CBNP) (transformation upregulated nuclear protein) (TUNP)           Q1347         Eakaryotic translation initiation factor 3 subunit 2 (eIF-3 β) (eIF3 56) (TGF-18 preciptor interacting protein 1) (TRIP-1)           Q16740         Putative ATP-dependent Clp protease proteolytic subunit, mittochondrial precursor (EG 34.21.22) (endopetiduse Clp)           Q99852         T-complex protein 1, η subunit (TCP-1-η) (CTC-η) (HIV-1 Nef interacting protein)           Signal transduction         Transfurget (CG 24.22) (endopetiduse Clp)           1082093         Phosphotyosyl phosphatase activator PTPA           1244400         hCRMP-2           3309170         COP9 complex subunit 4           4757834         BCL-associated athanogene 2 (RAG-family molecular chaperone regulator-2)           4827056         WD repart-containing protein 1, isoform 2           P04083         Annexin 1 (lipocortin 1) (calpactin II) (chromobindin 9) (P35) (phospholipase A2 inibitory protein)           07355         Annexin 11 (Lipocortin 1) (Calpactin 1 heavy chain) (chromobindin 8)(P36)(protein 1)[placental anticoagulant protein 1V)(PAP-IV)           P1016         Guanine nucleotide-fahing protein (CI/)(CGS)/CT(T) β subunit 1 (transducin β chain 2) (G protein β 2 subunit)           P2538         Guanine nucleotide-fahing protein (CI/)(CGS)/CT(T) (cP05) (receptor of activated protein kinase C 1) (RACK1)           P25354         Growth f		(interferon $\gamma$ upregulated I-5111 protein) (IGUP I-5111)
(DC-stretch binding protein) (CSRP) (transformation upregulated nuclear protein) (TNP)         Q13347       Eukaryotic translation initiation factor 3 subunit 2 (eIF-3 β) (eIF-3 p50) (TGF-5 receptor interacting protein 1) (TRP-1)         Q16740       Prative ATP-dependent CD protesses proteolytic subunit, mitochondrial precursor (EC 3.4.21.92) (endopeptiduse Clp)         Q99852       T-complex protein 1, n subunit (TCP-1-n) (ICT-n) (HIV-1 Nef interacting protein)         Signal transduction       Interacting protein         Signal transduction       Interacting protein         1082693       Phosphotyrosyl phosphatase activator PTPA         1244400       IcCRNP-2         3309170       COPO complex subunit 4         4757834       BCL2-associated athanogene 2 (BAG-family molecular chaperone regulator-2)         4827056       WD repeat-containing protein 1) isoform 2         P04083       Annexin 1 (lipocortin 1) (calpactin 1) (chromobindin 9)         (P35) (phospholipaes A2 inhibitory protein)         P04081       Guanine nucleoide-binding protein G(I)/G(S)/G(T)         β subunit 1 (transducin β chain 2) (G protein β 2 subunit)         P11016       Guanine nucleoide-binding protein finasce C 1) (RACK1) (receptor of activated protein kinase C 1) (RACK1) (receptor for activated c kinase) (GNB2-KS1)         P25388       Guanine nucleoide-binding protein (GNAS)         P23512       I-4-3-3 Protein /Å (protein kinase C 1)	Q07244	Heterogeneous nuclear ribonucleoprotein K (hnRNP K)
upregulated nuclear protein) (TUNP)           Q13347         Eukaryotic translation initiation factor 3 submit 2 (eIF-3 β) (eIF3 p36) (TGF-β receptor interacting protein 1) (TRIP-1)           Q16740         Prataive ATF-dependent CIp protease proteolytic submit, mitochondrial precursor (EC 3.4.2192) (endopendidase CIp)           Q9982         T-complex protein 1, η submit (TCP-1-η) (CCT-η) (HIV-1 Nef interacting protein)           Signal transduction         Nef interacting protein           1082693         Phosphotyrosyl phosphatase activator PTPA           1244400         CKPM-2           3309170         COP9 complex submit 4           4757834         BCL2-associated athanogene 2 (BAG-family molecular chaperone regulator-2)           4827056         WD repeat-containing protein 1, isoform 2           P04083         Annexin 1 (lipocortin 1) (clapactin 10 (clay CGT) β submit 1 (transducin β chain 1)           P04901         Guanine nucleotide-binding protein G(I)/G(S)/G(T)           β submit 1 (transducin β chain 1)         Postownit)           P0355         Annexin II (lipocottin I) (clapactin 1 heavy chain) (chromobindin S)/PSO (protein) D[polecental attricoagulant protein IV)(PAP-IV)           P1016         Gamine nucleotide-binding protein 2 (G protein β z submit)           P2332         Itassue attributor protein (SI (POKGT) (CCPT)) (factor activated C kinaso (ONB2-RS1) (receptor for activated C kinaso (ONB2-RS1) (receptor for activated C kinaso (ONB2-RS1) (receptor f		(DC-stretch binding protein) (CSBP) (transformation
Q13347       Eukaryotic translation initiation factor 3 subunit 2 (eIF-3 β)         Q16740       Putative ATP-dependent CIp protease proteolytic subunit, mitochondrial precursor (EC 3.4.21.92) (endopeptidase CIp)         Q99832       T-complex protein 1, a subunit (TCP-1-η) (CCT-η) (HIV-1         Nef interacting protein)         Signal transduction         Signal transduction         1082093       Phosphotyrosyl phosphatase activator PTPA         1244400       hCRMP-2         3309170       COP complex subunit 4         4757834       BCL2-associated athanogene 2 (BAC-family molecular chapenor regulator-2)         4827056       WD repeat-containing protein 1, isoform 2         P04083       Amexin 1 (lipocorin 1) (calpactin 10) (chromobindin 9)         (P55) (phospholipse A2 inhibitory protein)         P040901       Guanine nucleotide-binding protein 6(1)/G(S)/G(T)         β subunit 1 (transducin β chain 1)         P0355       Anexin 11 (lipocorin 1)(calpacita 1 lawy chain)         P1016       Guanine nucleotide-binding protein 6(G)/G(S)/G(T)         β subunit 2 (transducin β chain 2)       Gyratine nucleotide-binding protein β 2 subunit)         P25388       Guanine nucleotide-binding protein β a subunit-18e         P0401       Guanine nucleotide-binding protein (G)/G(S)/G(T)         β subunit 2 (transducin β chain 2)       Gyrote		upregulated nuclear protein) (TUNP)
Q16740       Peterster of the effective of the eff	Q13347	Eukaryotic translation initiation factor 3 subunit 2 (eIF-3 $\beta$ )
Q16740       Putative ATP-dependent Clp protease proteolytic subunit, mitochondrial precursor (EC 3.421.92) (endopendiase Clp)         Q99832       T-complex protein 1, η subunit (TCP-1-η) (CCT-η) (HIV-1 Nef interacting protein)         Signal transduction       1082693         Phospholyrosyl phosphatase activator PTPA         1244400       hCRMP-2         3309170       COP9 complex subunit 4         4757834       BCL2-associated athanogene 2 (BAG-family molecular chaperone regulator-2)         4827056       WD repeat-containing protein 1, isoform 2         P04083       Annexin 1 (lipocortin 1) (calpactin 10) (chromobindin 9) (P25) (phospholpase A2 inhibitory protein)         P04901       Guanine nucleotide-binding protein G(I)/G(S)/G(T)         β subunit 1 (transducin β chain 1)         P07355       Annexin II (lipocortin 10)(clapactin 1 heavy chain) (chromobindin 8)(P36)(protein 10)(placental anticoagulant protein IV)(PAP-IV)         P11016       Guanine nucleotide-binding protein G(S)/G(S)/G(T)         β subunit 2 (transducin β chain 2) (G protein β 2 subunit)         P25388       Guanine nucleotide-binding protein (FB2PAS)         (P205) (treecptor of activated protein kinase C 1) (RACK1) (treecptor for activated C kinase) (CMSP-RS1)         P23312       L4-3-3 Protein (J* (G protein A2 subunit)         P29314       Growth factor receptor-bound protein 2 (GRB2) (RCIP) (receptor) for activated protein) (PEBP) (treeuropl		(eIF3 p36) (TGF- $\beta$ receptor interacting protein 1) (TRIP-1)
mitochondrial precursor (EC 3.4.21.92) (endopeptidase Clp)         Q99832       T-complex protein 1, η subunit (TCP-1-η) (CCT-η) (HIV-1         Nof interacting protein       Nof interacting protein         Signal transduction       hCRMP-2         3309170       COP9 complex subunit 4         4757834       BCL2-associated adhanogene 2 (BAG-family molecular chaperone regulator-2)         4827056       WD repeat-containing protein 1, isoform 2         904083       Annexin I (Ipocortin I) (calpactin II) (chromobindin 9)         (P35) (Phospholipase A2 inhibitory protein)         904901       Guanine nucleotide-binding protein G(I)/G(S)/G(T)         β subunit 1 (Itransducin β chain 1)         P07355       Annexin I (Ipocortin II) (calpactin I heavy chain)         (chromobindin S)(P56)(protein I) (placental anticoagulant protein TV)(PAP-IV)         P11016       Guanine nucleotide-binding protein G subunit-Ike protein 12.3         (P205) (receptor of activated protein Å subunit-Ike protein 12.3         (P205) (receptor of activated protein Å subunit-Ike         P23324       Growth factor receptor-bound protein 2 (GB2-St1)         P23354       Growth factor receptor-bound protein 2 (GB2         (R205) (receptor of activated protein 3 (GB2-St1)         (P205) (receptor of activated Protein 3 (GB2-St1)         P23354       Growth factor receptor-bound protein 2 (GB	Q16740	Putative ATP-dependent Clp protease proteolytic subunit,
Q99832T-complex protein 1, η subunit (TCP-1-η) (CCT-η) (HIV-1 Nef interacting protein)Signal transduction1082093Phosphotyrosyl phosphatase activator PTPA124400hCRMP-23309170COP9 complex subunit 44757834BCL2-associated athanogene 2 (BAG-family molecular chaperone regulator-2)4827056WD repeat-containing protein 1, isoform 2904083Annexin 1 (lipocortin 1) (calpactin II) (chromobindin 9) (P35) (phospholipase A2 inhibitory protein)P04091Guanine nucleotide-binding protein G(I)/G(S)/G(T) β subunit 1 (transducin β chain 1)P07355Annexin II (lipocortin ID)(calpactin 1 heavy chain) (chromobindin 8)(P36)(protein 3)(PGG)/G(T) β subunit 2 (transducin β chain 2) (G protein β 2 subunit)P1016Guanine nucleotide-binding protein G(I)/G(S)/G(T) β subunit 2 (transducin β chain 2) (G protein β 2 subunit)P25388Guanine nucleotide-binding protein G(I)/G(S)/G(T) (receptor for activated C kinase 0 (GNB2-RS1) (receptor for activated C kinase 0 (GNB2-RS1)P25384Growth factor receptor-bound protein 2 (GRB2 adapter protein) (SH2/SH3 adapter GRB2) (ASH protein-1) (KCIP-1) (factor activating exoenzyme 8) (FAS)P29354Growth factor receptor-bound protein 2 (Reuropolypeptide h3) (thipocampal cholinergic neurosimulating peptide) (HCNP) (raf kinase inhibitor protein) (RKIP)P30153Serine/threonine protein phosphatase P2A, 65 KDa regulatory unit, α-isoform (P2A, subunit A, PR65-α isoform) (P2A, subunit A, R1-α isoform) (medium tumour antigen-associated 61 kDa protein)P4265514-3-3 Protein c (mitochondrial import simulation factor L subunit) (protein kinase C inhibitor protein) (K		mitochondrial precursor (EC 3.4.21.92) (endopeptidase Clp)
Nef interacting protein)Signal transductionSignal transductionPhosphotyrosyl phosphatase activator PTPA1244400hCRMP-23309170COP9 complex subunit 44757834RCL2-associated athanogene 2 (BAG-family molecular chaperone regulator-2)4827056WD repeat-containing protein 1, isoform 2PO4083Annexin 1 (lipocortin 1) (calpactin II) (chromobindin 9) (PS5) (phospholipase A2 inhibitory protein)P040901Guanine nucleotide-binding protein G(I)/G(S)/G(T) $\beta$ subunit 1 (transducin $\beta$ chain 1)P04901Guanine nucleotide-binding protein G(I)/G(S)/G(T) $\beta$ subunit 1 (transducin $\beta$ chain 1)P04901Guanine nucleotide-binding protein G(I)/G(S)/G(T) $\beta$ subunit 1 (transducin $\beta$ chain 2) (G protein $\beta$ 2 subunit)P04901Guanine nucleotide-binding protein $\beta$ subunit-like protein IV/(PAP-IV)P11016Guanine nucleotide-binding protein $\beta$ subunit.P25388Guanine nucleotide-binding protein $\beta$ subunit.P29351(RCIP-1) (factor activated protein shase C 1) (RACK1) (receptor for activated protein 2.(SRB)P39312(HCNP) (report in SIM grave activated protein GRB2) (neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide) (NCIP-1) (I4-3-31) (P29354Grave frame inhibitor protein 10 (RCIP-1) (I4-3-	Q99832	T-complex protein 1, η subunit (TCP-1-η) (CCT-η) (HIV-1
Signal transduction         Interpretation           1082:093         Phosphotyrosyl phosphatase activator PTPA           1244400         hCRMP-2           3300170         COPP complex subunit 4           4757834         BCL2-associated athanogene 2 (BAG-family molecular chaperone regulator-2)           4827056         WD repeat-containing protein 1, isoform 2           P04083         Annexin 1 (lipocortin 1) (calpactin II) (chromobindin 9) (P35) (phospholipase A2 inhibitory protein)           P04901         Guanine nucleotide-binding protein G(I)/G(S)/G(T)           β subunit 1 (transducin β chain 1)           P07355         Annexin II (lipocortin II)(calpactin I heavy chain) (chromobindin 8)(P36)(protein 10(placental anticoagulant protein IV)(PAP-IV)           P11016         Guanine nucleotide-binding protein (G)(G(S)/G(T)           β subunit 2 (transducin β chain 2) (G protein β 2 subunit)           P25388         Guanine nucleotide-binding protein (G)(S(G)/G(T)           (RCP-1) (factor activating exoenzyme S) (FAS)           P29312         I4-3-3 Protein ζ/δ (protein hinase C inhibitor protein 12.3           (KCIP-1) (factor activating exoenzyme S) (FAS)           P30086         Phosphatidylethanolamine-binding protein (PCBP)           (neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide)           (HCNP) (raf kinase inhibitor protein)           (KCIP-1) (factor ac		Nef interacting protein)
1082693       Phospholyrosyl phosphatase activator PTPA         1244400       hCRMP-2         3309170       COP9 complex subunit 4         4757834       BCL2-associated athanogene 2 (BAG-family molecular chaperone regulator-2)         4827056       WD repeat-containing protein 1, isoform 2         P04083       Annexin I (ipocortin 1) (calpactin 1) (chromobindin 9)         (P55) (phospholjase A2 inhibitory protein)         P04901       Guanine nucleotide-binding protein G(1)/G(S)/G(T)         β subuni 1 (transducin β chain 1)         P07355       Annexin II (ipocortin 1)(calpactin 1 heavy chain)         (chromobindin 8)(P36)(protein 10(R)/G(S)/G(T)       β subuni 2 (transducin β chain 2) (G protein β 2 subunit)         P11016       Guanine nucleotide-binding protein G (1)/G(S)/G(T)         β subuni 2 (transducin β chain 2) (G protein β 2 subunit)         P25388       Guanine nucleotide-binding protein β subunit-Like protein 12.3         (ECP05) (receptor of activated Protein Kinase C 1) (RACK1)         (receptor for activated C kinase) (GNB2-RS1)         P29312       14-3-3 Protein ζ/δ (protein kinase C 1) (RACK1)         (RCPI-1) (factor activating exoenzyme S) (FAS)         P29354       Growth factor activating exoenzyme S) (FAS)         P30086       Phosphatidylethanolamine-binding protein (2 (RBP)         P30153       Serine/threonine	Signal transduction	
1244400hCRMP-23309170COP9 complex subunit 43757834BCL2-associated athanogene 2 (BAG-family molecular chaperone regulator-2)4827056WD repeat-containing protein 1, isoform 2P04083Annexin I (lipocortin I) (calpactin II) (chromobindin 9) (P35) (phospholipase A2 inhibitory protein)P04901Guanine nucleotide-binding protein G(I)/G(S)/G(T) $\beta$ subunit 1 (transducin $\beta$ chain 1)P07355Annexin II (lipocortin II)(calpactin I heavy chain) (chromobindin 8)(P36)(protein 1)(placental anticoagulant protein IV)(PAP-IV)P11016Guanine nucleotide-binding protein G(I)/G(S)/G(T) $\beta$ subunit 2 (transducin $\beta$ chain 2) (G protein $\beta$ 2 subunit)P25388Guanine nucleotide-binding protein (Japacatent anticoagulant protein IV)(PAP-IV)P11016Guanine nucleotide-binding protein (ACKL1) (treceptor for activated C kinase) (GNB2-RS1)P25388Guanine nucleotide-binding protein (SNB2)(P205) (receptor of activated protein kinase C 1) (RACK1) (treceptor for activated C kinase) (SNB2-RS1)P2931214-3-3 Protein (L/S) dapter GRB2) (ASM)P30086Phosphatidylethanolamine-binding protein (PEBP) (neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide) (HCNP) (raf kinase inhibitor protein) (RKIP)P30153Serine / threonine protein protein.3P4265514-3-3 Protein e (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein)P4265514-3-3 Protein e (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein) JSBP51692Signal transducer and activator of transcription 5BQ00688 </td <td>1082693</td> <td>Phosphotyrosyl phosphatase activator PTPA</td>	1082693	Phosphotyrosyl phosphatase activator PTPA
3309170       COP9 complex subunit 4         4757834       BCL2-associated athanogene 2 (BAG-family molecular chaperone regulator-2)         4827056       WD repeat-containing protein 1, isoform 2         P04083       Annexin 1 (lipocortin 1) (calpactin 1) (chromobindin 9) (P35) (phospholipase A2 inhibitory protein)         P04901       Guanine nucleotide-binding protein G(1)/G(S)/G(T) β subuni 1 (transducin β chain 1)         P07355       Annexin II (ipocortin 1)(calpactin 1 heavy chain) (chromobindin 8)(P36)(protein 1)(placental anticoagulant protein IV)(PAP-IV)         P11016       Guanine nucleotide-binding protein G(1)/G(S)/G(T)         β subuni 2 (transducin β chain 2) (G protein β 2 subunit)         P25388       Guanine nucleotide-binding protein β subunit-like protein 12.3 (P205) (receptor of activated protein kinase C 1) (RACK1) (receptor of a activated C kinase) (GNB2-KS1)         P2312       14-33 Protein ζ/δ (protein kinase C inhibitor protein-1) (KCIP-1) (factor activating excenzyme S) (FAS)         P30086       Phosphatidylethanolamine-binding protein (PEBP) (neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide) (HCNP) (raf kinase inhibitor protein) (KHP)         P30153       Serine /threonine protein phosphatase PP2A, 65 KD aregulatory unit, α-isoform (PP2A, subunit A, PR65-α isoform) (PP2A, subunit A, R1-α isoform) (medium tumour antigen-associated 61 KDa protein)         P42655       14-3-3 Protein c (mitochondrial import simulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)	1244400	hCRMP-2
4757834       BCL2-associated athanogene 2 (BAG-family molecular chaperone regulator-2)         4827056       WD repeat-containing protein 1, isoform 2         P04083       Annexin 1 (lipocortin 1) (calpactin II) (chromobindin 9) (P35) (phospholipase A2 inhibitory protein)         P04901       Guanine nucleotide-binding protein G(I)/G(S)/G(T)         β subunit 1 (transducin β chain 1)         P07355       Annexin II (lipocortin I)(placental anticoagulant protein IV)(PAP-IV)         P11016       Guanine nucleotide-binding protein G(I)/G(S)/G(T)         β subunit 2 (transducin β chain 2) (G protein β 2 subunit)         P25388       Guanine nucleotide-binding protein β subunit-like protein 12.3         (P205) (receptor of activated protein kinase C I) (RACK1)       (receptor for activated C kinase) (GNB2-RS1)         P29312       14-3-3 Protein ζ/δ (protein kinase C inhibitor protein-1)         (KCIP-1) (factor activated grotein (PEBP)       (neuropolyperpide h3) (hippocampal cholinergic neurostimulating peptide)         (HCNP) (raf kinase inhibitor protein) (RKIP)       P30153         Serine/threonine protein protein jobsock action of P2A, subunit A,         R1-α isoform) (medium tumour antigen-associated 61 kDa protein)         P42655       14-3-3 Protein ϵ (mitochondrial import stimulation factor L subunit)         protein kinase C inhibitor protein-18         (protein kinase C inhibitor protein-18         (metroro	3309170	COP9 complex subunit 4
$\begin{array}{c} \mbox{chaperone regulator-2} \\ 4827056 & WD repeat-containing protein 1, isoform 2 \\ P04083 & Anexin 1 (lipocortin 1) (calpactin II) (chromobindin 9) \\ (P35) (phospholipase A2 inhibitory protein) \\ P04901 & Guanine nucleotide-binding protein G(1)/G(S)/G(T) \\ \beta subunit 1 (transducin \beta chain 1) \\ P07355 & Annexin II (lipocortin II)(calpactin I heavy chain)(chromobindin 8)(P36)(protein 1)(placental anticoagulant protein IV)(PAP-IV) \\ P11016 & Guanine nucleotide-binding protein G(1)/G(S)/G(T)\beta subunit 2 (transducin \beta chain 2) (G protein \beta 2 subunit) \\ P25388 & Guanine nucleotide-binding protein G(1)/G(S)/G(T)(receptor of activated protein infuncase C 1) (RACK1)(receptor if activated protein infuncase C 1) (RACK1)(receptor if activated protein infuncase C 1) (RACK1)(recreptor if activated protein infuncase C 1) (RACK1)(recreptor) (SH2/SH3 adapter GRB2) (ASH protein)Adapter protein) (SH2/SH3 adapter GRB2) (ASH protein)P30086 Phosphatidylethanolamine-binding protein (PEBP)(neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide)(HCNP) (raf kinase inhibitor protein) (RKIP)P30153 Serine/threonine protein phosphatase P2A, 65 kDa regulatoryunit, \alpha-isoform (pP2A, subunit A, PR65-\alpha isoform) (PP2A, subunit A, R1-\alpha isoform) (medium tumour antigen-associated 61 kDa protein)P42655 14-3-3 Protein e (mircohordini import simulation factor L subunit)(protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)(peptidyl-prolyl cis-trans isomerase) (EC 5.2.1.8) (PPiase) (rotamase)Transport/binding proteise(peptidyl-prolyl cis-trans isomerase) (EC 5.2.1.8) (PPiase) (rotamase)Transport/binding proteise(androg$	4757834	BCL2-associated athanogene 2 (BAG-family molecular
4827056       WD repeat-containing protein 1, isoform 2         P04083       Annexin I (lipocortin I) (calpactin II) (chromobindin 9)         (P35) (phospholipase A2 inhibitory protein)         P04901       Guanine nucleotide-binding protein G(I)/G(S)/G(T)         β subunit 1 (transducin β chain 1)         P07355       Annexin II (lipocortin II)(calpactin I heavy chain)         (chromobindin 8)(P36)(protein 10/placental anticoagulant protein IV)(PAP-IV)         P11016       Guanine nucleotide-binding protein G (D/G(S)/G(T)         β subunit 2 (transducin β chain 2) (G protein β 2 subunit)         P25388       Guanine nucleotide-binding protein G (D/G(S)/G(T)         (P205) (receptor of activated protein fixase (GNB2-RS1)         P2312       (14-3-3) (fortein kinase C inhibitor protein-1)         (KCIP-1) (factor activating exoenzyme S) (FAS)         P29354       Growth factor receptor-bound protein 2 (GRB2         adapter protein) (SH2/K31 adapter GRB2) (ASH protein)         P30086       Phosphatidylethanolamine-binding protein (PEBP)         (neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide)         (HCNP) (raf kinase inhibitor protein-1) (KCIP-1) (14-3-3E)         P30153       Serine (Hreonine protein phosphatase PP2A, 65 kDa regulatory         unit, α-isoform (PP2A, subunit A, PR65-α isoform) (PP2A, subunit A, R1-α isoform) (medium tumour antigen-associated 61 kDa protein)		chaperone regulator-2)
P04083       Anexin I (lipocortin Î) (calpactin II) (chromobindin 9) (P35) (phospholipase A2 inhibitory protein)         P04901       Guanine nucleotide-binding protein G(I)/G(S)/G(T) β subunit I (transducin β chain 1)         P07355       Annexin II (lipocortin II)(calpactin I heavy chain) (chromobindin 8)(P35)(protein 1)(placental anticoagulant protein IV)(PAP-IV)         P11016       Guanine nucleotide-binding protein G(I)/G(S)/G(T) β subunit 2 (transducin β chain 2) (G protein β 2 subunit)         P25388       Guanine nucleotide-binding protein β subunit-like protein 12.3 (P205) (receptor of activated protein kinase C 1) (RACK1) (receptor for activated C kinase) (GNB2-RS1)         P29312       14-3-3 Protein ζ/δ (protein t)(β laster GRB2) adapter protein) (SH2/SH3) adapter GRB2) (ASH protein)         P30086       Phosphatidylethanolamine-binding protein (PEBP) (neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide) (HCNP) (raf kinase inhibitor protein) (RKIP)         P30153       Serine /threonine protein phosphatase PP2A, 65 kDa regulatory unit α-isoform (PP2A, subunit A, PR65-α isoform) (PP2A, subunit A, R1-α isoform) (medium tumour antigen-associated 61 kDa protein)         P42655       Jia-33 Protein α (mitcohondriai impophilin (FKBP25) (peptidyl-prolyl cistrans isomerase) (EC 5.2.1.8) (PPiase) (rotamase)         Transport/binding proteis       Copin I         P02787       Serotransferrin precursor (siderophilin) (β-1-metal binding globulin) P17080         Grown I cancer protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24) <td>4827056</td> <td>WD repeat-containing protein 1, isoform 2</td>	4827056	WD repeat-containing protein 1, isoform 2
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	P04083	Annexin I (lipocortin I) (calpactin II) (chromobindin 9)
P04901       Guanine nucleotide-binding protein G(I)/G(S)/G(T) β subunit 1 (transducin β chain 1)         P07355       Annexin II (lipocotin I)(placental anticoagulant protein IV)(PAP-IV)         P11016       Guanine nucleotide-binding protein G(I)/G(S)/G(T) β subunit 2 (transducin β chain 2) (G protein β 2 subunit)         P25388       Guanine nucleotide-binding protein β subunit-like protein 12.3 (P205) (receptor of activated protein k subunit-like protein 12.3 (P205) (receptor of activated protein kinase C 1) (RACK1) (receptor for activated C kinase) (GNB2-RS1)         P29312       14-3-3 Protein $\xi/\delta$ (protein kinase C 1) (RACK1) (RCIP-1) (factor activating exoenzyme S) (FAS)         P29354       Growth factor receptor-bound protein 2 (GRB2 adapter protein) (SH2/SH3 adapter GRB2) (ASH protein)         P30086       Phosphatidylethanolamine-binding protein (RKP) (HCNP) (raf kinase inhibitor protein) (RKP)         P30153       Serine/threonine protein phosphatase PP2A, 65 kDa regulatory unit $\alpha$ -isoform (PP2A, subunit A, PR65- $\alpha$ isoform) (PP2A, subunit A, R1- $\alpha$ isoform) (medium tumour antigen-associated 61 kDa protein)         P42655       14-3-3 Protein $\epsilon$ (mitochondrial import simulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)         P51692       Signal transducer and activator of transcription 5B Q00688         Rapamycin-selective 25 kDa immunophilin (FKBP25) (peptidyl-prolyl cis-trans isomerase) (EC 5.2.1.8) (PPiase) (rotamase)         Transport/bindi		(P35) (phospholipase A2 inhibitory protein)
β subunit 1 (transducin β chain 1)         P07355       Annexin II (lipocortin II)(calpactin I heavy chain)         (chromobidin 8)(P36)(protein I)(placental anticoagulant protein IV)(PAP-IV)         P11016       Guanine nucleotide-binding protein G(I)/G(S)/G(T)         β subunit 2 (transducin β chain 2) (G protein β 2 subunit)         P25388       Guanine nucleotide-binding protein k G protein 12.3         (P205) (receptor of activated protein kinase C 1) (RACK1)         (receptor for activated C kinase) (GNB2-RS1)         P29312       14-3-3 Protein $\chi/\delta$ (protein kinase C inhibitor protein-1)         (KCIP-1) (factor activating excenzyme S) (FAS)         P29354       Growth factor receptor-bound protein 2 (GRB2         adapter protein) (SH2/SH3 adapter GRB2) (ASH protein)         P30086       Phosphatidylethanolamine-binding protein (PEBP)         (meuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide)         (HCNP) (raf kinase inhibitor protein) (RKIP)         P30153       Serine/threonine protein phosphatase PP2A, 65 kDa regulatory         unit, α-isoform) (medium tumour antigen-associated 61 kDa protein)         P42655       14-3-3 Protein € (mitochondrial import stimulation factor L subunit)         (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)         P51692       Signal transducer and activator of transcription 5B         Q00688       Rapamyc	P04901	Guanine nucleotide-binding protein G(I)/G(S)/G(T)
P07355       Annexin II (lipocortin II)(calpactin I heavy chain) (chromobindin 8)(P36)(protein J)(placental anticoagulant protein IV)(PAP-IV)         P11016       Guanine nucleotide-binding protein G(I)/G(S)/G(T) $\beta$ subunit 2 (transducin $\beta$ chain 2) (G protein $\beta$ 2 subunit)         P25388       Guanine nucleotide-binding protein $\beta$ subunit-like protein 12.3 (P205) (receptor of activated protein knase C 1) (RACK1) (receptor for activated protein knase C 1) (RACK1)         P29312       14-3-3 Protein $\zeta$ /8 (protein kinase C inhibitor protein-1) (KCIP-1) (factor activating exoenzyme S) (FAS)         P29354       Growth factor receptor-bound protein 2 (GRB2 adapter protein) (SH2/SH3 adapter GRB2) (ASH protein)         P30086       Phosphatidylethanolamine-binding protein (PEBP) (neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide) (HCNP) (raf kinase inhibitor protein) (RKIP)         P30153       Serine/threonine protein phosphatase PP2A, 65 kDa regulatory unit, α-isoform (PP2A, subunit A, PR65-α isoform) (PP2A, subunit A, R1-α isoform) (medium tumour antigen-associated 61 kDa protein)         P42655       14-3-3 Protein c (mitochordrial import stimulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)         P51692       Signal transducer and activator of transcription 5B Q00688         Rapamycin-selective 25 kDa immunophilin (FKBP25) (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase) <b>Transport/binding proteins</b> 4503013       Copine I         P02787       Serotransferrin precursor (siderophilin) (β-1-metal binding globulin		$\beta$ subunit 1 (transducin $\beta$ chain 1)
(chromobindin 8)(P36)(protein 1)(placental anticoagulant protein IV)(PAP-IV)         P11016       Guanine nucleotide-binding protein G(1)/G(S)/G(T)         β subunit 2 (transducin β chain 2) (G protein β 2 subunit)         P25388       Guanine nucleotide-binding protein β subunit-like protein 12.3         (P205) (receptor of activated protein kinase C 1) (RACK1)       (receptor for activated C kinase) (GNB2-RS1)         P29312       14-3-3 Protein {/8} (protein kinase C inhibitor protein-1)         (KCIP-1) (factor activating exoenzyme S) (FAS)         P29354       Growth factor receptor-bound protein 2 (GRB2         adapter protein) (SH2/SH3 adapter GRB2) (ASH protein)         P30086       Phosphatidylethanolamine-binding protein (PEBP)         (neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide)         (HCNP) (raf kinase inhibitor protein) (RKIP)         P30153       Serine/threonine protein phosphatase PP2A, 65 kDa regulatory         unit, α-isoform (PP2A, subunit A, PR65-α isoform) (PP2A, subunit A, R1-α isoform) (medium tumour antigen-associated 61 kDa protein)         P42655       14-3-3 Protein € (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)         P51692       Signal transducer and activator of transcription 5B         Q00688       Rapamycin-selective 25 kDa immunophilin (FKBP25) (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)	P07355	Annexin II (lipocortin II)(calpactin I heavy chain)
P11016       Guanine nucleotide-binding protein G(I)/G(S)/G(T)         β subunit 2 (transducin β chain 2) (G protein β 2 subunit)         P25388       Guanine nucleotide-binding protein β subunit-like protein 12.3         (P205)       (receptor of activated protein kinase C 1) (RACK1)         (receptor for activated C kinase) (GNB2-RS1)         P29312       14-3-3 Protein $\zeta/\delta$ (protein kinase C inhibitor protein-1)         (KCIP-1) (factor activating exoenzyme S) (FAS)         P29354       Growth factor receptor-bound protein 2 (GRB2         adapter protein) (SH2/SH3 adapter GRB2) (ASH protein)         P30086       Phosphatidylethanolamine-binding protein (PEBP)         (neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide)         (HCNP) (raf kinase inhibitor protein) (RKIP)         P30153       Serine/threonine protein protein fullomory stimulation factor L subunit A, R1-α isoform (PP2A, subunit A, PR65-α isoform) (PP2A, subunit A, R1-α isoform) (medium tumour antigen-associated 61 kDa protein)         P42655       14-3-3 Protein $\epsilon$ (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)         P51692       Signal transducer and activator of transcription 5B         Q00688       Rapamycin-selective 25 kDa immunophilin (FKBP25) (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)         Transport/binding proteins       4503013       Copine I <td></td> <td>(chromobindin 8)(P36)(protein I)(placental anticoagulant protein IV)(PAP-IV)</td>		(chromobindin 8)(P36)(protein I)(placental anticoagulant protein IV)(PAP-IV)
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	P11016	Guanine nucleotide-binding protein $G(I)/G(S)/G(T)$
P25388Guanine nucleotide-binding protein β subunit-like protein 12.3 (P205) (receptor of activated protein kinase C 1) (RACK1) (receptor for activated C kinase) (GNB2-RS1)P2931214-3-3 Protein $\zeta/\delta$ (protein kinase C inhibitor protein-1) (KCIP-1) (factor activating exoenzyme S) (FAS)P29354Growth factor receptor-bound protein 2 (GRB2 adapter protein) (SH2/SH3 adapter GRB2) (ASH protein)P30086Phosphatidylethanolamine-binding protein (PEBP) (neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide) (HCNP) (raf kinase inhibitor protein) (RKIP)P30153Serine/threonine protein phosphatase PP2A, 65 kDa regulatory unit, α-isoform (PP2A, subunit A, PR65-α isoform) (PP2A, subunit A, R1-α isoform) (medium tumour antigen-associated 61 kDa protein)P4265514-3-3 Protein € (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)P51692Signal transducer and activator of transcription 5B Q00688Rapamycin-selective 25 kDa immunophilin (FKBP25) (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)Transport/binding proteins4503013Copine I P02787P02787Serotransferrin precursor (siderophilin) (β-1-metal binding globulin) P17080P17080GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)		$\beta$ subunit 2 (transducin $\beta$ chain 2) (G protein $\beta$ 2 subunit)
$\begin{array}{cccc} (P205) \mbox{(receptor of activated protein kinase C 1) (RACK1)} \\ (receptor for activated C kinase) (GNB2-RS1) \\ P29312 14-3-3 \mbox{Protein $\zeta$} (fortein kinase C inhibitor protein-1) \\ (KCIP-1) \mbox{(factor activating exoenzyme S) (FAS)} \\ P29354 Growth factor receptor-bound protein 2 (GRB2 adapter protein) (SH2/SH3 adapter GRB2) (ASH protein) \\ P30086 Phosphatidylethanolamine-binding protein (PEBP) \\ (neuropolypeptide h3) \mbox{(hippocampal cholinergic neurostimulating peptide)} \\ (HCNP) \mbox{(raf kinase inhibitor protein) (RKIP) \\ P30153 Serine/htreonine protein phosphatase PP2A, 65 kDa regulatory \\ unit, $\alpha$-isoform (PP2A, subunit A, PR65-$\alpha$ isoform) (PP2A, subunit A, R1-$\alpha$ isoform) (medium tumour antigen-associated 61 kDa protein) \\ P42655 14-3-3 \mbox{Protein $\varepsilon$} (rnitochondrial import stimulation factor L subunit) \\ \mbox{(protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E) \\ P51692 Signal transducer and activator of transcription 5B \\ Q00688 Rapamycin-selective 25 kDa immunophilin (FKBP25) \\ \mbox{(peptidyl-prolyl cis-trans isomerase) (EC 5.2.1.8) (PPiase) (rotamase) \\ Transport/binding proteins \\ 4503013 Copine I \\ P02787 Serotransferrin precursor (siderophilin) (\beta-1metal binding globulin) \\ P17080 GTP-binding nuclear protein RAN (TC4) (RAN GTPase) \\ \mbox{(androgen receptor-associated protein 24) \\ \end{array}$	P25388	Guanine nucleotide-binding protein $\beta$ subunit-like protein 12.3
(receptor for activated C kinase) (GNB2-RS1)P2931214-3-3 Protein $\zeta/\delta$ (protein kinase C inhibitor protein-1) (KCIP-1) (factor activating exoenzyme S) (FAS)P29354Growth factor receptor-bound protein 2 (GRB2 adapter protein) (SH2/SH3 adapter GRB2) (ASH protein)P30086Phosphatidylethanolamine-binding protein (PEBP) (neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide) (HCNP) (raf kinase inhibitor protein) (RKIP)P30153Serine/threonine protein phosphatase PP2A, 65 kDa regulatory unit, $\alpha$ -isoform (PP2A, subunit A, PR65- $\alpha$ isoform) (PP2A, subunit A, R1- $\alpha$ isoform) (medium tumour antigen-associated 61 kDa protein)P4265514-3-3 Protein $\epsilon$ (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)P51692Signal transducer and activator of transcription 5B Q00688Q00688Rapamycin-selective 25 kDa immunophilin (FKBP25) (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)Transport/binding proteinsGropine I P02787P17080GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)		(P205) (receptor of activated protein kinase C 1) (RACK1)
P2931214-3-3 Protein $\zeta/\delta$ (protein kinase C inhibitor protein-1) (KCIP-1) (factor activating exoenzyme S) (FAS)P29354Growth factor receptor-bound protein 2 (GRB2 adapter protein) (SH2/SH3 adapter GRB2) (ASH protein)P30086Phosphatidylethanolamine-binding protein (PEBP) (neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide) (HCNP) (raf kinase inhibitor protein) (RKIP)P30153Serine/threonine protein phosphatase PP2A, 65 kDa regulatory unit, $\alpha$ -isoform (PP2A, subunit A, PR65- $\alpha$ isoform) (PP2A, subunit A, R1- $\alpha$ isoform) (medium tumour antigen-associated 61 kDa protein)P4265514-3-3 Protein $\epsilon$ (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)P51692Signal transducer and activator of transcription 5B Q00688Q00688Rapamycin-selective 25 kDa immunophilin (FKBP25) (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)Transport/binding proteins 4503013Copine I P02787P17080GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)		(receptor for activated C kinase) (GNB2-RS1)
$\begin{array}{c} (KCIP-1) \ (factor activating exoenzyme S) \ (FAS) \\ P29354 & Growth factor receptor-bound protein 2 \ (GRB2 \\ adapter protein) \ (SH2/SH3 adapter GRB2) \ (ASH protein) \\ P30086 & Phosphatidylethanolamine-binding protein (PEBP) \\ (neuropolypeptide h3) \ (hippocampal cholinergic neurostimulating peptide) \\ (HCNP) \ (raf kinase inhibitor protein) \ (RKIP) \\ P30153 & Serine/threonine protein phosphatase PP2A, 65 kDa regulatory \\ unit, $\alpha$-isoform (PP2A, subunit A, PR65-$\alpha$ isoform) (PP2A, subunit A, R1-$\alpha$ isoform) (medium tumour antigen-associated 61 kDa protein) \\ P42655 & 14-3-3 \ Protein $\epsilon$ (mitochondrial import stimulation factor L subunit) \\ (protein kinase C inhibitor protein-1) \ (KCIP-1) \ (14-3-3E) \\ P51692 & Signal transducer and activator of transcription 5B \\ Q00688 & Rapamycin-selective 25 kDa immunophilin \ (FKBP25) \\ (peptidyl-prolyl cis-trans isomerase) \ (EC 5.2.1.8) \ (PPiase) \ (rotamase) \\ \hline Transport/binding proteins \\ 4503013 & Copine I \\ P02787 & Serotransferrin precursor \ (siderophilin) \ (\beta-1-metal binding globulin) \\ P17080 & GTP-binding nuclear protein RAN \ (TC4) \ (RAN \ GTPase) \\ (androgen receptor-associated protein 24) \\ \hline \end{tabular}$	P29312	14-3-3 Protein $\zeta/\delta$ (protein kinase C inhibitor protein-1)
P29354Growth factor receptor-bound protein 2 (GRB2 adapter protein) (SH2/SH3 adapter GRB2) (ASH protein)P30086Phosphatidylethanolamine-binding protein (PEBP) (neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide) (HCNP) (raf kinase inhibitor protein) (RKIP)P30153Serine/threonine protein phosphatase PP2A, 65 kDa regulatory unit, $\alpha$ -isoform (PP2A, subunit A, PR65- $\alpha$ isoform) (PP2A, subunit A, R1- $\alpha$ isoform (medium tumour antigen-associated 61 kDa protein)P4265514-3-3 Protein $\epsilon$ (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)P51692Signal transducer and activator of transcription 5B (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)Transport/binding proteins4503013Copine I PO2787P17080GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)		(KCIP-1) (factor activating exoenzyme S) (FAS)
adapter protein) (SH2/SH3 adapter GRB2) (ASH protein)P30086Phosphatidylethanolamine-binding protein (PEBP) (neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide) (HCNP) (raf kinase inhibitor protein) (RKIP)P30153Serine/threonine protein phosphatase PP2A, 65 kDa regulatory unit, $\alpha$ -isoform (PP2A, subunit A, PR65- $\alpha$ isoform) (PP2A, subunit A, R1- $\alpha$ isoform) (medium tumour antigen-associated 61 kDa protein)P4265514-3-3 Protein $\epsilon$ (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)P51692Signal transducer and activator of transcription 5B (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)Transport/binding proteins4503013Copine I P02787P17080GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)	P29354	Growth factor receptor-bound protein 2 (GRB2
P30086       Phosphatidylethanolamine-binding protein (PEBP) (neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide) (HCNP) (raf kinase inhibitor protein) (RKIP)         P30153       Serine/threonine protein phosphatase PP2A, 65 kDa regulatory unit, α-isoform (PP2A, subunit A, PR65-α isoform) (PP2A, subunit A, R1-α isoform) (medium tumour antigen-associated 61 kDa protein)         P42655       14-3-3 Protein € (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)         P51692       Signal transducer and activator of transcription 5B Q00688         Rapamycin-selective 25 kDa immunophilin (FKBP25) (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase) <b>Transport/binding proteins</b> 4503013       Copine I         P02787       Serotransferrin precursor (siderophilin) (β-1-metal binding globulin)         P17080       GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)	DO000 C	adapter protein) (SH2/SH3 adapter GRB2) (ASH protein)
(neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide) (HCNP) (raf kinase inhibitor protein) (RKIP)P30153Serine/threonine protein phosphatase PP2A, 65 kDa regulatory unit, $\alpha$ -isoform (PP2A, subunit A, PR65- $\alpha$ isoform) (PP2A, subunit A, R1- $\alpha$ isoform) (medium tumour antigen-associated 61 kDa protein)P4265514-3-3 Protein $\epsilon$ (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)P51692Signal transducer and activator of transcription 5B (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)Transport/binding proteims4503013Copine I Serotransferrin precursor (siderophilin) ( $\beta$ -1-metal binding globulin) P17080P17080GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)	P30086	Phosphatidylethanolamine-binding protein (PEBP)
P30153Serine/threenine protein phosphatase PP2A, 65 kDa regulatory unit, $\alpha$ -isoform (PP2A, subunit A, PR65- $\alpha$ isoform) (PP2A, subunit A, R1- $\alpha$ isoform) (medium tumour antigen-associated 61 kDa protein)P4265514-3-3 Protein $\epsilon$ (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)P51692Signal transducer and activator of transcription 5B (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)Transport/binding proteins4503013Copine I Serotransferrin precursor (siderophilin) ( $\beta$ -1-metal binding globulin)P17080GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)		(neuropolypeptide h3) (hippocampal cholinergic neurostimulating peptide)
P30153Serine/threonine protein phosphatase PP2A, 65 KDa regulatory unit, α-isoform (PP2A, subunit A, PR65-α isoform) (PP2A, subunit A, R1-α isoform) (medium tumour antigen-associated 61 kDa protein)P4265514-3-3 Protein $\epsilon$ (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)P51692Signal transducer and activator of transcription 5B (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)Transport/binding proteins4503013Copine I Serotransferrin precursor (siderophilin) (β-1-metal binding globulin) GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)	D20152	(HCNP) (rat kinase inhibitor protein) (RKIP)
unit, $\alpha$ -isoform (PP2A, subunit A, PR65- $\alpha$ isoform) (PP2A, subunit A, R1- $\alpha$ isoform) (medium tumour antigen-associated 61 kDa protein)P4265514-3-3 Protein $\epsilon$ (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)P51692Signal transducer and activator of transcription 5B Q00688Q00688Rapamycin-selective 25 kDa immunophilin (FKBP25) (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)Transport/binding proteins4503013Copine I Serotransferrin precursor (siderophilin) ( $\beta$ -1-metal binding globulin)P17080GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)	P30153	Serine/threeonine protein phosphatase PPZA, 65 KDa regulatory
P4265514-3-3 Protein $\epsilon$ (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)P51692Signal transducer and activator of transcription 5B Q00688Q00688Rapamycin-selective 25 kDa immunophilin (FKBP25) (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)Transport/binding proteins4503013Copine I Serotransferrin precursor (siderophilin) ( $\beta$ -1-metal binding globulin) GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)		unit, $\alpha$ -isoform (PP2A, subunit A, PK65- $\alpha$ isoform) (PP2A, subunit A,
P42655       14-5-5 Protein € (mitochondrial import stimulation factor L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)         P51692       Signal transducer and activator of transcription 5B         Q00688       Rapamycin-selective 25 kDa immunophilin (FKBP25) (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)         Transport/binding proteins       4503013         4503013       Copine I         P02787       Serotransferrin precursor (siderophilin) (β-1-metal binding globulin)         P17080       GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)	D42655	K1-α isoform) (meanum tumour antigen-associated of KDa protein)
P51692       Signal transducer and activator of transcription 5B         Q00688       Rapamycin-selective 25 kDa immunophilin (FKBP25) (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)         Transport/binding proteins       4503013         4503013       Copine I         P02787       Serotransferrin precursor (siderophilin) (β-1-metal binding globulin)         P17080       GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)	P42055	(astric linear C is bitter partial 1/2000) (MCDE 1/2000)
P31092       Signal transducer and activator of transcription 3B         Q00688       Rapamycin-selective 25 kDa immunophilin (FKBP25) (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)         Transport/binding proteins       4503013         4503013       Copine I         P02787       Serotransferrin precursor (siderophilin) (β-1-metal binding globulin)         P17080       GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)	D51602	(protein kinase C inmotion protein-1) (KCIP-1) (14-3-5E) Signal transitions and activity of transmission 5D
G00088       Rapanychi-selective 25 KDa innititiopinini (FKBF25) (peptidyl-prolyl <i>cis-trans</i> isomerase) (EC 5.2.1.8) (PPiase) (rotamase)         Transport/binding proteins       4503013       Copine I         P02787       Serotransferrin precursor (siderophilin) (β-1-metal binding globulin)         P17080       GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)	P31092	Signai transducer and activator of transcription 5B Boomyogin coloriting (5) EDD immunosibilin (EVEPDS)
Transport/binding proteins         4503013       Copine I         P02787       Serotransferrin precursor (siderophilin) (β-1-metal binding globulin)         P17080       GTP-binding nuclear protein RAN (TC4) (RAN GTPase)         (androgen receptor-associated protein 24)	Q00088	(nentidyl_prolyl_cis_trans isomerase) (FC 5.2.1.8) (PPiase) (rotamase)
Transport/binding proteins         4503013       Copine I         P02787       Serotransferrin precursor (siderophilin) (β-1-metal binding globulin)         P17080       GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)		(pepidy) programs isomerase (De 5.2.1.0) (Trase) (roumase)
4503013     Copine 1       P02787     Serotransferrin precursor (siderophilin) (β-1-metal binding globulin)       P17080     GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)	Transport/binding	proteins
P17080 GTP-binding nuclear protein RAN (TC4) (RAN GTPase) (androgen receptor-associated protein 24)	4503013 D02787	Copine 1 Southangformin macaynage (cideraphilin) (0, 1 matal him time -laborlin)
(androgen receptor-associated protein 24)	PU2/8/ D17080	Serouansierin precursor (siderophilin) (p-1-metal binding globulin)
(androgen receptor-associated protein 24)	F1/080	(androgen resenter associated protein 24)
		(androgen receptor-associated protein 24)

Table 1. Continued

Accession no. <sup>b</sup>	Protein name(s) <sup>c</sup>
P17931	Galectin-3 (galactose-specific lectin 3) (MAC-2 antigen) (IgE-binding protein) (35 kDa lectin) (carbohydrate binding protein 35)
	(CBP 35) (laminin-binding protein) (lectin L-29) (L-31)
	(galactoside-binding protein) (GALBP)
P54920	$\alpha$ -Soluble NSF attachment protein (SNAP- $\alpha$ ) (N-ethylmaleimide-
	sensitive factor attachment protein, $\alpha$ )
Q02790	FK506-binding protein 4 (possible peptidyl-prolyl <i>cis-trans</i>
	isomerase FKBP4) (EC 5.2.1.8) (PPiase) (rotamase) (p59
	protein) (HSP binding immunophilin) (HBI) (FKBP52 protein)
	(52 kDa FK506 binding protein) (FKBP59)
Tumour associated	proteins
P13693	Translationally controlled tumour protein (TCTP) (p23)
	(histamine-releasing factor) (HRF)
Unannotated/function	on inferred
509033	GARS protein
2984585	P1.11659_4
2135068	Enhancer protein
3420179	WDR1 protein
3646128	Thioredoxin-like protein
3882167	KIAA0723 protein
4468253	A6 related protein
9966764	Lysophospholipase II
P12429	Annexin III (lipocortin III) (placental anticoagulant protein III)
	(PAP-III) ( $35-\alpha$ calcimedin) (inositol 1,2-cyclic phosphate
	2-phosphohydrolase)
Q61990	Poly(rC)-binding protein 2 (α-CP2) (putative heterogeneous nuclear ribonucleoprotein X) (hnRNP X) (CTBP) (CBP)
<sup>a</sup> Deced on the list	

<sup>a</sup> Based on the list of proteins identified in our earlier papers [12,13]. Note that protein names are according to the latest updates in the NCBI and swiss-PROT databases, which may differ from the names repeated in the previous papers, but the accession numbers remain the same.

<sup>b</sup> The proteins are sorted according to accession numbers within each category.

<sup>c</sup> Names in brackets are synonyms.

<sup>d</sup> Proteins that are involved in more than one metabolic pathway.

Table 2 List of HCC-M proteins implicated in HCC and other cancers

Protein name(s)	Accession no.	References
Chaperone/stress induced		
Heat shock 27 kDa protein	P04792	L.Yu et al., Electrophoresis, 21 (2000) 3058.
(HSP 27) (stress-responsive protein 27)		Identification of differentially expressed proteins
(SRP27) (oestrogen-regulated 24 kDa protein)		between human hepatoma and normal liver cell
(28 kDa heat shock protein)		lines by two-dimensional electrophoresis and liquid
		chromatography-ion trap mass spectrometry
Heat shock protein HSP 90-a	P07900	J. Hu and C. Seeger, Proc Natl Acad Sci USA
HSP 86)		93 (1996) 1060. Hsp90 is required for the
		activity of a hepatitis B virus reverse transcriptase
		G. Cho et al., Biochem Biophys Res Commun,
		269 (2000) 191. Localization of HSP90 binding
		in the human hepatitis B virus polymerase

Protein name(s)	Accession no.	References
Heat shock 70 kDa protein 1 (HSP70.1) (HSP70-1/HSP70-2)	P08107	M. Hantschel et al., Cell Stress Chaperones, 5 (2000) 438. Hsp70 plasma membrane expression on primary tumor biopsy material and bone marrow of leukemic patients
60 kDa heat shock protein, mitochondrial precursor (Hsp60) (60 kDa chaperonin) (CPN60) (heat shock protein 60) (HSP-60) (mitochondrial matrix protein P1) (P60 lymphocyte protein) (HuCHA60)	P10809	J. Schneider et al., Anticancer Res, 19 (1999) 2141. Immunohistochemical detection of HSP60-expression in human ovarian cancer. Correlation with survival in a series of 247 patients
Heat shock cognate 71 kDa protein	P11142	I. Byrjalsen et al., Mol Hum Reprod, 5 (1999) 748. Two-dimensional gel analysis of human endometrial proteins: characterization of proteins with increased expression in hyperplasia and adenocarcinoma
Endoplasmin precursor (94 kDa glucose-regulated protein) (GRP94) (GP96 homolog)	P14625	A. Menoret et al., Int J Cancer, 56 (1994) 400. Expression of the 100 kDa glucose-regulated protein (GRP100/endoplasmin) is associated with
(tumour rejection antigen 1)		tumorigenicity in a model of rat colon adenocarcinoma
Cytoskeleton/mobility Keratin, type II cytoskeletal 7	P08729	P. Van Eyken et al., Histopathology, 17 (1990) 101.
(Cytokeratin 7) (K7) (CK 7)		Abundant expression of cytokeratin 7 in fibrolamellar carcinoma of the liver
Tropomyosin $\alpha$ chain, fibroblast isoform TM3	P09494	
(tropomyosin 1, fibroblast isoform TM3)		P.J. Wirth, Electrophoresis. 15 (1994) 358. Two-dimensional polyacrylamide gel electrophoresis in experimental hepatocarcinogenesis studies
Fascin	Q16658	W. Hu et al., Clin Exp Metastasis, 18 (2000) 83.
(singed-like protein) (55 kDa actin bundling protein) (p55)		Increased expression of fascin, motility associated protein, in cell cultures derived from ovarian cancer and in borderline and carcinomatous ovarian tumors
DNA replication/gene regulation		
High mobility group protein HMG1	P09429	K. Kajino et al., Intervirology 44 (2001) 311.
(HMG-1)		Recombination hot spot of hepatitis B virus genome binds to members of the HMG domain protein family
		and the Y box binding protein family; implication of these proteins in genomic instability
		N. Kawahara et al., Cancer Res, 56 (1996) 5330.
		Enhanced coexpression of thioredoxin and high mobility group protein 1 genes in human hepatocellular carcinoma and the possible association with decreased sensitivity to cisplatin
Proliferating cell nuclear antigen (PCNA) (cyclin)	P12004	L. Nakopoulou et al., Pathol Res Pract, 191 (1995) 1208. Immunohistochemical expression of p53 protein and proliferating cell nuclear antigen in hepatocellular carcinoma T. Suehiro et al., Cancer, 76 (1995) 399.
		Chinicopathologic features and prognosis of resected hepatocellular carcinomas of varied sizes with special reference to proliferating cell nuclear antigen
Prohibitin	P35232	<ul> <li>S. Tanno et al., Jpn J Cancer Res, 88 (1997) 1155.</li> <li>Prohibitin expression is decreased in the regenerating liver but not in chemically induced hepatic tumors in rats</li> <li>T. Sato et al., Genomics, 17 (1993) 762.</li> <li>The human prohibitin (PHB) gene family and its somatic mutations in human tumors</li> </ul>

Protein name(s)	Accession no.	References	
Immunological response HLA class I histocompatibility antigen, α chainG precursor (HLA G antigen)	P17693	D.H. Moore et al., Gynecol Oncol, 38 (1990) 458. Class I histocompatibility antigen expression: a prognostic factor for aneuploid ovarian cancers	
Metabolism 3-Phosphoglycerate dehydrogenase	2674062	K. Snell et al., Biochem J. 245 (1987) 609. The modulation of serine metabolism in hepatoma 3924a during different phases of cellular proliferation in culture K. Snell and G. Weber, Biochem J, 233 (1986) 617.	
Isocitrate dehydrogenase 1 (NADP <sup>+</sup> ), soluble	5174471	A.N. Murphy et al., Biochem Biophys Res Commun, 157 (1988) 1218. Calcium sensitive isocitrate and 2-oxoglutarate dehydrogenase activities in rat liver and AS-30D hepatoma mitochondria	
Purine nucleoside phosphorylase (EC 2.4.2.1) (inosine phosphorylase) (PNP)	P00491	T.U. Krohne et al., Hepatology, 34 (2001) 511. Mechanisms of cell death induced by suicide genes encoding purine nucleoside phosphorylase and thymidine kinase in human hepatocellular carcinoma cells in vitro L. Mohr et al., Hepatology, 31 (2000) 606. Gene therapy of hepatocellular carcinoma in vitro and in vivo in nude mice by adenoviral transfer of the <i>Escherichia coli</i> purine nucleoside phosphorylase gene O. Sanfilippo et al., Cancer Biochem Biophys, 14 (1994) 57. Relationship between the levels of purine salvage pathway enzymes and clinical/biological aggressiveness of of human colon carcinoma	
Triosephosphate isomerase (EC 5.3.1.1) (TIM)	P00938	T. Nagase et al., Comp Biochem Physiol B, 99 (1991) 193. Analyses of polypeptides in the liver of a novel mutant (LEC rats) to hereditary hepatitis and hepatoma by two-dimensional gel electrophoresis: identification of P29/6.8 as carbonic anhydrase III and triosephosphate isomerase	
Glyceraldehyde-3-phosphate dehydrogenase, liver (EC 1.2.1.12)	P04406	Y. Gong et al., Hepatology, 23 (1996) 734. Comparison of glyceraldehyde-3-phosphate dehydrogenase and 28s-ribosomal RNA gene expression in human hepatocellular carcinoma as carbonic anhydrase III and triosephosphate isomerase	
ATP synthase $\beta$ chain, mitochondrial precursor (EC 3.6.3.14)	P06576	F. Capuano et al., J Bioenerg Biomembr, 29 (1997) 379. Oxidative phosphorylation enzymes in normal and neoplastic cell growth	
α-Enolase (EC 4.2.1.11) (2-phospho-D-glycerate hydrolyase) (NON-neural enolase) (NNE) (phosphopyruvate hydratase)	P06733	N. Durany et al., Br J Cancer, 75 (1997) 969. Phosphoglycerate mutase, 2,3-bisphosphoglycerate phosphatase and enolase activity and isoenzymes in lung, colon and liver carcinomas and neoplastic cell growth	
Inosine-5'-monophosphate dehydrogenase 2 (EC 1.1.1.205) (IMP dehydrogenase 2) (IMPDH-II) (IMPD 2) Creatine kinase, B-chain (EC 2.7.3.2) (B-CK)	P12268 P12277	<ul> <li>H.N. Jayaram et al., Curr Med Chem, 6 (1999) 561.</li> <li>Consequences of IMP dehydrogenase inhibition, and its relationship to cancer and apoptosis</li> <li>J. Joseph et al., Br J Cancer, 76 (1997) 600.</li> <li>Creatine kinase activity and isoenzymes in lune, colon and liver carcinomas</li> </ul>	

Protein name(s)	Accession no.	References
5'-Methylthioadenosine phosphorylase (EC 2.4.2.28) (MTA phosphorylase) (MTAPASE)	Q13126	<ul> <li>M. Schmid et al., Oncogene, 19 (2000) 5747.</li> <li>A methylthioadenosine phosphorylase (MTAP) fusion transcript identifies a new gene on chromosome 9p21 that is frequently deleted in cancer</li> <li>F. Della Ragione et al., Oncogene, 10 (1995) 827.</li> <li>5'-Deoxy-5'-methylthioadenosine phosphorylase and p16INK4 deficiency in multiple tumor cell lines</li> </ul>
Alcohol dehydrogenase [NADP <sup>+</sup> ] (EC 1.1.1.2) (aldehyde reductase)	P14550	<ul> <li>Z. Zhang and J. Bian, Zhonghua Yi Xue Yi Chuan Xue Za Zhi, 18 (2001) 62. [in Chinese]</li> <li>[Progress in researches on the relationship between genetic polymorphisms of alcohol-metabolizing enzymes and cancers]</li> </ul>
Nucleoside diphosphate kinase A (EC 2.7.4.6) (NDK A) (NDP kinase A) (tumour metastatic process-associated protein) (metastasis inhibition factor nm23) (nm23-H1)	P15531	<ul> <li>Y. Fujimoto et al., J Gastroenterol, 33 (1998) 368.</li> <li>Reduced expression and rare genomic alteration of nm23-H1 in human hepatocellular carcinoma and hepatoma cell lines</li> <li>N. lizuka et al., Cancer Res, 55 (1995) 652.</li> <li>NM23-H1 and NM23-H2 messenger RNA abundance in human hepatocellular carcinoma</li> </ul>
Phosphoglycerate mutase, brain form (EC 5.4.2.1) (PGAM-B) (EC 5.4.2.4) (EC 3.1.3.13) (BPG-dependent PGAM)	P18669	N. Durany et al., Br J Cancer, 75 (1997) 969. Phosphoglycerate mutase, 2,3-bisphosphoglycerate phosphatase and enolase activity and isoenzymes in lung, colon and liver carcinomas
Transaldolase (EC 2.2.1.2)	P37837	P.C. Heinrich et al., Cancer Res, 36 (1976) 3189. Behavior of transaldolase (EC 2.2.1.2) and transketolase (EC 2.2.1.1) Activities in normal, neoplastic, differentiating, and regenerating liver
Glutathione synthetase (EC 6.3.2.3) (glutathione synthase) (GSH synthetase) (GSH-S)	P48637	Z. Huang et al., FASEB J, 15 (2001) 19. Mechanism and significance of increased glutathione level in human hepatocellular carcinoma and liver regeneration
3-Hydroxyacyl-CoA dehydrogenase type II (EC 1.1.1.35) (Type II HADH) (endoplasmic reticulum-associated amyloid β-peptide binding protein) (short-chain type dehydrogenase/reductase XH98G2)	Q99714	K. Suto et al., J Cancer Res Clin Oncol, 125 (1999) 83. Decreased expression of the peroxisomal bifunctional enzyme and carbonyl reductase in human hepatocellular carcinomas
RNA-binding protein regulatory subunit	6005749	D. Nagakubo et al. Biochem. Biophys. Res. Commun. (1997) 509. DJ-1, a novel oncogene that transformes mouse NIH3T3 cells in cooporation with ras
Maspin precursor (protease inhibitor 5)	P36952	<ul> <li>L. Yu et al., Electrophoresis, 21 (2000) 3058.</li> <li>Identification of differentially expressed proteins between human hepatoma and normal liver cell lines by two-dimensional electrophoresis and liquid chromatography-ion trap mass spectrometry N. Maass et al., J Pathol, 195 (2001) 321.</li> <li>Decline in the expression of the serine proteinase inhibitor maspin is associated with tumour progression in ductal carcinomas of the breast</li> </ul>

Protection and detosilication         4507149         M. Marikovsky et al., Int J Cancer, 97 (2002) 34.           Supervised distantase procursor (MN), mitochondrial preusor (EC 1.15.1.)         P01179         V. Hajnicka et al., Acti VYA, 44 (2000) 343.           Anacxin V         P08758         Z.J. Gong et al., Hepatology, 39 (1999) 576.           (lipcortin V) (reducer, in II) (calpobind II) (CBP-1) (placental anticogulant protein D) (DPL-1) (Placental anticogulant-to) (VAC-a) (anchorin CII)         P09211         J.C. Tehou et al., Int J Oncol, 16 (2000) 663.           GSTPI CpG island DNA hypermetrylation in hepatocellular carcinomas         T. Zhon et al., Cancer Res, 57 (1097) 224.           Glutathione S transferase P (thoredoxin peroxidae 1) (thoredoxin peroxidae 1) (thoredoxin peroxidae 1)         P0211         J.C. Tehou et al., Cancer Res, 57 (1097) 224.           Glutathione S transferase expression in human biset cancer (thoredoxin peroxidae 1)         P32119         DY. Not et al., Anticarcer Res, 57 (1097) 224.           Glutathione S in monum by period and the period at all characters responsion in human biset cancer (thoredoxin peroxidae 1)         Transferase expression in human by portion in human by reat cancer (thoredoxin peroxidae 1)         P10404 1007           Cell etablacting factor B) (NSE-B)         S986482         N.N. Nupponen et al., Am J Pathol, 154 (1999) 177.	Protein name(s)	Accession no.	References
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Supervised dismates presensor (MN),       P01179       V. Hijnička et al., Arto, Wru, 44 (2000) 343.         mitochondial precursor (EC 1.15.1.)       Comparison of mangenes supervised dismutase precursor induction ability in human hepatoma cells with or without hepatomis is 3 vins DNA insertion         Anacxin V       P05758       Z. Gong et al., Repatolog. 20 (1999) 576.         (lipcortini V) feedonexin II)       Transferios of an thepatoma cell line with (a construct expressing human liver amexin V confers susceptibility to hepatinis B vinus infection         anticoagulat protein I) (RNP-1) (PP4)       Comparison of an angenose approach (RNP-1) (PP4)         (diabatistin I) (scalart anticoagulate) (VoCeo) (anchoin CII)       Strengenose (RS, 57 (197) 2794.         Ghanhione S-transferase P       P9211       J.C. Tchou et al., Int J Oncol, 16 (2000) 663.         (BC 2.5.1.18) (GST class-PI) (GSTP1-1)       P32119       DY. Noh et al., Antiot Accessing in hepatitis         Provincidoxin 2       P32119       DY. Noh et al., Cancer Res, 21 (2001) 2085.         (Ithioredoxin dependent provide       T. Yanagawa et al., Cancer Lett, 145 (1999) 127.         reduction specific (SR PR) (nutrunt lift)       Provincidoxia 1       Antioid Reso Signal, 1 (1999) 385.         reduction specific (SR PR) (nutrunt lift)       Provincidoxia 1       Antioid Reso Signal, 1 (1999) 385.         reduction dependent provide       Form cytoprotection to tumes suppression: thuman thyraid turnor provide NDA in turnor provi	sclerosis 1 (adult)] (Cu/Zn superoxide dismutase)		Cu/Zn superoxide dismutase plays a role in angiogenesis
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Glutathione S-transferase P       P9211       J.C. Tchou et al., Int J Oncol, 16 (2000) 663.         (EC 2.5.1.8) (GST class-PI) (GSTP1-1)       GGTP1 (2000) 663.       GGTP1 (2000) 663.         (EC 2.5.1.8) (GST class-PI) (GSTP1-1)       GGTP1 (2000) 663.       GGTP1 (2000) 663.         Peroxiredoxin 2       P22119       D1. Oncol, 16 (2000) 663.         (thioredoxin peroxidase 1)       Overexpression in hepatitis       B visua-associated human hepatocellular carcinogenesis         (thioredoxin dependent peroxide       P22119       D1. Noh et al., Anticarcer Res, 21 (2001) 2085.         (thioredoxin dependent peroxide       T. Yanagawa et al., Cancer Let, 145 (1999) 127.         reductase 1) (hiol-specific antioxidant       Porosiredoxin in human thyroid tumors         protein (TSA) (RPP) (nature Ikller       LH. Butterfield et al., Antioxia Rebox Signal, 1 (1999) 385.         cell enhancing factor B) (NKEF-B)       Translation initiation factor all p40       3986482         Protein synthesia and degradation       Translation initiation factor 3,       4503519       L Lin et al., J Cell Biochem, 80 (2001) 483.         subunit 5 (e, 47000)       Molecular interaction between human tumor       marker protein j153, the algost subunit of eIT3, and intermediate filament protein K7         Proteasome (prosome, macropain)       4506217       H. Highstingi et al., Nat Med, 6 (2000) 96.         26S subunit, non-ATPase, 10       ggalxyri	anticoagulant- $\alpha$ ) (VAC- $\alpha$ ) (anchorin CII)		
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(thioredown-dependent peroxide       T. Yangawa et al., Cancer Let, 145 (1999) 127.         reductase 1) (thio-specific antioxidant       Peroxiredoxin I expression in human thyroid tumors         protein) (TSA) (PRP) (natural killer       L.H. Butterfield et al., Antioxid Redox Signal, 1 (1999) 385.         cell enhancing factor B) (NKEF-B)       From cytoprotection to tumor suppression: the multifactorial role of peroxiredoxins         Protein synthesis and degradation       Translation initiation factor eIF3 p40         ranslation initiation factor 3, subunit (eIF3p40)       Amplification and overexpression of p40 subunit of eukaryotic translation initiation factor 3,         Eakaryotic translation initiation factor 3,       4503519         L Lin et al., J Cell Biochem, 80 (2001) 483.         subunit 5 (e, 47000)       Molecular interaction between human tumor marker protein p150, the largest subunit of eIF3, and intermediate filament protein K7         Proteasome (prosome, macropain)       4506217         26S subunit, non-ATPase, 10       gankyrin, an oncogenic ankyrin-repeat protein overexpressed in hepatomas         S.A. Shah et al., Surg Oncol, 10 (2001) 43.       Ubiquitin proteasome pathway: implications and advances in cancer therapy         Placental thrombin inhibitor       P35237       S.D. Mikolajczyk et al., Cancer Res, 59 (1999) 3927.         (cytoplasmic antiproteinase) (CAP)       Harding and protease inhibitor-6 in prostate convert fiscue	(thioredoxin perovidase 1)	152117	Overexpression of peroviredovin in human breast cancer
(university product       Protein product       Provincedoxin in expension in human thyroid tumors         protein) (TSA) (PRP) (natural killer       LH. Butterfield et al., Antioxid Redox Signal, 1 (1999) 385.         cell enhancing factor B) (NKEF-B)       From cytoprotection to tumor suppression: the multifactorial role of peroxiredoxins         Protein synthesis and degradation       Translation initiation factor eIF3 p40       3986482         Subunit (eIF3p40)       Same and overexpression of p40 subunit of eukaryotic translation initiation factor 3 in breast and prostate cancer         Eukaryotic translation initiation factor 3, subunit 5 (€, 47000)       4503519       L. Lin et al., J Cell Biochem, 80 (2001) 483.         Proteasome (prosome, macropain)       4506217       H. Higashitsuji et al., Nat Med, 6 (2000) 96.         26S subunit, non-ATPase, 10       Reduced stability of retinoblastoma protein by gankyrin, an oncogenic ankyrin-repeat protein overexpressed in hepatomas         Placental thrombin inhibitor (cytoplasmic antiproteinsee) (CAP)       P35237       S.D. Mikolajczyk et al., Cancer Res, 59 (1999) 3927.         Identification of a novel complex between human (protease inhibitor 6)       P35237       S.D. Mikolajczyk et al., Cancer Res, 59 (1999) 3927.	(thioredoxin-dependent peroxide		T Yanagawa et al. Cancer Lett. 145 (1999) 127
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Protein synthesis and degradation       the multifactorial role of peroxiredoxins         Translation initiation factor eIF3 p40       3986482       N.N. Nupponen et al., Am J Pathol, 154 (1999) 1777.         subunit (eIF3p40)       Amplification and overexpression of p40       subunit of eukaryotic translation initiation         Eukaryotic translation initiation factor 3,       4503519       L. Lin et al., J Cell Biochem, 80 (2001) 483.         subunit 5 (ε, 47000)       Molecular interaction between human tumor         marker protein p150, the largest subunit of eIF3, and intermediate filament protein K7         Proteasome (prosome, macropain)       4506217         26S subunit, non-ATPase, 10       Reduced stability of retinoblastoma protein by gankyrin, an oncogenic ankyrin-repeat protein overexpressed in hepatomas         S.A. Shah et al., Surg Oncol, 10 (2001) 43.       Ubiquitin proteasome pathway: implications and advances in cancer therapy         Placental thrombin inhibitor       P35237       S.D. Mikolajczyk et al., Cancer Res, 59 (1999) 3927.         (cytoplasmic antiproteinase) (CAP)       P35237       S.D. Mikolajczyk et al., Cancer Res, 59 (1999) 3927.         (cytoplasmic antiproteinase) (CAP)       Kalikrein 2 and protease inhibitor 6)       kalikrein 2 and protease inhibitor-6 in prostate	cell enhancing factor B) (NKEE-B)		From extoprotection to tumor suppression:
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subult (cfr.5pr0)       Full pincation and overlap testing of pro- subunit of eukaryotic translation initiation factor 3 in breast and prostate cancer         Eukaryotic translation initiation factor 3, subunit 5 (ε, 47000)       4503519       L. Lin et al., J Cell Biochem, 80 (2001) 483.         Molecular interaction between human tumor marker protein p150, the largest subunit of eIF3, and intermediate filament protein K7       Molecular interaction between human tumor marker protein p150, the largest subunit of eIF3, and intermediate filament protein K7         Proteasome (prosome, macropain)       4506217       H. Higashitsuji et al., Nat Med, 6 (2000) 96.         26S subunit, non-ATPase, 10       Reduced stability of retinoblastoma protein by gankyrin, an oncogenic ankyrin-repeat protein overexpressed in hepatomas         S.A. Shah et al., Surg Oncol, 10 (2001) 43.       Ubiquitin proteasome pathway: implications and advances in cancer therapy         Placental thrombin inhibitor (cytoplasmic antiproteinase) (CAP)       P35237       S.D. Mikolajczyk et al., Cancer Res, 59 (1999) 3927.         (protease inhibitor 6)       kallikrein 2 and protease inhibitor-6 in prostate cancer tissue       kallikrein 2 and protease inhibitor-6 in prostate cancer tissue	subunit (eIF3p40)	5900402	Amplification and overexpression of p40
Eukaryotic translation initiation factor 3,       4503519       L. Lin et al., J Cell Biochem, 80 (2001) 483.         subunit 5 (ε, 47000)       Molecular interaction between human tumor         marker protein p150, the largest subunit of eIF3, and intermediate filament protein K7         Proteasome (prosome, macropain)       4506217         26S subunit, non-ATPase, 10       Reduced stability of retinoblastoma protein by gankyrin, an oncogenic ankyrin-repeat protein overexpressed in hepatomas         S.A. Shah et al., Surg Oncol, 10 (2001) 43.       Ubiquitin proteasome pathway: implications and advances in cancer therapy         Placental thrombin inhibitor       P35237       S.D. Mikolajczyk et al., Cancer Res, 59 (1999) 3927.         (protease inhibitor 6)       kallikrein 2 and protease inhibitor-6 in prostate       cancer tiespe	subuliit (ch 5p+0)		subunit of eukarvotic translation initiation
Eukaryotic translation initiation factor 3,       4503519       L. Lin et al., J Cell Biochem, 80 (2001) 483.         subunit 5 (ε, 47000)       Molecular interaction between human tumor         marker protein p150, the largest subunit of eIF3, and intermediate filament protein K7         Proteasome (prosome, macropain)       4506217         26S subunit, non-ATPase, 10       Reduced stability of retinoblastoma protein by gankyrin, an oncogenic ankyrin-repeat protein overexpressed in hepatomas         S.A. Shah et al., Surg Oncol, 10 (2001) 43.       Ubiquitin proteasome pathway: implications and advances in cancer therapy         Placental thrombin inhibitor       P35237       S.D. Mikolajczyk et al., Cancer Res, 59 (1999) 3927.         (protease inhibitor 6)       kallikrein 2 and protease inhibitor-6 in prostate       cancer tissue			factor 3 in breast and prostate cancer
Likar your dialisation minimum factor 3,       450515       E. En et al., 5 Chi Dictuch, 60 (2001) 40.         subunit 5 (ε, 47000)       Molecular interaction between human tumor marker protein p150, the largest subunit of eIF3, and intermediate filament protein K7         Proteasome (prosome, macropain)       4506217       H. Higashitsuji et al., Nat Med, 6 (2000) 96.         26S subunit, non-ATPase, 10       Reduced stability of retinoblastoma protein by gankyrin, an oncogenic ankyrin-repeat protein overexpressed in hepatomas         S.A. Shah et al., Surg Oncol, 10 (2001) 43.       Ubiquitin proteasome pathway: implications and advances in cancer therapy         Placental thrombin inhibitor       P35237       S.D. Mikolajczyk et al., Cancer Res, 59 (1999) 3927.         (protease inhibitor 6)       kallikrein 2 and protease inhibitor-6 in prostate cancer tissue	Eukarvotic translation initiation factor 3	4503519	L Lin et al. L Cell Riochem 80 (2001) 483
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Placental thrombin inhibitor       P35237       S.D. Mikolajczyk et al., Cancer Res, 59 (1999) 3927.         (cytoplasmic antiproteinase) (CAP)       P35237       S.D. Mikolajczyk et al., Cancer Res, 59 (1999) 3927.         (protease inhibitor 6)       kalikrein 2 and protease inhibitor-6 in prostate       cancer tissue	Protessome (prosome macropain)	4506217	H Higgshitsuij et al. Not Med. 6 (2000) 96
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(cytoplasmic antiproteinase) (CAP)     Identification of a novel complex between human       (protease inhibitor 6)     kallikrein 2 and protease inhibitor-6 in prostate	Discontal thrombin inhibitor	P25227	S.D. Mikoloiaruk et al. Canaar Res. 50 (1000) 2027
(protease inhibitor 6) kallikrein 2 and protease inhibitor-6 in prostate	(cytoplasmic antiproteinase) (CAD)	1 33231	Identification of a noval complex between human
(process minoror o) Kamaron 2 and process minoror-o in prosate	(protease inhibitor 6)		kallikrein 2 and protease inhibitor.6 in prostate
	(protector minoritor 0)		cancer tissue

Signal transduction       P04083       C. dc Coupade et al., Hepatology, 31 (2000) 371.         Amexin 1       (ef35) (phospholipase A2 inhibitory protein)       Amexin 1 expression and phosphorylation are upregulated during itree regeneration and transformation in antihrowshin III SV40 T large antigen transgeric mice and expression of the protein Kinase T in Maski et al., Hepatology, 24 (1996) 72.         Guanize macleotide-binding protein β submit-like       P25388       D. Schechman et al., Oncogene, 30 (2001) 6339.         Guanize macleotide-binding protein β submit-like       P25388       D. Schechman et al., Oncogene, 30 (2001) 6339.         Guanize macleotide-binding protein β submit-like       P25388       D. Schechman et al., Oncogene, 10 (2001) 5298.         (fuortin kianse C inhibitor protein in protein kinase critical signal transduction activated (Stanse) (GNS2-881)       P29312       N. Iwata et al., Oncogene, 10 (2001) 5298.         (factor activating econzyme S) (FAS)       P29312       N. Iwata et al., Oncogene, 10 (2001) 5298.       Frequent hypermethylation of CQ6 islands and loss of expression din the J-3-3 sigma gene in humana bepatocellular carcinoma         Serine / thronine protein phosphatase       P30153       C. Fukukawa et al., Cancer Lett, 161 (2000) 89.         (P2A, submit A, PR65-si soform (P2A, submit A, PR65-si soform) (P2A, Submit A, PR65-si	Protein name(s)	Accession no.	References
Amexin I (Cab Congole et al., Phapology, 31 (2000) 371. (lipocortin I) (chlomobindin 9) (735) (phopholipse A2 inhbitory protein) (735) (phopholipse A2 inhbitory protein) (736) (phopholipse A2 inhbitory protein) (737) (phopholipse A2 inhbitory protein) (738) (phopholipse A2 inhbitory protein) (738) (phopholipse A2 inhbitory protein) (739) (phopholipse A2 inhbitory protein) (731) (phopholipse A2 inhbitory protein) (732) (phopholipse A2 inhbitory protein) (732) (phopholipse A2 inhbitory protein) (733) (phopholipse A2 inhbitory protein) (733) (phopholipse A2 inhbitory protein) (733) (phopholipse A2 inhbitory protein) (734) (phopholipse A2 inhbitory protein) (735) (phopholipse A2 inhibitory protein) (735) (phopholipse A2 inhibitory protein) (735) (phopholipse A2	Signal transduction		
(ipcourin I) (adpacin II) (chromobidin 9)         Annexin I expression and phosphorytation are upreglated during liver representation and transformation in antihrombin III SV40 T large antigen transgenic mice           (P55) (phospholipuse A2 inhibitory protein)         upreglated during liver representation and transformation in antihrombin III SV40 T large antigen transgenic mice           Guanine macleotide-binding protein β subunit-like         P25388         D. Schechtman et al., Oncogene, 20 (2001) 6339.           Guanine macleotide-binding protein β subunit-like         P25388         D. Schechtman et al., Oncogene, 20 (2001) 6339.           protein 1/23 (P250) (teceptor of activated         Cmediated signal transduction           protein kinase C (1RACK1) (receptor for         Cmediated signal transduction           4:13-3 Potein (3/6         P29312         N. Ivata et al., Oncogene, 19 (2000) 5298.           (protein kinase C inhibitor protein-1) (KCIP-1)         Prequent hypermethylation of CpG islands           (factor activating econzyme S) (PAS)         and loss of expression of the 14-3-3 sigma gene in human heptacellular carcinoma           Serine / Intronsine protein phosphatase         P30153         C. Fukdakwa et al., Cancer Lett, 161 (2000) 89.           (PP2A, suburit A, PR65-α isoform) (PP2A, suburit M, PR65-α isoform) (PP2A, suburit A, PR65-α isoform) (PP2A, suburit M, PR65-α isoform)         Bisruption of Tocin hophophatase           (Atta-3 Protein €         P12652         R. Ruediger et al., Oncogene, 19 (2000) 59.8.	Annexin I	P04083	C. de Coupade et al., Hepatology, 31 (2000) 371.
(P3) (phospholipase A2 inhibitory protein) upregulated diring liver regeneration and transperior mice antigen transperior mice T. Maski et al., Heaptology, 24 (1996) 72. Enhanced expression of the protein Knase substrue antexion in anualt heaptocellular carcinoma associated signal transperior mice associated signal transperior mice associated signal transperior mice associated signal transperior of activated Adaptor proteins in protein kinase (1092) (303). protein 12.3 (P205) (receptor of activated P25388 protein 12.3 (P205) (receptor of activated P25388) protein 12.3 (P205) (receptor of activated P25388) protein (7.6) (PARCAS1) (receptor for activated signal transduction activated (signal transduction activated activated (signal transduction activated (sign	(lipocortin I) (calpactin II) (chromobindin 9)		Annexin 1 expression and phosphorylation are
transformation in anthrombia III SV40 T large antigen transgenic mice       T. Maski et al., Hepatology, 24 (1996) 72.         Enhanced expression of the protein Kinase       substruct annoxin in human hepatocellular carcinoma         Guanine nucleoride-binding protein β subuni-like       P25388       D. Schechtman et al., Oncogene, 20 (2001) 6339.         Protein Kinase (Structed)       C. meditatol signal transduction       activated         protein Kinase (Chinese) (StR2S1)       Fequent hypermethylation of CPG islands         (factor activating excenzyme S) (FAS)       P29312       not loss of expression of the 14-33 sigma         Serine /thronine protein phosphatase       P30153       C. Fakukawa et al., Oncogene, 10 (2000) 5298.         (PP2A, submit A, P655-cisoform) (PP2A, submit A, P65	(P35) (phospholipase A2 inhibitory protein)		upregulated during liver regeneration and
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Guanie nucleotide-binding protein β submit-like       P25388       D. Schechman et al., Oncogene, 20 (2001) 6339.         protein 12.3 (P205) (receptor of activated       P25388       D. Schechman et al., Oncogene, 20 (2001) 6339.         protein 12.3 (P205) (receptor of activated       P25382       D. Schechman et al., Oncogene, 19 (2000) 5298.         protein kinase C 1) (RACK1) (receptor for       C-mediated signal transduction       C-mediated signal transduction         activated C kinase (Inhibitor protein-1) (KCIP-1)       Frequent hypermethylation of CpC islands       and loss of expression of the 14-3-3 sigma         (factor activating exoenzyme S) (FAS)       gene in human hepatocellular carcinoma       gene in human hepatocellular carcinoma         Serine /threonine protein phosphatase       P30153       C. Fukkawa et al., Cancer Lett, 161 (2000) 89.         (P2A, submit A, PR65-a isoform) (P2A, submit A,       in tar primary hepatomas and regenerating livers         (P2A, submit A, PR65-a isoform) (P2A, submit A,       in tar primary hepatomas and regenerating livers         (P2A, submit A, PR65-a isoform) (P2A, submit A,       R. Roediger et al., Oncogene, 20 (2001) 10         antigen-associated 61 kDa protein-1)       Disruption of protein phosphatase 2A submit interaction in human cancers with mutations in the A alpha submit gene         14-33 Protein €       P24055       N. Ivata et al., Oncogene, 19 (2000) 5298.         (RCP1-1) (14-3-3E)       Intera alpha submit gene <td></td> <td></td> <td>antigen transgenic mice</td>			antigen transgenic mice
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subarti a new in in human hepatocellular carcinoma Gamine muckoide-binding protein β subuni-like protein 1.2.3 (P205) (receptor of activated protein kinase C 1) (RACK1) (receptor for activated C Kinses (CKR2-RS1) 14-3.3 Protein ζ δ (protein kinase C inhibitor protein-1) (KCP-1) (factor activating excenzyme S) (FAS) Serine / thronine protein phosphatase P30153 P20153 P2015 Serine / thronine protein phosphatase P30153 P20153 P2015 P2015 Serine / thronine protein phosphatase P30153 P2015 P2			Enhanced expression of the protein kinase
Guanine nucleoide-binding protein ß submit-like       P25388       D. Schechman et al., Oncogene, 20 (2001) 6339.         protein kinase (Childe Signal transduction       Cnedialed Signal transduction         activated C kinase) (GNB2AS1)       Instanse Cinhibitor protein-11 (KCP-1)         14-3-3 Protein (Å       P29312       N. Iwata et al., Oncogene, 19 (2000) 5298.         (frotein kinase C inhibitor protein-11 (KCP-1)       Frequent hypermethylation of CpG islands         (factor activating excenzyme S) (FAS)       and loss of expression of the 14-3-3 sigma         Serine /threonine protein phosphatase       P30153       C. Fickukawa et al., Cancer Lett, 161 (2000) 89.         (PP2A, submit A, PR65-si isoform) (PP2A, submit A,       up-regulation of L-2(PP2A/SET gene expression         (PP2A, submit A, PR65-si isoform) (PP2A, submit A, Ref6-si isoform) (PP2A, submit A, Ref6-			substrate annexin in human hepatocellular carcinoma
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protein kinase C 1) (RACK1) (receptor for activated C kinase) (GNB2-RS1)       C-mediated signal transduction         14-3-3 Protein kinase C inhibitor protein-1) (KCIP-1)       Progent hypermethylation of CpG islands and loss of expression of the 14-3-3 signal gene in human hepatocellular carcinoma         Serine/threonine protein phosphatase       P30153       C. Fukukawa et al., Cancer Lett, 161 (2000) 89.         PP2A, 65 kDa regulatory unit, α-isoform (PP2A, subunit A, (PP2A, subunit A, RP65-a isoform) (PP2A, subunit A, RP67-a isoform) (PP2A, subunit A, RP67-a isoform (PP2A, subad et al., LP67-a isofore (PP2A, subad et al., LP67-a isoform (PP	protein 12.3 (P205) (receptor of activated		Adaptor proteins in protein kinase
activated C kinase) (GNB2-RS1)         14-3-3 Protein ζ/δ       P29312       N. Iwata et al., Oncogene, 19 (2000) 5298.         (factor activating excenzyme S) (FAS)       and loss of expression of the 14-3-3 sigma gene in human hepatocellular carcinoma         Serine / theronine protein phosphatase       P30153       C. Fukukawa et al., Cancer Lett. Iof (2000) 80.         PP2A, 65 kDa regulatory unit, α-isoform       Up-regulation of 1-2(PP2A)/SET gene expression       IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	protein kinase C 1) (RACK1) (receptor for		C-mediated signal transduction
14-3-3 Protein ζ/δ       P29312       N. Iwata et al., Oncogene, 19 (2000) 5298.         (protein kinase C inhibitor protein-1) (KCIP-1)       Frequent hypermethylation of CpG islands         (factor activating excenzyme S) (FAS)       and loss of expression of the 14-3-3 sigma         Serine/threonine protein phosphatase       P30153       C. Fukukawa et al., Cancer Lett, 161 (2000) 89.         PP2A, 65 kDa regulatory unit, α-isoform       Up-regulation of 1-2(PP2A)/SET gene expression of the 14-3-3 sigma         (PP2A, subunit A, PR65-α: isoform) (PP2A, subunit A, R1-α: isoform) (medium tumour       R. Ruediger et al., Oncogene, 20 (2001) 10         antigen-associated of kDa protein)       Distruption of protein phosphatase 2A subunit interaction in human cancers with mutations in the A alpha subunit gene         14-3-3 Protein €       P42655       N. Iwata et al., Oncogene, 19 (2000) 5298.         (mitochondrial import stimulation factor       Frequent hypermethylation of CpG islands and         L subunit) (protein kinase C inhibitor protein-1)       Ioss of expression of the 14-3-3 sigma gene in human hepatocellular carcinoma         (KCIP-1) (14-3-3E)       Tarsport/binding protein       Galectin-3         (galactose-specific lectin 3) (MAC-2 antigen)       Galectin-3       Galectin-3 phosphorylation is required for its anti-apoptotic function and cell cycle arrest         (galactoside-binding protein 3) (CBR 93)       K. Hsu et al., Int J Cancer, 81 (1999) 519.       Galectin-3 phosphorylation is re	activated C kinase) (GNB2-RS1)		
(protein kinase C inhibitor protein-1) (KCIP-1)       Frequent hypermethylation of CpG islands         (factr activating excenzyme S) (FAS)       and loss of expression of the 14-3-3 sigma gere in human hepatocellular carcinoma         Serine/threonine protein phosphatase       P30153       C. Fukukawa et al., Cancer Lett, 161 (2000) 89.         PP2A, dobini A, PR65-α isoform) (PP2A, subuit A, (PP2A, subunit A, PR65-α isoform) (PP2A, subunit A, RFC5-α isoform) (PP2A, subunit A, RFC5       R. Ruediger et al., Oncogene, 20 (2001) 10         antigen-associated 61 kDa protein)       Bixoption of protein phosphatase 2A subunit interaction in human cancers with mutations in the A alpha subunit gene       14-3-3 Protein €         (RCIP-1) (14-3-3E)       P42655       N. Ivata et al., Oncogene, 10 (2000) 5298.         (ratio-shordinal import simulation factor       Frequent hypermethylation of CpG islands and L subunit) (protein kinase C inhibitor protein-1) (KCIP-1) (14-3-3E)       Ivata et al., Oncogene, 10 (2000) 5298.         Tanagort/binding proteins       Erequent hypermethylation is required for its (galactos-specific lectin 3) (MAC-2 antigen)       Isso of expression of the 14-3-3 sigma gene in human hepatocellular carcinoma         Tanagort/binding proteins       Erequent hypermethylation is required for its (galactos-specific lectin 3) (MAC-2 antigen)       Isso of expression is inducted in cirrhooic lever (galactos-specific lectin 3) (MAC-2 antigen)       Galectin-3         (galactos-specific lectin 3) (MAC-2 antigen)       Galectin-3       Hopatocellular carcinoma <tr< td=""><td>14-3-3 Protein ζ/δ</td><td>P29312</td><td>N. Iwata et al., Oncogene, 19 (2000) 5298.</td></tr<>	14-3-3 Protein ζ/δ	P29312	N. Iwata et al., Oncogene, 19 (2000) 5298.
(factor activating excenzyme S) (FAS)       and loss of expression of the 14-3-3 sigma gene in human hepatocellular carcinoma         Serine/threonine protein phosphatase       P30153       C. Fukukawa et al., Cancer, Lett, 161 (2000) 89.         PP2A, 65 kDa regulatory unit, α-isoform       Up-regulation of 1-2(PP2A)/SET gene expression         (PP2A, subunit A, PR65-α isoform) (PP2A, subunit A, PR6	(protein kinase C inhibitor protein-1) (KCIP-1)		Frequent hypermethylation of CpG islands
Serie/threonine protein phosphatase       P30153       C. Fukukava et al., Cancer Lett, 161 (2000) 89.         PP2A, 65 kDa regulatory unit, α-isoform       Up-regulation of 1-2(PP2A)/SET gene expression         (PP2A, subunit A, PR65-α isoform) (PP2A, subunit A,       in rat primary hepatonase and regenerating livers         (PP2A, subunit A, PR65-α isoform) (PP2A, subunit A,       R. Ruediger et al., Oncogene, 20 (2001) 10         antigen-associated 61 kDa protein)       Disruption of protein phosphatase 2A subunit interaction in human cancers with mutations in the A alpha subunit gene         14-3-3 Protein €       P42655       N. Ivata et al., Oncogene, 19 (2000) 5298.         (mitochondrial import simulation factor       Frequent hypermethylation of CPG islands and         L subunit (protein knase C inhibitor protein-1)       Ioss of expression of the 14-3-3 sigma gene in human hepatocellular carcinoma         (galactin-3       P17931       T. Yoshii et al., J Biol Chem, 2001 (in press)         (galactin-3       potein (55 kDa lectin)       Galectin-3 expression is induced in cirrhotic liver anti-apoptotic function and cell cycle arrest         (galactoside-binding protein (Sta Da lectin)       K. Hsu et al., Int J Cancer, 81 (1999) 519.       Galectin-3 expression is induced in cirrhotic liver and hepatocellular carcinoma         Tumour associated proteins       P13693       J.C. Sanchez et al., Electrophoresis, 18 (1997) 150.       Translationally controlled tumor protein: a protein identified in several non-tumoral cells i	(factor activating exoenzyme S) (FAS)		and loss of expression of the 14-3-3 sigma
Serine/threonine protein phosphatase       P30153       C. Fukukawa et al., Cancer Lett, 161 (2000) 89.         PP2A, 65 kDa regulatory unit, α-isoform       (P2A, subunit A, PR65-α isoform) (P2A, subunit A,       in rat primary hepatomas and regenerating livers         (P2A, subunit A, PR65-α isoform) (P2A, subunit A, PR65-α isoform) (P2A, subunit A, RP65-α isoform) (medium tumour       R. Ruediger et al., Oncogene, 20 (2001) 10         antigen-associated 61 kDa protein)       Interaction in human cancers with mutations       interaction in human cancers with mutations         14-3.3 Protein €       P42655       N. Iwata et al., Oncogene, 19 (2000) 5298.         (mitochondrial inport stimulation factor       Frequent hypermethylation of CpG islands and         L subunit (protein kinase C inhibitor protein-1)       Ions of expression of the 14-3-33 sigma gene in human hepatocellular carcinoma         (KCIP-1) (14-3-3E)       human hepatocellular carcinoma         Tarsport/binding proteins       P17931       T. Yoshii et al., J Biol Chem, 2001 (in press)         (galactose-specific lectin 3) (MAC-2 antigen)       DK. Ku et al., Int J Cancer, 81 (1999) 519.         (lgE-binding protein) (Sic kDa lectin)       Galectin-3 expression is induced in cirrhotic liver         (galactoid-binding protein (GLBP)       DK. Ku et al., LI Zancer, 81 (1997) 150.         (Translationally controlled tumour protein       P13693       J.C. Sanchez et al., Electrophoresis, 18 (1997) 150.         (TCTP)			gene in human hepatocellular carcinoma
PP2A, 65 kDa regulatory uni, α-isoform       Up-regulation of 1-2(PP2A)/SET gene expression         (PP2A, subunit A, PR65-α isoform) (PP2A,       in rat primary hepatomas and regenerating livers         (PP2A, subunit A, PR65-α isoform) (PP2A,       Ruediger et al., Oncogene, 20 (2001) 10         antigen-associated 61 kDa protein)       Disruption of protein phosphatase 2A subunit interaction in human cancers with mutations         antigen-associated 61 kDa protein       P42655       N. Ivata et al., Oncogene, 10 (2000) 5298.         (mitochondrial import stimulation factor       Frequent hypermethylation of CpG islands and         L subunit) (protein kinase C inhibitor protein-1)       loss of expression of the 14-3-3 sigma gene in (KCIP-1) (14-3-3E)         Tamsort/binding proteins       P17931       T. Yoshii et al., J Biol Chem, 2001 (in press)         (galactos-specific lectin 3) (MAC-2 antigen)       galectin-3 phosphorylation is required for its (galactos-specific lectin 3) (MAC-2 antigen)       Galectin-3 phosphorylation is required for its (galactos-specific lectin 3) (MAC-2 antigen)         (galactos-specific lectin 3) (MAC-2 antigen)       Galectin-3 capression is induced in cirrhotic liver anti-apoptotic function and cell cycle arrest         (galactos-specific lectin 3) (MAC-2 antigen)       Galectin-3 capression is induced in cirrhotic liver anti-apoptotic function and cell cycle arrest         (galactoside-binding protein 35) (CBP 35)       DK. Hsu et al., Int J Cancer, 81 (1999) 519.         (lamini-binding protein) (GALBP)	Serine/threonine protein phosphatase	P30153	C. Fukukawa et al., Cancer Lett, 161 (2000) 89.
(PP2A, subunit A, PR65-α isoform) (PP2A, subunit A,       in rat primary hepatomas and regenerating livers         (PP2A, subunit A, PR65-α isoform) (PP2A, subunit A, RI-α isoform) (medium tumour antigen-associated 61 kDa protein)       R Ruediger et al., Oncogene, 20 (2001) 10         antigen-associated 61 kDa protein)       R Ruediger et al., Oncogene, 20 (2001) 10         interaction in human cancers with mutations interaction in human cancers with mutations interaction in human cancers with mutations         14-3-3 Protein €       P42655         (mitochondrial import simulation factor       Ioss of expression of the 14-3-3 sigma gene in         (KCIP-1) (14-3-3E)       human hepatocellular carcinoma         Tansport/binding proteins       Ios of expression of the 14-3-3 sigma gene in         (galactose-specific lectin 3) (MAC-2 antigen)       Ios of expression of the 14-3-3 sigma gene in         (galactose-specific lectin 3) (MAC-2 antigen)       Galectin-3       Galectin-3         (galactose-specific lectin 3) (MAC-2 antigen)       Galectin-3       Interacer, 81 (1999) 519.         (galactoside-binding protein) (35 kDa lectin)       DK. Hsu et al., Int J Cancer, 81 (1999) 519.       Ios Galectin-3 expression is induced in cirrhotic liver         (galactoside-binding protein) (lectin L-29) (L-31)       Galectin-3       IS C Sanchez et al., Electrophoresis, 18 (1997) 150.         (TTDP) (p23) (histamine-releasing factor)       Translationally controlled tumor protein: a protein identified in se	PP2A, 65 kDa regulatory unit, α-isoform		Up-regulation of I-2(PP2A)/SET gene expression
(PP2A, subunit A, PR65-α isoform) (PP2A,         subunit A, R1-α isoform) (medium tumour       R. Ruediger et al., Oncogene, 20 (2001) 10         antigen-associated 61 kDa protein)       Disruption of protein phosphatase 2A subunit         interaction in human cancers with mutations       in the A alpha subunit gene         14-3-3 Protein €       P42655       N. Iwata et al., Oncogene, 19 (2000) 5298.         (mitochondrial import stimulation factor       Frequent hypermethylation of CPG islands and         L subunit) (protein kinase C inhibitor protein-1)       Ioss of expression of the 14-3-3 signa gene in         (KCIP-1) (14-3-3E)       human hepatocellular carcinoma         Transport/binding proteins       galectin-3         (galactose-specific lectin 3) (MAC-2 antigen)       Galectin-3 phosphorylation is required for its         (galactose-specific lectin 3) (MAC-2 antigen)       Galectin-3 expression and cell cycle arrest         (galactoid-binding protein) (35 kDa lectin)       Galectin-3 expression is induced in cirrhotic liver         (galactoid-binding protein) (GALBP)       DK. Huu et al., Int J Cancer, 81 (1999) 519.         Tanslationally controlled tumour protein       P13693       JC. Sanchez et al., Electrophoresis, 18 (1997) 150.         Translationally controlled tumour protein       P13693       JC. Sanchez et al., Electrophoresis, 18 (1997) 150.         Translationally conturolled tumour protein       P13693	(PP2A, subunit A, PR65-α isoform) (PP2A, subunit A,		in rat primary hepatomas and regenerating livers
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14-3-3 Protein €       P42655       N. Iwata et al., Oncogene, 19 (2000) 5298.         (mitochondrial import simulation factor       Frequent hypermethylation of CpG islands and         L subunit) (protein kinase C inhibitor protein-1)       Ioss of expression of the 14-3-3 sigma gene in         (KCIP-1) (14-3-3E)       human hepatocellular carcinoma         Transport/binding proteins         Galectin-3       P17931       T. Yoshii et al., J Biol Chem, 2001 (in press)         (galactos-specific lectin 3) (MAC-2 antigen)       Galectin-3 falosphorylation is required for its         (galactos-specific lectin 3) (MAC-2 antigen)       Galectin-3 falosphorylation is required for its         (galactos-specific lectin 3) (MAC-2 antigen)       Galectin-3 phosphorylation is required for its         (galactosid-binding protein) (35 kDa lectin)       Galectin-3 phosphorylation is required for its         (galactosid-binding protein) (lectin L-29) (L-31)       Galectin-3 expression is induced in cirrhotic liver         (galactoside-binding protein) (GALBP)       P13693       J.C. Sanchez et al., Electrophoresis, 18 (1997) 150.         Translationally controlled tumour protein       P13693       J.C. Sanchez et al., Electrophoresis, 18 (1997) 150.         (TCTP) (p23) (histamine-releasing factor)       Franslationally controlled tumour protein: a protein identified in several non-tumoral cells including erythrocytes         (HRF)       S. Chung et al., Cancer Lett,	antigen-associated 61 kDa protein)		Disruption of protein phosphatase 2A subunit
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Translationally controlled tumour protein       P13693       J.C. Sanchez et al., Electrophoresis, 18 (1997) 150.         (TCTP) (p23) (histamine-releasing factor)       Translationally controlled tumor protein: a protein identified in several non-tumoral cells including erythrocytes         (HRF)       S. Chung et al., Cancer Lett, 156 (2000) 185.         Expression of translationally controlled tumor protein mRNA in human colon cancer	Tumour associated proteins		
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Expression of translationally controlled tumor protein mRNA in human colon cancer			S. Chung et al., Cancer Lett, 156 (2000) 185.
mRNA in human colon cancer			Expression of translationally controlled tumor protein
			mRNA in human colon cancer

retrieved by using the View Protein Spot Location button. Currently only one protein can be selected at any one time.

For Option 2, two image maps were used in the interactive protein spots query format: (i) a preparative 2-DE map (HCCM074) with a protein load of

 $\sim$ 300 µg and (ii) an analytical 2-DE map (HCCM105) with a protein load of  $\sim$ 120 µg. Fig. 6 shows the 2-DE map of HCCM074 with the identified proteins labelled as red spots. Moving the mouse pointer over the spot will display its accession number, and the protein information (Fig. 5) can be











Fig. 6. HCCM074 image page.

accessed by clicking on the spot. The database is now freely accessible through the world wide web at http://proteome.btc.nus.edu.sg/hccm/.

# 4. Conclusions

As a result of the rapid development of proteomics, many proteome projects are currently

underway. One of the major goals in this endeavour is to establish a protein database for the tissue, cell or model organism of interest that is accessible on the world wide web [10,19,20]. This will serve as a useful resource for scientists working in the same area of research. Thus, the establishment of the 2-DE proteome database of the HCC cell line, HCC-M, will be a useful repository of information for HCC. This would definitely facilitate the rapid identification of novel diagnostic and therapeutic markers for HCC, which is an important first step towards the early diagnosis and treatment of this cancer.

### 5. Nomenclature

HCC or hepatoma	hepatocellular carcinoma		
HBV	hepatitis B virus		
HCV	hepatitis C virus		
2-DE	two-dimensional electropho-		
	resis		
MALDI-TOF MS	matrix-assisted laser desorp-		
	tion/ionisation time-of-flight		
	mass spectrometry		
nESI-MS-MS	nanoelectrospray ionisation tan-		
	dem MS		
DMEM	Dulbelcco's modified Eagle		
	medium		
FCS	foetal calf serum		
CHAPS	3-[(3-cholamidop-		
	ropyl)dimethylammonio]-1-pro-		
	panesulphonate		
PMSF	phenylmethylsulphonyl fluoride		
IEF	isoelectric focusing		
IPG	immobilised pH gradient		
DTT	dithiothreitol		
SDS-PAGE	sodium dodecyl sulphate-poly-		
	acrylamide gel electrophoresis		
IAA	iodoacetamide		
ACN	acetonitrile		
TFA	trifluoroacetic acid		

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