

cDNA Sequences for Asialoglycoprotein Receptor from Human Fetal Liver

Dong Gun Lee, Sung Gu Lee, Kil Lyong Kim and Kyung-Soo Hahm*

Peptide Engineering Research Unit, Korea Research Institute of Bioscience & Biotechnology (KRIBB), P.O. Box 115, Yusong, Taejeon 305-600, Korea

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Abstract : The asialoglycoprotein receptor (ASGPR) was the first described mammalian lectin that mediates the specific binding and internalization of galactose/N-acetylgalactosamine-terminating glycoproteins by hepatic parenchymal cells. H1 and H2 are known as essential subunits of the functional ASGPR. There were close similarities in ASGPR H2 subunits between cultured cell line HepG2 and normal human liver cells including identical sequences at both termini. It was therefore expected that there may be some similarities between the subunits from normal liver cells and fetal liver cells. The two subunits of human fetal liver ASGPR, designated *FL-H1* and *FL-H2*, were cloned from cDNA library by PCR and the sequences were compared with the known H1 and H2 sequences of HepG2, and the *H1* sequence of normal human liver cells. The results showed that *FL-H1* was identical to *H1* of HepG2. Whereas *FL-H2* contains a 15-bp miniexon, but missing 57-bp at the near upstream from the membrane-spanning domain compared to *H2* of HepG2 and normal human liver cells indicating that *FL-H2* resulted from a differential splicing compared to HepG2 and normal liver cells.

Keywords : hepatitis B virus, HepG2, miniexon, polymerase chain reaction, preS1

The asialoglycoprotein receptor (ASGPR) was the first described mammalian lectin (Morell *et al.*, 1968) that mediates the specific binding and internalization of galactose/N-acetylgalactosamine-terminating glycoproteins by hepatic parenchymal cells (Ashwell and Harford, 1982; Stockert and Morell, 1983; Schwartz, 1984). Following ligand binding to this cell surface receptor, the receptor-ligand complex is internalized and transported by a series of membrane vesicles and tubules to an acidic sorting organelle where receptors and ligands dissociate (Geuze *et al.*, 1983). The receptor returns to the cell surface, while the ligand is transported to lysosomes where it is degraded (Hubbard *et al.*, 1979; Schwartz *et al.*, 1982; Ciechanover *et al.*, 1983). It has recently been suggested that the hepatic ASGPR is able to bind natural hepatitis B virus (HBV) specifically by its preS1 region and that this attachment might provide a clue to understand the hepatic endocytosis of HBV (Treichel *et al.*, 1994). The human hepatic ASGPR is constructed of two polypeptides of related amino acid sequences, namely H1 and H2 (Baenziger and Maynard, 1980; Lederkremer *et al.*, 1991). Both polypeptides span the membrane once.

with a large carboxyl-terminal exoplasmic segment containing the galactose-binding sites. The cDNAs encoding the subunits of ASGPR have been previously cloned from rat (Halberg *et al.*, 1987) and human hepatoma cell line, HepG2 (Spiess *et al.*, 1985; Spiess and Lodish, 1985). In human liver cells, however, only subunit *H2* was cloned from normal liver cells (Paietta *et al.*, 1992). There were close similarities between ASGPR *H2* subunit from both cultured cell line HepG2 and from normal liver cells. Both termini of cloned subunits *H2* (Spiess and Lodish, 1985; Paietta *et al.*, 1992b) showed identical sequences. The same was reported also in several variants (Spiess and Lodish, 1985; Lederkremer and Lodish, 1991; Paietta *et al.*, 1992a). It was therefore expected that there may be some similarities between *H2* subunits from normal liver cells and fetal liver cells. In an attempt to clone the subunits of ASGPR from human fetal liver cells, we obtained the genes of two subunits from human fetal liver cDNA library. Here we report the cloning of both subunits, nucleotide sequences and alignments of their cDNAs coding for the complete ORF.

Materials and Methods

Four oligo primers were designed and synthesized from the known sequences of the two subunits from

*To whom correspondence should be addressed.

Tel : 82-42-860-4160, Fax : 82-42-860-4593

E-mail : hahmks@kribb4680.kribb.re.kr

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H T R E Y Q D L Q W L D W E E S D R H Q L R K G P F P P P P
FL-H1 ATGACAGAGCTAT CAGAGCTTCAGACT CTGAGAAATGAGAGG AATGACACATGAG CTGAGAAAGAGGCA GTCCTCCCAAGCC 90
FL-H2 ATGACAGAGCTAT CAGAGCTTCAGACT CTGAGAAATGAGAGG AATGACACATGAG CTGAGAAAGAGGCA GTCCTCCCAAGCC 97
N A K D F Q D I Q Q L S E E E N D R P F R Q G P F P A Q P

L L Q R L C A C P R L L L L L L G L S L L L L V V C V I G
FL-H1 CTCCTCAGCTCTC TCTCCTCAGCTCTC CTCCTCCTCCTGCTC CTGCTCCTCAGCTCTC CTGCTCCTCCTGCTC GTCCTCTGATCGGA 180
FL-H2 CTCCTCAGCTCTC TCTCCTCAGCTCTC CTCCTCCTCCTGCTC CTGCTCCTCAGCTCTC CTGCTCCTCCTGCTC GTCCTCTGATCGGA 177
L A Q R L C S M V C F S L L A L S P N I L L L V V I C V T G

S Q N S Q L Q E E L R G L R E T F S H F T A S T E
FL-H1 TCTGAAAG TCCAG CTGACGAGAGCTG CGGCTCTGAGAG ACCTTCAGACTTC ACAGCAGAGCCGAG 259
FL-H2 TCCGAAAGTCCAG CTGACGAGAGCTG CGGCTCTGAGAG ACCTTCAGACTTC TCTCAGAGCCCTG 267
S Q S E G R C A Q L Q A E L R L E K A F S H F S E S L L

G A Q V R L S T Q G G N V V G R K M R E L E S O L E K Q Q K D
FL-H1 GGCAGCTCAGGCT TCGAGCCAGCCGAG GCGAATGAGTCTGAG GATTCAGACTTCAG GATTCAGACTTCAG AACAGCAGAGAGC 245
FL-H2 GGCAGCTCAGGCT ATCAGCCAGCCGAG GCGAATGAGTCTGAG GATTCAGACTTCAG GATTCAGACTTCAG AACAGCAGAGAGC 257
T V T Q A I S T R C G S V G D K I T S L G A X L E K Q Q Q D

L S E D E S S L L L V R V Q P V S D L R S L S C Q M A A L Q
FL-H1 CTCAGTCAAGATC TCGAGCTCTCCTC CAGCTCAGGACTTC CTCCTCAGCTCTGAG AGCTTCAGACTTCAG ATGCGGCTCTCAG 435
FL-H2 CTCAGTCAAGATC GATCCTCCTCCTC CAGCTCAGGACTTC CTCCTCAGCTCTGAG AGCTTCAGACTTCAG ATGCGGCTCTCAG 447
L K A D H D A L L F H L K E H F P V D L R F V A C Q M E L L H

G W S E E R T C C P V M W V E H E R S C T M F R S R C R A M
FL-H1 GCGAATGCTGAG AAGACTCTCTCTC CTGAACTCTCTCTC CAGAGCCAGCTCTC TACTCTCTCTCTC TCGCGAGAGCCCTG 525
FL-H2 GCGAATGCTGAG AAGACTCTCTCTC CTGAACTCTCTCTC CAGAGCCAGCTCTC TACTCTCTCTCTC TCGCGAGAGCCCTG 537
S H C S Q R T C C P V M W V E H E R S C T M F R S R C R A M

A D A D H T C R L E D A N L V V V T S W E R K G P V Q R E I
FL-H1 CTCAGCTCAGGACT TACTCTCTCTCTC GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG 615
FL-H2 CTCAGCTCAGGACT TACTCTCTCTCTC GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG 627
A E A R K I T C Q L E M A R L V I N S W E R K V Y I Q V T T

G P V N T M M G L R D Q M C P W E W V D G T D Y E T O P E N
FL-H1 GCGCTCTCAGGACT TCGAGCTCTCTC GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG 705
FL-H2 GCGCTCTCAGGACT TCGAGCTCTCTC GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG 717
M F P N T H I C L T D S D C S W E W V D G T D Y R E M Y K H

W R P E Q P D D W T G H C L G C E E D C A N P T D D G R W H
FL-H1 TCGAGCTCTCTC CCGAGCTCTCTC GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG 795
FL-H2 TCGAGCTCTCTC CCGAGCTCTCTC GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG GAGCTCAGCTCTGAG 807
M A V T Q P D M W G R E L G G E E D C V E V Q P D G R W H

D D V C Q R P T A V V C E T D L E D R A S Q E P P L L *
FL-H1 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 876
FL-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 879
D D F C L Q V T R W V C E R R R N A T G R V A *
    
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Fig. 1. Nucleotide sequences of the human fetal liver *FL-H1* and *FL-H2*-encoding cDNA ORF and the deduced amino acid sequences. The GenBank accession number for *FL-H2* cDNA is U97197.

HepG2 cells (Spiess *et al.*, 1985; Spiess and Lodish, 1985) in order to amplify the whole two subunits of ASGPR from human fetal liver cells by PCR. The derived oligo primers, H1-For (5'-ATG ACC AAG GAG TAT CAA GAC CTT-3') and H1-Rev (5'-TTA AAG GAG AGG TGG CTC CTG-3') were completely conserved sequence segments in the N-terminal and C-terminal regions of the subunit *H1* of ASGPR. Oligo primers, H2-For (5'-ATG GCC AAG GAC TTT CAA GAT ATC-3') and H2-Rev (5'-TCA GGC CAC CTC GCC GGT GGC-3') were also completely conserved segments in both termini of the subunit *H2* of ASGPR. Using a λ gt11 human fetal liver 5'-stretch plus cDNA library purchased from Clontech Laboratories, Inc (California, USA) and the four designed primers, PCR amplification of ASGPR subunits was performed by a thermal cycler (Perkin-Elmer, GeneAmp PCR system 2400). Twenty pmol of each oligonucleotide primer was used and 35 cycles, each consisting of a 30 s melting at 95°C, 2 min annealing at 55°C, and 1 min 30 s polymerization at 72°C were performed. Amplified PCR products were resolved on a 1.5% agarose gel and the bands obtained were eluted using a QIAquick gel Ex-

traction Kit from Qiagen Inc (De Soto Avenue, USA). Purified PCR products were directly subcloned using a pGEM-T vector system obtained from Promega (Madison, USA). Plasmids containing each insert were sequenced by the dideoxy chain termination technique (Sanger *et al.*, 1977). The nucleotide sequences of two whole subunits of ASGPR from human fetal liver, designated *FL-H1* and *FL-H2*, were determined and amino acid sequences (Fig. 1) were deduced.

Results and Discussion

Two subunits of ASGPR in human fetal liver, *FL-H1* and *FL-H2*, were cloned by PCR. The identified sequence of each subunit was compared with the known sequences of H1 and H2 from HepG2, and the result showed that *FL-H1* was completely identical to that of HepG2 H1 (Spiess *et al.*, 1985), whereas *FL-H2* shows some differences.

Near the upstream of the membrane-spanning segment, 57-bp intron (Paietta *et al.*, 1992), which was retained in *H2* of HepG2 (bp 67-125), is missing in *FL-H2* as in normal liver *H2*. However, *FL-H2* contains

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1 15 16 30 31 45 46 60 61 75 76 90
H-H2 ATGACAGAGCTAT CAGAGCTTCAGACT CTGAGAAATGAGAGG AATGACACATGAG CTGAGAAAGAGGCA GTCCTCCCAAGCC 90
H-H2 ATGACAGAGCTAT CAGAGCTTCAGACT CTGAGAAATGAGAGG AATGACACATGAG CTGAGAAAGAGGCA GTCCTCCCAAGCC 90
L-H2 ATGACAGAGCTAT CAGAGCTTCAGACT CTGAGAAATGAGAGG AATGACACATGAG CTGAGAAAGAGGCA GTCCTCCCAAGCC 68
FL-H2 ATGACAGAGCTAT CAGAGCTTCAGACT CTGAGAAATGAGAGG AATGACACATGAG CTGAGAAAGAGGCA GTCCTCCCAAGCC 97

91 105 106 120 121 135 136 150 151 165 166 180
H-H2 ATGACAGAGCTAT CAGAGCTTCAGACT CTGAGAAATGAGAGG AATGACACATGAG CTGAGAAAGAGGCA GTCCTCCCAAGCC 180
H-H2 ATGACAGAGCTAT CAGAGCTTCAGACT CTGAGAAATGAGAGG AATGACACATGAG CTGAGAAAGAGGCA GTCCTCCCAAGCC 180
L-H2 ATGACAGAGCTAT CAGAGCTTCAGACT CTGAGAAATGAGAGG AATGACACATGAG CTGAGAAAGAGGCA GTCCTCCCAAGCC 123
FL-H2 ATGACAGAGCTAT CAGAGCTTCAGACT CTGAGAAATGAGAGG AATGACACATGAG CTGAGAAAGAGGCA GTCCTCCCAAGCC 123

181 195 196 210 211 225 226 240 241 255 256 270
H-H2 ATGACAGAGCTAT CAGAGCTTCAGACT CTGAGAAATGAGAGG AATGACACATGAG CTGAGAAAGAGGCA GTCCTCCCAAGCC 270
H-H2 ATGACAGAGCTAT CAGAGCTTCAGACT CTGAGAAATGAGAGG AATGACACATGAG CTGAGAAAGAGGCA GTCCTCCCAAGCC 255
L-H2 ATGACAGAGCTAT CAGAGCTTCAGACT CTGAGAAATGAGAGG AATGACACATGAG CTGAGAAAGAGGCA GTCCTCCCAAGCC 198
FL-H2 ATGACAGAGCTAT CAGAGCTTCAGACT CTGAGAAATGAGAGG AATGACACATGAG CTGAGAAAGAGGCA GTCCTCCCAAGCC 213

271 285 286 300 301 315 316 330 331 345 346 360
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 360
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 345
L-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 288
FL-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 303

361 375 376 390 391 405 406 420 421 435 436 450
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 450
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 435
L-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 378
FL-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 391

451 465 466 480 481 495 496 510 511 525 526 540
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 540
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 525
L-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 468
FL-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 483

541 555 556 570 571 585 586 600 601 615 616 630
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 630
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 615
L-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 559
FL-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 573

631 645 646 660 661 675 676 690 691 705 706 720
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 720
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 705
L-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 648
FL-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 663

721 735 736 750 751 765 766 780 781 795 796 810
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 810
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 795
L-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 738
FL-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 753

811 825 826 840 841 855 856 870 871 885 886 900
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 900
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 885
L-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 843
FL-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 863

901 915 916 930 931 945 946
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 946
H-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 931
L-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 884
FL-H2 GAGCTCTCTCTC CAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC GAGCTCTCTCTC CTTTAA 919
    
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Fig. 2. Comparison of the nucleotide sequence of *FL-H2* with other *H2* subunit. The hydrophobic membrane-spanning segment is indicated by a box. Dashed lines indicate the spliced-out segments. Termination codon is indicated by an asterisk (*).

an extra 15-bp miniexon which is present in HepG2 but not in normal liver H2 (Paietta *et al.*, 1992). This miniexon is known to encode a positively charged five amino acid segment at the carboxyl-terminal side to the membrane-spanning segment in the exoplasmic domain (Spiess and Lodish, 1985). These comparisons are shown in Fig. 2. The nucleotide sequence of FL-H2 was deposited in the GenBank (accession number, U 97197).

The result therefore indicates that *FL-H2* may be generated from a single gene by another alternative splicing comparable to HepG2 *H2* (Lederkremer and Lodish, 1991). Although this 'another' alternative splicing and its exact biological function in liver cells could not be identified yet, this variant subunit, *FL-H2* could provide a clue to investigate why different forms of *H2* are present in cells.

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References

- Ashwell, G. and Harford, J. (1982) *Annu. Rev. Biochem.* **51**, 531.
- Baenzler, J. U. and Maynard, Y. (1980) *J. Biol. Chem.* **255**, 4607.
- Ciechanover, A., Schwartz, A. L. and Lodish, H. F. (1983) *Cell* **32**, 267.
- Geuze, H. J., Slot, J. W., Strous, G. J., Lodish, H. F. and Schwartz, A. L. (1983) *Cell* **32**, 277.
- Halberg, D. F., Wager, R. E., Farrell, D. C., Hildreth, J. IV, Quesenberry, M. S., Loeb, J. A. and Holland E. C. (1987) *J. Biol. Chem.* **262**, 9828.
- Hubbard, A. L., Wilson, G., Ashwell, G. and Stukenbrok, H. (1979) *J. Cell. Biol.* **83**, 47.
- Lederkremer, G. Z. and Lodish, H. F. (1991) *J. Biol. Chem.* **266**, 1237.
- Morell, A. G., Irving, R. A., Sternlieb, I., Scheinberg, I. H. and Ashwell, G. (1968) *J. Biol. Chem.* **243**, 155.
- Paietta, E., Stockert, R. J. and Racevskis, J. (1992a) *J. Biol. Chem.* **267**, 11078.
- Paietta, E., Stockert, R. J. and Racevskis, J. (1992b) *Hepatology* **15**, 395.
- Sanger, F., Nicklen, S. and Coulson, A. R. (1977) *Proc. Natl. Acad. Sci. USA* **74**, 5463.
- Schwartz, A. L. (1984) *CRC. Crit. Rev. Biochem.* **16**, 207.
- Schwartz, A. L., Fridovich, S. E. and Lodish, H. F. (1982) *J. Biol. Chem.* **257**, 4230.
- Spiess, M. and Lodish, H. F. (1985) *Proc. Natl. Acad. Sci. USA* **82**, 6465.
- Spiess, M., Schwartz, A. L. and Lodish, H. F. (1985) *J. Biol. Chem.* **260**, 1979.
- Stockert, R. J. and Morell, A. G. (1983) *Hepatology* **3**, 750.
- Treichel, U., Echenfelde, K-H. M. Z., Stockert, R. J., Poralla, T. and Gerken, G. (1994) *J. Gen. Virol.* **75**, 3021.