Supplementary Material

# Supplementary Data

Table S1. List of NCBI references of protein sequences of animal ABC transporters use for local alignment and phylogenetic analysis with the *P. dumerilii* proteome

Table S2. List of most specific domains for ABC transport proteins selected for the Pfam analysis from https://pfam.xfam.org/. The accession number, source database and a description of each domain are reported

Table S3. Real-time PCR primer sequences including amplicon size in base pairs (bp), efficiency (%) and melting temperature (°C). TCONS ID from genome sequencing and gene annotation from the genome-wide study described in Chapter 2 are also reported

Table S4. Summary of the 81 ABC transport proteins identified in the *P. dumerilii* genome

Table S5. Number of ABC transport proteins already identified in invertebrates and vertebrate species and the composition of each subfamily

Figure S1. Conserved domains of the *P. dumerilii* ABC transport proteins. Purple and yellow show NBD (ABC\_tran), except for MTABC\_N which is a TMD. Pink and green show TMD. The HMMR web server was used to identify the NBD and TMD domains of each worm ABCs

Discussion: Characterization of *P. dumerilii* ABC transport proteins subfamilies

Table S1. List of NCBI references of protein sequences of animal ABC transporters use for local alignment and phylogenetic analysis with the *P. dumerilii* proteome.

>sp|P26363.1|CFTR\_XENLA RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|P50532.1|SMC4\_XENLA RecName: Full=Structural maintenance of chromosomes protein 4; Short=SMC protein 4; Short=SMC-4; AltName: Full=Chromosome assembly protein XCAP-C; AltName: Full=Chromosome-associated protein C

>sp|P50533.1|SMC2\_XENLA RecName: Full=Structural maintenance of chromosomes protein 2; Short=SMC protein 2; Short=SMC-2; AltName: Full=Chromosome assembly protein XCAP-E; AltName: Full=Chromosome-associated protein E

>sp|O93308.1|SMC1A\_XENLA RecName: Full=Structural maintenance of chromosomes protein 1A; Short=SMC protein 1A; Short=SMC-1A; Short=xSMC1

>sp|Q805A1.1|SMC5\_XENLA RecName: Full=Structural maintenance of chromosomes protein 5; Short=SMC protein 5; Short=SMC-5

>sp|Q6IP59.1|CTL2\_XENLA RecName: Full=Choline transporter-like protein 2; AltName: Full=Solute carrier family 44 member 2

>sp|Q6P9I7.1|SMC6\_XENLA RecName: Full=Structural maintenance of chromosomes protein 6; Short=SMC protein 6; Short=SMC-6; Short=xSMC6

>sp|O93309.2|SMC3\_XENLA RecName: Full=Structural maintenance of chromosomes protein 3; Short=SMC protein 3; Short=SMC-3

>sp|Q27256.1|WHITE\_ANOGA RecName: Full=Protein white

>sp|Q108U0.1|CFTR\_LOXAF RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q16928.1|WHITE\_ANOAL RecName: Full=Protein white

>sp|B5X3W7.1|CTL2\_SALSA RecName: Full=Choline transporter-like protein 2; AltName: Full=Solute carrier family 44 member 2

>sp|Q05360.2|WHITE\_LUCCU RecName: Full=Protein white

>sp|Q09427.3|ABCC8\_CRICR RecName: Full=ATP-binding cassette sub-family C member 8; AltName: Full=Sulfonylurea receptor 1

>sp|Q09YK5.1|CFTR\_ATEGE RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q09YH0.1|CFTR\_SAIBB RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|P48996.1|DPY27\_CAEEL RecName: Full=Chromosome condensation protein dpy-27; AltName: Full=Protein dumpy-27

>sp|Q09466.1|WHT3\_CAEEL RecName: Full=ABC transporter ATP-binding protein/permease wht-3; AltName: Full=White related ABC transporter 3

>sp|Q09591.2|MIX1\_CAEEL RecName: Full=Mitotic chromosome and X-chromosome-associated protein mix-1; AltName: Full=Lethal protein 29; AltName: Full=Structural maintenance of chromosomes protein 2

>sp|Q11088.2|NLP1\_CAEEL RecName: Full=Neuropeptide-like protein 1; Flags: Precursor

>sp|P34358.6|CED7\_CAEEL RecName: Full=ABC transporter ced-7; AltName: Full=Cell death protein 7

>sp|Q20060.1|SMC4\_CAEEL RecName: Full=Structural maintenance of chromosomes protein 4; Short=SMC protein 4; Short=SMC-4

>sp|P34712.2|PGP1\_CAEEL RecName: Full=Multidrug resistance protein pgp-1; AltName: Full=P-glycoprotein A; AltName: Full=P-glycoprotein-related protein 1

>sp|P34713.2|PGP3\_CAEEL RecName: Full=Multidrug resistance protein pgp-3; AltName: Full=P-glycoprotein C; AltName: Full=P-glycoprotein-related protein 3

>sp|Q23405.2|HIM14\_CAEEL RecName: Full=MutS protein homolog him-14; AltName: Full=High incidence of males protein 14; AltName: Full=MutS protein homolog 4

>sp|Q19272.2|MSH5\_CAEEL RecName: Full=MutS protein homolog 5

>sp|O44199.1|RAD50\_CAEEL RecName: Full=DNA repair protein rad-50

>sp|Q18237.2|SMC5\_CAEEL RecName: Full=Structural maintenance of chromosomes protein 5

>sp|Q18616.2|SMCL1\_CAEEL RecName: Full=Structural maintenance of chromosomes-like protein 1

>sp|B2FDA8.1|SMC3\_CAEEL RecName: Full=Structural maintenance of chromosomes protein 3

>sp|O01789.4|SMC1\_CAEEL RecName: Full=Structural maintenance of chromosomes protein 1; AltName: Full=High incidence of males protein 1

>sp|Q11180.3|WHT1\_CAEEL RecName: Full=ABC transporter ATP-binding protein/permease wht-1

>sp|G5EE72.1|MRP5\_CAEEL RecName: Full=Multidrug resistance-associated protein 5; AltName: Full=ATP-binding cassette sub-family C member mrp-5

>sp|A5JYS0.1|PCS1\_CAEEL RecName: Full=Glutathione gamma-glutamylcysteinyltransferase; AltName: Full=Phytochelatin synthase; Short=PC synthase

>sp|G5EFD4.1|HMT1\_CAEEL RecName: Full=Heavy metal tolerance factor 1

>sp|Q9U2G5.3|MRP7\_CAEEL RecName: Full=Multidrug resistance protein mrp-7

>sp|O97594.1|SMC3\_BOVIN RecName: Full=Structural maintenance of chromosomes protein 3; Short=SMC protein 3; Short=SMC-3; AltName: Full=Chondroitin sulfate proteoglycan 6

>sp|Q865B7.1|PRGC1\_BOVIN RecName: Full=Peroxisome proliferator-activated receptor gamma coactivator 1-alpha; Short=PGC-1-alpha; Short=PPAR-gamma coactivator 1-alpha; Short=PPARGC-1-alpha

>sp|Q5EA70.1|T229B\_BOVIN RecName: Full=Transmembrane protein 229B

>sp|Q8WN95.1|ITPR3\_BOVIN RecName: Full=Inositol 1,4,5-trisphosphate receptor type 3; AltName: Full=IP3 receptor isoform 3; Short=IP3R 3; Short=InsP3R3; AltName: Full=Type 3 inositol 1,4,5-trisphosphate receptor; Short=Type 3 InsP3 receptor

>sp|Q8HXQ5.1|MRP1\_BOVIN RecName: Full=Multidrug resistance-associated protein 1; AltName: Full=ATP-binding cassette sub-family C member 1; AltName: Full=Glutathione-S-conjugate-translocating ATPase ABCC1; AltName: Full=Leukotriene C(4) transporter; Short=LTC4 transporter

>sp|Q3MHE4.1|MSH2\_BOVIN RecName: Full=DNA mismatch repair protein Msh2; AltName: Full=MutS protein homolog 2

>sp|Q4GZT4.2|ABCG2\_BOVIN RecName: Full=Broad substrate specificity ATP-binding cassette transporter ABCG2; AltName: Full=ATP-binding cassette sub-family G member 2; AltName: Full=Urate exporter; AltName: CD\_antigen=CD338

>sp|Q2KJA2.1|ABCF2\_BOVIN RecName: Full=ATP-binding cassette sub-family F member 2

>sp|P35071.2|CFTR\_BOVIN RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|F1MWM0.2|ABCA4\_BOVIN RecName: Full=Retinal-specific phospholipid-transporting ATPase ABCA4; AltName: Full=ATP-binding cassette sub-family A member 4; AltName: Full=RIM ABC transporter; Short=RIM protein; Short=RmP; AltName: Full=Retinal-specific ATP-binding cassette transporter

>sp|Q90988.1|SMC2\_CHICK RecName: Full=Structural maintenance of chromosomes protein 2; Short=SMC protein 2; Short=SMC-2; AltName: Full=Chromosome scaffold protein ScII

>sp|Q9DGG6.1|ADCY9\_CHICK RecName: Full=Adenylate cyclase type 9; AltName: Full=ATP pyrophosphate-lyase 9; AltName: Full=Adenylate cyclase type IX; AltName: Full=Adenylyl cyclase 9

>sp|Q5ZJY5.1|SMC5\_CHICK RecName: Full=Structural maintenance of chromosomes protein 5; Short=SMC protein 5; Short=SMC-5

>sp|Q5F3L7.1|T229B\_CHICK RecName: Full=Transmembrane protein 229B

>sp|Q5F364.1|MRP1\_CHICK RecName: Full=Multidrug resistance-associated protein 1; AltName: Full=ATP-binding cassette sub-family C member 1; AltName: Full=Glutathione-S-conjugate-translocating ATPase ABCC1; AltName: Full=Leukotriene C(4) transporter; Short=LTC4 transporter

>sp|Q7YR37.1|ABCF1\_PANTR RecName: Full=ATP-binding cassette sub-family F member 1; AltName: Full=ATP-binding cassette 50

>sp|Q2QLE5.1|CFTR\_PANTR RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|P21448.2|MDR1\_CRIGR RecName: Full=ATP-dependent translocase ABCB1; AltName: Full=ATP-binding cassette sub-family B member 1; AltName: Full=Multidrug resistance protein 1; AltName: Full=P-glycoprotein 1; AltName: Full=Phospholipid transporter ABCB1; AltName: CD\_antigen=CD243

>sp|P21449.2|MDR2\_CRIGR RecName: Full=Multidrug resistance protein 2; AltName: Full=P-glycoprotein 2

>sp|P23174.1|MDR3\_CRIGR RecName: Full=Phosphatidylcholine translocator ABCB4; AltName: Full=ATP-binding cassette sub-family B member 4; AltName: Full=Multidrug resistance protein 3; AltName: Full=P-glycoprotein 3

>sp|Q5D1Z7.1|CFTR\_TRIVU RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q9ERA5.1|SMC4\_MICAR RecName: Full=Structural maintenance of chromosomes protein 4; Short=SMC protein 4; Short=SMC-4; AltName: Full=Chromosome-associated polypeptide C; AltName: Full=XCAP-C homolog

>sp|Q7JII8.1|CFTR\_MACFA RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q864R9.1|MRP1\_MACFA RecName: Full=Multidrug resistance-associated protein 1; AltName: Full=ATP-binding cassette sub-family C member 1; AltName: Full=Glutathione-S-conjugate-translocating ATPase ABCC1; AltName: Full=Leukotriene C(4) transporter; Short=LTC4 transporter

>sp|Q6UR05.1|MRP1\_CANLF RecName: Full=Multidrug resistance-associated protein 1; AltName: Full=ATP-binding cassette sub-family C member 1; AltName: Full=Glutathione-S-conjugate-translocating ATPase ABCC1; AltName: Full=Leukotriene C(4) transporter; Short=LTC4 transporter

>sp|Q5U820.2|CFTR\_CANLF RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|B8K1W2.1|ABCBB\_CANLF RecName: Full=Bile salt export pump

>sp|Q07E16.1|CFTR\_MUSPF RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q00552.2|CFTR\_CAVPO RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q24739.1|BROWN\_DROVI RecName: Full=Protein brown; AltName: Full=ATP-binding cassette transporter sub-family G member brown; AltName: Full=Broad substrate specificity ATP-binding cassette transporter brown

>sp|P12428.1|BROWN\_DROME RecName: Full=Protein brown; AltName: Full=ATP-binding cassette transporter sub-family G member brown; AltName: Full=Broad substrate specificity ATP-binding cassette transporter brown

>sp|P10090.2|WHITE\_DROME RecName: Full=Protein white; AltName: Full=ATP-binding cassette transporter sub-family G member white; AltName: Full=Broad substrate specificity ATP-binding cassette transporter white

>sp|Q9VUM0.2|MSH6\_DROME RecName: Full=Probable DNA mismatch repair protein Msh6

>sp|Q00748.2|MDR65\_DROME RecName: Full=Multidrug resistance protein homolog 65; AltName: Full=P-glycoprotein 65

>sp|P45843.3|SCRT\_DROME RecName: Full=Protein scarlet; AltName: Full=ATP-binding cassette transporter sub-family G member scarlet; AltName: Full=Broad substrate specificity ATP-binding cassette transporter scarlet

>sp|Q9VNJ5.1|DISP\_DROME RecName: Full=Protein dispatched

>sp|Q9VSS1.1|ABCE1\_DROME RecName: Full=Protein Pixie; AltName: Full=ATP-binding cassette sub-family E member 1

>sp|P43248.4|MSH2\_DROME RecName: Full=DNA mismatch repair protein spellchecker 1

>sp|Q7JUN3.1|ABCD\_DROME RecName: Full=ATP-binding cassette sub-family D member

>sp|Q00449.2|MDR49\_DROME RecName: Full=Multidrug resistance protein homolog 49; AltName: Full=P-glycoprotein 49

>sp|Q9VL32.4|SUR\_DROME RecName: Full=ATP-binding cassette sub-family C member Sur; AltName: Full=Sulfonylurea receptor; Short=Dsur

>sp|Q9W252.4|RAD50\_DROME RecName: Full=DNA repair protein RAD50

>sp|P91660.4|L259\_DROME RecName: Full=Probable multidrug resistance-associated protein lethal(2)03659; AltName: Full=Wunen region A protein

>sp|A0A125QXJ1.1|ABCB6\_MESAU RecName: Full=ATP-binding cassette sub-family B member 6; AltName: Full=ABC-type heme transporter ABCB6; AltName: Full=Mitochondrial ABC transporter 3; Short=Mt-ABC transporter 3; AltName: Full=P-glycoprotein-related protein; AltName: Full=Ubiquitously-expressed mammalian ABC half transporter

>sp|Q2QL83.1|CFTR\_MICMU RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q2IBB3.1|CFTR\_RHIFE RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q5XXB5.1|MSH2\_CHLAE RecName: Full=DNA mismatch repair protein Msh2; AltName: Full=MutS protein homolog 2

>sp|Q2IBA1.1|CFTR\_CHLAE RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q2QLA3.1|CFTR\_HORSE RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|P06795.1|MDR1B\_MOUSE RecName: Full=ATP-dependent translocase ABCB1; AltName: Full=ATP-binding cassette sub-family B member 1B; AltName: Full=Multidrug resistance protein 1B; AltName: Full=P-glycoprotein 1; AltName: Full=Phospholipid transporter ABCB1; AltName: CD\_antigen=CD243

>sp|P13705.3|MSH3\_MOUSE RecName: Full=DNA mismatch repair protein Msh3; AltName: Full=Protein repair-1; Short=REP-1; AltName: Full=Protein repair-3; Short=REP-3

>sp|P36371.1|TAP2\_MOUSE RecName: Full=Antigen peptide transporter 2; Short=APT2; AltName: Full=ATP-binding cassette sub-family B member 3; AltName: Full=Histocompatibility antigen modifier 2

>sp|P43247.1|MSH2\_MOUSE RecName: Full=DNA mismatch repair protein Msh2; AltName: Full=MutS protein homolog 2

>sp|P48410.1|ABCD1\_MOUSE RecName: Full=ATP-binding cassette sub-family D member 1; AltName: Full=Adrenoleukodystrophy protein; Short=ALDP

>sp|Q64343.1|ABCG1\_MOUSE RecName: Full=ATP-binding cassette sub-family G member 1; AltName: Full=ATP-binding cassette transporter 8; AltName: Full=White protein homolog

>sp|Q9JIB3.1|BIR1G\_MOUSE RecName: Full=Baculoviral IAP repeat-containing protein 1g; AltName: Full=Neuronal apoptosis inhibitory protein 7

>sp|Q99PE8.1|ABCG5\_MOUSE RecName: Full=ATP-binding cassette sub-family G member 5; AltName: Full=Sterolin-1

>sp|Q9DBM0.1|ABCG8\_MOUSE RecName: Full=ATP-binding cassette sub-family G member 8; AltName: Full=Sterolin-2

>sp|P70170.2|ABCC9\_MOUSE RecName: Full=ATP-binding cassette sub-family C member 9; AltName: Full=Sulfonylurea receptor 2

>sp|P26361.2|CFTR\_MOUSE RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q05921.2|RN5A\_MOUSE RecName: Full=2-5A-dependent ribonuclease; Short=2-5A-dependent RNase; AltName: Full=Ribonuclease 4; AltName: Full=Ribonuclease L; Short=RNase L

>sp|Q9JI39.1|ABCBA\_MOUSE RecName: Full=ATP-binding cassette sub-family B member 10, mitochondrial; AltName: Full=ABC-mitochondrial erythroid protein; Short=ABC-me protein; AltName: Full=ATP-binding cassette transporter 10; Short=ABC transporter 10 protein; Flags: Precursor

>sp|Q9JJ59.1|ABCB9\_MOUSE RecName: Full=ABC-type oligopeptide transporter ABCB9; AltName: Full=ATP-binding cassette sub-family B member 9; AltName: Full=ATP-binding cassette transporter 9; Short=ABC transporter 9 protein; Short=mABCB9; AltName: Full=TAP-like protein; Short=TAPL

>sp|Q920F6.1|SMC1B\_MOUSE RecName: Full=Structural maintenance of chromosomes protein 1B; Short=SMC protein 1B; Short=SMC-1-beta; Short=SMC-1B

>sp|Q99MT2.1|MSH4\_MOUSE RecName: Full=MutS protein homolog 4; Short=mMsh4

>sp|P61222.1|ABCE1\_MOUSE RecName: Full=ATP-binding cassette sub-family E member 1; AltName: Full=RNase L inhibitor; AltName: Full=Ribonuclease 4 inhibitor; Short=RNS4I

>sp|Q99LE6.1|ABCF2\_MOUSE RecName: Full=ATP-binding cassette sub-family F member 2

>sp|O35379.1|MRP1\_MOUSE RecName: Full=Multidrug resistance-associated protein 1; AltName: Full=ATP-binding cassette sub-family C member 1; AltName: Full=Glutathione-S-conjugate-translocating ATPase ABCC1; AltName: Full=Leukotriene C(4) transporter; Short=LTC4 transporter

>sp|Q6P542.1|ABCF1\_MOUSE RecName: Full=ATP-binding cassette sub-family F member 1

>sp|O35600.1|ABCA4\_MOUSE RecName: Full=Retinal-specific phospholipid-transporting ATPase ABCA4; AltName: Full=ATP-binding cassette sub-family A member 4; AltName: Full=RIM ABC transporter; Short=RIM protein; Short=RmP; AltName: Full=Retinal-specific ATP-binding cassette transporter

>sp|P70388.1|RAD50\_MOUSE RecName: Full=DNA repair protein RAD50; Short=mRad50

>sp|P41234.4|ABCA2\_MOUSE RecName: Full=ATP-binding cassette sub-family A member 2; AltName: Full=ATP-binding cassette transporter 2; Short=ATP-binding cassette 2

>sp|Q7TMS5.1|ABCG2\_MOUSE RecName: Full=Broad substrate specificity ATP-binding cassette transporter ABCG2; AltName: Full=ATP-binding cassette sub-family G member 2; AltName: Full=Breast cancer resistance protein 1 homolog; AltName: Full=Urate exporter; AltName: CD\_antigen=CD338

>sp|P70227.3|ITPR3\_MOUSE RecName: Full=Inositol 1,4,5-trisphosphate receptor type 3; AltName: Full=IP3 receptor isoform 3; Short=IP3R 3; Short=InsP3R3; AltName: Full=Type 3 inositol 1,4,5-trisphosphate receptor; Short=Type 3 InsP3 receptor

>sp|Q8CG46.1|SMC5\_MOUSE RecName: Full=Structural maintenance of chromosomes protein 5; Short=SMC protein 5; Short=SMC-5; Short=mSMC5; AltName: Full=Protein expressed in male leptotene and zygotene spermatocytes 453; Short=MLZ-453

>sp|Q924W5.1|SMC6\_MOUSE RecName: Full=Structural maintenance of chromosomes protein 6; Short=SMC protein 6; Short=SMC-6; Short=mSMC6

>sp|Q8BFQ2.1|T229B\_MOUSE RecName: Full=Transmembrane protein 229B

>sp|Q8VIM9.1|IRGQ\_MOUSE RecName: Full=Immunity-related GTPase family Q protein

>sp|Q9QUM7.1|MSH5\_MOUSE RecName: Full=MutS protein homolog 5

>sp|Q5SSE9.1|ABCAD\_MOUSE RecName: Full=ATP-binding cassette sub-family A member 13

>sp|Q80WJ6.1|MRP9\_MOUSE RecName: Full=ATP-binding cassette sub-family C member 12; AltName: Full=Multidrug resistance-associated protein 9

>sp|Q8K268.1|ABCF3\_MOUSE RecName: Full=ATP-binding cassette sub-family F member 3

>sp|Q8R4P9.1|MRP7\_MOUSE RecName: Full=ATP-binding cassette sub-family C member 10; AltName: Full=Multidrug resistance-associated protein 7

>sp|Q91V24.1|ABCA7\_MOUSE RecName: Full=ATP-binding cassette sub-family A member 7

>sp|Q91WA9.2|ABCG4\_MOUSE RecName: Full=ATP-binding cassette subfamily G member 4; AltName: Full=ATP-binding cassette transporter White2

>sp|Q9CXJ4.1|MITOS\_MOUSE RecName: Full=Mitochondrial potassium channel ATP-binding subunit; AltName: Full=ATP-binding cassette sub-family B member 8, mitochondrial; Short=ABCB8; AltName: Full=Mitochondrial sulfonylurea-receptor; Short=MITOSUR; Flags: Precursor

>sp|Q9DC29.1|ABCB6\_MOUSE RecName: Full=ATP-binding cassette sub-family B member 6; AltName: Full=ABC-type heme transporter ABCB6

>sp|Q8K440.2|ABC8B\_MOUSE RecName: Full=ABC-type organic anion transporter ABCA8B; AltName: Full=ATP-binding cassette sub-family A member 8B

>sp|Q8K448.2|ABCA5\_MOUSE RecName: Full=Cholesterol transporter ABCA5; AltName: Full=ATP-binding cassette sub-family A member 5

>sp|Q9QYC1.3|PCX1\_MOUSE RecName: Full=Pecanex-like protein 1; AltName: Full=Pecanex homolog protein 1

>sp|P21447.3|MDR1A\_MOUSE RecName: Full=ATP-dependent translocase ABCB1; AltName: Full=ATP-binding cassette sub-family B member 1A; AltName: Full=MDR1A; AltName: Full=Multidrug resistance protein 1A; AltName: Full=Multidrug resistance protein 3; AltName: Full=P-glycoprotein 3; AltName: Full=Phospholipid transporter ABCB1

>sp|B9EJI9.1|T229A\_MOUSE RecName: Full=Transmembrane protein 229A

>sp|Q8K442.2|ABC8A\_MOUSE RecName: Full=ABC-type organic anion transporter ABCA8A; AltName: Full=ATP-binding cassette sub-family A member 8A

>sp|Q8K441.2|ABCA6\_MOUSE RecName: Full=ATP-binding cassette sub-family A member 6

>sp|Q8K449.2|ABCA9\_MOUSE RecName: Full=ATP-binding cassette sub-family A member 9

>sp|Q9QY30.2|ABCBB\_MOUSE RecName: Full=Bile salt export pump; AltName: Full=ATP-binding cassette sub-family B member 11; AltName: Full=Sister of P-glycoprotein

>sp|P55096.2|ABCD3\_MOUSE RecName: Full=ATP-binding cassette sub-family D member 3; AltName: Full=68 kDa peroxisomal membrane protein; Short=PMP68; AltName: Full=70 kDa peroxisomal membrane protein; Short=PMP70

>sp|O89016.2|ABCD4\_MOUSE RecName: Full=Lysosomal cobalamin transporter ABCD4; AltName: Full=ATP-binding cassette sub-family D member 4; AltName: Full=PMP70-related protein; Short=P70R; AltName: Full=Peroxisomal membrane protein 1-like; Short=PXMP1-L; AltName: Full=Peroxisomal membrane protein 69; Short=PMP69

>sp|Q61102.3|ABCB7\_MOUSE RecName: Full=Iron-sulfur clusters transporter ABCB7, mitochondrial; AltName: Full=ATP-binding cassette sub-family B member 7, mitochondrial; AltName: Full=ATP-binding cassette transporter 7; Short=ABC transporter 7 protein; Flags: Precursor

>sp|Q8R420.3|ABCA3\_MOUSE RecName: Full=Phospholipid-transporting ATPase ABCA3; AltName: Full=ATP-binding cassette sub-family A member 3; AltName: Full=Xenobiotic-transporting ATPase ABCA3; Contains: RecName: Full=150 Kda mature form

>sp|P21440.2|MDR3\_MOUSE RecName: Full=Phosphatidylcholine translocator ABCB4; AltName: Full=ATP-binding cassette sub-family B member 4; AltName: Full=Multidrug resistance protein 2; AltName: Full=Multidrug resistance protein 3; AltName: Full=P-glycoprotein 2; AltName: Full=P-glycoprotein 3

>sp|Q8VI47.2|MRP2\_MOUSE RecName: Full=ATP-binding cassette sub-family C member 2; AltName: Full=Canalicular multispecific organic anion transporter 1; AltName: Full=Multidrug resistance-associated protein 2

>sp|Q9R1X5.2|MRP5\_MOUSE RecName: Full=ATP-binding cassette sub-family C member 5; AltName: Full=Multi-specific organic anion transporter C; Short=MOAT-C; AltName: Full=Multidrug resistance-associated protein 5; AltName: Full=SMRP

>sp|P21958.3|TAP1\_MOUSE RecName: Full=Antigen peptide transporter 1; Short=APT1; AltName: Full=ATP-binding cassette sub-family B member 2; AltName: Full=Histocompatibility antigen modifier 1; AltName: Full=Peptide transporter TAP1

>sp|Q99P81.2|ABCG3\_MOUSE RecName: Full=ATP-binding cassette sub-family G member 3

>sp|Q9QUK4.2|BIR1B\_MOUSE RecName: Full=Baculoviral IAP repeat-containing protein 1b; AltName: Full=Neuronal apoptosis inhibitory protein 2

>sp|Q9JIB6.2|BIR1F\_MOUSE RecName: Full=Baculoviral IAP repeat-containing protein 1f; AltName: Full=Neuronal apoptosis inhibitory protein 6

>sp|Q9QWK5.3|BIR1A\_MOUSE RecName: Full=Baculoviral IAP repeat-containing protein 1a; AltName: Full=Neuronal apoptosis inhibitory protein 1

>sp|P41233.4|ABCA1\_MOUSE RecName: Full=Phospholipid-transporting ATPase ABCA1; AltName: Full=ATP-binding cassette sub-family A member 1; AltName: Full=ATP-binding cassette transporter 1; Short=ABC-1; Short=ATP-binding cassette 1

>sp|P54276.3|MSH6\_MOUSE RecName: Full=DNA mismatch repair protein Msh6; AltName: Full=G/T mismatch-binding protein; Short=GTBP; Short=GTMBP; AltName: Full=MutS protein homolog 6; AltName: Full=MutS-alpha 160 kDa subunit; Short=p160

>sp|Q9R1S7.3|MRP6\_MOUSE RecName: Full=ATP-binding cassette sub-family C member 6; AltName: Full=Multidrug resistance-associated protein 6

>sp|B5X0E4.1|ABCB5\_MOUSE RecName: Full=ATP-binding cassette sub-family B member 5; AltName: Full=ABCB5 P-gp; AltName: Full=P-glycoprotein ABCB5

>sp|E9PX95.1|ABCAH\_MOUSE RecName: Full=ATP-binding cassette sub-family A member 17

>sp|B2RX12.2|MRP3\_MOUSE RecName: Full=ATP-binding cassette sub-family C member 3; AltName: Full=Canalicular multispecific organic anion transporter 2; AltName: Full=Multidrug resistance-associated protein 3

>sp|E9Q236.1|MRP4\_MOUSE RecName: Full=ATP-binding cassette sub-family C member 4; AltName: Full=Multidrug resistance-associated protein 4

>sp|E9Q876.1|ABCAC\_MOUSE RecName: Full=Glucosylceramide transporter ABCA12; AltName: Full=ATP-binding cassette sub-family A member 12

>sp|Q61285.2|ABCD2\_MOUSE RecName: Full=ATP-binding cassette sub-family D member 2; AltName: Full=Adrenoleukodystrophy-related protein

>sp|P28288.1|ABCD3\_HUMAN RecName: Full=ATP-binding cassette sub-family D member 3; AltName: Full=70 kDa peroxisomal membrane protein; Short=PMP70

>sp|Q03519.1|TAP2\_HUMAN RecName: Full=Antigen peptide transporter 2; Short=APT2; AltName: Full=ATP-binding cassette sub-family B member 3; AltName: Full=Peptide supply factor 2; AltName: Full=Peptide transporter PSF2; Short=PSF-2; AltName: Full=Peptide transporter TAP2; AltName: Full=Peptide transporter involved in antigen processing 2; AltName: Full=Really interesting new gene 11 protein; Short=RING11

>sp|Q05823.2|RN5A\_HUMAN RecName: Full=2-5A-dependent ribonuclease; Short=2-5A-dependent RNase; AltName: Full=Ribonuclease 4; AltName: Full=Ribonuclease L; Short=RNase L

>sp|O43196.1|MSH5\_HUMAN RecName: Full=MutS protein homolog 5; Short=hMSH5

>sp|P78363.3|ABCA4\_HUMAN RecName: Full=Retinal-specific phospholipid-transporting ATPase ABCA4; AltName: Full=ATP-binding cassette sub-family A member 4; AltName: Full=RIM ABC transporter; Short=RIM proteinv; Short=RmP; AltName: Full=Retinal-specific ATP-binding cassette transporter; AltName: Full=Stargardt disease protein

>sp|O14678.1|ABCD4\_HUMAN RecName: Full=Lysosomal cobalamin transporter ABCD4; AltName: Full=ATP-binding cassette sub-family D member 4; AltName: Full=PMP70-related protein; Short=P70R; AltName: Full=Peroxisomal membrane protein 1-like; Short=PXMP1-L; AltName: Full=Peroxisomal membrane protein 69; Short=PMP69

>sp|O15438.3|MRP3\_HUMAN RecName: Full=ATP-binding cassette sub-family C member 3; AltName: Full=Canalicular multispecific organic anion transporter 2; AltName: Full=Multi-specific organic anion transporter D; Short=MOAT-D; AltName: Full=Multidrug resistance-associated protein 3

>sp|O15440.2|MRP5\_HUMAN RecName: Full=ATP-binding cassette sub-family C member 5; AltName: Full=Multi-specific organic anion transporter C; Short=MOAT-C; AltName: Full=Multidrug resistance-associated protein 5; AltName: Full=SMRP; AltName: Full=pABC11

>sp|O75027.2|ABCB7\_HUMAN RecName: Full=Iron-sulfur clusters transporter ABCB7, mitochondrial; AltName: Full=ATP-binding cassette sub-family B member 7, mitochondrial; AltName: Full=ATP-binding cassette transporter 7; Short=ABC transporter 7 protein; Flags: Precursor

>sp|Q9UBJ2.1|ABCD2\_HUMAN RecName: Full=ATP-binding cassette sub-family D member 2; AltName: Full=Adrenoleukodystrophy-like 1; AltName: Full=Adrenoleukodystrophy-related protein; Short=hALDR

>sp|Q9UG63.2|ABCF2\_HUMAN RecName: Full=ATP-binding cassette sub-family F member 2; AltName: Full=Iron-inhibited ABC transporter 2

>sp|Q9NP58.1|ABCB6\_HUMAN RecName: Full=ATP-binding cassette sub-family B member 6; AltName: Full=ABC-type heme transporter ABCB6; AltName: Full=Mitochondrial ABC transporter 3; Short=Mt-ABC transporter 3; AltName: Full=P-glycoprotein-related protein; AltName: Full=Ubiquitously-expressed mammalian ABC half transporter

>sp|Q9H172.2|ABCG4\_HUMAN RecName: Full=ATP-binding cassette sub-family G member 4

>sp|Q9H221.1|ABCG8\_HUMAN RecName: Full=ATP-binding cassette sub-family G member 8; AltName: Full=Sterolin-2

>sp|Q9H222.1|ABCG5\_HUMAN RecName: Full=ATP-binding cassette sub-family G member 5; AltName: Full=Sterolin-1

>sp|P45844.3|ABCG1\_HUMAN RecName: Full=ATP-binding cassette sub-family G member 1; AltName: Full=ATP-binding cassette transporter 8; AltName: Full=White protein homolog

>sp|Q9NSE7.2|ABCCD\_HUMAN RecName: Full=Putative ATP-binding cassette sub-family C member 13

>sp|Q9NP78.1|ABCB9\_HUMAN RecName: Full=ABC-type oligopeptide transporter ABCB9; AltName: Full=ATP-binding cassette sub-family B member 9; AltName: Full=ATP-binding cassette transporter 9; Short=ABC transporter 9 protein; Short=hABCB9; AltName: Full=TAP-like protein; Short=TAPL

>sp|Q9NTJ3.2|SMC4\_HUMAN RecName: Full=Structural maintenance of chromosomes protein 4; Short=SMC protein 4; Short=SMC-4; AltName: Full=Chromosome-associated polypeptide C; Short=hCAP-C; AltName: Full=XCAP-C homolog

>sp|O15457.2|MSH4\_HUMAN RecName: Full=MutS protein homolog 4; Short=hMSH4

>sp|P61221.1|ABCE1\_HUMAN RecName: Full=ATP-binding cassette sub-family E member 1; AltName: Full=2'-5'-oligoadenylate-binding protein; AltName: Full=HuHP68; AltName: Full=RNase L inhibitor; AltName: Full=Ribonuclease 4 inhibitor; Short=RNS4I

>sp|Q8NE71.2|ABCF1\_HUMAN RecName: Full=ATP-binding cassette sub-family F member 1; AltName: Full=ATP-binding cassette 50; AltName: Full=TNF-alpha-stimulated ABC protein

>sp|Q8NDV3.2|SMC1B\_HUMAN RecName: Full=Structural maintenance of chromosomes protein 1B; Short=SMC protein 1B; Short=SMC-1-beta; Short=SMC-1B

>sp|Q92878.1|RAD50\_HUMAN RecName: Full=DNA repair protein RAD50; Short=hRAD50

>sp|Q9UNQ0.3|ABCG2\_HUMAN RecName: Full=Broad substrate specificity ATP-binding cassette transporter ABCG2; AltName: Full=ATP-binding cassette sub-family G member 2; AltName: Full=Breast cancer resistance protein; AltName: Full=CDw338; AltName: Full=Mitoxantrone resistance-associated protein; AltName: Full=Placenta-specific ATP-binding cassette transporter; AltName: Full=Urate exporter; AltName: CD\_antigen=CD338

>sp|P33897.2|ABCD1\_HUMAN RecName: Full=ATP-binding cassette sub-family D member 1; AltName: Full=Adrenoleukodystrophy protein; Short=ALDP

>sp|P52701.2|MSH6\_HUMAN RecName: Full=DNA mismatch repair protein Msh6; Short=hMSH6; AltName: Full=G/T mismatch-binding protein; Short=GTBP; Short=GTMBP; AltName: Full=MutS protein homolog 6; AltName: Full=MutS-alpha 160 kDa subunit; Short=p160

>sp|Q8NBD8.1|T229B\_HUMAN RecName: Full=Transmembrane protein 229B

>sp|Q9NUN5.1|LMBD1\_HUMAN RecName: Full=Lysosomal cobalamin transport escort protein LMBD1; Short=LMBD1; AltName: Full=HDAg-L-interacting protein NESI; AltName: Full=LMBR1 domain-containing protein 1; AltName: Full=Nuclear export signal-interacting protein

>sp|Q4W5N1.1|ABCAB\_HUMAN RecName: Full=Putative ATP-binding cassette sub-family A member 11

>sp|Q5T3U5.1|MRP7\_HUMAN RecName: Full=ATP-binding cassette sub-family C member 10; AltName: Full=Multidrug resistance-associated protein 7

>sp|Q8IUA7.1|ABCA9\_HUMAN RecName: Full=ATP-binding cassette sub-family A member 9

>sp|Q96J66.1|MRP8\_HUMAN RecName: Full=ATP-binding cassette sub-family C member 11; AltName: Full=Multidrug resistance-associated protein 8

>sp|Q99758.2|ABCA3\_HUMAN RecName: Full=Phospholipid-transporting ATPase ABCA3; AltName: Full=ABC-C transporter; AltName: Full=ATP-binding cassette sub-family A member 3; AltName: Full=ATP-binding cassette transporter 3; Short=ATP-binding cassette 3; AltName: Full=Xenobiotic-transporting ATPase ABCA3; Contains: RecName: Full=150 Kda mature form

>sp|P98196.3|AT11A\_HUMAN RecName: Full=Phospholipid-transporting ATPase IH; AltName: Full=ATPase IS; AltName: Full=ATPase class VI type 11A; AltName: Full=P4-ATPase flippase complex alpha subunit ATP11A

>sp|Q9NUQ8.2|ABCF3\_HUMAN RecName: Full=ATP-binding cassette sub-family F member 3

>sp|Q8WWZ7.2|ABCA5\_HUMAN RecName: Full=Cholesterol transporter ABCA5; AltName: Full=ATP-binding cassette sub-family A member 5

>sp|Q8N139.2|ABCA6\_HUMAN RecName: Full=ATP-binding cassette sub-family A member 6

>sp|Q96RV3.2|PCX1\_HUMAN RecName: Full=Pecanex-like protein 1; AltName: Full=Pecanex homolog protein 1

>sp|Q5BJH7.1|YIF1B\_HUMAN RecName: Full=Protein YIF1B; AltName: Full=YIP1-interacting factor homolog B

>sp|Q8IY18.2|SMC5\_HUMAN RecName: Full=Structural maintenance of chromosomes protein 5; Short=SMC protein 5; Short=SMC-5; Short=hSMC5

>sp|P21439.2|MDR3\_HUMAN RecName: Full=Phosphatidylcholine translocator ABCB4; AltName: Full=ATP-binding cassette sub-family B member 4; AltName: Full=Multidrug resistance protein 3; AltName: Full=P-glycoprotein 3

>sp|Q9NUT2.3|MITOS\_HUMAN RecName: Full=Mitochondrial potassium channel ATP-binding subunit; AltName: Full=ATP-binding cassette sub-family B member 8, mitochondrial; Short=ABCB8; AltName: Full=Mitochondrial ATP-binding cassette 1; Short=M-ABC1; AltName: Full=Mitochondrial sulfonylurea-receptor; Short=MITOSUR; Flags: Precursor

>sp|Q9NRK6.2|ABCBA\_HUMAN RecName: Full=ATP-binding cassette sub-family B member 10, mitochondrial; AltName: Full=ABC-mitochondrial erythroid protein; Short=ABC-me protein; AltName: Full=ATP-binding cassette transporter 10; Short=ABC transporter 10 protein; AltName: Full=Mitochondrial ATP-binding cassette 2; Short=M-ABC2; Flags: Precursor

>sp|P13569.3|CFTR\_HUMAN RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q8IZY2.3|ABCA7\_HUMAN RecName: Full=Phospholipid-transporting ATPase ABCA7; AltName: Full=ABCA-SSN; AltName: Full=ATP-binding cassette sub-family A member 7; AltName: Full=Autoantigen SS-N; AltName: Full=Macrophage ABC transporter

>sp|Q96J65.2|MRP9\_HUMAN RecName: Full=ATP-binding cassette sub-family C member 12; AltName: Full=Multidrug resistance-associated protein 9

>sp|Q92619.2|HMHA1\_HUMAN RecName: Full=Rho GTPase-activating protein 45; Contains: RecName: Full=Minor histocompatibility antigen HA-1; Short=mHag HA-1

>sp|P35575.2|G6PC1\_HUMAN RecName: Full=Glucose-6-phosphatase catalytic subunit 1; AltName: Full=Glucose-6-phosphatase; Short=G-6-Pase; Short=G6Pase; AltName: Full=Glucose-6-phosphatase alpha; Short=G6Pase-alpha

>sp|O15439.3|MRP4\_HUMAN RecName: Full=ATP-binding cassette sub-family C member 4; AltName: Full=MRP/cMOAT-related ABC transporter; AltName: Full=Multi-specific organic anion transporter B; Short=MOAT-B; AltName: Full=Multidrug resistance-associated protein 4

>sp|O95347.2|SMC2\_HUMAN RecName: Full=Structural maintenance of chromosomes protein 2; Short=SMC protein 2; Short=SMC-2; AltName: Full=Chromosome-associated protein E; Short=hCAP-E; AltName: Full=XCAP-E homolog

>sp|O60706.2|ABCC9\_HUMAN RecName: Full=ATP-binding cassette sub-family C member 9; AltName: Full=Sulfonylurea receptor 2

>sp|P08183.3|MDR1\_HUMAN RecName: Full=ATP-dependent translocase ABCB1; AltName: Full=ATP-binding cassette sub-family B member 1; AltName: Full=Multidrug resistance protein 1; AltName: Full=P-glycoprotein 1; AltName: Full=Phospholipid transporter ABCB1; AltName: CD\_antigen=CD243

>sp|O95342.2|ABCBB\_HUMAN RecName: Full=Bile salt export pump; AltName: Full=ATP-binding cassette sub-family B member 11

>sp|O95255.2|MRP6\_HUMAN RecName: Full=ATP-binding cassette sub-family C member 6; AltName: Full=Anthracycline resistance-associated protein; AltName: Full=Multi-specific organic anion transporter E; Short=MOAT-E; AltName: Full=Multidrug resistance-associated protein 6

>sp|Q86UK0.3|ABCAC\_HUMAN RecName: Full=Glucosylceramide transporter ABCA12; AltName: Full=ATP-binding cassette sub-family A member 12; AltName: Full=ATP-binding cassette transporter 12; Short=ATP-binding cassette 12

>sp|B2RXF0.2|T229A\_HUMAN RecName: Full=Transmembrane protein 229A

>sp|P33527.3|MRP1\_HUMAN RecName: Full=Multidrug resistance-associated protein 1; AltName: Full=ATP-binding cassette sub-family C member 1; AltName: Full=Glutathione-S-conjugate-translocating ATPase ABCC1; AltName: Full=Leukotriene C(4) transporter; Short=LTC4 transporter

>sp|Q9UP83.3|COG5\_HUMAN RecName: Full=Conserved oligomeric Golgi complex subunit 5; Short=COG complex subunit 5; AltName: Full=13S Golgi transport complex 90 kDa subunit; Short=GTC-90; AltName: Full=Component of oligomeric Golgi complex 5; AltName: Full=Golgi transport complex 1

>sp|Q8WWZ4.3|ABCAA\_HUMAN RecName: Full=ATP-binding cassette sub-family A member 10

>sp|Q15155.5|NOMO1\_HUMAN RecName: Full=Nodal modulator 1; AltName: Full=pM5 protein; Flags: Precursor

>sp|Q92887.3|MRP2\_HUMAN RecName: Full=ATP-binding cassette sub-family C member 2; AltName: Full=Canalicular multidrug resistance protein; AltName: Full=Canalicular multispecific organic anion transporter 1; AltName: Full=Multidrug resistance-associated protein 2

>sp|O95477.3|ABCA1\_HUMAN RecName: Full=Phospholipid-transporting ATPase ABCA1; AltName: Full=ATP-binding cassette sub-family A member 1; AltName: Full=ATP-binding cassette transporter 1; Short=ABC-1; Short=ATP-binding cassette 1; AltName: Full=Cholesterol efflux regulatory protein

>sp|Q09428.6|ABCC8\_HUMAN RecName: Full=ATP-binding cassette sub-family C member 8; AltName: Full=Sulfonylurea receptor 1

>sp|P20585.4|MSH3\_HUMAN RecName: Full=DNA mismatch repair protein Msh3; Short=hMSH3; AltName: Full=Divergent upstream protein; Short=DUP; AltName: Full=Mismatch repair protein 1; Short=MRP1

>sp|Q86UQ4.3|ABCAD\_HUMAN RecName: Full=ATP-binding cassette sub-family A member 13

>sp|P28062.3|PSB8\_HUMAN RecName: Full=Proteasome subunit beta type-8; AltName: Full=Low molecular mass protein 7; AltName: Full=Macropain subunit C13; AltName: Full=Multicatalytic endopeptidase complex subunit C13; AltName: Full=Proteasome component C13; AltName: Full=Proteasome subunit beta-5i; AltName: Full=Really interesting new gene 10 protein; Flags: Precursor

>sp|Q2M3G0.4|ABCB5\_HUMAN RecName: Full=ATP-binding cassette sub-family B member 5; AltName: Full=ABCB5 P-gp; AltName: Full=P-glycoprotein ABCB5

>sp|Q9BZC7.4|ABCA2\_HUMAN RecName: Full=ATP-binding cassette sub-family A member 2; AltName: Full=ATP-binding cassette transporter 2; Short=ATP-binding cassette 2

>sp|O94911.4|ABCA8\_HUMAN RecName: Full=ABC-type organic anion transporter ABCA8; AltName: Full=ATP-binding cassette sub-family A member 8

>sp|Q03518.3|TAP1\_HUMAN RecName: Full=Antigen peptide transporter 1; Short=APT1; AltName: Full=ATP-binding cassette sub-family B member 2; AltName: Full=Peptide supply factor 1; AltName: Full=Peptide transporter PSF1; Short=PSF-1; AltName: Full=Peptide transporter TAP1; AltName: Full=Peptide transporter involved in antigen processing 1; AltName: Full=Really interesting new gene 4 protein; Short=RING4

>sp|Q7JII7.1|CFTR\_MACFU RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|H2LRU7.2|PKD2\_ORYLA RecName: Full=Polycystin-2; AltName: Full=Polycystic kidney disease 2 protein homolog

>sp|H2LNR5.2|ABCB7\_ORYLA RecName: Full=Iron-sulfur clusters transporter ABCB7, mitochondrial; AltName: Full=ATP-binding cassette sub-family B member 7, mitochondrial; Flags: Precursor

>sp|Q07DV2.1|CFTR\_AOTNA RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q07DY5.1|CFTR\_COLGU RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q17320.1|WHITE\_CERCA RecName: Full=Protein white

>sp|Q00PJ2.1|CFTR\_ATEAB RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q09YJ4.1|CFTR\_MUNMU RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q07E42.1|CFTR\_DASNO RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q2QL74.1|CFTR\_DIDVI RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q07DX5.1|CFTR\_NOMLE RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|P16970.3|ABCD3\_RAT RecName: Full=ATP-binding cassette sub-family D member 3; AltName: Full=70 kDa peroxisomal membrane protein; Short=PMP70

>sp|P36372.1|TAP2\_RAT RecName: Full=Antigen peptide transporter 2; Short=APT2; AltName: Full=ATP-binding cassette sub-family B member 3

>sp|P43245.1|MDR1\_RAT RecName: Full=ATP-dependent translocase ABCB1; AltName: Full=ATP-binding cassette sub-family B member 1; AltName: Full=Multidrug resistance protein 1; AltName: Full=P-glycoprotein 1; AltName: Full=Phospholipid transporter ABCB1; AltName: CD\_antigen=CD243

>sp|Q08201.1|MDR3\_RAT RecName: Full=Phosphatidylcholine translocator ABCB4; AltName: Full=ATP-binding cassette sub-family B member 4; AltName: Full=Multidrug resistance protein 2; AltName: Full=Multidrug resistance protein 3; AltName: Full=P-glycoprotein 2; AltName: Full=P-glycoprotein 3

>sp|P54275.1|MSH2\_RAT RecName: Full=DNA mismatch repair protein Msh2; AltName: Full=MutS protein homolog 2

>sp|P36370.2|TAP1\_RAT RecName: Full=Antigen peptide transporter 1; Short=APT1; AltName: Full=ATP-binding cassette sub-family B member 2; AltName: Full=Peptide transporter TAP1

>sp|Q63120.1|MRP2\_RAT RecName: Full=ATP-binding cassette sub-family C member 2; AltName: Full=Canalicular multidrug resistance protein; AltName: Full=Canalicular multispecific organic anion transporter 1; AltName: Full=Multidrug resistance-associated protein 2

>sp|O88563.1|MRP3\_RAT RecName: Full=ATP-binding cassette sub-family C member 3; AltName: Full=Canalicular multispecific organic anion transporter 2; AltName: Full=MRP-like protein 2; Short=MLP-2; AltName: Full=Multidrug resistance-associated protein 3

>sp|O88269.1|MRP6\_RAT RecName: Full=ATP-binding cassette sub-family C member 6; AltName: Full=MRP-like protein 1; Short=MLP-1; AltName: Full=Multidrug resistance-associated protein 6

>sp|O70127.1|ABCBB\_RAT RecName: Full=Bile salt export pump; AltName: Full=ATP-binding cassette sub-family B member 11; AltName: Full=Sister of P-glycoprotein

>sp|Q63269.1|ITPR3\_RAT RecName: Full=Inositol 1,4,5-trisphosphate receptor type 3; AltName: Full=IP3 receptor isoform 3; Short=IP3R 3; Short=InsP3R3; AltName: Full=Type 3 inositol 1,4,5-trisphosphate receptor; Short=Type 3 InsP3 receptor

>sp|Q63563.1|ABCC9\_RAT RecName: Full=ATP-binding cassette sub-family C member 9; AltName: Full=Sulfonylurea receptor 2

>sp|Q09429.4|ABCC8\_RAT RecName: Full=ATP-binding cassette sub-family C member 8; AltName: Full=Sulfonylurea receptor 1

>sp|Q9QYJ4.1|ABCB9\_RAT RecName: Full=ABC-type oligopeptide transporter ABCB9; AltName: Full=ATP-binding cassette sub-family B member 9; AltName: Full=ATP-binding cassette transporter 9; Short=ABC transporter 9 protein; AltName: Full=TAP-like protein; Short=TAPL

>sp|P97690.1|SMC3\_RAT RecName: Full=Structural maintenance of chromosomes protein 3; Short=SMC protein 3; Short=SMC-3; AltName: Full=Basement membrane-associated chondroitin proteoglycan; Short=Bamacan; AltName: Full=Chondroitin sulfate proteoglycan 6; AltName: Full=Chromosome segregation protein SmcD

>sp|Q9Z1M9.1|SMC1A\_RAT RecName: Full=Structural maintenance of chromosomes protein 1A; Short=SMC protein 1A; Short=SMC-1A

>sp|Q99PE7.3|ABCG5\_RAT RecName: Full=ATP-binding cassette sub-family G member 5; AltName: Full=Sterolin-1

>sp|P58428.2|ABCG8\_RAT RecName: Full=ATP-binding cassette sub-family G member 8; AltName: Full=Sterolin-2

>sp|Q9ESR9.1|ABCA2\_RAT RecName: Full=ATP-binding cassette sub-family A member 2; AltName: Full=ATP-binding cassette transporter 2; Short=ATP-binding cassette 2

>sp|Q6MG08.1|ABCF1\_RAT RecName: Full=ATP-binding cassette sub-family F member 1; AltName: Full=ATP-binding cassette 50

>sp|Q9JIL8.1|RAD50\_RAT RecName: Full=DNA repair protein RAD50

>sp|Q80W57.1|ABCG2\_RAT RecName: Full=Broad substrate specificity ATP-binding cassette transporter ABCG2; AltName: Full=ATP-binding cassette sub-family G member 2; AltName: Full=Breast cancer resistance protein 1 homolog; AltName: Full=Urate exporter; AltName: CD\_antigen=CD338

>sp|Q704E8.1|ABCB7\_RAT RecName: Full=Iron-sulfur clusters transporter ABCB7, mitochondrial; AltName: Full=ATP-binding cassette sub-family B member 7, mitochondrial; AltName: Full=ATP-binding cassette transporter 7; Short=ABC transporter 7 protein; Flags: Precursor

>sp|Q6MG62.1|MSH5\_RAT RecName: Full=MutS protein homolog 5

>sp|O70595.1|ABCB6\_RAT RecName: Full=ATP-binding cassette sub-family B member 6; AltName: Full=ABC-type heme transporter ABCB6; AltName: Full=Ubiquitously-expressed mammalian ABC half transporter

>sp|Q4V887.1|S39A6\_RAT RecName: Full=Zinc transporter ZIP6; AltName: Full=Solute carrier family 39 member 6; AltName: Full=Zrt- and Irt-like protein 6; Short=ZIP-6; Flags: Precursor

>sp|Q5RKI8.1|MITOS\_RAT RecName: Full=Mitochondrial potassium channel ATP-binding subunit; AltName: Full=ATP-binding cassette sub-family B member 8, mitochondrial; Short=ABCB8; AltName: Full=Mitochondrial sulfonylurea-receptor; Short=MITOSUR; Flags: Precursor

>sp|Q66H39.1|ABCF3\_RAT RecName: Full=ATP-binding cassette sub-family F member 3

>sp|Q6Y306.1|MRP9\_RAT RecName: Full=ATP-binding cassette sub-family C member 12; AltName: Full=Multidrug resistance-associated protein 9

>sp|Q7TNJ2.1|ABCA7\_RAT RecName: Full=ATP-binding cassette sub-family A member 7

>sp|Q8CF82.1|ABCA5\_RAT RecName: Full=Cholesterol transporter ABCA5; AltName: Full=ATP-binding cassette sub-family A member 5

>sp|Q8CG09.2|MRP1\_RAT RecName: Full=Multidrug resistance-associated protein 1; AltName: Full=ATP-binding cassette sub-family C member 1; AltName: Full=Glutathione-S-conjugate-translocating ATPase ABCC1; AltName: Full=Leukotriene C(4) transporter; Short=LTC4 transporter

>sp|P34158.3|CFTR\_RAT RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|E9PU17.1|ABCAH\_RAT RecName: Full=ATP-binding cassette sub-family A member 17

>sp|D3ZHR2.1|ABCD1\_RAT RecName: Full=ATP-binding cassette sub-family D member 1; AltName: Full=Adrenoleukodystrophy protein; Short=ALDP

>sp|A0A0G2K1Q8.1|ABCA3\_RAT RecName: Full=Phospholipid-transporting ATPase ABCA3; AltName: Full=ATP-binding cassette sub-family A member 3; AltName: Full=Xenobiotic-transporting ATPase ABCA3; Contains: RecName: Full=150 Kda mature form

>sp|F1M3J4.3|MRP4\_RAT RecName: Full=ATP-binding cassette subfamily C member 4; AltName: Full=Multidrug resistance-associated protein 4

>sp|D3ZCM3.1|ABCG4\_RAT RecName: Full=ATP-binding cassette subfamily G member 4; AltName: Full=ATP-binding cassette, sub-family G (WHITE), member 4

>sp|Q9QY44.2|ABCD2\_RAT RecName: Full=ATP-binding cassette sub-family D member 2; AltName: Full=Adrenoleukodystrophy-related protein

>sp|Q9QYM0.2|MRP5\_RAT RecName: Full=ATP-binding cassette sub-family C member 5; AltName: Full=Multidrug resistance-associated protein 5

>sp|Q9TSP5.1|CFTR\_PAPAN RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q767L0.1|ABCF1\_PIG RecName: Full=ATP-binding cassette sub-family F member 1

>sp|Q8MIB3.1|ABCG2\_PIG RecName: Full=Broad substrate specificity ATP-binding cassette transporter ABCG2; AltName: Full=ATP-binding cassette sub-family G member 2; AltName: Full=Brain multidrug resistance protein; AltName: Full=Urate exporter; AltName: CD\_antigen=CD338

>sp|Q6PQZ2.1|CFTR\_PIG RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q9TUQ2.1|CFTR\_MACNE RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q07DZ6.1|CFTR\_ORNAN RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q28689.1|MRP2\_RABIT RecName: Full=ATP-binding cassette sub-family C member 2; AltName: Full=Canalicular multidrug resistance protein; AltName: Full=Canalicular multispecific organic anion transporter 1; AltName: Full=Epithelial basolateral chloride conductance regulator; AltName: Full=Multidrug resistance-associated protein 2

>sp|Q9N0V3.1|ABCBB\_RABIT RecName: Full=Bile salt export pump; AltName: Full=ATP-binding cassette sub-family B member 11; AltName: Full=Sister of P-glycoprotein

>sp|P82451.1|ABCC9\_RABIT RecName: Full=ATP-binding cassette sub-family C member 9; AltName: Full=Sulfonylurea receptor 2

>sp|Q00554.4|CFTR\_RABIT RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q2QLB4.1|CFTR\_PLEMO RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q07DW5.1|CFTR\_MUNRE RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q5MB13.1|ABCG2\_MACMU RecName: Full=Broad substrate specificity ATP-binding cassette transporter ABCG2; AltName: Full=ATP-binding cassette sub-family G member 2; AltName: Full=Urate exporter; AltName: CD\_antigen=CD338

>sp|Q00553.2|CFTR\_MACMU RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|O63852.1|MSHM\_SARGL RecName: Full=Mitochondrial DNA mismatch repair protein mutS homolog

>sp|Q2QLC5.1|CFTR\_CARPS RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q00555.2|CFTR\_SHEEP RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q2QLH0.1|CFTR\_OTOGA RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|P26362.1|CFTR\_SQUAC RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=Dogfish transmembrane conductance regulator; AltName: Full=cAMP-dependent chloride channel

>sp|Q5R9Z5.1|ABCF3\_PONAB RecName: Full=ATP-binding cassette sub-family F member 3

>sp|Q5RFQ9.1|MITOS\_PONAB RecName: Full=Mitochondrial potassium channel ATP-binding subunit; AltName: Full=ATP-binding cassette sub-family B member 8, mitochondrial; Short=ABCB8; AltName: Full=Mitochondrial sulfonylurea-receptor; Short=MITOSUR; Flags: Precursor

>sp|Q2IBE4.1|CFTR\_PONAB RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q802R8.1|SMC6\_TAKRU RecName: Full=Structural maintenance of chromosomes protein 6; Short=SMC protein 6; Short=SMC-6

>sp|Q802R9.1|SMC5\_TAKRU RecName: Full=Structural maintenance of chromosomes protein 5; Short=SMC protein 5; Short=SMC-5

>sp|Q08D64.1|ABCB6\_XENTR RecName: Full=ATP-binding cassette sub-family B member 6; AltName: Full=ABC-type heme transporter ABCB6

>sp|Q0V9V2.1|T229B\_XENTR RecName: Full=Transmembrane protein 229b

>sp|B2GUP8.1|MITOS\_XENTR RecName: Full=Mitochondrial potassium channel ATP-binding subunit; AltName: Full=ATP-binding cassette sub-family B member 8, mitochondrial; Short=ABCB8; AltName: Full=Mitochondrial sulfonylurea-receptor; Short=MITOSUR; Flags: Precursor

>sp|Q28433.2|TAP1\_GORGO RecName: Full=Antigen peptide transporter 1; Short=APT1; AltName: Full=ATP-binding cassette sub-family B member 2; AltName: Full=Peptide transporter TAP1

>sp|Q2IBF6.1|CFTR\_GORGO RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q2QLF9.1|CFTR\_CALJA RecName: Full=Cystic fibrosis transmembrane conductance regulator; Short=CFTR; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|Q08CG9.1|T229B\_DANRE RecName: Full=Transmembrane protein 229b

>sp|Q1LX78.1|CFTR\_DANRE RecName: Full=Cystic fibrosis transmembrane conductance regulator; AltName: Full=ATP-binding cassette sub-family C member 7; AltName: Full=Channel conductance-controlling ATPase; AltName: Full=cAMP-dependent chloride channel

>sp|F1RBC8.1|ABCD1\_DANRE RecName: Full=ATP-binding cassette sub-family D member 1; AltName: Full=Adrenoleukodystrophy protein; Short=ALDP

>sp|Q56A55.2|MITOS\_DANRE RecName: Full=Mitochondrial potassium channel ATP-binding subunit; AltName: Full=ATP-binding cassette sub-family B member 8, mitochondrial; Short=ABCB8; AltName: Full=Mitochondrial sulfonylurea-receptor; Short=MITOSUR; Flags: Precursor

>sp|E7F6F7.1|ABCB7\_DANRE RecName: Full=Iron-sulfur clusters transporter ABCB7, mitochondrial; AltName: Full=ATP-binding cassette sub-family B member 7, mitochondrial; Flags: Precursor

Table S2. List of most specific domains for ABC transport proteins selected for the Pfam analysis from https://pfam.xfam.org/. The accession number, source database and a description of each domain are reported.

|  |  |  |  |
| --- | --- | --- | --- |
| **ABC specific domains** | **Accession** | **Description** | **Source database** |
| ABC\_membrane | PF00664 | This family represents a unit of six transmembrane helices. Many members of the ABC transporter family (Pfam:PF00005) have two such regions. | PFAM |
| ABC\_membrane\_2 | PF06472 | This domain covers the transmembrane of a small family of ABC transporters and shares sequence similarity with Pfam:PF00664. Mutations in this domain in Swiss:P28288 are believed responsible for Zellweger Syndrome-2 [[cite:PUB00012622]]; mutations in Swiss:P33897 are responsible for recessive X-linked adrenoleukodystrophy [[cite:PUB00012623]]. A Saccharomyces cerevisiae homolog is involved in the import of long-chain fatty acids [[cite:PUB00012624]]. | PFAM |
| ABC\_membrane\_3 | PF13748 | This family represents a unit of six transmembrane helices. | PFAM |
| ABC\_trans\_N | PF14510 | This domain is found at the N-terminus of ABC-transporter proteins from fungi, plants to higher eukaryotes. It is predicted to be an intracellular domain [[cite:PUB00087237], [cite:PUB00087238], [cite:PUB00087239]]. | PFAM |
| ABC2\_membrane | PF01061 | ABC-2 type transporter | PFAM |
| ABC2\_membrane\_2 | IPR032688 | This family is related to the ABC-2 membrane transporter family [[cite:PUB00004998]]. Proteins in this entry include NosY from *Pseudomonas which* is required for the assembly of the copper chromophores of nitrous oxide reductase [[cite:PUB00151890]] and YtrC from *Bacillus subtilis*, which is part of the ABC transporter complex YtrBCDEF that plays a role in acetoin utilization during stationary phase and sporulation [[cite:PUB00054122]]. | INTERPRO |
| ABC2\_membrane\_3 | PF12698 | This family is related to the ABC-2 membrane transporter family Pfam:PF01061 [[cite:PUB00004998]]. | PFAM |
| ABC2\_membrane\_4 | PF12730 | This family is related to the ABC-2 membrane transporter family Pfam:PF01061 [[cite:PUB00004998]]. | PFAM |
| ABC2\_membrane\_5 | PF13346 | This family is related to the ABC-2 membrane transporter family Pfam:PF01061 [[cite:PUB00004998]]. | PFAM |
| ABC2\_membrane\_6 | PF06182 | This family acts as the transmembrane domain (TMD) of ABC transporters [[cite:PUB00101288], [cite:PUB00101289]]. The family includes proteins responsible for the transport of herbicides [[cite:PUB00101288]]. | PFAM |
| ABC2\_membrane\_7 | PF19055 | ABC-2 type transporter | PFAM |
| EscB | PF05975 | This family consists of several bacterial ABC transporter proteins which are homologous to the EcsB protein of *Bacillus subtilis*. EcsB is thought to encode a hydrophobic protein with six membrane-spanning helices in a pattern found in other hydrophobic components of ABC transporters [[cite:PUB00011939]]. | PFAM |
| MTABC\_N | IPR032410 | This is the N-terminal five transmembrane (TM) helices domain found in ATP-binding cassette sub-family B member 6 (ABCB6), which has a crucial role in lysosomal targeting [[cite:PUB00076308]]. | INTERPRO |
| PDR\_assoc | PF08370 | This domain is found on the C-terminus of ABC-2 type transporter domains (Pfam:PF01061). It seems to be associated with the plant pleiotropic drug resistance (PDR) protein family of ABC transporters. Like in yeast, plant PDR ABC transporters may also play a role in the transport of antifungal agents [1, also Pfam:PF06422]. The PDR family is characterized by a configuration in which the ABC domain is nearer the N-terminus of the protein than the transmembrane domain [[cite:PUB00020871]]. | PFAM |
| PDR\_CDR | PF06422 | Corresponds to a region of the PDR/CDR subgroup of ABC transporters comprising extracellular loop 3, transmembrane segment 6 and linker region. | PFAM |
| SbmA\_BacA | IPR009248 | The *Rhizobium meliloti* (*Sinorhizobium meliloti*) bacA gene encodes a function that is essential for bacterial differentiation into bacteroids within plant cells in the symbiosis between *R. meliloti* and alfalfa. An *Escherichia coli* homologue of BacA, SbmA, is implicated in the uptake of microcins and bleomycin. This family is likely to be a subfamily of the ABC transporter family. | INTERPRO |

Table S3. Real-time PCR primer sequences including amplicon size in base pairs (bp), efficiency (%) and melting temperature (°C). TCONS ID from genome sequencing and gene annotation from the genome-wide study described in Chapter 2 are also reported.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Gene ID** | **TCONS ID** | **Annotation** | **Primer sequence (5' --> 3')** | **Amplicon size (bp)** | **Efficency (%)** | **Tm (°C)** | **Source** |
| ABCB\_1 | Pd\_ABCB139572 | ABCB(1) | TGCCCTTGCCTTCTGGTATGCACTCCGTCCCTGCCATATC | 553 | 127.4 | 60 | Primer3Plus |
| ABCB\_2 | Pd\_ABCB135452 | ABCB(1/4) | TCAACTACCCAACACGACCGTCCAGTGCTTCTTGGACGAC | 532 | 108.8 | 60 | Primer3Plus |
| ABCB\_3 | Pd\_ABCB10492 | ABCB(1/4) | GAGGCTATCGTCCAGTCTGCCGAAGACAACGGCAAAAGCA | 505 | 97.1 | 60 | Primer3Plus |
| ABCC\_1 | Pd\_ABCC55070 | ABCC(1/3)/MRP | CAAGGTGCTGCAGGAGAAGATGAGCGGGAGGATGACAGTA | 575 | 113.1 | 60 | Primer3Plus |
| ABCC\_2 | Pd\_ABCC32347 | ABCC10/MRP7 | CGTTGTGACCTGCTATGGGTACTGACTGCTCCCTGTTTCG | 571 | 99.2 | 60 | Primer3Plus |
| ABCC\_3 | Pd\_ABCC100004 | ABCC4 | GATGATCCGCTGAGTGCTGTAGCAGCCAATCTGAGCCATT | 512 | 108.3 | 60 | Primer3Plus |
| ABCG | Pd\_ABCG164919 | ABCG(2) | CAGTGGCTATGTGGTCCAGGAAGTCAGCCGGGTTGTTGAA | 519 | 93.6 | 60 | Primer3Plus |
| a-TUB |  |  | TTGCTGTCTACCCAGCTCCTAGATGGCCTCATTGTCAACC | 123 | 100.5 | 60 | Wäge et al; 2018 |
| 18S |  |  | GCGCATTTATCAGCACAAGACTTGGATGTGGTAGCCGTTT | 239 | 110.3 | 60 | Wäge et al; 2018 |

Table S4. Summary of the 81 ABC transport proteins identified in the *P. dumerilii* genome.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Subfamily** | **Protein ID** | **Gene ID** | **Leght (AA)** | **Matched gene** | **E-value** |
| A | TCONS\_00002395 | XLOC\_000682 | 139 | ABCA2 | 1E-14 |
| A | TCONS\_00002398 | XLOC\_000683 | 187 | ABCA2 | 7E-58 |
| A | TCONS\_00031247 | XLOC\_011353 | 1002 | ABCA1 | 0 |
| A | TCONS\_00031254 | XLOC\_011354 | 314 | ABCA1 | 1E-138 |
| A | TCONS\_00045720 | XLOC\_017000 | 1730 | ABCA3 | 0 |
| A | TCONS\_00063641 | XLOC\_024852 | 2583 | ABCA1 | 0 |
| A | TCONS\_00075910 | XLOC\_028180 | 1814 | ABCA3 | 0 |
| A | TCONS\_00075920 | XLOC\_028182 | 132 | ABCA3 | 2E-13 |
| A | TCONS\_00082134 | XLOC\_033621 | 132 | ABCA3 | 3E-13 |
| A | TCONS\_00087171 | XLOC\_036016 | 1739 | ABCA1 | 0 |
| A | TCONS\_00135065 | XLOC\_056294 | 2527 | ABCA2 | 0 |
| A | TCONS\_00148961 | XLOC\_062211 | 336 | ABCA5 | 8E-69 |
| B | TCONS\_00010492 | XLOC\_002742 | 1326 | ABCB1 | 0 |
| B | TCONS\_00026209 | XLOC\_009262 | 738 | ABCB8 | 0 |
| B | TCONS\_00031112 | XLOC\_011315 | 726 | ABCB7 | 0 |
| B | TCONS\_00034076 | XLOC\_012197 | 845 | ABCB9 | 0 |
| B | TCONS\_00038111 | XLOC\_013292 | 875 | ABCB9 | 9E-149 |
| B | TCONS\_00038113 | XLOC\_013294 | 460 | ABCB9 | 7E-16 |
| B | TCONS\_00049137 | XLOC\_018463 | 1052 | ABCB6 | 0 |
| B | TCONS\_00063831 | XLOC\_024891 | 886 | ABCB | 0 |
| B | TCONS\_00064329 | XLOC\_025023 | 704 | ABCB7 | 0 |
| B | TCONS\_00109357 | XLOC\_045452 | 862 | ABCB6 | 0 |
| B | TCONS\_00135452 | XLOC\_056415 | 1415 | ABCB1 | 0 |
| B | TCONS\_00139572 | XLOC\_058473 | 1338 | ABCB1 | 0 |
| B | TCONS\_00143986 | XLOC\_059922 | 914 | ABCB9 | 6E-150 |
| B | TCONS\_00147129 | XLOC\_060880 | 751 | ABCB1 | 0 |
| C | TCONS\_00000104 | XLOC\_000030 | 1376 | ABCC4 | 0 |
| C | TCONS\_00003436 | XLOC\_000950 | 1564 | ABCC3 | 0 |
| C | TCONS\_00007827 | XLOC\_002041 | 1557 | ABCC1 | 0 |
| C | TCONS\_00007845 | XLOC\_002042 | 1312 | ABCC1 | 0 |
| C | TCONS\_00018415 | XLOC\_004951 | 1551 | ABCC1 | 0 |
| C | TCONS\_00032347 | XLOC\_011769 | 1557 | ABCC1 | 0 |
| C | TCONS\_00049429 | XLOC\_018592 | 1581 | ABCC1 | 0 |
| C | TCONS\_00055070 | XLOC\_020922 | 1462 | ABCC1 | 0 |
| C | TCONS\_00063749 | XLOC\_024871 | 547 | ABCC9 | 1E-107 |
| C | TCONS\_00069762 | XLOC\_026428 | 787 | ABCC9 | 2E-146 |
| C | TCONS\_00070619 | XLOC\_026657 | 1594 | ABCC3 | 0 |
| C | TCONS\_00083715 | XLOC\_034335 | 454 | ABCC1/3 | 0 |
| C | TCONS\_00086325 | XLOC\_035585 | 1556 | ABCC1 | 0 |
| C | TCONS\_00088200 | XLOC\_036443 | 1028 | ABCC1 | 0 |
| C | TCONS\_00088205 | XLOC\_036444 | 1524 | ABCC1 | 0 |
| C | TCONS\_00093468 | XLOC\_038638 | 1356 | ABCC4 | 0 |
| C | TCONS\_00094207 | XLOC\_038949 | 1409 | ABCC | 0 |
| C | TCONS\_00099169 | XLOC\_040468 | 1546 | ABCC1 | 0 |
| C | TCONS\_00100004 | XLOC\_040729 | 1341 | ABCC4 | 0 |
| C | TCONS\_00101157 | XLOC\_041142 | 916 | ABCC4 | 0 |
| C | TCONS\_00101175 | XLOC\_041145 | 921 | ABCC4 | 0 |
| C | TCONS\_00110564 | XLOC\_045862 | 660 | ABCC4 | 0 |
| C | TCONS\_00111371 | XLOC\_046126 | 1382 | ABCC4 | 0 |
| C | TCONS\_00118296 | XLOC\_049433 | 1624 | ABCC4 | 0 |
| C | TCONS\_00118682 | XLOC\_049598 | 1215 | ABCC1 | 0 |
| C | TCONS\_00124024 | XLOC\_051579 | 1514 | ABCC1 | 0 |
| C | TCONS\_00124201 | XLOC\_051635 | 506 | ABCC1 | 4E-73 |
| C | TCONS\_00135841 | XLOC\_056543 | 1499 | ABCC3 | 0 |
| C | TCONS\_00136569 | XLOC\_056764 | 1474 | ABCC1 | 0 |
| C | TCONS\_00149996 | XLOC\_062594 | 1546 | ABCC1/3 | 0 |
| C | TCONS\_00151725 | XLOC\_063246 | 1452 | ABCC5 | 0 |
| C | TCONS\_00154278 | XLOC\_064047 | 1415 | ABCC4 | 0 |
| C | TCONS\_00155789 | XLOC\_064578 | 1376 | ABCC5 | 0 |
| C | TCONS\_00165537 | XLOC\_069286 | 1157 | ABCC1 | 0 |
| D | TCONS\_00009961 | XLOC\_002588 | 668 | ABCD3 | 0 |
| D | TCONS\_00145087 | XLOC\_060238 | 484 | ABCD4 | 2E-156 |
| D | TCONS\_00147343 | XLOC\_060943 | 726 | ABCD2 | 0 |
| E | TCONS\_00053666 | XLOC\_020264 | 601 | ABCE1 | 0 |
| F | TCONS\_00009806 | XLOC\_002546 | 619 | ABCF2 | 0 |
| F | TCONS\_00046094 | XLOC\_017094 | 711 | ABCF3 | 0 |
| F | TCONS\_00132528 | XLOC\_055446 | 728 | ABCF1 | 0 |
| G | TCONS\_00007718 | XLOC\_002015 | 688 | ABCG21 | 3E-166 |
| G | TCONS\_00007824 | XLOC\_002040 | 688 | ABCG14 | 2E-165 |
| G | TCONS\_00010501 | XLOC\_002743 | 778 | ABCG1 | 0 |
| G | TCONS\_00027564 | XLOC\_009634 | 701 | ABCG1 | 0 |
| G | TCONS\_00027576 | XLOC\_009636 | 474 | ABCG1 | 2E-149 |
| G | TCONS\_00060637 | XLOC\_023279 | 779 | ABCG2 | 0 |
| G | TCONS\_00109623 | XLOC\_045530 | 648 | ABCG | 1E-163 |
| G | TCONS\_00109630 | XLOC\_045531 | 661 | ABCG | 9E-164 |
| G | TCONS\_00111058 | XLOC\_046027 | 717 | ABCG20 | 0 |
| G | TCONS\_00116151 | XLOC\_047802 | 721 | ABCG1 | 0 |
| G | TCONS\_00161980 | XLOC\_067429 | 684 | ABCG | 5E-167 |
| G | TCONS\_00164919 | XLOC\_068985 | 651 | ABCG2 | 0 |
| G | TCONS\_00164921 | XLOC\_068986 | 645 | ABCG2 | 0 |
| G | TCONS\_00165285 | XLOC\_069152 | 440 | ABCG1 | 3E-128 |

Table S5. Number of ABC transport proteins already identified in invertebrates and vertebrate species and the composition of each subfamily.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ABC subfamily** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **Total** |
| **Annelida** |
| *Platynereis dumerilii* | 12 | 14 | 34 | 3 | 1 | 3 | 14 | 0 | 81 |
| **Platyhelminthes** |
| *Gyrodactylus salaris a* | 3 | 8 | 10 | 1 | 1 | 4 | 5 | 0 | 32 |
| *Protopolystoma xenopodis a* | 5 | 12 | 16 | 0 | 2 | 4 | 1 | 0 | 40 |
| *Eudiplozoon nipponicum a* | 2 | 6 | 18 | 3 | 3 | 10 | 4 | 0 | 46 |
| *Neobenedenia melleni a* | 0 | 1 | 4 | 0 | 1 | 3 | 0 | 0 | 9 |
| *Schistosoma mansoni a* | 3 | 7 | 3 | 0 | 1 | 4 | 3 | 0 | 21 |
| *Echinococcus granulosus a* | 1 | 13 | 2 | 0 | 1 | 2 | 3 | 0 | 22 |
| *Macrostomun lignano a* | 32 | 11 | 19 | 6 | 1 | 4 | 19 | 0 | 92 |
| *Schmidtea mediterranea a* | 13 | 14 | 13 | 3 | 1 | 12 | 4 | 0 | 60 |
| *Opisthorchis felineus b* | 4 | 8 | 5 | 1 | 0 | 2 | 3 | 0 | 23 |
| **Arthropoda** |
| *Tigriopus japonicus c* | 5 | 5 | 17 | 3 | 1 | 3 | 7 | 5 | 46 |
| *Daphnia pulex d* | 4 | 7 | 7 | 3 | 1 | 4 | 24 | 15 | 65 |
| *Drosophila melanogaster e* | 10 | 10 | 12 | 2 | 1 | 3 | 15 | 3 | 56 |
| *Paracyclopina nana f* | 4 | 5 | 14 | 2 | 1 | 3 | 4 | 4 | 37 |
| *Caligus rogercresseyi g* | 7 | 12 | 15 | 4 | 5 | 8 | 3 | 3 | 57 |
| *Tribolium castaneum h* | 10 | 6 | 35 | 2 | 1 | 3 | 13 | 3 | 73 |
| *Anopheles gambiae i* | 9 | 5 | 13 | 2 | 1 | 3 | 16 | 3 | 52 |
| *Apis mellifera j* | 3 | 5 | 9 | 2 | 1 | 3 | 15 | 3 | 41 |
| *Tetranychus urticae k* | 9 | 4 | 39 | 2 | 1 | 3 | 23 | 22 | 103 |
| *Bombyx mori l* | 6 | 8 | 15 | 2 | 1 | 3 | 13 | 3 | 51 |
| *Cydia pomonella m* | 9 | 11 | 12 | 2 | 1 | 2 | 14 | 3 | 54 |
| *Mythimna separata n* | 6 | 4 | 13 | 2 | 1 | 3 | 11 | 3 | 43 |
| *Culex pipiens o* | 10 | 5 | 15 | 2 | 1 | 3 | 24 | 3 | 63 |
| **Rotifera** |
| *Braciunus koreanus* p | 11 | 19 | 15 | 3 | 1 | 3 | 8 | 2 | 61 |
| **Nematoda** |
| *Caenorhabditis elegans* q | 7 | 24 | 9 | 5 | 1 | 3 | 9 | 2 | 60 |
| **Chordata** |
| *Oryzias melastigma r* | 10 | 10 | 13 | 4 | 1 | 3 | 8 | 1 | 50 |
| *Ictalurus punctatus s* | 9 | 12 | 12 | 5 | 2 | 4 | 6 | 0 | 50 |
| *Danio rerio t* | 9 | 14 | 13 | 5 | 1 | 3 | 9 | 1 | 55 |
| *Homo sapiens e* | 12 | 11 | 12 | 4 | 1 | 3 | 5 | 0 | 48 |

a Caña-Bozada et al., 2019, b Mordvinov et al., 2017, c Jeong et al., 2014, d Sturm et al., 2009, e Dean et al., 2001, f Jeong et al., 2017b, g Valenzuela-Muñoz et al., 2015, h Broehan et al., 2013 ,i Roth et al., 2003, j Dermauw and Leewne, 2014, k Dermauw et al., 2013, l Liu et al., 2011, m Ju et al., 2022, n Xie et al., 2023, o Xu et al., 2023, p Jeong et al., 2017c, q Sheps et al., 2004, r Jeong et al., 2015, s Liu et al., 2013, t Annilo et al., 2006



Figure S1. Conserved domains of the *P. dumerilii* ABC transport proteins. Purple and yellow show NBD (ABC\_tran), except for MTABC\_N which is a TMD. Pink and green show TMD. The HMMR web server was used to identify the NBD and TMD domains of each worm ABCs.

*Discussion: Characterization of P. dumerilii ABC transport proteins subfamilies*

*Subfamily A*

ABCA transport proteins are known to act as lipid translocators in specialized cellular secretory pathways in mammals (Wenzel et al., 2007). Very limited information is available on the function of ABCA proteins in invertebrates. Broehan et al. (2013) studied ABCA-9A and ABCA-9B in *T*. *castaneum* revealing stage-specific mortality with severe defects in the development of wings and elytra in knock down individuals. In insects (*Cydia pomonella*, *Chilo suppressalis* and *Helicoverpa armigera*) ABCA genes were upregulated by a wide range of insecticides (abamectin, indoxacarb, tebufenozide, chlorpyrifos, lambda-cyhalothrin and chlorantraniliprole) suggesting a protective role towards neurotoxicity (Meng et al., 2020; Jin et al., 2019; Ju et al., 2022).

*P. dumerilii* possesses 12 ABCA genes as ABCA1, ABCA2, ABCA3 and ABCA5 divided in full transporters (4), half transporters (1), transporter containing 2 NBDs and 1 TMDs (1) and transporters with missed NBD (6) (Figure S1). TCONS\_00002398 and TCONS\_00135065 grouped with ABCA2 transporters of *H. sapiens*, *Mus musculus,* and *Rattus norvegicus*. TCONS\_00045720, TCONS\_00075910, TCONS\_00082134, and TCONS\_00075920 resulted related to the ABCA3 of *H. sapiens*, *M. musculus,* and *R. norvegicus*. TCONS\_00087171 and TCONS\_00063641 grouped together with ABCA12 and ABCA 13 of *H. sapiens* and *M. musculu*s. TCONS\_ 00148961 was related to *H. sapiens*, *M. musculus,* and *R. norvegicus* ABCA5, ABCA8, and ABCA9. TCONS\_00031247, TCONS\_00031254 and TCONS\_00002395 grouped with *H*. *sapiens*, *M*. *musculus,* and *R*. *norvegicus* ABCA genes furthermore TCONS\_0002395 was also close to the ABCA ced-7 from *C*. *elegans*.

*Subfamily B*

Mammalian ABCB proteins have a role in physiological homeostasis, e.g. trafficking peptide and bile salt (Vore, 2023), and are well known for their involvement in MDR and MXR. In particular, ABCB1/P-glycoprotein (P-gp) is the main efflux pump of MDR or either MXR, in the latter involved xenobiotic resistance including in marine species (Bard, 2000). For instance, transcriptional changes, differential protein level, and activity of P-gp and other ABCB transport proteins have been found in response to xenobiotic exposure in the sea urchin *S. purpuratus* (Bosnjak et al., 2009; Hamdoun et al., 2004), in the mussel *M. galloprovincialis* (Della Torre et al., 2015), in the copepods *P*. *nana*, and *T*. *japonicus* (Jeong et al., 2014; 2017b) and in the Nematoda *C*. *elegans* (VanDuyn and Nass, 2014).

14 ABCB transport proteins have been identified in *P. dumerilii* as ABCB1, ABCB6, ABCB7, ABCB8, ABCB9. ABCB1 is one of the most abundant classes counting 4 members, as is the ABCB9 class. The ABCB subfamily includes full transporters (3), half transporters (9), transporters containing 1 NBD and 2 TMDs (1), and proteins with only one TMD (1) (Figure S1). The results of the phylogenetic analysis supported the annotation of ABCB genes in *P. dumerilii* (Figure 9). TCONS\_00010492, TCONS\_00135452, and TCONS\_00139572 were clustered together with sister P-gp protein of *H. sapiens*, *M. musculus,* *R. norvegicus*, *Oryctolagus cuniculus*, and *Canis lupus familiaris*. TCONS\_00049137 and TCONS\_00109357 were clustered to *H*. *sapiens*, *M*. *musculus*, *R*. *norvegicus*, *Mesocricetus auratus,* and *Xenopus tropicalis* ABCB6. TCONS\_00064329 and TCONS\_00031112 grouped together with ABCB7 of *H. sapiens*, *M. musculus,* *R. norvegicus*, *D. rerio*, and *Oryzias latipes*. TCONS\_00026209 was related to the ABCB8/MITOS protein of *H. sapiens*, *M. musculus,* *R. norvegicus*, *Pongo abelii*, *D. rerio*, and *X*. *tropicalis*. TCONS\_00147129 grouped with this cluster and with *H. sapiens*, and *M. musculus* ABCBA. TCONS\_00063831 was related to the previous 2 TCONSs and with other ABCB transporters. TCONS\_00143986, TCONS\_00038111, and TCONS\_00038113 grouped together and with TCONS\_00034076 and ABCB2, ABCB3 and ABCB9 of *H*. *sapiens*, *M*. *musculus,* and *Gorilla gorilla gorilla*.

*Subfamily C*

The ABCC subfamily is one of the most expanded among taxa being most represented with a higher number of genes in almost all species (Table S5). Subfamily C transporters consist of cystic fibrosis transmembrane conductance regulator, cell-surface receptor, membrane-bound sulfonylurea receptors, and several multi-related resistance proteins (MRPs). ABCC transport proteins are involved in trafficking various substrates and in cell signaling pathways (Dean et al., 2001; Franco and Zavala-Flores, 2012; Keppler, 2011; Leslie et al., 2005). Studies on invertebrate species, such as the arthropods *Mythimna separata* and *C*. *pomonella*, displayed the role of ABCC proteins in detoxification processes (Ju et al., 2022; Xie et al., 2023). In aquatic invertebrates, MRPs are some of the most abundantly diversified ABC genes with a widely expanded function and they might play a central role in adaptation to environmental stressors (Jeong et al., 2017a).

34 ABCC transport proteins were identified including ABCC1, ABCC3, ABCC4, ABCC5, and ABCC9 in *P. dumerilii*. Most of them (32) aligned with MRP transporters. 26 out of 34 were full transporters, the others were divided into half transporters (2), transporters containing 2 NBDs and 1 TMD (2), proteins containing 2 NDBs and 3 TMDs (1), and transporters with missed NBD (3) (Figure S1). Phylogenetic analysis showed three main clusters of homolog genes (Figure 9). The first one contained TCONS\_00003436, TCONS\_00118682, TCONS\_00070619, TCONS\_00086325, TCONS\_00135841, TCONS\_00094207, TCONS\_00088205, TCONS\_00088200, TCONS\_00083715, TCONS\_00124024, TCONS\_00149996, TCONS\_00136569, TCONS\_00099169, TCONS\_00165537 and TCONS\_00124201 and it was grouped with the second cluster (TCONS\_00049429, TCONS\_00018415, TCONS\_ 00007845, TCONS\_000007827) and with MRP2 of *H*. *sapiens*, *M*. *musculus*, *R. norvegicus*, and *O. cuniculus* and with the *H*. *sapiens* ABCCD. The third cluster consisted of TCONS\_00093468, TCONS\_00118296, TCONS\_00110564, TCONS\_00111371, TCONS\_00101157, TCONS\_00101175 and TCONS\_00100004 which were related to TCONS\_00154278, TCONS\_00000104 and MRP4 of *H*. *sapiens*, *M*. *musculus*, and *R*. *norvegicus*. TCONS\_00155789 and TCONS\_00151725 resulted in homologs and grouped together with MRP5 of *C. elegans*, *H*. *sapiens*, *M*. *musculus*, and *R*. *norvegicus*. The homologs TCONS\_00063749 and 00069762 were related to ABCC-Sur of *D*. *melanogaster* and with *H*. *sapiens*, *R. norvegicus*, *Cricetus cricetus*, and *O. cuniculus* ABCC8 and ABCC9. TCONS\_00055070 clustered with MRP1, MRP3, and MRP6 of *H*. *sapiens*, *Macaca fascicularis*, *M*. *musculus*, *R*. *norvegicus*, *Gallus gallus*, *C. lupus familiaris*, and *Bos taurus*. TCONS\_00032347 grouped with *H*. *sapiens*, and *M*. *musculus* MRP7.

*Subfamily D*

The ABC subfamily D members are peroxisomal transporters participating in the transport of fatty acids and/or acyl-CoA with different substrate specificities in mammals (Morita and Imanaka, 2012; Theodoulou et al., 2006). No information is available on their function in invertebrate species. To date, all ABCD subfamilies are known to be half transporters and are poorly represented in taxa (Table S5).

3 ABCD transporters were found in the *P. dumerilii* as ABCD2, ABCD3, and ABCD4. As in all the other species investigated so far, the 3 proteins are half transporters (Figure S1). The phylogenetic analysis confirmed the identification of ABCD genes in the *P. dumerilii* genome (Figure 9). TCONS\_00147343 grouped with ABCD1 and ABCD2 of *H*. *sapiens*, *M*. *musculus*, *R*. *norvegicus*, and *D. rerio*. TCONS\_00009961 was related to *H*. *sapiens*, *M*. *musculus*, and *R*. *norvegicus* ABCD3. TCONS\_00145087 clustered with ABCD4 of *H*. *sapiens*, and *M*. *musculus*.

*Subfamily E*

The ABCE subfamily genes do not possess a TMD, indicating that they are not involved in transmembrane function. Human ABCE has various functions, such as inhibition of ribonuclease L, tumor cell proliferation, viral infection, and anti-apoptosis (Bisbal et al., 1995; Hassel et al., 1993; Le Roy et al., 2001). In invertebrates, this gene seemed to have a role in early-stage survival and growth, possibly controlling translation and transcription (Broehan et al., 2013; Zhao et al., 2004).

As the majority of species, *P. dumerilii* possesses just 1 ABCE protein (ABCE1) which contains 2 NBDs and no TMD (Figure S1). TCONS\_00053666 grouped with ABCE1 of *H*. *sapiens*, *M*. *musculus*, and *D*. *melanogaster* (Figure 9).

*Subfamily F*

Similar to ABCE, ABCF proteins also lack TMDs. Well conserved across taxa, ABCFs are involved in the regulation of gene translation, cell physiology and ribosome assembly (Hirose and Horvitz, 2014; Paytubi et al., 2009; Tyzack et al., 2000; Yasui et al., 2004). ABCF2 has been correlated with drug resistance in human cancer cells (Zhou et al., 2013).

In the *P. dumerilii* genome 3 ABCF genes were identified, from the classes ABCF1, ABCF2, and ABCF3. They contained 3 NBDs and no TMD (Figure S1). TCONS\_00132528 clustered with ABCF1 of *H*. *sapiens*, and *M*. *musculus*. TCONS\_00009806 grouped with *H*. *sapiens*, *M*. *musculus*, and *B*. *taurus* ABCF2. TCONS\_00046094 was related to ABCF3 of *H*. *sapiens*, *M*. *musculus*, *R*. *norvegicus,* and *P*. *abelii* (Figure 9).

*Subfamily G*

Members of subfamily G participate in multiple cellular homeostatic processes, in cholesterol and other sterols efflux, and in MDR/MXR functionalities (Dean and Annilo, 2005; Tarr et al., 2009). ABCG proteins are half transporters, which require dimerization with the other half to become functional (Kage et al., 2002; Litman et al., 2002). In mammals, MXR is conferred by ABCG2, together with P-gp and MRPs (Leslie et al., 2005; Robey et al., 2009). In aquatic invertebrates, this transporter presumably has highly conserved MXR function (Jeong et al., 2017a; Pignatelli et al., 2018; Xu et al., 2023).

14 ABCG transporters occurred in the *P. dumerilii* genome classified as ABCG1, ABCG2, ABCG14, 20, and ABCG21. 10 of these were half transporters while 2 contained 1 NBD and 2 TMDs and 2 lost the NBD and had 2 TMDs (Figure S1). The phylogenetic analysis supported the *P. dumerilii* ABCG gene annotation (Figure 9). ABCGs were divided into 3 main homolog clusters. The first one included TCONS\_00007718, TCONS\_00007824, TCONS\_00109623, TCONS\_00109630, TCONS\_00116151 and TCONS\_00161980 and grouped with ABCG1 and ABCG4 of *H*. *sapiens*, *M*. *musculus*, and *R*. *norvegicus*. The second one was composed by TCONS\_00060637, TCONS\_00164919, and TCONS\_00164921 and was related to ABCG2 and ABCG3 of *H*. *sapiens*, *Macaca mulatta*, *Sus scrofa*, *M*. *musculus*, *R*. *norvegicus*, and *B*. *taurus*. The third cluster of homologs contained TCONS\_00010501, TCONS\_00027576, TCONS\_00027564, and TCONS\_00165285 and grouped with *C. elegans* ABC transporter ATP-binding protein/permease wht-1.

*Subfamily H*

The ABCH superfamily has been found only in invertebrates and zebrafish and its physiological functions are still poorly understood (Dermauw et al., 2013; Peng et al., 2021; Popovic et al., 2010).

In *P. dumerilii*, any ABCH was found neither in Platyhelminthes, which are phylogenetically close to Annelida (Omond et al., 2017) (Table S5).

References

Bard, S.M. (2000). Multixenobiotic resistance as a cellular defense mechanism in aquatic organisms. *Aquat. Toxicol*. 48 (4), 357–389. doi: https://doi.org/10.1016/s0166-445x(00)00088-6

Bisbal, C., Martinand, C., Silhol, M., Lebleu, B. and Salehzada, T. (1995). Cloning and characterization of a RNase L inhibitor. A new component of the interferon-regulated 2-5 A pathway. *J. Biol. Chem*. 270, 13308–13317. doi: https://doi.org/10.1074/jbc.270.22.13308

Bošnjak, I., Uhlinger, K.R., Heim, W., Smital, T., Franekić-Colić, J., Coale, K., Epel, D. and Hamdoun, A. (2009). Multidrug efflux transporters limit accumulation of inorganic, but not organic mercury in sea urchin embryos. *Environ. Sci. Technol*. 43, 8374–8380. doi: https://doi.org/10.1021/es901677r

Broehan, G., Kroeger, T., Lorenzen, M. and Merzendorfer, H. (2013). Functional analysis of the ATP-binding cassette (ABC) transporter gene family of *Tribolium castaneum*. *BMC Genom*. 14, 6. doi: https://doi.org/10.1186/1471-2164-14-6

Dean, M. and Annilo, T. (2005). Evolution of the ATP-binding cassette (ABC) transporter superfamily in vertebrates. *Annu. Rev. Genomics Hum. Genet*. 6, 123–142. doi: https://doi.org/10.1146/annurev.genom.6.080604.162122

Dean, M., Rzhetsky, A. and Allikmets, R. (2001). The human ATP-binding cassette (ABC) transporter superfamily. *Genome Res*. 11, 1156–1166. doi: https://doi.org/10.1101/gr.184901

Della Torre, C., Balbi, T., Grassi, G., Frenzilli, G., Bernardeschi, M., Smerilli, A., Guidi, P., Canesi, L., Nigro, M., Monaci, F., Scarcelli, V., Rocco, L., Focardi, S., Monopoli, M. and Corsi, I. (2015). Titanium dioxide nanoparticles modulate the toxicological response to cadmium in the gills of *Mytilus galloprovincialis*. J. Hazard Mater. 297, 92–100. doi: https://doi.org/10.1016/j.jhazmat.2015.04.072

Dermauw, W., Osborne, E.J., Clark, R.M., Grbić, M., Tirry, L. and Van Leeuwen, T. (2013). A burst of ABC genes in the genome of the polyphagous spider mite *Tetranychus urticae*. *BMC Genom*. 14, 317. doi: https://doi.org/10.1186/1471-2164-14-317

Franco, R. and Zavala-Flores, L. (2012). ABCC Transporters. In: Schwab, M. (eds) Encyclopedia of Cancer. Springer, Berlin, Heidelberg. doi: https://doi.org/10.1007/978-3-642-27841-9\_7076-2

Hamdoun, A.M., Cherr, G.N., Roepke, T.A. and Epel, D. (2004). Activation of multidrug efflux transporter activity at fertilization in sea urchin embryos (*Strongylocentrotus purpuratus*). *Dev. Biol*. 276 (2), 452–462. doi: https://doi.org/10.1016/j.ydbio.2004.09.013

Hassel, B.A., Zhou, A., Sotomayor, C., Maran, A. and Silverman, R.H. (1993). A dominant negative mutant of 2-5A-dependent RNase suppresses antiproliferative and antiviral effects of interferon. EMBO J. 12, 3297–3304. doi: https://doi.org/10.1002/j.1460-2075.1993.tb05999.x

Hirose, T. and Horvitz, H.R. (2014). The translational regulators GCN-1 and ABCF-3 act together to promote apoptosis in *C. Elegan*s. *PLoS Genet*. 10 (8), e1004512. doi: https://doi.org/10.1371/journal.pgen.1004512

Jeong, C.-B., Kim, B.-M., Kim, R.-K., Park, H.G., Lee, S.-J., Shin, K.-H., Leung, K.M.Y., Rhee, J.-S. and Lee, J.-S. (2014). Functional characterization of P-glycoprotein in the intertidal copepod *Tigriopus japonicus* and its potential role in remediating metal pollution. *Aquat. Toxicol*. 156, 135–147. doi: https://doi.org/10.1016/j.aquatox.2014.08.005

Jeong, C.-B., Kim, D.-H., Kang, H.-M., Lee, Y.H., Kim, H.-S. and Lee, J.-S. (2017b). Thirty seven ATP-binding cassette (ABC) transporters in the copepod *Paracyclopina nana* genome and their roles in response to polycyclic aromatic hydrocarbons. *Sci. Rep*. 7, 41323

Jeong, C.-B., Kim, H.-S., Kang, H.-M. and Lee, J.-S. (2017a). ATP-binding cassette (ABC) proteins in aquatic invertebrates: Evolutionary significance and application in marine ecotoxicology. *Aquat. Toxicol*. 185, 29–39. doi: dx.doi.org/10.1016/j.aquatox.2017.01.013

Jin, M., Liao, C., Chakrabarty, S., Zheng, W., Wu, K. and Xiao, Y. (2019). Transcriptional response of ATP-binding cassette (ABC) transporters to insecticides in the cotton bollworm, *Helicoverpa armigera*. *Pestic. Biochem. Physiol*. 154, 46–59. doi: 10.1016/j.pestbp.2018.12.007

Ju, D., Dewer, Y., Zhang, S., Hu, C., Li, P. and Yang, X. (2022) Genome-wide identification, characterization, and expression profiling of ATP-binding cassette (ABC) transporter genes potentially associated with abamectin detoxification in *Cydia pomonella*. *Ecotoxicol. Environ. Saf*. 230, 113152. doi: https://doi.org/10.1016/j.ecoenv.2021.113152

Kage, K., Tsukahara, S., Sugiyama, T., Asada, S., Ishikawa, E., Tsuruo, T. and Sugimoto, Y. (2002). Dominant-negative inhibition of breast cancer resistance protein as drug efflux pump through the inhibition of S–S dependent homodimerization. *Int. J. Cancer* 97, 626–630. doi: https://doi.org/10.1002/ijc.10100

Keppler, D. (2011). Multidrug resistance proteins (MRPs, ABCCs): importance for pathophysiology and drug therapy. *Handb. Exp. Pharmacol*. 201, 299–323. doi: https://doi.org/10.1007/978-3-642-14541-4\_8

Le Roy, F., Bisbal, C., Silhol, M., Martinand, C., Lebleu, B. and Salehzada, T. (2001). The 2-5A/RNase L/RNase L inhibitor (RLI) [correction of (RNI)] pathway regulates mitochondrial mRNAs stability in interferon alpha-treated H9 cells. *J. Biol. Chem*. 276, 48473–48482. doi: https://doi.org/10.1074/jbc.M107482200

Leslie, E.M., Deeley, R.G. and Cole, S.P.C. (2005). Multidrug resistance proteins: role of P-glycoprotein, MRP1, MRP2, and BCRP (ABCG2) in tissue defense. *Toxicol. Appl. Pharmacol*. 204 (3), 216–237. doi: https://doi.org/10.1016/j.taap.2004.10.012

Litman, T., Jensen, U., Hansen, A., Covitz, K.-M., Zhan, Z., Fetsch, P., Abati, A., Hansen, P.R., Horn, T., Skovsgaard, T. and Bates, S.E. (2002). Use of peptide antibodies to probe for the mitoxantrone resistance associated protein MXR/BCRP/ABCP/ABCG2. Biochim. Biophys. Acta 1565, 6–16. doi: https://doi.org/10.1016/S0005-2736(02)00492-3

Meng, X., Yang, X., Wu, Z., Shen, Q., Miao, L., Zheng, Y., Qian, K. and Wang, J. (2020). Identification and transcriptional response of ATP-binding cassette transporters to chlorantraniliprole in the rice striped stem borer, *Chilo suppressalis*. Pest Manag. Sci. 76 (11), 3626–3635. doi: https://doi.org/10.1002/ps.5897

Morita, M. and Imanaka, T. (2012). Peroxisomal ABC transporters: structure, function and role in disease. *Biochim. Biophys. Acta* 1822, 1387–1396. doi: https://doi.org/10.1016/j.bbadis.2012.02.009

Omond, S., Ly, L.M.T., Beaton, R., Storm, J.J., Hale, M.W. and Lesku, J.A. (2017). Inactivity is nycthemeral, endogenously generated, homeostatically regulated, and melatonin modulated in a free-living platyhelminth flatworm. *Sleep* 40 (10), zsx124. doi: https://doi.org/10.1093/sleep/zsx124

Paytubi, S., Wang, X., Lam, Y.W., Izquierdo, L., Hunter, M.J., Jan, E., Hundal, H.S. and Proud, C.G. (2009). ABC50 promotes translation initiation in mammalian cells. *J. Biol. Chem*. 284, 24061–24073. doi: https://doi.org/10.1074/jbc.m109.031625

Peng, Y., Zhao, J., Sun, Y., Wan, P., Hu, Y., Luo, G., Qin, W. and Huang, S. (2021). Insights into chlorantraniliprole resistance of *Chilo suppressalis*: Expression profiles of ATP-binding cassette transporter genes in strains ranging from low-to high-level resistance. *J. Asia Pac. Èntomol*. 24 (2), 224–231. doi: https://doi.org/10.1016/j.aspen.2021.02.006

Pignatelli, P., Ingham, V.A., Balabanidou, V., Vontas, J., Lycett, G. and Ranson, H. (2018). The *Anopheles gambiae* ATP-binding cassette transporter family: phylogenetic analysis and tissue localization provide clues on function and role in insecticide resistance. *Insect. Mol. Biol*. 27, 110–122. doi: https://doi.org/10.1111/imb.12351

Popovic, M., Zaja, R., Loncar, J. and Smital, T. (2010). A novel ABC transporter: the first insight into zebrafish (*Danio rerio*) ABCH1. *Mar. Environ. Res*. 69, S11–S13. doi: https:// doi.org/10.1016/j.marenvres.2009.10.016

Robey, R.W., To, K.K.K., Polgar, O., Dohse, M., Fetsch, P., Dean, M. and Bates, S.E. (2009). ABCG2: a perspective. *Adv. Drug Deliv. Rev*. 61, 3–13. doi: 10.1016/j.addr.2008.11.003

Tarr, P.T., Tarling, E.J., Bojanic, D.D., Edwards, P.A. and Baldán, A. (2009). Emerging new paradigms for ABCG transporters. *BBA Mol. Cell Biol. Lip*. 1791, 584–593

Theodoulou, F.L., Holdsworth, M. and Baker, A. (2006). Peroxisomal ABC transporters. *FEBS Lett*. 580, 1139–1155. doi: https://doi.org/10.1016/j.febslet.2005.12.095

Tyzack, J.K., Wang, X., Belsham, G.J. and Proud, C.G. (2000). ABC50 interacts with eukaryotic initiation factor 2 and associates with the ribosome in an ATP-dependent manner. *J. Biol. Chem*. 275, 34131–34139. doi: https://doi.org/10.1074/jbc.m002868200

VanDuyn, N. and Nass, R. (2014). The putative multidrug resistance protein MRP-7 inhibits methylmercury-associated animal toxicity and dopaminergic neurodegeneration in *Caenorhabditis elegans*. *J. Neurochem*. 128, 962–974. doi: 10.1111/jnc.515

Vore, M. (2023). ABCB subfamily in GtoPdb v.2023.1. IUPHAR/BPS Guide to Pharmacology CITE, 2023(1). Available from: https://doi.org/10.2218/gtopdb/F152/2023.1

Wenzel, J.J., Piehler, A., Kaminski and W.E. (2007). ABC A-subclass proteins: gatekeepers of cellular phosphor- and sphingolipid transport. *Front. Biosci*. 12, 3177–3193. doi: 10.2741/2305

Xie, D., Zhu, C., Zhang, L., Liu, Y., Cheng, Y. and Jiang, X. (2023). Genome-scale analysis of ABC transporter genes and characterization of the ABCC type transporter genes in the oriental armyworm, *Mythimna separata* (Walker). *Int. J. Biol. Macromol*. 235, 123915. doi: https://doi.org/10.1016/j.ijbiomac.2023.123915

Xu, J., Zheng, J., Zhang, R., Wang, H., Du, J., Li, J., Zhou, D., Sun, Y. and Shen, B. (2023). Identification and functional analysis of ABC transporter genes related to deltamethrin resistance in *Culex pipiens* pallens. *Pest. Manag. Sci*. 79, 3642–3655. doi: 10.1002/ps.7539

Yasui, K., Mihara, S., Zhao, C., Okamoto, H., Saito-Ohara, F., Tomida, A., Funato, T., Yokomizo, A., Naito, S., Imoto, I., Tsuruo, T. and Inazawa, J. (2004). Alteration in copy numbers of genes as a mechanism for acquired drug resistance. *Cancer Res*. 64, 1403–1410. doi: https://doi.org/10.1158/0008-5472.can-3263-2

Zhao, Z., Fang, L.L., Johnsen, R. and Baillie, D.L. (2004). ATP-binding cassette protein E is involved in gene transcription and translation in *Caenorhabditis elegans*. *Biochem. Bioph. Res. Comm*. 323, 104–111. doi: https://doi.org/10.1016/j.bbrc.2004.08.068

Zhou, J., Lin, Y., Shi, H., Huo, K. and Li, Y. (2013). hABCF3, a TPD52L2 interacting partner, enhances the proliferation of human liver cancer cell lines in vitro. *Mol. Biol. Rep*. 40, 5759–5767. doi: https://doi.org/10.1007/s11033-013-2679-z