Table III. *Predominant pumps and carriers in the plasma membrane of guard cells and their functional characteristics*

Genetic codes relate to Arabidopsis; functional data relate to *V. faba* unless noted otherwise. For I_{sat}, current saturation is at V > > 0 for ATPases or V < < 0 for coupled transport; I_V are typical currents within the physiological voltage range; currents are converted where necessary assuming 1 μA cm^{-2} = 1 pA pF^{-1}, guard cell surface area of 3×10^{-5} cm^2, and volume of 4 pL. Shorthand identifiers in parentheses cross-reference to Box 1. n.d., not determined. References are as follows: A (Blatt, 1987a; Blatt et al., 1990a; Lohse and Hedrich, 1992; Thiel et al., 1992; Becker et al., 1993; Gaxiola et al., 2007); B (Gräf and Weiler, 1990; Carnelli et al., 1992; Askerlund, 1997; Palmgren and Harper, 1999; Bonza et al., 2000; Geisler et al., 2000; Sze et al., 2000; Bonza and De Michelis, 2011; Pittman, 2011); C (Rodriguez-Navarro et al., 1986; Blatt et al., 1987; Blatt and Slayman, 1987; Clint and Blatt, 1989; Maathuis and Sanders, 1994; Maathuis et al., 1997; Quintero and Blatt, 1997; Kim et al., 1998; Rubio et al., 2000, 2008; Chérel et al., 2002; Gierth et al., 2005; Nieves-Cordones et al., 2008; Remy et al., 2013); D (Beilby and Walker, 1981; Sanders and Hansen, 1981; Sanders et al., 1985, 1989; Meharg and Blatt, 1995; Guo et al., 2003; Hawkesford and Miller, 2004); E (Reddy and Das, 1986; Slone et al., 1991; Buckhout, 1994; Ritte et al., 1999; Stadler et al., 2003; Lee et al., 2008; Bates et al., 2012; Santelia and Lawson, 2016); F (Kang et al., 2010; Kuromori et al., 2010, 2011; Kanno et al., 2012; Zhang et al., 2014).

Transporter	Name	Locus	Function	No.	Stoichiometry	I_{sat}	I_V	E_{rev}	Ion Selectivity	References
				$\times 10^6$ $cell^{-1}$		μA cm^{-2}	μA cm^{-2}	mV		
H^+-ATPase (H-ATPase)	AHA1 AHA2 AHA5	AT2G18960 AT4G30190 AT2G24520	H^+ extrusion, energization	1–3*	1 H^+:1 ATP	22 ± 5 15 ± 5[a]	2–15 5–9[a]	−359 to −457[3,a,d]	n.d.; assumed selective from pH dependence	A
Ca^{2+}-ATPase (Ca-ATPase)	ACA.L ACA1 ACA3 ACA8 ACA10 ACA11 ACA12	AT1G13210 AT1G27770 AT1G07810 AT5G57110 AT4G29900 AT3G57330 AT3G63380	Ca^{2+} extrusion	0.1–0.3**	1 Ca^{2+}:1 ATP	1–2	n.d.	−200[4]	n.d.	B
H^+/Ca^{2+} antiport	CAX11	AT1G08960	Ca^{2+} extrusion	0.1–0.3**	2 or 3 H^+:1 Ca^{2+}	n.d.	−0.6[1,b]	>+100[5]	Transport of K, Na, Mn, Zn, Li possible	B
H^+-K^+ symport (H-K symp)	KUP/HAK/KT1 KUP/HAK/KT2 KUP3 = KT4 KUP/KT5 HAK5 KUP/HAK/KT6 KUP/HAK/KT7 KUP/HAK/KT8 KUP/HAK/KT9 KUP/HAK/KT10 KUP/HAK/KT11 ZIFL1.3	AT2G30070 AT2G40540 AT3G02050 AT4G33530 AT4G13420 AT1G70300 AT5G09400 AT5G14880 AT4G19960 AT1G31120 AT2G35060 AT5G13750	K^+ uptake	0.1–0.5**	1 H^+:1 K^+	−2 to −12[c] −0.1 to −0.3[b]	−0.08 to −0.3 −1 to −2[c] −0.1[b]	>0[6,c] +22[7,b]	K^+ ~ Rb^+ > > Cs^+	C
H^+-Cl^- (NO_3^-) symport (H-Cl symp)	NRT1.1 NRT2.1	AT1G12110 AT1G08090	Inorganic anion uptake	0.1–0.5**	2 H^+:1 Cl^- (NO_3^-)	−3 to −12[b] −1 to 3[a]	−1 to −2[b] −0.4 to −1[b]	Near 0[8,a,b]	n.d.	D
H^+-Mal symport	ABCB14	AT1G28010	Malate uptake	n.d.	3 H^+:1 Mal^{2-}***	n.d.	n.d.	>+20[9]	Malate ~ fumarate >> succinate ~ citrate	E
H^+-sugar symport	SUC1 SUC3 STP1 STP4	AT1G71880 AT2G02860 AT1G11260 AT3G19930	Sugar uptake	0.02–0.05**	1 H^+:1 sugar***	n.d.	−0.01 to −0.03[2,e,f]	>+20[10]	Various hexose sugars	E
ABA transport	ABCG22 ABCG40 AIT1 ABCG25 DTX50	AT5G06530 AT1G15520 AT1G69850 AT1G71960 AT5G52050	ABA import ABA import ABA import ABA efflux ABA efflux	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	F

(*Table continues on following page.*)

Table III. (*Continued from previous page.*)

[a]*Chara corallina.* [b]Arabidopsis. [c]*Neurospora crassa.* [d]*Vicia faba.* [e]*Commelina communis.* [f]*Pisum sativum.* [1]Estimated for 3 H^+:1 Ca^{2+}. [2]1 mM sugar, pH_o 5.5. [3]pH_o 4.5 to 7.5. [4]1 mM $[Ca^{2+}]_o$. [5]3 H^+:1 Ca^{2+}, pH_o 5.5, 1 mM $[Ca^{2+}]_o$. [6]200 μM K^+, pH_o 6.1. [7]275 μM K^+, pH_o 4.5. [8]pH_o 7, 100 μM Cl^-/NO_3^-. [9]0.1 mM Mal, pH_o 6.1. [10]0.1 mM Suc, pH_o 6.1. *Calculated assuming a transport rate of 60 H^+ s^{-1} (Sze et al., 1999), a current of 15 to 20 μA cm^{-2} (Blatt, 1987a; Clint and Blatt, 1989), and guard cell surface area of 3×10^{-5} cm^2. **Calculated from I_{sat} or the typical transport current assuming a transport turnover rate of 50 s^{-1} and guard cell surface area of 3×10^{-5} cm^2; estimates for the Ca^{2+}-ATPase are based on assumption of a 30-fold lower density than the plasma membrane H^+-ATPase (Sze et al., 2000) and H^+-coupled transporters scaled accordingly by current densities. ***Stoichiometry determined as the minimum thermodynamic requirement to drive net accumulation.