Dynamic Regulation of Vesicle Pools in a Detailed Spatial Model of the Complete Synaptic Vesicle Cycle

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Model Species, Parameters, and Reactions

Supplementary Table 1

Model Species	Full name	Initial concentration (μM)/(number)	Ref.
Ca (cytosol)	Calcium	0.045	Doi 2005; Antunes 2012; Bartol 2015
CBhi',	Calbindin (high affinity)	0.99	Doi 2005; Antunes 2012; Bartol 2015
CBlo	Calbindin (low affinity)	0.99	Doi 2005; Antunes 2012; Bartol 2015
CRTT		0.1976	Faas 2007
CRind		0.494	Faas 2007
PV	Parvalbumin	4.55	Lee 2000
CaPV		8.4	Antunes 2012
MgPV		30.45	Antunes 2012
AC18	Adenylyl cyclase	0.2	Bhalla 1999
R2C2	PKA (inactive form)	0.5	Bhalla 1999
SERCA	See code	SERCA_count	Doi 2005; Antunes 2012; Bartol 2015
PMCA_P0	See code	PMCA_count	Bartol 2015
Ca (ER)	Calcium	150	Doi 2005
Rab3	Rab3-GTP	10 per vesicle	Takamori 2006
SYB	Synaptobrevin	69 per vesicle	Takamori 2006
syt	Synaptotagmin-1	27 per vesicle	Takamori 2006
DYNp	Dynamin	1 per raft in RRetP	Ross 2011; Chugh 2006; Jimah_2019
RIM_M13	RIM1_Munc13 complex	4 per docking site	Imig 2014, Murthy 1999
CaP_m0	P-type Ca channel	4 per docking site	Althof 2015
M18	Munc18	28.4	Wilhelm 2014
M13	Munc13	10.36	Wilhelm 2014
CXN	Complexin	16.59	Wilhelm 2014
aSNAP	alphaSNAP	7.68	Wilhelm 2014
NSF	NSF	27.14	Wilhelm 2014
Synapsin	Synapsin	156	Wilhelm 2014
PP2A	PP2A	0.5	Bhalla 1999; Gallimore 2018
SYX	Syntaxin	(32153)	Wilhelm 2014
SNP25	SNAP25	(42697)	Wilhelm 2014

CaM_N_0_C_0	Calmodulin (free form)	60	Kawaguchi 2013; Kitagawa 2009; Wilhelm 2014
CaN	Calcineurin	5	Kitagawa 2009
CDK5	CDK5	1	Shin 2019
Rab3	Rab3-GTP	125.8	Wilhelm 2014
SYN1	Syndapin-1	21.37	Wilhelm 2014
TOMO_p	Tomosyn-1 (phospho form)	1500	Barak 2010; Fujita 1998

Supplementary Table 2

Species	**Cytosolic diffusion constant (μm2/s)**	**Membrane diffusion constant (μm2/s)**
Unlisted species don't diffuse.	**Obtained from Reshetniak 2020 (where available)**	**Obtained from Reshetniak 2020 (where available)**
Vesicles	0.01	
Ca (cytosol)	223	
CBhi',	2.0	
CBlo	2.0	
CRTT	2.0	
CRind	2.0	
PV	2.0	
CaPV	2.0	
MgPV	2.0	
AC18	2.0	
R2C2	2.0	
SERCA		0.25
PMCA_P0		0.25
Rab3	1.7793	0.25
SYB		0.3245
syt		0.25
M18	2.2357	
M13	2.2796	
CXN	1.7793	
aSNAP	2.1959	
NSF	2.2788	
Synapsin	2.65	
PP2A	2.0	
SYX	0.2429	
SNP25		0.651
CaM_N_0_C_0	0.25	
CaN	0.25	
CDK5	0.25	
SYN1	2.1959	
TOMO_p	1.7793	

Supplementary Table 3

Parameter	Value	Units	Notes and ref.
kon_SNARE_syt_CXN_ca1	1000	$\mu M^{-1}s^{-1}$	Millet 2002; Davis 1999; Hui 2005
koff_SNARE_syt_CXN_ca1	1270	s^{-1}	" "
kon_SNARE_syt_CXN_ca2	1000	$\mu M^{-1}s^{-1}$	" "
koff_SNARE_syt_CXN_ca2	227670	s^{-1}	" "
kon_SNARE_syt_CXN_ca3	1000	$\mu M^{-1}s^{-1}$	" "
koff_SNARE_syt_CXN_ca3	12370	s^{-1}	" "
kon_SNARE_syt_CXN_bca1	1000	$\mu M^{-1}s^{-1}$	" "
koff_SNARE_syt_CXN_bca1	50000	s^{-1}	" "
kon_SNARE_syt_CXN_bca2	1000	$\mu M^{-1}s^{-1}$	" "
koff_SNARE_syt_CXN_bca2	25780	s^{-1}	" "
koff_SNARE_syt_CXN_ca1_s	1000	s^{-1}	" "
koff_SNARE_syt_CXN_ca2_s	2000	s^{-1}	" "
koff_SNARE_syt_CXN_ca3_s	5000	s^{-1}	" "
kon_rim_rab3	1000	$\mu M^{-1}s^{-1}$	Model calibration
koff_rim_rab3	0	s^{-1}	Docking assumed to be irreversible once vesicle is positioned at the dock site.
kon_syx_m18	5	$\mu M^{-1}s^{-1}$	Burkhardt 2008
koff_syx_m18	0.0011	s^{-1}	" "
kon_m13_syx	20	$\mu M^{-1}s^{-1}$	Mezer 2004
koff_m13_syx	2.6	s^{-1}	" "
kon_syx_snp25	10	$\mu M^{-1}s^{-1}$	Zikich 2008; Coppola_2001
koff_syx_snp25	1.26	s^{-1}	" "
kon_syb_syx	2.35	$\mu M^{-1}s^{-1}$	Lai 2017; Shu 2020; Walter 2010
koff_syb_syx	0.0047	s^{-1}	" "
kon_syt_snare	57	$\mu M^{-1}s^{-1}$	Mezer 2004
koff_syt_snare	0.24	s^{-1}	" "
kon_cxn_snare	30	$\mu M^{-1}s^{-1}$	Mezer 2004; Li 2007; Bowen 2005
koff_cxn_snare	0.33	s^{-1}	" "
kon_snare_snap	0.17	$\mu M^{-1}s^{-1}$	Rickman 2002
koff_snare_snap	0.26	s^{-1}	" "
kon_nsf_snap	20	$\mu M^{-1}s^{-1}$	Vivona 2013; Cipriano 2013

kcat_nsf	0.116	s^{-1}	Vivona 2013; Cipriano 2013
kon_cam_NT	770	$\mu M^{-1}s^{-1}$	Faas 2011; Sun 2010
kon_cam_CT	84	$\mu M^{-1}s^{-1}$	" "
kon_cam_NR	32000	$\mu M^{-1}s^{-1}$	" "
kon_cam_CR	25	$\mu M^{-1}s^{-1}$	" "
koff_cam_NT	$1.6x10^5$	s^{-1}	" "
koff_cam_CT	$2.2x10^4$	s^{-1}	" "
koff_cam_CR	2600	s^{-1}	" "
koff_cam_NR	6.5	s^{-1}	" "
kon_can_cam	46	$\mu M^{-1}s^{-1}$	Quintana 2005
koff_can_cam	1.2	s^{-1}	" "
kon_can_dyn	10	$\mu M^{-1}s^{-1}$	Model calibration
koff_can_dyn	1	s^{-1}	" "
kcat_can	0.5	s^{-1}	" "
kon_dyn_syn	100	$\mu M^{-1}s^{-1}$	Smillie 2005
koff_dyn_syn	1	s^{-1}	Anggono 2006
kon_cdk_dyn	3	$\mu M^{-1}s^{-1}$	Liu 2010
koff_cdk_dyn	10	s^{-1}	" "
kcat_cdk	0.5	s^{-1}	" "
kon_syb_ap180	2000	$\mu M^{-1}s^{-1}$	Assumed to be fast and irreversible. Gordon 2014
kon_syb_ap2	2000	$\mu M^{-1}s^{-1}$	Diril 2006
kon_ac_cam	500	$\mu M^{-1}s^{-1}$	Wang 2003
koff_ac_cam	0.1	s^{-1}	" "
kcat_ac18	18	s^{-1}	Wu 1993; Bhalla 1999
kdeg_camp	1	s^{-1}	This paper.
kon_r2c2_camp1	2	$\mu M^{-1}s^{-1}$	Buxbaum 1989; Bhalla 1999
koff_r2c2_camp1	0.75	s^{-1}	" "
kon_r2c2_camp2bb	1	$\mu M^{-1}s^{-1}$	" "
koff_r2c2_camp2bb	1.5	s^{-1}	" "
kon_r2c2_camp2ab	10	$\mu M^{-1}s^{-1}$	" "
koff_r2c2_camp2ab	7.5	s^{-1}	" "
kon_r2c2_camp3bb	20	$\mu M^{-1}s^{-1}$	" "
koff_r2c2_camp3bb	7.5	s^{-1}	" "
kon_r2c2_camp3ab	1	$\mu M^{-1}s^{-1}$	" "
koff_r2c2_camp3ab	0.75	s^{-1}	" "
kon_r2c2_camp4	10	$\mu M^{-1}s^{-1}$	" "
koff_r2c2_camp4	15	s^{-1}	" "
kact_pka_23	0.005	s^{-1}	" "

kdeact_pka_23	$5x10^6$	s^{-1}	" "
kact_pka_4	6	s^{-1}	" "
kdeact_pka_4	$5x10^6$	s^{-1}	" "
kon_r2c_camp3	1	$\mu M^{-1}s^{-1}$	" "
koff_r2c_camp3	0.75	s^{-1}	" "
kon_r2c_camp4	10	$\mu M^{-1}s^{-1}$	" "
koff_r2c_camp4	7.5	s^{-1}	" "
kact_pka_r2c	3	s^{-1}	" "
kdeact_pka_r2c	$10x10^6$	s^{-1}	" "
kon_PKA_syn	10	$\mu M^{-1}s^{-1}$	Model calibration
koff_PKA_syn	1	s^{-1}	" "
kcat_PKA_syn	10	s^{-1}	" "
kon_pp2a_synapsin	2	$\mu M^{-1}s^{-1}$	Gallimore 2018
koff_pp2a_synapsin	8	s^{-1}	" "
kcat_pp2a_syn	2	s^{-1}	" "
kon_synapsin_actin	1000	$\mu M^{-1}s^{-1}$	Model calibration
koff_synapsin_actin	1	s^{-1}	" "
koff_synapsin_actin_p	1000	s^{-1}	" "
kon_cdk_tomo	3	$\mu M^{-1}s^{-1}$	" "
koff_cdk_tomo	10	s^{-1}	" "
kcat_cdk_tomo	0.5	s^{-1}	" "
kon_can_tomo	1	$\mu M^{-1}s^{-1}$	" "
koff_can_tomo	10	s^{-1}	" "
kcat_can_tomo	1	s^{-1}	" "
kon_rab3_TOMO_p	1	$\mu M^{-1}s^{-1}$	" "
koff_rab3_TOMO_p	10	s^{-1}	" "
kon_TOMO_p_synapsin	100	$\mu M^{-1}s^{-1}$	" "
koff_TOMO_p_synapsin	1	s^{-1}	" "
kon_TOMO_synapsin	100	$\mu M^{-1}s^{-1}$	" "
koff_TOMO_synapsin	100	s^{-1}	Increased off-rate with dephos.
kon_synapsin_dimer	10	$\mu M^{-1}s^{-1}$	This paper.
koff_synapsin_dimer	10	s^{-1}	" "
kon_synapsin_dimer_p	10000	$\mu M^{-1}s^{-1}$	Increased off-rate with phos.
kon_synapsin_ves	10.7	$\mu M^{-1}s^{-1}$	Calibration against Reshetniak 2020
koff_synapsin_ves	0.123	s^{-1}	" "
koff_synapsin_p_ves	123	s^{-1}	Increased off-rate with phos.
kon_cxn_ves	1.2	$\mu M^{-1}s^{-1}$	Zdanowicz 2017
koff_cxn_ves	1000	s^{-1}	" "

kon_rab3_ves	10	$\mu M^{-1}s^{-1}$	Calibration against Reshetniak 2020
koff_rab3_ves	1	s^{-1}	" "
kon_m13_ves	1.6	$\mu M^{-1}s^{-1}$	" "
koff_m13_ves	1000	s^{-1}	" "
kon_m18_ves	1.6	$\mu M^{-1}s^{-1}$	" "
koff_m18_ves	1000	s^{-1}	" "
kon_syn1_ves	2.8	$\mu M^{-1}s^{-1}$	" "
koff_syn1_ves	1000	s^{-1}	" "
kon_asnap_ves	2.8	$\mu M^{-1}s^{-1}$	" "
koff_asnap_ves	1000	s^{-1}	" "
kon_nsf_ves	0.9	$\mu M^{-1}s^{-1}$	" "
koff_nsf_ves	1000	s^{-1}	" "

Supplementary Table 4

Reaction	**Parameter**
Synaptotagmin (Syt) model	
Syt + Ca ↔ Syt_Ca	kon_SNARE_syt_CXN_ca1 koff_SNARE_syt_CXN_ca1
Syt_Ca + Ca ↔ Syt_Ca2	kon_SNARE_syt_CXN_ca2 koff_SNARE_syt_CXN_ca2
Syt_Ca2 + Ca ↔ Syt_Ca3	kon_SNARE_syt_CXN_ca3 koff_SNARE_syt_CXN_ca3
Syt + Ca ↔ Syt_bCa	kon_SNARE_syt_CXN_bca1 koff_SNARE_syt_CXN_bca1
Syt_bCa + Ca ↔ Syt_bCa2	kon_SNARE_syt_CXN_bca2 koff_SNARE_syt_CXN_bca2
Syt_bCa + Ca ↔ Syt_Ca_bCa	kon_SNARE_syt_CXN_ca1 koff_SNARE_syt_CXN_ca1
Syt_Ca_bCa + Ca ↔ Syt_Ca2_bCa	kon_SNARE_syt_CXN_ca2 koff_SNARE_syt_CXN_ca2
Syt_Ca2_bCa + Ca ↔ Syt_Ca3_bCa	kon_SNARE_syt_CXN_ca3 koff_SNARE_syt_CXN_ca3
Syt_Ca + Ca ↔ Syt_Ca_bCa	kon_SNARE_syt_CXN_bca1 koff_SNARE_syt_CXN_bca1
Syt_Ca_bCa + Ca ↔ Syt_Ca_bCa2	kon_SNARE_syt_CXN_bca2 koff_SNARE_syt_CXN_bca2
Syt_Ca2 + Ca ↔ Syt_Ca2_bCa	kon_SNARE_syt_CXN_bca1 koff_SNARE_syt_CXN_bca1
Syt_Ca2_bCa + Ca ↔ Syt_Ca2_bCa2	kon_SNARE_syt_CXN_bca2 koff_SNARE_syt_CXN_bca2
Syt_Ca3 + Ca ↔ Syt_Ca3_bCa	kon_SNARE_syt_CXN_bca1 koff_SNARE_syt_CXN_bca1
Syt_Ca3_bCa + Ca ↔ Syt_Ca3_bCa2	kon_SNARE_syt_CXN_bca2 koff_SNARE_syt_CXN_bca2

Syt_bCa2 + Ca ↔ Syt_Ca_bCa2	kon_SNARE_syt_CXN_ca1 koff_SNARE_syt_CXN_ca1_s
Syt_Ca_bCa2 + Ca ↔ Syt_Ca2_bCa2	kon_SNARE_syt_CXN_ca2 koff_SNARE_syt_CXN_ca2_s
Syt_Ca2_bCa2 + Ca ↔ Syt_Ca3_bCa2	kon_SNARE_syt_CXN_ca3 koff_SNARE_syt_CXN_ca3_s
Vesicle Docking.	
Rab3(vesicle) + RIM_M13(membrane) ↔ RIM_M13_Rab3	kon_rim_rab3 koff_rim_rab3
Vesicle Priming I	
SYX + M18 ↔ SYX_M18	kon_syx_m18 koff_syx_m18
RIM_M13_Rab3 + SYX_M18 ↔ RIM_M13_Rab3_SYX_M18	kon_m13_syx koff_m13_syx
RIM_M13_Rab3_SYX_M18 SNP25 ↔ RIM_M13_Rab3_SYX_M18_SNP25	kon_syx_snp25 koff_syx_snp25
RIM_M13_Rab3_SYX_M18_SNP25 + SYB ↔ SNARE	kon_syb_syx koff_syb_syx
Vesicle Priming II	
SNARE + Syt ↔ SNARE_Syt	kon_syt_snare koff_syt_snare
SNARE_Syt + CXN ↔ SNARE_syt_CXN	kon_cxn_snare koff_cxn_snare
Vesicle Fusion (exocytosis)	
Requires 2xSNARE_syt_CXN_Ca3_bCa2	3e03
Requires 3xSNARE_syt_CXN_Ca3_bCa2	3e04
Requires 4xSNARE_syt_CXN_Ca3_bCa2	3e05
NSF dismantling of SNARE complex	
cisSNARE + aSNAP ↔ SNARE_aSNAP	kon_snare_snap koff_snare_snap
SNARE_aSNAP + NSF → SNARE_aSNAP_NSF	kon_nsf_snap
SNARE_aSNAP_NSF → SYB + SYX + SNP25 + NSF + aSNAP + M18	kcat_nsf
Ca_Calmodulin Model	
Ca ON Reactions	
CaM_N_0_C_0 + Ca → CaM_N_1_C_0	2*kon_cam_NT
CaM_N_0_C_0 + Ca → CaM_N_0_C_1	2*kon_cam_CT
CaM_N_1_C_0 + Ca → CaM_N_1_C_1	2*kon_cam_CT
CaM_N_1_C_0 + Ca → CaM_N_2_C_0	kon_cam_NR
CaM_N_0_C_1 + Ca → CaM_N_0_C_2	kon_cam_CR
CaM_N_0_C_1 + Ca → CaM_N_1_C_1	2*kon_cam_NT
CaM_N_1_C_1 + Ca → CaM_N_2_C_1	kon_cam_NR
CaM_N_1_C_1 + Ca → CaM_N_1_C_2	kon_cam_CR
CaM_N_2_C_0 + Ca → CaM_N_2_C_1	2*kon_cam_CT
CaM_N_0_C_2 + Ca → CaM_N_1_C_2	2*kon_cam_NT
CaM_N_1_C_1 + Ca → CaM_N_2_C_1	kon_cam_NR

CaM_N_1_C_1 + Ca → CaM_N_1_C_2	kon_cam_CR
CaM_N_2_C_1 + Ca → CaM_N_2_C_2	kon_cam_CR
CaM_N_1_C_2 + Ca → CaM_N_2_C_2	kon_cam_NR
Ca OFF Reactions	
CaM_N_1_C_0 → CaM_N_0_C_0 + Ca	koff_cam_NT
CaM_N_0_C_1 → CaM_N_0_C_0 + Ca	koff_cam_CT
CaM_N_1_C_1 → CaM_N_0_C_1 + Ca	koff_cam_NT
CaM_N_1_C_1 → CaM_N_1_C_0 + Ca	koff_cam_CT
CaM_N_2_C_0 → CaM_N_1_C_0 + Ca	2*koff_cam_NR
CaM_N_0_C_2 → CaM_N_0_C_1 + Ca	2*koff_cam_CR
CaM_N_2_C_1 → CaM_N_1_C_1 + Ca	2*koff_cam_NR
CaM_N_2_C_1 → CaM_N_2_C_0 + Ca	koff_cam_CT
CaM_N_1_C_2 → CaM_N_0_C_2 + Ca	koff_cam_NT
CaM_N_1_C_2 → CaM_N_1_C_1 + Ca	2*koff_cam_CR
CaM_N_2_C_2 → CaM_N_1_C_2 + Ca	2*koff_cam_NR
CaM_N_2_C_2 → CaM_N_2_C_1 + Ca	2*koff_cam_CR
Calcineurin Model.	
CaN + CaM_N_2_C_2 ↔ CaN_CaM	kon_can_cam koff_can_cam
Calcinueurin Dephosphorylation of Dynamin	
CaN_CaM + DYNp ↔ CaN_DYNp	kon_can_dyn koff_can_dyn
CaN_DYNp → CaN_CaM, DYN	kcat_can
Binding of dynamin to syndapin 1 (SYN1)	
DYN + SYN1 ↔ DYN_SYN1	kon_dyn_syn koff_dyn_syn
CDK5 phosphorylation of dynamin	
DYN + CDK5 ↔ DYN_CDK5	kon_cdk_dyn koff_cdk_dyn
DYN_CDK5 ↔ DYNp + CDK5	kcat_cdk
Reclustering of vesicle proteins in rafts (pits)	
SYB(membrane) + AP180 → SYB(raft)	kon_syb_ap180
Syt(membrane) + AP2 → Syt(raft)	kon_syt_ap2
PKA/AC Model.	
CaM_N_2_C_2 + AC18 ↔ AC18_CaM	kon_ac_cam koff_ac_cam
AC18_CaM → AC18_CaM + cAMP	kcat_ac18
cAMP → null	kdeg_camp
R2C2 + cAMP ↔ R2C2_cAMP	kon_r2c2_camp1 koff_r2c2_camp1
R2C2_cAMP + cAMP ↔ R2C2_2cAMPbb	kon_r2c2_camp2bb koff_r2c2_camp2bb
R2C2_cAMP + cAMP ↔ R2C2_2cAMPab	kon_r2c2_camp2ab koff_r2c2_camp2ab
R2C2_2cAMPbb + cAMP ↔ R2C2_3cAMP	kon_r2c2_camp3bb koff_r2c2_camp3bb

R2C2_2cAMPab + cAMP ↔ R2C2_3cAMP	kon_r2c2_camp3ab koff_r2c2_camp3ab
R2C2_3cAMP + cAMP ↔ R2C2_4cAMP	kon_r2c2_camp4 koff_r2c2_camp4
R2C2_2cAMPab ↔ R2C_2cAMPab + PKA	kact_pka_23 kdeact_pka_23
R2C2_3cAMP ↔ R2C_3cAMP + PKA	kact_pka_23 kdeact_pka_23
R2C2_4cAMP ↔ R2C_4cAMP + PKA	kact_pka_4 kdeact_pka_4
R2C_2cAMPab + cAMP ↔ R2C_3cAMP	kon_r2c_camp3 koff_r2c_camp3
R2C_3cAMP + cAMP ↔ R2C_4cAMP	kon_r2c_camp4 koff_r2c_camp4
R2C_4cAMP ↔ R2_4cAMP + PKA	kact_pka_r2c kdeact_pka_r2c
(De)phosphorylation of synapsin.	
PKA + synapsin ↔ PKA_synapsin	kon_PKA_syn koff_PKA_syn
PKA_synapsin → PKA + synapsin_p	kcat_PKA_syn
PP2A + synapsin_p ↔ PP2A_synapsin_p	kon_pp2a_synapsin koff_pp2a_synapsin
PP2A_synapsin_p → PP2A + synapsin	kcat_pp2a_syn
Vesicle Clustering Model.	
Synapsin binding to actin(immobile)	
Synapsin + actin ↔ Synapsin_actin	kon_synapsin_actin koff_synapsin_actin
Synapsin_p + actin ↔ Synapsin_p_actin	kon_synapsin_actin koff_synapsin_actin_p
Tomosyn (de)phosphorylation	
TOMO + CDK5 ↔ TOMO_CDK5	kon_cdk_tomo koff_cdk_tomo
TOMO_CDK5 → TOMO_p + CDK5	kcat_cdk_tomo
TOMO_p + CaN_CaM ↔ TOMO_p_CaN_CaM	kon_can_tomo koff_can_tomo
TOMO_p_CaN_CaM → TOMO + CaN_CaM	kcat_can_tomo
Tomosyn binding Rab3	
TOMO_p + Rab3 ↔ Rab3_TOMO_p	kon_rab3_TOMO_p koff_rab3_TOMO_p
Rab3_TOMO →Rab3 + TOMO	koff_rab3_TOMO_p
Rab3_TOMO binds synapsin.	
Rab3_TOMO_p + synapsin ↔ Rab3_TOMO_p_synapsin	kon_TOMO_p_synapsin koff_TOMO_p_synapsin
Rab3_TOMO + synapsin ↔ Rab3_TOMO_synapsin	kon_TOMO_synapsin koff_TOMO_synapsin
Synapsin Dimerisation (vesicle crosslinking)	

Synapsin + synapsin ↔ synapsin_dimer	kon_synapsin_dimer koff_synapsin_dimer
synapsin_dimer_p ↔ synapsin + synapsin_p	kon_synapsin_dimer koff_synapsin_dimer_p
Binding of proteins to vesicles (buffering)	
Synapsin:	
ves_syn1_site + synapsin(cytosol) ↔ synapsin(ves)	kon_synapsin_ves koff_synapsin_ves
ves_syn1_site + synapsin_p(cytosol) ↔ synapsin_p(ves)	kon_synapsin_ves koff_synapsin_p_ves
Complexin:	
ves_CXN_site + CXN(cytosol) ↔ CXN(ves)	kon_cxn_ves koff_cxn_ves
Rab3-GTP:	
ves_rab3_site + Rab3(cytosol) ↔ Rab3(ves)	kon_rab3_ves koff_rab3_ves
Munc13/18:	
ves_m13_site + M13(cytosol) ↔ M13(ves)	kon_m13_ves koff_m13_ves
ves_m18_site + M13(cytosol) ↔ M13(ves)	kon_m18_ves koff_m18_ves
Syndapin-1:	
ves_syndap_site + SYN1(cyt) ↔ SYN(ves)	kon_syn1_ves koff_syn1_ves
AlphaSNAP:	
ves_asnap_site + aSNAP(cyt) ↔ aSNAP	kon_asnap_ves koff_asnap_ves
NSF:	
ves_nsf_site + NSF(cyt) ↔ NSF(ves)	kon_nsf_ves koff_nsf_ves

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