SWISS-MODEL Homology Modelling Report

Model Building Report

This document lists the results for the homology modelling project "VMAT1_HUMAN P54219 Chromaffin granule amine transporter-LNR" submitted to SWISS-MODEL workspace on Aug. 27, 2024, 8:02 a.m..The submitted primary amino acid sequence is given in Table T1.

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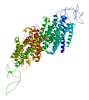
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- Bertoni M, Kiefer F, Biasini M, Bordoli L, Schwede T
  Modeling protein quaternary structure of homo- and hetero-oligomers beyond binary interactions by homology.
  Scientific Reports 7. (2017) 28874689 10.1038/s41598-017-09654-8

Results

The SWISS-MODEL template library (SMTL version 2024-08-21, PDB release 2024-08-16) was searched with BLAST (Camacho et al.) and HHblits (Steinegger et al.) for evolutionary related structures matching the target sequence in Table T1. For details on the template search, see Materials and Methods. Overall 1222 templates were found (Table T2).

Models

The following model was built (see Materials and Methods "Model Building"):

Model #05	File	Built with	Oligo-State	Ligands	GMQE	QMEANDisCo Global
	PDB	ProMod3 3.4.1	homo-dimer (matching prediction)	1 x LNR: L-NOREPINEPHRINE; 1 x YHR: reserpine;	0.66	0.67 ± 0.05

Template	Seq Identity	Oligo-state	QSQE	Found by	Method	Resolution	Seq Similarity	Range	Coverage	Description
8tgl.1.A	99.36	homo-dimer	0.60	BLAST	EM	-	0.61	19 - 484	0.90	Chromaffin granule amine transporter

Included Ligands

Ligand	Description
1 x LNR	L-NOREPINEPHRINE
1 x YHR	reserpine

```
Target    MLRTILDAPQRLLKEGRASRQLVLVVVFVALLLDNMLFTVVVPIVPTFLYDMEFKEVNSSLHLGHAGSSPHALASPAFST
8tgl.1.A  MLRTILDAPQRLLKEGRASRQLVLVVVFVALLLDNMLFTVVVPIVPTFLYDMEFKEVNSSL---HLG---HA--------
```

```
Target    IFSFFNNNTVAVEESVPSGIAWMNDTASTIPPPATEAISAHKNNCLQGTGFLEEEITRVGVLFASKAVMQLLVNPFVGPL
8tgl.1.A  ----------------------------------------GSNCLQGTGFLEEEITRVGVLFASKAVMQLLVNPFVGPL

Target    TNRIGYHIPMFAGFVIMFLSTVMFAFSGTYTLLFVARTLQGIGSSFSSVAGLGMLASVYTDDHERGRAMGTALGGLALGL
8tgl.1.A  TNRIGYHIPMFAGFVIMFLSTVMFAFSGTYTLLFVARTLQGIGSSFSSVAGLGMLASVYTDDHERGRAMGTALGGLALGL

Target    LVGAPFGSVMYEFVGKSAPFLILAFLALLDGALQLCILQPSKVSPESAKGTPLFMLLKDPYILVAAGSICFANMGVAILE
8tgl.1.A  LVGAPFGSVMYEFVGKSAPFLILAFLALLDGALQLCILQPSKVSPESAKGTPLFMLLKDPYILVAAGSICFANMGVAILE

Target    PTLPIWMMQTMCSPKWQLGLAFLPASVSYLIGTNLFGVLANKMGRWLCSLIGMLVVGTSLLCVPLAHNIFGLIGPNAGLG
8tgl.1.A  PTLPIWMMQTMCSPKWQLGLAFLPASVSYLIGTNLFGVLANKMGRWLCSLIGMLVVGTSLLCVPLAHNIFGLIGPNAGLG

Target    LAIGMVDSSMMPIMGHLVDLRHTSVYGSVYAIADVAFCMGFAIGPSTGGAIVKAIGFPWLMVITGVINIVYAPLCYYLRS
8tgl.1.A  LAIGMVDSSMMPIMGHLVDLRHTSVYGSVYAIADVAFCMGFAIGPSTGGAIVKAIGFPWLMVITGVINIVYAPLCYYLRS

Target    PPAKEEKLAILSQDCPMETRMYATQKPTKEFPLGEDSDEEPDHEE
8tgl.1.A  PPAKEEKLAILSQDCPMETRMYATQKPTKEFPLGEDSDEEPDHEE


Target    MLRTILDAPQRLLKEGRASRQLVLVVVFVALLLDNMLFTVVVPIVPTFLYDMEFKEVNSSLHLGHAGSSPHALASPAFST
8tgl.1.B  MLRTILDAPQRLLKEGRASRQLVLVVVFVALLLDNMLFTVVVPIVPTFLYDMEFKEVNSSL---HLG---HA--------

Target    IFSFFNNNTVAVEESVPSGIAWMNDTASTIPPPATEAISAHKNNCLQGTGFLEEEITRVGVLFASKAVMQLLVNPFVGPL
8tgl.1.B  ----------------------------------------GSNCLQGTGFLEEEITRVGVLFASKAVMQLLVNPFVGPL

Target    TNRIGYHIPMFAGFVIMFLSTVMFAFSGTYTLLFVARTLQGIGSSFSSVAGLGMLASVYTDDHERGRAMGTALGGLALGL
8tgl.1.B  TNRIGYHIPMFAGFVIMFLSTVMFAFSGTYTLLFVARTLQGIGSSFSSVAGLGMLASVYTDDHERGRAMGTALGGLALGL

Target    LVGAPFGSVMYEFVGKSAPFLILAFLALLDGALQLCILQPSKVSPESAKGTPLFMLLKDPYILVAAGSICFANMGVAILE
8tgl.1.B  LVGAPFGSVMYEFVGKSAPFLILAFLALLDGALQLCILQPSKVSPESAKGTPLFMLLKDPYILVAAGSICFANMGVAILE

Target    PTLPIWMMQTMCSPKWQLGLAFLPASVSYLIGTNLFGVLANKMGRWLCSLIGMLVVGTSLLCVPLAHNIFGLIGPNAGLG
8tgl.1.B  PTLPIWMMQTMCSPKWQLGLAFLPASVSYLIGTNLFGVLANKMGRWLCSLIGMLVVGTSLLCVPLAHNIFGLIGPNAGLG

Target    LAIGMVDSSMMPIMGHLVDLRHTSVYGSVYAIADVAFCMGFAIGPSTGGAIVKAIGFPWLMVITGVINIVYAPLCYYLRS
8tgl.1.B  LAIGMVDSSMMPIMGHLVDLRHTSVYGSVYAIADVAFCMGFAIGPSTGGAIVKAIGFPWLMVITGVINIVYAPLCYYLRS

Target    PPAKEEKLAILSQDCPMETRMYATQKPTKEFPLGEDSDEEPDHEE
8tgl.1.B  PPAKEEKLAILSQDCPMETRMYATQKPTKEFPLGEDSDEEPDHEE
```

Materials and Methods

Template Search

Template search with BLAST and HHblits has been performed against the SWISS-MODEL template library (SMTL, last update: 2024-08-21, last included PDB release: 2024-08-16).

The target sequence was searched with BLAST against the primary amino acid sequence contained in the SMTL. A total of 26 templates were found.

An initial HHblits profile has been built using the procedure outlined in (Steinegger et al.), followed by 1 iteration of HHblits against Uniclust30 (Mirdita, von den Driesch et al.). The obtained profile has then be searched against all profiles of the SMTL. A total of 1216 templates were found.

Template Selection

For each identified template, the template's quality has been predicted from features of the target-template alignment. The templates with the highest quality have then been selected for model building.

Model Building

Models are built based on the target-template alignment using ProMod3 (Studer et al.). Coordinates which are conserved between the target and the template are copied from the template to the model. Insertions and deletions are remodelled using a fragment library. Side chains are then rebuilt. Finally, the geometry of the resulting model is regularized by using a force field.

Model Quality Estimation

The global and per-residue model quality has been assessed using the QMEAN scoring function (Studer et al.).

Ligand Modelling

Ligands present in the template structure are transferred by homology to the model when the following criteria are met: (a) The ligands are annotated as biologically relevant in the template library, (b) the ligand is in contact with the model, (c) the ligand is not clashing with the protein, (d) the residues in contact with the ligand are conserved between the target and the template. If any of these four criteria is not satisfied, a certain ligand will not be included in the model. The model summary includes information on why and which ligand has not been included.

Oligomeric State Conservation

The quaternary structure annotation of the template is used to model the target sequence in its oligomeric form. The method (Bertoni et al.) is based on a supervised machine learning algorithm, Support Vector Machines (SVM), which combines interface conservation, structural clustering, and other template features to provide a quaternary structure quality estimate (QSQE). The QSQE score is a number between 0 and 1, reflecting the expected accuracy of the interchain contacts for a model built based a given alignment and template. Higher numbers indicate higher reliability. This complements the GMQE score which estimates the accuracy of the tertiary structure of the resulting model.

References

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  BLAST+: architecture and applications.
  BMC Bioinformatics, 10, 421-430. (2009) 20003500 10.1186/1471-2105-10-421
- Steinegger M, Meier M, Mirdita M, Vöhringer H, Haunsberger SJ, Söding J
  HH-suite3 for fast remote homology detection and deep protein annotation.
  BMC Bioinformatics 20, 473. (2019) 31521110 10.1186/s12859-019-3019-7
- Mirdita M, von den Driesch L, Galiez C, Martin MJ, Söding J, Steinegger M
  Uniclust databases of clustered and deeply annotated protein sequences and alignments.
  Nucleic Acids Res, 45, D170–D176. (2016) 27899574 10.1093/nar/gkw1081

Table T1:

Primary amino acid sequence for which templates were searched and models were built.

```
MLRTILDAPQRLLKEGRASRQLVLVVVFVALLLDNMLFTVVVPIVPTFLYDMEFKEVNSSLHLGHAGSSPHALASPAFSTIFSFFNNNTVAVEESVPSGI
AWMNDTASTIPPPATEAISAHKNNCLQGTGFLEEEITRVGVLFASKAVMQLLVNPFVGPLTNRIGYHIPMFAGFVIMFLSTVMFAFSGTYTLLFVARTLQ
GIGSSFSSVAGLGMLASVYTDDHERGRAMGTALGGLALGLLVGAPFGSVMYEFVGKSAPFLILAFLALLDGALQLCILQPSKVSPESAKGTPLFMLLKDP
YILVAAGSICFANMGVAILEPTLPIWMMQTMCSPKWQLGLAFLPASVSYLIGTNLFGVLANKMGRWLCSLIGMLVVGTSLLCVPLAHNIFGLIGPNAGLG
LAIGMVDSSMMPIMGHLVDLRHTSVYGSVYAIADVAFCMGFAIGPSTGGAIVKAIGFPWLMVITGVINIVYAPLCYYLRSPPAKEEKLAILSQDCPMETR
MYATQKPTKEFPLGEDSDEEPDHEE
```

Table T2:

Template	Seq Identity	Oligo-state	QSQE	Found by	Method	Resolution	Seq Similarity	Coverage	Description
8tgj.1.B	99.36	homo-dimer	0.61	BLAST	EM	NA	0.61	0.90	VMAT1 dimer in unbound form and with reserpine
8tgl.1.A	99.36	homo-dimer	0.60	BLAST	EM	NA	0.61	0.90	Chromaffin granule amine transporter
8tgg.1.A	99.36	homo-dimer	0.59	BLAST	EM	NA	0.61	0.90	Chromaffin granule amine transporter
8tgj.1.B	99.77	homo-dimer	0.61	HHblits	EM	NA	0.61	0.82	VMAT1 dimer in unbound form and with reserpine
8tgl.1.B	99.36	homo-dimer	0.60	BLAST	EM	NA	0.61	0.90	Chromaffin granule amine transporter

Template	Seq Identity	Oligo-state	QSQE	Found by	Method	Resolution	Seq Similarity	Coverage	Description
8tgg.1.A	99.77	homo-dimer	0.59	HHblits	EM	NA	0.61	0.82	Chromaffin granule amine transporter
8tgg.1.B	99.36	homo-dimer	0.59	BLAST	EM	NA	0.61	0.90	Chromaffin granule amine transporter
P54219.1.A	100.00	monomer	-	AFDB search	AlphaFold v2	NA	0.61	1.00	Chromaffin granule amine transporter
8wlj.1.A	65.58	monomer	-	HHblits	EM	NA	0.50	0.88	Synaptic vesicular amine transporter
8wlj.1.A	67.41	monomer	-	BLAST	EM	NA	0.51	0.86	Synaptic vesicular amine transporter
8t6a.1.A	65.93	monomer	-	HHblits	EM	NA	0.50	0.86	Synaptic vesicular amine transporter
8xo9.1.A	65.85	monomer	-	HHblits	EM	NA	0.50	0.86	Synaptic vesicular amine transporter,Synaptic vesicular amine transporter,transporter A
8tgg.1.B	99.77	homo-dimer	0.59	HHblits	EM	NA	0.61	0.82	Chromaffin granule amine transporter
8xit.1.A	66.10	homo-dimer	0.63	HHblits	EM	NA	0.49	0.90	OaVMAT2-BRIL
8xit.1.B	66.10	homo-dimer	0.63	HHblits	EM	NA	0.49	0.90	OaVMAT2-BRIL
8xoa.1.A	66.30	monomer	-	HHblits	EM	NA	0.50	0.86	Synaptic vesicular amine transporter,Synaptic vesicular amine transporter,transporterA
8wlm.1.A	67.41	monomer	-	BLAST	EM	NA	0.51	0.86	Synaptic vesicular amine transporter
8wlm.1.A	65.58	monomer	-	HHblits	EM	NA	0.50	0.88	Synaptic vesicular amine transporter
8wll.1.A	65.52	monomer	-	HHblits	EM	NA	0.50	0.88	Synaptic vesicular amine transporter
8wlk.1.A	65.58	monomer	-	HHblits	EM	NA	0.50	0.88	Synaptic vesicular amine transporter
8wll.1.A	67.18	monomer	-	BLAST	EM	NA	0.51	0.86	Synaptic vesicular amine transporter
8wlk.1.A	67.41	monomer	-	BLAST	EM	NA	0.51	0.86	Synaptic vesicular amine transporter
8t6b.1.A	65.93	monomer	-	HHblits	EM	NA	0.50	0.86	Synaptic vesicular amine transporter
8t6a.1.A	66.23	monomer	-	BLAST	EM	NA	0.51	0.88	Synaptic vesicular amine transporter
8t69.1.A	66.45	monomer	-	BLAST	EM	NA	0.51	0.88	Synaptic vesicular amine transporter
8t6b.1.A	66.23	monomer	-	BLAST	EM	NA	0.51	0.88	Synaptic vesicular amine transporter
8xiu.1.A	66.26	monomer	-	BLAST	EM	NA	0.50	0.94	XlVMAT2
8thr.1.A	67.67	monomer	-	BLAST	EM	NA	0.51	0.82	fluorescent protein mVenus,Synaptic vesicular amine transporter,GFP nano body,Synaptic vesicular amine transporter,Synaptic vesicular amine transporter
8xiu.1.A	66.67	monomer	-	HHblits	EM	NA	0.50	0.88	XlVMAT2
8xit.1.B	63.24	homo-dimer	0.48	BLAST	EM	NA	0.47	0.65	OaVMAT2-BRIL
8xit.1.A	63.24	homo-dimer	0.48	BLAST	EM	NA	0.47	0.65	OaVMAT2-BRIL

The table above shows the top 31 filtered templates. A further 323 templates were found which were considered to be less suitable for modelling than the filtered list.

1pv6.2.A, 1pw4.1.A, 2cfp.1.A, 2cfq.1.A, 2gfp.1.A, 2nop.1.A, 2npd.1.A, 2npg.1.A, 2v8n.1.A, 2xut.1.A, 2y5y.1.A, 2y5y.1.B, 3c1i.1.A, 3o7p.1.A, 3o7q.1.A, 3wdo.1.A, 4aps.1.A, 4d2b.1.A, 4d2c.1.A, 4gc0.1.A, 4ikv.1.A, 4ikw.1.A, 4ikx.1.A, 4iky.1.A, 4iu8.1.A, 4iu8.2.A, 4iu9.2.A, 4ja3.1.A, 4ja4.1.A, 4jr9.1.A, 4lds.1.A, 4lds.1.B, 4lep.3.A, 4m64.1.A, 4m64.2.A, 4m64.3.A, 4m64.4.A, 4oaa.1.A, 4oaa.1.B, 4oh3.1.A, 4oh3.1.B, 4pyp.1.A, 4q65.1.A, 4qiq.1.A, 4tph.1.B, 4tpj.1.A, 4u4t.1.A, 4u4w.1.A, 4uvm.1.A, 4w6v.1.A, 4xni.1.A, 4yb9.1.A, 4ybq.1.A, 4zow.1.A, 4zp0.1.A, 4zw9.1.A, 4zwc.1.A, 4zyr.1.A, 4zyr.2.A, 5a2n.1.A, 5a2n.1.B, 5aym.1.A, 5ayo.1.A, 5c65.1.A, 5d58.1.A, 5d59.1.A, 5d6k.1.A, 5eqg.1.A, 5gxb.1.A, 5mmt.1.A, 5oxk.1.A, 5oxn.1.A, 5v2s.1.A, 6bm8.1.A, 6btx.1.A, 6c9w.1.A, 6e8j.1.A, 6e9c.1.A, 6e9n.1.A, 6e9n.2.A, 6e9o.1.A, 6e9o.2.A, 6eba.1.A, 6ei3.1.A, 6euq.1.A, 6exs.1.A, 6fmr.1.A, 6gs1.1.A, 6gs4.1.A, 6gv1.1.A, 6gz9.1.A, 6h7d.1.A, 6h7u.1.A, 6hcl.1.A, 6ji1.1.A, 6jkc.1.C, 6kki.1.A, 6kkj.1.A, 6kkk.1.A, 6kkl.1.A, 6lyy.1.A, 6lz0.1.A, 6m20.1.A, 6m2l.1.A, 6n3i.1.A, 6ob6.2.A, 6oom.1.A, 6ooq.1.A, 6rw3.1.A, 6rw3.2.A, 6rw3.3.A, 6s4m.1.A, 6s7v.1.A, 6t1z.1.A, 6tha.1.A, 6vbg.1.A, 6vrz.1.A, 6vs1.1.A, 6vyh.1.A, 6w4s.1.A, 6wbv.1.B, 6wik.1.C, 6yof.1.A, 7aaq.1.A, 7aar.1.A, 7ac6.1.A, 7bc6.1.A, 7bp3.1.A, 7c76.1.B, 7c77.1.B, 7cko.1.A, 7ckr.1.A, 7d5p.1.A, 7d5q.1.A, 7da5.1.A, 7dl9.1.A, 7dla.1.A, 7eeb.1.I, 7fci.1.A, 7l16.1.A, 7lo7.1.A, 7lo8.1.A, 7mjs.1.C, 7n98.1.A, 7nqk.1.A, 7oix.1.B, 7pmw.1.A, 7pmx.1.A, 7pmy.1.A, 7pn1.1.A, 7q0l.1.A, 7q0m.1.A, 7s8u.1.A, 7sp5.1.A, 7sps.1.A, 7spt.1.A, 7t3n.1.A, 7t3o.1.A, 7tx6.1.A, 7vad.1.A, 7vaf.1.C, 7vag.1.A, 7vcf.1.A, 7wn0.1.A, 7wn1.1.A, 7wsi.1.A, 7wsm.1.A, 7wsn.1.A, 7xpz.1.A, 7xtk.1.A, 7xzi.1.F, 7y1q.1.A, 7y58.1.A, 7ydq.1.A, 7yr5.1.B, 7yub.1.D, 7zc2.1.A, 7zh0.1.A, 7zh6.1.A, 7zha.1.A, 7zyi.1.A, 8b17.1.A, 8b1g.1.A, 8bb6.1.A, 8bvr.1.A, 8bvs.1.A, 8bvt.1.A, 8bw7.1.A, 8bzy.1.A, 8c02.1.A, 8c03.1.A, 8cni.1.A, 8d2s.1.A, 8d2v.1.A, 8dl6.1.A, 8dl7.1.A, 8dl8.1.A, 8dwi.1.A, 8et6.1.A, 8et9.1.A, 8ex4.1.A, 8ex5.1.A, 8ex6.1.A, 8ex7.1.A, 8ex8.1.A, 8fed.1.K, 8fq9.1.A, 8fvz.1.A, 8g92.1.A, 8goe.1.A, 8hii.1.A, 8hij.1.A, 8hik.1.A, 8hnb.1.A, 8hnc.1.A, 8hnd.1.A, 8hnh.1.A, 8hpj.1.A, 8hpk.1.A, 8hry.1.A, 8jhq.1.A, 8jhr.1.A, 8jlc.1.A, 8jli.1.A, 8jsw.1.A, 8jt9.1.A, 8jta.1.A, 8jtc.1.A, 8jts.1.A, 8jtt.1.A, 8jtv.1.A, 8jtw.1.A, 8jtx.1.A, 8jty.1.A, 8jtz.1.A, 8ju0.1.A, 8jzr.1.A, 8jzs.1.A, 8jzu.1.A, 8k6l.1.A, 8kgi.1.A, 8kgv.1.A, 8p6a.1.A, 8pcz.1.A, 8pd2.1.A, 8pd3.1.A, 8pd5.1.A, 8pd7.1.A, 8pd8.1.A, 8pd9.1.A, 8pdu.1.A, 8pdv.1.A, 8pg0.1.A, 8phw.1.A, 8pnl.1.A, 8pnl.2.A, 8qcs.1.A, 8qct.1.A, 8qcx.1.A, 8qcy.1.A, 8qd0.1.A, 8qsk.1.A, 8r8q.1.A, 8rqf.1.A, 8sbe.1.A, 8sc1.1.A, 8sc2.1.A, 8sc3.1.A, 8sdu.1.A, 8t60.1.A, 8t69.1.A, 8t6a.1.A, 8t6b.1.A, 8tgg.1.A, 8tgg.1.B, 8tgj.1.B, 8tgl.1.A, 8tgl.1.B, 8thr.1.A, 8tte.1.A, 8ttf.1.A, 8ttg.1.A, 8tth.1.A, 8u3d.1.A, 8u3f.1.A, 8u3g.1.A, 8u3h.1.A, 8ubw.1.A, 8ubx.1.A, 8ubz.1.A, 8uc0.1.A, 8uo8.1.A, 8uo9.1.A, 8vzn.1.A, 8vzo.1.A, 8wlj.1.A, 8wlk.1.A, 8wll.1.A, 8wlm.1.A, 8wx2.1.A, 8wx3.1.A, 8wx5.1.A, 8xit.1.A, 8xit.1.B, 8xiu.1.A, 8xo9.1.A, 8xoa.1.A, 8xq7.1.A, 8xq8.1.A, 8xv2.1.A, 8xv9.1.A, 8y65.1.A, 8y66.1.A, 8yf0.1.A, 8yf0.1.B, 8yf1.1.A, 8yf1.1.B, 8zmr.1.A, 8zms.1.A, 9ayb.1.A, 9bir.1.A, 9biu.1.A, 9g11.1.A