**Table S1: The related prediction methods for membrane protein features.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Method | Year | Model | Prediction | URL |
| $α-$helical transmembrane protein |
| TMHMM2.0 [1] | 2001 | HMM | Topology | https://services.healthtech.dtu.dk/service.php?TMHMM-2.0 |
| MEMSAT3 [2] | 2007 | NN | http://bioinf.cs.ucl.ac.uk/?id=756 |
| OCTOPUS [3] | 2008 | HMM, ANN | http://topcons.net/ |
| SCAMPI2 [4] | 2016 | HMM | http://scampi.bioinfo.se/ |
| MemBrain3.0 [5] | 2020 | ResNet | http://www.csbio.sjtu.edu.cn/bioinf/MemBrain/ |
| PolyPhobius [6] | 2005 | HMM | TopologySignal peptide | http://phobius.sbc.su.se/poly.html |
| Philius [7] | 2008 | DBN | http://www.yeastrc.org/philius/pages/philius/runPhilius.jsp |
| SPOCTOPUS [8] | 2008 | HMM, ANN | http://topcons.net/ |
| TOPCONS2 [9] | 2009 | HMM | http://topcons.net/ |
| MEMSAT-SVM [10] | 2009 | SVM | http://bioinf.cs.ucl.ac.uk/psipred/ |
| CCTOP [11] | 2015 | HMM | http://cctop.enzim.ttk.mta.hu/ |
| MPRAP [12] | 2010 | SVM | Surface accessibility | https://mprap.cbr.su.se/ |
| $β-$barrel transmembrane protein |
| PROFtmb [13] | 2006 | HMM | Topology | https://www.predictprotein.org/ |
| BetAware [14] | 2013 | ELM, GRHCRF | http://betaware.biocomp.unibo.it/BetAware |
| BOCTOPUS2 [15] | 2016 | SVM, HMM | http://boctopus.bioinfo.se/ |
| PRED-TMBB2 [16] | 2016 | HMM | http://www.compgen.org/tools/PRED-TMBB2/ |
| $α-$helical transmembrane protein or $β-$barrel transmembrane protein |
| BCL::Jufo9D [17] | 2013 | ANN | Transmembrane spans | http://meilerlab.org/index.php/servers/show?s\_id=5 |
| mp\_lipid\_acc [18] | 2017 | Concave hull algorithm | Lipid accessibility | https://rosie.graylab.jhu.edu/mp\_lipid\_acc/submit |

HMM: Hidden Markov model; NN: Neural network; DBN: Dynamic Bayesian network; ANN: Artificial neural network; SVM: Support vector machine; ELM: Extreme learning machine; GRHCRF: Grammatical-restrained hidden conditional random field.

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