

**Table S5:** For each of R1 to R8, the average Tc of paired GRASP fingerprints over drug-target pairs of all promiscuous drugs in the corresponding cluster, and that over  $10^5$  clusters, each having interactions randomly selected out of the original 8,475 promiscuous drug-target pairs and keeping the cluster size the same as that of the corresponding cluster.

Cluster	R1	R2	R3	R4	R5	R6	R7	R8
Average Tc of GRASP fingerprints	0.3384	0.2739	0.3627	0.2801	0.3998	0.3510	0.4113	0.4930
Average Tc of GRASP fingerprints over $10^5$ random clusters (RC)	0.03938	0.03938	0.03938	0.03936	0.03938	0.03938	0.03939	0.03938
Standard deviation of RC	0.00408	0.00397	0.00141	0.00498	0.00252	0.00280	0.00444	0.00227
Maximum of RC	0.061	0.06227	0.0466	0.06966	0.05120	0.05320	0.06454	0.04962