# Learned chemical perception of force field typing rules using Monte Carlo sampling

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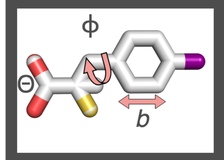
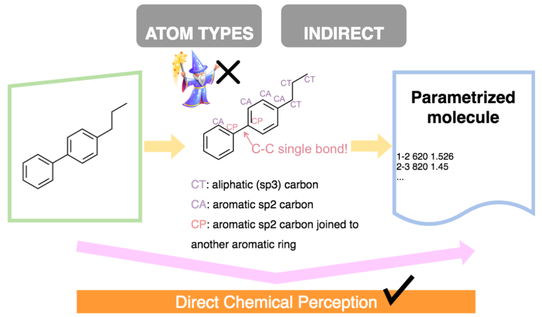
## BACKGROUND

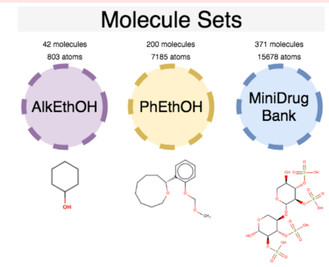
- FORCE FIELDS (FF) GIVE THE ENERGY AND FORCES OF AN ATOMISTIC SYSTEM AS A FUNCTION OF THE COORDINATES.
- WE USE FF TO RUN MD OR MC SIMULATIONS.
- CONSIDERABLE HUMAN EXPERTISE IS REQUIRED FOR FF DEVELOPMENT.
- CHEMICAL PERCEPTION THROUGH ATOM TYPES (INDIRECT) CAN RELY IN EXPERT HUMAN INTUITION AND HAND-TWEAKING, CAN RESULT IN A POOR DATA STRUCTURE, AND CAN LEAD TO MANY REDUNDANT PARAMETERS.




WE DEVELOPED TWO TOOLS → SMARTY → ATOM TYPES; SMIRKY → FRAGMENTS




## INPUT

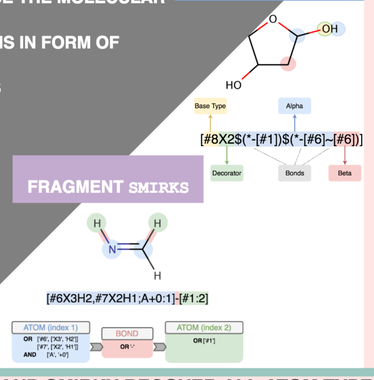



**GOAL: BE ABLE TO LEARN CHEMICAL PERCEPTION OF MOLECULES WHILE SAMPLING OVER ATOM TYPES OR FRAGMENTS**

## METHODS

SMARTS AND SMIRKS LANGUAGES ARE USED TO DESCRIBE THE MOLECULAR PATTERNS IN FORM OF STRINGS

**ATOM TYPE SMARTS**

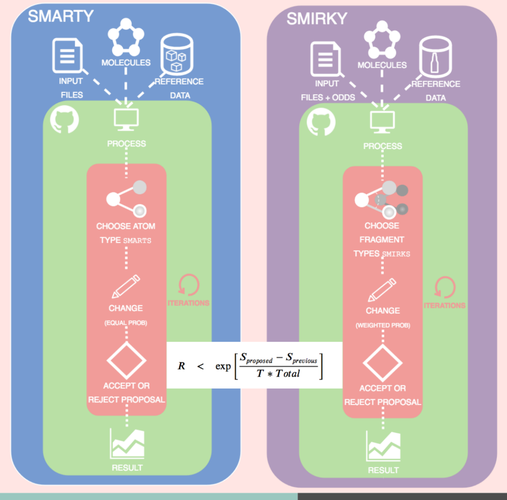



**FRAGMENT SMIRKS**



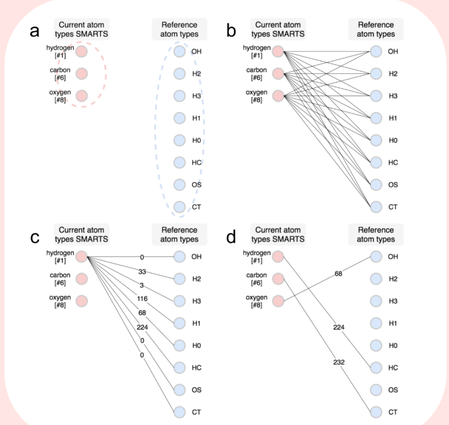

## SMARTY AND SMIRKY REPLACE HAND PICKED ATOM TYPES USING MONTE CARLO SAMPLING

### WORKFLOW




$$R < \exp\left[\frac{S_{proposed} - S_{previous}}{T * Total}\right]$$

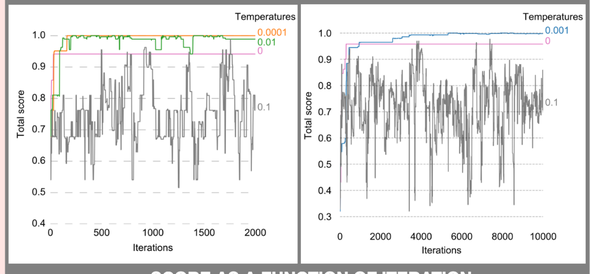
### PROPOSED ATOM TYPES OR FRAGMENTS ARE SCORED USING A BIPARTITE GRAPH




## RESULTS

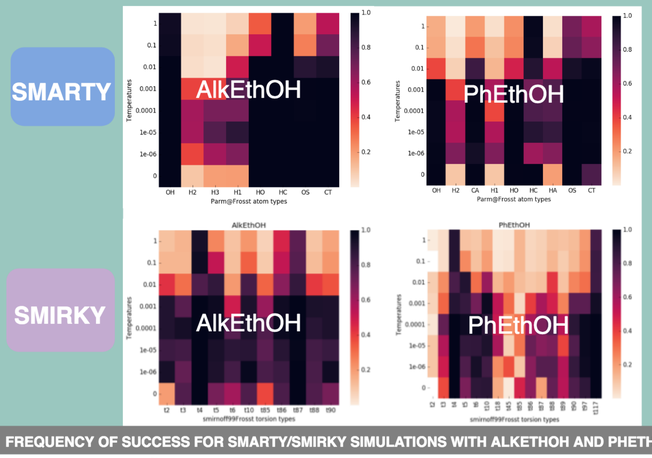
**SMARTY** **SMIRKY**

**100 % SUCCESS ON *AlkEthOH* AND *PhEthOH* SETS**




**SCORE AS A FUNCTION OF ITERATION**

### SMARTY AND SMIRKY RECOVER ALL ATOM TYPES AND FRAGMENTS OF *AlkEthOH* AND *PhEthOH*




**FREQUENCY OF SUCCESS FOR SMARTY/SMIRKY SIMULATIONS WITH ALKETHOH AND PHETHOH**

### *MiniDrugBank* IS SIGNIFICANTLY MORE CHALLENGING FOR SMARTY AND SMIRKY

| | AlkEthOH | PhEthOH | MiniDrugBank |
|---|---|---|---|
| SMARTY * | 100% | 100% | 89.2% |

| SMIRKY ** | BOND | ANGLE | TORSION | NONBONDED |
|---|---|---|---|---|
| AlkEthOH | 5/5 | 4/4 | 11/11 | 8/8 |
| PhEthOH | 10/10 | 6/6 | 16/16 | 9/9 |
| MiniDrugBank | 68/73 | 32/34 | 117/136 | 25/26 |

*PERCENTAGEM OF ATOM TYPES FOUND.
**NUMBER OF FRAGMENTS FOUND OVER THE TOTAL NUMBER OF FRAGMENTS.

## CONCLUSION

THIS STUDY DEMONSTRATES PROMISING RESULTS WHERE WE CAN REPLACE THE HUMAN EXPERT WITH AN AUTOMATED MACHINERY FOR SAMPLING DIRECT CHEMICAL PERCEPTION.

## ACKNOWLEDGEMENTS

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