CS339: Abstractions and Paradigms for Programming

Logic Paradigm

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Declarative vs Operational

- **Square root** of x:
  - A number y such that $y^2 = x$ Declarative
  - Newton's method

Operational

```
(define (sqrt x)
  (define (good-enough? guess)
    (< (abs (- (square guess) x)) 0.001))
  (define (improve guess)
    (average guess (/ x guess)))
  (define (sqrt-iter guess)
    (if (good-enough? guess)
        guess
        (sqrt-iter (improve guess))))
  (sqrt-iter 1.0))
```

Sum a list of numbers: Imperative (Java)

```java
int sum(int[] list) {
    int result = 0;
    for (int i = 0; i < list.length; i++) {
        result += list[i];
    }
    return result;
}
```

Sum a list of numbers: Functional (Scheme)

```
(define (sum list)
   (if (null? list)
       0
       (+ (car list) (sum (cdr list)))))
```

Sum a list of numbers: Logic (Prolog)

```
sum([], 0).
sum([H | T], N) :- sum(T, M), N is H + M.
```

Functional is sometimes close to declarative, but logic is closer.

Logic Paradigm

- Programs consist of just facts and rules.
- Not necessary to describe the “procedure” or the control flow at a very low-level.
- Who does the computation then?
- In other words, who has the onus of translating the “declarative” description to an “algorithm” that computes on the von-Neumann architecture?
  - The Interpreter!

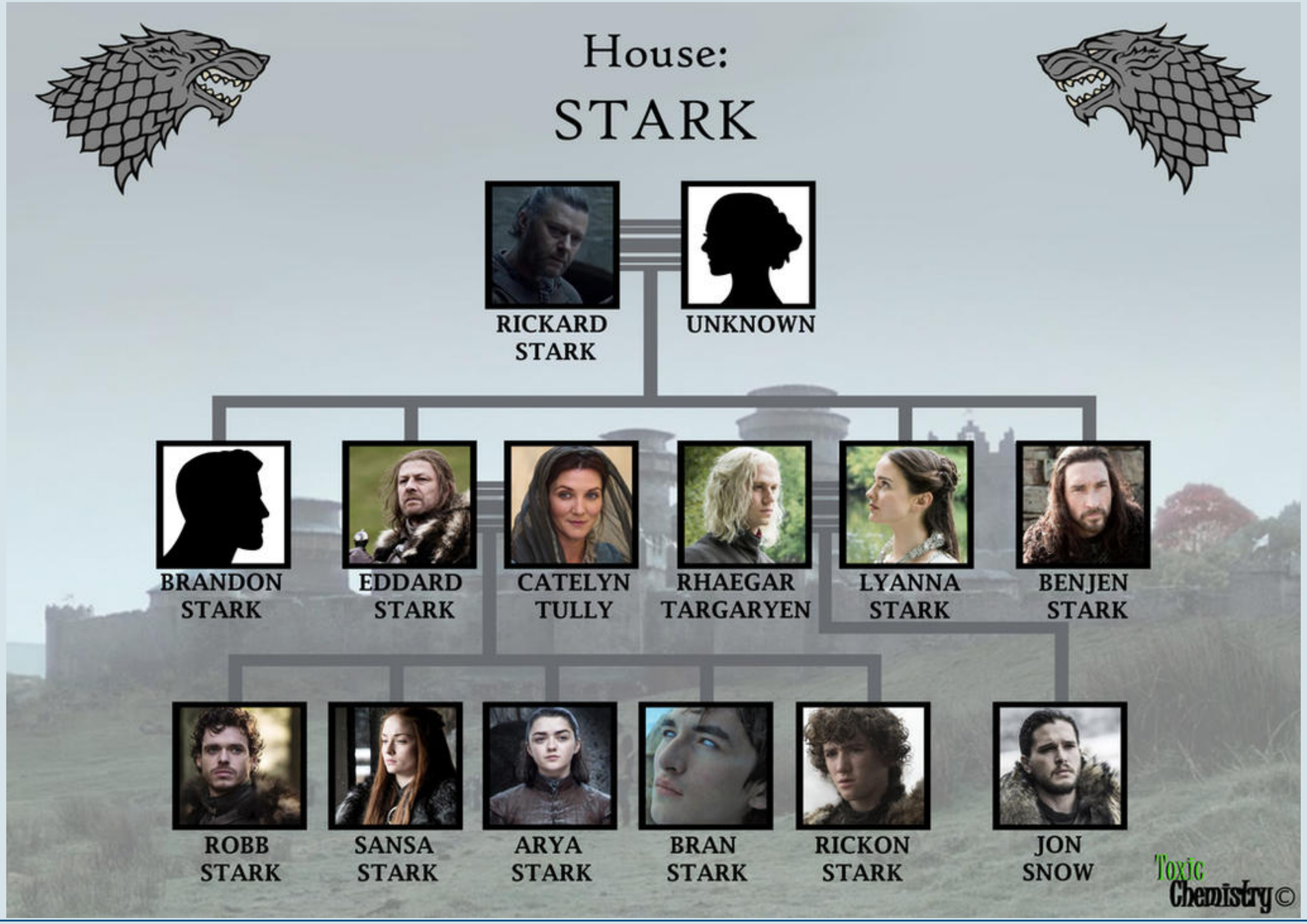
Logic Paradigm: Usage

- Prolog quite popular in rule-based Artificial Intelligence.
- Datalog becoming very popular in program analysis, code optimization, and type inference.
- SQL already the de-facto of relational databases.

Predicates and Horn Clauses

- If it is precipitating in a city C and the temperature in C is freezing, then it is snowing in C.
  - `snowing(C); precipitation(C); freezing(C)` Predicates
  - `snowing(C) <- precipitation(C) AND freezing(C)` Horn clauses

- When does it snow at Mumbai?
  - **Instantiate** the variables.


House:
STARK
RICKARD STARK
UNKNOWN
BRANDON STARK
EDDARD STARK
CATELYN TULLY
RHAEGAR TARGARYEN
LYANNA STARK
BENJEN STARK
ROBB STARK
SANSA STARK
ARYA STARK
BRAN STARK
RICKON STARK
JON SNOW
Toxic Chemistry©

(The Shortest?) Introduction to Prolog

- Two kinds of *terms*:
  - Facts
    - `father(ned, arya).`
    - `mother(catelyn, bran).`
  - Rules
    - `parent(X, Y) :- father(X, Y).`
    - `parent(X, Y) :- mother(X, Y).`
    - `grandparent(X, Z) :- parent(X, Y), parent(Y, Z).`

Rules of the game (*aka Syntax*):

- Constants start with small letters.
- Variables start with capital letters.
- Full stop necessary after each fact/rule.
- No space before the opening parenthesis.
- Multiple terms with the same *head* indicate disjunction.
- A comma between terms indicates conjunction.

Querying in Prolog

- `?- father(ned, sansa).`
- `?- grandparent(rickard, bran).`

Homework: Define rules *cousin, uncle, aunt, sibling*.

Closed World Assumption

- Inferences can be drawn only from known facts.