CS 186 - Week 12

ARIES and ER Modeling

Last time

- Logging
  - Write ahead logging protocol
- Buffer Policies
  - STEAL vs. NO STEAL
  - FORCE vs. NO FORCE
- Transaction State
  - Transaction Table
  - Dirty Page Table
  - Checkpoints

Today

- ARIES Protocol for Crash Recovery
  - How do we achieve Atomicity and Durability
    - **In the face of failures.**
    - With STEAL/NO-FORCE Buffer Management policy.
- ER Modeling
  - Pivot!
  - What's the right way to model data before we create a database.

Crash Recovery

- System crashes.
- General plan?
  - Re-apply changes made by committed xacts to make sure they get to disk.
  - Undo changes made by in-flight xacts, as they didn’t get to finish.

Crash Recovery

- 3 stages:
  - Analyze: Rebuild Xact Table and Dirty Page Table
  - REDO: Redo all actions.
  - UNDO: Undo effects of failed xacts.
- Why REDO some changes just to UNDO them?
  - Keeps recovery simple and straightforward.
- When does REDO start?
  A. Oldest LSN in Dirty Page Table
  B. Oldest LSN in Transaction Table

Crash Recovery

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- When does REDO start?

A. <u>Oldest LSN in Dirty Page Table</u>

B. Oldest LSN in Transaction Table

Details: Analyze

- Starts at first LSN since last checkpoint.
- Rebuilding Dirty Page Table
  - Start from checkpoint DPT.
  - Add new entry for every dirtied page.
  - NOTE: We don't know if things got flushed since the last checkpoint, so this is just a **conservative approximation** of the DPT.
- Rebuilding Xact table
  - Start from checkpoint Xact table.
  - Add/change Xact states & lastLSNs as you go.
  - Remove Xacts when you see END.
  - The Xact table will be **precisely correct** at the end.

Details: REDO

- Start at the smallest recLSN in the DPT.
- Redo each log record or CLR
- Optimization: don't REDO things in the following cases:
  - Affected page not in DPT
  - Affected page in DPT but recLSN > LSN of record
    - recLSN is LSN of first update that dirtied the page. If recLSN > LSN, it means that the LSN that made changes to that change has already been committed to disk.
  - pageLSN >= LSN (pageLSN is on the page in disk – the most recent LSN written to that page)
    - If the page is more up to date than the LSN you're considering to redo, then it already has that LSN's changes

Details: UNDO

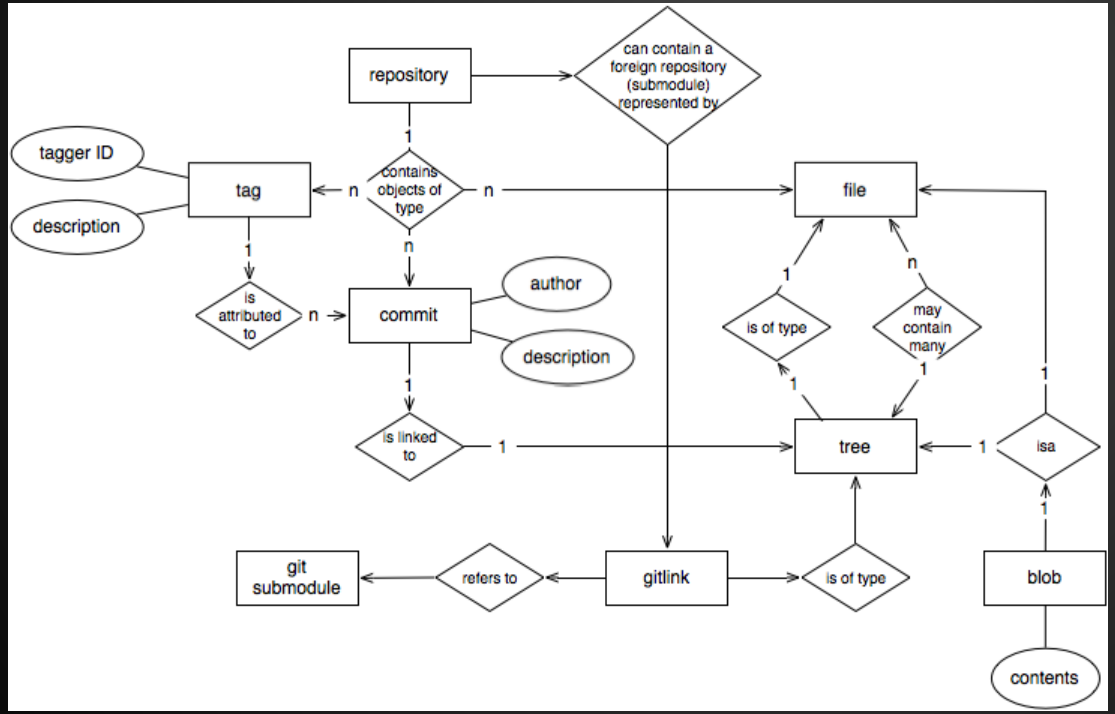
- ToUndo = {lastLSN of all Xacts in Xact Table}
- while ToUndo not empty:
  - Choose largest LSN in ToUndo (most recent)
  - If LSN is an update record:
    - UNDO, write CLR, and add **prevLSN** to ToUndo.
  - If LSN is a CLR and undoNextLSN != null:
    - Add undoNextLSN to ToUndo
  - If LSN is a CLR and undoNextLSN == null:
    - Write END

Questions?

- Worksheet!

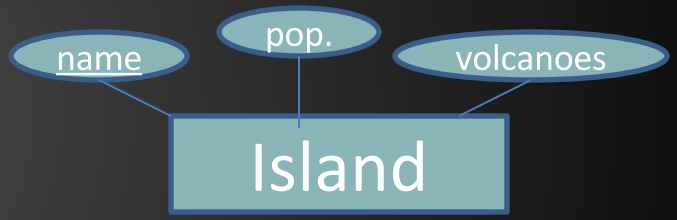
ER Diagrams: Motivation

- Visualize data schema



ER Diagrams: Entities

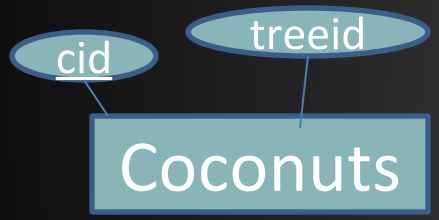
- Example: Examining coconuts falling on the islands of Hawai'i.

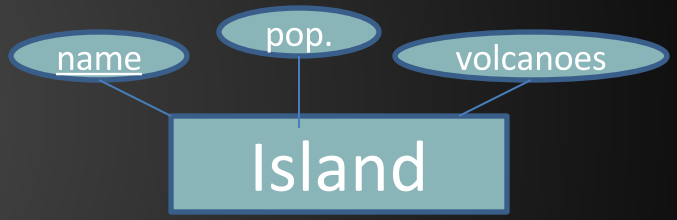


- Entity: "Thing"
- Attribute: Properties of entities
  - Primary key underlined

ER Diagrams: Relationships

- Need to talk about how they interact.





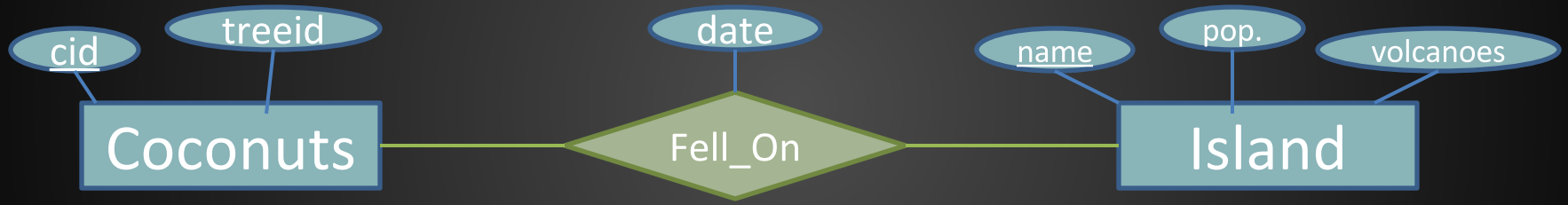
ER Diagrams: Relationships

- Need to talk about how they interact.

- Example: Coconut 3 fell on Oahu.

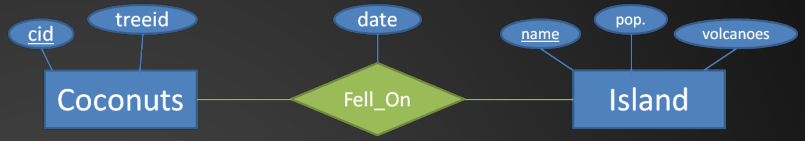
ER Diagrams: Relationships

- Want to add attribute: “date of falling”.



- Example: Coconut 3 fell on Oahu on 9/12.

ER Diagrams: Constraints



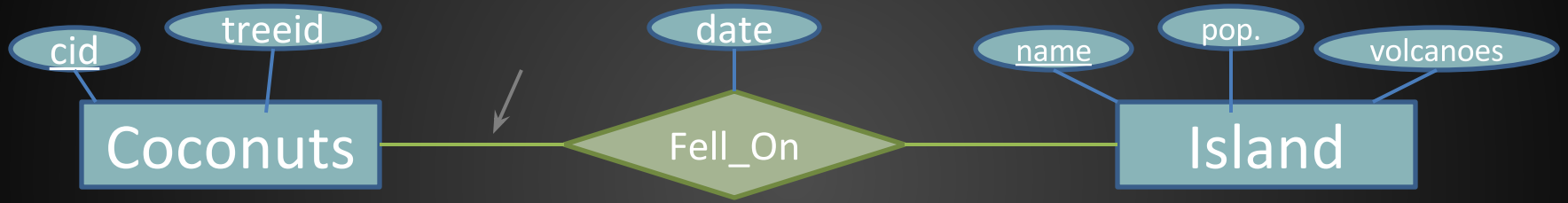
- Make relationship lines meaningful
- Participation constraint (Total / Partial)
  - Total participation: participates at least once
- Key / Non-Key constraint
  - Key: Participates at most once

	Partial Participation	Total Participation
Non-Key	0 or more	1 or more
Key	0 or 1	Exactly 1

Typo alert!

ER Diagrams: Constraints

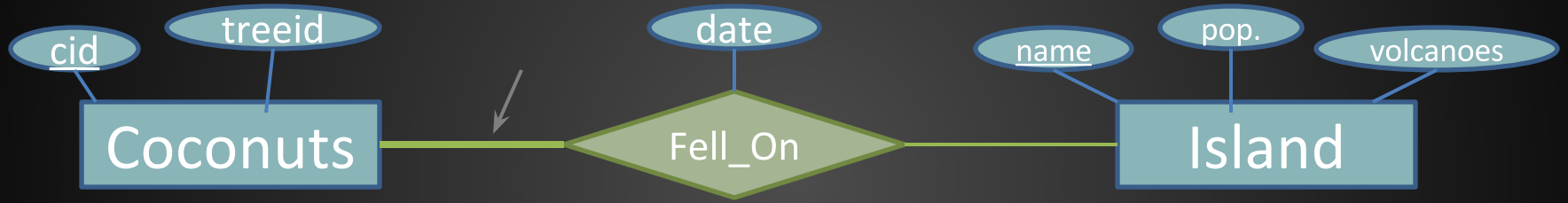
- What constraint do we want from Coconuts?



- Currently: “Coconuts participates in the Fell_On Relationship zero or more times.”
- English?
  - A coconut can fall on an island zero or more times.
  - Slightly more precise: A coconut can fall zero or more times.

ER Diagrams: Constraints

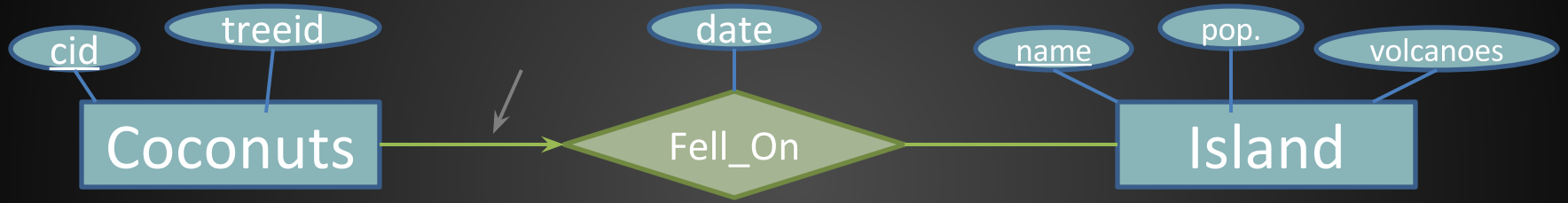
- What constraint do we want from Coconuts?



- A coconut must fall at least once.

ER Diagrams: Constraints

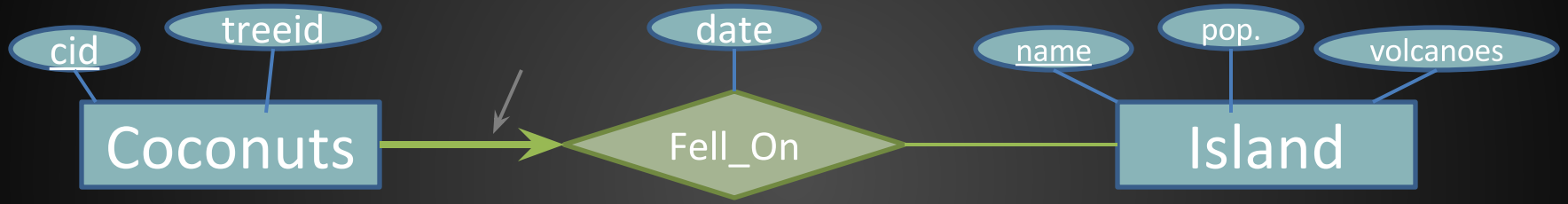
- What constraint do we want from Coconuts?



- A coconut can fall 0 or 1 times.

ER Diagrams: Constraints

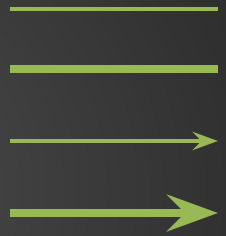
- What constraint do we want from Coconuts?



- A coconut falls exactly once.

ER Diagrams: Constraints

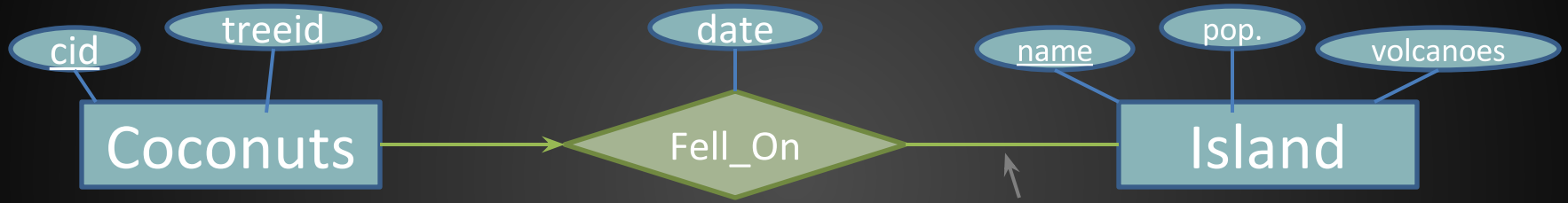
- What constraint do we want from Coconuts?
  - A. A coconut falls 0 or more times.
  - B. A coconut falls 1 or more times.
  - C. A coconut falls 0 or 1 times.
  - D. A coconut falls exactly once.



- Probably C. Could argue for any, though!

ER Diagrams: Constraints

- What constraint do we want from **Island**?



A. An island can be fell upon 0 or more times.

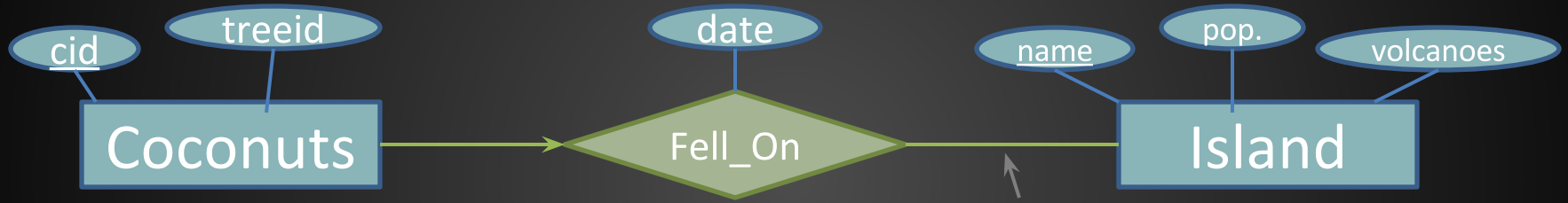
B. An island can be fell upon 1 or more times.

C. An island can be fell upon 0 or 1 times.

D. An island can be fell upon exactly once.

ER Diagrams: Constraints

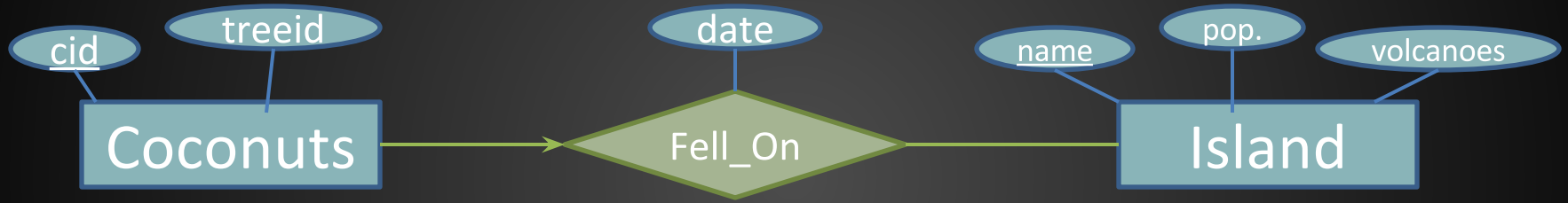
- What constraint do we want from **Island**?



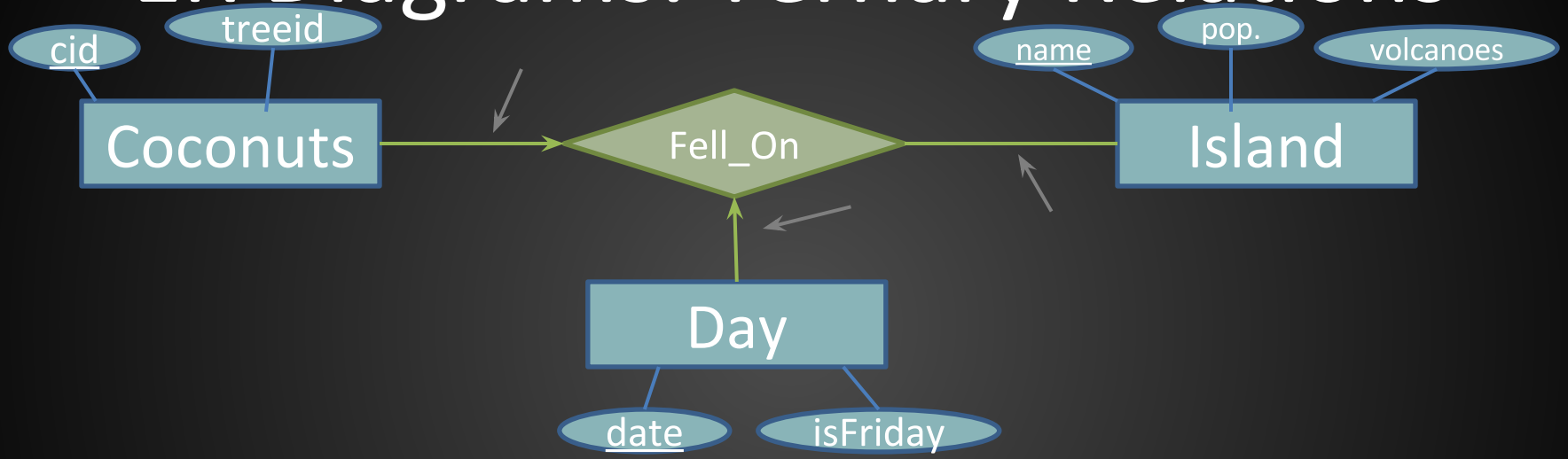
A. **An island can be fell upon 0 or more times.**
B. An island can be fell upon 1 or more times.
C. An island can be fell upon 0 or 1 times.
D. An island can be fell upon exactly once.

ER Diagrams: Constraints

- Done!

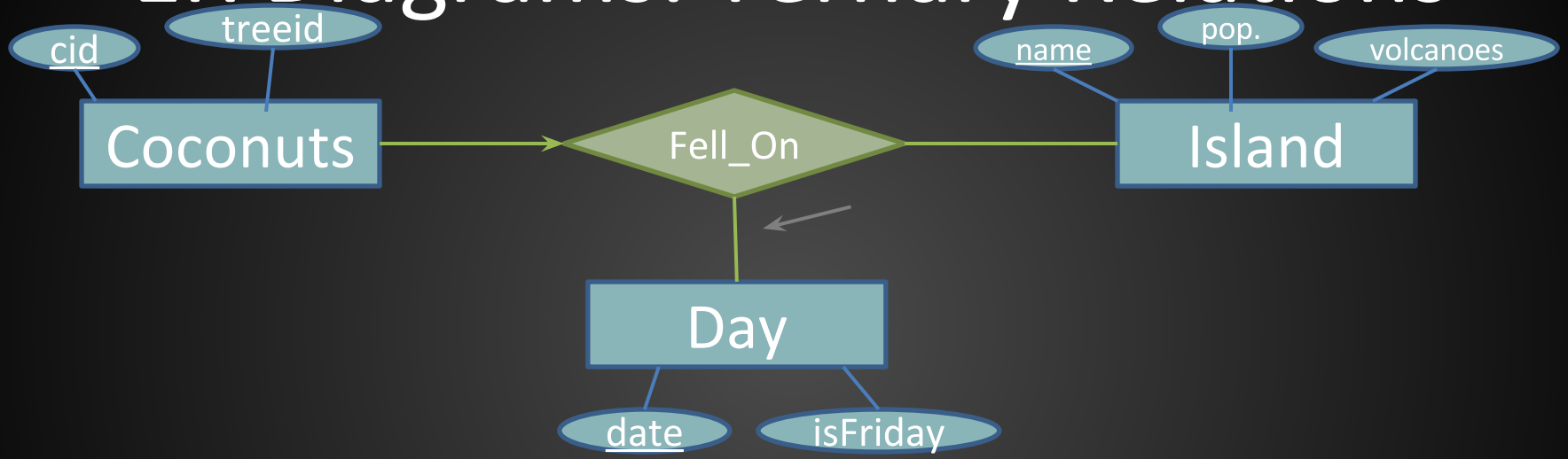


ER Diagrams: Ternary Relations



- Coconuts may fall 0 or 1 times.
- Islands may be fell upon 0 or more times.
- Falling can occur 0 or 1 times during a day.
  - ????

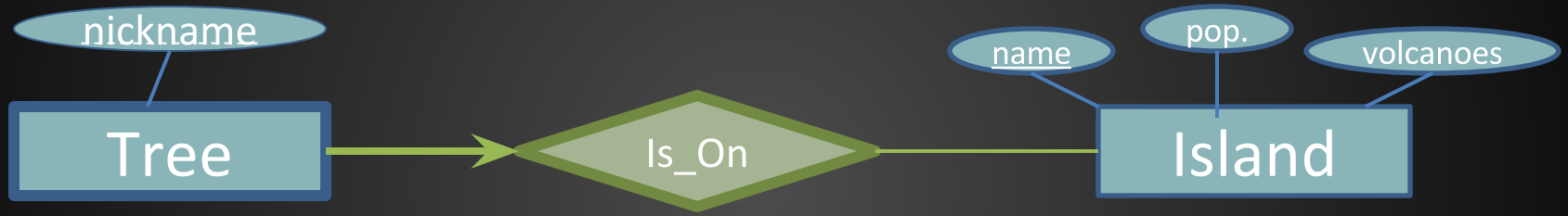
ER Diagrams: Ternary Relations



- Coconuts may fall 0 or 1 times.
- Islands may be fell upon 0 or more times.
- Falling can occur 0 or **more** times during a day.

ER Diagrams: Weak Entities

- Idea: entity which only makes sense with a parent one.



- A Tree's key is actually (Island.name, Tree.nickname).
- Can there be 2 Trees with the same nickname?
  - On the same island?
- Can a Tree exist without an Island?
  - Can we use something other than a bold arrow constraint?

Worksheet time!