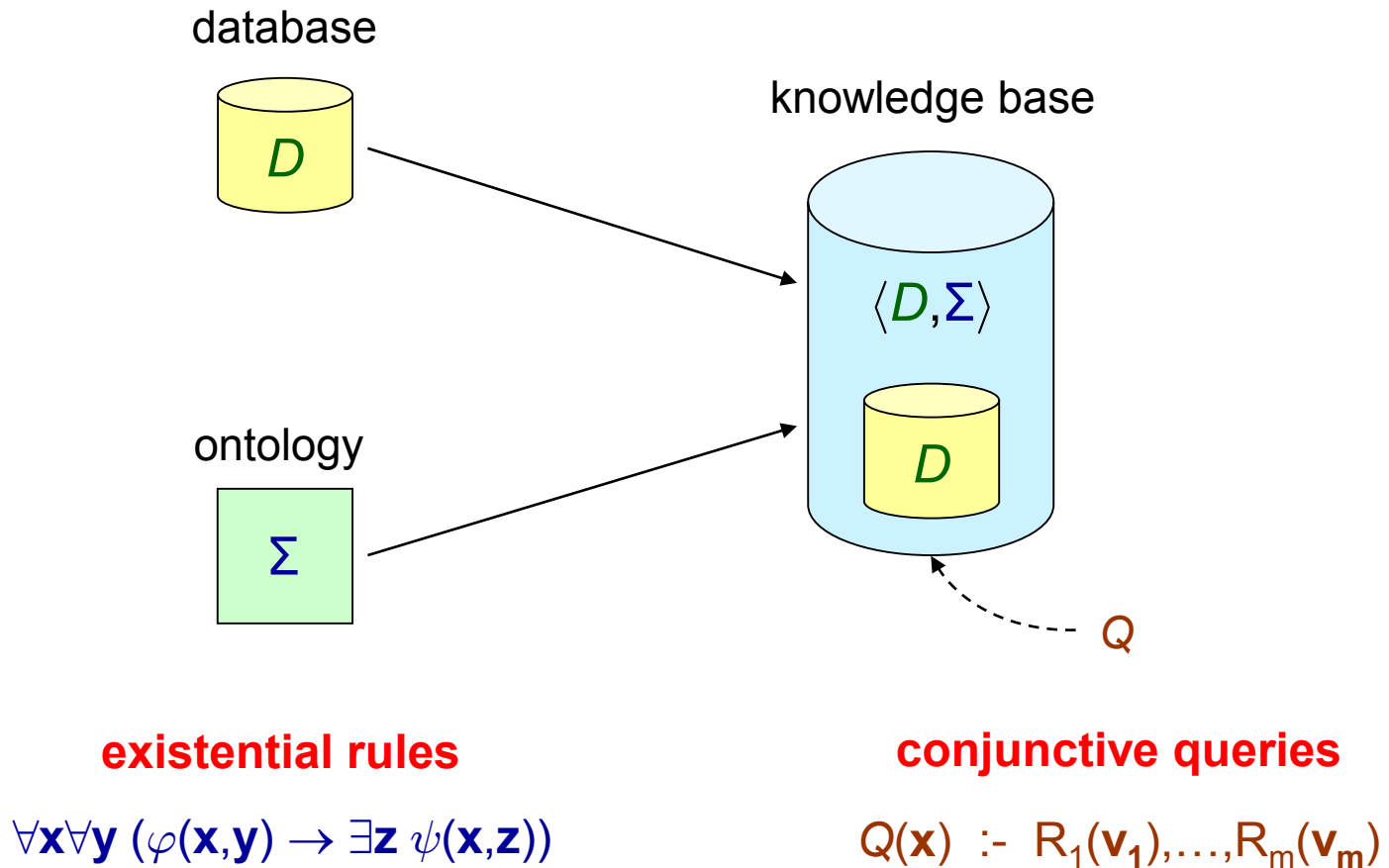


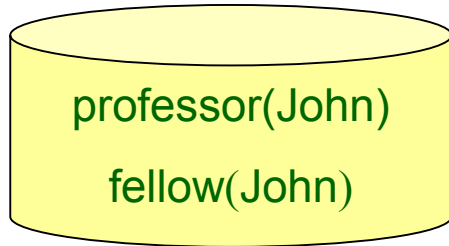
Consistent Query Answering in OBDA

Ontology-Based Query Answering (OBQA)



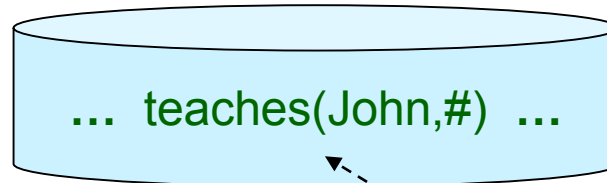
A Simple Example

$D =$



$\Sigma =$

$\forall x (\text{professor}(x) \rightarrow \exists y (\text{faculty}(x) \wedge \text{teaches}(x,y)))$
 $\forall x (\text{fellow}(x) \rightarrow \text{faculty}(x))$



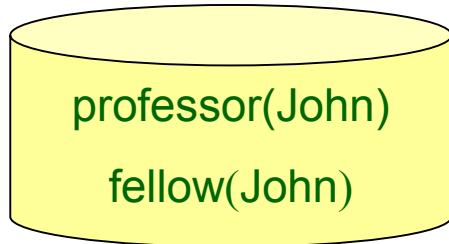
$\{\text{John} \rightarrow \text{John}, x \rightarrow \#\}$

$Q :- (\text{teaches}(\text{John},x))$



A Simple Example

$D =$



$\Sigma =$

$\forall x (\text{professor}(x) \rightarrow \exists y (\text{faculty}(x) \wedge \text{teaches}(x,y)))$

$\forall x (\text{fellow}(x) \rightarrow \text{faculty}(x))$

$\forall x (\text{professor}(x) \wedge \text{fellow}(x) \rightarrow \perp)$

no model \Rightarrow every query is entailed

Handling Data Inconsistencies

- The data are likely to be **inconsistent** with the ontology
- **Standard semantics fails**: everything is inferred - not meaningful answers
- Two approaches to inconsistency-handling:
 - Resolve the inconsistencies - ideal, but not always possible
 - Live with the inconsistencies - **inconsistency-tolerant semantics**

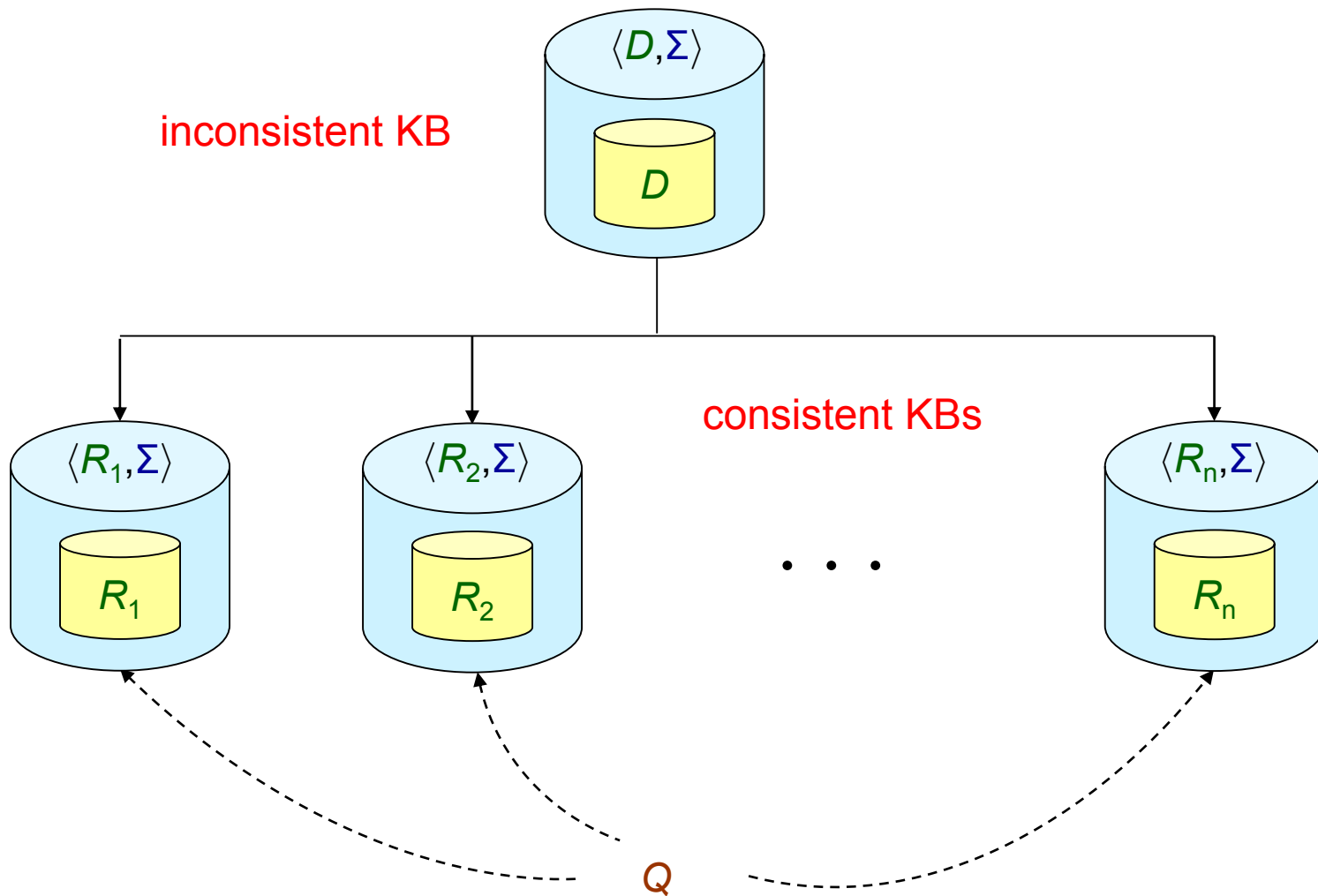
ABox Repair (AR) Semantics

- Standard inconsistency-tolerant semantics
- **IDEA:** The query must be entailed by every **database repair**

⊆-maximal consistent subsets of the database



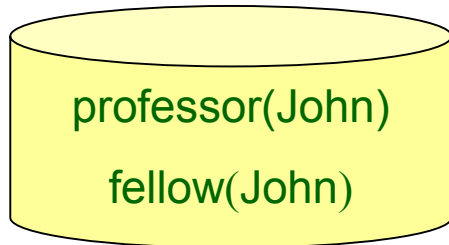
ABox Repair (AR) Semantics



$$\text{AR-answers}(Q, \langle D, \Sigma \rangle) = \bigcap_{R \in \{R_1, \dots, R_n\}} \text{certain-answers}(Q, \langle R, \Sigma \rangle)$$

ABox Repair (AR) Semantics: Example

$D =$



$\Sigma =$

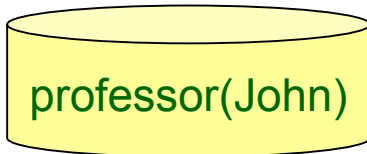
$\forall x (\text{professor}(x) \rightarrow \exists y (\text{faculty}(x) \wedge \text{teaches}(x,y)))$

$\forall x (\text{fellow}(x) \rightarrow \text{faculty}(x))$

$\forall x (\text{professor}(x) \wedge \text{fellow}(x) \rightarrow \perp)$

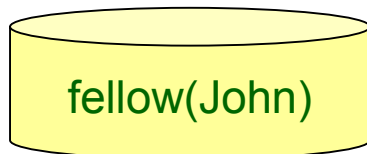
$Q :- \text{faculty}(\text{John})$ ✓

$R_1 =$



$() \in \text{AR-answers}(Q, \langle R_1, \Sigma \rangle)$

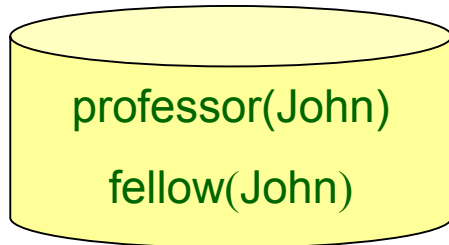
$R_2 =$



$() \in \text{AR-answers}(Q, \langle R_2, \Sigma \rangle)$

ABox Repair (AR) Semantics: Example

$D =$



$\Sigma =$

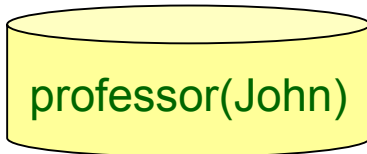
$\forall x (\text{professor}(x) \rightarrow \exists y (\text{faculty}(x) \wedge \text{teaches}(x,y)))$

$\forall x (\text{fellow}(x) \rightarrow \text{faculty}(x))$

$\forall x (\text{professor}(x) \wedge \text{fellow}(x) \rightarrow \perp)$

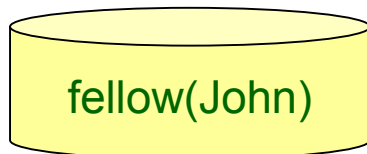
$Q :- \text{teaches}(\text{John},x) \quad \mathbf{x}$

$R_1 =$



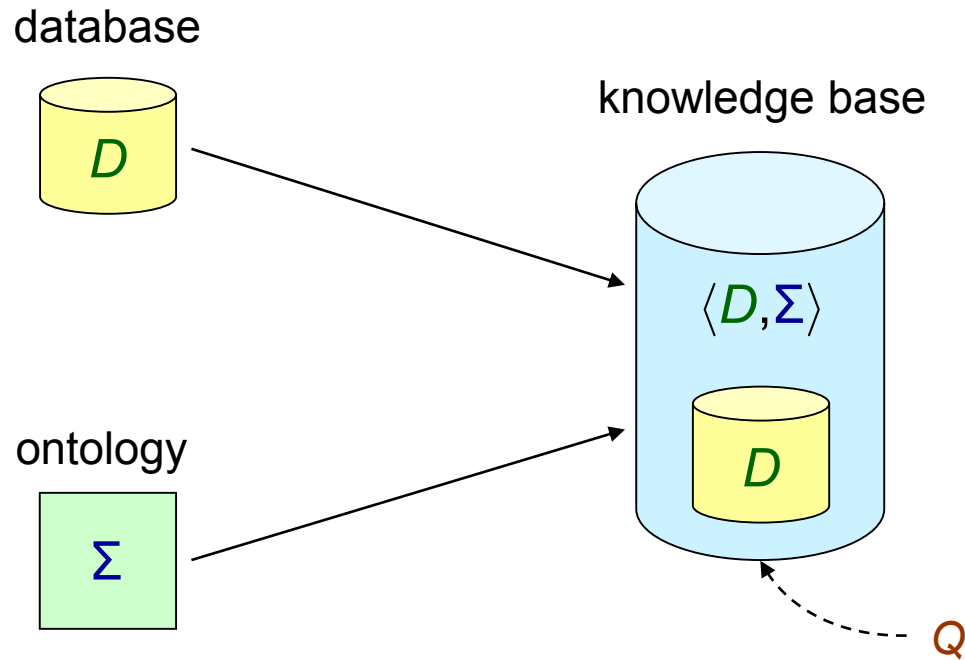
$() \in \text{AR-answers}(Q, \langle R_1, \Sigma \rangle)$

$R_2 =$



$() \notin \text{AR-answers}(Q, \langle R_2, \Sigma \rangle)$

Consistent Query Answering in OBQA



existential rules + negative constraints

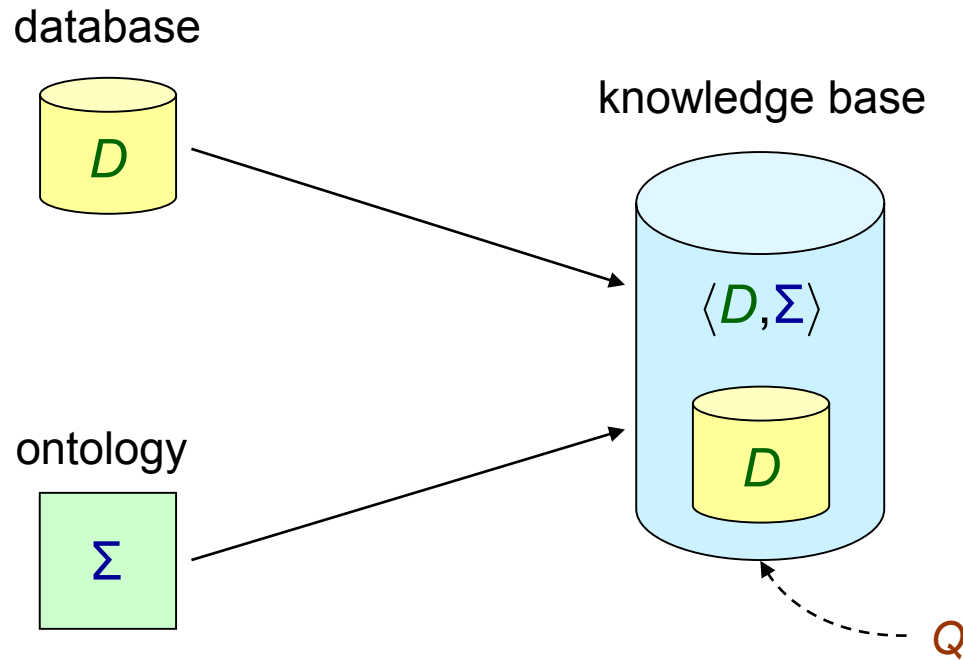
$$\forall \mathbf{x} \forall \mathbf{y} (\varphi(\mathbf{x}, \mathbf{y}) \rightarrow \exists \mathbf{z} \psi(\mathbf{x}, \mathbf{z}))$$

$$\forall \mathbf{x} (\varphi(\mathbf{x}) \rightarrow \perp)$$

conjunctive queries

$$Q(\mathbf{x}) \text{ :- } R_1(\mathbf{v}_1), \dots, R_m(\mathbf{v}_m)$$

Consistent Query Answering in OBQA



$$\text{AR-answers}(Q, \langle D, \Sigma \rangle) = \bigcap_{R \in \text{drep}(D, \Sigma)} \text{certain-answers}(Q, \langle R, \Sigma \rangle)$$

$$\{D' \mid D \supseteq D', \text{models}(D' \wedge \Sigma) \neq \emptyset, \text{there is no } \alpha \in D \text{ such that } \text{models}(D' \cup \{\alpha\} \wedge \Sigma) \neq \emptyset\}$$

Consistent Query Answering in OBQA

Guess and check algorithm (for the complement of the problem)

Input: D , Σ , $Q(\mathbf{x})$, tuple \mathbf{t}

1. Guess $R \subseteq D$ - a possible repair

2. Verify that R is a repair, i.e., $\langle R, \Sigma \rangle$ is consistent and R is \subseteq -maximal

3. Verify that $\langle R, \Sigma \rangle$ does not entail $Q(\mathbf{t})$

we exploit classical query answering

- 2.1. Check that for every $\forall \mathbf{x} (\varphi(\mathbf{x}) \rightarrow \perp) \in \Sigma$, $\langle R, \Sigma \rangle$ does not entail $Q :- \varphi(\mathbf{x})$

- 2.2. Check that for every $\alpha \in D \setminus R$, there exists $\forall \mathbf{x} (\varphi(\mathbf{x}) \rightarrow \perp) \in \Sigma$, such that $\langle R \cup \{\alpha\}, \Sigma \rangle$ entails $Q :- \varphi(\mathbf{x})$

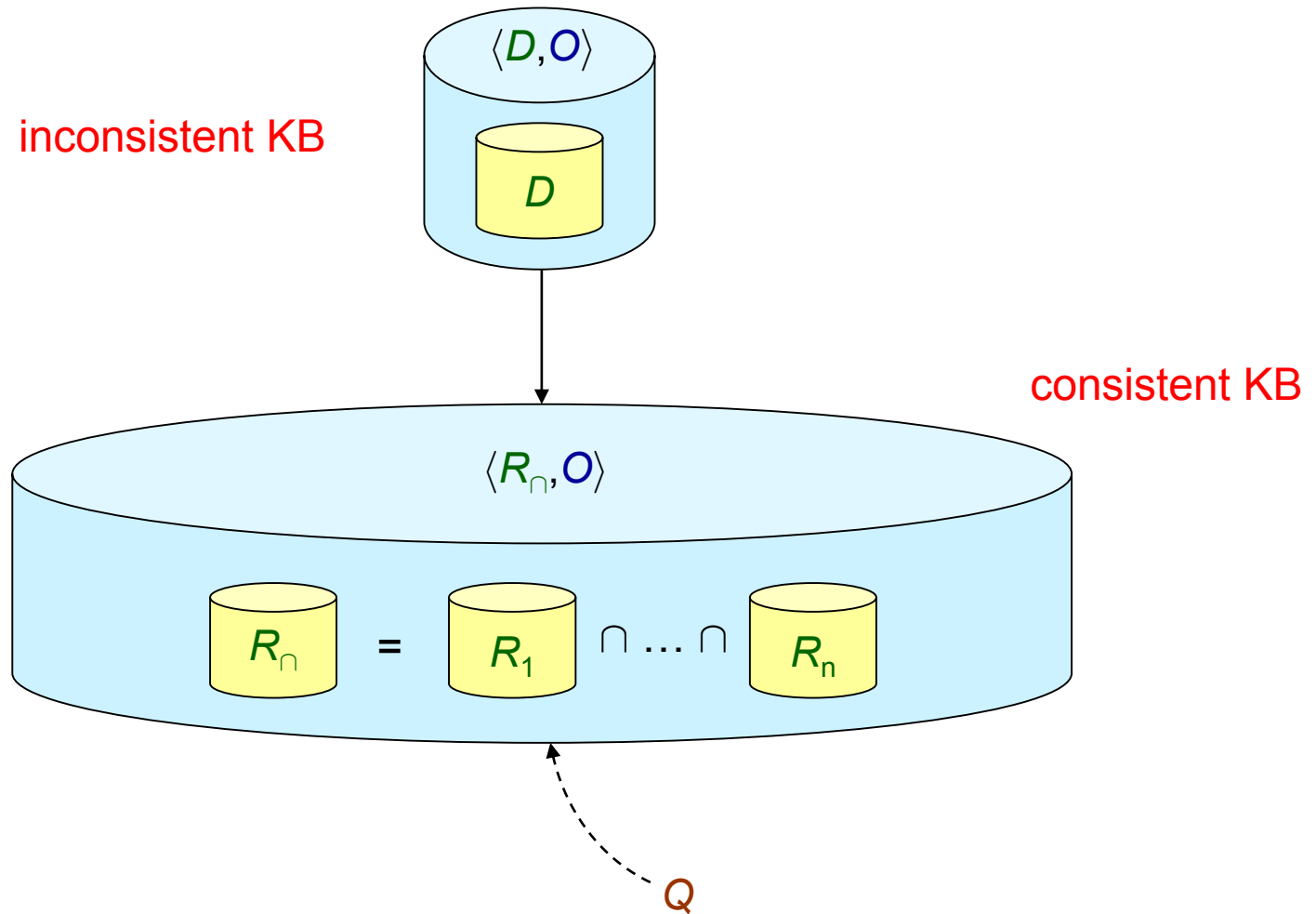
Intersection ABox Repair (IAR) Semantics

- One of the basic sound approximations of the AR semantics
- **IDEA:** The query must be entailed by the **intersection of the database repairs**

\subseteq -maximal consistent subsets of the database

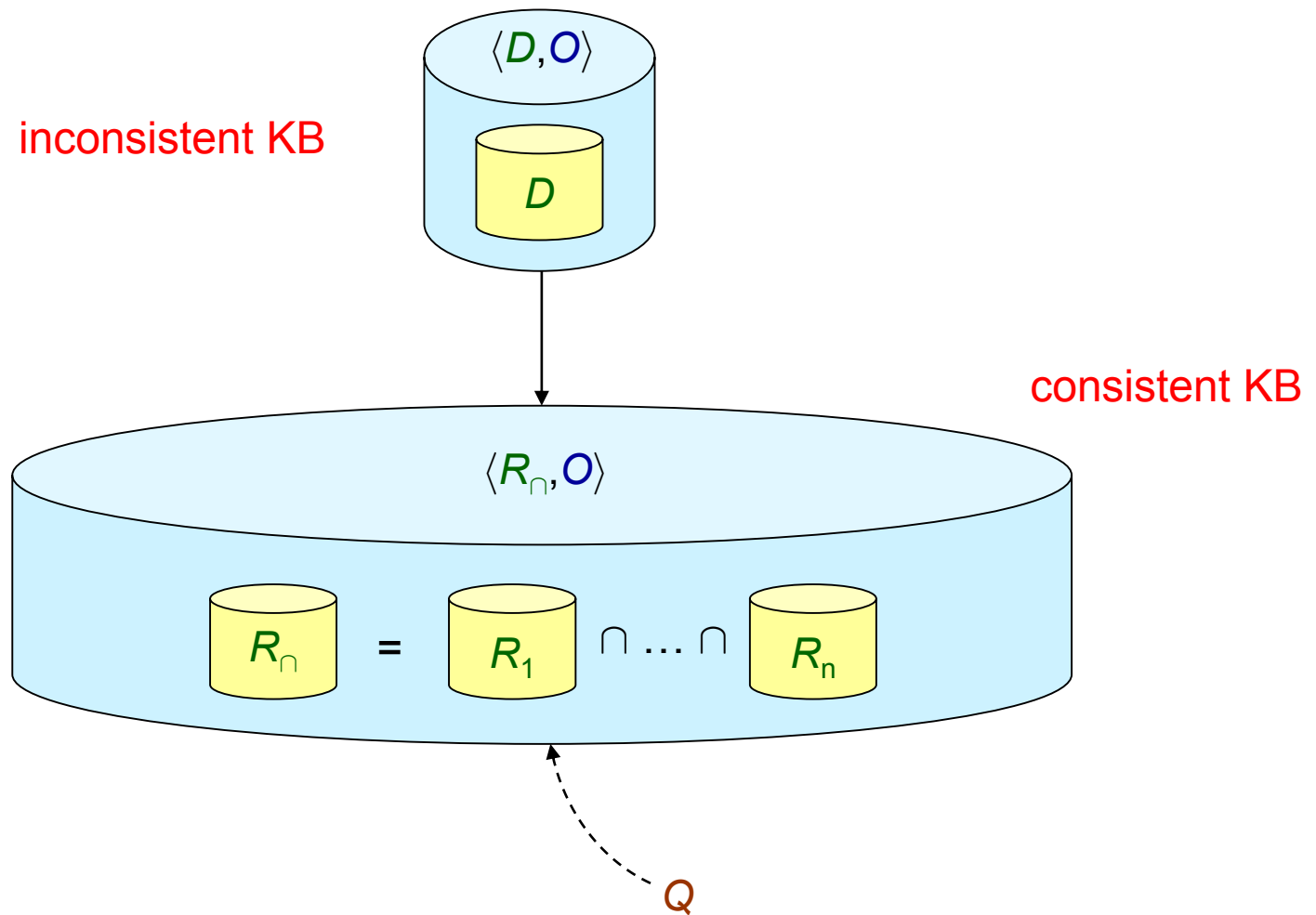


Intersection ABox Repair (IAR) Semantics



$$\text{IAR-answers}(Q, \langle D, \Sigma \rangle) = \text{certain-answers}(Q, \langle R_{\cap}, \Sigma \rangle)$$

Intersection ABox Repair (IAR) Semantics



$$\text{IAR-answers}(Q, \langle D, \Sigma \rangle) \subseteq \text{AR-answers}(Q, \langle D, \Sigma \rangle)$$