EECS-317 Data Management and Information Processing

Lecture 5 – OUTER JOINs and CROSS JOINs

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Spring 2019

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Announcements

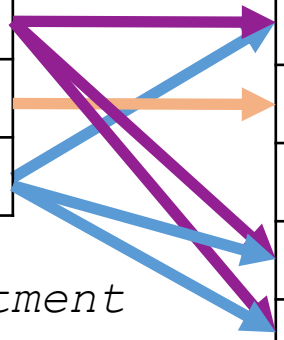
- HW2 is due on Monday.

Last Lecture

- Illustrated GROUP BY
- Introduced JOINs
- Default type of JOIN is the **INNER JOIN**
- Combines rows from two tables using a **join predicate**, which usually specifies that two columns must be equal.
- Multiple JOINs can be combined
- Must refer to columns as *table.column*
- Can use AS to give a table an alias for use in the statement
  - Do this when joining a table two or more times, to distinguish each copy of the table.

INNER JOIN review

staff			
id	***name***	***room***	***departmentId***
11	Bob	100	1
20	Betsy	100	2
21	Fran	101	1



department		
id	***name***	***buildingId***
1	Industrial Eng.	1
2	Computer Sci.	2
4	Chemistry	1
1	Physics	4
1	Materials Sci.	5

```
SELECT * FROM staff JOIN department
ON staff.departmentId=department.id
```

In output,

- multiple matches leads to multiple rows.
- no matches leads to no rows

staff.***id***	staff.***name***	***staff.room***	staff.***departmentId***	department.***id***	department.***name***	department.***buildingId***
11	Bob	100	1	1	Industrial Eng.	1
11	Bob	100	1	1	Physics	4
11	Bob	100	1	1	Materials Sci.	5
20	Betsy	100	2	2	Computer Sci.	2
21	Fran	101	1	1	Industrial Eng.	1
21	Fran	101	1	1	Physics	4
21	Fran	101	1	1	Materials Sci.	5

NATURAL JOIN

- A shorthand notation to make some JOINs shorter to express.
- NATURAL JOIN matches rows using whatever columns have identical names.

For example:

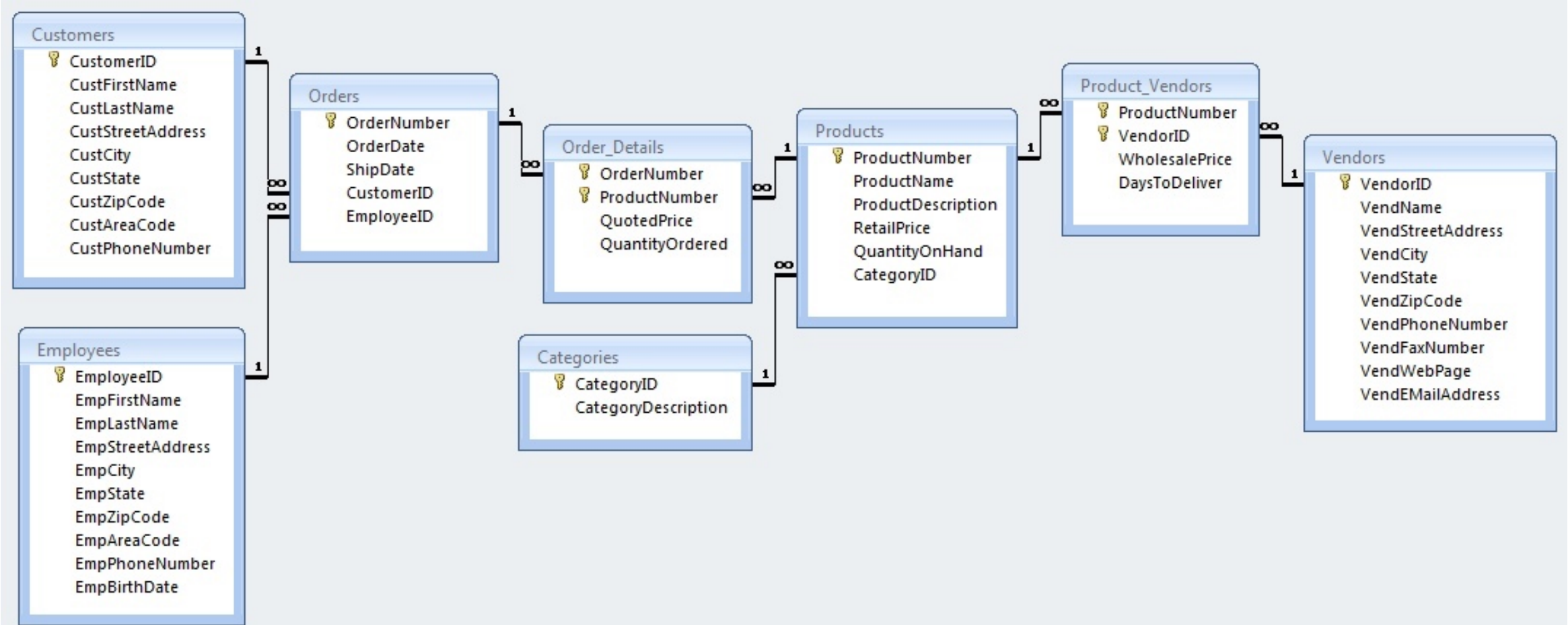
```
SELECT * FROM Orders JOIN Order_Details
  ON Orders.OrderNumber=Order_Details.OrderNumber;
```

Becomes:

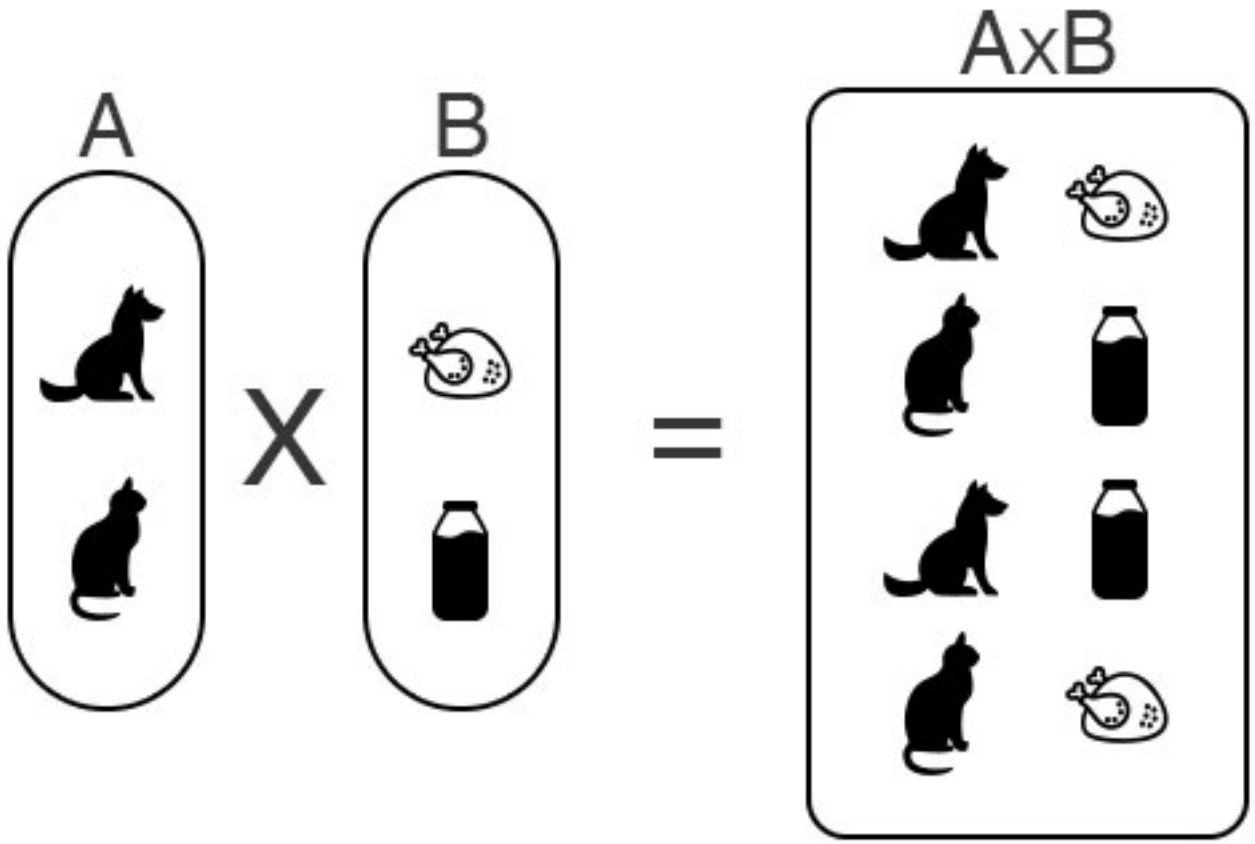
```
SELECT * FROM Orders NATURAL JOIN Order_Details;
```

Designing your data model NATURAL-ly

- Consistent column naming allows you to use NATURAL JOINs.
- This is a reason to avoid generic column names like “id” or “name”



CROSS JOIN is like the **cartesian product** of two sets



Cartesian Product of Two Sets.

- Take every element (row) of the first set (table) and combine it with every element of the second set.
- If first set has N elements and second set has M elements, then cartesian product has N·M elements.
- There is no "ON" expression to limit results:
  - `SELECT * FROM Orders CROSS JOIN Order_Details;`

ON functions exactly like WHERE

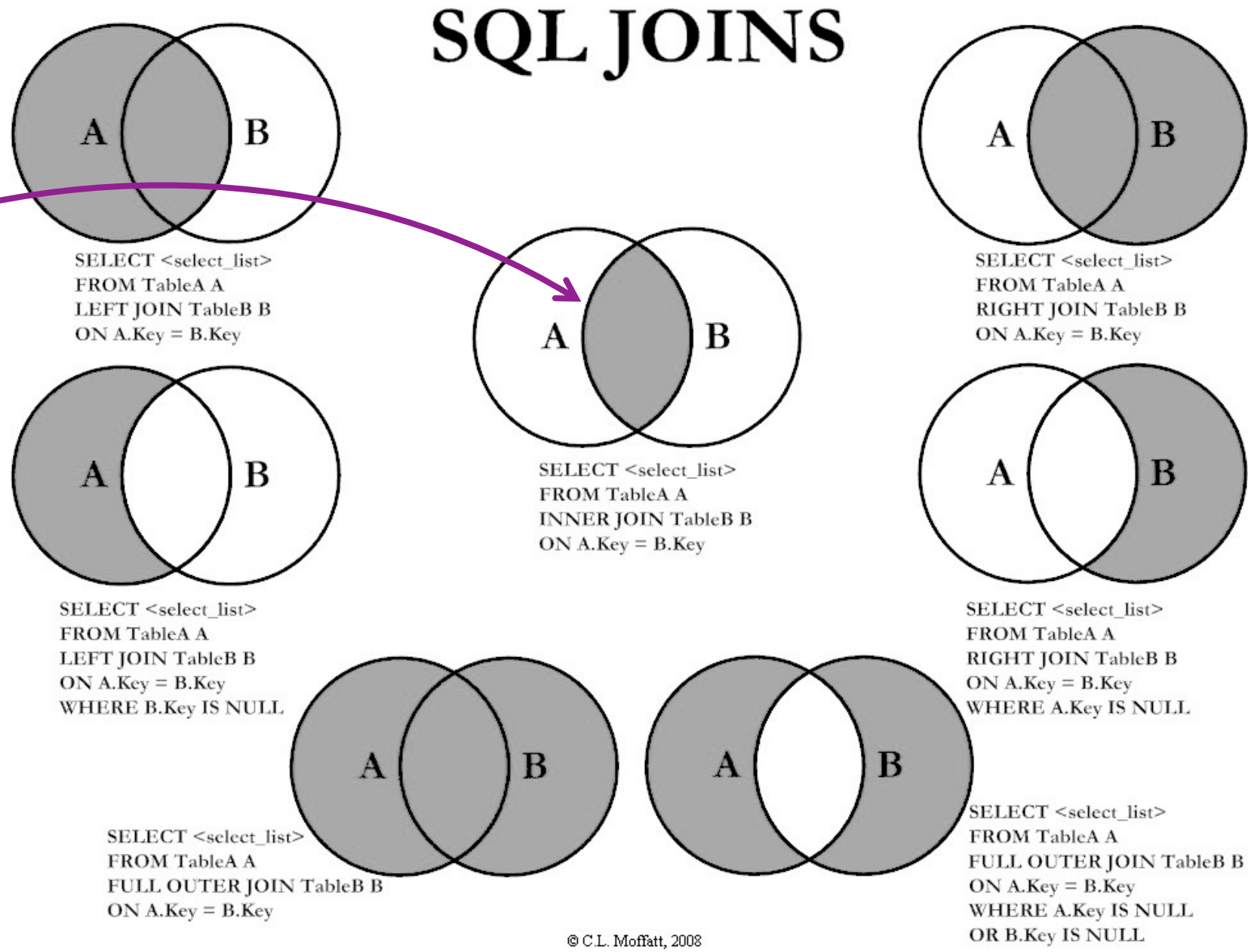
These two expressions are actually equivalent:

- `SELECT * FROM Orders JOIN Order_Details ON Orders.OrderNumber=Order_details.OrderNumber;`
- `SELECT * FROM Orders CROSS JOIN Order_Details WHERE Orders.OrderNumber=Order_details.OrderNumber;`

- However, using ON may be more efficient because it tells the DBMS to avoid building the full N·M cartesian product, and just match rows according to a rule.
- It's also makes the join easier to think about, by separating the filtering and JOINing predicates.

Different JOINs

- `INNER JOIN` constructs a table of all pairs of matching rows from two tables.
  - `INNER` is the default.
  - Useful for *foreign keys* (numeric identifiers)
- However, there are many other ways to JOIN tables if you don't require matching.



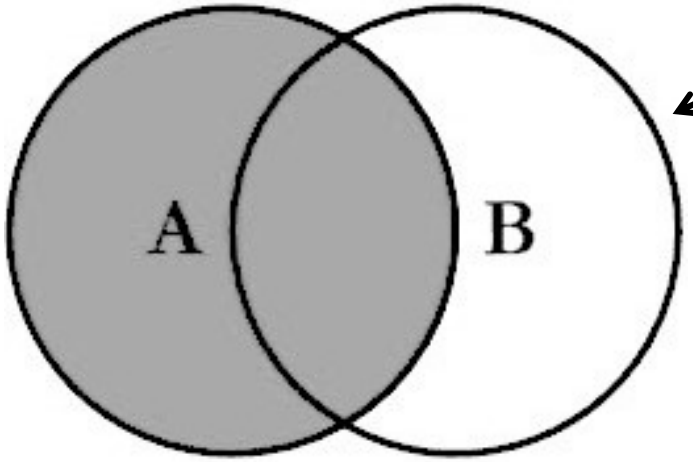
LEFT JOIN

- LEFT JOIN includes **all** rows in the first table (***left***-hand side) and just the matching rows in the second table (right-hand side).

LEFT JOIN

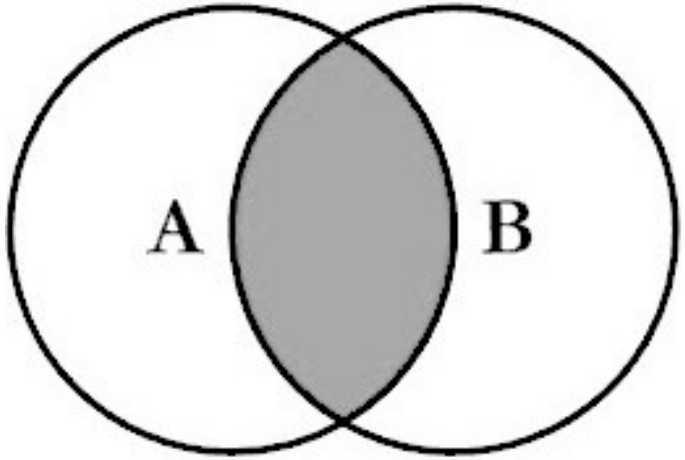
All rows from First table

Matching rows from Second table




```
SELECT <select_list>
FROM TableA A
LEFT JOIN TableB B
ON A.Key = B.Key
```

(standard)
INNER JOIN




```
SELECT <select_list>
FROM TableA A
INNER JOIN TableB B
ON A.Key = B.Key
```

LEFT JOIN output

- Like all JOINs, LEFT JOIN prints columns from the left table followed by columns from the right table.
- However, with LEFT JOIN, some rows will have *NULL* values in the right table columns, meaning that no match was found in the right table.
- When to use LEFT JOIN?
  - To supplement a table with additional information that may be available for some rows, but not available for all the rows.

staff			
id	***name***	***room***	***departmentId***
11	Bob	100	1
20	Betsy	100	*NULL*
21	Fran	101	1
22	Frank	102	99999
35	Sarah	200	5
40	Sam	10	7
54	Pat	102	2

department		
id	***name***	***buildingId***
1	Industrial Eng.	1
2	Computer Sci.	2
5	Physics	4
7	Materials Sci.	5

- Betsy and Frank have NULLs in the right haft of the output because no matching department was found.
- In other words no pair of rows was found to satisfy the ON staff.departmentId=department.id

```
SELECT * FROM staff LEFT JOIN department ON staff.departmentId=department.id;
```

staff.***id***	staff.***name***	***staff.room***	staff.***departmentId***	department.***id***	department.***name***	department.***buildingId***
11	Bob	100	1	1	Industrial Eng.	1
20	Betsy	100	*NULL*	***NULL***	***NULL***	***NULL***
21	Fran	101	1	1	Industrial Eng.	1
22	Frank	102	99999	***NULL***	***NULL***	***NULL***
35	Sarah	200	5	5	Physics	4
40	Sam	10	7	7	Materials Sci.	5
54	Pat	102	2	2	Computer Sci.	2

LEFT JOIN with Grouping

- When computing an *aggregation* on a *many-to-one* relationship, LEFT JOIN includes rows from the parent table with no children.

In ClassScheduling.slite, count the classes taught by each faculty member:

- If you want this report to include faculty members teaching zero classes, you must use LEFT JOIN:

```
SELECT StaffID, ClassID,
      COUNT(ClassID) AS num_classes
   FROM Faculty NATURAL LEFT JOIN Faculty_Classes
   GROUP BY StaffID;
```

- Note that "`COUNT(*)`" would return "1" for faculty members with no classes, because there would still be one unmatched row from the left table.

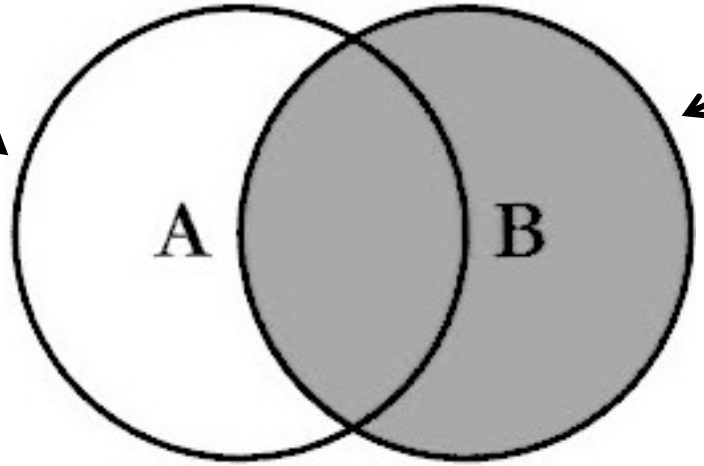
RIGHT JOIN is symmetrical to LEFT

- Includes all rows from right table and matching rows from left table
- Reordering the tables makes a RIGHT JOIN a LEFT JOIN, so it is not necessary to use the RIGHT JOIN syntax.

RIGHT JOIN

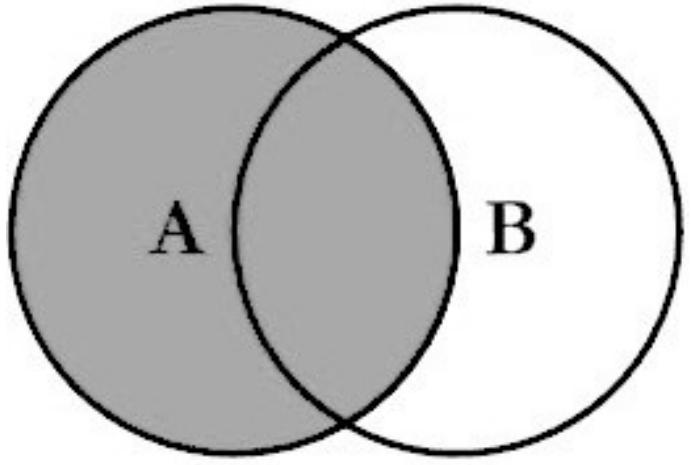
Matching rows from 1st table

All rows from 2nd table



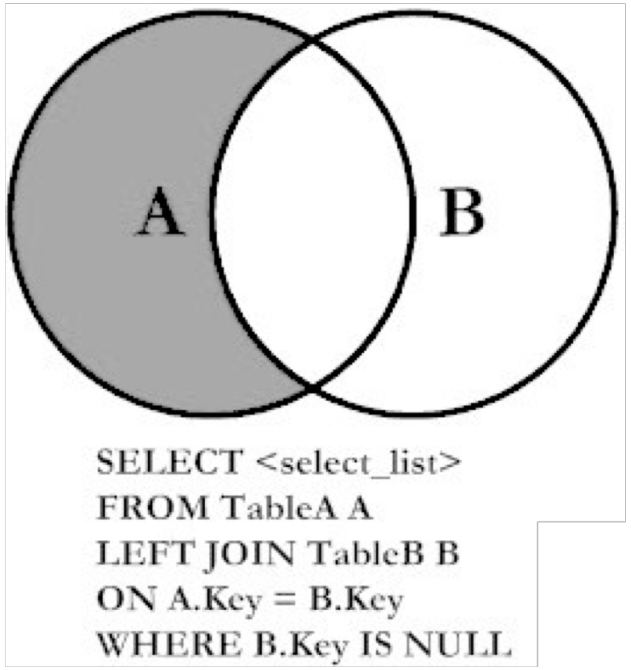

```
SELECT <select_list>
FROM TableA A
RIGHT JOIN TableB B
ON A.Key = B.Key
```

LEFT JOIN




```
SELECT <select_list>
FROM TableA A
LEFT JOIN TableB B
ON A.Key = B.Key
```

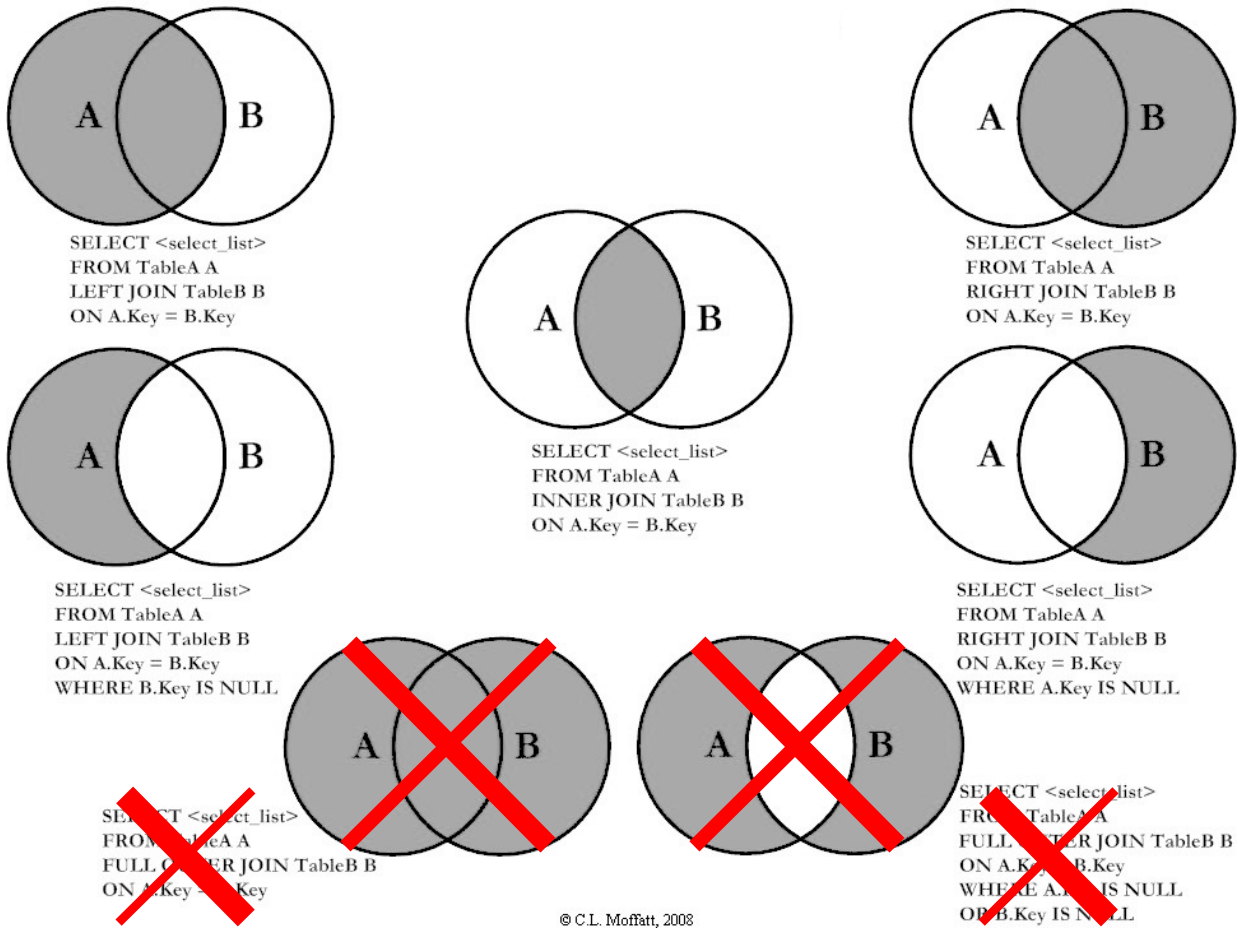
LEFT JOIN with exclusion



- Includes rows from a table that ***must not*** match another table.
- Useful for finding rows lacking something.
- Just add a `WHERE` clause to look for *NULL* values in the right-hand side of the joined table
- For example, to determine which faculty members should be assigned a class:
  - `SELECT * FROM Faculty NATURAL LEFT JOIN Faculty_Classes` **`WHERE ClassID IS NULL`**`;`
- Which classrooms are unused?
  - `SELECT * FROM Class_Rooms NATURAL LEFT JOIN Classes` **`WHERE ClassID IS NULL`**`;`

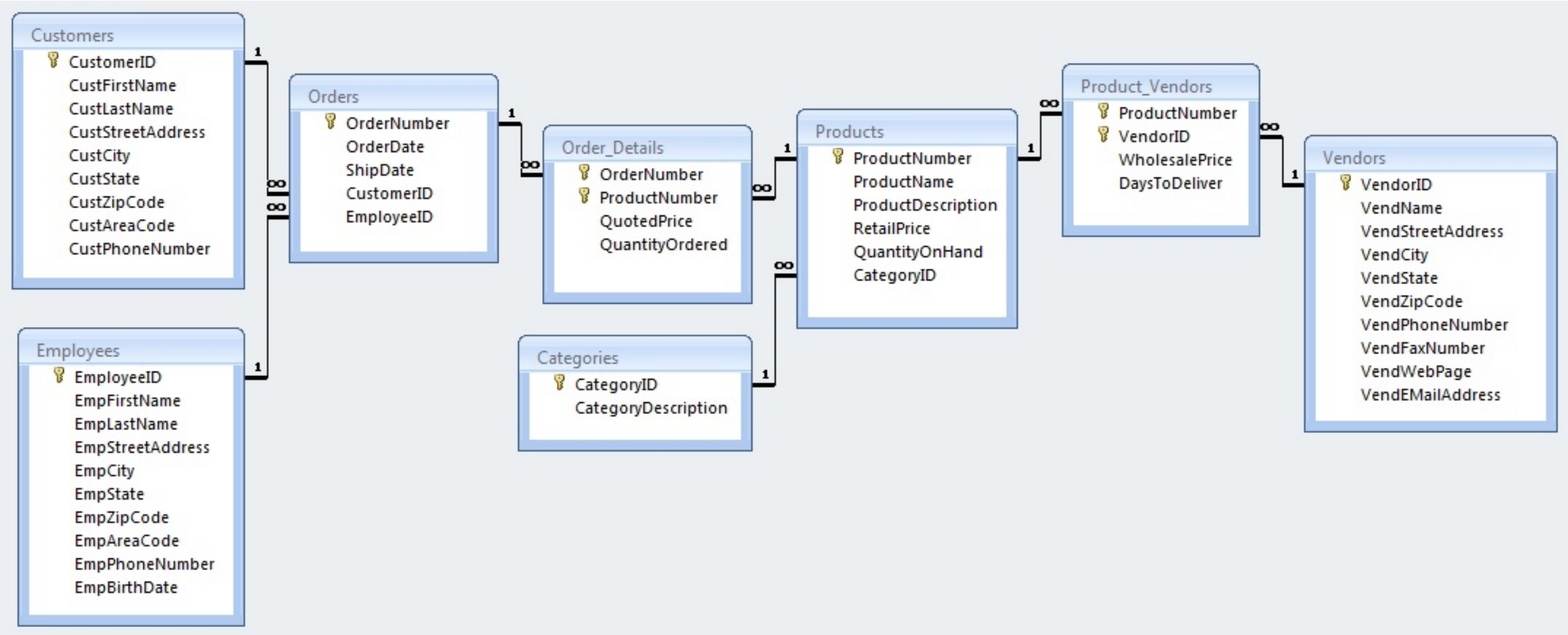
FULL OUTER JOINs are not available in MySQL or SQLite

- You can *emulate* `FULL OUTER JOIN` with the `UNION` of two queries.



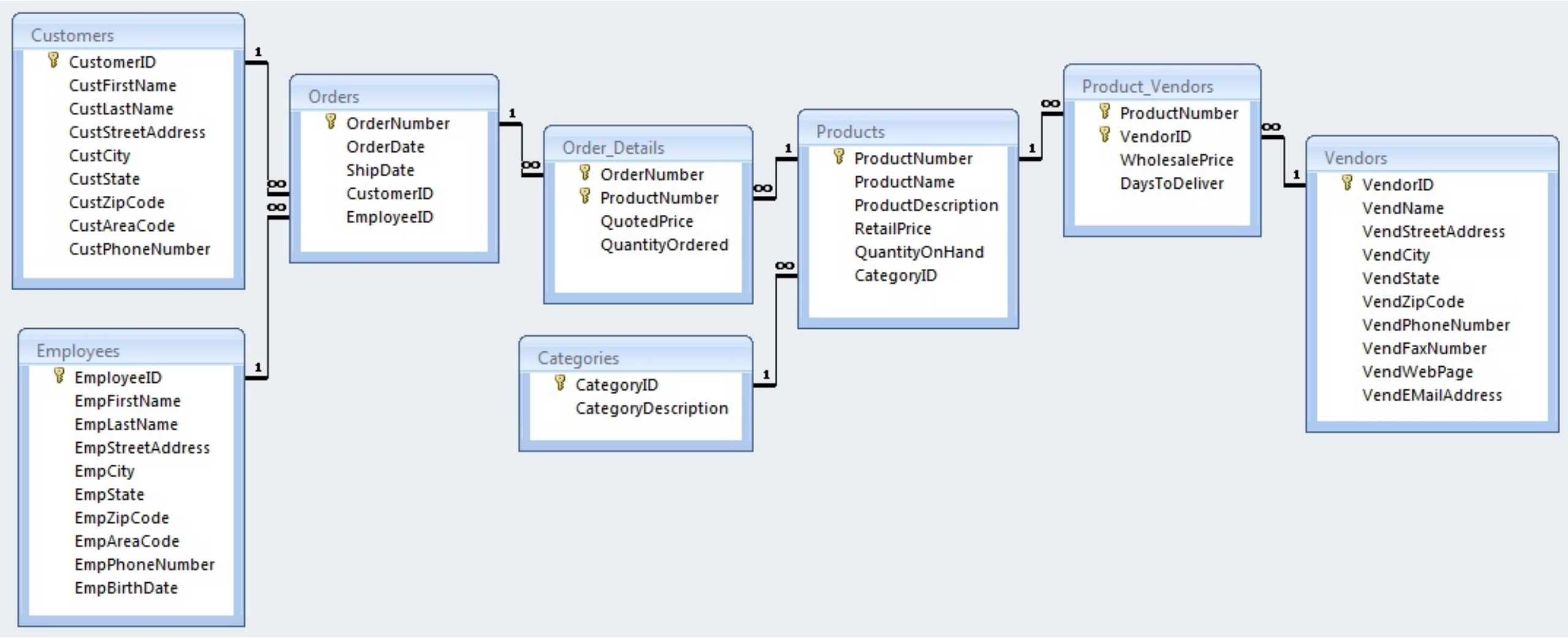
SalesOrders.sqlite: List all products and the dates for any orders (of that product).

```
SELECT Products.ProductNumber, ProductName, OrderDate FROM
Products LEFT NATURAL JOIN (Order_Details NATURAL JOIN Orders);
```



Display customers who have no sales rep (employees) in the same ZIP Code.

```
SELECT * FROM Customers LEFT JOIN Employees ON
CustZipCode=EmpZipCode WHERE EmpZipCode IS NULL;
```



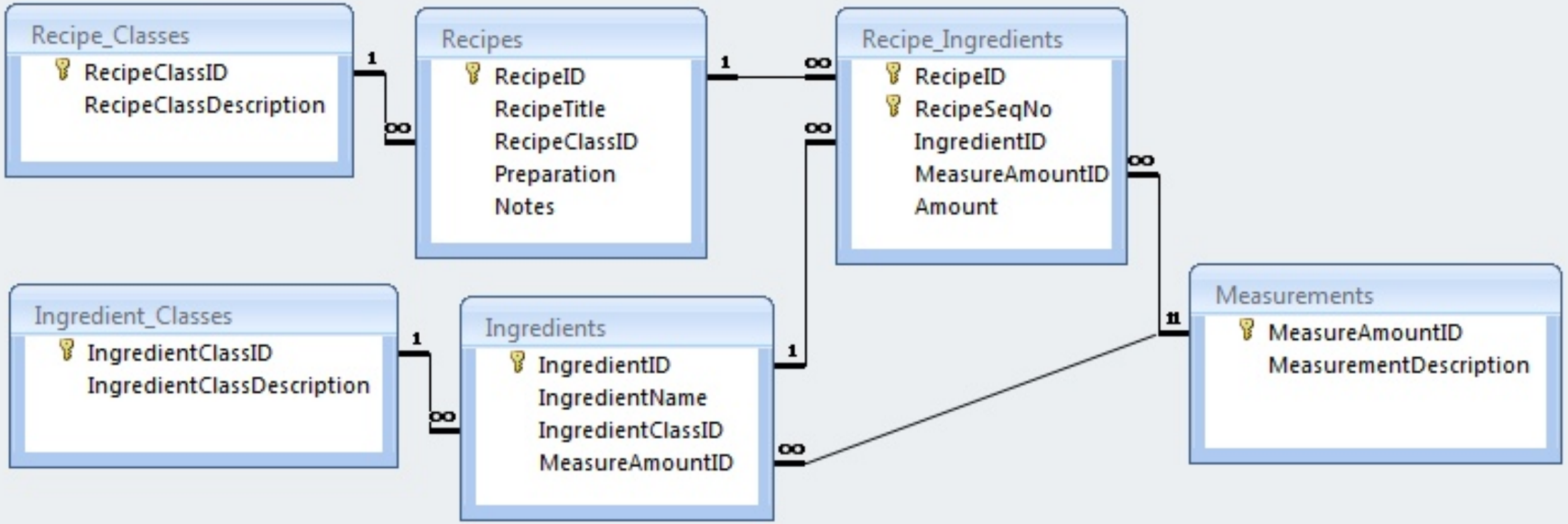
Show me customers who have never ordered a Watch.

First solution uses EXCEPT (introduced later), second solution uses LEFT JOIN with exclusion:

- ```
  SELECT CustomerID FROM Customers EXCEPT
     SELECT CustomerID FROM Customers NATURAL JOIN Orders
              NATURAL JOIN Order_Details NATURAL JOIN Products
       WHERE ProductName LIKE "%Watch%" GROUP BY CustomerID;
  ```
- ```
  SELECT CustomerID FROM Customers LEFT JOIN
    (SELECT CustomerID AS watch_customer FROM Orders
     NATURAL JOIN Order_Details NATURAL JOIN Products
     WHERE ProductName LIKE "%Watch%" GROUP BY CustomerID)
    ON CustomerID=watch_customer
    WHERE Watch_customer IS NULL;
  ```

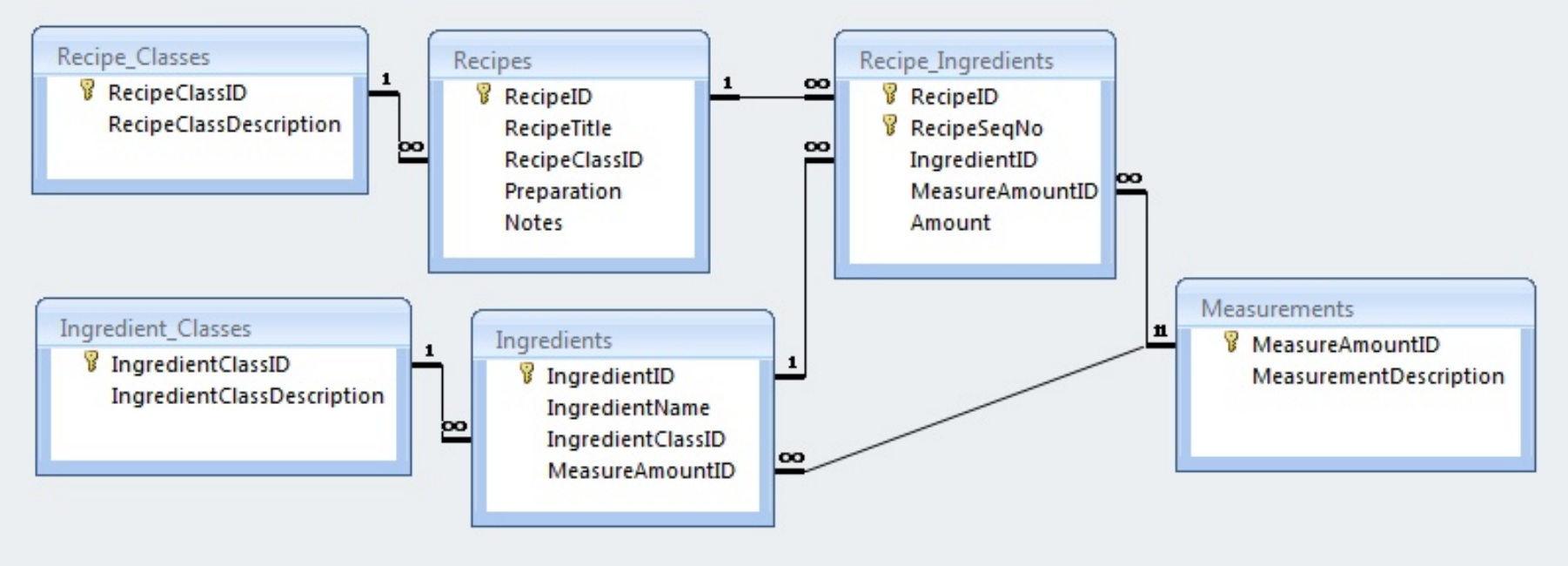
Recipes.sqlite: List the number of recipes in each category (RecipeClassID)

```
SELECT RecipeClassDescription, COUNT(RecipeID) AS RecipeCount
FROM Recipe_Classes LEFT NATURAL JOIN Recipes GROUP BY RecipeClassID
```



Recipes: Print every pair of recipes and the number of ingredients they share in common

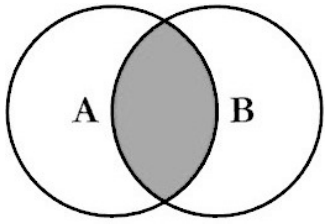
```
SELECT r1.RecipeTitle, r2.RecipeTitle,
COUNT(i2.IngredientID) AS common_ingredients
FROM
  Recipes AS r1 CROSS JOIN Recipes AS r2
  JOIN Recipe_Ingredients AS i1 ON r1.RecipeID = i1.RecipeID
  LEFT JOIN Recipe_Ingredients AS i2 ON
    r2.RecipeID = i2.RecipeID AND i1.IngredientID=i2.IngredientID
GROUP BY r1.RecipeID, r2.RecipeID
HAVING r1.RecipeID < r2.RecipeID
ORDER BY common_ingredients DESC;
```



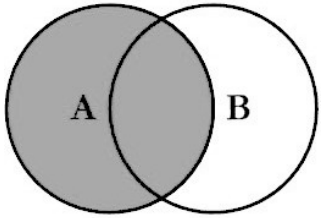
Recap

Introduced different types of JOINs:

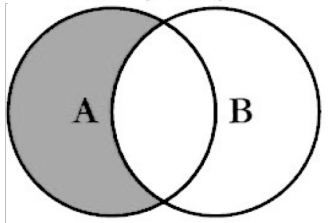
- **INNER** (default): prints all pairs of rows (one from first table, one from second table) that satisfy the *JOIN predicate*.
- **LEFT**: same as INNER, but adds rows from LEFT table that never satisfied the JOIN predicate.
- **LEFT with exclusion**: only print rows from left table that never satisfied the JOIN predicate.
- **CROSS JOIN**: print the cartesian project, meaning all rows from the first table combined with all rows from the second table. There is no "ON" to match rows.



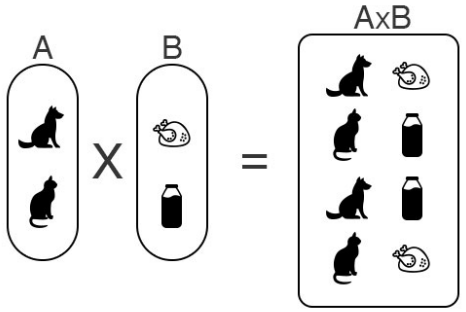

```
SELECT <select_list>
FROM TableA A
INNER JOIN TableB B
ON A.Key = B.Key
```




```
SELECT <select_list>
FROM TableA A
LEFT JOIN TableB B
ON A.Key = B.Key
```




```
SELECT <select_list>
FROM TableA A
LEFT JOIN TableB B
ON A.Key = B.Key
WHERE B.Key IS NULL
```



Cartesian Product of Two Sets.