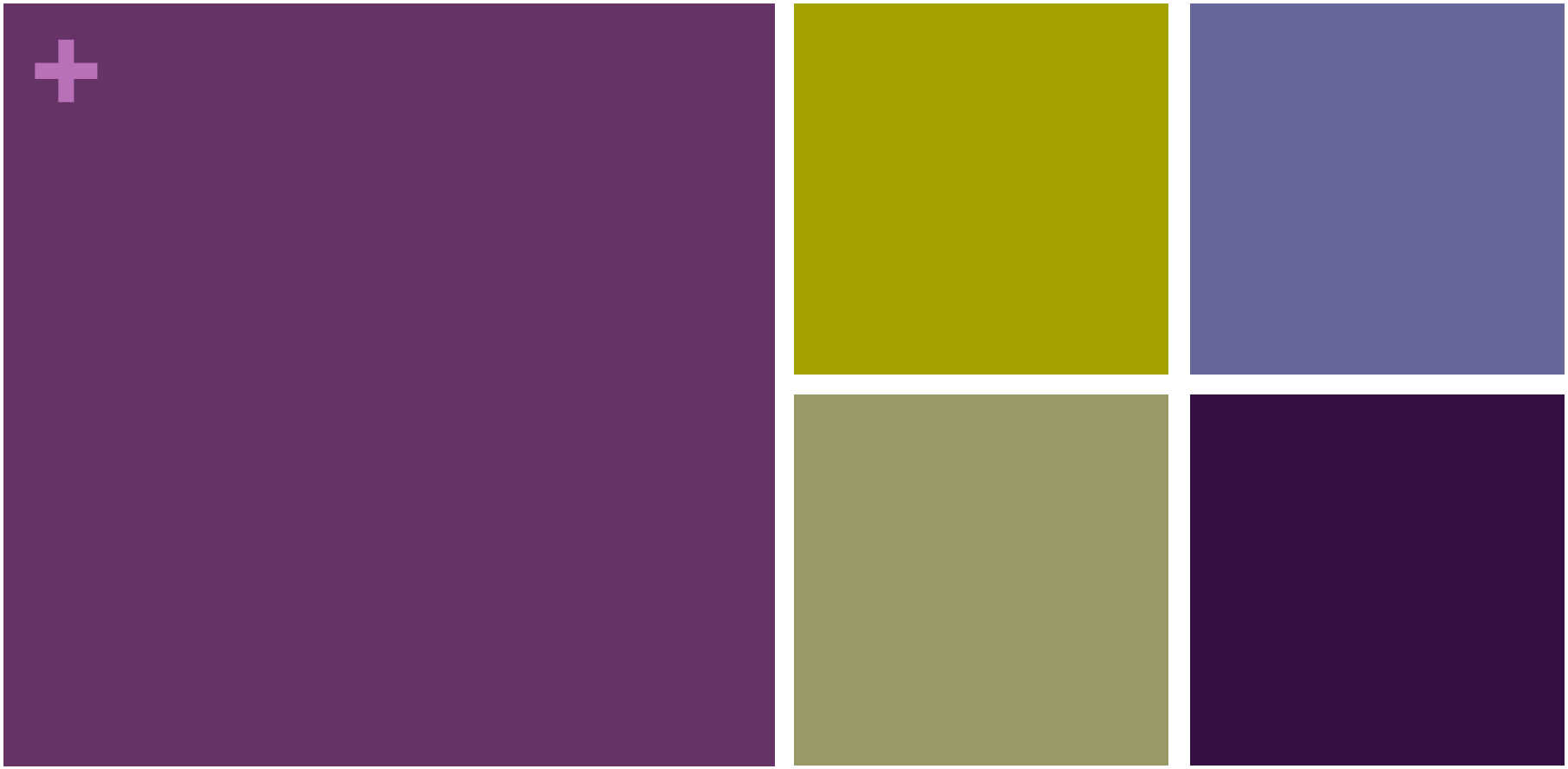
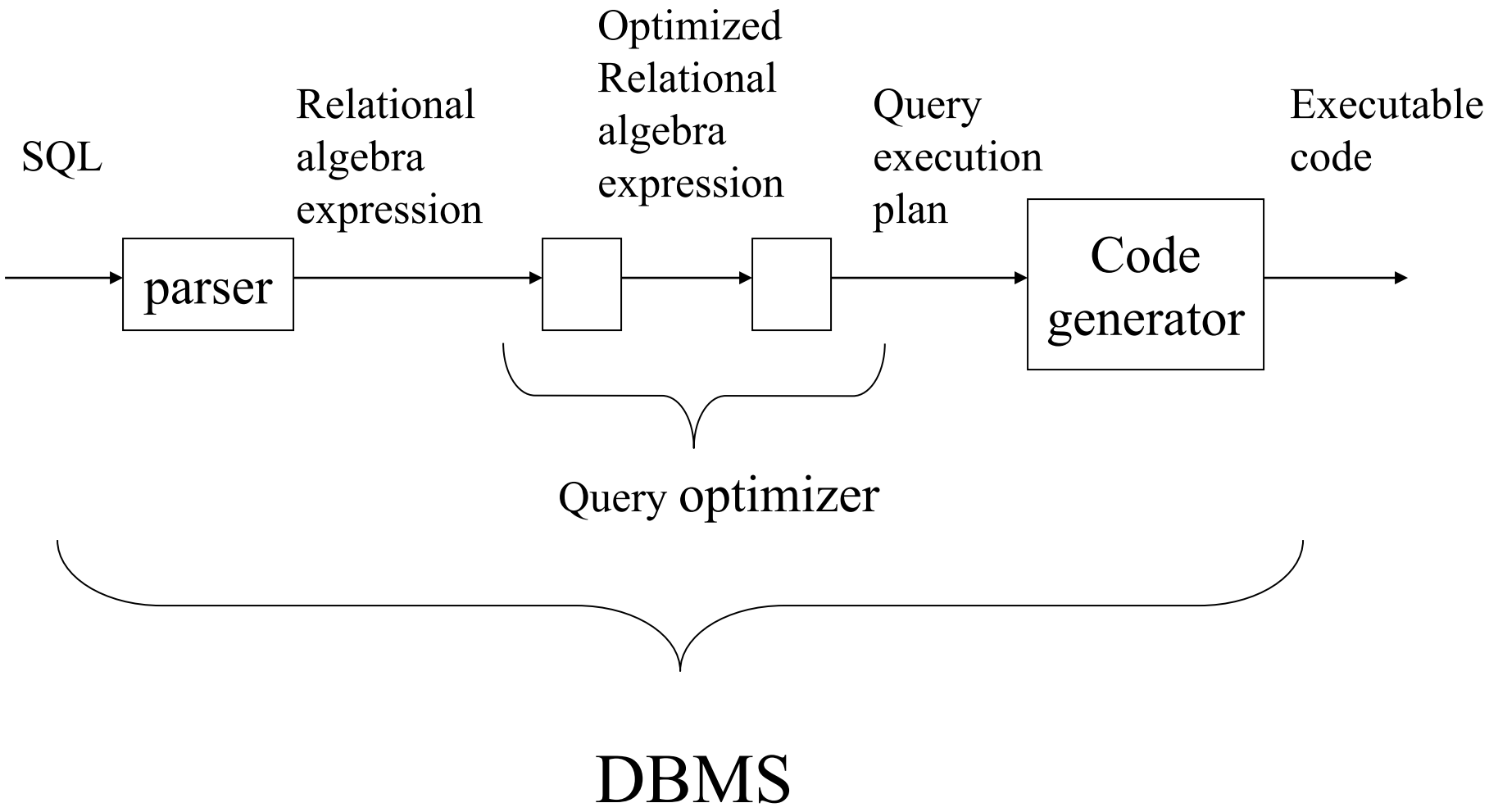


From Relational Algebra to SQL

W2013

CSCI 2141

Relational algebra, SQL, and the DBMS?



Basic Relational Algebra Operations (Unary): Selection, Projection

Selection: $\sigma_{\text{<condition(s)>}}(\text{<relation>})$

- Picks tuples from the relation

Projection: $\Pi_{\text{<attribute-list>}}(\text{<relation>})$

- Picks columns from the relation

Relational Algebra Operations (Set): Union, Set Difference

Union: (<relation>) U (<relation>)

- New relation contains all tuples from both relations, duplicate tuples eliminated.

Set Difference: R – S

- Produces a relation with tuples that are in R but NOT in S.

Relational Algebra Operations (Set): Cartesian Product, Intersect

Cartesian Product: R x S

- Produces a relation that is concatenation of every tuple of R with every tuple of S
- The Above operations are the 5 fundamental operations of relational algebra.

Intersection: R ∩ S

- All tuples that are in both R and S

Relational Algebra Operations (Join): Theta Join, Natural Join

Theta Join: $R \bowtie_F S = \sigma_F (R \times S)$

- Select all tuples from the Cartesian product of the two relations, matching condition F
- When F contains only equality "=", it is called Equijoin

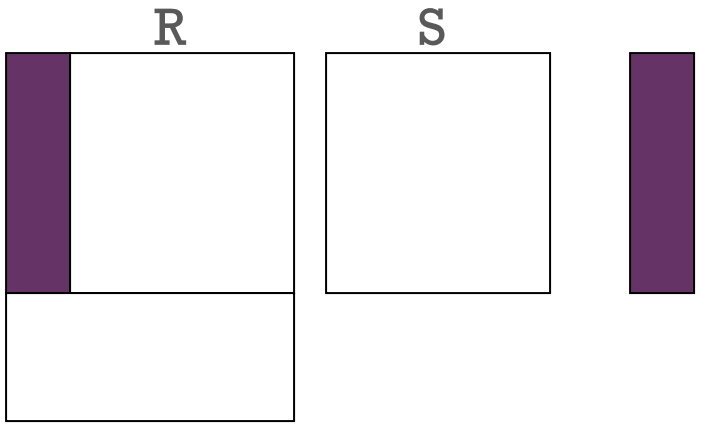
Natural Join: $R \bowtie S$

- Equijoin with common attributes eliminated

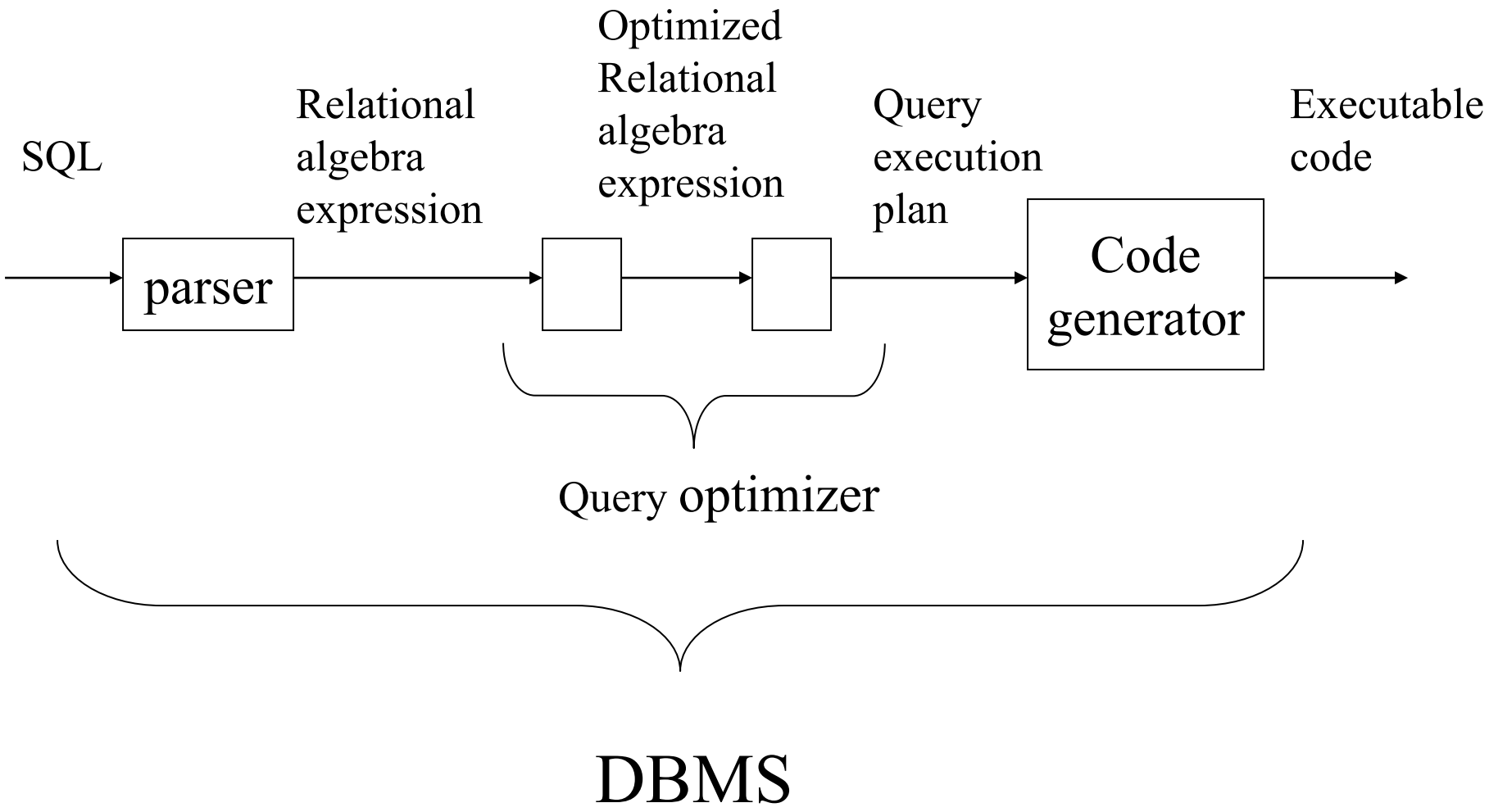
Relational Algebra Operations: Division

- Division: R ÷ S
- Produce a relation consist of the set of tuples from R that matches the combination of every tuple in S

R÷S



Relational algebra, SQL, and the DBMS?



SQL Introduction

Standard language for querying and manipulating data

Structured **Q**uery **L**anguage

Many standards out there:

- ANSI SQL, SQL92 (a.k.a. SQL2), SQL99 (a.k.a. SQL3), ….
- Vendors support various subsets
- When starting to work with a specific database, make sure you are aware of the specific SQL form/syntax in use and the features supported
- MySQL:
  - http://dev.mysql.com/doc/refman/5.0/en/what-is-mysql.html
  - http://dev.mysql.com/doc/refman/5.0/en/features.html

SQL

- Data Definition Language (DDL)
  - Create/alter/delete tables and their attributes
  - http://dev.mysql.com/doc/refman/5.0/en/tutorial.html
    - 3.3.1 Creating and Selecting a Database
    - 3.3.2 Creating a Table
    - 3.3.3 Loading Data into a table
  - Friday
- Data Manipulation Language (DML)
  - Query one or more tables (today)
  - Insert/delete/modify tuples in tables (Monday)

Data Types in SQL

- Atomic types:
  - Characters: CHAR(20), VARCHAR(50), LONG VARCHAR
  - Numbers: INT, BIGINT, SMALLINT, FLOAT
  - Others: MONEY, DATETIME, …
- MySQL
  - http://dev.mysql.com/doc/refman/5.0/en/data-types.html
  - Characters: CHIAR(20), VARCHAR(50), MEDIUMTEXT
  - Numbers: INT, BIGINT, SMALLINT, FLOAT
  - Others: (couldn't find money), DATETIME
- Handy table of translations:
  - http://dev.mysql.com/doc/refman/5.0/en/other-vendor-data-types.html
- Every attribute must have an atomic type
  - Hence tables are flat

SQL Query

Basic form: (plus many many more bells and whistles)

```
SELECT  <attributes>
FROM    <one or more relations>
WHERE   <conditions>
```

Relational algebra queries to SQL queries

- FROM clause produces Cartesian product (x) of listed tables
- WHERE clause assigns rows to C in sequence and produces table containing only rows satisfying condition (sort of like σ)
- SELECT clause retains listed columns (Π)

Example Relational Algebra Translation to SQL

- SELECT C.CrsName
- FROM Course C, Teaching T
- WHERE C.CrsCode=T.CrsCode AND T.Sem= 'W2013'

- List CS courses taught in W2013
- Tuple variables (Course C, Teaching T) (aka aliases in MYSQL) clarify meaning (Course AS C)
- Join condition "C.CrsCode=T.CrsCode"
  - eliminates those courses not being taught (junk)
- Selection condition " T.Sem= 'W2013' "
  - eliminates irrelevant rows
- Equivalent (using natural join) to:

$\pi CrsName(Course \bowtie (\sigma Sem = \text{'W2013'} (Teaching)))$

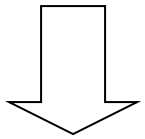
$\pi CrsName(\sigma Sem = \text{'W2013'} (Course \bowtie Teaching))$

Simple SQL Query

Product

PName	Price	Category	Manufacturer
Gizmo	$19.99	Gadgets	GizmoWorks
Powergizmo	$29.99	Gadgets	GizmoWorks
SingleTouch	$149.99	Photography	Canon
MultiTouch	$203.99	Household	Hitachi

```
SELECT   *
FROM     Product
WHERE    category= 'Gadgets'
```



PName	Price	Category	Manufacturer
Gizmo	$19.99	Gadgets	GizmoWorks
Powergizmo	$29.99	Gadgets	GizmoWorks

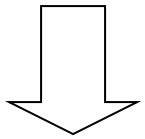
"selection"

Simple SQL Query

Product

PName	Price	Category	Manufacturer
Gizmo	$19.99	Gadgets	GizmoWorks
Powergizmo	$29.99	Gadgets	GizmoWorks
SingleTouch	$149.99	Photography	Canon
MultiTouch	$203.99	Household	Hitachi

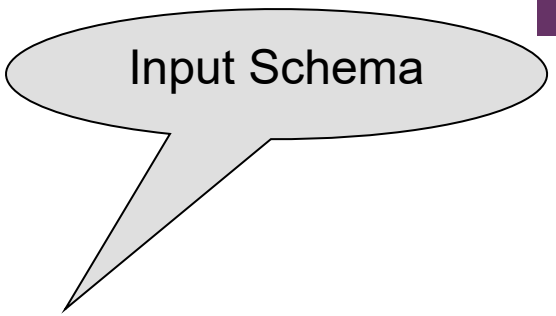
```
SELECT   PName, Price, Manufacturer
FROM     Product
WHERE    Price > 100
```



"selection" and "projection"

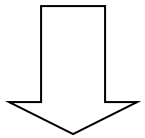
PName	Price	Manufacturer
SingleTouch	$149.99	Canon
MultiTouch	$203.99	Hitachi

Notation

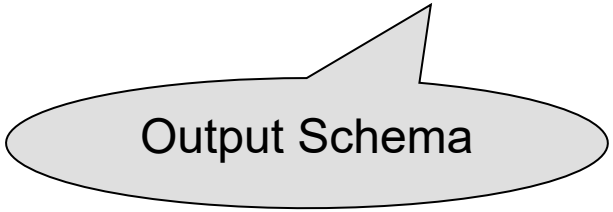


Product(PName, Price, Category, Manfacturer)

```
SELECT   PName, Price, Manufacturer
FROM     Product
WHERE    Price > 100
```



Answer(PName, Price, Manfacturer)



Details

- Case insensitive:
  - Same: SELECT Select select
  - Same: Product product
  - Different: ‘Seattle’ ‘seattle’
- Constants:
  - ‘abc’ - yes
  - “abc” - no

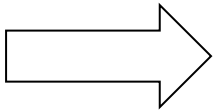
The **LIKE** operator

```
SELECT   *
FROM     Products
WHERE    PName LIKE '%gizmo%'
```

- s **LIKE** p: pattern matching on strings
- p may contain two special symbols:
  - % = any sequence of characters
  - _ = any single character

Eliminating Duplicates

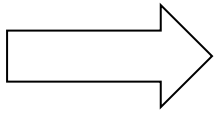
```
SELECT   DISTINCT category
FROM     Product
```



Category
Gadgets
Photography
Household

Compare to:

```
SELECT   category
FROM     Product
```



Category
Gadgets
Gadgets
Photography
Household

Ordering the Results

```
SELECT   pname, price, manufacturer
FROM     Product
WHERE    category= ‘gizmo’ AND price > 50
ORDER BY  price, pname
```

You can use more than one column in the ORDER BY clause.

Make sure whatever column you are using to sort is in the column-list of the SELECT

Ties are broken by the second attribute on the ORDER BY list, etc.

Ordering is ascending, unless you specify the DESC keyword.

ORDER BY price ASC, pname DESC

Keys and Foreign Keys

Company

CName	StockPrice	Country
GizmoWorks	25	USA
Canon	65	Japan
Hitachi	15	Japan

Key

Product

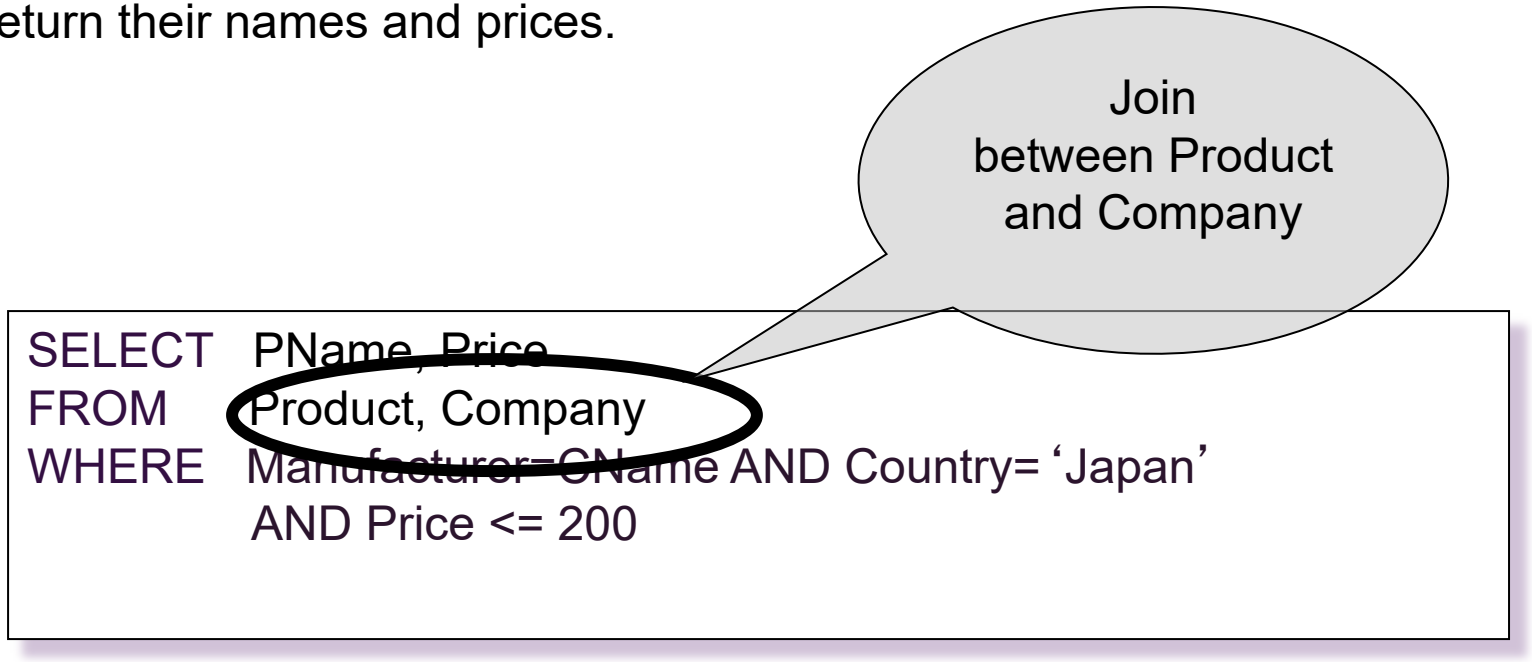
PName	Price	Category	Manufacturer
Gizmo	$19.99	Gadgets	GizmoWorks
Powergizmo	$29.99	Gadgets	GizmoWorks
SingleTouch	$149.99	Photography	Canon
MultiTouch	$203.99	Household	Hitachi

Foreign key

Joins

Product (pname, price, category, manufacturer)
Company (cname, stockPrice, country)

Find all products under $200 manufactured in Japan;
return their names and prices.



Joins

Product

PName	Price	Category	Manufacturer
Gizmo	$19.99	Gadgets	GizmoWorks
Powergizmo	$29.99	Gadgets	GizmoWorks
SingleTouch	$149.99	Photography	Canon
MultiTouch	$203.99	Household	Hitachi

Company

Cname	StockPrice	Country
GizmoWorks	25	USA
Canon	65	Japan
Hitachi	15	Japan

```
SELECT   PName, Price
FROM     Product, Company
WHERE    Manufacturer=CName AND Country= 'Japan'
         AND Price <= 200
```

PName	Price
SingleTouch	$149.99

A Subtlety about Joins

Product (pname, price, category, manufacturer)
Company (cname, stockPrice, country)

Find all countries that manufacture some product in the 'Gadgets' category.

```
SELECT   Country
FROM     Product, Company
WHERE    Manufacturer=CName AND Category= 'Gadgets'
```

Unexpected duplicates

A Subtlety about Joins

Product

Name	Price	Category	Manufacturer
Gizmo	$19.99	Gadgets	GizmoWorks
Powergizmo	$29.99	Gadgets	GizmoWorks
SingleTouch	$149.99	Photography	Canon
MultiTouch	$203.99	Household	Hitachi

Company

Cname	StockPrice	Country
GizmoWorks	25	USA
Canon	65	Japan
Hitachi	15	Japan

```
SELECT   Country
FROM     Product, Company
WHERE    Manufacturer=CName AND Category= 'Gadgets'
```

Country
??
??

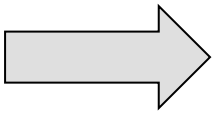
What is the problem ? What's the solution ?

Tuple Variables

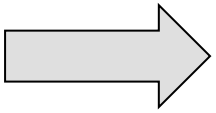
Person(pname, address, worksfor)
Company(cname, address)

```
SELECT   DISTINCT pname, address
FROM     Person, Company
WHERE    worksfor = cname
```

Which address ?



```
SELECT   DISTINCT Person.pname, Company.address
FROM     Person, Company
WHERE    Person.worksfor = Company.cname
```



```
SELECT   DISTINCT x.pname, y.address
FROM     Person AS x, Company AS y
WHERE    x.worksfor = y.cname
```

Subqueries Returning Relations

Company(name, city)
Product(pname, maker)
Purchase(id, product, buyer)

Return cities where one can find companies that manufacture products bought by Joe Blow

```
SELECT  Company.city
FROM    Company
WHERE  Company.name  IN
                (SELECT Product.maker
                  FROM   Purchase , Product
                  WHERE Product.pname=Purchase.product
                       AND Purchase .buyer =  'Joe Blow ');
```

Subqueries Returning Relations

Is it equivalent to this ?

```
SELECT  Company.city
FROM      Company, Product, Purchase
WHERE   Company.name= Product.maker
          AND  Product.pname  = Purchase.product
          AND  Purchase.buyer =  'Joe Blow'
```

Beware of duplicates !

Removing Duplicates

```
SELECT DISTINCT Company.city
FROM     Company
WHERE  Company.name  IN
                (SELECT Product.maker
                  FROM   Purchase , Product
                  WHERE Product.pname=Purchase.product
                       AND Purchase .buyer =  'Joe Blow ');
```

```
SELECT DISTINCT Company.city
FROM      Company, Product, Purchase
WHERE   Company.name= Product.maker
          AND  Product.pname  = Purchase.product
          AND  Purchase.buyer =  'Joe Blow'
```

Now
they are
equivalent

Subqueries Returning Relations

You can also use: s > ALL R
s > ANY R
EXISTS R

Product (pname, price, category, maker)
Find products that are more expensive than all those produced
By "Gizmo-Works"

```
SELECT  name
FROM    Product
WHERE  price >  ALL (SELECT price
                     FROM    Purchase
                     WHERE  maker= 'Gizmo-Works' )
```

Question: How are EXISTS and IN different?

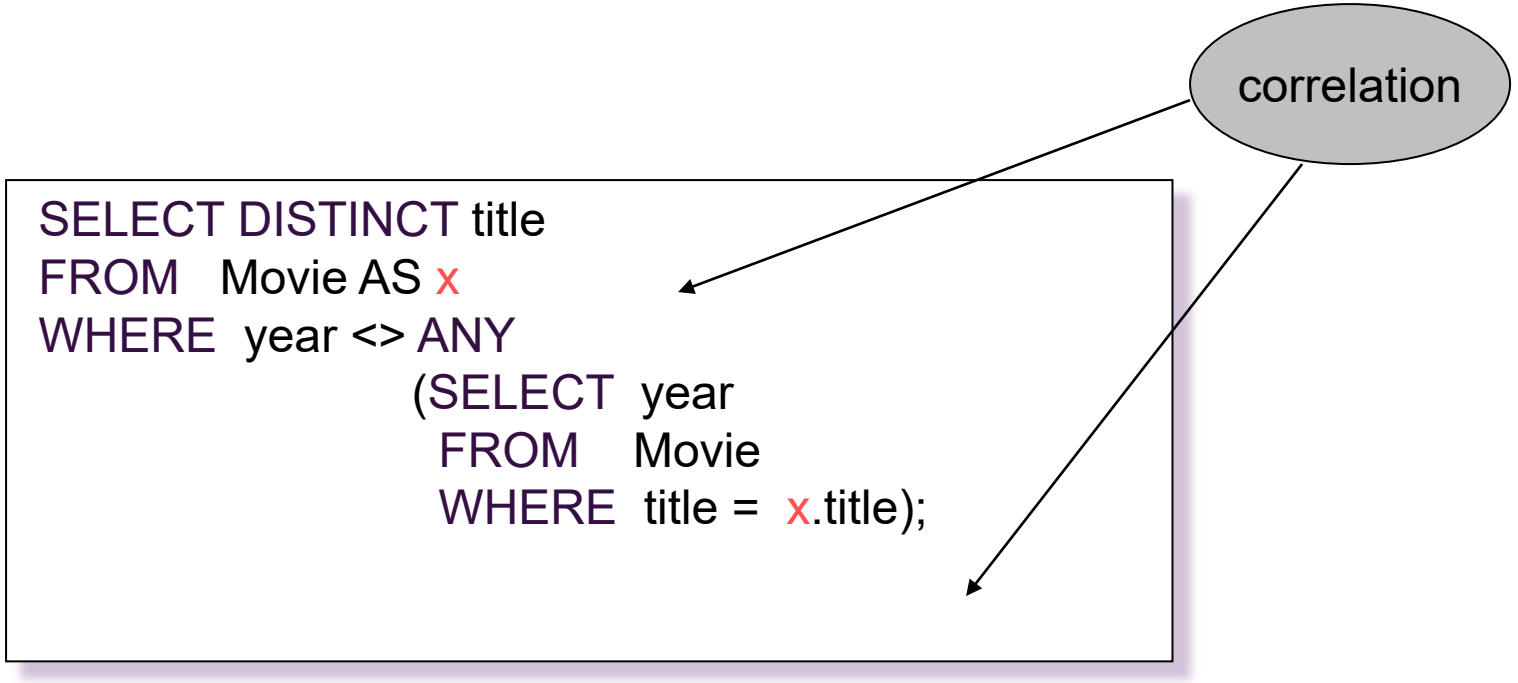
- http://dev.mysql.com/doc/refman/5.0/en/comparison-operators.html
- http://dev.mysql.com/doc/refman/5.0/en/comparison-operators.html#function_in
- http://dev.mysql.com/doc/refman/5.0/en/any-in-some-subqueries.html
- http://dev.mysql.com/doc/refman/5.1/en/exists-and-not-exists-subqueries.html

Short answer: EXISTS returns TRUE if there is a row returned in the subquery, IN evaluates as TRUE if a value matches a value in a list (list of constants or subquery results)

Correlated Queries

Movie (title, year, director, length)

Find movies whose title appears more than once.



Complex Correlated Query

Product (pname, price, category, maker, year)

- Find products (and their manufacturers) that are more expensive than all products made by the same manufacturer before 1972

```
SELECT DISTINCT  pname, maker
FROM     Product AS x
WHERE  price > ALL  (SELECT  price
                              FROM    Product AS y
                              WHERE  x.maker = y.maker AND y.year < 1972);
```

Aggregation

```
SELECT  avg(price)
FROM    Product
WHERE   maker="Toyota"
```

```
SELECT  count(*)
FROM    Product
WHERE   year > 1995
```

SQL supports several aggregation operations:

sum, count, min, max, avg

Except count, all aggregations apply to a single attribute

Aggregation: Count

COUNT applies to duplicates, unless otherwise stated:

```
SELECT  Count(category)
FROM    Product
WHERE   year > 1995
```

same as Count(*)

We probably want:

```
SELECT  Count(DISTINCT category)
FROM    Product
WHERE   year > 1995
```

More Examples

Purchase(product, date, price, quantity)

```
SELECT  Sum(price * quantity)
FROM    Purchase
```

```
SELECT  Sum(price * quantity)
FROM    Purchase
WHERE   product = 'bagel'
```

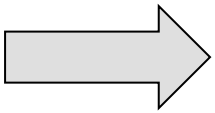
What do they mean ?

Simple Aggregations

Purchase

Product	Date	Price	Quantity
Bagel	10/21	1	20
Banana	10/3	0.5	10
Banana	10/10	1	10
Bagel	10/25	1.50	20

```
SELECT  Sum(price * quantity)
FROM    Purchase
WHERE   product = 'bagel'
```



50 (= 20+30)

Grouping and Aggregation

Purchase(product, date, price, quantity)

Find total sales after 10/1/2005 per product.

```
SELECT    product, Sum(price*quantity) AS TotalSales
FROM      Purchase
WHERE     date > '10/1/2005'
GROUP BY  product
```

Let's see what this means…

Grouping and Aggregation

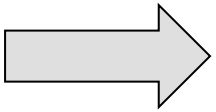
1. Compute the FROM and WHERE clauses.
2. Group by the attributes in the GROUPBY
3. Compute the SELECT clause: grouped attributes and aggregates.

1&2. FROM-WHERE-GROUPBY

Product	Date	Price	Quantity
Bagel	10/21	1	20
Bagel	10/25	1.50	20
Banana	10/3	0.5	10
Banana	10/10	1	10

3. SELECT

Product	Date	Price	Quantity
Bagel	10/21	1	20
Bagel	10/25	1.50	20
Banana	10/3	0.5	10
Banana	10/10	1	10



Product	TotalSales
Bagel	50
Banana	15

```
SELECT      product, Sum(price*quantity) AS TotalSales
FROM        Purchase
WHERE       date > '10/1/2005'
GROUP BY    product
```

GROUP BY v.s. Nested Quereis

```
SELECT      product, Sum(price*quantity) AS TotalSales
FROM        Purchase
WHERE       date > '10/1/2005'
GROUP BY    product
```

```
SELECT DISTINCT  x.product, (SELECT Sum(y.price*y.quantity)
                             FROM     Purchase y
                             WHERE x.product = y.product
                                   AND y.date > '10/1/2005' )
                            AS TotalSales
FROM        Purchase x
WHERE       x.date > '10/1/2005'
```

Another Example

What does it mean ?

```
SELECT      product,
             sum(price * quantity) AS SumSales
             max(quantity) AS MaxQuantity
FROM        Purchase
GROUP BY product
```

HAVING Clause

Same query, except that we consider only products that had at least 100 buyers.

```
SELECT      product, Sum(price * quantity)
FROM        Purchase
WHERE       date > '10/1/2005'
GROUP BY product
HAVING      Sum(quantity) > 30
```

HAVING clause contains conditions on aggregates.

General form of Grouping and Aggregation

SELECT S

FROM $R_1,\ldots,R_n$

WHERE C1

GROUP BY $a_1,\ldots,a_k$

HAVING C2

S = may contain attributes $a_1,\ldots,a_k$ and/or any aggregates but NO OTHER ATTRIBUTES

C1 = is any condition on the attributes in $R_1,\ldots,R_n$

C2 = is any condition on aggregate expressions

General form of Grouping and Aggregation

```
SELECT    S
FROM      R1,…,Rn
WHERE     C1
GROUP BY  a1,…,ak
HAVING    C2
```

Evaluation steps:

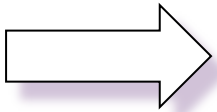
1. Evaluate FROM-WHERE, apply condition C1
2. Group by the attributes $a_1,\ldots,a_k$
3. Apply condition C2 to each group (may have aggregates)
4. Compute aggregates in S and return the result

Advanced SQLizing

1. Getting around INTERSECT and EXCEPT
2. Quantifiers
3. Aggregation v.s. subqueries

1. INTERSECT and EXCEPT:

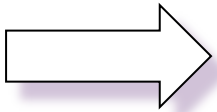
```
(SELECT R.A, R.B
FROM    R)
   INTERSECT
(SELECT S.A, S.B
FROM    S)
```



```
SELECT R.A, R.B
FROM    R
WHERE
    EXISTS(SELECT *
                FROM S
                WHERE R.A=S.A and R.B=S.B)
```

If R, S have no duplicates, then can write without subqueries (HOW ?)

```
(SELECT R.A, R.B
FROM    R)
   EXCEPT
(SELECT S.A, S.B
FROM    S)
```



```
SELECT R.A, R.B
FROM    R
WHERE
  NOT  EXISTS(SELECT *
                FROM S
                WHERE R.A=S.A and R.B=S.B)
```

2. Quantifiers

Product (pname, price, company)
Company(cname, city)

Find all companies that make some products with price < 100

```
SELECT DISTINCT  Company.cname
FROM     Company, Product
WHERE  Company.cname = Product.company and Product.price < 100
```

Existential: easy ! ☺

2. Quantifiers

Product (pname, price, company)
Company(cname, city)

Find all companies that make only products with price < 100

same as:

Find all companies s.t. all of their products have price < 100

Universal: hard ! ☹

2. Quantifiers

1. Find *the other* companies: i.e. s.t. some product ≥ 100

```
SELECT DISTINCT  Company.cname
FROM     Company
WHERE  Company.cname IN (SELECT Product.company
                         FROM Product
                         WHERE Produc.price >= 100
```

2. Find all companies s.t. all their products have price < 100

```
SELECT DISTINCT  Company.cname
FROM     Company
WHERE  Company.cname NOT IN (SELECT Product.company
                             FROM Product
                             WHERE Produc.price >= 100
```

3. Group-by v.s. Nested Query

Author(login,name)

Wrote(login,url)

- Find authors who wrote ≥ 10 documents:
- Attempt 1: with nested queries

This is SQL by a novice

```
SELECT DISTINCT Author.name
FROM        Author
WHERE       count(SELECT Wrote.url
                  FROM Wrote
                  WHERE Author.login=Wrote.login)
                > 10
```

3. Group-by v.s. Nested Query

- Find all authors who wrote at least 10 documents:
- Attempt 2: SQL style (with GROUP BY)

```
SELECT      Author.name
FROM        Author, Wrote
WHERE       Author.login=Wrote.login
GROUP BY Author.name
HAVING      count(wrote.url) > 10
```

This is SQL by an expert

No need for DISTINCT: automatically from GROUP BY

3. Group-by v.s. Nested Query

Author(login,name)

Wrote(login,url)

Mentions(url,word)

Find authors with vocabulary ≥ 10000 words:

```
SELECT      Author.name
FROM        Author, Wrote, Mentions
WHERE       Author.login=Wrote.login AND Wrote.url=Mentions.url
GROUP BY    Author.name
HAVING      count(distinct Mentions.word) > 10000
```

Two Examples

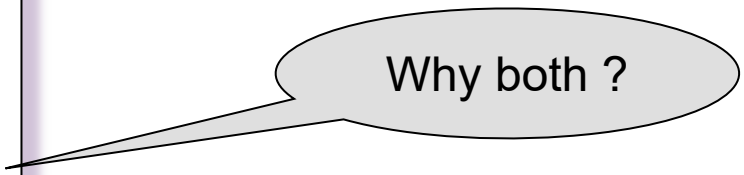
Store(sid, sname)
Product(pid, pname, price, sid)

Find all stores that sell *only* products with price > 100

same as:

Find all stores s.t. all their products have price > 100)

```
SELECT Store.name
FROM    Store, Product
WHERE  Store.sid = Product.sid
GROUP BY  Store.sid, Store.name
HAVING 100 < min(Product.price)
```



Almost equivalent…

```
SELECT Store.name
FROM    Store
WHERE
   100 < ALL (SELECT Product.price
                FROM product
                WHERE Store.sid = Product.sid)
```

```
SELECT Store.name
FROM    Store
WHERE  Store.sid NOT IN
            (SELECT Product.sid
              FROM Product
              WHERE  Product.price <= 100)
```

Two Examples

Store(sid, sname)
Product(pid, pname, price, sid)

For each store,
find its most expensive product

Two Examples

This is easy but doesn't do what we want:

```
SELECT Store.sname, max(Product.price)
FROM    Store, Product
WHERE  Store.sid = Product.sid
GROUP BY  Store.sid, Store.sname
```

Better:

```
SELECT Store.sname, x.pname
FROM    Store, Product x
WHERE  Store.sid = x.sid and
            x.price >=
                ALL (SELECT y.price
                        FROM Product y
                        WHERE Store.sid = y.sid)
```

But may return multiple product names per store

Two Examples

Finally, choose some pid arbitrarily, if there are many with highest price:

```
SELECT Store.sname, max(x.pname)
FROM    Store, Product x
WHERE  Store.sid = x.sid and
              x.price >=
                   ALL (SELECT y.price
                             FROM Product y
                             WHERE Store.sid = y.sid)
GROUP BY Store.sname
```

Announcement

- "A note taker is required to assist a student in this class. There is an honorarium of $75/course/term, with some conditions. If you are interested, please go to the Advising and Access Services Centre (AASC), 6227 University Avenue, to obtain information and to fill out a Confidentiality form."
- I wanted to confirm for you that the notetaker would be paid in full and will mostly likely be asked to provide retroactive notes for the term.

Subqueries Returning Relations

You can also use: s > ALL R
s > ANY R
EXISTS R

Product (pname, price, category, maker)
Find products that are more expensive than all those produced
By "Gizmo-Works"

```
SELECT  name
FROM    Product
WHERE  price >  ALL (SELECT price
                     FROM    Purchase
                     WHERE  maker= 'Gizmo-Works' )
```

Question: How are EXISTS and IN different?

- http://dev.mysql.com/doc/refman/5.0/en/comparison-operators.html
- http://dev.mysql.com/doc/refman/5.0/en/comparison-operators.html#function_in
- http://dev.mysql.com/doc/refman/5.0/en/any-in-some-subqueries.html
- http://dev.mysql.com/doc/refman/5.1/en/exists-and-not-exists-subqueries.html

Short answer: EXISTS returns TRUE if there is a row returned in the subquery, IN evaluates as TRUE if a value matches a value in a list (list of constants or subquery results)

NULLS in SQL

- Whenever we do not have a value, we can put a NULL
- Can mean many things:
  - Value does not exists
  - Value exists but is unknown
  - Value not applicable
  - Etc.
- The schema specifies for each attribute if can be null (*nullable* attribute) or not
- How does SQL cope with tables that have NULLs ?

Null Values

- If x= NULL then 4*(3-x)/7 is still NULL

- If x= NULL then x= "Joe" is UNKNOWN
- In SQL there are three boolean values:

  FALSE = 0

  UNKNOWN = 0.5

  TRUE = 1

Null Values

- C1 AND C2 = min(C1, C2)
- C1 OR C2 = max(C1, C2)
- NOT C1 = 1 – C1

```
SELECT *
FROM Person
WHERE  (age < 25) AND
              (height > 6 OR weight > 190)
```

E.g.
age=20
height=NULL
weight=200

Rule in SQL: include only tuples that yield TRUE

Null Values

Unexpected behavior:

```
SELECT *
FROM    Person
WHERE  age < 25  OR  age >= 25
```

Some Persons are not included !

Null Values

Can test for NULL explicitly:

- x IS NULL
- x IS NOT NULL

```
SELECT *
FROM    Person
WHERE  age < 25  OR  age >= 25 OR
            age IS NULL
```

Now it includes all Persons

Outerjoins

Explicit joins in SQL = "inner joins":

Product(name, category)
Purchase(prodName, store)

```
SELECT Product.name, Purchase.store
FROM   Product JOIN Purchase ON
                    Product.name = Purchase.prodName
```

Same as:

```
SELECT Product.name, Purchase.store
FROM   Product, Purchase
WHERE  Product.name = Purchase.prodName
```

But Products that never sold will be lost !

Outer Joins

- Left outer join:
  - Include the left tuple even if there's no match
- Right outer join:
  - Include the right tuple even if there's no match
- Full outer join:
  - Include the both left and right tuples even if there's no match

Outerjoins

Left outer joins in SQL:

Product(name, category)

Purchase(prodName, store)

```
SELECT Product.name, Purchase.store
FROM     Product LEFT OUTER JOIN Purchase ON
                    Product.name = Purchase.prodName
```

```
SELECT Product.name, Purchase.store
FROM   Product LEFT OUTER JOIN Purchase ON
                  Product.name = Purchase.prodName
```

Product

Name	Category
Gizmo	gadget
Camera	Photo
OneClick	Photo

Purchase

ProdName	Store
Gizmo	Wiz
Camera	Ritz
Camera	Wiz

Name	Store
Gizmo	Wiz
Camera	Ritz
Camera	Wiz
OneClick	NULL

Application

Compute, for each product, the total number of sales in 'September'

Product(name, category)

Purchase(prodName, month, store)

```
SELECT Product.name, count(*)
FROM     Product, Purchase
WHERE   Product.name = Purchase.prodName
        and  Purchase.month = 'September'
GROUP BY Product.name
```

What's wrong ?

Application

Compute, for each product, the total number of sales in 'September'

Product(name, category)

Purchase(prodName, month, store)

```
SELECT Product.name, count(*)
FROM     Product LEFT OUTER JOIN Purchase ON
                    Product.name = Purchase.prodName
               and  Purchase.month = 'September'
GROUP BY Product.name
```

Now we also get the products who sold in 0 quantity

Modifying the Database

Three kinds of modifications

- Insertions
- Deletions
- Updates

Sometimes they are all called "updates"

Insertions

General form:

```
INSERT INTO R(A1,…., An) VALUES (v1,…., vn)
```

Example: Insert a new purchase to the database:

```
INSERT INTO Purchase(buyer, seller, product, store)
        VALUES ('Joe', 'Fred', 'wakeup-clock-espresso-machine',
                'The Sharper Image')
```

Missing attribute → NULL.
May drop attribute names if give them in order.

Insertions

```
INSERT   INTO   PRODUCT(name)

    SELECT  DISTINCT  Purchase.product
    FROM      Purchase
    WHERE   Purchase.date > “10/26/01”
```

The query replaces the VALUES keyword.
Here we insert *many* tuples into PRODUCT

Insertion: an Example

Product(name, listPrice, category)
Purchase(prodName, buyerName, price)

prodName is foreign key in Product.name

Suppose database got corrupted and we need to fix it:

Product

name	listPrice	category
gizmo	100	gadgets

Purchase

prodName	buyerName	price
camera	John	200
gizmo	Smith	80
camera	Smith	225

Task: insert in Product all prodNames from Purchase

Insertion: an Example

```
INSERT   INTO   Product(name)

 SELECT  DISTINCT  prodName
 FROM     Purchase
 WHERE   prodName  NOT IN (SELECT  name FROM  Product)
```

name	listPrice	category
gizmo	100	Gadgets
camera	-	-

Insertion: an Example

```
INSERT  INTO  Product(name, listPrice)

SELECT  DISTINCT  prodName, price
FROM  Purchase
WHERE  prodName  NOT IN (SELECT  name FROM  Product)
```

name	listPrice	category
gizmo	100	Gadgets
camera	200	-
camera ??	225 ??	-

← Depends on the implementation

Deletions

Example:

```
DELETE    FROM    PURCHASE

WHERE     seller = 'Joe'    AND
                  product = 'Brooklyn Bridge'
```

Factoid about SQL: there is no way to delete only a single occurrence of a tuple that appears twice in a relation.

Updates

Example:

```
UPDATE   PRODUCT
SET    price = price/2
WHERE  Product.name  IN
                (SELECT product
                  FROM    Purchase
                  WHERE  Date = 'Oct, 25, 1999' );
```