Unit 2:
SQL

2.1. DML: Queries and Data Manipulation

2.2. SQL Exercises (Lab. sessions)

2.3. DDL: Data Definition Language

Unit 2.1 DML: Queries and Data Manipulation

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3. Database updates
4. Commands for handling transactions

UD 2.1 DML: Queries and Data Manipulation

SQL

SQL (**S**tructured **Q**uery **L**anguage) is a standard language for defining and manipulating a relational database.

Includes:

- Features from Relational Algebra (Algebraic Approach)
- Features from Tuple Relational Calculus (Logical Approach)
- Others

- SQL has evolved: SQL'92, SQL'99, SQL:2003, SQL:2008, SQL:2011, SQL:2011, SQL:2016
- We will use the basics of the language (present from the main revision SQL'92)

SQL sublanguages

DDL (Data Definition Language): Creation and modification of relational DB schemas.

DML (Data Manipulation Language): Queries and database updates.

- SELECT: Allows the declaration of queries to retrieve the information from the database
- INSERT: Performs the insertion of one or more rows in a table
- DELETE: Allows the user to delete one o more rows from a table
- UPDATE: Modifies the values of one or more columns and/or one or more rows in a table

DCL (Data Control Language): Dynamically changes the database properties

Cycling race

TEAM (teamname: char(25), director: char(30))
PK:{teamname}

CYCLIST (cnum: integer, name: char(30), age: integer, teamname: char(25))
PK:{cnum} FK:{teamname}→ TEAM
NNV:{teamname} NNV:{name}

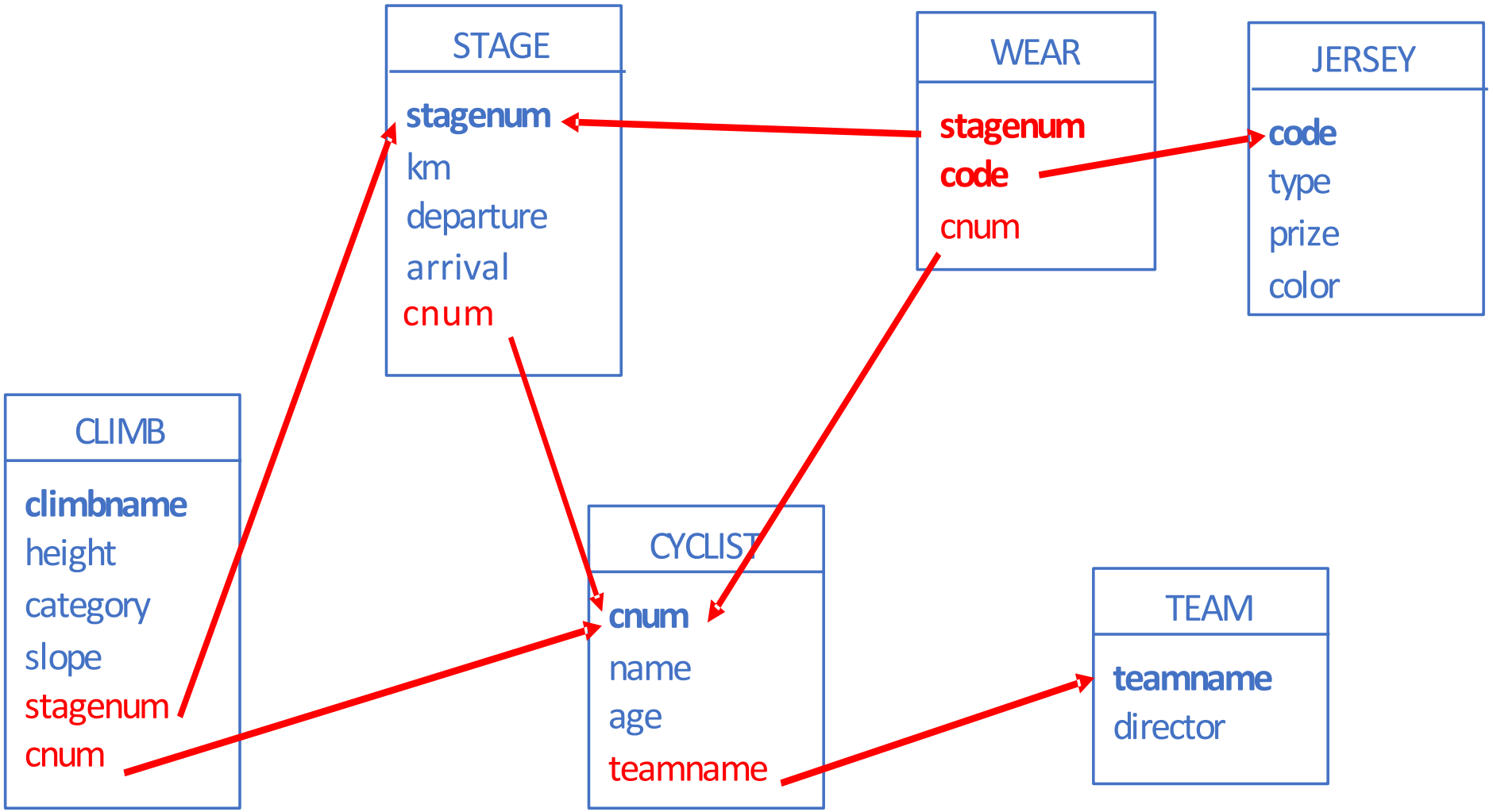
STAGE (stagenum: integer, km: integer, departure: char(35), arrival: char(35), cnum: integer)
PK:{stagenum} FK:{cnum}→ CYCLIST

JERSEY (code: char(3), type: char(30), prize: integer, color: char(25))
PK:{code}

CLIMB (climbname: char(30), height: integer, category: char(1), slope: real, stagenum: integer, cnum: integer)
PK:{climbname} FK:{stagenum}→ STAGE
FK:{cnum}→ CYCLIST NNV:{stagenum}

WEAR (stagenum: integer, code: char(3), cnum: integer)
PK:{stagenum, code} FK:{stagenum}→ STAGE
FK:{cnum}→ CYCLIST FK:{code}→ JERSEY
NNV:{cnum}

Cycling race



UD 2.1 DML: Queries and Data Manipulation

1. Introduction to SQL
2. Queries
    - **2.1. Simple queries using one table.**
    - 2.2. Simple queries with several tables
    - 2.3. Subqueries
    - 2.4. Universal Quantification
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    - 2.6. Grouping
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    - 2.8. Joins
3. Database updates
4. Commands for handling transactions

Example:

List the name and the age of all the cyclists.

```
SELECT name, age
FROM Cyclist;
```

Mathematics operations

+, –, *, /, …

Example:

List for each jersey its type and the prize in euros (suppose that the prizes are in pesetas and 1€ = 166 ptas.) but only for those jerseys which prize is greater than 100 euros.

```
SELECT type, prize / 166
FROM Jersey
WHERE prize / 166 > 100;
```

Sorting the result

Example:
List the name, the height and the category of all the climbs (order by height and category).

```
SELECT climbname, height, category
FROM Climb
ORDER BY height, category ;
```

The order can be **ASC**ending (by default) or **DESC**ending;

Example: List the name and the height of all the climbs in the1ª category in ascending order according to the height

1. Which tables contain the information?
2. What are the conditions for the tuples?
3. What information is going to be returned?
4. Is any order required?

```
SELECT climbname, height
FROM Climb
WHERE category = ´1´
ORDER BY height ;
```

DISTINCT

Example:

List the teams of the cyclists (only the team).

```
SELECT DISTINCT teamname
FROM Cyclist;
```

Example:

List all the information in the Team table.

```
SELECT  *
FROM Team;
```

LIKE

LIKE is followed by a pattern which will be used with strings

Wildcards in SQL:

- % The percent sign represents zero, one, or multiple characters
- _ The underscore represents a single character

Example:
Obtain the name and age of the cyclists who belong to the teams whose name contains the string “cyclist”.

```
SELECT name, age
FROM Cyclist
WHERE teamname LIKE ‘%cyclist%’
```

Example:

List the stage numbers where the arrival city name has, as first letter, an “A”, or where the departure city name contains two or more ‘e’s

```
SELECT stagenum
FROM Stage
WHERE arrival LIKE ‘A%’ OR departure LIKE ‘%e%e%’ ;
```

BETWEEN

Example:

Name of the cyclists with an age between 20 and 30

```
SELECT name
FROM Cyclist
WHERE age BETWEEN 20 AND 30;
```

exp between exp_1 and exp_2 ≡ (*exp* >= exp_1) and (*exp* <= exp_2)

IS NULL

Wrong query (sintax error)

```
SELECT teamname
FROM Team
WHERE  director = null
```

The right query is:

```
SELECT teamname
FROM Team
WHERE  director IS NULL
```

Using the NULL VALUE

A α B (where α is a comparison operator) is evaluated as undefined if at least one A or B is null; otherwise it is evaluated to the certainty value of the comparison A α B

Example:

```
SELECT *
FROM T
WHERE atrib1 > atrib2
```

If a tuple has $atrib_1$ = 50 and $atrib_2$ is null, the comparison is undefined, and therefore that tuple will not be included in the query result.

Aggregated values (non-grouped queries)

{ AVG | MAX | MIN | SUM | COUNT }

([ALL | DISTINCT] ***expression*****) | COUNT(*)**

- DISTINCT is used to remove the duplicate values before the aggregated function calculate the result.
- The NULL values are removed before the aggregated function calculate the result.
- If the number of selected rows is 0, COUNT returns 0, and the rest of the functions return the NULL value.

Example:

```
SELECT 'Num. cyclists=', COUNT(*), 'average age=', AVG(age)
FROM Cyclist
WHERE teamname = 'Banesto';
```

In non-grouped queries, the SELECT clause can only include references to aggregated functions or literals, since the functions will return just a single value.

WRONG EXAMPLE:

```
SELECT name, AVG(age)
FROM Cyclist
WHERE teamname = 'ONCE';
```

Alias

Name and age of the ‘Banesto’ cyclists ordered from oldest to youngest. The column name must be “Banesto”

```
SELECT name AS Banesto, age
FROM Cyclist
WHERE teamname = ‘Banesto’
ORDER BY age DESC;
```

UD 2.1 DML: Queries and Data Manipulation

If the information required by the query is in several tables, the query will include those tables in the FROM clause.

A query over several tables corresponds to the Cartesian product:

- If we do not express several conditions to connect them, the number of rows will be very high.
- If there are foreign keys defined, it is usual that some conditions are formed by an equality between the foreign key and the corresponding attributes in the table to which it refers.
- With n tables, we will typically have (at least) n-1 connections. (The way in which tables are connected and the attributes that are used determine the meaning of the query.)

Example: SELECT * FROM T1, T2 WHERE T1.n = T2.n

T1

t1	n
a1	b1
a2	b2
a3	b3

T2

t2	n
c1	d1
c2	b2

T1 x T2

t1	n	t2	n
~~a1~~	~~b1~~	~~c1~~	~~d1~~
~~a1~~	~~b1~~	~~c2~~	~~b2~~
~~a2~~	~~b2~~	~~c1~~	~~d1~~
a2	b2	c2	b2
~~a3~~	~~b3~~	~~c1~~	~~d1~~
~~a3~~	~~b3~~	~~c2~~	~~b2~~

Example: List pairs stage-climb which have been won by the same cyclist.

1. Which tables contain the information?

```
FROM Stage, Climb
```

2. Which rows must be selected? (same winner)

```
WHERE Stage.cnum = Climb.cnum;
```

3. What attributes are going to be returned? (stage and climb)

```
SELECT Stage.stagenum, climbname
```

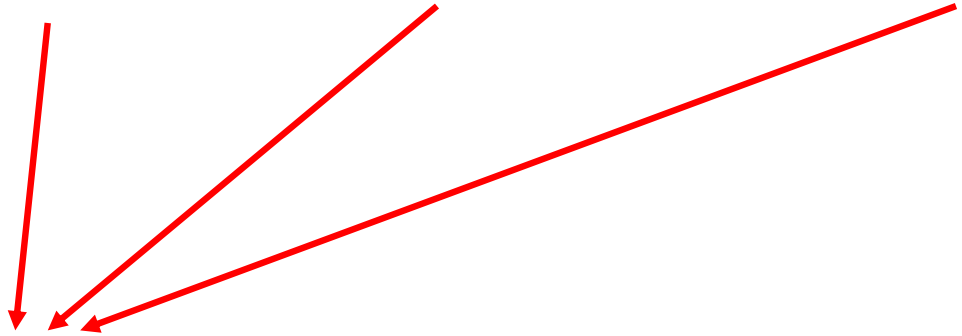
Note that the columns *cnum* from *stage* and *cnum* from *Climb* are prefixed by the table name to avoid ambiguity:

```
SELECT Stage.stagenum, climbname
FROM Stage, Climb
WHERE Stage.cnum = Climb.cnum ;
```

Alias

Example: Obtain the name of the cyclists who belong to the team directed by 'Alvaro Pino'

```
SELECT C.name
FROM Cyclist C, Team T
WHERE C.teamname = T.teamname AND T.director = 'Alvaro Pino';
```



The alias can be used to refer any table*:

Syntax: **FROM** table **[AS]** *alias*

* In Oracle the "AS keyword is not allowed in the FROM clause

Example:

Obtain the name of the cyclists and the stage number such that the cyclist has won that stage. Additionally, the stage must be more than 150 km long

```
SELECT C.name, S.stagenum
FROM Cyclist C, Stage S
WHERE C.cnum = S.cnum AND S.km > 150;
```

Example: List the names of the cyclists who belongs to the same team as ‘Miguel Induráin’ but who are younger than he is

1. Which tables contain the information?

FROM Cyclist

But we need to compare tuples of Cyclist with tuples of the same table, so we use this **table twice**

FROM Cyclist C1, Cyclist C2

2. Which rows must be selected?

WHERE C2.name=‘Miguel Induráin’ AND C1.teamname = C2.teamname
AND C1.age < C2.age;

3. What attributes are going to be returned?

SELECT C1.name

SELECT C1.name **FROM** Cyclist C1, Cyclist C2
==> **WHERE** C2.name=‘Miguel Induráin’
AND C1.teamname = C2.teamname AND C1.age < C2.age;

UD 2.1 DML: Queries and Data Manipulation

Informal definition

What is a subquery ?

A subquery is a query between parenthesis included inside other query.

Example: Calculate the number and length of the stages with climbs

```
SELECT DISTINCT S.stagenum, km
FROM Stage S, Climb CL
WHERE S.stagenum = CL.stagenum
```

Using a subquery:

```
SELECT stagenum, km
FROM Stage
WHERE stagenum IN (SELECT stagenum
                   FROM Climb)
```

Main query

The subquery returns the number of the stages

Example: Obtain the names of the cyclists who belong to the team directed by 'Alvaro Pino'.

Solved through equalities:

```
SELECT C.name
FROM Cyclist C, Team T
WHERE C.teamname = T.teamname AND T.director = 'Alvaro Pino';
```

Using a subquery:

```
SELECT C.name
FROM Cyclist C
WHERE C.teamname IN ( SELECT T.teamname
                      FROM Team T
                      WHERE T.director = 'Alvaro Pino' );
```

The name of the cyclist is not in the table used in the subquery (Team)

Name of the team directed by 'Alvaro Pino'

Predicates accepting subqueries

Subqueries can appear in the search conditions, either in the “where” or in the “having” clauses, as arguments of some predicates:

- Comparison predicates: **=, <>, >, <, >=, <=.**

- **IN**: Cheks that a value belongs to the collection (table) returned by the subquery

- **EXISTS**: It is equivalent to the existential quantifier. It checks if a subquery returns some row.

Comparison Predicates: =, <>, >, <, >=, <=

SYNTAX:

row_constructor ***comparison predicate*** *row_constructor*

"row_constructor" is either a sequence of constants or a subquery.

```
('Álvaro Pino', 28) =   (SELECT name , age
                         FROM Cyclist
                         WHERE cnum= '666')
```

When row constructor returns more than one column, the lexicographic order will be used in the comparison of each operator.

For simplicity, we will only see queries with one column in the subquery.

Subqueries can be a parameter of a comparison if (and only if):

- Return only a single row, and
- the number of columns match (in number and type) with the other side of the comparison predicate.

If the result of the subquery is empty, the row is converted into a row with NULL values in all its columns and the result of the comparison will be undefined.

Example: Obtain the name of the climbs whose height is greater than the mean of the height of all 2nd category climbs.

1. Which tables contain the information?

Climb ==> FROM Climb

2. Which rows must be selected?

height > AVG(height) of the second category climbs

It is 1 value = 1 row

==> WHERE height > (SELECT AVG(height) FROM Climb
WHERE category = '2');

Check any height (height) with the value returned by AVG(height)

Example: Obtain the name of the climbs whose height is greater than the mean of the height of all 2nd category climbs.

1. Which tables contain the information?

Climb ==> FROM Climb

2. Which rows must be selected?

height > AVG(height) of the second category climbs

==> WHERE height > (SELECT AVG(height) FROM Climb
WHERE category = '2');

3. What attributes are going to be returned?

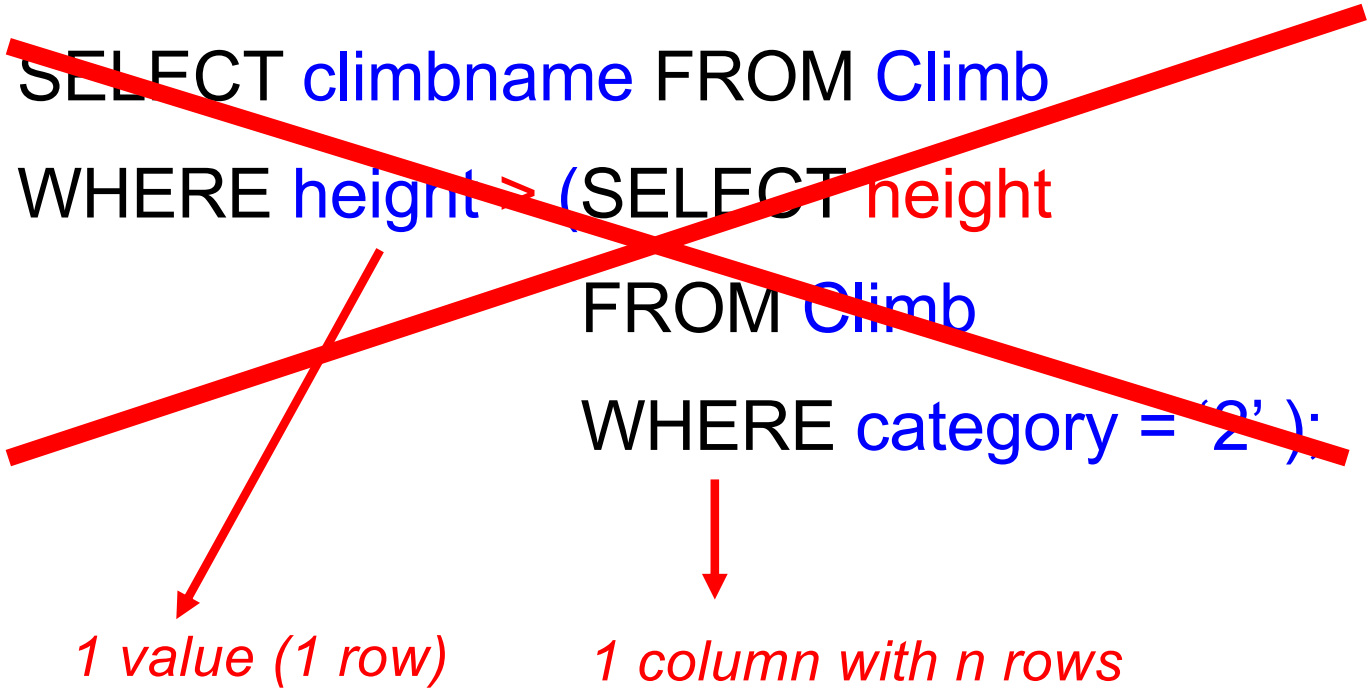
climbname ==> SELECT climbname ==> *1 column with n rows*

==> SELECT climbname FROM Climb
WHERE height > (SELECT AVG(height) FROM Climb
WHERE category = '2');

Example: Obtain the name of the climbs whose height is greater than the mean of the height of all 2nd category climbs.

```
SELECT climbname FROM Climb
WHERE height >   (  SELECT AVG(height)
                    FROM Climb
                    WHERE category = '2' );
```

Example: Obtain the name of the climbs whose height is greater than the mean of the height of all 2nd category climbs.



==> It can't be checked !

WRONG: (execution error).

Example: Obtain the name of the climbs whose height is greater than the mean of the height of all 2nd category climbs.

WRONG: (Execution error):

```
SELECT climbname
FROM Climb
WHERE height > AVG (SELECT height
                    FROM Climb
                    WHERE category = '2' );
```

Example: List the name of the departure and the arrival cities of the stages where the steepest climbs are located.

```
SELECT DISTINCT S.departure, S.arrival
FROM Stage S, Climb CL
WHERE S.stagenum = CL.stagenum
    AND slope = (SELECT MAX(slope)
                 FROM Climb) ;
```

IN Predicate

SYNTAX:

row_constructor [NOT] IN (*table_expression*)

Example:
Obtain the *stagenum* of the stages which have been won by cyclists whose age is greater than 30 years.

```
SELECT stagenum
FROM Stage
WHERE cnum IN ( SELECT cnum
                FROM Cyclist
                WHERE age > 30);
```

NOT IN and NULL values

E_0 NOT IN (E_1, E_2, … E_n)

The expression is **true if E_0 is different to all** the values of the set E_1, E_2, … E_n

What will be the result if the NULL value is in the set ?

E_0<>E_1 **and** E_0<>E_2 **and** … E_0<>NULL … **and** E_0<>E_n → *undefined*

Solution: Remove NULL values from the subquery.

Example:
Obtain the name of the cyclists who haven't won any stage.

```
SELECT name
FROM Cyclist
WHERE cnum NOT IN ( SELECT cnum
                    FROM Stage
                    WHERE cnum IS NOT NULL );
```

Subqueries and DISTINCT

Example: Obtain the director of the teams which have one or more cyclists with a name starting with 'B'.

```
SELECT director
FROM Team
WHERE teamname IN
        (SELECT teamname
         FROM Cyclist
         WHERE name LIKE 'B%');
```

We don't need the DISTINCT

But …

```
SELECT DISTINCT T.director
FROM Cyclist C, Team T
WHERE C.teamname = T.teamname
      AND C.name LIKE 'B%' ;
```

Nested Queries

Example:

Obtain the stage number won by cyclists who belong to teams whose director has a name beginning with ‘B’.

```
SELECT stagenum
FROM Stage
WHERE cnum IN
        (SELECT cnum
        FROM Cyclist
        WHERE teamname IN (SELECT teamname
                           FROM Team
                           WHERE director LIKE ‘B%’));
```

EXISTS Predicate

Syntax:

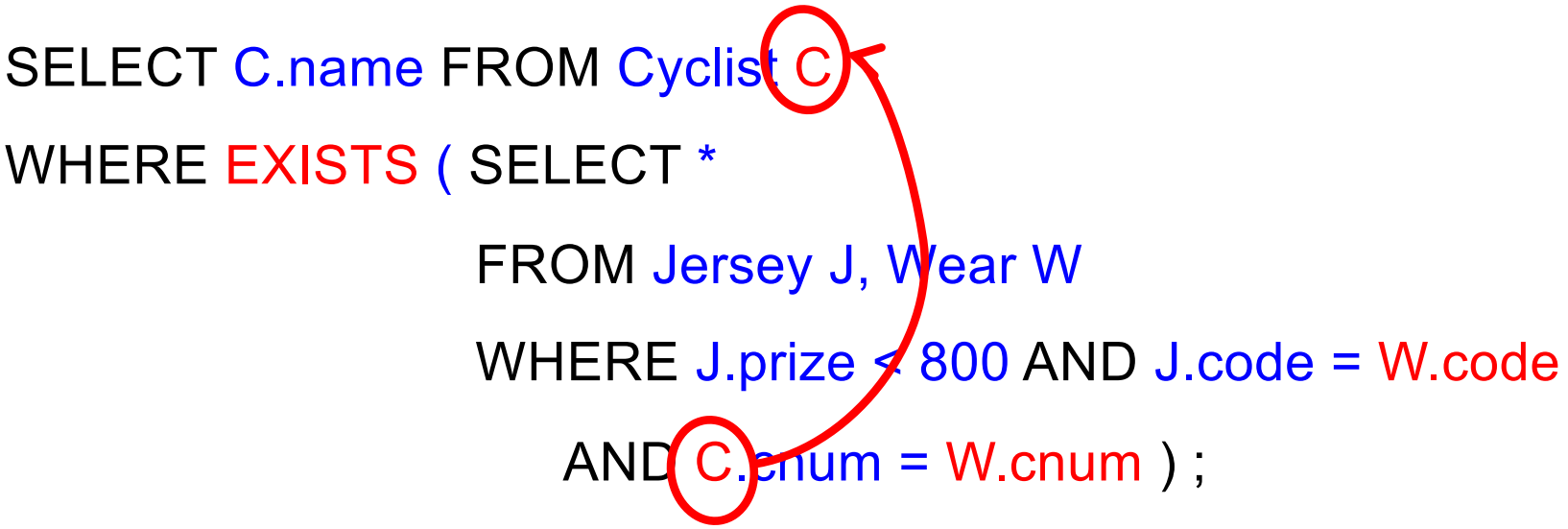
EXISTS (*table_expression*)

The exists predicate is evaluated to true if the expression SELECT returns at least one row.

In general, IN and EXISTS are interchangeable and, when there is no negation, they can be eliminated (creating queries using multiple tables and adding comparison with the foreign keys)*

(*) That is also true for “NOT IN” and “NOT EXISTS”

Example: Obtain the name of the cyclists who has worn a jersey with a prize lower than 800 eur.



```
SELECT C.name FROM Cyclist C
WHERE EXISTS ( SELECT *
                 FROM Jersey J, Wear W
                 WHERE J.prize < 800 AND J.code = W.code
                   AND C.cnum = W.cnum ) ;
```

Also:

```
SELECT C.name FROM Cyclist C
WHERE 0 <  ( SELECT COUNT(*)
               FROM Jersey J, Wear W
               WHERE J.prize < 800 AND J.code = W.code
                 AND C.cnum = W.cnum );
```

Example: Obtain the name of the cyclists who has worn a jersey with a prize lower than 800 eur.

```
SELECT C.name FROM Cyclist C
    WHERE  C.cnum IN ( SELECT W.cnum
                       FROM Wear W, Jersey J
                       WHERE J.prize < 800
                           AND W.code = J.code ) ;
```

Also:

```
SELECT DISTINCT C.name
FROM Cyclist C, Wear W, Jersey J
WHERE  C.cnum = W.cnum
      AND W.code = J.code
      AND J.prize < 800 ;
```

Example: Obtain the name of the cyclists who haven't won any stage.

```
SELECT name
FROM Cyclist C
WHERE NOT EXISTS (SELECT *
                  FROM Stage S
                  WHERE S.cnum = C.cnum);
```

WHERE NOT EXISTS (SELECT * FROM …)

Is equivalent to: WHERE 0 = (SELECT COUNT(*) FROM …)

Example: Obtain the name of the cyclists who haven't won any stage.

```
SELECT name
FROM Cyclist C
WHERE cnum NOT IN (SELECT cnum
                   FROM Stage S
                   WHERE S.cnum IS NOT NULL);
```

~~SELECT name~~
~~FROM Cyclist C, Stage S~~
~~WHERE C.cnum <> S.cnum ;~~

No sense

Universal Quantification

SQL'92 and most DBMS nowadays do not provide the universal quantification (FORALL). We must transform the query to solve it with an EXISTS:

$$\forall X\ F(X) \equiv \neg\exists X \neg F(X)$$

Example:

"Obtain the name of the cyclists (if any) who have won all the stages with more than 200 km.

The query is converted into:

"Obtain the name of the cyclists such that there does not exist a stage of more than 200 km which has not been won by that cyclist"

(*) Assuming that we know that there are some stage with more than 200 km

Obtain the name of the cyclists such that there does not exist a stage of more than 200 km which has not been won by that cyclist

```
SELECT name FROM Cyclist C
WHERE NOT EXISTS ( SELECT *
                   FROM Stage S
                   WHERE km > 200 AND
                         C.cnum <> S.cnum );
```

Assuming that we know that there are some stage with more than 200 km

Problem: What happens if there is no stage with more than 200 km?

```
SELECT name
FROM Cyclist C
WHERE NOT EXISTS ( SELECT *
                   FROM Stage S
                   WHERE km > 200 AND C.cnum <> S.cnum );
```

In that case, this query returns the name of all the cyclists !!!

Solution:

Check that exists at least one stage with more tan 200 Km (ADD-ON).

```
SELECT name
FROM Cyclist C
WHERE NOT EXISTS (SELECT *
                  FROM Stage S
                  WHERE km > 200 AND
                        C.cnum <> S.cnum )
      AND EXISTS ( SELECT *
                   FROM Stage S
                   WHERE km > 200)        ;
```

Example:
Name of the cyclists who have worn all the (kinds of) jerseys.

```
SELECT C.name
FROM Cyclist C
WHERE NOT EXISTS
                (SELECT *
                 FROM Jersey J
                  WHERE NOT EXISTS
                                (SELECT *
                                 FROM Wear W
                                WHERE C.cnum = W.cnum )
                                    AND W.código = J.código )
      AND EXISTS ( SELECT *   FROM jersey )
```

Example: List the name of all the cyclists who have won all the climbs in some stage and have won that stage

```
SELECT C.name
FROM Cyclist C
WHERE C.cnum IN
        (SELECT S.cnum
         FROM Stage S
         WHERE NOT EXISTS ( SELECT *
                            FROM Climb CL
                            WHERE CL.stagenum=S.stagenum
                              AND C.cnum <> CL.cnum )
           AND EXISTS ( SELECT *  FROM Climb CL
                        WHERE CL.stagenum=S.stagenum ) ) ;
```

Because there could be some stage with no climbs

UD 2.1 DML: Queries and Data Manipulation

SYNTAX:

row_constructor { ALL | ANY | SOME } (*table_expression*)

- The comparison predicate which is quantified with ALL is evaluated to true if it is true for all the rows in the table expression (if the table is empty it is also evaluated to true).

- The comparison predicate which is quantified with ANY or SOME is evaluated to true if it is true for some of the rows in the table expression (if the table is empty it is evaluated to false).

(*) The predicate “IN” is equivalent to the quantified comparison predicate “=any”.

Example:

Obtain the name of the climb/s and the cyclist/s who won the climb/s with the highest slope.

```
SELECT CL.climbname, C.name
FROM Climb CL, Cyclist C
WHERE CL.cnum = C.cnum
      AND CL.slope >= ALL (SELECT slope
                           FROM Climb):
```

Example:

Obtain the name of the climbs and the name of the cyclists who won them, such that the climb is not the one with the lowest slope.

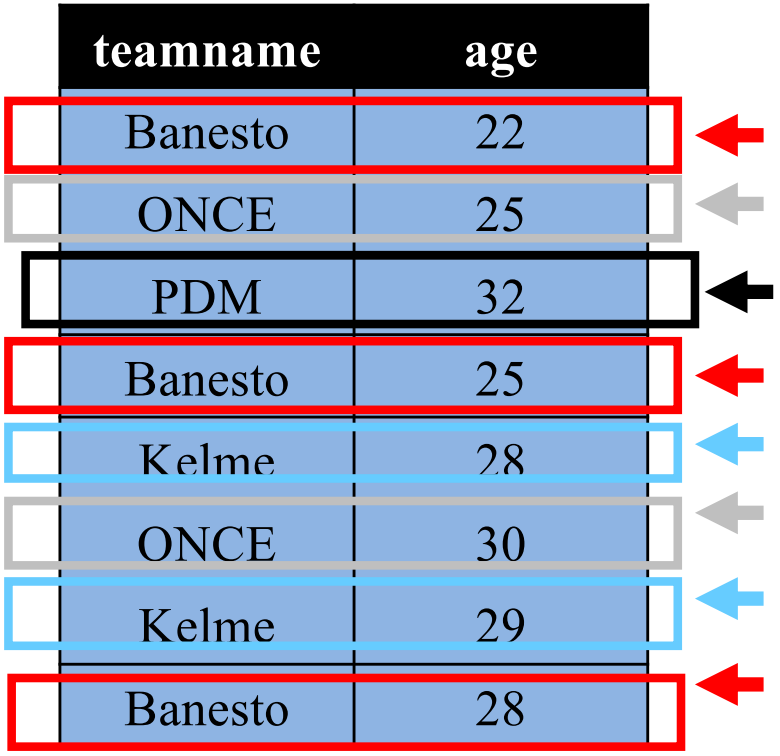
```
SELECT CL.climbname, C.name
FROM Climb CL, Cyclist C
WHERE CL.cnum = C.cnum
    AND CL.slope > ANY (SELECT slope
                        FROM Climb);
```

(*) ANY can always be converted into an ALL by negating the condition and adding a NOT, and vice versa.

A group is a set of rows with the same value for the subset of columns used for grouping (used in the GROUP BY).

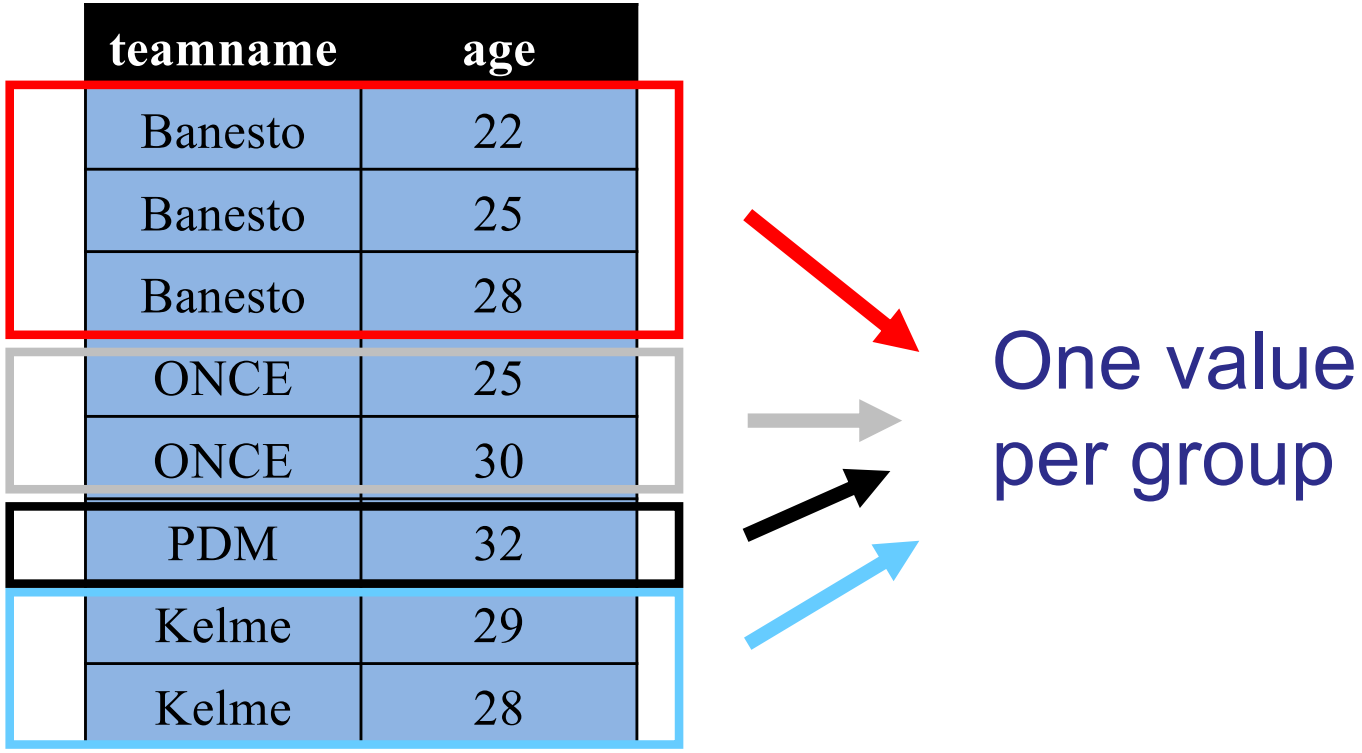
Example: Obtain the name of all the teams and the average age of the cyclists in each team.

```
SELECT teamname, AVG(age)
FROM Cyclist
GROUP BY teamname;
```



teamname	age
Banesto	22
ONCE	25
PDM	32
Banesto	25
Kelme	28
ONCE	30
Kelme	29
Banesto	28

The aggregated functions in the grouped queries do not work like the rest of queries: They return a value for each group which is formed.



```
SELECT teamname, AVG(age)
FROM Cyclist
GROUP BY teamname;
```

Returns:

teamnames	age
Banesto	25
ONCE	27,5
PDM	32
Kelme	28,5

SYNTAX:

SELECT [ALL | DISTINCT] {expression1, $expression_2$,..., $expression_n$|*}
FROM $table_1$, $table_2$ …, $table_n$
[WHERE condition]
[GROUP BY $column_1$, $column_2$,..., $column_n$
[HAVING *conditional_expression*]]
[ORDER BY $column_1$, $column_2$,..., $column_n$]

Group, where and having

The HAVING clause can only appear in grouped queries, and it is an extra condition similar to WHERE, but applied to the groups:

1º) WHERE condition (used for the rows)

2º) Grouping and calculation of aggregated functions

3º) HAVING condition (used for the groups)

In the HAVING and SELECT clauses can only appear references to columns used in the group by, aggregated functions, or subqueries.

WRONG EXAMPLE:

```
SELECT teamname, name, AVG(age)
FROM Cyclist
GROUP BY teamname;
```

Group, where and having

The where clause is applied before grouping.

Example:

Obtain the name of the teams with a name starting with ‘K’, and the average age of their cyclists who are older than 25

```
5 ----> SELECT teamname, AVG(age)
1 ----> FROM Cyclist
2 ----> WHERE age > 25
3 ----> GROUP BY teamname
4 ----> HAVING teamname LIKE “K%” ;
```

In the grouped queries, it is possible to use nested aggregated functions.

Example:

Obtain the average age for the team with the maximum average age (of their members).

```
SELECT  MAX(AVG(age))
FROM Cyclist
GROUP BY teamname;
```

Obtain the name of the teams and the average age of their cyclists who are older than 25, from those teams with more than 8 cyclists who are older than 25.

```
SELECT teamname, AVG(age)
FROM Cyclist
WHERE age > 25
GROUP BY teamname
HAVING COUNT(cnum) > 8 ;
```

Obtain the name of the teams and the average age of their cyclists who are older than 25, from those teams with more than 8 cyclists ~~who are older than 25~~.

```
SELECT C.teamname, AVG(C.age)
FROM Cyclist C
WHERE C.age > 25
GROUP BY C.teamname
HAVING 8 < (SELECT COUNT(*)
            FROM Cyclist C2
            WHERE C.teamname = C2.teamname);
```

Example:

Obtain the name of the cyclist and the number of climbs he has won, but only if the mean of the slope of the climbs that he has won is greater than 10.

```
SELECT C.name, COUNT(CL.climbname)
FROM Cyclist C, Climb CL
WHERE C.cnum = CL.cnum
GROUP BY C.cnum, C.name        /*Always group by the PK */
HAVING AVG (CL.slope) >10 ;
```

Example:

Obtain the name of the cyclists who have won at least one stage and belong to a team with more than 5 cyclists, indicating how many stages has won that cyclist.

```
SELECT C.name, count(*)
FROM Cyclist C, Stage S
WHERE C.cnum = S.cnum
    AND   5< ( SELECT count(*)
               FROM Cyclist C2
               WHERE C2.teamname = C.teamname )
GROUP BY C.cnum, C.name ;
```

Other table combinations

There are other ways to combine several tables in the same query. All of them, along with the ways we have already seen, are what we have called "*table_expression*".

- Include several tables in the FROM clause.
- Use of subqueries in the conditions in the where or having clause .
- **Set table combinations**: use the set operators to combine the tables.
- **Table joins**: combine two tables by using different variants of the JOIN operator in Relational Algebra.

Set combinations

Correspond to the UNION, DIFFERENCE and INTERSECTION in the relational algebra.

- UNION
- EXCEPT (MINUS in Oracle)
- INTERSECT

They make possible to combine tables with compatible schemas.

UNION

table_expression union [all] *table_expression*

Performs a union of the rows of the tables expressed by the two “table_expression”.

Duplicates will be allowed if the option ALL is set.

Example:

Obtain the name of all the people participating in the cycling race.

```
(SELECT name FROM Cyclist)
        UNION
(SELECT director FROM Team)
```

Obtain the name of the cyclists who have worn some jersey or have won a climb or a stage.

```
SELECT name
FROM Cyclist
WHERE cnum IN
        (SELECT cnum FROM Wear
                UNION
        SELECT cnum FROM Climb
                UNION
        SELECT cnum FROM Stage)
```

INTERSECCION

table_expression intersect *table_expression*

Performs a intersection of the rows of the tables expressed by the two “table_expression”.

Example:

Obtain the name of the cyclists with the same name as a team director.

```
(SELECT name FROM Cyclist)
        INTERSECT
(SELECT director FROM Team)
```

DIFERENCE

table_expression$_1$ except[1] *table_expression*$_2$

Return the tupls in table_expression$_1$ which do not appear in table_expresion$_2$.

Example:

Name of cyclist which do not appear in the table of teams as director

```
(SELECT name FROM Cyclist)
        EXCEPT
(SELECT director FROM Team)
```

[1]MINUS in Oracle

UD 2.1 DML: Queries and Data Manipulation

JOIN

3 Types of Joins (concatenation in the relational algebra).

1. Cross join
2. Inner Join
3. Outer join

1. Cross join

table_reference$_1$ cross join *table_reference*$_2$

≡

SELECT * FROM *table_reference*$_1$, *table_reference*$_2$

2. Inner Join

Syntax (3 different forms):

table_reference$_1$
[NATURAL] [INNER] JOIN
table_reference$_2$
[ON condition| USING (*column*$_1$, *column*$_2$,…,*column*$_n$)]

Form 1 (ON):

table$_1$* [inner] join *table$_2$* on *conditional expression

≡ SELECT * FROM *table1*, *table2*
WHERE *conditional_expression*

Example: Obtain the names of the climbs and the number of the stage in which the climb is, if the stage length is greater than 200km.

```
SELECT climbname, CL.stagenum
FROM Climb CL JOIN Stage S ON CL.stagenum= S.stagenum
WHERE S.km>200
```

Form 2 (USING):

table1 **[inner] join *table2*** **using (c1, c2,… cn)**

≡ SELECT * from *table1, table2*
WHERE *table1.c1 = table2.c1*
AND *table1.c2 = table2.c2*
AND..... and *table1.cn = table2.cn*

Example: Obtain the name of the climbs, the number of the stage in which the climb is and the length of the stage, but only if the climb is higher than 800 (height).

```
SELECT climbname, stagenum, km
FROM Climb JOIN Stage USING (stagenum)
WHERE height>800
```

Form 3 (NATURAL):

table1 **natural inner join** ***table2***

≡ *table1* join *table2* using (c1, c2, ..., cn)
where table1 has n attributes.

*(It is a regular JOIN but using the **common** attributes of both tables)*

Example: Obtain the name of the cyclists of the team directed by 'Alvaro Pino'.

```
SELECT name
FROM Cyclist  NATURAL JOIN Team
WHERE director = 'Alvaro Pino';
```

Example: Obtain the name of the climbs, their stage, and the km of the stage of those climbs higher than 800.

WRONG:

```
SELECT climbname, stagenum, km
FROM Climb CL NATURAL JOIN Stage
WHERE CL.height>800
```

because cnum appears in both tables

Obtain the number and name of the cyclists, and the amount of jerseys worn by each of them

```
SELECT C.cnum, C.name, COUNT (DISTINCT L.code)
FROM  Cyclist C, Wear W
WHERE C.cnum = W.cnum
GROUP BY C.cnum, C.name
```

```
SELECT cnum, Cyclist.name, COUNT (DISTINCT wear.code)
FROM Cyclist NATURAL INNER JOIN Wear
GROUP BY cnum, cyclist.name
```

3. OuterJoin

Combine **all** the rows from one of the tables (even if there is no correspondence for some row in the other table)

table_expression

[NATURAL] {LEFT | RIGHT | FULL} [OUTER] JOIN *table_expression*

[ON condition| USING ($column_1, column_2, ..., column_n$)]

Table1 LEFT JOIN Table2 ON conditional_expression

Inner join of *Table1* and *Table2* UNION tuples from *Table1* that do not appear in the inner join, using **NULL** values in the rest of columns

FULL: Returns all the tuples from *table1* and *table2*

Example:

Obtain the name of all the cyclists and the total number of stages won by each of them.

```
SELECT name, COUNT(stagenum)
FROM Cyclist NATURAL LEFT JOIN stage
GROUP BY cnum, name
```


The result includes cyclists who haven't won any stage

Example:

Obtain for all cyclist, his/her number, name and the code of every jersey worn by that cyclist (and the number of the stage in which that cyclist has worn that jersey).

```
SELECT C.cnum, name, code, stagenum
FROM Cyclist C LEFT JOIN Wear W ON  C.cnum = W.cnum
```

List the name of all the teams, indicating how many cyclist there are in each of them

```
SELECT team.teamname, COUNT(cnum)
FROM Team LEFT JOIN Cyclist
                    ON team.teamname= cyclist.teamname
GROUP BY team.teamname
```

```
( SELECT teamname, count(*)
  FROM cyclist
  GROUP BY teamname )
UNION
( SELECT teamname, 0
  FROM team
  WHERE teamname NOT IN (SELECT teamname FROM cyclist) )
```

3. Database updates

DML (Data Manipulation Language): Queries and database updates.

- SELECT: Allows the declaration of queries to retrieve the information from the database
- INSERT: Performs the insertion of one or more rows in a table
- DELETE: Allows the user to delete one o more rows from a table
- UPDATE: Modifies the values of one or more columns and/or one or more rows in a table

The INSERT command

INSERT INTO table [(*column1, column2,…, column$_n$*)]

{ DEFAULT VALUES |

VALUES (atom$_1$, atom$_2$,… atom$_n$) |

table_expression}

- If we do not include the list of columns, we will have to specify all the attributes of the table.
- If we include the option "*default values*", we will insert a single row with all the default values which were defined in the definition of the table.
- In the option (*atom$_1$, atom$_2$,,… atom$_n$*), the atoms are given by scalar expressions.
- In the option *table_expression*, we insert the rows which result from the execution of the expression (a SELECT).

Example (a complete tuple):

Add a cyclist with cnum 101, name ‘Joan Peris’, age 27, and team ‘Kelme’.

```
INSERT INTO Cyclist
VALUES (101, ‘Joan Peris’, 27,‘Kelme’);
```

Example (an incomplete tuple) :

Add a cyclist with cnum 101, name ‘Joan Peris’, and team ‘Kelme’ (we don’t know the age):

```
INSERT INTO Cyclist (cnum, name, teamname)
VALUES (101, ‘Joan Peris’, ‘Kelme’);
```

Example (inserting many tuples):

Add into the Winner table (same schema as Cyclist) all the information of the cyclists who have won some stage.

```
INSERT INTO Winner
( SELECT cnum, name, age, teamname
  FROM Cyclist
  WHERE cnum IN (SELECT cnum FROM Stage) )
```

The DELETE command

DELETE FROM *table* [WHERE conditional_expression]

If we include the WHERE clause, then it will only delete the rows which make the condition true. In other case, all the tuples will be deleted.

Example:

Delete the information about the cyclist ‘M. Indurain’ because he is retired.

```
DELETE FROM Cyclist
WHERE name = ‘M. Indurain’
```

The UPDATE command

UPDATE *table*
SET asignnment$_{1,}$ asignnment $_{2,\ldots,}$ asignnment $_{n}$
[WHERE conditional_expression]

Where the assignements are of the form::

column = {DEFAULT | NULL | scalar_expression}

Example:
Increase the *prize* of the jerseys by 10%

```
UPDATE jersey
SET prize = prize * 1.10
```

Example:

Move all the Kelme cyclists to the *K10* team.

```
UPDATE Cyclist
SET teamname = 'K10'
WHERE teamname='Kelme' ;
```

1. Introduction to SQL
2. Queries
    - 2.1. Simple queries using one table.
    - 2.2. Simple queries with several tables
    - 2.3. Subqueries
    - 2.4. Universal Quantification
    - 2.5. Quantified comparison predicates
    - 2.6. Grouping
    - 2.7. Set operations
    - 2.8. Joins
3. Database updates
4. **Commands for handling transactions**

4. Commands for handling transactions

A transaction is a logical unit of work consisting of one or more SQL statements that is guaranteed to be atomic with respect to recovery.

Transaction initiation:

In *Oracle* is implicit. A transaction begins with the first SQL statement in a session, or when the previous transaction ends.

In SQL3: BEGIN TRANSACTION

Transaction completion:

- COMMIT: The transaction ends **successfully**, making the database changes permanent.

- ROLLBACK: The transaction **aborts**, backing out any changes made by the transactions.

Example:
The ‘Banesto’ team changes its name to ‘BanQue’

/* Here we must write a command (SET CONSTRAINT) to differ the evaluation of the foreign key *teamname* in *Cyclist*. We will study this command in next units */

```
UPDATE Team SET name = ‘BanQue’
WHERE teamname = ‘Banesto’;

UPDATE Cyclist SET teamname = ‘BanQue’
WHERE teamname = ‘Banesto’;

COMMIT;
```

Successful transaction

SQL Queries review

Find some basic examples and exercises at: https://www.w3schools.com/sql

Operator	Relational Algebra	SQL
selection	R Donde F	SELECT ... FROM R WHERE F
projection	R [A_i , A_j ..., A_k]	SELECT A_i , A_j ..., A_k FROM R
Cartesian product	R_1 x R_2, ... x R_n	SELECT ... FROM R_1, R_2, ..., R_n, o SELECT...FROM R_1 CROSS JOIN R_2, ..., CROSS JOIN R_n
join	R_1 R_2	SELECT... FROM R_1 NATURAL JOIN R_2
union	$R_1 \cup R_2$	SELECT * FROM R_1 UNION SELECT * FROM R_2
difference	R_1 - R_2	SELECT * FROM R_1 EXCEPT SELECT * FROM R_2
intersection	$R_1 \cap R_2$	SELECT * FROM R_1 INTERSECT SELECT * FROM R_2

Some exercises

1. List the name of the youngest cyclist. (21)
2. List the value of the attribute stagenum and the departure city for those stages with no climbs. (16)
3. List the name of the departure and the arrival of the stages where the steepest climbs are located. (19)
4. List the name of the cyclists who have won all the climbs in one stage and have also won the stage. (27)
5. List the code and the color of those jerseys which have only been worn by cyclists of the same team. (29)
6. List the name of the cyclists who belong to a team which has more than five cyclists and they have also won one or more stages. Please also indicate how many stages he has won.
7. List the name of all the cyclists who belong to a team which has more than five cyclists indicating how many stages he has won. (35)
8. List the cyclist number and the name of the cyclists who have not worn all the jerseys worn by the cyclist with number 20. (40)
9. List the name of the teams and the average age of the cyclists of those teams who have the highest average age of all the teams. (36)
10. List the name of those teams such that their cyclists have only won climbs of category = 1. (30)

1. List the name of the youngest cyclist. (21)

```
SELECT name
FROM Cyclist
WHERE age = ( SELECT MIN(age) FROM Cyclist )
```

2. List the value of the attribute stagenum and the departure city for those stages with no climbs. (16)

```
SELECT S.stagenum, S.departure
FROM Stage S
WHERE  NOT EXISTS
                (SELECT *
                 FROM Climb C
                 WHERE C.stagenum=S.stagenum )
```

3. List the name of the departure and the arrival of the stages where the steepest climbs are located. (19)

```
SELECT DISTINCT S.departure, S.arrival
FROM Stage S, Climb C
WHERE S.stagenum = C.stagenum AND
        C.slope=( SELECT MAX(slope)
                  FROM Climb )
```

4. List the name of the cyclists who have won all the climbs in one stage and have also won the stage. (27)

```
SELECT DISTINCT C.name FROM Cyclist C, Stage S
WHERE S.cnum=C.cnum AND
    NOT EXISTS ( SELECT * FROM Climb P
                 WHERE P.stagenum=S.stagenum
                 AND C.cnum <> P.cnum )
```

What could happen if there were stages with no climbs?

```
    AND EXISTS ( SELECT * FROM Climb CL
                 WHERE CL.stagenum=S.stagenum )
```

4. List the name of the cyclists who have won all the climbs in one stage and have also won the stage. (27)

What could happen if there are more than one cyclist with the same name ?

```
SELECT DISTINCT C.name FROM Cyclist C, Stage S
WHERE S.cnum=C.cnum AND
    NOT EXISTS ( SELECT * FROM Climb P
                    WHERE P.stagenum=S.stagenum
                        AND C.cnum <> P.cnum )

    AND EXISTS ( SELECT * FROM Climb CL
                    WHERE CL.stagenum=S.stagenum )
```

4. List the name of the cyclists who have won all the climbs in one stage and have also won the stage. (27)

Better solution

```
SELECT C.name
FROM Cyclist C
WHERE C.cnum IN
        (SELECT S.cnum
         FROM Stage S
         WHERE NOT EXISTS ( SELECT *
                            FROM Climb CL
                            WHERE CL.stagenum=S.stagenum
                              AND C.cnum <> CL.cnum )
       AND EXISTS ( SELECT *  FROM Climb CL
                    WHERE CL.stagenum=S.stagenum ) ) ;
```

5. List the code and the color of those jerseys which have only been worn by cyclists of the same team. (29)

```
SELECT DISTINCT color
FROM Jersey J, Wear W, Cyclist C
WHERE W.code = J.code AND
        C.cnum = W.cnum AND
        NOT EXISTS( SELECT * FROM Wear W2, Cyclist C2
                    WHERE C2.cnum = W2.cnum
                     AND  C2.teamname <> C.teamname
                    AND  W2.code = W.code)
```

6. List the name of the cyclists who belong to a team which has more than five cyclists and have also won one or more stages. Please also indicate how many stages he has won.

```
SELECT C.name, count(*)
FROM Cyclist C, Stage S
WHERE C.cnum = S.cnum
    AND   5< ( SELECT count(*)
               FROM Cyclist C2
               WHERE C2.teamname = C.teamname )
GROUP BY C.name, C.cnum;
```

7. List the name of all the cyclists who belong to a team which has more than five cyclists indicating how many stages he has won.

See the difference with the previous one !

```
SELECT C.name, COUNT(S.cnum)
FROM Cyclist C LEFT JOIN Stage S on (C.cnum=S.cnum)
WHERE   5 < ( SELECT COUNT(*)
                FROM Cyclist C2
                WHERE C2.teamname=C.teamname )
GROUP BY C.name, C.cnum
```

8. List the cyclist number and the name of the cyclists who have not worn all the jerseys worn by the cyclist with number 20. (40)

Cyclist C such as there is some jersey worn by the 20 but not by the cyclist C

```
SELECT C.cnum, C.name
FROM Cyclist C
WHERE EXISTS
        (SELECT * FROM Wear W
          WHERE W.cnum = 20
              AND NOT EXISTS (SELECT *
                              FROM Wear W2
                              WHERE W2.cnum=C.cnum
                                AND W2.code=W.code))
```

9. List the name of the teams and the average age of the cyclists of those teams who have the highest average age of all the teams. (36)

```
SELECT C.teamname, AVG(C.age)
FROM Cyclist C
GROUP BY C.teamname
HAVING AVG(C.age) = (SELECT MAX(AVG(D.age))
                     FROM Cyclist D
                     GROUP BY D.teamname)
```

10. List the name of those teams such that their cyclists have only won climbs of category = 1. (30)

```
SELECT T.teamname
FROM Team T
WHERE NOT EXISTS
                ( SELECT * FROM Cyclist C, Climb CL
                  WHERE C.cnum = CL.cnum
                      AND CL.category <> '1'
                      AND C.teamname = T.teamname  )
   AND EXISTS ( SELECT *
                      FROM Cyclist C2, Climb CL2
                      WHERE C2.cnum = CL2.cnum
                          AND C2.teamname = T.teamname);
```

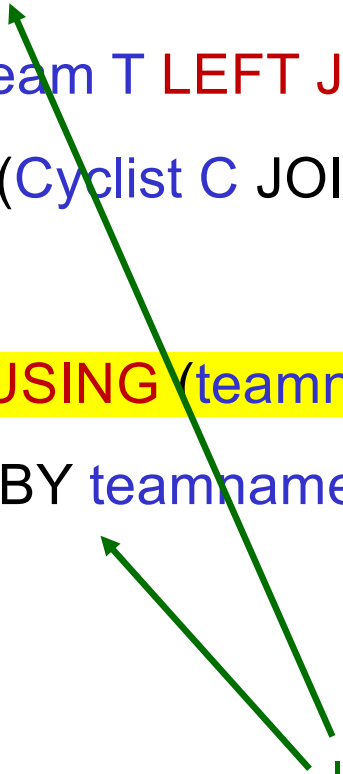

Some cyclist in the T team has won some climb (of 1st category)

11. Obtain for all the teams, the team's name, the director and amount of cyclist from that team who have won a "2nd" category climb (Similar to Movie Database, 52)

```
SELECT T.teamname, T.director, COUNT(DISTINCT C.cnum)
FROM Team T LEFT JOIN
        (Cyclist C JOIN Climb Cl ON (Cl.category = '2nd'
                                     AND C.cnum= Cl.cnum))
      ON (T.teamname = C.teamname)
GROUP BY T.teamname, T.director
```

11. Obtain for all the teams, the team's name, the director and amount of cyclist from that team who have won a "2nd" category climb (Similar to Movie Database, 52)

```
SELECT teamname, T.director, COUNT(DISTINCT C.cnum)
FROM Team T LEFT JOIN
        (Cyclist C JOIN Climb Cl ON (Cl.category = '2nd'
                                     AND C.cnum= Cl.cnum))
        USING (teamname)
GROUP BY teamname, T.director
```



In the solution with USING we cannot qualify the attribute "rwamname" because neither T.teamname nor C.teamname exists, only "teamname" exists.

12. Obtain the cyclist number and the name of the cyclist who has worn the same jersey during more kilometers than any other cyclist, and also indicate the color of this jersey. (45)

```
SELECT C.cnum, C.name, J.color
FROM Cyclist C, Wear W, Stage S, Jersey J
WHERE S.stagenum = W.stagenum
    AND C.cnum = W.cnum
    AND J.code=W.code
GROUP BY C.cnum, W.code, C.name, J.color
HAVING SUM(S.km) >= ALL (SELECT SUM(S.km)
                         FROM Cyclist C2, Wear W2, Stage S2
                         WHERE S2.stagenum = W2.stagenum
                             AND C2.cnum =W2.cnum
                         GROUP BY C2.name, C2.cnum, W2.code);
```