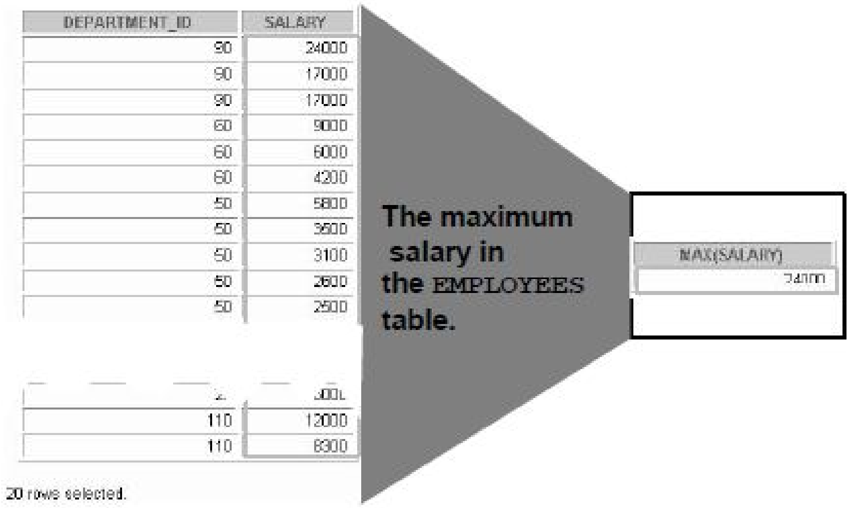
Aggregating Data Using Group Functions

What Are Group Functions?

Group functions operate on sets of rows to give one result per group.

EMPLOYEES



DEPARTMENT_ID	SALARY
90	24000
90	17000
90	17000
60	9000
60	6000
60	4200
50	5800
50	3500
50	3100
50	2600
50	2500
110	12000
110	8300

20 rows selected.

The maximum salary in the EMPLOYEES table.

MAX(SALARY)
24000

Types of Group Functions

- AVG
- COUNT
- MAX
- MIN
- STDDEV
- SUM
- VARIANCE

Each of the functions accepts an argument. The following table identifies the options that you can use in the syntax:

Function	Description
AVG([DISTINCT|ALL]*n*)	Average value of *n*, ignoring null values
COUNT({*|[DISTINCT|ALL]*expr*})	Number of rows, where *expr* evaluates to something other than null (count all selected rows using *, including duplicates and rows with nulls)
MAX([DISTINCT|ALL]*expr*)	Maximum value of *expr*, ignoring null values
MIN([DISTINCT|ALL]*expr*)	Minimum value of *expr*, ignoring null values
STDDEV([DISTINCT|ALL]*x*)	Standard deviation of *n*, ignoring null values
SUM([DISTINCT|ALL]*n*)	Sum values of *n*, ignoring null values
VARIANCE([DISTINCT|ALL]*x*)	Variance of *n*, ignoring null values

Group Functions Syntax

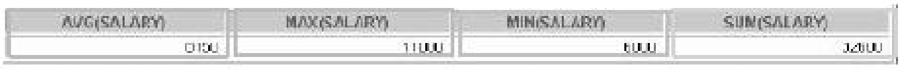
```
SELECT          [column,] group_function(column), ..
FROM            table
[WHERE          condition]
[GROUP BY       column]
[ORDER BY       column];
```

Guidelines for Using Group Functions

- DISTINCT makes the function consider only nonduplicate values; ALL makes it consider every value including duplicates. The default is ALL and therefore does not need to be specified.
- The data types for the functions with an expr argument may be CHAR, VARCHAR2, NUMBER, or DATE.
- All group functions ignore null values. To substitute a value for null values, use the NVL, NVL2, or COALESCE functions.
- The Oracle Server implicitly sorts the result set in ascending order when using a GROUP BY clause. To override this default ordering, DESC can be used in an ORDER BY clause.

You can use AVG and SUM for numeric data.

```
SELECT AVG(salary), MAX(salary),
       MIN(salary), SUM(salary)
FROM   employees
WHERE  job_id LIKE '%REP%';
```

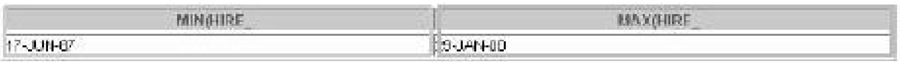


AVG(SALARY)	MAX(SALARY)	MIN(SALARY)	SUM(SALARY)
8150	11000	6000	32600

You can use AVG, SUM, MIN, and MAX functions against columns that can store numeric data. The example in the slide displays the average, highest, lowest, and sum of monthly salaries for all sales representatives.

You can use MIN and MAX for any data type.

```
SELECT MIN(hire_date), MAX(hire_date)
FROM   employees;
```

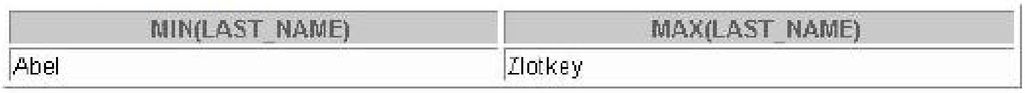


MIN(HIRE_	MAX(HIRE_
17-JUN-87	29-JAN-00

You can use the MIN and MAX functions for any data type. The slide example displays the most junior and most senior employee.

The following example displays the employee last name that is first and the employee last name that is the last in an alphabetized list of all employees.

```
SELECT MIN(last_name), MAX(last_name)
FROM   employees;
```

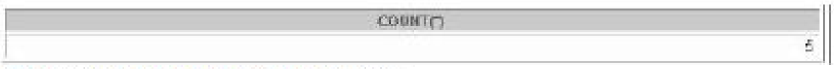


MIN(LAST_NAME)	MAX(LAST_NAME)
Abel	Zlotkey

Note: AVG, SUM, VARIANCE, and STDDEV functions can be used only with numeric data types.

COUNT(*) returns the number of rows in a table.

```
SELECT  COUNT(*)
FROM    employees
WHERE   department_id = 50;
```



COUNT(*)
5

The COUNT function has three formats:

- COUNT(*)
- COUNT(*expr*)
- COUNT(DISTINCT *expr*)

COUNT(*) returns the number of rows in a table that satisfy the criteria of the SELECT statement, including duplicate rows and rows containing null values in any of the columns. If a WHERE clause is included in the SELECT statement, COUNT(*) returns the number of rows that satisfies the condition in the WHERE clause.

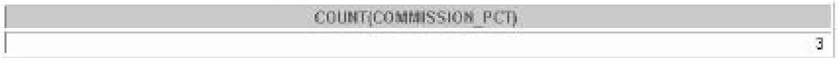
In contrast, COUNT(*expr*) returns the number of nonnull values in the column identified by *expr*.

COUNT(DISTINCT *expr*) returns the number of unique, non-null values in the column identified by *expr*.

The example in the slide displays the number of employees in department 50.

- **COUNT(*expr*) returns the number of rows with non-null values for the *expr*.**
- **Display the number of department values in the EMPLOYEES table, excluding the null values.**

```
SELECT COUNT(commission_pct)
FROM employees
WHERE department_id = 80;
```



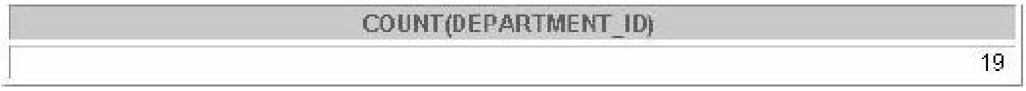
COUNT(COMMISSION_PCT)
3

The example in the slide displays the number of employees in department 80 who can earn a commission.

Example

Display the number of department values in the EMPLOYEES table.

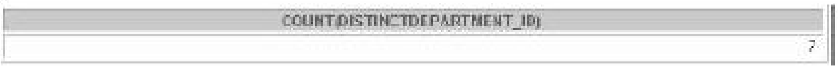
```
SELECT COUNT(department_id)
FROM   employees;
```



COUNT(DEPARTMENT_ID)
19

- **COUNT(DISTINCT *expr*) returns the number of distinct nonnull values of the *expr*.**
- **Display the number of distinct department values in the EMPLOYEES table.**

```
SELECT COUNT(DISTINCT department_id)
FROM   employees;
```



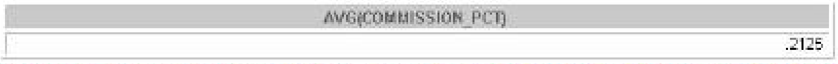
COUNT(DISTINCTDEPARTMENT_ID)
7

Use the DISTINCT keyword to suppress the counting of any duplicate values within a column.

The example in the slide displays the number of distinct department values in the EMPLOYEES table.

Group functions ignore null values in the column.

```
SELECT AVG(commission_pct)
FROM   employees;
```

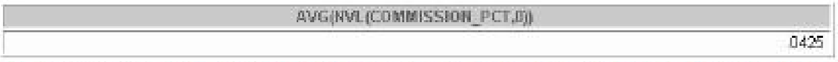


AVG(COMMISSION_PCT)
.2125

All group functions ignore null values in the column. In the example in the slide, the average is calculated based *only* on the rows in the table where a valid value is stored in the COMMISSION_PCT column. The average is calculated as the total commission paid to all employees divided by the number of employees receiving a commission.

The NVL function forces group functions to include null values.

```
SELECT AVG(NVL(commission_pct, 0))
FROM   employees;
```

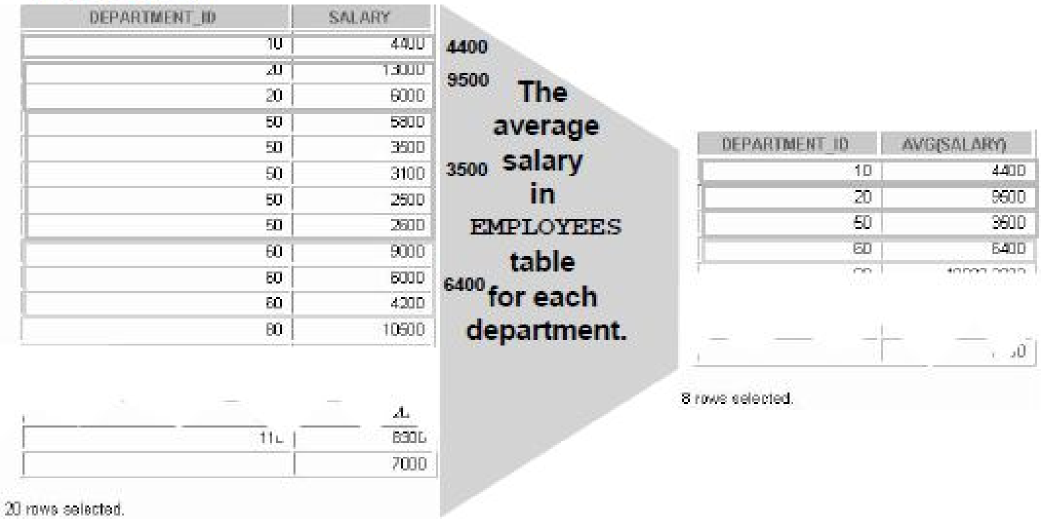


AVG(NVL(COMMISSION_PCT,0))
0425

The NVL function forces group functions to include null values. In the example in the slide, the average is calculated based on *all* rows in the table, regardless of whether null values are stored in the COMMISSION_PCT column. The average is calculated as the total commission paid to all employees divided by the total number of employees in the company.

Creating Groups of Data

EMPLOYEES



DEPARTMENT_ID	SALARY
10	4400
20	13000
20	6000
50	5800
50	3500
50	3100
50	2500
50	2600
60	9000
60	6000
60	4200
80	10500
11[illegible]	8300
	7000

20 rows selected.

DEPARTMENT_ID	AVG(SALARY)
10	4400
20	9500
50	3500
60	6400

8 rows selected.

Until now, all group functions have treated the table as one large group of information. At times, you need to divide the table of information into smaller groups. This can be done by using the GROUP BY clause.

GROUP BY Clause Syntax

```
SELECT        column, group_function(column)
FROM          table
[WHERE        condition]
[GROUP BY     group_by_expression]
[ORDER BY     column];
```

Divide rows in a table into smaller groups by using the GROUP BY clause.

You can use the GROUP BY clause to divide the rows in a table into groups. You can then use the group functions to return summary information for each group.

In the syntax:

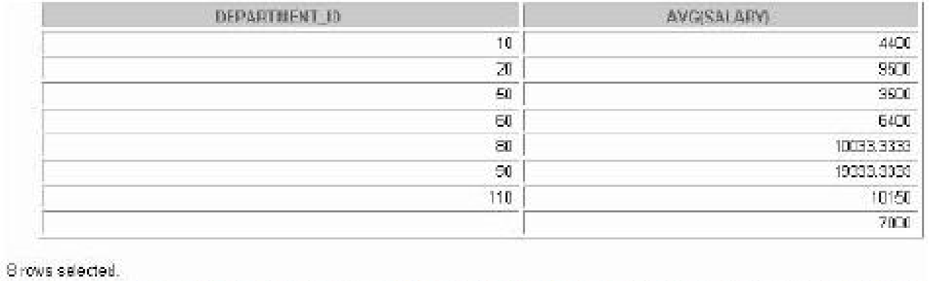
group_by_expression	specifies columns whose values determine the basis for grouping rows

Guidelines

- If you include a group function in a SELECT clause, you cannot select individual results as well, *unless* the individual column appears in the GROUP BY clause. You receive an error message if you fail to include the column list in the GROUP BY clause.
- Using a WHERE clause, you can exclude rows before dividing them into groups.
- You must include the columns in the GROUP BY clause.
- You cannot use a column alias in the GROUP BY clause.
- By default, rows are sorted by ascending order of the columns included in the GROUP BY list. You can override this by using the ORDER BY clause.

All columns in the `SELECT` list that are not in group functions must be in the `GROUP BY` clause.

```
SELECT department_id, AVG(salary)
FROM   employees
GROUP BY department_id;
```



DEPARTMENT_ID	AVG(SALARY)
10	4400
20	9500
50	3500
60	6400
80	10033.3333
90	19333.3333
110	10150
	7000

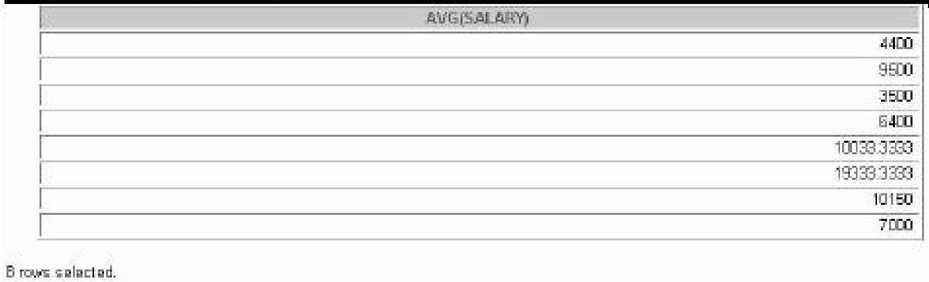
8 rows selected.

When using the GROUP BY clause, make sure that all columns in the SELECT list that are not group functions are included in the GROUP BY clause. The example in the slide displays the department number and the average salary for each department. Here is how this SELECT statement, containing a GROUP BY clause, is evaluated:

- The SELECT clause specifies the columns to be retrieved:
  - The department number column in the EMPLOYEES table
  - The average of all the salaries in the group you specified in the GROUP BY clause
- The FROM clause specifies the tables that the database must access: the EMPLOYEES table.
- The WHERE clause specifies the rows to be retrieved. Because there is no WHERE clause, all rows are retrieved by default.
- The GROUP BY clause specifies how the rows should be grouped. The rows are being grouped by department number, so the AVG function that is being applied to the salary column will calculate the average salary for each department.

The `GROUP BY` column does not have to be in the `SELECT` list.

```
SELECT    AVG(salary)
FROM      employees
GROUP BY department_id;
```

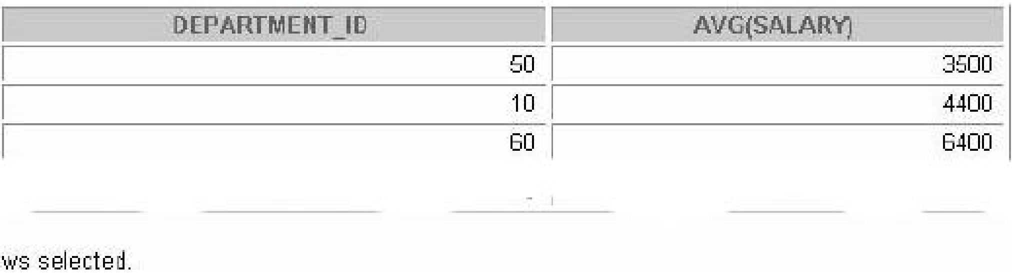


AVG(SALARY)
4400
9500
3500
6400
10033.3333
19333.3333
10150
7000

8 rows selected.

You can use the group function in the ORDER BY clause.

```
SELECT   department_id, AVG(salary)
FROM     employees
GROUP BY department_id
ORDER BY AVG(salary);
```

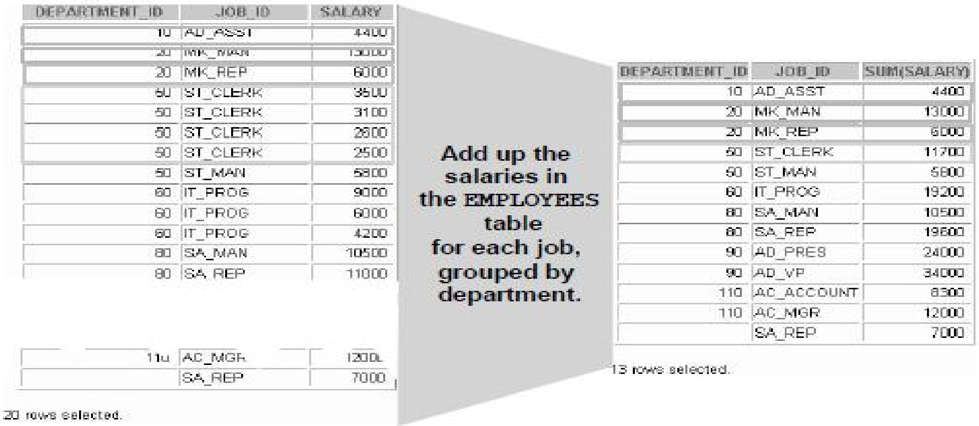


DEPARTMENT_ID	AVG(SALARY)
50	3500
10	4400
60	6400

8 rows selected.

Grouping by More Than One Column

EMPLOYEES



DEPARTMENT_ID	JOB_ID	SALARY
10	AD_ASST	4400
20	MK_MAN	13000
20	MK_REP	6000
50	ST_CLERK	3500
50	ST_CLERK	3100
50	ST_CLERK	2600
50	ST_CLERK	2500
50	ST_MAN	5800
60	IT_PROG	9000
60	IT_PROG	6000
60	IT_PROG	4200
80	SA_MAN	10500
80	SA_REP	11000
110	AC_MGR	12000
	SA_REP	7000

20 rows selected.

Add up the salaries in the EMPLOYEES table for each job, grouped by department.

DEPARTMENT_ID	JOB_ID	SUM(SALARY)
10	AD_ASST	4400
20	MK_MAN	13000
20	MK_REP	6000
50	ST_CLERK	11700
50	ST_MAN	5800
60	IT_PROG	19200
80	SA_MAN	10500
80	SA_REP	19600
90	AD_PRES	24000
90	AD_VP	34000
110	AC_ACCOUNT	8300
110	AC_MGR	12000
	SA_REP	7000

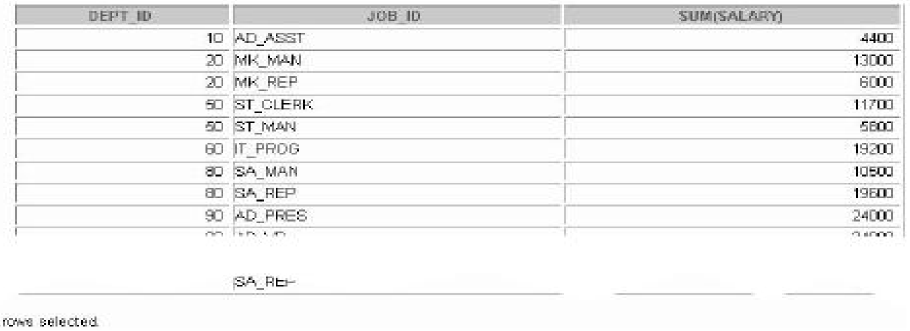
13 rows selected.

Sometimes you need to see results for groups within groups. The slide shows a report that displays the total salary being paid to each job title, within each department.

The EMPLOYEES table is grouped first by department number and, within that grouping, by job title. For example, the four stock clerks in department 50 are grouped together and a single result (total salary) is produced for all stock clerks within the group.

Using the GROUP BY Clause on Multiple Columns

```
SELECT   department_id dept_id, job_id, SUM(salary)
FROM     employees
GROUP BY department_id, job_id;
```



DEPT_ID	JOB_ID	SUM(SALARY)
10	AD_ASST	4400
20	MK_MAN	13000
20	MK_REP	6000
50	ST_CLERK	11700
50	ST_MAN	5800
60	IT_PROG	19200
80	SA_MAN	10500
80	SA_REP	19600
90	AD_PRES	24000
90	AD_VP	34000
	SA_REP	

13 rows selected.

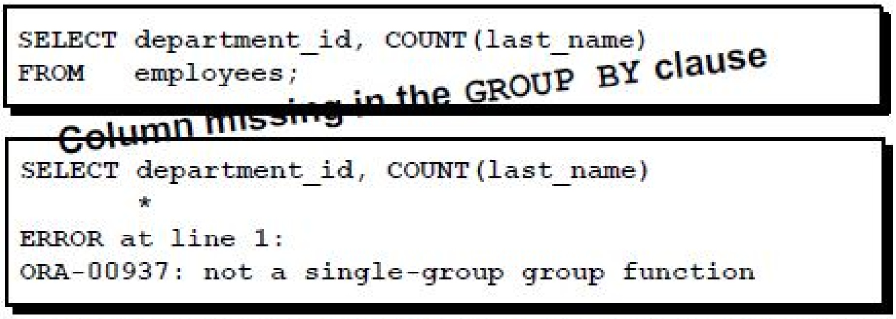
You can return summary results for groups and subgroups by listing more than one GROUP BY column. You can determine the default sort order of the results by the order of the columns in the GROUP BY clause. Here is how the SELECT statement on the slide, containing a GROUP BY clause, is evaluated:

- The SELECT clause specifies the column to be retrieved:
  - Department number in the EMPLOYEES table
  - Job ID in the EMPLOYEES table
  - The sum of all the salaries in the group that you specified in the GROUP BY clause
- The FROM clause specifies the tables that the database must access: the EMPLOYEES table
- The GROUP BY clause specifies how you must group the rows:
  - First, the rows are grouped by department number
  - Second, within the department number groups, the rows are grouped by job ID

So the SUM function is being applied to the salary column for all job IDs within each department number group.

Illegal Queries Using Group Functions

Any column or expression in the SELECT list that is not an aggregate function must be in the GROUP BY clause.

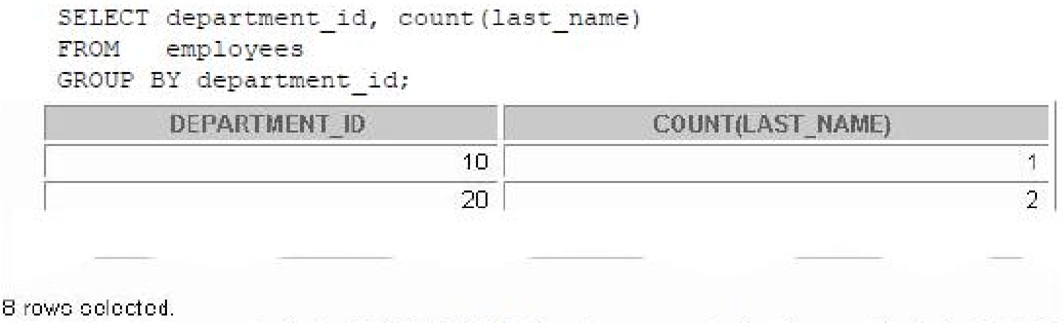


```
SELECT department_id, COUNT(last_name)
FROM   employees;
```

Column missing in the GROUP BY clause

```
SELECT department_id, COUNT(last_name)
       *
ERROR at line 1:
ORA-00937: not a single-group group function
```

Whenever you use a mixture of individual items (DEPARTMENT_ID) and group functions (COUNT) in the same SELECT statement, you must include a GROUP BY clause that specifies the individual items (in this case, DEPARTMENT_ID). If the GROUP BY clause is missing, then the error message not a single-group group function appears and an asterisk (*) points to the offending column. You can correct the error on the slide by adding the GROUP BY clause.



```
SELECT department_id, count(last_name)
FROM   employees
GROUP BY department_id;
```

DEPARTMENT_ID	COUNT(LAST_NAME)
10	1
20	2

8 rows selected.

Any column or expression in the SELECT list that is not an aggregate function must be in the GROUP BY clause.

- You cannot use the **WHERE** clause to restrict groups.
- You use the **HAVING** clause to restrict groups.
- You cannot use group functions in the **WHERE** clause.

```
SELECT department_id, AVG(salary)
FROM   employees
WHERE  AVG(salary) > 8000
GROUP BY department_id;
```

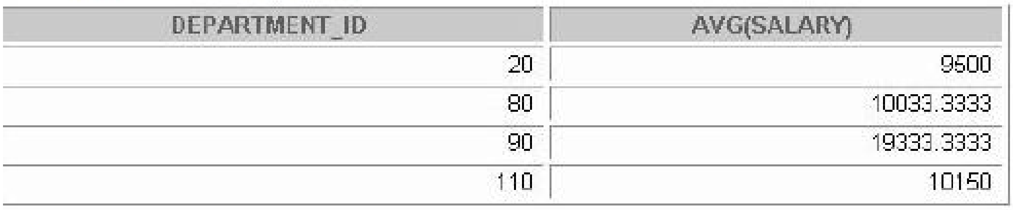
```
WHERE  AVG(salary) > 8000
       *
ERROR at line 3:
ORA-00934: group function is not allowed here
```

Cannot use the WHERE clause to restrict groups

The WHERE clause cannot be used to restrict groups. The SELECT statement in the slide results in an error because it uses the WHERE clause to restrict the display of average salaries of those departments that have an average salary greater than $8,000.

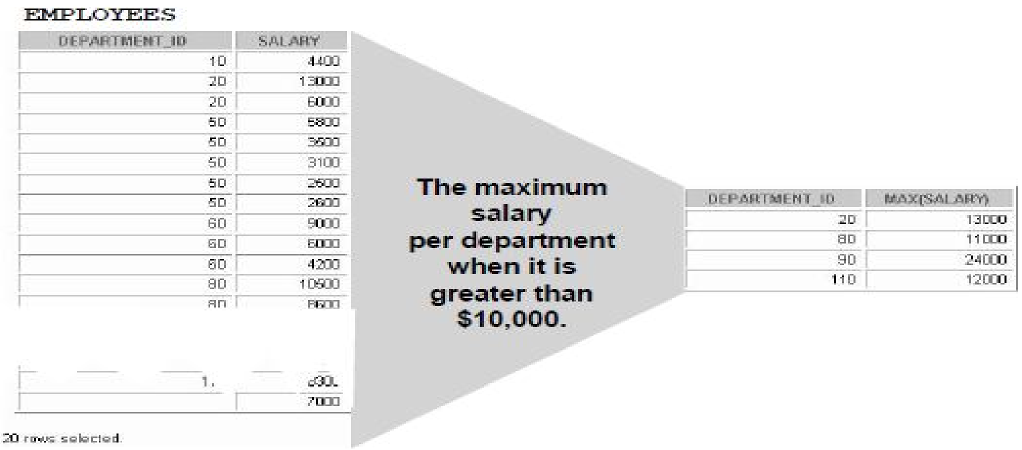
You can correct the slide error by using the HAVING clause to restrict groups.

```
SELECT department_id, AVG(salary)
FROM   employees
HAVING  AVG(salary) > 8000
GROUP BY department_id;
```



DEPARTMENT_ID	AVG(SALARY)
20	9500
80	10033.3333
90	19333.3333
110	10150

Excluding Group Results



EMPLOYEES

DEPARTMENT_ID	SALARY
10	4400
20	13000
20	6000
50	5800
50	3500
50	3100
50	2500
50	2600
60	9000
60	6000
60	4200
80	10500
80	8600
1.	230.
	7000

20 rows selected.

The maximum salary per department when it is greater than $10,000.

DEPARTMENT_ID	MAX(SALARY)
20	13000
80	11000
90	24000
110	12000

Restricting Group Results

In the same way that you use the WHERE clause to restrict the rows that you select, you use the HAVING clause to restrict groups. To find the maximum salary of each department, but show only the departments that have a maximum salary of more than $10,000, you need to do the following:

1. Find the average salary for each department by grouping by department number.
2. Restrict the groups to those departments with a maximum salary greater than $10,000.

Use the HAVING clause to restrict groups:

1. Rows are grouped.
2. The group function is applied.
3. Groups matching the HAVING clause are displayed.

```
SELECT       column, group_function
FROM         table
[WHERE       condition]
[GROUP BY    group_by_expression]
[HAVING      group_condition]
[ORDER BY    column];
```

The HAVING Clause

You use the HAVING clause to specify which groups are to be displayed, and thus, you further restrict the groups on the basis of aggregate information.

In the syntax:

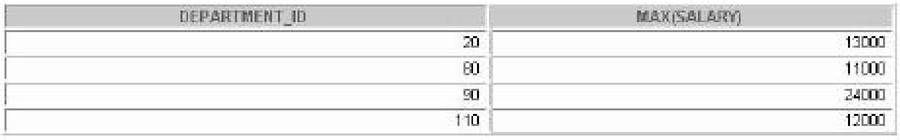
group_condition	restricts the groups of rows returned to those groups for which the specified condition is true

The Oracle Server performs the following steps when you use the HAVING clause:

1. Rows are grouped.
2. The group function is applied to the group.
3. The groups that match the criteria in the HAVING clause are displayed.

The HAVING clause can precede the GROUP BY clause, but it is recommended that you place the GROUP BY clause first because that is more logical. Groups are formed and group functions are calculated before the HAVING clause is applied to the groups in the SELECT list.

```
SELECT   department_id, MAX(salary)
FROM     employees
GROUP BY department_id
HAVING   MAX(salary)>10000;
```



DEPARTMENT_ID	MAX(SALARY)
20	13000
80	11000
90	24000
110	12000

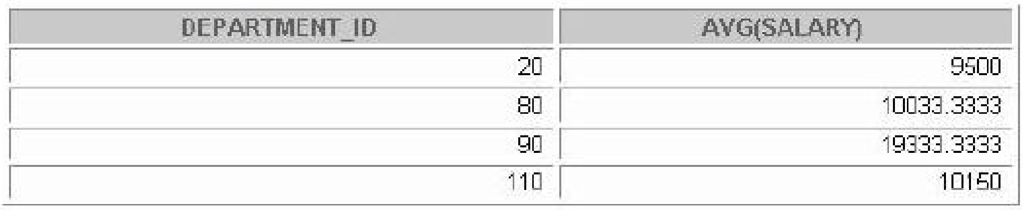
The example in the slide displays department numbers and maximum salaries for those departments whose maximum salary is greater than $10,000.

You can use the GROUP BY clause without using a group function in the SELECT list.

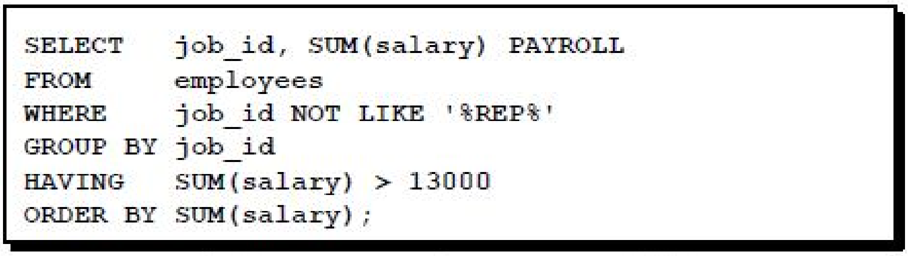
If you restrict rows based on the result of a group function, you must have a GROUP BY clause as well as the HAVING clause.

The following example displays the department numbers and average salaries for those departments whose maximum salary is greater than $10,000:

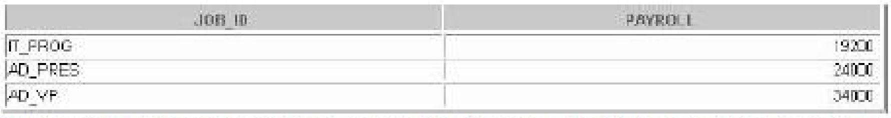
```
SELECT   department_id, AVG(salary)
FROM     employees
GROUP BY department_id
HAVING   max(salary)>10000;
```



DEPARTMENT_ID	AVG(SALARY)
20	9500
80	10033.3333
90	19333.3333
110	10150



```
SELECT   job_id, SUM(salary) PAYROLL
FROM     employees
WHERE    job_id NOT LIKE '%REP%'
GROUP BY job_id
HAVING   SUM(salary) > 13000
ORDER BY SUM(salary);
```

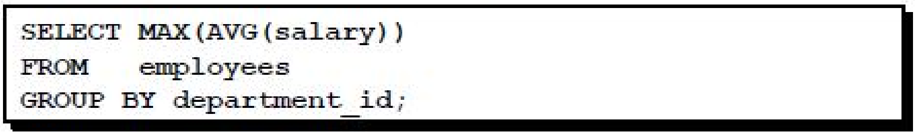


JOB_ID	PAYROLL
IT_PROG	19200
AD_PRES	24000
AD_VP	34000

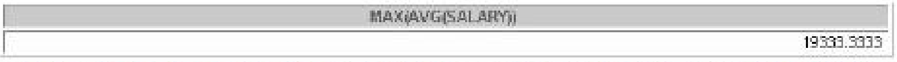
The example in the slide displays the job ID and total monthly salary for each job with a total payroll exceeding $13,000. The example excludes sales representatives and sorts the list by the total monthly salary.

Nesting Group Functions

Display the maximum average salary.



```
SELECT MAX(AVG(salary))
FROM   employees
GROUP BY department_id;
```



MAX(AVG(SALARY))
19333.3333

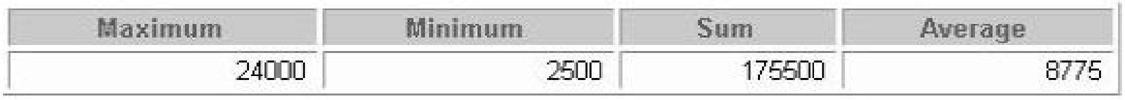
Group functions can be nested to a depth of two. The example in the slide displays the maximum average salary.

ASSIGNMENTS

Determine the validity of the following three statements. Circle either True or False.

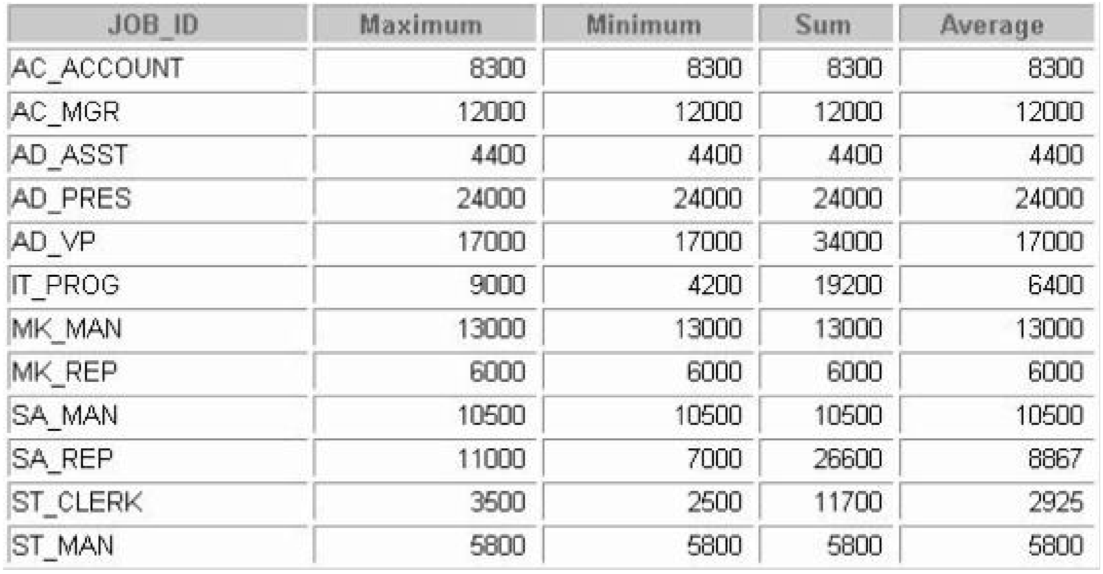
1. Group functions work across many rows to produce one result per group.
   True/False
2. Group functions include nulls in calculations.
   True/False
3. The WHERE clause restricts rows prior to inclusion in a group calculation.
   True/False

4. Display the highest, lowest, sum, and average salary of all employees. Label the columns Maximum, Minimum, Sum, and Average, respectively. Round your results to the nearest whole number. Place your SQL statement in a text file named lab7_6.sql.



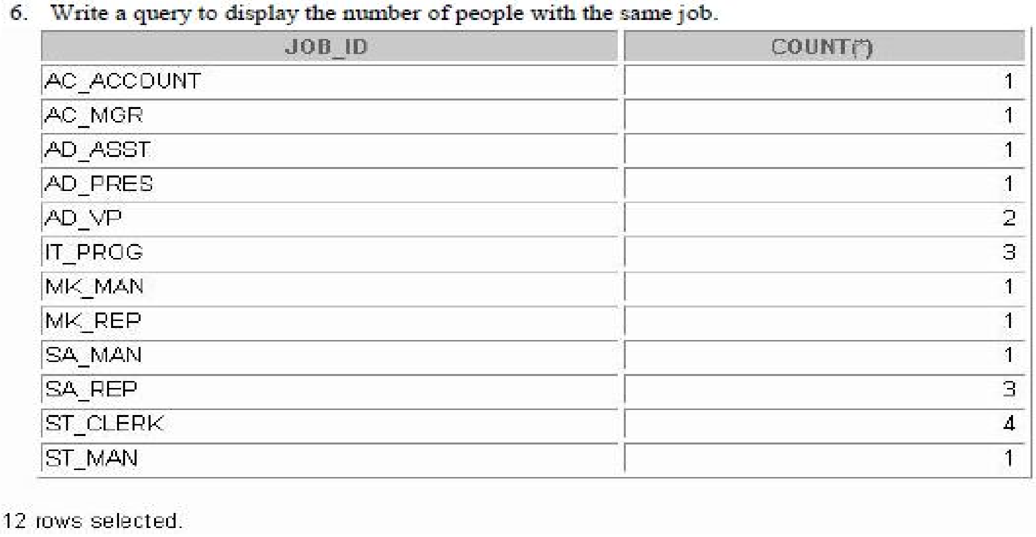
Maximum	Minimum	Sum	Average
24000	2500	175500	8775

5. Modify the query in lab7_4.sql to display the minimum, maximum, sum, and average salary for each job type. Resave lab7_4.sql to lab7_5.sql. Run the statement in lab7_5.sql.



JOB_ID	Maximum	Minimum	Sum	Average
AC_ACCOUNT	8300	8300	8300	8300
AC_MGR	12000	12000	12000	12000
AD_ASST	4400	4400	4400	4400
AD_PRES	24000	24000	24000	24000
AD_VP	17000	17000	34000	17000
IT_PROG	9000	4200	19200	6400
MK_MAN	13000	13000	13000	13000
MK_REP	6000	6000	6000	6000
SA_MAN	10500	10500	10500	10500
SA_REP	11000	7000	26600	8867
ST_CLERK	3500	2500	11700	2925
ST_MAN	5800	5800	5800	5800

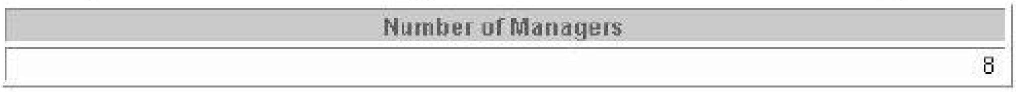
6. Write a query to display the number of people with the same job.



JOB_ID	COUNT(*)
AC_ACCOUNT	1
AC_MGR	1
AD_ASST	1
AD_PRES	1
AD_VP	2
IT_PROG	3
MK_MAN	1
MK_REP	1
SA_MAN	1
SA_REP	3
ST_CLERK	4
ST_MAN	1

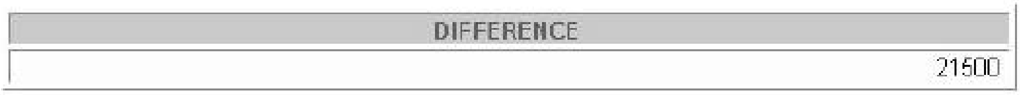
12 rows selected.

7. Determine the number of managers without listing them. Label the column `Number of Managers`. **Hint:** Use the `MANAGER_ID` column to determine the number of managers.



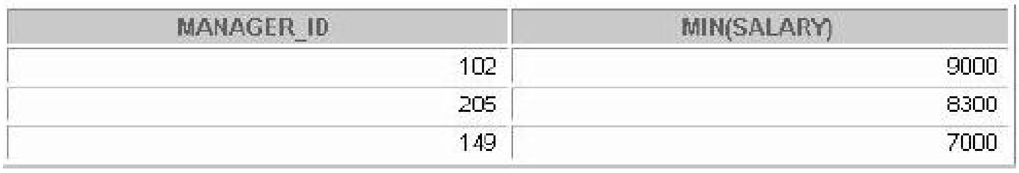
Number of Managers
8

8. Write a query that displays the difference between the highest and lowest salaries. Label the column `DIFFERENCE`.



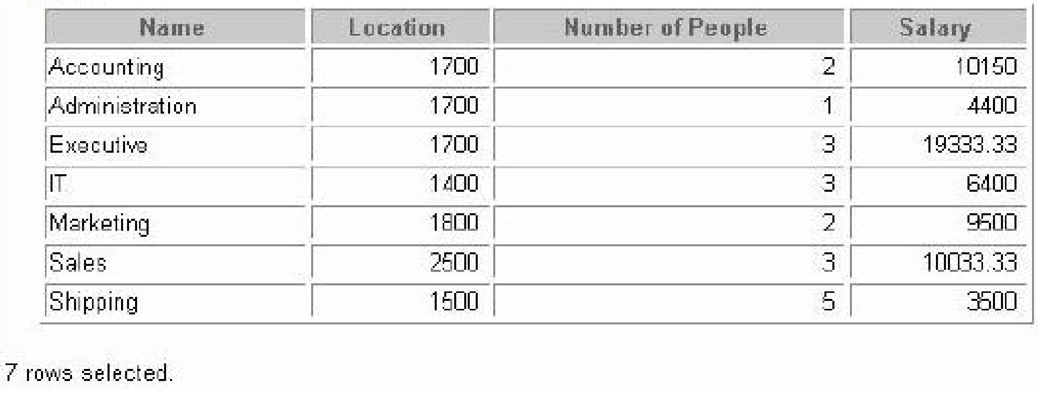
DIFFERENCE
21500

9. Display the manager number and the salary of the lowest paid employee for that manager. Exclude anyone whose manager is not known. Exclude any groups where the minimum salary is less than $6,000. Sort the output in descending order of salary.



MANAGER_ID	MIN(SALARY)
102	9000
205	8300
149	7000

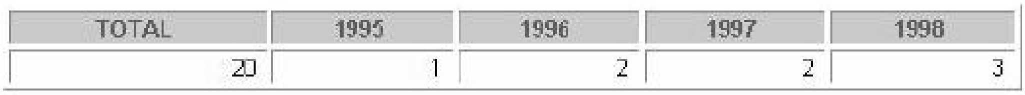
10. Write a query to display each department's name, location, number of employees, and the average salary for all employees in that department. Label the columns `Name`, `Location`, `Number of People`, and `Salary`, respectively. Round the average salary to two decimal places.



Name	Location	Number of People	Salary
Accounting	1700	2	10150
Administration	1700	1	4400
Executive	1700	3	19333.33
IT	1400	3	6400
Marketing	1800	2	9500
Sales	2500	3	10033.33
Shipping	1500	5	3500

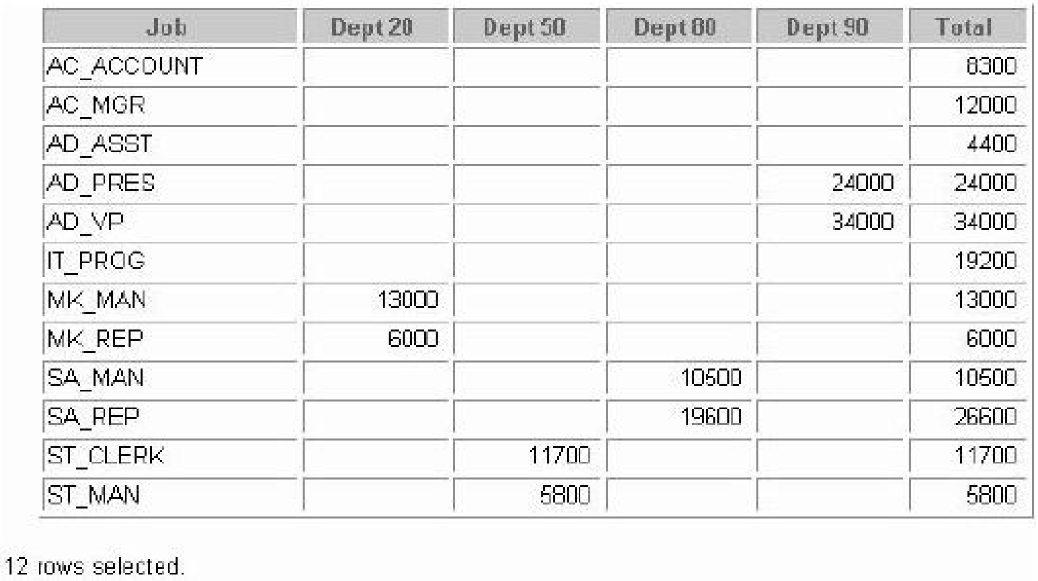
7 rows selected.

11. Create a query that will display the total number of employees and, of that total, the number of employees hired in 1995, 1996, 1997, and 1998. Create appropriate column headings.



TOTAL	1995	1996	1997	1998
20	1	2	2	3

12. Create a matrix query to display the job, the salary for that job based on department number, and the total salary for that job, for departments 20, 50, 80, and 90, giving each column an appropriate heading.



Job	Dept 20	Dept 50	Dept 80	Dept 90	Total
AC_ACCOUNT					8300
AC_MGR					12000
AD_ASST					4400
AD_PRES				24000	24000
AD_VP				34000	34000
IT_PROG					19200
MK_MAN	13000				13000
MK_REP	6000				6000
SA_MAN			10500		10500
SA_REP			19600		26600
ST_CLERK		11700			11700
ST_MAN		5800			5800

12 rows selected.