BASIC SQL

CHAPTER 4 (6/E)

CHAPTER 8 (5/E)

LECTURE OUTLINE

- SQL Data Definition and Data Types
- Specifying Constraints in SQL
- Basic Retrieval Queries in SQL
- Set Operations in SQL

BASIC SQL

- **Structured Query Language**
- Considered one of the major reasons for the commercial success of relational databases
- Statements for data definitions, queries, and updates
  - Both DDL and DML
  - Core specification plus specialized extensions
- Terminology:

Relational Model	SQL
relation	**table**
tuple	**row**
attribute	**column**

- *Syntax notes*:
  - Some interfaces require each statement to end with a semicolon.
  - SQL is not case-sensitive.

SQL DATA DEFINITION

- `CREATE` statement
  - Main SQL command for data definition
- **SQL schema**
  - Identified by a **schema name**
  - Includes an **authorization identifier** (owner)
  - Components are **descriptors** for each schema element
    - Tables, constraints, views, domains, and other constructs
- `CREATE SCHEMA` statement
  - `CREATE SCHEMA COMPANY AUTHORIZATION 'Jsmith';`

CREATE TABLE COMMAND

- Specify a new relation
  - Provide name
  - Specify attributes and initial constraints
  - **Base tables** (**base relations**)
    - Relation and its tuples are physically stored and managed by DBMS
- Can optionally specify schema:
  - `CREATE TABLE COMPANY.EMPLOYEE ...`

    or
  - `CREATE TABLE EMPLOYEE ...`
- Include information for each column (attribute) plus constraints
  - Column name
  - Column type (domain)
  - Key, uniqueness, and null constraints

BASIC DATA TYPES

- **Numeric** data types
  - Integer numbers: `INT`, `INTEGER`, `SMALLINT`, `BIGINT`
  - Floating-point (real) numbers: `REAL`, `DOUBLE` , `FLOAT`
  - Fixed-point numbers: `DECIMAL(`*n*`,`*m*`)` , `DEC(`*n*`,`*m*`)` , `NUMERIC(`*n*`,`*m*`)` , `NUM(`*n*`,`*m*`)`
- **Character-string** data types
  - Fixed length: `CHAR(`*n*`)` , `CHARACTER(`*n*`)`
  - Varying length: `VARCHAR(`*n*`)` , `CHAR VARYING(`*n*`)` , `CHARACTER VARYING(`*n*`)` , `LONG VARCHAR`
- **Large object** data types
  - Characters: `CLOB`, `CHAR LARGE OBJECT` , `CHARACTER LARGE OBJECT`
  - Bits: `BLOB`, `BINARY LARGE OBJECT`
- **Boolean** data type
  - Values of `TRUE` or `FALSE` or `NULL`
- `DATE` data type
  - Ten positions
  - Components are `YEAR`, `MONTH`, and `DAY` in the form YYYY-MM-DD

MORE DATA TYPES

- Additional data types
  - `TIMESTAMP` data type
    - Includes the `DATE` and `TIME` fields
    - Plus a minimum of six positions for decimal fractions of seconds
    - Optional `WITH TIME ZONE` qualifier
  - `INTERVAL` data type
    - Specifies a relative value that can be used to increment or decrement an absolute value of a date, time, or timestamp
- Columns can be declared to be `NOT NULL`
- Columns can be declared to have a default value
  - Assigned to column in any tuple for which a value is not specified
- Example

```
CREATE TABLE EMPLOYEE (
    …
    NICKNAME VARCHAR(20) DEFAULT NULL,
    …
    Province CHAR(2) NOT NULL DEFAULT 'ON',
    …
    );
```

```
CREATE TABLE EMPLOYEE
        ( Fname          VARCHAR(15)        NOT NULL,
          Minit          CHAR,
          Lname          VARCHAR(15)        NOT NULL,
          Ssn            CHAR(9)            NOT NULL,
          Bdate          DATE,
          Address        VARCHAR(30),
          Sex            CHAR,
          Salary         DECIMAL(10,2),
          Super_ssn      CHAR(9),
          Dno            INT                NOT NULL ) ;

CREATE TABLE DEPARTMENT
        ( Dname          VARCHAR(15)        NOT NULL,
          Dnumber        INT                NOT NULL,
          Mgr_ssn        CHAR(9)            NOT NULL,
          Mgr_start_date DATE                        ) ;
```

Figure 4.1
SQL CREATE TABLE

DOMAINS IN SQL

- Name used in place of built-in data type
- Makes it easier to change the data type used by numerous columns
- Improves schema readability
- Example:

```
CREATE DOMAIN SIN_TYPE AS CHAR(9);
```

SPECIFYING KEY CONSTRAINTS

- **`PRIMARY KEY`** clause
  - Specifies one or more attributes that make up the primary key of a relation

```
Dnumber INT NOT NULL PRIMARY KEY,
```

  - Primary key attributes must be declared `NOT NULL`
- **`UNIQUE`** clause
  - Specifies alternate (candidate) keys

```
Dname VARCHAR(15) UNIQUE;
```

  - May or may not allow null values, depending on declaration

- If no key constraints, two or more tuples may be identical in *all* columns.
  - SQL deviates from pure relational model!
  - Multiset (bag) behaviour

REFERENTIAL CONSTRAINTS

- **`FOREIGN KEY`** clause

```
FOREIGN KEY (Dept) REFERENCES DEPARTMENT (Dnum),
```

  - Default operation: reject update on violation
  - Attach **referential triggered action** clause in case referenced tuple is deleted
    - Options include `SET NULL`, `CASCADE`, and `SET DEFAULT`
- Foreign key declaration must refer to a table already created

SPECIFYING TUPLE CONSTRAINTS

- Some constraints involve several columns
- `CHECK` clause at the end of a `CREATE TABLE` statement
  - Apply to each tuple individually
- Example
  - `CHECK (Dept_create_date <= Mgr_start_date)`

EXAMPLE

- Recall Employee example:

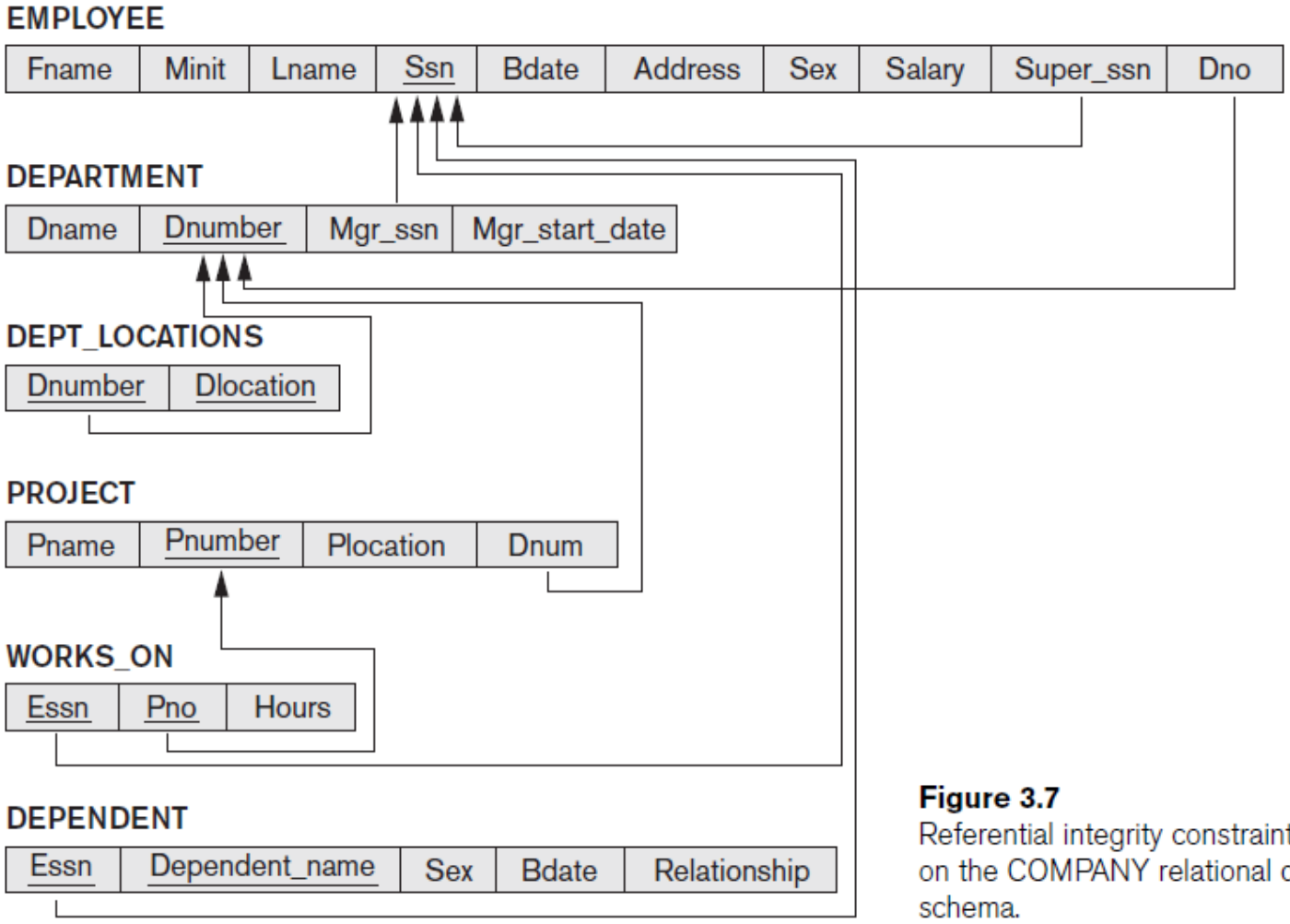


Figure 3.7
Referential integrity constraints displayed on the COMPANY relational database schema.

```
CREATE TABLE EMPLOYEE
    ( . . . ,
      Dno        INT          NOT NULL        DEFAULT 1,
    CONSTRAINT EMPPK
      PRIMARY KEY (Ssn),
    CONSTRAINT EMPSUPERFK
      FOREIGN KEY (Super_ssn) REFERENCES EMPLOYEE(Ssn)
                  ON DELETE SET NULL          ON UPDATE CASCADE,
    CONSTRAINT EMPDEPTFK
      FOREIGN KEY(Dno) REFERENCES DEPARTMENT(Dnumber)
                  ON DELETE SET DEFAULT       ON UPDATE CASCADE);
CREATE TABLE DEPARTMENT
    ( . . . ,
      Mgr_ssn    CHAR(9)       NOT NULL        DEFAULT '888665555',
      . . . ,
    CONSTRAINT DEPTPK
      PRIMARY KEY(Dnumber),
    CONSTRAINT DEPTSK
      UNIQUE (Dname),
    CONSTRAINT DEPTMGRFK
      FOREIGN KEY (Mgr_ssn) REFERENCES EMPLOYEE(Ssn)
                  ON DELETE SET DEFAULT   ON UPDATE CASCADE);
CREATE TABLE DEPT_LOCATIONS
    ( . . . ,
    PRIMARY KEY (Dnumber, Dlocation),
    FOREIGN KEY (Dnumber) REFERENCES DEPARTMENT(Dnumber)
                  ON DELETE CASCADE           ON UPDATE CASCADE);
```

Figure 4.2
Example illustrating how default attribute values and referential integrity triggered actions are specified in SQL.

```
CREATE TABLE PROJECT
        ( Pname                 VARCHAR(15)             NOT NULL,
          Pnumber               INT                     NOT NULL,
          Plocation             VARCHAR(15),
          Dnum                  INT                     NOT NULL,
        PRIMARY KEY (Pnumber),
        UNIQUE (Pname),
        FOREIGN KEY (Dnum) REFERENCES DEPARTMENT(Dnumber) );
CREATE TABLE WORKS_ON
        ( Essn                  CHAR(9)                 NOT NULL,
          Pno                   INT                     NOT NULL,
          Hours                 DECIMAL(3,1)            NOT NULL,
        PRIMARY KEY (Essn, Pno),
        FOREIGN KEY (Essn) REFERENCES EMPLOYEE(Ssn),
        FOREIGN KEY (Pno) REFERENCES PROJECT(Pnumber) );
CREATE TABLE DEPENDENT
        ( Essn                  CHAR(9)                 NOT NULL,
          Dependent_name        VARCHAR(15)             NOT NULL,
          Sex                   CHAR,
          Bdate                 DATE,
          Relationship          VARCHAR(8),
        PRIMARY KEY (Essn, Dependent_name),
        FOREIGN KEY (Essn) REFERENCES EMPLOYEE(Ssn) );
```

Figure 4.1
SQL CREATE TABLE data definition statements for defining the COMPANY schema from Figure 3.7.

BASIC SQL RETRIEVAL QUERIES

- All retrievals use `SELECT` statement:

```
SELECT  <return list>
FROM    <table list>
[ WHERE   <condition> ] ;
```

where

`<return list>` is a list of expressions or column names whose values are to be retrieved by the query

`<table list>` is a list of relation names required to process the query

`<condition>` is a Boolean expression that identifies the tuples to be retrieved by the query

- Example

```
SELECT title, year, genre
FROM Film
WHERE director = 'Steven Spielberg' AND year > 1990;
```

- Omitting WHERE clause implies all tuples selected.

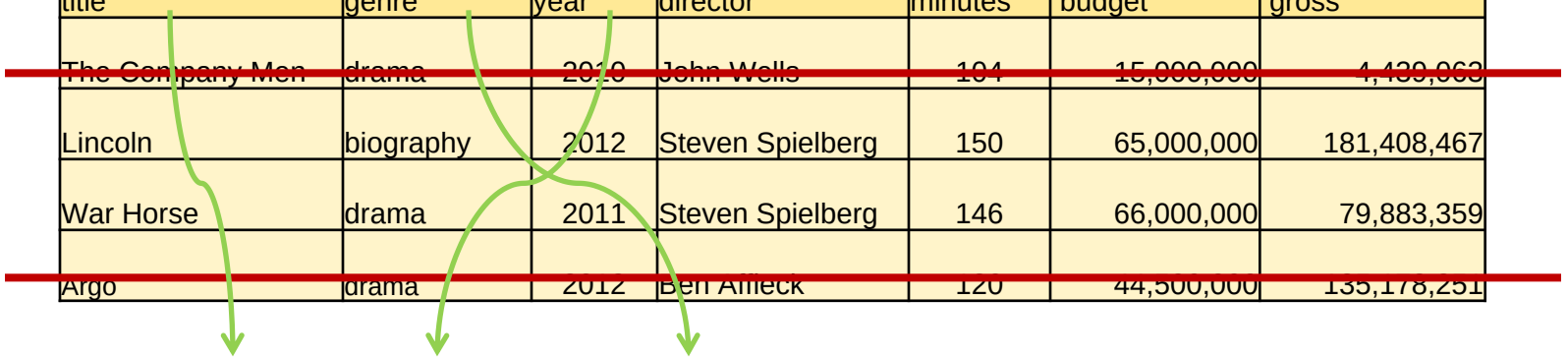
SEMANTICS FOR 1 RELATION

1. Start with the relation named in the `FROM` clause
2. Consider each tuple one after the other, eliminating those that do not satisfy the `WHERE` clause.
   - Boolean condition that must be *true* for any retrieved tuple
   - Logical comparison operators

     =, <, <=, >, >=, and <>
3. For each remaining tuple, create a return tuple with columns for each expression (column name) in the `SELECT` clause.
   - Use `SELECT *` to select all columns.

Film

title	genre	year	director	minutes	budget	gross
The Company Men	drama	2010	John Wells	104	15,000,000	4,439,063
Lincoln	biography	2012	Steven Spielberg	150	65,000,000	181,408,467
War Horse	drama	2011	Steven Spielberg	146	66,000,000	79,883,359
Argo	drama	2012	Ben Affleck	120	44,500,000	135,178,251



SELECT-FROM-WHERE SEMANTICS

- What if there are several relations in the `FROM` clause?

1. Start with cross-product of all relation(s) listed in the `FROM` clause.
   - Every tuple in R_1 paired up with every tuple in R_2 paired up with …
2. Consider each tuple one after the other, eliminating those that do not satisfy the `WHERE` clause.
3. For each remaining tuple, create a return tuple with columns for each expression (column name) in the `SELECT` clause.

Steps 2 and 3 are just the same as before.

```
SELECT actor, birth, movie
FROM Role, Person
WHERE actor = name and birth > 1940;
```

Role

actor	movie	persona
Ben Affleck	Argo	Tony Mendez
Alan Arkin	Argo	Lester Siegel
Ben Affleck	The Company Men	Bobby Walker
Tommy Lee Jones	The Company Men	Gene McClary

Person

name	birth	city
Ben Affleck	1972	Berkeley
Alan Arkin	1934	New York
Tommy Lee Jones	1946	San Saba

AMBIGUOUS COLUMN NAMES

- Same name may be used for two (or more) columns (in different relations)
  - Must **qualify** the column name with the relation name to prevent ambiguity

Customer

custid	name	address	phone

Sale

saleid	date	custid

LineItem

saleid	product	quantity	price

```
SELECT name, date, product, quantity
FROM Customer, Sale, LineItem
WHERE price > 100 AND Customer.custid = Sale.custid AND
      Sale.saleid = LineItem.saleid;
```

- Note
  - If SELECT clause includes custid, it must specify whether to use Customer.custid or Sale.custid *even though the values are guaranteed to be identical*. ☹

2-RELATION SELECT-FROM-WHERE

```
SELECT award, actor, persona, Role.movie
FROM Honours, Role
WHERE category = 'actor' AND winner = actor
      AND Honours.movie = Role.movie
```

Honours

movie	award	category	winner
Lincoln	Critic's Choice	actor	Daniel Day-Lewis
Argo	Critic's Choice	director	Ben Affleck
Lincoln	SAG	supporting actor	Tommy Lee Jones
Lincoln	Critic's Choice	screenplay	Tony Kushner
War Horse	BMI Flim	music	John Williams

Role

actor	movie	persona
Ben Affleck	Argo	Tony Mendez
Tommy Lee Jones	Lincoln	Thaddeus Stevens
Daniel Day-Lewis	The Boxer	Danny Flynn
Daniel Day-Lewis	Lincoln	Abraham Lincoln

Honours.movie	award	category	winner	actor	Role.movie	persona	
Lincoln	Critic's Choice	actor	Daniel Day-Lewis	Ben Affleck	Argo	Tony Mendez	✗
Lincoln	Critic's Choice	actor	Daniel Day-Lewis	Tommy Lee Jones	Lincoln	Thaddeus Stevens	✗
Lincoln	Critic's Choice	actor	Daniel Day-Lewis	Daniel Day-Lewis	The Boxer	Danny Flynn	✗
Lincoln	Critic's Choice	actor	Daniel Day-Lewis	Daniel Day-Lewis	Lincoln	Abraham Lincoln	☑
Argo	Critic's Choice	director	Ben Affleck	Ben Affleck	Argo	Tony Mendez	✗
Argo	Critic's Choice	director	Ben Affleck	Tommy Lee Jones	Lincoln	Thaddeus Stevens	✗
Argo	Critic's Choice	director	Ben Affleck	Daniel Day-Lewis	The Boxer	Danny Flynn	✗
Argo	Critic's Choice	director	Ben Affleck	Daniel Day-Lewis	Lincoln	Abraham Lincoln	✗
Lincoln	SAG	supporting actor	Tommy Lee Jones	Ben Affleck	Argo	Tony Mendez	✗
Lincoln	SAG	supporting actor	Tommy Lee Jones	Tommy Lee Jones	Lincoln	Thaddeus Stevens	✗
Lincoln	SAG	supporting actor	Tommy Lee Jones	Daniel Day-Lewis	The Boxer	Danny Flynn	✗
...							

RECALL SAMPLE TABLES

Figure 3.6
One possible database state for the COMPANY relational database schema.

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date
Research	5	333445555	1988-05-22
Administration	4	987654321	1995-01-01
Headquarters	1	888665555	1981-06-19

DEPT_LOCATIONS

Dnumber	Dlocation
1	Houston
4	Stafford
5	Bellaire
5	Sugarland
5	Houston

Figure 3.6
One possible database state for the COMPANY relational database schema.

WORKS_ON

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0
333445555	10	10.0
333445555	20	10.0
999887777	30	30.0
999887777	10	10.0
987987987	10	35.0
987987987	30	5.0
987654321	30	20.0
987654321	20	15.0
888665555	20	NULL

PROJECT

Pname	Pnumber	Plocation	Dnum
ProductX	1	Bellaire	5
ProductY	2	Sugarland	5
ProductZ	3	Houston	5
Computerization	10	Stafford	4
Reorganization	20	Houston	1
Newbenefits	30	Stafford	4

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship
333445555	Alice	F	1986-04-05	Daughter
333445555	Theodore	M	1983-10-25	Son
333445555	Joy	F	1958-05-03	Spouse
987654321	Abner	M	1942-02-28	Spouse
123456789	Michael	M	1988-01-04	Son
123456789	Alice	F	1988-12-30	Daughter
123456789	Elizabeth	F	1967-05-05	Spouse

Figure 4.3
Results of SQL queries when applied to the COMPANY database state shown in Figure 3.6. (a) Q0. (b) Q1. (c) Q2. (d) Q8. (e) Q9. (f) Q10. (g) Q1C.

(a)

Bdate	Address
1965-01-09	731Fondren, Houston, TX

(b)

Fname	Lname	Address
John	Smith	731 Fondren, Houston, TX
Franklin	Wong	638 Voss, Houston, TX
Ramesh	Narayan	975 Fire Oak, Humble, TX
Joyce	English	5631 Rice, Houston, TX

Query 0. Retrieve the birth date and address of the employee(s) whose name is 'John B. Smith'.

```
Q0:   SELECT   Bdate, Address
      FROM     EMPLOYEE
      WHERE    Fname='John' AND Minit='B' AND Lname='Smith';
```

Query 1. Retrieve the name and address of all employees who work for the 'Research' department.

```
Q1:   SELECT   Fname, Lname, Address
      FROM     EMPLOYEE, DEPARTMENT
      WHERE    Dname='Research' AND Dnumber=Dno;
```

Figure 4.3
Results of SQL queries when applied to the COMPANY database state shown in Figure 3.6. (a) Q0. (b) Q1. (c) Q2. (d) Q8. (e) Q9. (f) Q10. (g) Q1C.

(c)

Pnumber	Dnum	Lname	Address	Bdate
10	4	Wallace	291Berry, Bellaire, TX	1941-06-20
30	4	Wallace	291Berry, Bellaire, TX	1941-06-20

Query 2. For every project located in 'Stafford', list the project number, the controlling department number, and the department manager's last name, address, and birth date.

```
Q2:   SELECT   Pnumber, Dnum, Lname, Address, Bdate
      FROM     PROJECT, DEPARTMENT, EMPLOYEE
      WHERE    Dnum=Dnumber AND Mgr_ssn=Ssn AND
               Plocation='Stafford';
```

TABLES AS SETS IN SQL

- Duplicate tuples may appear in query results
  - From duplicates in base tables
  - From projecting out distinguishing columns
- Keyword **`DISTINCT`** in the `SELECT` clause eliminates duplicates

Query 11. Retrieve the salary of every employee (Q11) and all distinct salary values (Q11A).

```
Q11:    SELECT    ALL Salary
        FROM      EMPLOYEE;

Q11A:   SELECT    DISTINCT Salary
        FROM      EMPLOYEE;
```

SET OPERATIONS

- Result treated as a set (no duplicates)
  - **UNION**, **EXCEPT** (difference), **INTERSECT**
- Corresponding multiset (bag) operations:
  - UNION ALL, EXCEPT ALL, INTERSECT ALL
- Arguments must be *union-compatible*
  - Same number of columns
  - Corresponding columns of same type

Query 4. Make a list of all project numbers for projects that involve an employee whose last name is 'Smith', either as a worker or as a manager of the department that controls the project.

```
Q4A: (SELECT    DISTINCT Pnumber
      FROM      PROJECT, DEPARTMENT, EMPLOYEE
      WHERE     Dnum=Dnumber AND Mgr_ssn=Ssn
                AND Lname='Smith' )
      UNION
     ( SELECT   DISTINCT Pnumber
      FROM      PROJECT, WORKS_ON, EMPLOYEE
      WHERE     Pnumber=Pno AND Essn=Ssn
                AND Lname='Smith' );
```

OTHER OPERATORS

- Standard arithmetic operators:
  - Addition (+), subtraction (–), multiplication (*), and division (/)
- **[NOT] LIKE** comparison operator
  - Used for string **pattern matching**
  - Percent sign (%) matches zero or more characters
  - Underscore (_) matches a single character

  e.g., to also match Tommy Lee Jones as supporting actor:

```
SELECT award, actor, persona, Role.movie
FROM Honours, Role
WHERE category LIKE '%actor' AND winner = actor
      AND Honours.movie = Role.movie;
```

- **[NOT] BETWEEN** comparison operator

```
WHERE year BETWEEN 1990 AND 2010
```

equivalent to `WHERE year >= 1990 AND YEAR <= 2010`

LECTURE SUMMARY

- Introduction to SQL
  - Comprehensive language
  - Data definition including constraint specification
  - Basic SELECT-FROM-WHERE
  - Set operators