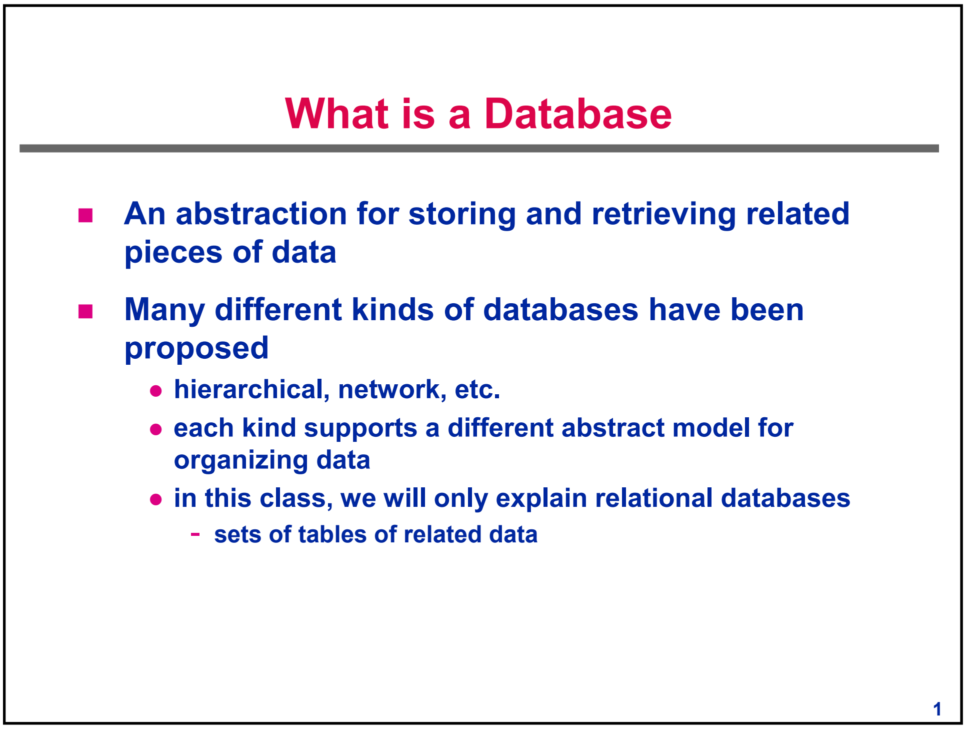
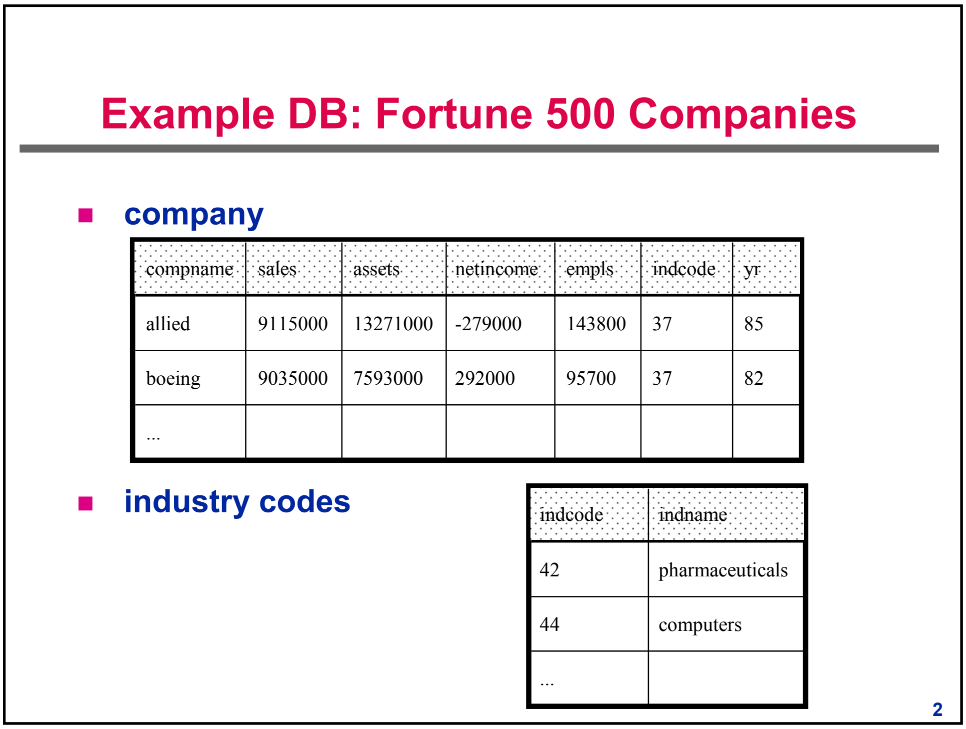


What is a Database

- An abstraction for storing and retrieving related pieces of data
- Many different kinds of databases have been proposed
  - hierarchical, network, etc.
  - each kind supports a different abstract model for organizing data
  - in this class, we will only explain relational databases
    - sets of tables of related data



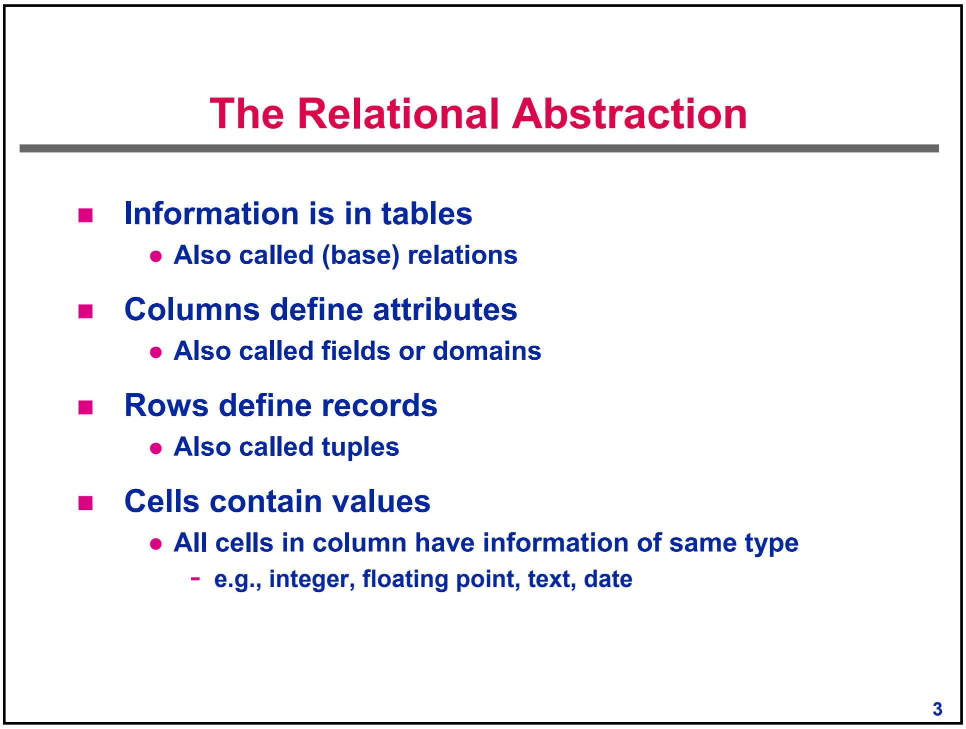
Example DB: Fortune 500 Companies

- company

compname	sales	assets	netincome	empls	indcode	yr
allied	9115000	13271000	-279000	143800	37	85
boeing	9035000	7593000	292000	95700	37	82
...						

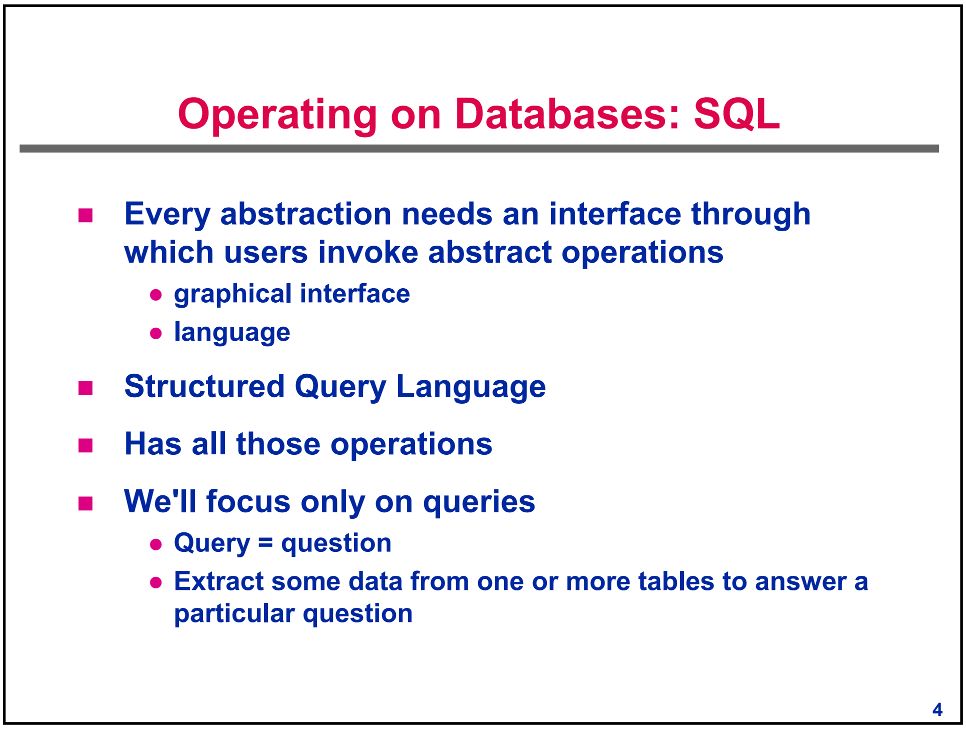
- industry codes

indcode	indname
42	pharmaceuticals
44	computers
...	



The Relational Abstraction

- Information is in tables
  - Also called (base) relations
- Columns define attributes
  - Also called fields or domains
- Rows define records
  - Also called tuples
- Cells contain values
  - All cells in column have information of same type
    - e.g., integer, floating point, text, date



Operating on Databases: SQL

- Every abstraction needs an interface through which users invoke abstract operations
  - graphical interface
  - language
- Structured Query Language
- Has all those operations
- We'll focus only on queries
  - Query = question
  - Extract some data from one or more tables to answer a particular question

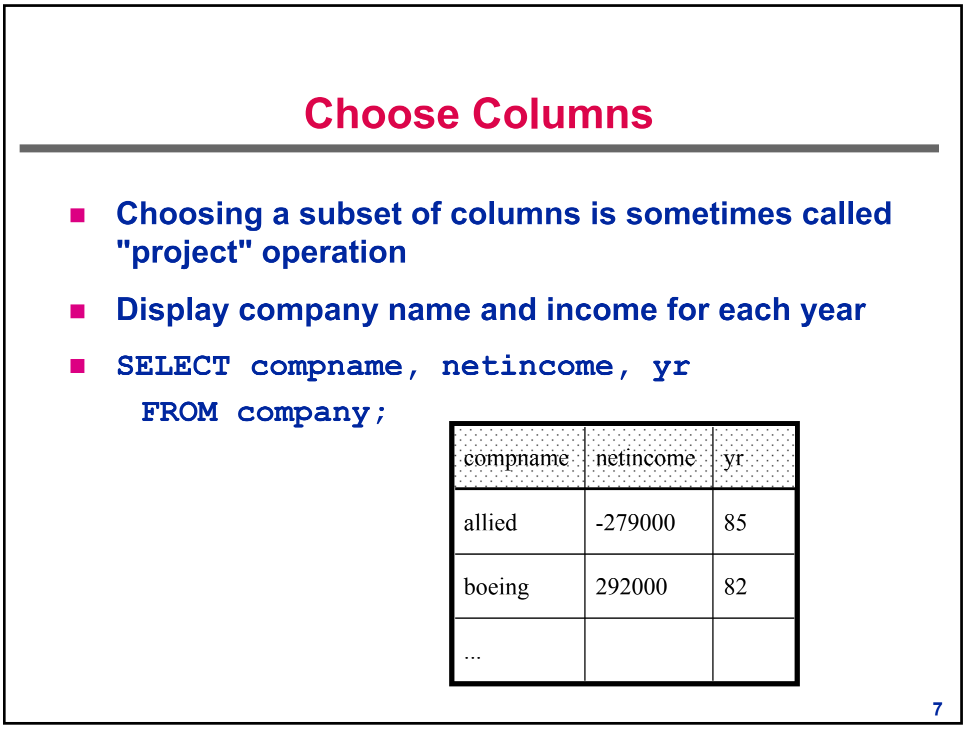
The Select Statement

- Every select statement yields a table of values as output
  - Sometimes there’s only one row in the table!

select	columns and/or expressions
from	tables
where	conditions on the rows
group by	group rows together
having	conditions on the groups
order by	order the rows
into temp	save results of query in a temporary table

Display Company Data

```
SELECT *
    FROM company;
```



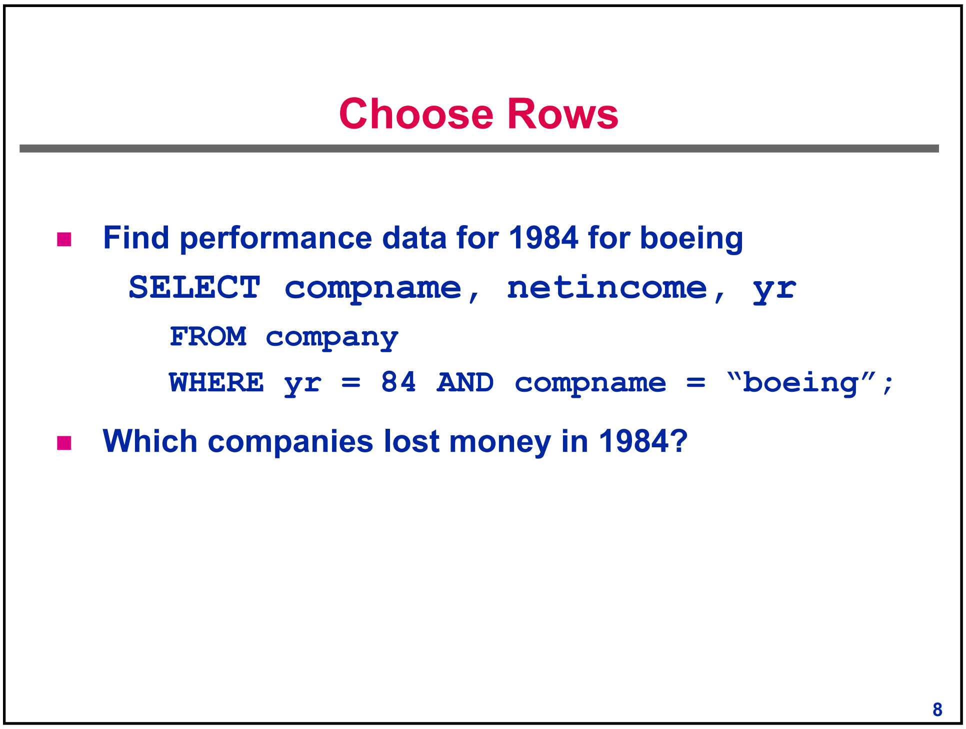
Choose Columns

- Choosing a subset of columns is sometimes called "project" operation
- Display company name and income for each year

-
  ```
  SELECT compname, netincome, yr
    FROM company;
  ```

compname	netincome	yr
allied	-279000	85
boeing	292000	82
...		

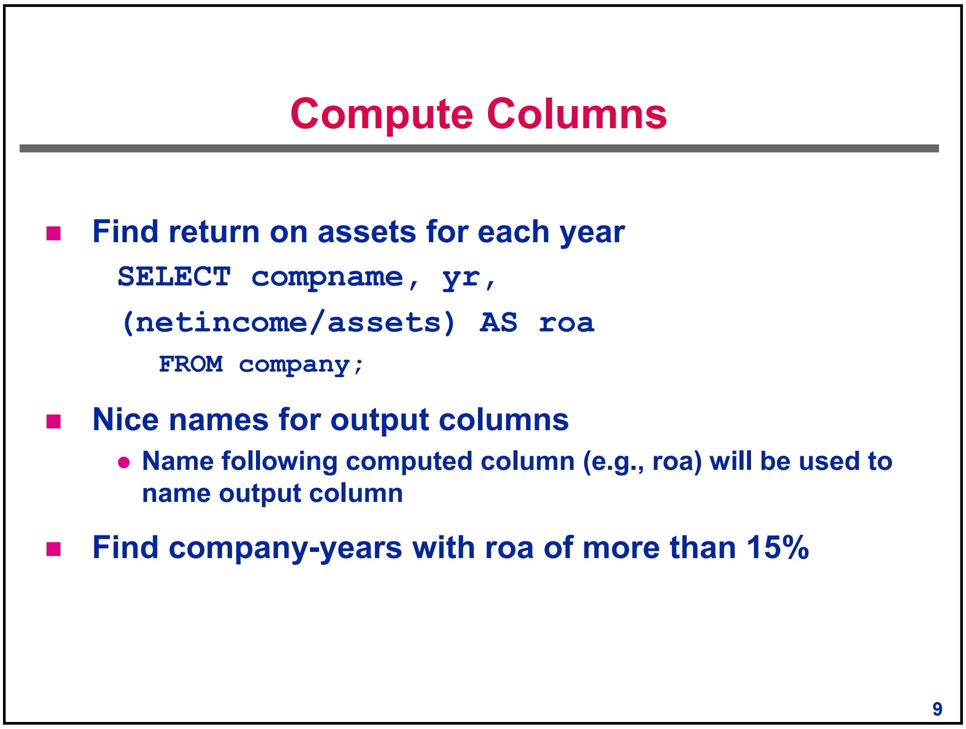
7



Choose Rows

- Find performance data for 1984 for boeing
  ```
  SELECT compname, netincome, yr
    FROM company
    WHERE yr = 84 AND compname = "boeing";
  ```
- Which companies lost money in 1984?

8

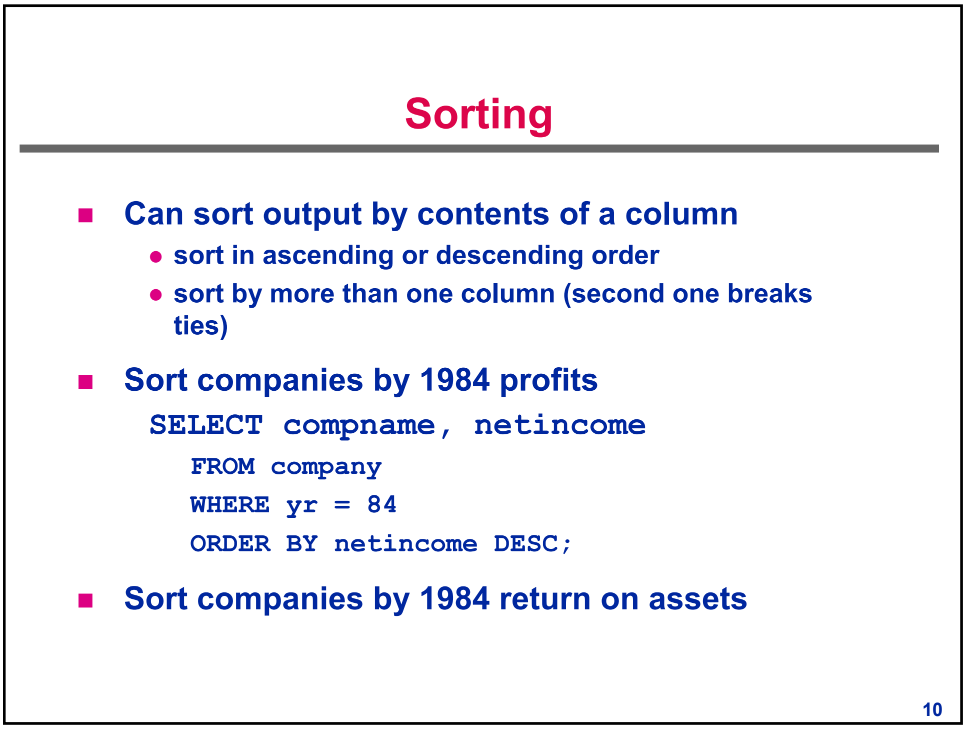


Compute Columns

- Find return on assets for each year

```
SELECT compname, yr,
(netincome/assets) AS roa
  FROM company;
```

- Nice names for output columns
  - Name following computed column (e.g., roa) will be used to name output column
- Find company-years with roa of more than 15%

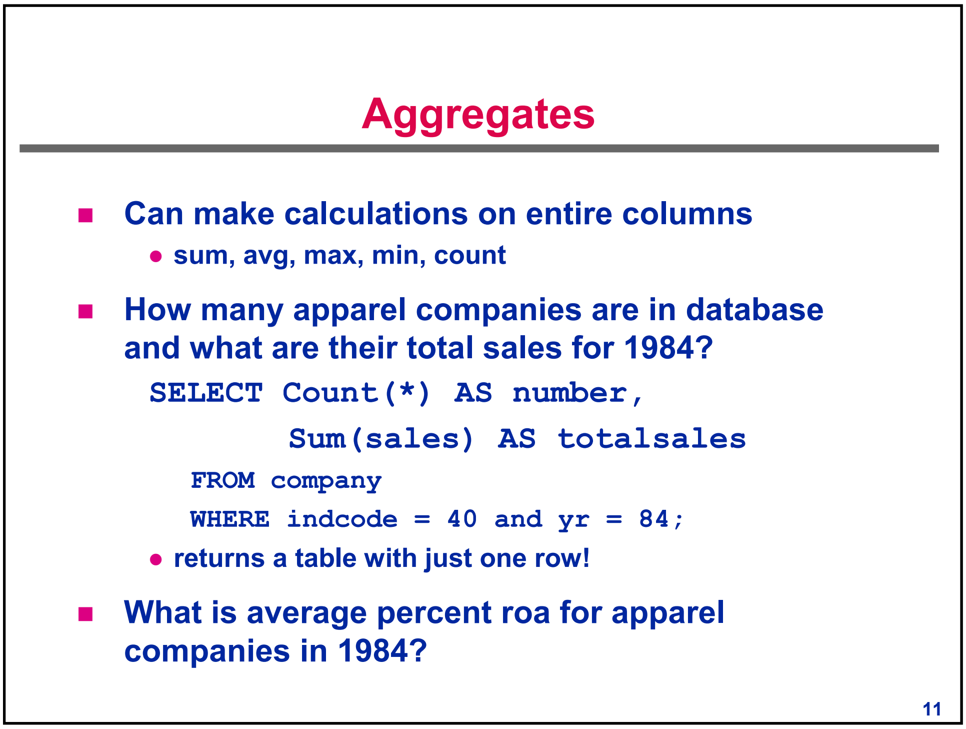


Sorting

- Can sort output by contents of a column
  - sort in ascending or descending order
  - sort by more than one column (second one breaks ties)
- Sort companies by 1984 profits

```
SELECT compname, netincome
  FROM company
  WHERE yr = 84
  ORDER BY netincome DESC;
```

- Sort companies by 1984 return on assets

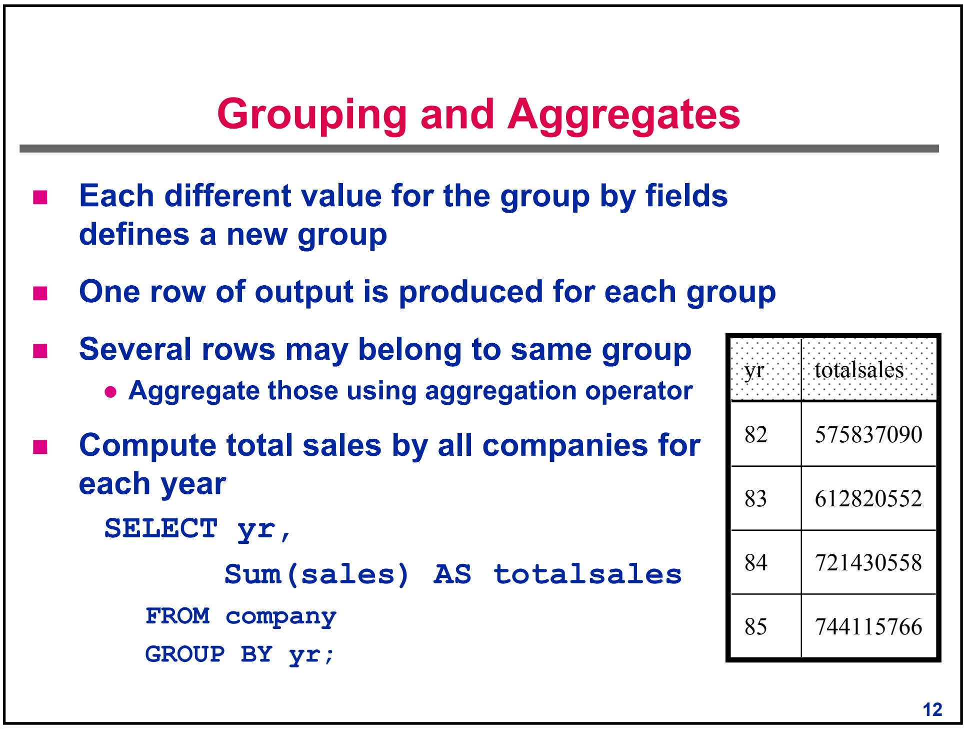


Aggregates

- Can make calculations on entire columns
  - sum, avg, max, min, count
- How many apparel companies are in database and what are their total sales for 1984?

```
SELECT Count(*) AS number,
       Sum(sales) AS totalsales
  FROM company
  WHERE indcode = 40 and yr = 84;
```

  - returns a table with just one row!
- What is average percent roa for apparel companies in 1984?



Grouping and Aggregates

- Each different value for the group by fields defines a new group
- One row of output is produced for each group
- Several rows may belong to same group
  - Aggregate those using aggregation operator
- Compute total sales by all companies for each year

```
SELECT yr,
       Sum(sales) AS totalsales
  FROM company
  GROUP BY yr;
```

yr	totalsales
82	575837090
83	612820552
84	721430558
85	744115766

More examples

- Compute total sales by all companies for each year

```
SELECT yr, Sum(sales) AS totalsales
   FROM company
   GROUP BY yr;
```

- Compute total sales for each company

- What are the leading industries in total sales for 1984?

13

Joins

- Combine rows from one table with rows from another
- Usually join on some common column
  - Don't combine rows unless their value in the common column is the same
  - Where clause says the common column must be same in each table
- Find the industry name for each company

```
SELECT company.compname AS compname,
  codes.indname AS industry
   FROM company, codes
   WHERE company.indcode = codes.indcode;
```

compname	*industry*
allied	aerospace
boeing	aerospace
...	

14

Example DB: Fortune 500 Companies

- company

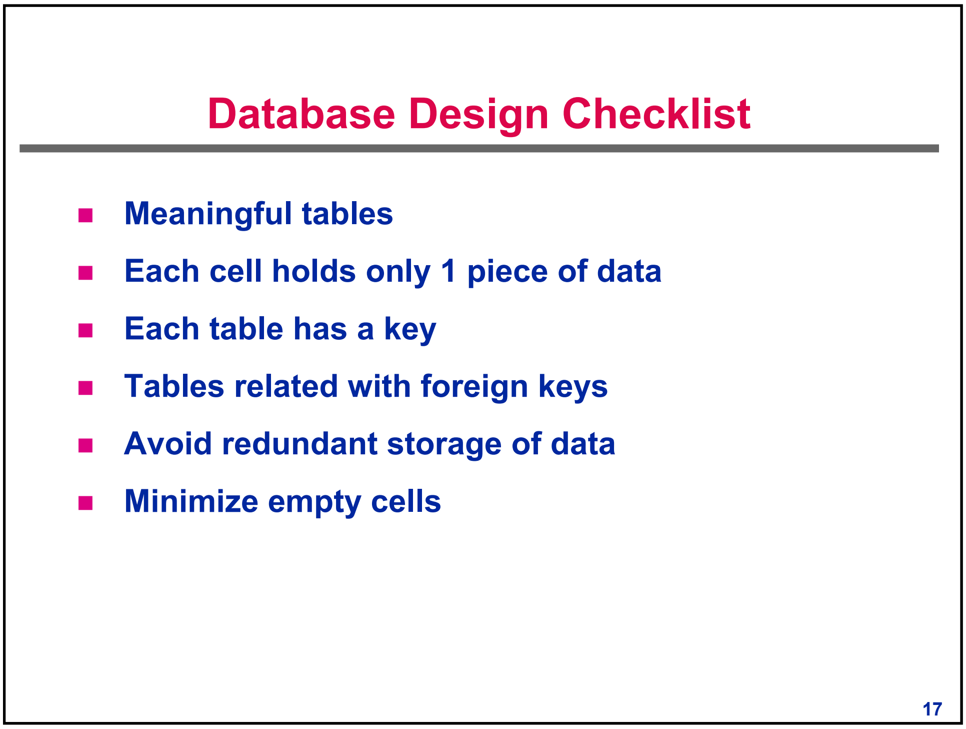
compname	sales	assets	netincome	empls	indcode	yr
allied	9115000	13271000	-279000	143800	37	85
boeing	9035000	7593000	292000	95700	37	82
...						

- industry codes

indcode	indname
42	pharmaceuticals
44	computers
...	

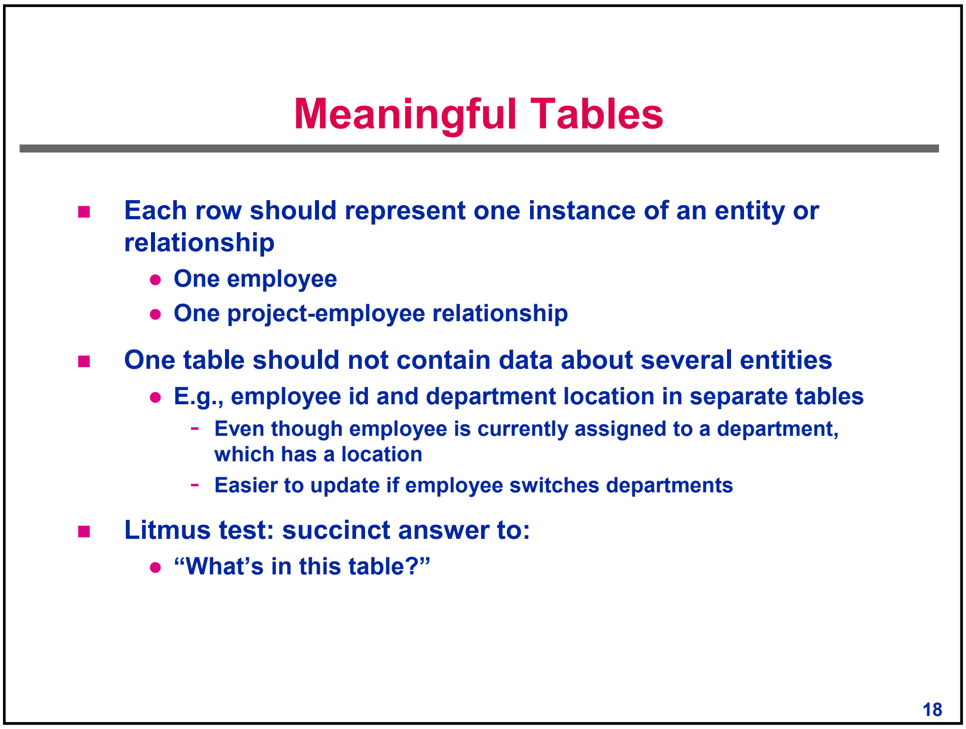
SQL Summary

select	columns and/or expressions
from	tables
where	conditions on the rows
group by	group rows together
having	conditions on the groups
order by	order the rows
into temp	save results of query in a temporary table



Database Design Checklist

- Meaningful tables
- Each cell holds only 1 piece of data
- Each table has a key
- Tables related with foreign keys
- Avoid redundant storage of data
- Minimize empty cells



Meaningful Tables

- Each row should represent one instance of an entity or relationship
  - One employee
  - One project-employee relationship
- One table should not contain data about several entities
  - E.g., employee id and department location in separate tables
    - Even though employee is currently assigned to a department, which has a location
    - Easier to update if employee switches departments
- Litmus test: succinct answer to:
  - “What’s in this table?”

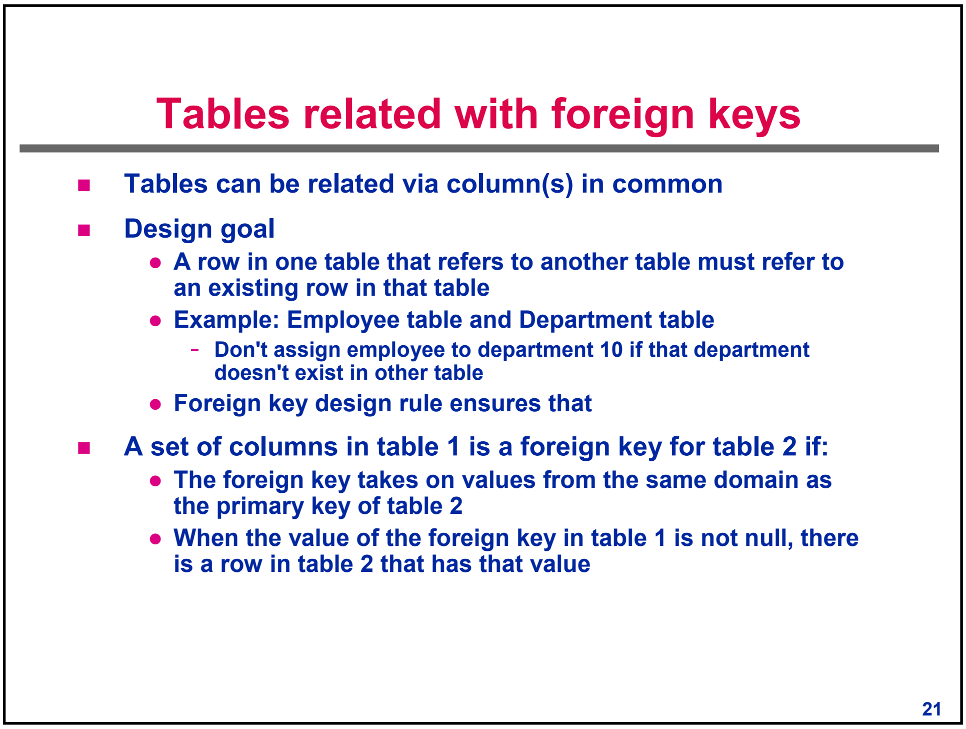
Each cell holds only 1 piece of data

- PHONE_NUM field should contain only 1 phone number
- If more than one phone number
  - Add another column if exactly two
  - Separate phone numbers table if number of phones not predetermined

Employee_id	Phone1	Phone2

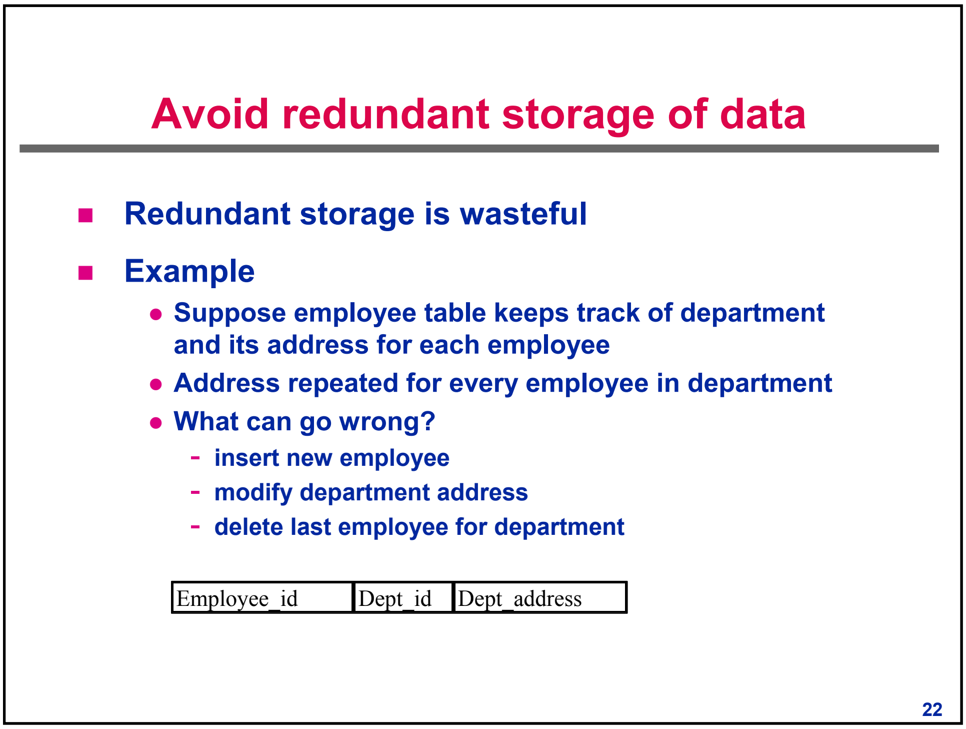
Each table has a key

- Key: a set of columns that picks out a unique row from the table
  - Last name not a key
  - First name not a key
  - First + middle + last may be a key
    - Social security number may be a more reliable key
- A table can have several keys
  - Choose one as the primary key
- Each table must have at least one key
  - Just means no duplicate rows
  - Key could be the entire set of columns
- Key cannot be null (blank)



Tables related with foreign keys

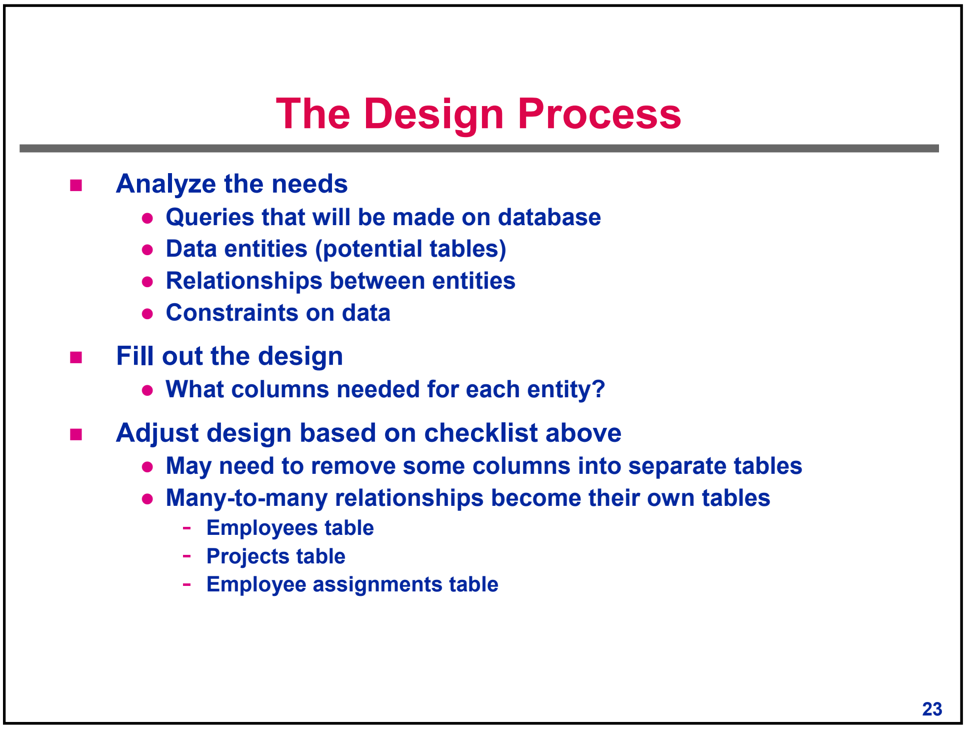
- Tables can be related via column(s) in common
- Design goal
  - A row in one table that refers to another table must refer to an existing row in that table
  - Example: Employee table and Department table
    - Don't assign employee to department 10 if that department doesn't exist in other table
  - Foreign key design rule ensures that
- A set of columns in table 1 is a foreign key for table 2 if:
  - The foreign key takes on values from the same domain as the primary key of table 2
  - When the value of the foreign key in table 1 is not null, there is a row in table 2 that has that value



Avoid redundant storage of data

- Redundant storage is wasteful
- Example
  - Suppose employee table keeps track of department and its address for each employee
  - Address repeated for every employee in department
  - What can go wrong?
    - insert new employee
    - modify department address
    - delete last employee for department

Employee_id	Dept_id	Dept_address



The Design Process

- Analyze the needs
  - Queries that will be made on database
  - Data entities (potential tables)
  - Relationships between entities
  - Constraints on data
- Fill out the design
  - What columns needed for each entity?
- Adjust design based on checklist above
  - May need to remove some columns into separate tables
  - Many-to-many relationships become their own tables
    - Employees table
    - Projects table
    - Employee assignments table