

# More complex databases

**Flat-file databases** can have problems with **data redundancy** and **data inconsistency**

| id  | name  | species | age | gender | height |
|-----|-------|---------|-----|--------|--------|
| 001 | Marg  | Giraffe | 12  | F      | 4.7    |
| 002 | Molly | Giraffe | 6   | F      | 4.4    |
| 003 | Molly | Giraffe | 5   | F      | 4.2    |
| 004 | Mike  | Giraffe | 14  | M      | 5.1    |
| 005 | Sammy | Giraffe | 1   | M      | 2.4    |
| 006 | Rex   | Lion    | 4   | M      | 1.8    |

# More complex databases

We can solve redundancy and inconsistency by designing more complex databases which use more than one table

# More complex databases

| id  | name  | species | age | gender | height | keeper  | phone | e-mail              |
|-----|-------|---------|-----|--------|--------|---------|-------|---------------------|
| 001 | Marg  | Giraffe | 12  | F      | 4.7    | Ford    | 321   | iford@thezoo.com    |
| 002 | Molly | Giraffe | 6   | F      | 4.4    | Wright  | 521   | nwright@thezoo.com  |
| 003 | Molly | Giraffe | 5   | F      | 4.2    | Remedio | 894   | rremedio@thezoo.com |
| 004 | Mike  | Giraffe | 14  | M      | 5.1    | Ford    | 321   | iford@thezoo.com    |
| 005 | Sammy | Giraffe | 1   | M      | 2.4    | Ford    | 400   | cford@thezoo.com    |
| 006 | Rex   | Lion    | 4   | M      | 1.8    | Remedio | 894   | rremedio@thezoo.com |

I've added data about the zookeeper responsible for each animal. This creates data redundancy

# More complex databases

| id  | name  | species | age | gender |
|-----|-------|---------|-----|--------|
| 001 | Marg  | Giraffe | 12  | female |
| 002 | Molly | Giraffe | 6   | female |
| 003 | Molly | Giraffe | 5   | female |
| 004 | Mike  | Giraffe | 14  | male   |
| 005 | Sammy | Giraffe | 1   | male   |
| 006 | Rex   | Lion    | 4   | male   |

To solve the redundancy problem  
I can split my data into **two tables**  
- one about animals and the other  
about zookeepers

| keeper  | phone | e-mail              |
|---------|-------|---------------------|
| Ford    | 321   | iford@thezoo.com    |
| Wright  | 521   | nwright@thezoo.com  |
| Remedio | 894   | rremedio@thezoo.com |
| Ford    | 321   | iford@thezoo.com    |
| Ford    | 400   | cford@thezoo.com    |
| Remedio | 894   | rremedio@thezoo.com |

# More complex databases

| id  | name  | species | age | gender | weight | height | keeper | phone | e-mail |
|-----|-------|---------|-----|--------|--------|--------|--------|-------|--------|
| 001 | Marg  | Giraffe | 12  | F      | 4.7    |        |        |       |        |
| 002 | Molly | Giraffe | 6   | F      | 4.4    |        |        |       |        |
| 003 | Molly | Giraffe | 5   |        |        |        |        |       |        |
| 004 | Mike  | Giraffe | 14  |        |        |        |        |       |        |
| 005 | Sammy | Giraffe | 1   |        |        |        |        |       |        |
| 006 | Rex   | Lion    | 4   |        |        |        |        |       |        |

I can delete some **redundant** rows where data is simply repeated

| keeper  | phone | e-mail              |
|---------|-------|---------------------|
| Ford    | 321   | iford@thezoo.com    |
| Wright  | 521   | nwright@thezoo.com  |
| Remedio | 894   | rremedio@thezoo.com |
| Ford    | 400   | cford@thezoo.com    |

What needs to be added to the zookeeper table?

| id  | name  | species | age | gender | height |
|-----|-------|---------|-----|--------|--------|
| 001 | Marg  | Giraffe | 12  | F      | 4.7    |
| 002 | Molly | Giraffe | 6   | F      | 4.4    |
| 003 | Molly | Giraffe | 5   | F      | 4.2    |
| 004 | Mike  | Giraffe | 14  | M      | 5.1    |
| 005 | Sammy | Giraffe | 1   | M      | 2.4    |
| 006 | Rex   | Lion    | 4   | M      | 1.8    |

Now we need to link each keeper to their animal

Primary key added

| keeperID | keeperName | phone | e-mail              |
|----------|------------|-------|---------------------|
| 001      | Ford       | 321   | iford@thezoo.com    |
| 002      | Wright     | 521   | nwright@thezoo.com  |
| 003      | Bufford    | 894   | wbufford@thezoo.com |
| 004      | Ford       | 400   | cford@thezoo.com    |

| id  | name  | species | age | gender | height | keeperID |
|-----|-------|---------|-----|--------|--------|----------|
| 001 | Marg  | Giraffe | 12  | F      | 4.7    | 001      |
| 002 | Molly | Giraffe | 6   | F      | 4.4    | 002      |
| 003 | Molly | Giraffe | 5   | F      | 4.2    | 003      |
| 004 | Mike  | Giraffe | 14  | M      | 5.1    | 001      |
| 005 | Sammy | Giraffe | 1   | M      | 2.4    | 004      |
| 006 | Rex   | Lion    | 4   | M      | 1.8    | 003      |

| keeperID | keeperName | phone | e-mail              |
|----------|------------|-------|---------------------|
| 001      | Ford       | 321   | iford@thezoo.com    |
| 002      | Wright     | 521   | nwright@thezoo.com  |
| 003      | Bufford    | 894   | wbufford@thezoo.com |
| 004      | Ford       | 400   | cford@thezoo.com    |

You do this by  
using the  
keeperID in **both**  
tables

| id  | name | species  | age | gender | height | keeperID |
|-----|------|----------|-----|--------|--------|----------|
| 001 | Tim  | Elephant | 12  | F      | 2.7    | 001      |
| 002 | Spot | Elephant | 10  | M      | 2.4    | 002      |
| 003 | Spot | Elephant | 12  | M      | 2.2    | 003      |
| 004 | Spot | Elephant | 10  | M      | 2.1    | 001      |
| 005 | Spot | Elephant | 10  | M      | 2.4    | 004      |
| 006 | Rex  | Lion     | 4   | M      | 1.8    | 003      |

**Important idea:** each keeper can look after more than one animal  
So the keeperID field in the animals table can contain the same value multiple times

But in the keepers table, the keeperID is the primary key so can only appear once

| keeperID | keeperName | phone | e-mail              |
|----------|------------|-------|---------------------|
| 001      | Ford       | 321   | iford@thezoo.com    |
| 002      | Wright     | 521   | nwright@thezoo.com  |
| 003      | Bufford    | 894   | wbufford@thezoo.com |
| 004      | Ford       | 400   | cford@thezoo.com    |

# More complex databases

A database with more than one table which are linked together is called a **relational database**

Relational databases reduce data redundancy and data inconsistency by only recording the data for each entity once

Each set of entities should have their own table with a primary key. The primary key is then used in the other table to link the data tables together

# More complex databases

The tables **Airport** and **Country** form a relational database set up for Badger Air, a small airline.

## Airport

| AirportName | Code | CountryName | Terminals |
|-------------|------|-------------|-----------|
| Manchester  | MAN  | UK          | 3         |
| Heathrow    | LHR  | UK          | 5         |
| Frankfurt   | FRA  | Germany     | 2         |
| Gatwick     | LGW  | UK          | 2         |
| Hamburg     | HAM  | Germany     | 2         |
| Fiumicino   | FCO  | UK          | 4         |

## Country

| CountryName | Currency       | Timezone |
|-------------|----------------|----------|
| Germany     | Euro           | 1        |
| Italy       | Euro           | 1        |
| UK          | Pound Sterling | 0        |

The tables are linked using the CountryName field

In the Country table it is the primary key

In the Airport table we say that it is the **foreign key**

# More complex databases

**Foreign key:** a field in one table which is the primary key in another table

This allows the tables to be linked together

Because the primary key is unique, the foreign key links to one (and only one) record in the other table. This means it can be used to avoid duplicating data in the first table, reducing data redundancy

| id  | name  | species | age | gender | height | keeperID |
|-----|-------|---------|-----|--------|--------|----------|
| 001 | Marg  | Giraffe | 12  | F      | 4.7    | 001      |
| 002 | Molly | Giraffe | 6   | F      | 4.4    | 002      |
| 003 | Molly | Giraffe |     |        |        | 003      |
| 004 | Mike  | Giraffe |     |        |        | 001      |
| 005 | Sammy | Giraffe |     |        |        | 004      |
| 006 | Rex   | Lion    | 4   | M      | 1.8    | 003      |

Foreign key here  
– it can be repeated  
in this table

Primary key  
there – it's  
unique here

| keeperID | keeperName | phone | e-mail              |
|----------|------------|-------|---------------------|
| 001      | Ford       | 321   | iford@thezoo.com    |
| 002      | Wright     | 521   | nwright@thezoo.com  |
| 003      | Bufford    | 894   | wbufford@thezoo.com |
| 004      | Ford       | 400   | cford@thezoo.com    |