Filtering Data with SQL

Introduction

After `SELECT` and `FROM`, the next SQL clause you're most likely to use as a data scientist is `WHERE`.

With just a `SELECT` expression, we can specify which **columns** we want to select, as well as transform the column values using aliases, built-in functions, and other expressions.

However if we want to filter the **rows** that we want to select, we also need to include a `WHERE` clause.

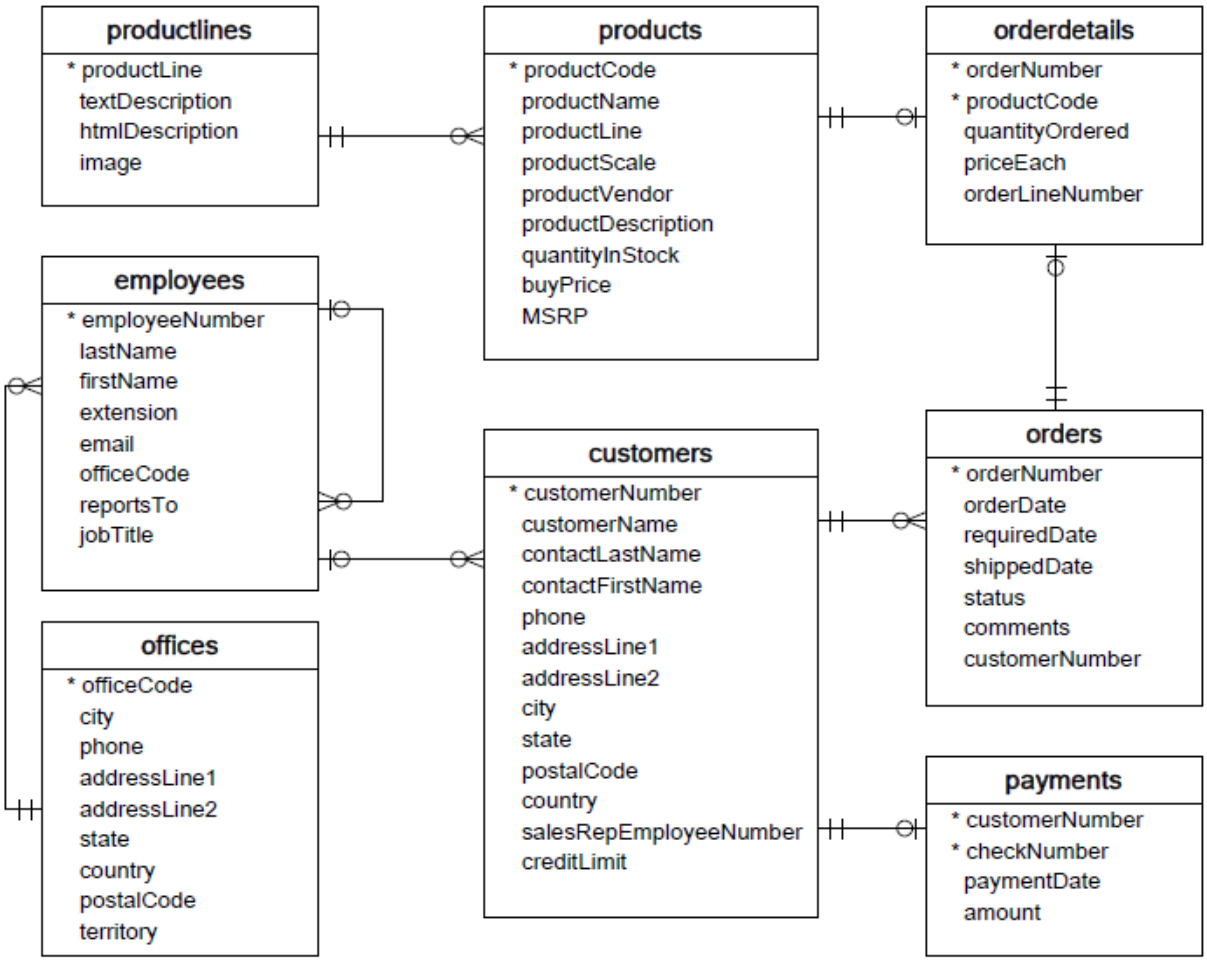
Objectives

You will be able to:

- Retrieve a subset of records from a table using a `WHERE` clause
- Filter results using conditional operators such as `BETWEEN`, `IS NULL`, and `LIKE`
- Apply an aggregate function to the result of a filtered query

Introduction to the `WHERE` Clause

For this section of the lesson, we'll use the Northwind database, the ERD (entity-relationship diagram) of which is shown below:



Northwind Data

Below, we connect to a SQLite database using the Python `sqlite3` library (documentation here (https://docs.python.org/3/library/sqlite3.html)), then display the contents of the `employees` table:

In [5]:
```
import pandas as pd
import sqlite3
conn = sqlite3.connect('data.sqlite')
pd.read_sql("""
SELECT *
  FROM employees;
""", conn)
```

Out[5]:

	employeeNumber	lastName	firstName	extension	email	officeCode
0	1002	Murphy	Diane	x5800	dmurphy@classicmodelcars.com	1
1	1056	Patterson	Mary	x4611	mpatterso@classicmodelcars.com	1
2	1076	Firrelli	Jeff	x9273	jfirrelli@classicmodelcars.com	1
3	1088	Patterson	William	x4871	wpatterson@classicmodelcars.com	6
4	1102	Bondur	Gerard	x5408	gbondur@classicmodelcars.com	4
5	1143	Bow	Anthony	x5428	abow@classicmodelcars.com	1
6	1165	Jennings	Leslie	x3291	ljennings@classicmodelcars.com	1
7	1166	Thompson	Leslie	x4065	lthompson@classicmodelcars.com	1
8	1188	Firrelli	Julie	x2173	jfirrelli@classicmodelcars.com	2
9	1216	Patterson	Steve	x4334	spatterson@classicmodelcars.com	2
10	1286	Tseng	Foon Yue	x2248	ftseng@classicmodelcars.com	3
11	1323	Vanauf	George	x4102	gvanauf@classicmodelcars.com	3
12	1337	Bondur	Loui	x6493	lbondur@classicmodelcars.com	4
13	1370	Hernandez	Gerard	x2028	ghernande@classicmodelcars.com	4
14	1401	Castillo	Pamela	x2759	pcastillo@classicmodelcars.com	4
15	1501	Bott	Larry	x2311	lbott@classicmodelcars.com	7
16	1504	Jones	Barry	x102	bjones@classicmodelcars.com	7
17	1611	Fixter	Andy	x101	afixter@classicmodelcars.com	6
18	1612	Marsh	Peter	x102	pmarsh@classicmodelcars.com	6

	employeeNumber	lastName	firstName	extension	email	officeCode
19	1619	King	Tom	x103	tking@classicmodelcars.com	6
20	1621	Nishi	Mami	x101	mnishi@classicmodelcars.com	5
21	1625	Kato	Yoshimi	x102	ykato@classicmodelcars.com	5
22	1702	Gerard	Martin	x2312	mgerard@classicmodelcars.com	4

When filtering data using `WHERE`, you are trying to find rows that match a specific condition. The simplest condition involves checking whether a specific column contains a specific value. In SQLite, this is done using `=`, which is similar to `==` in Python:

In [2]:
```
pd.read_sql("""
SELECT *
  FROM employees
 WHERE lastName = "Patterson";
""", conn)
```

Out[2]:

	employeeNumber	lastName	firstName	extension	email	officeCode	r
0	1056	Patterson	Mary	x4611	mpatterso@classicmodelcars.com	1	
1	1088	Patterson	William	x4871	wpatterson@classicmodelcars.com	6	
2	1216	Patterson	Steve	x4334	spatterson@classicmodelcars.com	2	

Note that we are selecting all columns (`SELECT *`) but are no longer selecting all rows. Instead, we are only selecting the 3 rows where the value of `lastName` is "Patterson".

SQL is essentially doing something like this:

In [3]:
```
# Selecting all of the records in the database
result = pd.read_sql("SELECT * FROM employees;", conn)
# Create a list to store the records that match the query
employees_named_patterson = []
# Loop over all of the employees
for _, data in result.iterrows():
    # Check if the last name is "Patterson"
    if data["lastName"] == "Patterson":
        # Add to list
        employees_named_patterson.append(data)

# Display the result list as a DataFrame
pd.DataFrame(employees_named_patterson)
```

Out[3]:

	employeeNumber	lastName	firstName	extension	email	officeCode	r
1	1056	Patterson	Mary	x4611	mpatterso@classicmodelcars.com	1	
3	1088	Patterson	William	x4871	wpatterson@classicmodelcars.com	6	
9	1216	Patterson	Steve	x4334	spatterson@classicmodelcars.com	2	

Except SQL is designed specifically to perform these kinds of queries efficiently! **Even if you are pulling data from SQL into Python for further analysis, `SELECT * FROM <table>;` is very rarely the most efficient approach.** You should be thinking about how to get SQL to do the "heavy lifting" for you in terms of selecting, filtering, and transforming the raw data!

You can also combine `WHERE` clauses with `SELECT` statements other than `SELECT *` in order to filter rows and columns at the same time. For example:

In [6]:
```
pd.read_sql("""
SELECT firstName, lastName, email
  FROM employees
 WHERE lastName = "Patterson";
""", conn)
```

Out[6]:

	firstName	lastName	email
0	Mary	Patterson	mpatterso@classicmodelcars.com
1	William	Patterson	wpatterson@classicmodelcars.com
2	Steve	Patterson	spatterson@classicmodelcars.com

`WHERE` clauses are especially powerful when combined with more-complex `SELECT` statements. Most of the time you will want to use aliases (with `AS`) in the `SELECT` statements to make the `WHERE` clauses more concise and readable.

Selecting Employees Based on String Conditions

If we wanted to select all employees with 5 letters in their first name, that would look like this:

In [7]:
```
pd.read_sql("""
SELECT *, length(firstName) AS name_length
  FROM employees
 WHERE name_length = 5;
""", conn)
```

Out[7]:

	employeeNumber	lastName	firstName	extension	email	officeCode	r
0	1002	Murphy	Diane	x5800	dmurphy@classicmodelcars.com	1	
1	1188	Firrelli	Julie	x2173	jfirrelli@classicmodelcars.com	2	
2	1216	Patterson	Steve	x4334	spatterson@classicmodelcars.com	2	
3	1501	Bott	Larry	x2311	lbott@classicmodelcars.com	7	
4	1504	Jones	Barry	x102	bjones@classicmodelcars.com	7	
5	1612	Marsh	Peter	x102	pmarsh@classicmodelcars.com	6	

Or, to select all employees with the first initial of "L", that would look like this:

In [8]:
```
pd.read_sql("""
SELECT *, substr(firstName, 1, 1) AS first_initial
  FROM employees
 WHERE first_initial = "L";
""", conn)
```

Out[8]:

	employeeNumber	lastName	firstName	extension	email	officeCode	r
0	1165	Jennings	Leslie	x3291	ljennings@classicmodelcars.com	1	
1	1166	Thompson	Leslie	x4065	lthompson@classicmodelcars.com	1	
2	1337	Bondur	Loui	x6493	lbondur@classicmodelcars.com	4	
3	1501	Bott	Larry	x2311	lbott@classicmodelcars.com	7	

Important note: Just like in Python, you can compare numbers in SQL just by typing the number (e.g. `name_length = 5`) but if you want to compare to a string value, you need to surround the value with quotes (e.g. `first_initial = "L"`). If you forget the quotes, you will get an error, because SQL will interpret it as a variable name rather than a hard-coded value:

In [9]:
```
pd.read_sql("""
SELECT *, substr(firstName, 1, 1) AS first_initial
  FROM employees
 WHERE first_initial = L;
""", conn)
```

```
---------------------------------------------------------------------------
OperationalError                          Traceback (most recent call last)
/opt/conda/lib/python3.9/site-packages/pandas/io/sql.py in execute(self, *arg
s, **kwargs)
   2055         try:
-> 2056             cur.execute(*args, **kwargs)
   2057             return cur

OperationalError: no such column: L

The above exception was the direct cause of the following exception:

DatabaseError                             Traceback (most recent call last)
/tmp/ipykernel_66/2492926221.py in <module>
----> 1 pd.read_sql("""
      2 SELECT *, substr(firstName, 1, 1) AS first_initial
      3   FROM employees
      4  WHERE first_initial = L;
      5 """, conn)

/opt/conda/lib/python3.9/site-packages/pandas/io/sql.py in read_sql(sql, con,
index_col, coerce_float, params, parse_dates, columns, chunksize)
    600
    601     if isinstance(pandas_sql, SQLiteDatabase):
--> 602         return pandas_sql.read_query(
    603             sql,
    604             index_col=index_col,

/opt/conda/lib/python3.9/site-packages/pandas/io/sql.py in read_query(self, s
ql, index_col, coerce_float, params, parse_dates, chunksize, dtype)
   2114
   2115         args = _convert_params(sql, params)
-> 2116         cursor = self.execute(*args)
   2117         columns = [col_desc[0] for col_desc in cursor.description]
   2118

/opt/conda/lib/python3.9/site-packages/pandas/io/sql.py in execute(self, *arg
s, **kwargs)
   2066
   2067             ex = DatabaseError(f"Execution failed on sql '{args[0]}':
{exc}")
-> 2068             raise ex from exc
   2069
   2070     @staticmethod

DatabaseError: Execution failed on sql '
SELECT *, substr(firstName, 1, 1) AS first_initial
  FROM employees
 WHERE first_initial = L;
```

```
': no such column: L
```

Selecting Order Details Based on Price

Below we select all order details where the price each, rounded to the nearest integer, is 30 dollars:

In [10]:
```
pd.read_sql("""
SELECT *, CAST(round(priceEach) AS INTEGER) AS rounded_price_int
  FROM orderDetails
 WHERE rounded_price_int = 30;
""", conn)
```

Out[10]:

	orderNumber	productCode	quantityOrdered	priceEach	orderLineNumber	rounded_price_int
0	10104	S24_2840	44	30.41	10	30
1	10173	S24_1937	31	29.87	9	30
2	10184	S24_2840	42	30.06	7	30
3	10280	S24_1937	20	29.87	12	30
4	10332	S24_1937	45	29.87	6	30
5	10367	S24_1937	23	29.54	13	30
6	10380	S24_1937	32	29.87	4	30

Selecting Orders Based on Date

We can use the `strftime` function to select all orders placed in January of any year:

In [11]:
```
pd.read_sql("""
SELECT *, strftime("%m", orderDate) AS month
  FROM orders
 WHERE month = "01";
""", conn)
```

Out[11]:

	orderNumber	orderDate	requiredDate	shippedDate	status	comments	customerNumber	m
0	10100	2003-01-06	2003-01-13	2003-01-10	Shipped		363	
1	10101	2003-01-09	2003-01-18	2003-01-11	Shipped	Check on availability.	128	
2	10102	2003-01-10	2003-01-18	2003-01-14	Shipped		181	
3	10103	2003-01-29	2003-02-07	2003-02-02	Shipped		121	
4	10104	2003-01-31	2003-02-09	2003-02-01	Shipped		141	
5	10208	2004-01-02	2004-01-11	2004-01-04	Shipped		146	
6	10209	2004-01-09	2004-01-15	2004-01-12	Shipped		347	
7	10210	2004-01-12	2004-01-22	2004-01-20	Shipped		177	
8	10211	2004-01-15	2004-01-25	2004-01-18	Shipped		406	
9	10212	2004-01-16	2004-01-24	2004-01-18	Shipped		141	
10	10213	2004-01-22	2004-01-28	2004-01-27	Shipped	Difficult to negotiate with customer. We need ...	489	
11	10214	2004-01-26	2004-02-04	2004-01-29	Shipped		458	
12	10215	2004-01-29	2004-02-08	2004-02-01	Shipped	Customer requested that FedEx Ground is used f...	475	
13	10362	2005-01-05	2005-01-16	2005-01-10	Shipped		161	
14	10363	2005-01-06	2005-01-12	2005-01-10	Shipped		334	
15	10364	2005-01-06	2005-01-17	2005-01-09	Shipped		350	
16	10365	2005-01-07	2005-01-18	2005-01-11	Shipped		320	
17	10366	2005-01-10	2005-01-19	2005-01-12	Shipped		381	

	orderNumber	orderDate	requiredDate	shippedDate	status	comments	customerNumber	m
18	10367	2005-01-12	2005-01-21	2005-01-16	Resolved	This order was disputed and resolved on 2/1/20...	205	
19	10368	2005-01-19	2005-01-27	2005-01-24	Shipped	Can we renegotiate this one?	124	
20	10369	2005-01-20	2005-01-28	2005-01-24	Shipped		379	
21	10370	2005-01-20	2005-02-01	2005-01-25	Shipped		276	
22	10371	2005-01-23	2005-02-03	2005-01-25	Shipped		124	
23	10372	2005-01-26	2005-02-05	2005-01-28	Shipped		398	
24	10373	2005-01-31	2005-02-08	2005-02-06	Shipped		311	

We can also check to see if any orders were shipped late (`shippedDate` after `requiredDate` , i.e. the number of days late is a positive number):

In [12]:
```
pd.read_sql("""
SELECT *, julianday(shippedDate) - julianday(requiredDate) AS days_late
  FROM orders
 WHERE sign(days_late) = +1;
""", conn)
```

Out[12]:

	orderNumber	orderDate	requiredDate	shippedDate	status	comments	customerNumber	day
0	10165	2003-10-22	2003-10-31	2003-12-26	Shipped	This order was on hold because customers's cre...	148	

That was the last query in this lesson using the Northwind data, so let's close that connection:

In [13]:
```
conn.close()
```

Conditional Operators in SQL

In all of the above queries, we used the `=` operator to check if we had an exact match for a given value. However, what if you wanted to select the order details where the price was at least 30 dollars? Or all of the orders that don't currently have a shipped date?

We'll need some more advanced conditional operators for that.

Some important ones to know are:

- `!=` ("not equal to")
  - Similar to `not` combined with `==` in Python
- `>` ("greater than")
  - Similar to `>` in Python
- `>=` ("greater than or equal to")
  - Similar to `>=` in Python
- `<` ("less than")
  - Similar to `<` in Python
- `<=` ("less than or equal to")
  - Similar to `<=` in Python
- `AND`
  - Similar to `and` in Python
- `OR`
  - Similar to `or` in Python
- `BETWEEN`
  - Similar to placing a value between two values with `<=` and `and` in Python, e.g. `(2 <= x) and (x <= 5)`
- `IN`
  - Similar to `in` in Python
- `LIKE`
  - Uses wildcards to find similar strings. No direct equivalent in Python, but similar to some Bash terminal commands.

Cats Data

For this section as the queries get more advanced we'll be using a simpler database called `pets_database.db` containing a table called `cats`.

The `cats` table is populated with the following data:

id	name	age	breed	owner_id
1	Maru	3.0	Scottish Fold	1.0
2	Hana	1.0	Tabby	1.0
3	Lil' Bub	5.0	American Shorthair	NaN
4	Moe	10.0	Tabby	NaN
5	Patches	2.0	Calico	NaN
6	None	NaN	Tabby	NaN

Below we make a new database connection and read all of the data from this table:

In [14]:
```
conn = sqlite3.connect('pets_database.db')
pd.read_sql("SELECT * FROM cats;", conn)
```

Out[14]:

	id	name	age	breed	owner_id
0	1	Maru	3.0	Scottish Fold	1.0
1	2	Hana	1.0	Tabby	1.0
2	3	Lil' Bub	5.0	American Shorthair	NaN
3	4	Moe	10.0	Tabby	NaN
4	5	Patches	2.0	Calico	NaN
5	6	None	NaN	Tabby	NaN

`WHERE` Code-Along

In this exercise, you'll walk through executing a handful of common and handy SQL queries that use `WHERE` with conditional operators. We'll start by giving you an example of what this type of query looks like, then have you type a query specifically related to the `cats` table.

`WHERE` with `>=`

For the `=`, `!=`, `<`, `<=`, `>`, and `>=` operators, the query looks like:

```
SELECT column(s)
  FROM table_name
 WHERE column_name operator value;
```

> Note: The example above is not valid SQL, it is a template for how the queries are constructed

Type this SQL query between the quotes below to select all cats who are at least 5 years old:

```
SELECT *
  FROM cats
 WHERE age >= 5;
```

In [15]:
```
pd.read_sql("""
SELECT *
   FROM cats
  WHERE age >= 5;
""", conn)
```

Out[15]:

	id	name	age	breed	owner_id
0	3	Lil' Bub	5	American Shorthair	None
1	4	Moe	10	Tabby	None

This should return:

id	name	age	breed	owner_id
3	Lil' Bub	5.0	American Shorthair	None
4	Moe	10.0	Tabby	None

`WHERE` with `BETWEEN`

If you wanted to select all rows with values in a range, you *could* do this by combining the `<=` and `AND` operators. However, since this is such a common task in SQL, there is a shorter and more efficient command specifically for this purpose, called `BETWEEN`.

A typical query with `BETWEEN` looks like:

```
SELECT column_name(s)
  FROM table_name
 WHERE column_name BETWEEN value1 AND value2;
```

> Note that `BETWEEN` is an **inclusive** range, so the returned values can match the boundary values (not like `range()` in Python)

Let's say you need to select the names of all of the cats whose age is between 1 and 3. Type this SQL query between the quotes below to select all cats who are in this age range:

```
SELECT *
  FROM cats
 WHERE age BETWEEN 1 AND 3;
```

In [16]:
```
pd.read_sql("""
SELECT *
   FROM cats
  WHERE age BETWEEN 1 AND 3;
""", conn)
```

Out[16]:

	id	name	age	breed	owner_id
0	1	Maru	3	Scottish Fold	1.0
1	2	Hana	1	Tabby	1.0
2	5	Patches	2	Calico	NaN

This should return:

id	name	age	breed	owner_id
1	Maru	3.0	Scottish Fold	1.0
2	Hana	1.0	Tabby	1.0
5	Patches	2.0	Calico	NaN

`WHERE` Column Is Not `NULL`

`NULL` in SQL represents missing data. It is similar to `None` in Python or `NaN` in NumPy or pandas. However, we use the `IS` operator to check if something is `NULL`, not the `=` operator (or `IS NOT` instead of `!=`).

To check if a value is `NULL` (or not), the query looks like:

```
SELECT column(s)
  FROM table_name
 WHERE column_name IS (NOT) NULL;
```

> You might have noticed when we selected all rows of `cats`, some owner IDs were `NaN`, then in the above query they are `None` instead. This is a subtle difference where Python/pandas is converting SQL `NULL` values to `NaN` when there are numbers in other rows, and converting to `None` when all of the returned values are `NULL`. This is a subtle difference that you don't need to memorize; it is just highlighted to demonstrate that the operators we use in SQL are *similar* to Python operators, but not quite the same.

If we want to select all cats that don't currently belong to an owner, we want to select all cats where the `owner_id` is `NULL`.

Type this SQL query between the quotes below to select all cats that don't currently belong to an owner:

```
SELECT *
  FROM cats
 WHERE owner_id IS NULL;
```

In [17]:
```
pd.read_sql("""
SELECT *
  FROM cats
 WHERE owner_id IS NULL;
""", conn)
```

Out[17]:

	id	name	age	breed	owner_id
0	3	Lil' Bub	5.0	American Shorthair	None
1	4	Moe	10.0	Tabby	None
2	5	Patches	2.0	Calico	None
3	6	None	NaN	Tabby	None

This should return:

id	name	age	breed	owner_id
3	Lil' Bub	5.0	American Shorthair	None
4	Moe	10.0	Tabby	None
5	Patches	2.0	Calico	None
6	None	NaN	Tabby	None

`WHERE` with `LIKE`

The `LIKE` operator is very helpful for writing SQL queries with messy data. It uses *wildcards* to specify which parts of the string query need to be an exact match and which parts can be variable.

When using `LIKE`, a query looks like:

```
SELECT column(s)
  FROM table_name
 WHERE column_name LIKE 'string_with_wildcards';
```

The most common wildcard you'll see is `%`. This is similar to the `*` wildcard in Bash or regex: it means zero or more characters with any value can be in that position.

So for example, if we want all cats with names that start with "M", we could use a query containing `M%`. This means that we're looking for matches that start with one character "M" (or "m", since this is a case-insensitive query in SQLite) and then zero or more characters that can have any value.

Type this SQL query between the quotes below to select all cats with names that start with "M" (or "m"):

```
SELECT *
  FROM cats
 WHERE name LIKE 'M%';
```

In [ ]:
```
pd.read_sql("""

""", conn)
```

This should return:

id	name	age	breed	owner_id
1	Maru	3.0	Scottish Fold	1.0
4	Moe	10.0	Tabby	NaN

Note that we also could have used the `substr` SQL built-in function here to perform the same task:

```
SELECT *
  FROM cats
 WHERE substr(name, 1, 1) = "M";
```

Unlike in Python where:

> There should be one-- and preferably only one --obvious way to do it. *(Zen of Python)*

there will often be multiple valid approaches to writing the same SQL query. Sometimes one will be more efficient than the other, and sometimes the only difference will be a matter of preference.

The other wildcard used for comparing strings is `_` , which means exactly one character, with any value.

For example, if we wanted to select all cats with four-letter names where the second letter was "a", we could use `_a__` .

Type this SQL query between the quotes below to select all cats with names where the second letter is "a" and the name is four letters long:

```
SELECT *
  FROM cats
 WHERE name LIKE '_a__';
```

In [ ]:
```
pd.read_sql("""

""", conn)
```

This should return:

id	name	age	breed	owner_id
1	Maru	3	Scottish Fold	1
2	Hana	1	Tabby	1

Again, we could have done this using `length` and `substr`, although it would be much less concise:

```
SELECT *
  FROM cats
 WHERE length(name) = 4 AND substr(name, 2, 1) = "a";
```

These examples are a bit silly, but you can imagine how this technique would help to write queries between multiple datasets where the names don't quite match exactly! You can combine `%` and `_` in your string to narrow and expand your query results as needed.

`SELECT` with `COUNT`

Now, let's talk about the SQL aggregate function `COUNT`.

SQL aggregate functions are SQL statements that can get the average of a column's values, retrieve the minimum and maximum values from a column, sum values in a column, or count a number of records that meet certain conditions. You can learn more about these SQL aggregators here (http://www.sqlclauses.com/sql+aggregate+functions) and here (http://zetcode.com/db/sqlite/select/).

For now, we'll just focus on `COUNT`, which counts the number of records that meet a certain condition. Here's a standard SQL query using `COUNT`:

```
SELECT COUNT(column_name)
  FROM table_name
 WHERE conditional_statement;
```

Let's try it out and count the number of cats who have an `owner_id` of `1`. Type this SQL query between the quotes below:

```
SELECT COUNT(owner_id)
  FROM cats
 WHERE owner_id = 1;
```

In [ ]:
```
pd.read_sql("""

""", conn)
```

This should return:

	COUNT(owner_id)
0	2

Note on `SELECT`

We are now familiar with this syntax:

```
SELECT name
  FROM cats;
```

However, you may not know that this can be written like this as well:

```
SELECT cats.name
  FROM cats;
```

Both return the same data.

SQLite allows us to explicitly state the `tableName.columnName` you want to select. This is particularly useful when you want data from two different tables.

Imagine you have another table called `dogs` with a column containing all of the dog names:

```
CREATE TABLE dogs (
    id   INTEGER PRIMARY KEY,
    name TEXT
);

INSERT INTO dogs (name)
VALUES ("Clifford");
```

If you want to get the names of all the dogs and cats, you can no longer run a query with just the column name. `SELECT name FROM cats,dogs;` will return `Error: ambiguous column name: name` .

Instead, you must explicitly follow the `tableName.columnName` syntax.

```
SELECT cats.name, dogs.name
  FROM cats, dogs;
```

You may see this in the future. Don't let it trip you up!

In [13]:
```
conn.close()
```

Summary

In this lesson, you saw how to filter the resulting rows of a SQL query using a `WHERE` clause that checked whether a given column was equal to a specific value. You also got a basic introduction to aggregate functions by seeing an example of `COUNT` , and dove deeper into some conditional operators including `BETWEEN` and `LIKE` .