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Workshop

Introducing SQL:
A Foundation of Data Analytics

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Agenda

- Introduction
  - Why SQL?
  - What about Python? R?
  - Data Analytics
- Relational Database
  - What is a database?
  - Terminology
  - SQLite
  - **Exercise 1**
- SQL
  - Data Definition Language (DDL)
  - **Exercise 2**
  - Data Manipulation Language (DML)
  - **Exercise 3**
- Open Data Portal
  - How I prepared for today

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Robb Sombach

- Work Experience
  - 15+ years working in the IT industry
  - 10+ years Self-Employed IT Consultant
- IT Positions
  - Systems Analyst / Business Analyst
  - Database Administrator (Oracle / SQL Server)
  - Network Administrator
  - Developer

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Robb Sombach

- Teaching Experience
  - 5 years teaching at NAIT
    - Computer Systems Technology (CST)
    - Digital Media and Information Technology (DMIT)
  - 6+ years teaching at University of Alberta
    - Technology Training Centre
    - Alberta School of Business

Resources

All Workshop files can be downloaded here

http://bit.ly/odd_2019

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Introduction

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Introducing SQL: Foundation of Data Analytics

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Goals

- Introduce relational database concepts
- Provides hands-on, real world database experience using data from the City of Edmonton Open Data Portal
- Foster a collaborative workshop
  - Please interupt and ask questions

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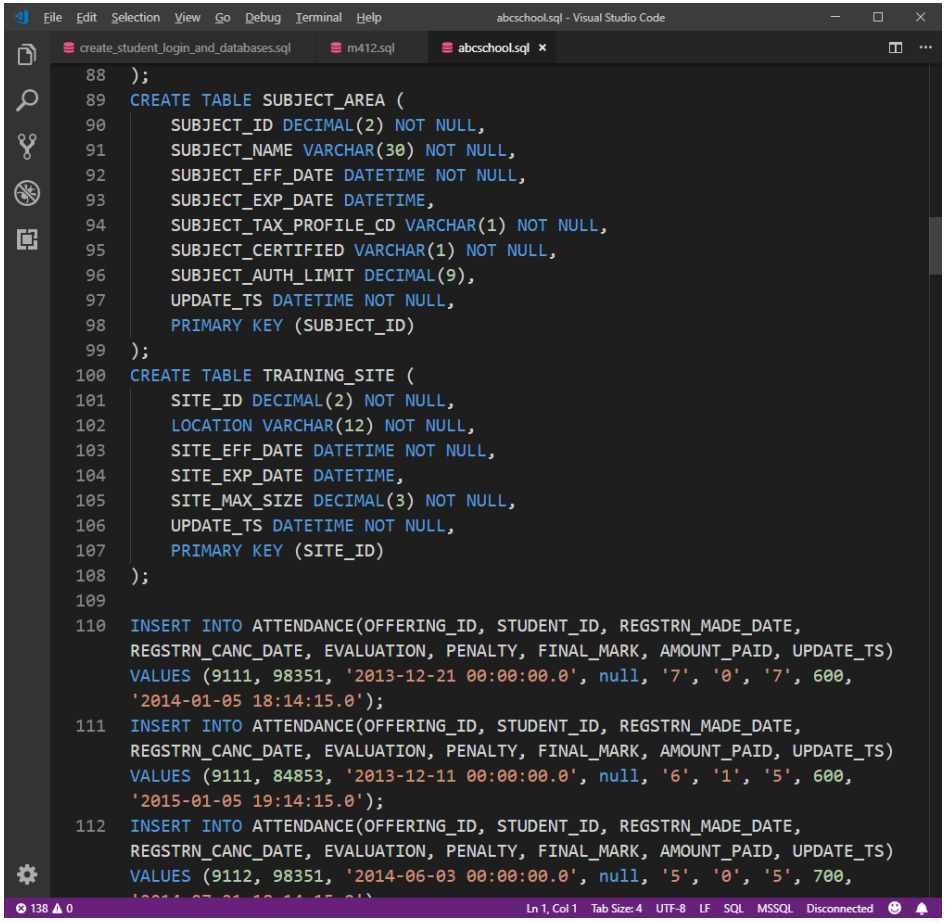
Why SQL?

- Simple
- Accessible
- Applicable
- Powerful
- Pervasive
- Valuable
- Universal



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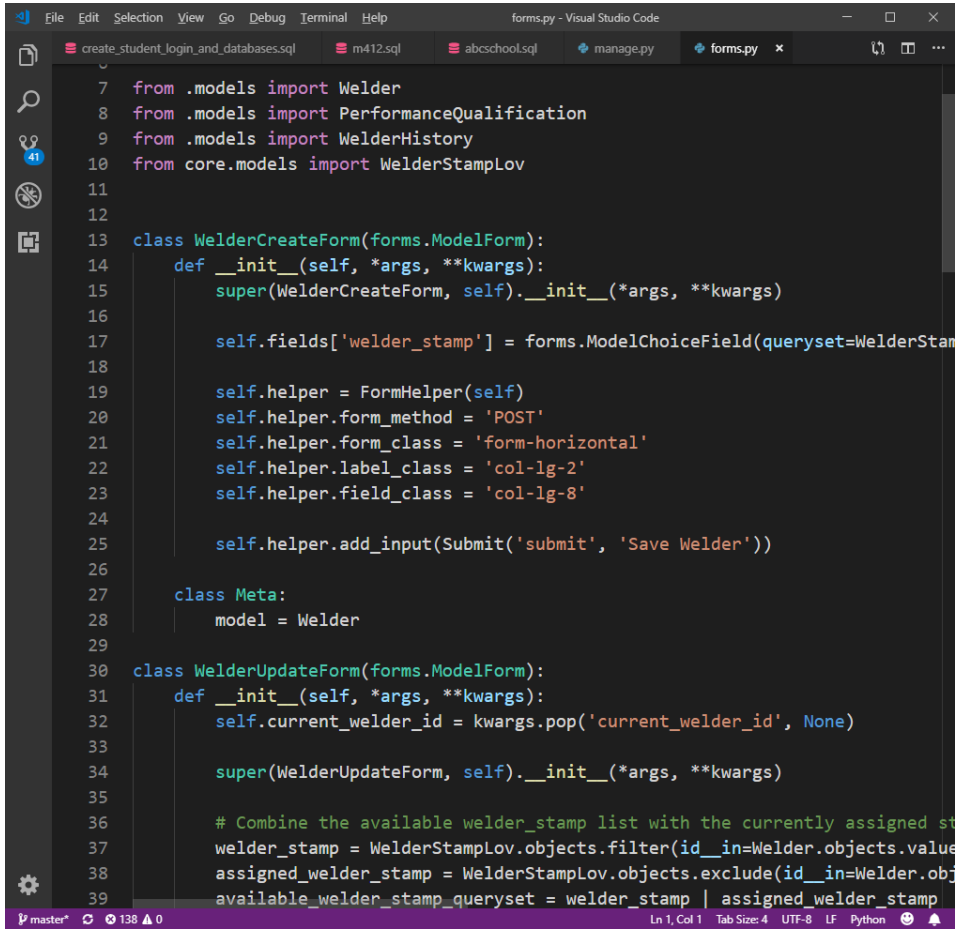
Why not Python? R?

- Difficult for beginners
- Complicated syntax
- Requires programming knowledge (logic, algorithms)
- Is SQL better than Python or R?
  - SQL is good for some things
  - Python/R is good for other things
  - Compliment each other
- SQL is a great starting point



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Data Analytics

- Analytics is the discovery, interpretation, and communication of meaningful patterns in **data**; and the process of applying those patterns towards effective decision making
- Organizations may apply analytics to business **data** to describe, predict, and improve business performance
    - https://en.wikipedia.org/wiki/Analytics

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Relational Database

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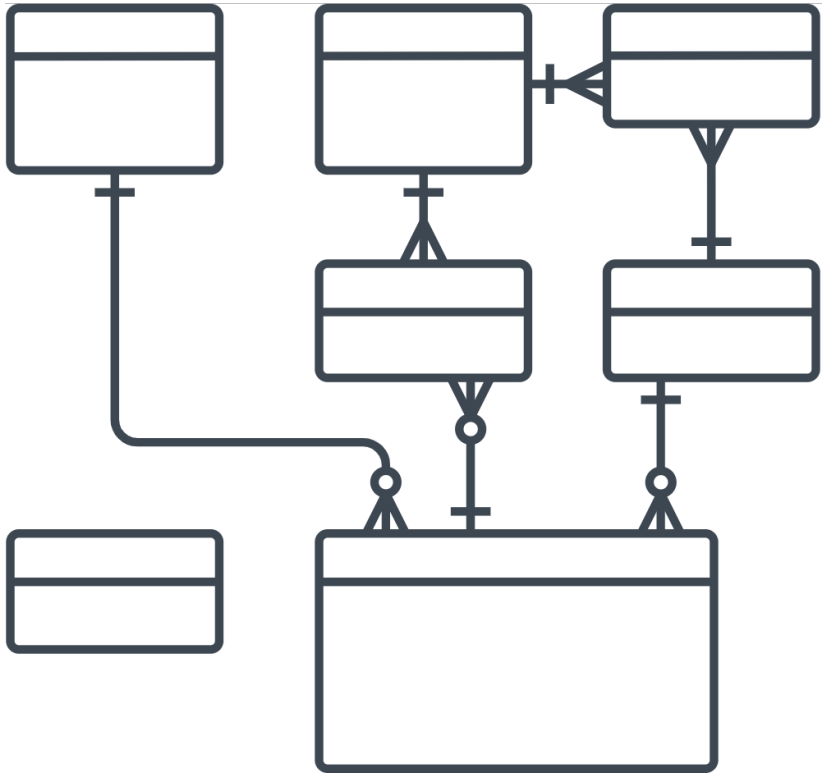
What is a database?

- A relational “database” management system (RDBMS) organizes **data**
- The logical structure of the database is based upon the information needs of an organization
  - Entities (“things” of interest to the organization),

  AND
  - Relationships (how the Entities are associated with each other)



Advantages of a RDBMS

- Establish a centralized, logical view of data
- Minimizes data duplication (i.e. “redundancy”)
- Promote data accuracy and integrity
- Capacity of database
- Superior multi-user or concurrent access
- Security
- Retrieve information quickly
- Inter-operability

https://www.bespokesoftwaredevelopment.com/blog/advantages-database-development-business/

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Database Terminology

- **Table**, Entity, Relation, (similar to an Excel Worksheet)
- **Row**, Record, Instance
- **Column**, Field, Attribute
- **Primary Key** – unique and mandatory
- **Foreign Key** – a cross-reference between tables because it references the primary key of another table
- **Relationship** – created though foreign keys

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How to introduce SQL?

- Microsoft Access
  - https://products.office.com/en-ca/access
- Microsoft SQL Server
  - https://www.microsoft.com/en-us/sql-server/sql-server-2017
- MariaDB, MySQL
  - https://mariadb.org/
  - https://www.mysql.com/
- Postgresql
  - https://www.postgresql.org/
- Oracle
  - https://www.oracle.com/database/
- Hadoop, Spark, Hive, Pig
  - https://hadoop.apache.org/

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A database that …

- Has full-featured SQL
- Has billions and billions of deployments
- Is a single-file database
- Has public domain source code
- Small footprint
- Has a max DB size of 140 terabytes
- Has a max row size of 1 gigabyte
- Is faster than direct file access
- Aviation-grade quality and testing
- Zero-configuration
- Has ACID (Atomic, Consistent, Isolated, and Durable) transactions, even after power loss
- Has a stable, enduring file format
- Is has extensive, detailed documentation
- Has long-term support (to the year 2050)

https://www.sqlite.org/about.html

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SQLite

- “SQLite is the most widely deployed database in the world with more applications than we can count, including several high-profile projects”
  - https://www.sqlite.org/famous.html
- “SQLite is an in-process library that implements a self-contained, serverless, zero-configuration, transactional SQL database engine”
  - https://www.sqlite.org/about.html
- Perfect for learning SQL (the foundation of data analytics)

Exercise 1: Download and Run SQLite BD Browser

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- Download SQLite
- Download SQLite DB Browser Portable
  - https://sqlitebrowser.org/dl/

Exercise 1: Download and Run SQLite

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- Extract the ZIP archive to the Desktop
- Start SQLite
  - SQLiteDatabaseBrowserPortable.exe
- Create a New database
  - open_data_day_2019.db
- Save the database in the Data folder
- Click Cancel when prompted to create a table
- Done!

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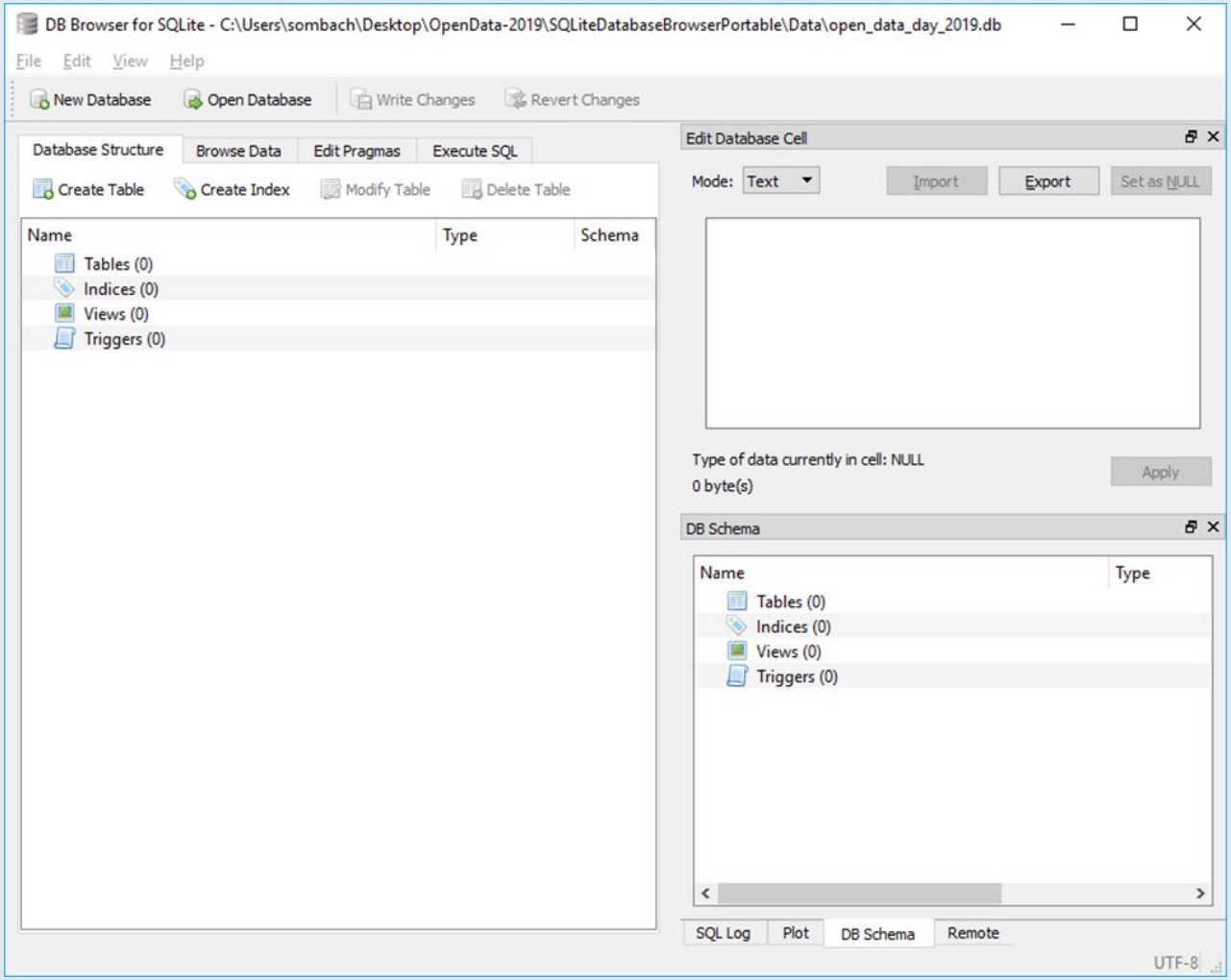
Exercise 1: Completed



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SQL

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Introducing SQL: Foundation of Data Analytics

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What is SQL?

- SQL stands for Structured Query Language
  - SQL is pronounced S-Q-L or sequel
  - SQL is a standard language for managing, manipulating and querying databases
  - Developed at IBM in the early 1970's
  - In 1986, ANSI and ISO standard groups officially adopted the standard "Database Language SQL" definition
  - Most SQL databases have their own proprietary extensions in addition to the SQL standard
- SQL is the language used to ask questions (query) of a database which will return answers (results)

Why is SQL the foundation of Data Analytics?

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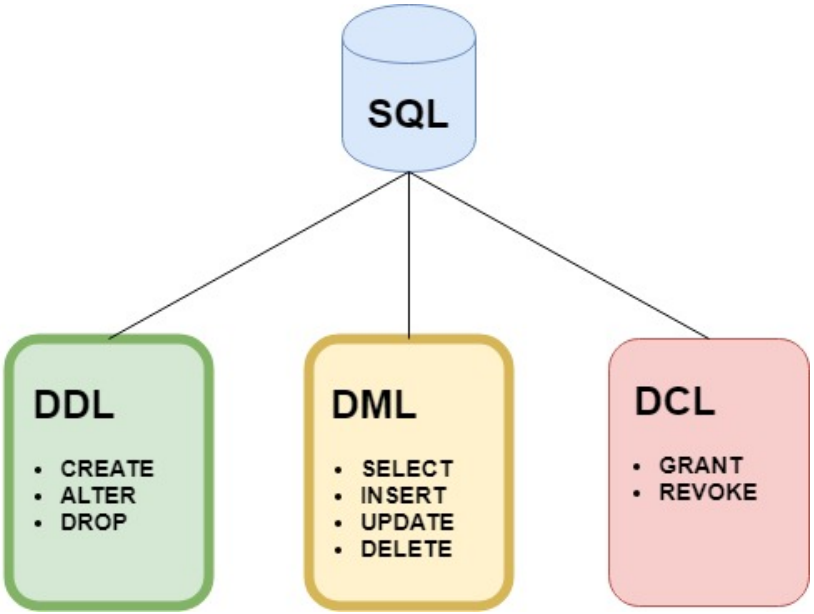
- Data engineers and database administrators will use SQL to ensure that everybody in their organization has access to the data they need
- Data scientists will use SQL to load data into their models
- Data analysts will use SQL to query tables of data and derive insights from it

Components of SQL

- SQL consists of three components which offer everything required to manage, maintain and use a database
  1. Data Definition Language
  2. Data Manipulation Language
  3. Data Control Language



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Data Definition Language (DDL)

- This component is used to define the structure (or schema) of the database
- For tables there are three main commands:

- `CREATE TABLE table_name`
  - To create a table in the database
- `ALTER TABLE table_name`
  - To add or remove columns from a table in the database
- `DROP TABLE table_name`
  - To remove a table from the database

Exercise 2: Data Definition Language

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- Select the Execute SQL tab in SQLite
- Type or copy/paste the CREATE TABLE statement into the empty SQLite Execute SQL window
- Click the **Execute SQL** ▶ button on the toolbar
- If the table is created successfully, you should receive the following message:
  - Query executed successfully: CREATE TABLE "MOSQUITO_TRAP_DATA“
- Click Write Changes to make commit the changes permanent
- View the changes in the Database Structure tab

```
CREATE TABLE "MOSQUITO_TRAP_DATA" (
  `SAMPLEID` INTEGER PRIMARY KEY AUTOINCREMENT,
  `TRAP_DATE` NUMERIC,
  `GENUS` TEXT,
  `SPECIES` TEXT,
  `TYPE` TEXT,
  `GENDER` TEXT
);
```

https://www.sqlite.org/lang_createtable.html

Exercise 2: Data Definition Language

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- Select the Execute SQL tab in SQLite
- Type or copy/paste the ALTER TABLE statements into the empty SQLite Execute SQL window
- Click the **Execute SQL** ▶ button on the toolbar
- If the table is created successfully, you should receive the following message:
  - Query executed successfully: ALTER TABLE "MOSQUITO_TRAP_DATA“
- Click **Write Changes** to make commit the changes permanent
- View the changes in the **Database Structure** tab

```
ALTER TABLE "MOSQUITO_TRAP_DATA" ADD COLUMN `RURALNORTHWEST` INTEGER;
ALTER TABLE "MOSQUITO_TRAP_DATA" ADD COLUMN `RURALNORTHEAST` INTEGER;
ALTER TABLE "MOSQUITO_TRAP_DATA" ADD COLUMN `RURALSOUTHEAST` INTEGER;
ALTER TABLE "MOSQUITO_TRAP_DATA" ADD COLUMN `RIVERVALLEYEAST` INTEGER;
ALTER TABLE "MOSQUITO_TRAP_DATA" ADD COLUMN `RIVERVALLEYWEST` INTEGER;
ALTER TABLE "MOSQUITO_TRAP_DATA" ADD COLUMN `RESIDENTIALNORTH` INTEGER;
ALTER TABLE "MOSQUITO_TRAP_DATA" ADD COLUMN `RURALSOUTHWEST` INTEGER;
ALTER TABLE "MOSQUITO_TRAP_DATA" ADD COLUMN `LAGOON` INTEGER;
ALTER TABLE "MOSQUITO_TRAP_DATA" ADD COLUMN `GOLFCOURSE` INTEGER;
ALTER TABLE "MOSQUITO_TRAP_DATA" ADD COLUMN `INDUSTRIALPARK` INTEGER;
ALTER TABLE "MOSQUITO_TRAP_DATA" ADD COLUMN `RESIDENTIALSOUTH` INTEGER;
ALTER TABLE "MOSQUITO_TRAP_DATA" ADD COLUMN `TOTAL` INTEGER;
```

https://www.sqlite.org/lang_altertable.html

Exercise 2: Data Definition Language

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- Select the Execute SQL tab in SQLite
- Type or copy/paste the DROP TABLE statement into the empty SQLite Execute SQL window
- Click the **Execute SQL** ▶ button on the toolbar
- If the table is created successfully, you should receive the following message:
  - Query executed successfully: DROP TABLE "MOSQUITO_TRAP_DATA"
- Click Write Changes to make commit the changes permanent
- View the changes in the Database Structure tab

```
DROP TABLE "MOSQUITO_TRAP_DATA";
```

https://www.sqlite.org/lang_droptable.html

Exercise 2: Data Definition Language

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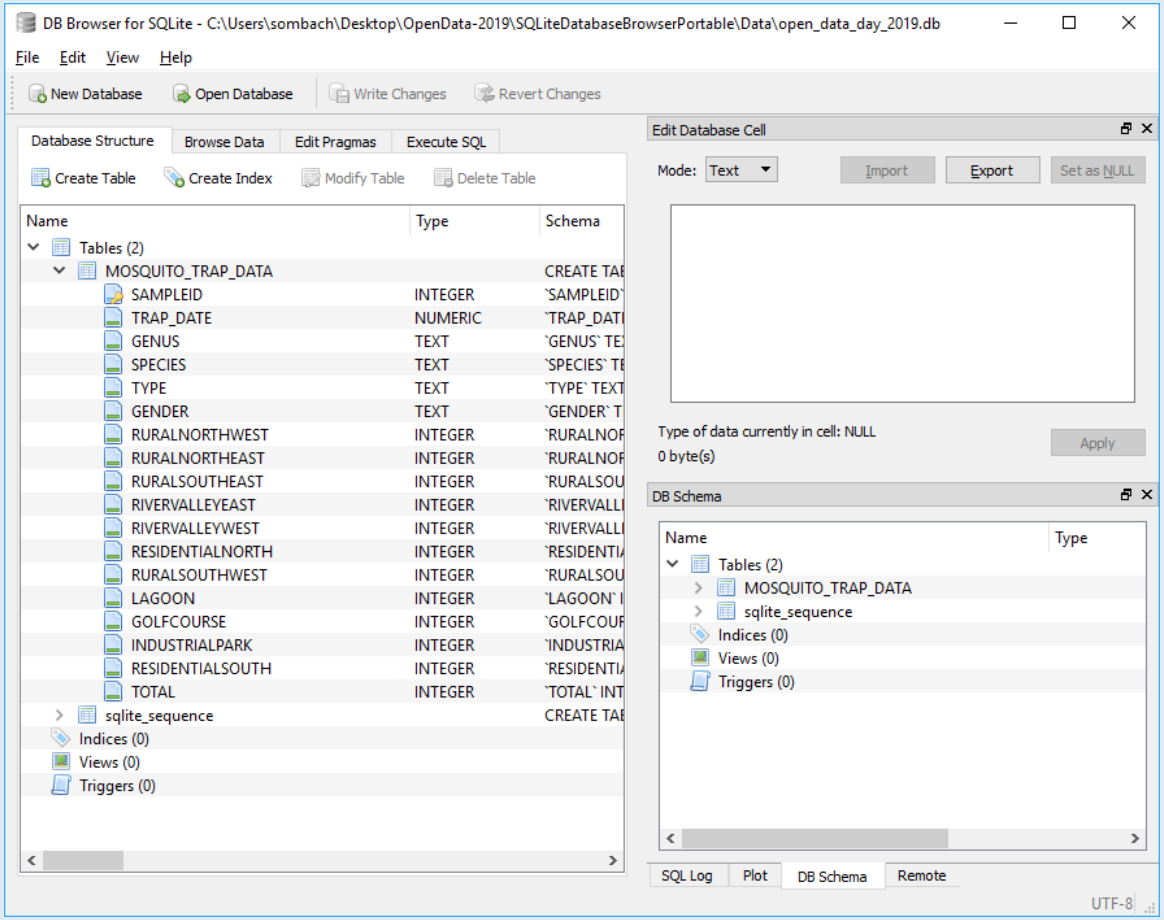
- Create the MOSQUITO_TRAP_DATA table again using the DDL on the next slide
- Click **Write Changes** to make commit the changes permanent
- View the changes in the Database Structure tab
- Done!

```
CREATE TABLE "MOSQUITO_TRAP_DATA" (
   `SAMPLEID` INTEGER PRIMARY KEY AUTOINCREMENT,
   `TRAP_DATE` NUMERIC,
   `GENUS` TEXT,
   `SPECIES` TEXT,
   `TYPE` TEXT,
   `GENDER` TEXT,
   `RURALNORTHWEST` INTEGER,
   `RURALNORTHEAST` INTEGER,
   `RURALSOUTHEAST` INTEGER,
   `RIVERVALLEYEAST` INTEGER,
   `RIVERVALLEYWEST` INTEGER,
   `RESIDENTIALNORTH` INTEGER,
   `RURALSOUTHWEST` INTEGER,
   `LAGOON` INTEGER,
   `GOLFCOURSE` INTEGER,
   `INDUSTRIALPARK` INTEGER,
   `RESIDENTIALSOUTH` INTEGER,
   `TOTAL` INTEGER
)
```

https://www.sqlite.org/lang_createtable.html

Exercise 1: Completed



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Data Manipulation Language

- This component is used to manipulate data within a table
- There are four main commands:

- SELECT
  - To select rows of data from a table
- INSERT
  - To insert rows of data into a table
- UPDATE
  - To change rows of data in a table
- DELETE
  - To remove rows of data from a table

Exercise 3: SELECT Data Manipulation Language

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- Select the Execute SQL tab in SQLite
- Type or copy/paste the SELECT statement into the empty SQLite Execute SQL window
  - SELECT COUNT(*) FROM MOSQUITO_TRAP_DATA;
- Click the **Execute SQL** ▶ button on the toolbar
- Do you get an answer? Why not?

https://www.sqlite.org/lang_select.html

Exercise 3: INSERT Data Manipulation Language

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- Add some data to the MOSQUITO_TRAP_DATA table created in Exercise 2
- Type or copy/paste the INSERT statement into the empty SQLite Execute SQL window
- Click the **Execute SQL** ▶ button on the toolbar
- Click **Write Changes** to make commit the changes permanent
- View the changes in the **Browse Data** tab
- The MOSQUITO_TRAP_DATA table now has seven rows of data

```
INSERT INTO "MOSQUITO_TRAP_DATA" (TRAP_DATE, GENUS, SPECIES, TYPE, GENDER, RURALNORTHWEST,
RURALNORTHEAST, RURALSOUTHEAST, RIVERVALLEYEAST, RIVERVALLEYWEST, RESIDENTIALNORTH,
RURALSOUTHWEST, LAGOON, GOLFCOURSE, INDUSTRIALPARK, RESIDENTIALSOUTH, TOTAL) VALUES ('2014-
07-01','Aedes','spencerii','Black legs','Female',0,0,0,0,0,1,0,0,0,1,1,3);
INSERT INTO "MOSQUITO_TRAP_DATA" (TRAP_DATE, GENUS, SPECIES, TYPE, GENDER, RURALNORTHWEST,
RURALNORTHEAST, RURALSOUTHEAST, RIVERVALLEYEAST, RIVERVALLEYWEST, RESIDENTIALNORTH,
RURALSOUTHWEST, LAGOON, GOLFCOURSE, INDUSTRIALPARK, RESIDENTIALSOUTH, TOTAL) VALUES ('2014-
07-01','Aedes','dorsalis','Banded legs','Female',0,1,0,0,0,0,2,0,0,0,0,3);
INSERT INTO "MOSQUITO_TRAP_DATA" (TRAP_DATE, GENUS, SPECIES, TYPE, GENDER, RURALNORTHWEST,
RURALNORTHEAST, RURALSOUTHEAST, RIVERVALLEYEAST, RIVERVALLEYWEST, RESIDENTIALNORTH,
RURALSOUTHWEST, LAGOON, GOLFCOURSE, INDUSTRIALPARK, RESIDENTIALSOUTH, TOTAL) VALUES ('2014-
07-01','Aedes','euedes','Banded legs','Female',1,1,0,0,2,0,0,0,0,0,0,4);
INSERT INTO "MOSQUITO_TRAP_DATA" (TRAP_DATE, GENUS, SPECIES, TYPE, GENDER, RURALNORTHWEST,
RURALNORTHEAST, RURALSOUTHEAST, RIVERVALLEYEAST, RIVERVALLEYWEST, RESIDENTIALNORTH,
RURALSOUTHWEST, LAGOON, GOLFCOURSE, INDUSTRIALPARK, RESIDENTIALSOUTH, TOTAL) VALUES ('2014-
07-01','Aedes','excrucians','Banded legs','Female',1,2,0,0,2,1,0,0,0,1,0,7);
INSERT INTO "MOSQUITO_TRAP_DATA" (TRAP_DATE, GENUS, SPECIES, TYPE, GENDER, RURALNORTHWEST,
RURALNORTHEAST, RURALSOUTHEAST, RIVERVALLEYEAST, RIVERVALLEYWEST, RESIDENTIALNORTH,
RURALSOUTHWEST, LAGOON, GOLFCOURSE, INDUSTRIALPARK, RESIDENTIALSOUTH, TOTAL) VALUES ('2014-
07-01','Aedes','fitchii','Banded legs','Female',0,2,0,0,1,0,0,0,0,0,4,7);
INSERT INTO "MOSQUITO_TRAP_DATA" (TRAP_DATE, GENUS, SPECIES, TYPE, GENDER, RURALNORTHWEST,
RURALNORTHEAST, RURALSOUTHEAST, RIVERVALLEYEAST, RIVERVALLEYWEST, RESIDENTIALNORTH,
RURALSOUTHWEST, LAGOON, GOLFCOURSE, INDUSTRIALPARK, RESIDENTIALSOUTH, TOTAL) VALUES ('2014-
07-01','Aedes','flavescens','Banded legs','Female',6,5,8,0,0,0,5,0,0,3,1,28);
INSERT INTO "MOSQUITO_TRAP_DATA" (TRAP_DATE, GENUS, SPECIES, TYPE, GENDER, RURALNORTHWEST,
RURALNORTHEAST, RURALSOUTHEAST, RIVERVALLEYEAST, RIVERVALLEYWEST, RESIDENTIALNORTH,
RURALSOUTHWEST, LAGOON, GOLFCOURSE, INDUSTRIALPARK, RESIDENTIALSOUTH, TOTAL) VALUES ('2014-
07-01','Aedes','vexans','Banded legs','Female',3,168,1,21,38,8,16,0,0,3,32,290);
```

https://www.sqlite.org/lang_insert.html

Exercise 3: SELECT Data Manipulation Language

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- Type or copy/paste the SELECT statement into the empty SQLite Execute SQL window
  - SELECT COUNT(*) FROM MOSQUITO_TRAP_DATA;
- Click the **Execute SQL** ▶ button on the toolbar
- When you execute the query, you are asking the database a question
  - Can you tell me the number of rows in the MOSQUITO_TRAP_DATA table?
- The database gives you an answer (the result) and you should have received the following message:
  - 7 rows returned in 1ms from: SELECT * FROM MOSQUITO_TRAP_DATA;

https://www.sqlite.org/lang_select.html

Exercise 3: SELECT
Data Manipulation Language

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- What if you want to see all the rows in your database?
  - SELECT * FROM MOSQUITO_TRAP_DATA;
  - Returns all columns and rows in a table
- What if you only want to see the Genus, Species and Total of each row?
  - SELECT GENUS, SPECIES, TOTAL FROM MOSQUITO_TRAP_DATA;
  - Returns only the GENUS, SPECIES, TOTAL columns for each row in a table

https://www.sqlite.org/lang_select.html

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Data Manipulation Language

- The WHERE clause
  - Uses operators to extract only those records that fulfill a specified condition
- Used to ask more complicated questions
- SQL will do exactly what you ask, not always what you expect
- "I do not think it means what you think it means"
  - *Inigo Montoya*

Operator	Description
=	Equal
<>	Not equal. **Note:** In some versions of SQL this operator may be written as !=
>	Greater than
<	Less than
>=	Greater than or equal
<=	Less than or equal
BETWEEN	Between a certain range
LIKE	Search for a pattern
IN	To specify multiple possible values for a column

https://www.sqlite.org/lang_select.html

Exercise 3: SELECT
Data Manipulation Language

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- Show the rows that have a mosquito TYPE of “Black legs”
  - SELECT * FROM MOSQUITO_TRAP_DATA WHERE TYPE = 'Black legs';

YOUR TURN

- Write and execute a DML statement to answer the question below:
  - Which mosquito species’ were caught in the traps placed in the west river valley?

https://www.sqlite.org/lang_select.html

Exercise 3: UPDATE
Data Manipulation Language

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- Select the Execute SQL tab in SQLite
- Type or copy/paste the UPDATE statement into an empty SQLite Execute SQL window
- Click the **Execute SQL** ▶ button on the toolbar
- You should receive the following message:
  - Query executed successfully: … (took 1ms, 4 rows affected)

https://www.sqlite.org/lang_update.html

```
UPDATE MOSQUITO_TRAP_DATA
SET GENDER = 'Male‘
WHERE SAMPLEID IN (1,3,5,7);
```

https://www.sqlite.org/lang_update.html

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Data Manipulation Language

- The GROUP BY clause
  - Used in collaboration with the SELECT statement to arrange identical data into groups
- The GROUP BY statement is often used with aggregate functions

Function	Description
AVG	Calculates the average of a set of values
COUNT	Counts rows in a specified table or view
MAX	Gets the minimum value in a set of values
MIN	Gets the maximum value in a set of values
SUM	Calculates the sum of values

https://www.sqlite.org/lang_aggfunc.html

Exercise 3: SELECT
Data Manipulation Language

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YOUR TURN

- Write and execute a DML statement to answer the question below:
  - How many mosquitos of each gender were caught in traps throughout the city?

https://www.sqlite.org/lang_select.html

Exercise 3: DELETE
Data Manipulation Language

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- Select the Execute SQL tab in SQLite
- Type or copy/paste the DELETE statement into an empty SQLite Execute SQL window
- Click the **Execute SQL** ▶ button on the toolbar
- You should receive the following message:
  - Query executed successfully: … (took 0ms, 4 rows affected)

https://www.sqlite.org/lang_update.html

```
DELETE FROM
MOSQUITO_TRAP_DATA WHERE
GENDER = "Male";
```

https://www.sqlite.org/lang_delete.html

Exercise 3: SELECT
Data Manipulation Language

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YOUR TURN

- Write and execute a DML statement to answer the question below:
  - At which traps were more mosquitos caught? Rural north east or rural north west?
- Done!

https://www.sqlite.org/lang_select.html

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Advanced SQL

- The MOSQUITO database only has one table
- Databases with more than one table require tables to be joined
- Foreign keys create relationships between tables and must be joined in a DML statement

- Download the LED Streetlight Conversion database called odd_streetlight.db
- Execute the query below

```
SELECT LED_STREETLIGHT.STREETLIGHT_ID, LED_STREETLIGHT.TYPE,
LOCATION.LOCATION
FROM LED_STREETLIGHT, LOCATION
WHERE LED_STREETLIGHT.STREETLIGHT_ID = LOCATION.STREETLIGHT_ID
AND LED_STREETLIGHT.STREETLIGHT_ID = 12;
```

https://www.sqlite.org/lang_select.html

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City of Edmonton Open Data Portal

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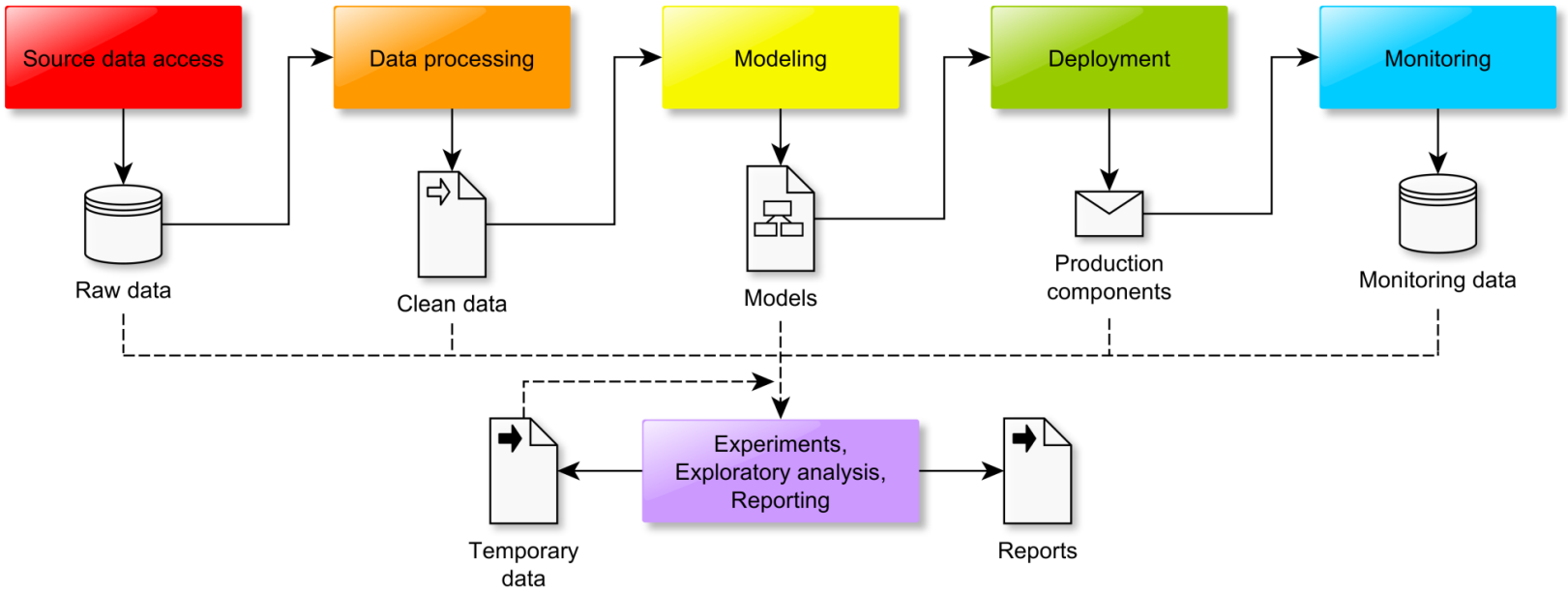
Using the Open Data Portal

- https://data.edmonton.ca/
- Data sets are usually available in comma separated value (CSV) format
- To use the dataset requires cleaning, importing, exploring and understand the data set
  - Workshop: Exploring & Cleaning Data with OpenRefine
- Requires work

Data Work Flow



http://fouryears.eu/wp-content/uploads/2018/11/pipeline.png

How I prepared the data sets for today

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- Selected data sets from the Open Data Portal
- Downloaded the CSV and surveyed in Google Sheets
- Cleaned the data set
  - E.g. reformatted dates from MMM DD YYYY to YYYY-MM-DD
- Imported into directly into SQLite tables
- Added primary keys
- Explored data set using DML

Some "Mosquitoes Trap Data" questions

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- How many mosquitos caught in 2014?

```
SELECT strftime('%Y', TRAP_DATE) as YEAR, SUM(TOTAL)
FROM MOSQUITO_TRAP_DATA
WHERE TOTAL <> ''
AND TOTAL > 0
GROUP BY YEAR;
```

- How many mosquitos of each species were caught?
- Which traps caught the most mosquitos?

https://www.sqlite.org/lang_datefunc.html

Some "LED Streetlight Conversion" questions

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- How many total streetlights?
- How many streetlights are converted to LED?
- How many streetlights were converted by year?

```
SELECT strftime('%Y', STARTDATE) as YEAR, TYPE,
COUNT(STREETLIGHT_ID)
FROM LED_STREETLIGHT
WHERE TYPE = "LED"
GROUP BY YEAR;
```

https://www.sqlite.org/lang_datefunc.html

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SQL and Climate Change

- Connecting and linking various data sets
- Builds an understanding of what that data means

- Data is a universal language, climate change is a global problem

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Next steps

- Playing with data and SQL forces you to think and understand the data (builds knowledge)
  - The relationships between data
  - The meaning of those relationships
  - The validity of the data
- SQL is iterative, often a “trial and error” process
  - Don’t be afraid to make mistakes
  - Team sport – discuss, share, question, collaborate
- Data is everywhere which raises questions of privacy, security and ethics

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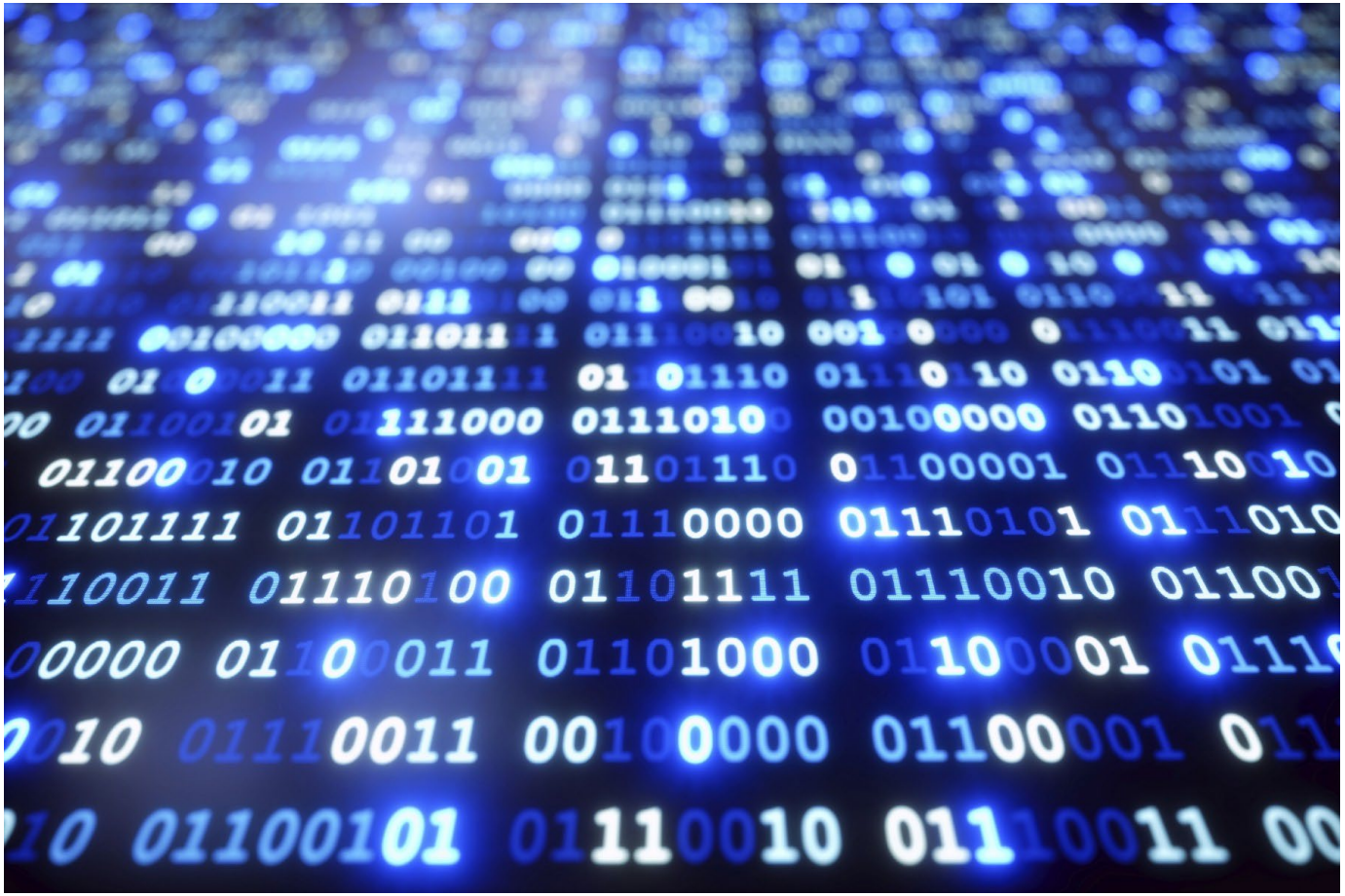
Experiment



https://www.manchester.ac.uk/discover/news/major-leap-towards-storing-data-at-the-molecular-level/

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If there's time … (I talked too fast)

- Let's (democratically):
  1. Choose a dataset not discussed during the workshops
  2. Formulate a question related to the dataset
  3. Load the data into SQLite
  4. Execute some DML to answer the question

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Thank you!

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References

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