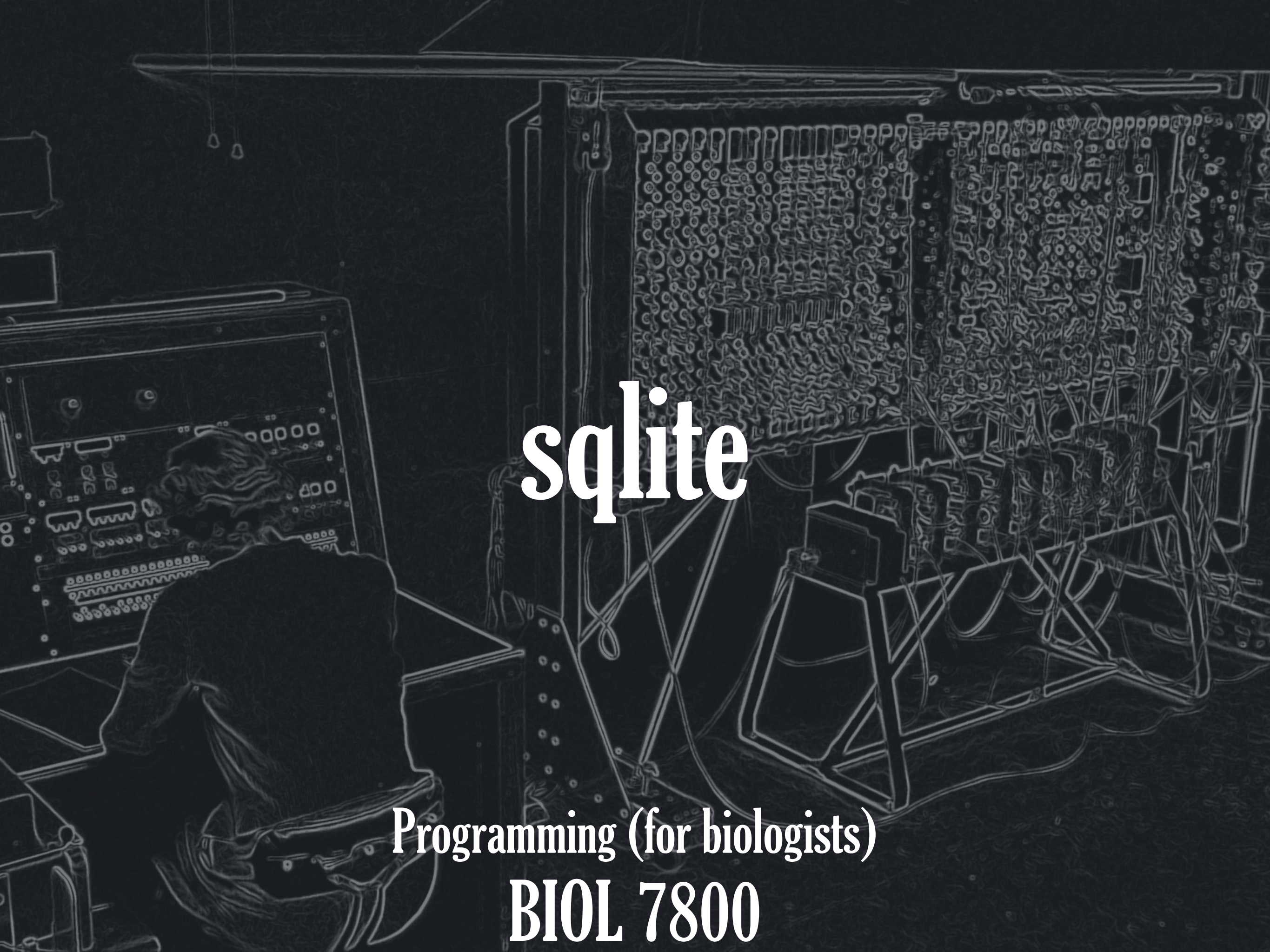




sqlite

Programming (for biologists)
BIOL 7800

tabular data

What you are probably used to...

	A	B	C	D	E	F	G	H	I	J	K	L
L1												
	class	order	family	genus	species	subspecies	common_name	female_maturity_d	litter_or_clutch_size_n	litters_or_clutches_per_y	adult_body_mass_g	max
1	Aves	Accipitriformes	Accipitridae	Accipiter	albogularis	-999	Pied Goshawk	-999	-999	-999	251.5	
2	Aves	Accipitriformes	Accipitridae	Accipiter	badius	-999	Shikra	363.468	3.25	1	140	
3	Aves	Accipitriformes	Accipitridae	Accipiter	bicolor	-999	Bicolored Hawk	-999	2.7	-999	345	
4	Aves	Accipitriformes	Accipitridae	Accipiter	brachyurus	-999	New Britain Sparrowhawk	-999	-999	-999	142	
5	Aves	Accipitriformes	Accipitridae	Accipiter	brevipes	-999	Levant Sparrowhawk	363.468	4	1	203.5	
6	Aves	Accipitriformes	Accipitridae	Accipiter	castanilius	-999	Chestnut-flanked Sparrowhawk	-999	-999	-999	159.375	
7	Aves	Accipitriformes	Accipitridae	Accipiter	chilensis	-999	Chilean Hawk	-999	2.7	-999	345	
8	Aves	Accipitriformes	Accipitridae	Accipiter	chionogaster	-999	White-breasted Hawk	547.875	4.25	1	138.5	
9	Aves	Accipitriformes	Accipitridae	Accipiter	cirrocephalus	-999	Collared Sparrowhawk	-999	3.25	-999	180	
10	Aves	Accipitriformes	Accipitridae	Accipiter	cooperii	-999	Cooper's Hawk	730	4.35	1	452	
11	Aves	Accipitriformes	Accipitridae	Accipiter	erythrauchen	-999	Rufous-necked Sparrowhawk	-999	-999	-999	156	
12	Aves	Accipitriformes	Accipitridae	Accipiter	erythroneurus	-999	Rufous-thighed Hawk	547.875	4.25	1	138.5	
13	Aves	Accipitriformes	Accipitridae	Accipiter	erythropus	-999	Red-thighed Sparrowhawk	-999	2	-999	107	
14	Aves	Accipitriformes	Accipitridae	Accipiter	fasciatus	-999	Brown Goshawk	-999	3	-999	453.5	
15	Aves	Accipitriformes	Accipitridae	Accipiter	francesiae	-999	Frances's Sparrowhawk	-999	3	-999	135.25	
16	Aves	Accipitriformes	Accipitridae	Accipiter	gentilis	-999	Northern Goshawk	636.835	3.5	1	988.75	
17	Aves	Accipitriformes	Accipitridae	Accipiter	griseiceps	-999	Sulawesi Goshawk	-999	-999	-999	255.5	
18	Aves	Accipitriformes	Accipitridae	Accipiter	gularis	-999	Japanese Sparrowhawk	-999	3.2	-999	118.75	
19	Aves	Accipitriformes	Accipitridae	Accipiter	gundlachi	-999	Gundlach's Hawk	-999	3.75	-999	675	
20	Aves	Accipitriformes	Accipitridae	Accipiter	haplochrous	-999	White-bellied Goshawk	-999	3	-999	240.5	
21	Aves	Accipitriformes	Accipitridae	Accipiter	henstii	-999	Henst's Goshawk	-999	2	-999	1050	
22	Aves	Accipitriformes	Accipitridae	Accipiter	hiogaster	-999	Variable Goshawk	-999	2.725	-999	342.75	
23	Aves	Accipitriformes	Accipitridae	Accipiter	imitator	-999	Imitator Goshawk	-999	-999	-999	237.75	
24	Aves	Accipitriformes	Accipitridae	Accipiter	luteoschistaceus	-999	Slaty-mantled Goshawk	-999	-999	-999	213.75	
25	Aves	Accipitriformes	Accipitridae	Accipiter	madagascariensis	-999	Madagascan Sparrowhawk	-999	3	-999	182	
26	Aves	Accipitriformes	Accipitridae	Accipiter	melanochlamys	-999	Black-mantled Goshawk	-999	-999	-999	269	
27	Aves	Accipitriformes	Accipitridae	Accipiter	melanoleucus	-999	Black Sparrowhawk	1090.404	2.8	1	701.8833333	
28	Aves	Accipitriformes	Accipitridae	Accipiter	meyerianus	-999	Meyer's Goshawk	-999	3	-999	815	
29	Aves	Accipitriformes	Accipitridae	Accipiter	minullus	-999	Little Sparrowhawk	363.468	2	-999	84.05	

tabular data

Or, maybe this...

Amniote_Database_Aug_2015.csv																														
Amniote_Database_Aug_2015.csv																														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20											
class,order,family,genus,species,subspecies,common_name,female_maturity_d,litter_or_clutch_size_n,litters_or_clutches_per_y,adult_body_mass_g,maximum_longevity_y,mean_body_mass_g,mean_longevity_y,mean_litter_size_n,mean_litters_per_y,mean_adult_body_mass_g,mean_maximum_longevity_y,mean_mean_body_mass_g,mean_mean_longevity_y	Aves,Accipitriformes,Accipitridae,Accipiter,albogularis,-999,Pied Goshawk,-999,-999,-999,251.5,-999,-999,-999,-999,-999,-999,-999,-999,-999,352.5,223,-999	Aves,Accipitriformes,Accipitridae,Accipiter,badius,-999,Shikra,363.468,3.25,1,140,-999,-999,-999,-999,-999,21,30,32,-999,-999,-999,168.5,125,123,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,bicolor,-999,Bicolored Hawk,-999,2.7,-999,345,-999,-999,-999,-999,-999,32,-999,-999,-999,-999,390,212,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,brachyurus,-999,New Britain Sparrowhawk,-999,-999,-999,142,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,brevipes,-999,Levant Sparrowhawk,363.468,4,1,203.5,-999,-999,-999,-999,-999,21.85,32.5,42.5,-999,-999,-999,230.5,170,-999	Aves,Accipitriformes,Accipitridae,Accipiter,castanilius,-999,Chestnut-flanked Sparrowhawk,-999,-999,-999,159.375,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,chilensis,-999,Chilean Hawk,-999,2.7,-999,345,-999,-999,-999,-999,-999,32,-999,-999,-999,-999,377,212,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,chionogaster,-999,White-breasted Hawk,547.875,4.25,1,138.5,19.9,-999,-999,-999,-999,19.3,33,24.25,12.58333333,365,-999	Aves,Accipitriformes,Accipitridae,Accipiter,cirrocephalus,-999,Collared Sparrowhawk,-999,3.25,-999,180,-999,-999,-999,-999,-999,20.75,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,cooperii,-999,Cooper's Hawk,730,4.35,1,452,20.33333333,-999,-999,28,-999,40,29.75,32,12,730,-999,529,338.5,452,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,erythrauchen,-999,Rufous-necked Sparrowhawk,-999,-999,-999,156,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,erythronemius,-999,Rufous-thighed Hawk,547.875,4.25,1,138.5,19.9,-999,-999,-999,-999,19.3,33,24.25,12.58333333,365,-999	Aves,Accipitriformes,Accipitridae,Accipiter,erythropus,-999,Red-thighed Sparrowhawk,-999,2,-999,107,-999,-999,-999,-999,-999,20.5,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,fasciatus,-999,Brown Goshawk,-999,3,-999,453.5,-999,-999,-999,-999,-999,31,30,30,-999,-999,-999,499.375,303.25,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,francesiae,-999,Frances's Sparrowhawk,-999,3,-999,135.25,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,gentilis,-999,Northern Goshawk,636.835,3.5,1,988.75,22,-999,-999,37,-999,58,34.75,41.65,17.70833333,730,-999,1117.33	Aves,Accipitriformes,Accipitridae,Accipiter,griseiceps,-999,Sulawesi Goshawk,-999,-999,-999,255.5,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,gularis,-999,Japanese Sparrowhawk,-999,3.2,-999,118.75,-999,-999,-999,-999,-999,18,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,gundlachi,-999,Gundlach's Hawk,-999,3.75,-999,675,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,haplochrous,-999,White-bellied Goshawk,-999,3,-999,240.5,-999,-999,-999,-999,-999,25.5,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,henstii,-999,Henst's Goshawk,-999,2,-999,1050,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,hiogaster,-999,Variable Goshawk,-999,2.725,-999,342.75,-999,-999,-999,-999,-999,40.5,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,imitator,-999,Imitator Goshawk,-999,-999,-999,237.75,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,luteoschistaceus,-999,Slaty-mantled Goshawk,-999,-999,-999,213.75,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,madagascariensis,-999,Madagascan Sparrowhawk,-999,3,-999,182,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,melanochlamys,-999,Black-mantled Goshawk,-999,-999,-999,269,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,melanoleucus,-999,Black Sparrowhawk,1090.404,2.8,1,701.8833333,10,-999,-999,-999,-999,50.75,37.5,40,7.5,-999,-999,86	Aves,Accipitriformes,Accipitridae,Accipiter,meyerianus,-999,Meyer's Goshawk,-999,3,-999,815,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999,-999	Aves,Accipitriformes,Accipitridae,Accipiter,minullus,-999,Little Sparrowhawk,363.468,2,-999,84.05,-999,-999,-999,-999,-999,17.95,31.5,25.5,-999,-999,-999,97.25,-999	Aves,Accipitriformes,Accipitridae,Accipiter,frontalis,-999,Frontal Goshawk,363.468,2,-999,84.05,-999,-999,-999,-999,-999,17.95,31.5,25.5,-999,-999,-999,97.25,-999

458738 Words, Page 1/1530, Line 1, Column 1

120717 misspelled words Spaces: 4 Plain Text

We've talked about manipulating these data with

pandas

```
In: amniote = pd.read_csv('Amniote_Database_Aug_2015.csv')
```

```
In: amniote.info()
```

Out:

```
<class 'pandas.core.frame.DataFrame'>
```

```
Int64Index: 21322 entries, 0 to 21321
```

```
Data columns (total 36 columns):
```

class	21322	non-null	object
order	21322	non-null	object
family	21322	non-null	object
genus	21322	non-null	object
species	21322	non-null	object
subspecies	21322	non-null	int64
common_name	21322	non-null	object
female_maturity_d	21322	non-null	float64
(...truncated...)			
egg_width_mm	21322	non-null	float64
egg_length_mm	21322	non-null	float64
fledging_mass_g	21322	non-null	float64
adult_svl_cm	21322	non-null	float64
male_svl_cm	21322	non-null	float64
female_svl_cm	21322	non-null	float64
birth_or_hatching_svl_cm	21322	non-null	float64
female_svl_at_maturity_cm	21322	non-null	float64
female_body_mass_at_maturity_g	21322	non-null	int64
no_sex_svl_cm	21322	non-null	float64
no_sex_maturity_d	21322	non-null	float64

```
dtypes: float64(28), int64(2), object(6)
```

```
memory usage: 6.0+ MB
```

But there's another way...

And, that's by using a **database**

What is a **database**?

A collection of data organized
according to some scheme
(databases, tables, etc.)

Many databases are "**relational**". What's a **relational database**?

A collection of data organized to
recognize the **relationships** among
the data

Relational database

The screenshot shows an Excel spreadsheet with the following data:

	A	B	C	D	E	F	G	H	I	J	K	L
1	class	order	family	genus	species	subspecies	common_name	female_maturity_d	litter_or_clutch_size_n	litters_or_clutches_per_y	adult_body_mass_g	max
2	Aves	Accipitriformes	Accipitridae	Accipiter	albogularis	-999	Pied Goshawk	-999	-999	-999	251.5	
3	Aves	Accipitriformes	Accipitridae	Accipiter	badius	-999	Shikra	363.468	3.25	1	140	
4	Aves	Accipitriformes	Accipitridae	Accipiter	bicolor	-999	Bicolored Hawk	-999	2.7	-999	345	
5	Aves	Accipitriformes	Accipitridae	Accipiter	brachyurus	-999	New Britain Sparrowhawk	-999	-999	-999	142	
6	Aves	Accipitriformes	Accipitridae	Accipiter	brevipes	-999	Levant Sparrowhawk	363.468	4	1	203.5	
7	Aves	Accipitriformes	Accipitridae	Accipiter	castanilius	-999	Chestnut-flanked Sparrowhawk	-999	-999	-999	159.375	
8	Aves	Accipitriformes	Accipitridae	Accipiter	chilensis	-999	Chilean Hawk	-999	2.7	-999	345	

class (table)

index	class
1	Aves
2	Reptilia
3	Mammalia

order (table)

index	order
1	Accipitriformes
2	Anseriformes
3	Apodiformes

family (table)

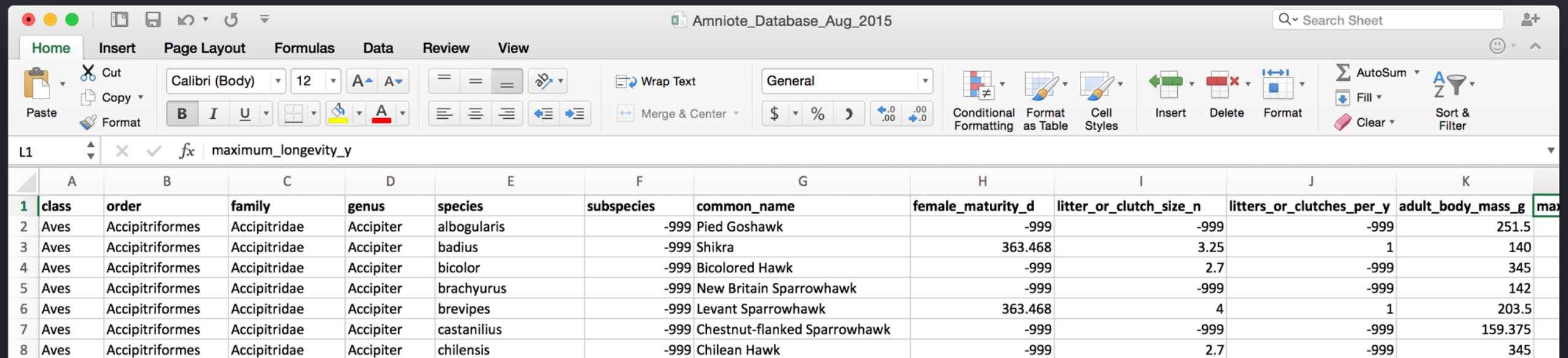
index	family
1	Accipitridae
2	Cathartidae
3	Pandionidae

species (table)

index	class	order	family	genus	species	common
1	class.1	order.1	family.1	Accipiter	albogularis	Pied Goshawk
2	class.1	order.1	family.1	Accipiter	badius	Shikra
3	class.1	order.1	family.1	Accipiter	bicolor	Bicolored Hawk

Relational databases

Unlike a spreadsheet, **relational databases** give you more control over column contents



	A	B	C	D	E	F	G	H	I	J	K	L
1	class	order	family	genus	species	subspecies	common_name	female_maturity_d	litter_or_clutch_size_n	litters_or_clutches_per_y	adult_body_mass_g	maximum_longevity_y
2	Aves	Accipitriformes	Accipitridae	Accipiter	albogularis	-999	Pied Goshawk	-999	-999	-999	251.5	
3	Aves	Accipitriformes	Accipitridae	Accipiter	badius	-999	Shikra	363.468	3.25	1	140	
4	Aves	Accipitriformes	Accipitridae	Accipiter	bicolor	-999	Bicolored Hawk	-999	2.7	-999	345	
5	Aves	Accipitriformes	Accipitridae	Accipiter	brachyurus	-999	New Britain Sparrowhawk	-999	-999	-999	142	
6	Aves	Accipitriformes	Accipitridae	Accipiter	brevipes	-999	Levant Sparrowhawk	363.468	4	1	203.5	
7	Aves	Accipitriformes	Accipitridae	Accipiter	castanilius	-999	Chestnut-flanked Sparrowhawk	-999	-999	-999	159.375	
8	Aves	Accipitriformes	Accipitridae	Accipiter	chilensis	-999	Chilean Hawk	-999	2.7	-999	345	

Can limit
to only
valid
classes

Can limit
to only
valid
families

Can limit
to only
valid
orders

In respective tables

Can limit
to valid
values
(int)

Can limit
to valid
values
(float)

Can limit to boolean (**true** or **false**)

Can limit to **category** ('big', 'medium', 'small')

Can limit to **date range** (> 01 Dec 2015)

etc.

Relational databases

come in many **flavors**

mysql

client/server

fast + powerful

hard to install

postgresql

client/server

fast + powerful

hard to install

sqlite

"single" file

fast + powerful

easy to install

Relational databases

are meant to handle and organize **LOTS** of data

mysql

5×10^9

4096 columns

256 TB
("max" db size)

4 TB
(max table size)

66 KB
(max row size)

postgresql

unlimited rows

250-1600 columns

unlimited
("max" db size)

32 terabytes
(max table size)

1.6 terabytes
(max row size)

sqlite

2^{64} rows

32767 columns

140 terabytes
("max" db size)

Relational databases

are generally "controlled" by (1) internal server commands and (2) SQL

Structured Query Language (SQL)

Get all rows

```
SELECT * FROM order
```

order (table)

index	order
1	Accipitriformes
2	Anseriformes
3	Apodiformes

Get rows where index = 1

```
SELECT * FROM order WHERE index=1
```

Get count of all rows

```
SELECT COUNT(*) FROM order
```

Insert a new row

```
INSERT INTO order (index, order) VALUES (4, Galliformes)
```

Why am I telling you this?

```
In: amniote = pd.read_csv('Amniote_Database_Aug_2015.csv')
```

```
In: amniote.info()
```

```
Out:
```

```
<class 'pandas.core.frame.DataFrame'>
```

```
Int64Index: 21322 entries, 0 to 21321
```

```
Data columns (total 30 columns):
```

class	21322	non-null	object
order	21322	non-null	object
family	21322	non-null	object
genus	21322	non-null	object
species	21322	non-null	object
subspecies	21322	non-null	int64
common_name	21322	non-null	object
female_maturity_d	21322	non-null	float64
(...truncated...)			
egg_width_mm	21322	non-null	float64
egg_length_mm	21322	non-null	float64
fledging_mass_g	21322	non-null	float64
adult_svl_cm	21322	non-null	float64
male_svl_cm	21322	non-null	float64
female_svl_cm	21322	non-null	float64
birth_or_hatching_svl_cm	21322	non-null	float64
female_svl_at_maturity_cm	21322	non-null	float64
female_body_mass_at_maturity_g	21322	non-null	int64
no_sex_svl_cm	21322	non-null	float64
no_sex_maturity_d	21322	non-null	float64

```
dtypes: float64(28), int64(2), object(6)
```

```
memory usage: 6.0+ MB
```

There may come a time
when you can't
(or don't want to)
use

pandas

Why am I telling you this?

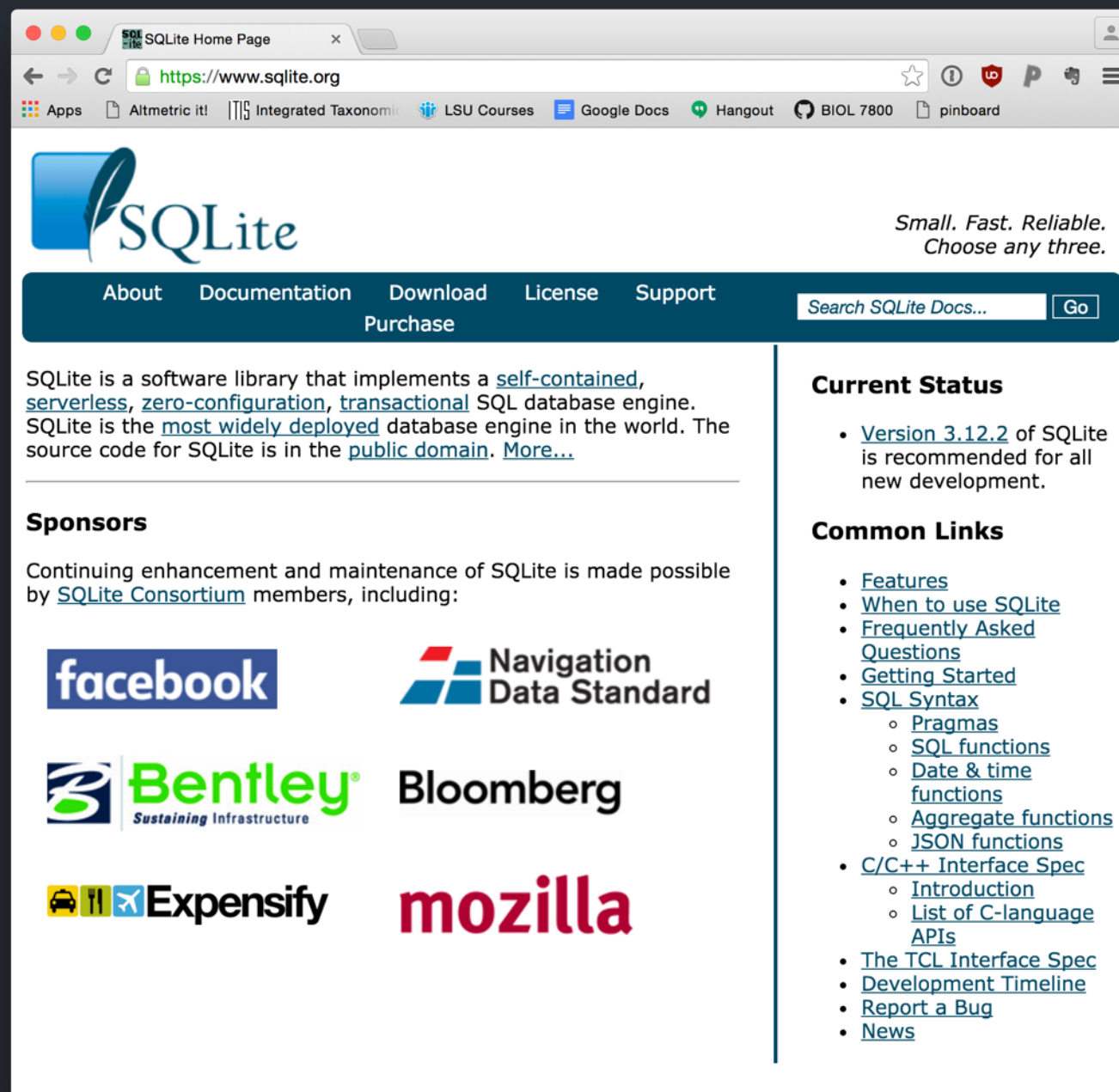
And, Python has built-in support for `sqlite`
the "little database that can" (do pretty much everything)

`sqlite`

2^{64} rows

32767 columns

140 terabytes
("max" db size)



The screenshot shows the SQLite Home Page in a web browser. The browser's address bar displays `https://www.sqlite.org`. The page features the SQLite logo, a navigation bar with links for About, Documentation, Download, License, Support, and Purchase, and a search bar. The main content area describes SQLite as a self-contained, serverless, zero-configuration, transactional SQL database engine. It also lists sponsors such as Facebook, Navigation Data Standard, Bentley, Bloomberg, Expensify, and Mozilla. On the right side, there are sections for Current Status (Version 3.12.2) and Common Links (Features, When to use SQLite, Frequently Asked Questions, Getting Started, SQL Syntax, C/C++ Interface Spec, The TCL Interface Spec, Development Timeline, Report a Bug, and News).

SQLite Home Page

<https://www.sqlite.org>

Apps | Altmetric it! | TIS Integrated Taxonomic | LSU Courses | Google Docs | Hangout | BIOL 7800 | pinboard

SQLite

Small. Fast. Reliable.
Choose any three.

About | Documentation | Download | License | Support | Purchase

Search SQLite Docs...

SQLite is a software library that implements a [self-contained](#), [serverless](#), [zero-configuration](#), [transactional](#) SQL database engine. SQLite is the [most widely deployed](#) database engine in the world. The source code for SQLite is in the [public domain](#). [More...](#)

Sponsors

Continuing enhancement and maintenance of SQLite is made possible by [SQLite Consortium](#) members, including:

facebook | **Navigation Data Standard**

Bentley | **Bloomberg**

Expensify | **mozilla**

Current Status

- [Version 3.12.2](#) of SQLite is recommended for all new development.

Common Links

- [Features](#)
- [When to use SQLite](#)
- [Frequently Asked Questions](#)
- [Getting Started](#)
- [SQL Syntax](#)
 - [Pragmas](#)
 - [SQL functions](#)
 - [Date & time functions](#)
 - [Aggregate functions](#)
 - [JSON functions](#)
- [C/C++ Interface Spec](#)
 - [Introduction](#)
 - [List of C-language APIs](#)
- [The TCL Interface Spec](#)
- [Development Timeline](#)
- [Report a Bug](#)
- [News](#)

sqlite

Example

	A	B	C	D	E	F	G	H
1	class	order	family	genus	species	common_name	female_maturity_d	litter_or_clutch_size_n
2	Aves	Accipitriformes	Accipitridae	Accipiter	albogularis	Pied Goshawk	-999	-999
3	Aves	Accipitriformes	Accipitridae	Accipiter	badius	Shikra	363.468	3.25
4	Aves	Accipitriformes	Accipitridae	Accipiter	bicolor	Bicolored Hawk	-999	2.7
5	Aves	Accipitriformes	Accipitridae	Accipiter	brachyurus	New Britain Sparrowhawk	-999	-999
6	Aves	Accipitriformes	Accipitridae	Accipiter	brevipes	Levant Sparrowhawk	363.468	4
7	Aves	Accipitriformes	Accipitridae	Accipiter	castanilius	Chestnut-flanked Sparrowhawk	-999	-999
8	Aves	Accipitriformes	Accipitridae	Accipiter	chilensis	Chilean Hawk	-999	2.7
9	Aves	Accipitriformes	Accipitridae	Accipiter	chionogaster	White-breasted Hawk	547.875	4.25
10	Aves	Accipitriformes	Accipitridae	Accipiter	cirrocephalus	Collared Sparrowhawk	-999	3.25
11	Aves	Accipitriformes	Accipitridae	Accipiter	cooperii	Cooper's Hawk	730	4.35
12	Aves	Accipitriformes	Accipitridae	Accipiter	erythrauchen	Rufous-necked Sparrowhawk	-999	-999
13	Aves	Accipitriformes	Accipitridae	Accipiter	erythronemius	Rufous-thighed Hawk	547.875	4.25
14	Aves	Accipitriformes	Accipitridae	Accipiter	erythropus	Red-thighed Sparrowhawk	-999	2
15	Aves	Accipitriformes	Accipitridae	Accipiter	fasciatus	Brown Goshawk	-999	3
16	Aves	Accipitriformes	Accipitridae	Accipiter	francesiae	Frances's Sparrowhawk	-999	3
17	Aves	Accipitriformes	Accipitridae	Accipiter	gentilis	Northern Goshawk	636.835	3.5
18	Aves	Accipitriformes	Accipitridae	Accipiter	griseiceps	Sulawesi Goshawk	-999	-999
19	Aves	Accipitriformes	Accipitridae	Accipiter	gularis	Japanese Sparrowhawk	-999	3.2
20	Aves	Accipitriformes	Accipitridae	Accipiter	gundlachi	Gundlach's Hawk	-999	3.75
21	Aves	Accipitriformes	Accipitridae	Accipiter	haplochrous	White-bellied Goshawk	-999	3
22	Aves	Accipitriformes	Accipitridae	Accipiter	henstii	Henst's Goshawk	-999	2
23	Aves	Accipitriformes	Accipitridae	Accipiter	hiogaster	Variable Goshawk	-999	2.725
24	Aves	Accipitriformes	Accipitridae	Accipiter	imitator	Imitator Goshawk	-999	-999
25	Aves	Accipitriformes	Accipitridae	Accipiter	luteoschistaceus	Slaty-mantled Goshawk	-999	-999
26	Aves	Accipitriformes	Accipitridae	Accipiter	madagascariensis	Madagascan Sparrowhawk	-999	3
27	Aves	Accipitriformes	Accipitridae	Accipiter	melanochlamys	Black-mantled Goshawk	-999	-999
28	Aves	Accipitriformes	Accipitridae	Accipiter	melanoleucus	Black Sparrowhawk	1090.404	2.8

Truncated amniote.csv

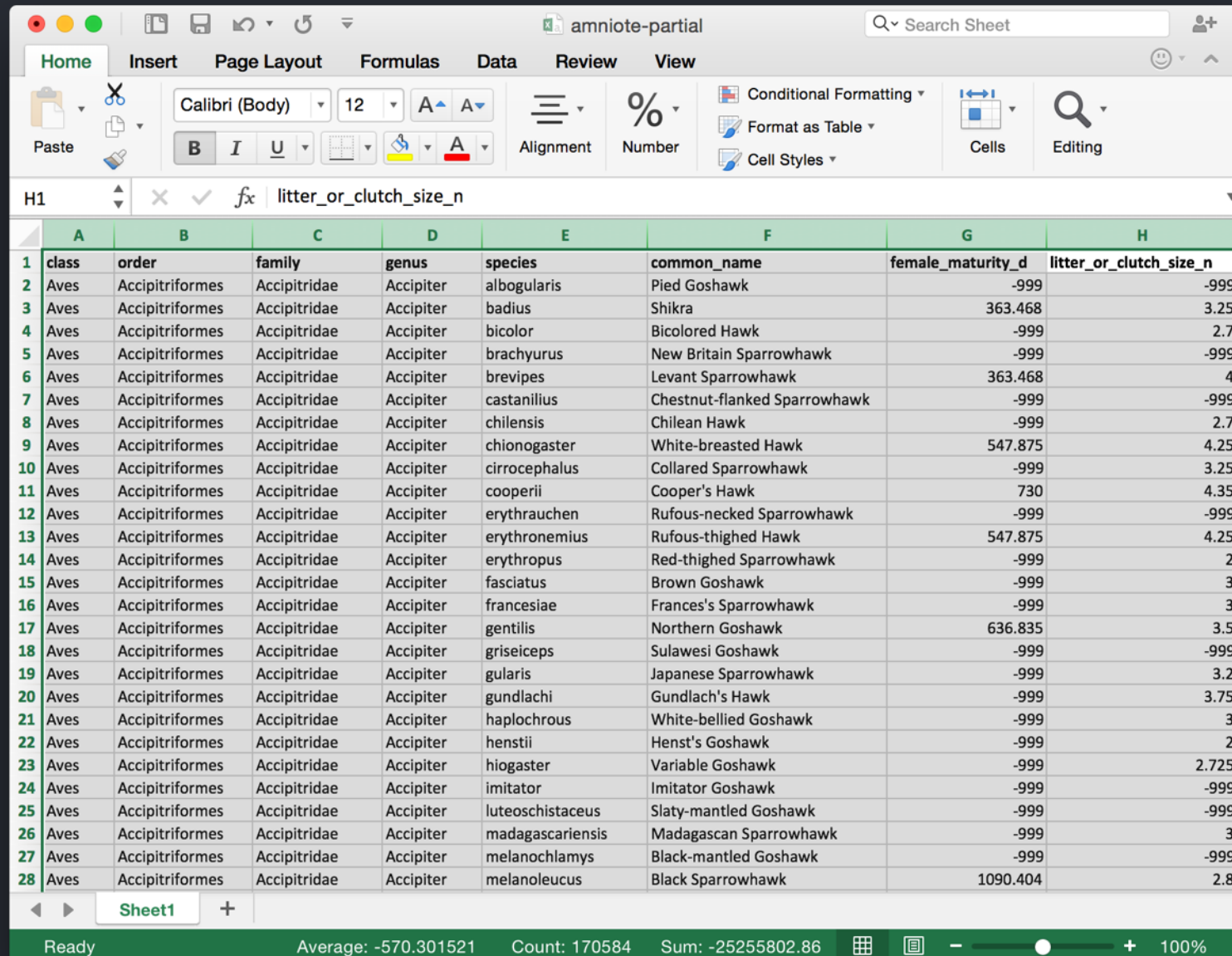
8 columns

21323 rows

<http://biolprogramming.s3.amazonaws.com/amniote-partial.csv.zip>

sqlite

Example



	A	B	C	D	E	F	G	H
1	class	order	family	genus	species	common_name	female_maturity_d	litter_or_clutch_size_n
2	Aves	Accipitriformes	Accipitridae	Accipiter	albogularis	Pied Goshawk	-999	-999
3	Aves	Accipitriformes	Accipitridae	Accipiter	badius	Shikra	363.468	3.25
4	Aves	Accipitriformes	Accipitridae	Accipiter	bicolor	Bicolored Hawk	-999	2.7
5	Aves	Accipitriformes	Accipitridae	Accipiter	brachyurus	New Britain Sparrowhawk	-999	-999
6	Aves	Accipitriformes	Accipitridae	Accipiter	brevipes	Levant Sparrowhawk	363.468	4
7	Aves	Accipitriformes	Accipitridae	Accipiter	castanilius	Chestnut-flanked Sparrowhawk	-999	-999
8	Aves	Accipitriformes	Accipitridae	Accipiter	chilensis	Chilean Hawk	-999	2.7
9	Aves	Accipitriformes	Accipitridae	Accipiter	chionogaster	White-breasted Hawk	547.875	4.25
10	Aves	Accipitriformes	Accipitridae	Accipiter	cirrocephalus	Collared Sparrowhawk	-999	3.25
11	Aves	Accipitriformes	Accipitridae	Accipiter	cooperii	Cooper's Hawk	730	4.35
12	Aves	Accipitriformes	Accipitridae	Accipiter	erythrauchen	Rufous-necked Sparrowhawk	-999	-999
13	Aves	Accipitriformes	Accipitridae	Accipiter	erythronemius	Rufous-thighed Hawk	547.875	4.25
14	Aves	Accipitriformes	Accipitridae	Accipiter	erythropus	Red-thighed Sparrowhawk	-999	2
15	Aves	Accipitriformes	Accipitridae	Accipiter	fasciatus	Brown Goshawk	-999	3
16	Aves	Accipitriformes	Accipitridae	Accipiter	francesiae	Frances's Sparrowhawk	-999	3
17	Aves	Accipitriformes	Accipitridae	Accipiter	gentilis	Northern Goshawk	636.835	3.5
18	Aves	Accipitriformes	Accipitridae	Accipiter	griseiceps	Sulawesi Goshawk	-999	-999
19	Aves	Accipitriformes	Accipitridae	Accipiter	gularis	Japanese Sparrowhawk	-999	3.2
20	Aves	Accipitriformes	Accipitridae	Accipiter	gundlachi	Gundlach's Hawk	-999	3.75
21	Aves	Accipitriformes	Accipitridae	Accipiter	haplochrous	White-bellied Goshawk	-999	3
22	Aves	Accipitriformes	Accipitridae	Accipiter	henstii	Henst's Goshawk	-999	2
23	Aves	Accipitriformes	Accipitridae	Accipiter	hiogaster	Variable Goshawk	-999	2.725
24	Aves	Accipitriformes	Accipitridae	Accipiter	imitator	Imitator Goshawk	-999	-999
25	Aves	Accipitriformes	Accipitridae	Accipiter	luteoschistaceus	Slaty-mantled Goshawk	-999	-999
26	Aves	Accipitriformes	Accipitridae	Accipiter	madagascariensis	Madagascan Sparrowhawk	-999	3
27	Aves	Accipitriformes	Accipitridae	Accipiter	melanochlamys	Black-mantled Goshawk	-999	-999
28	Aves	Accipitriformes	Accipitridae	Accipiter	melanoleucus	Black Sparrowhawk	1090.404	2.8

Truncated amniote.csv

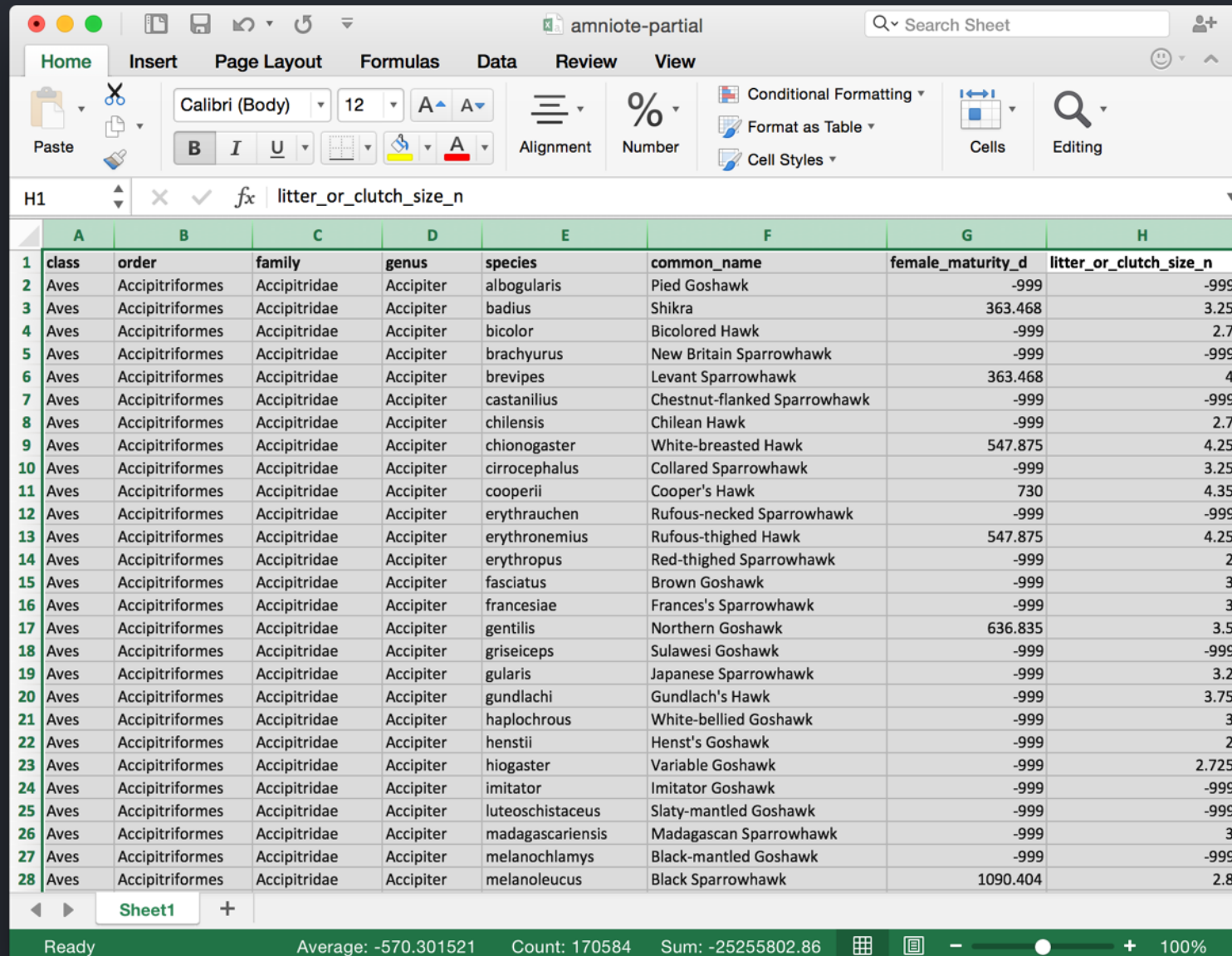
8 columns

21323 rows

Removed header row

sqlite

Example



	A	B	C	D	E	F	G	H
1	class	order	family	genus	species	common_name	female_maturity_d	litter_or_clutch_size_n
2	Aves	Accipitriformes	Accipitridae	Accipiter	albogularis	Pied Goshawk	-999	-999
3	Aves	Accipitriformes	Accipitridae	Accipiter	badius	Shikra	363.468	3.25
4	Aves	Accipitriformes	Accipitridae	Accipiter	bicolor	Bicolored Hawk	-999	2.7
5	Aves	Accipitriformes	Accipitridae	Accipiter	brachyurus	New Britain Sparrowhawk	-999	-999
6	Aves	Accipitriformes	Accipitridae	Accipiter	brevipes	Levant Sparrowhawk	363.468	4
7	Aves	Accipitriformes	Accipitridae	Accipiter	castanilius	Chestnut-flanked Sparrowhawk	-999	-999
8	Aves	Accipitriformes	Accipitridae	Accipiter	chilensis	Chilean Hawk	-999	2.7
9	Aves	Accipitriformes	Accipitridae	Accipiter	chionogaster	White-breasted Hawk	547.875	4.25
10	Aves	Accipitriformes	Accipitridae	Accipiter	cirrocephalus	Collared Sparrowhawk	-999	3.25
11	Aves	Accipitriformes	Accipitridae	Accipiter	cooperii	Cooper's Hawk	730	4.35
12	Aves	Accipitriformes	Accipitridae	Accipiter	erythrauchen	Rufous-necked Sparrowhawk	-999	-999
13	Aves	Accipitriformes	Accipitridae	Accipiter	erythronemius	Rufous-thighed Hawk	547.875	4.25
14	Aves	Accipitriformes	Accipitridae	Accipiter	erythropus	Red-thighed Sparrowhawk	-999	2
15	Aves	Accipitriformes	Accipitridae	Accipiter	fasciatus	Brown Goshawk	-999	3
16	Aves	Accipitriformes	Accipitridae	Accipiter	francesiae	Frances's Sparrowhawk	-999	3
17	Aves	Accipitriformes	Accipitridae	Accipiter	gentilis	Northern Goshawk	636.835	3.5
18	Aves	Accipitriformes	Accipitridae	Accipiter	griseiceps	Sulawesi Goshawk	-999	-999
19	Aves	Accipitriformes	Accipitridae	Accipiter	gularis	Japanese Sparrowhawk	-999	3.2
20	Aves	Accipitriformes	Accipitridae	Accipiter	gundlachi	Gundlach's Hawk	-999	3.75
21	Aves	Accipitriformes	Accipitridae	Accipiter	haplochrous	White-bellied Goshawk	-999	3
22	Aves	Accipitriformes	Accipitridae	Accipiter	henstii	Henst's Goshawk	-999	2
23	Aves	Accipitriformes	Accipitridae	Accipiter	hiogaster	Variable Goshawk	-999	2.725
24	Aves	Accipitriformes	Accipitridae	Accipiter	imitator	Imitator Goshawk	-999	-999
25	Aves	Accipitriformes	Accipitridae	Accipiter	luteoschistaceus	Slaty-mantled Goshawk	-999	-999
26	Aves	Accipitriformes	Accipitridae	Accipiter	madagascariensis	Madagascan Sparrowhawk	-999	3
27	Aves	Accipitriformes	Accipitridae	Accipiter	melanochlamys	Black-mantled Goshawk	-999	-999
28	Aves	Accipitriformes	Accipitridae	Accipiter	melanoleucus	Black Sparrowhawk	1090.404	2.8

Truncated amniote.csv

8 columns

21323 rows

Removed header row

sqlite

Example (SQL commands end in semicolon)

```
$ sqlite amniote.sqlite
```

← start **sqlite** and create db **amniote.sqlite**

```
SQLite version 3.9.2 2015-11-02 18:31:45
```

```
Enter ".help" for usage hints.
```

CREATE a table using **SQL** language

```
sqlite> create table amniote (class text, ord text, family text, genus text, species text, common_name text, female_maturity_d float, litter_or_clutch_size float);
```



```
sqlite> .mode csv
```

Use internal **sqlite** command to set data mode

```
sqlite> .import amniote-partial.csv amniote
```

Import our **CSV** data to our amniote table

```
sqlite> .mode column
```

Use internal **sqlite** command to set data mode

```
sqlite> select * from amniote limit 3;
```

Query the data using SQL statement

Aves	Accipitriformes	Accipitridae	Accipiter	albogularis	Pied Goshawk	-999	-999
Aves	Accipitriformes	Accipitridae	Accipiter	badius	Shikra	363.468	3.25
Aves	Accipitriformes	Accipitridae	Accipiter	bicolor	Bicolored Ha	-999	2.7

sqlite

Example

```
sqlite> .mode column
```

← start **sqlite** and create db **amniote.sqlite**

```
sqlite> select * from amniote limit 3;
```

Aves	Accipitriformes	Accipitridae	Accipiter	albogularis	Pied Goshawk	-999	-999
Aves	Accipitriformes	Accipitridae	Accipiter	badius	Shikra	363.468	3.25
Aves	Accipitriformes	Accipitridae	Accipiter	bicolor	Bicolored Ha	-999	2.7

Where are the headers?

```
sqlite> .headers on
```

Use internal **sqlite** command to turn on headers

```
sqlite> select * from amniote limit 3;
```

class	ord	family	genus	species	common_name	female_maturity_d	litter_or_clutch_size
Aves	Accipitriformes	Accipitridae	Accipiter	albogularis	Pied Goshawk	-999.0	-999.0
Aves	Accipitriformes	Accipitridae	Accipiter	badius	Shikra	363.468	3.25
Aves	Accipitriformes	Accipitridae	Accipiter	bicolor	Bicolored Ha	-999.0	2.7

sqlite

Example (cool stuff)

```
sqlite> select count(*) from amniote;
```

```
count(*)
```

```
-----
```

```
21322
```

← count all records

```
sqlite> select count(distinct(family)) from amniote;
```

```
count(distinct(family))
```

```
-----
```

```
465
```

← count all unique families

```
sqlite> select family, count(family) from amniote group by family order by
```

```
count(family) desc;
```

← get count of all rows in distinct families

family	count(family)
-----	-----
Scincidae	1351
Gekkonidae	701
Muridae	638
Cricetidae	609
Tyrannidae	402
Agamidae	391
Vespertili	382
Dactyloida	350
Thraupidae	334
Psittacida	324
Trochilida	311

(...truncated...)

sqlite

Example (cool stuff)

```
sqlite> select class, ord, genus, species, common_name from amniote where family =  
'Scincidae' limit 5;
```

class	ord	genus	species	common_name
Reptilia	Squamata	Ablepharus	bivittatus	Twin-striped Skink
Reptilia	Squamata	Ablepharus	budaki	-999
Reptilia	Squamata	Ablepharus	chernovi	Chernov's Skink
Reptilia	Squamata	Ablepharus	darvazi	-999
Reptilia	Squamata	Ablepharus	deserti	Desert Lidless Skink

get specific columns

```
sqlite> select distinct(common_name) from amniote where common_name like "-99%";
```

common_name
-999

get all null-like designations

```
sqlite> update amniote set common_name = NULL where common_name = '-999';
```

change those to NULL

```
sqlite> select class, ord, genus, species, common_name from amniote where family =  
'Scincidae' limit 5;
```

class	ord	genus	species	common_name
Reptilia	Squamata	Ablepharus	bivittatus	Twin-striped Skink, Two-Streaked Snake-Eyed Skink
Reptilia	Squamata	Ablepharus	budaki	
Reptilia	Squamata	Ablepharus	chernovi	Chernov's Skink
Reptilia	Squamata	Ablepharus	darvazi	
Reptilia	Squamata	Ablepharus	deserti	Desert Lidless Skink

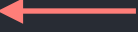
python sqlite3

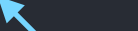
The **python** (native) module for using **sqlite3**

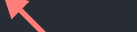
In: `import sqlite3`  import the sqlite3 module

In: `conn = sqlite3.connect('amniote.sqlite')`  create a connection to the database

In: `cur = conn.cursor()`  create a `conn.cursor()` instance
(this is how we run queries)

In: `result = cur.execute('select * from amniote limit 5')`  use our `cur` instance to
run **SQL** statements

In: `result.fetchone()`  fetch and return a single result

Out:  regular old **SQL** statement (don't need semicolon)

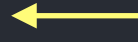
```
('Aves',  
'Accipitriformes',  
'Accipitridae',  
'Accipiter',  
'albogularis',  
'Pied Goshawk',  
-999.0,  
-999.0)
```

What happens if we run `result.fetchone()` again?

python sqlite3

The **python** (native) module for using **sqlite3**

In: `result = cur.execute('select * from amniote limit 5')`  use our **cur** instance to run **SQL** statements

In: `for row in result.fetchall():`
`print(row[1], row[2], row[3], row[4])`  fetch and return all results...

Out:

```
Accipitriformes Accipitridae Accipiter albogularis
Accipitriformes Accipitridae Accipiter badius
Accipitriformes Accipitridae Accipiter bicolor
Accipitriformes Accipitridae Accipiter brachyurus
Accipitriformes Accipitridae Accipiter brevipes
```

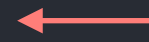
In: `for row in result.fetchall():`
`print(row[1], row[2], row[3], row[4])`  What if we do this **again**?
Why is there no data?

Out:

python sqlite3

The **python** (native) module for using **sqlite3**

In: `result = cur.execute('select * from amniote')`



use our **cur** instance to
run **SQL** statements
(no **limit** this time)

In: `data = result.fetchall()`



fetch and return all results...

In: `type(data)`

Out: `list`

← data are returned as a list

In: `len(data)`

Out: `21322`

← and the list is looooooong

In: `data[:2]`

Out:

```
[('Aves',  
  'Accipitriformes',  
  'Accipitridae',  
  'Accipiter',  
  'albogularis',  
  'Pied Goshawk',  
  -999.0,  
  -999.0),  
 ('Aves',  
  'Accipitriformes',  
  'Accipitridae',  
  'Accipiter',  
  'badius',  
  'Shikra',  
  363.468,  
  3.25)]
```

← here's what a slice
of the list looks like

Do we want to do this??

python sqlite3

The **python** (native) module for using **sqlite3**

In: <code>result = cur.execute('select * from amniote')</code>	←	use our cur instance to run SQL statements (no limit this time)
In: <code>type(result)</code> Out: <code>sqlite3.Cursor</code>	←	let's see what the type() of result is
In: <code>len(result)</code> Out: TypeError: object of type 'sqlite3.Cursor' has no len()	←	What's its length?
In: <code>for row in result:</code> <code>print(row[1], row[2], row[3], row[4])</code>	←	Let's try to iterate over result

So, **result** is an iterator - fetching one row at a time
(**versus** fetching them all and putting them in a list)

python sqlite3

The **python** (native) module for using **sqlite3**

String substitutions

Don't do this

```
In: result = cur.execute('select * from amniote where family = {}'.format('Accipitridae'))
```

It can cause **security problems** (due to the way SQL handles text)

python sqlite3

The **python** (native) module for using **sqlite3**

String substitutions

Do this

In: `result = cur.execute('select * from amniote where family = ?', ('Accipitridae',))`



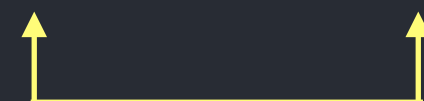
Note comma.
Why?

Or this

In: `result = cur.execute('select * from amniote where family = ? or family = ?',
('Accipitridae', 'Gekkonidae'))`

Or this

In: `result = cur.execute('select * from amniote where family = :family', {'family': 'Accipitridae'})`



Dictionary Style

python sqlite3

The **python** (native) module for using **sqlite3**

Table Creation

In: `import sqlite3`

In: `conn = sqlite3.connect('my_new_table.sqlite')`

In: `cur = conn.cursor()`

← import, create connection,
instantiate cursor

In: `cur.execute('create table my_table (var1 text, var2 int, var3 float)')` ← create table

In: `cur.execute("insert into my_table values ('test', 1, 20.5)")` ← insert values into table
(note apostrophes. why?)

In: `result = cur.execute('select * from my_table')` ← select what we just
inserted

Out:
`[('test', 1, 20.5)]`

In: `cur.execute("insert into my_table values ('test1', 2, 80.5)")`

In: `result = cur.execute('select * from my_table')`

Out:
`[('test', 1, 20.5), ('test1', 2, 80.5)]`

python sqlite3

The **python** (native) module for using **sqlite3**

Closing the connection

```
In: import sqlite3
```

```
In: conn = sqlite3.connect('my_new_table.sqlite')
```

```
In: cur = conn.cursor()
```

```
In: cur.execute('create table my_table (var1 text, var2 int, var3 float)')
```

```
In: cur.execute("insert into my_table values ('test', 1, 20.5)")
```

```
In: result = cur.execute('select * from my_table')
```

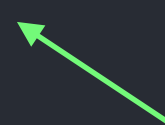
```
In: cur.execute("insert into my_table values ('test1', 2, 80.5)")
```

```
In: result = cur.execute('select * from my_table')
```

Out:

```
[('test', 1, 20.5), ('test1', 2, 80.5)]
```

```
In: conn.close()
```



When finished with a database (connection), you should **close** it