

Algorithmic Approaches for Biological Data, Lecture #12

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Outline



- File Overview:

Outline



- File Overview:
 - ▶ Standard I/O

Outline



- File Overview:
 - ▶ Standard I/O
 - ▶ CSV reader

Outline



- File Overview:
 - ▶ Standard I/O
 - ▶ CSV reader
 - ▶ matplotlib's imread()

Outline



- File Overview:
 - ▶ Standard I/O
 - ▶ CSV reader
 - ▶ matplotlib's imread()
 - ▶ The urllib reader

Outline



- File Overview:
 - ▶ Standard I/O
 - ▶ CSV reader
 - ▶ matplotlib's imread()
 - ▶ The urllib reader
- Structured Data files: CSV, PNG (Image), SQL, FASTA & friends

Standard File Input/Output

infile.txt

Hello!

This is

a

test.

123

Standard File Input/Output

infile.txt

Hello!

This is
a

test.

123

"Hello!\nThis is \na \ntest.\n123"

Standard File Input/Output

infile.txt

Hello!

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test.

123

"Hello!\nThis is \na \ntest.\n123"

- Text files are multi-lined strings.

Standard File Input/Output

infile.txt

Hello!

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123

"Hello!\nThis is \na \ntest.\n123"

- Text files are multi-lined strings.
- Lines are indicated by '\n' characters.

Files Commands

- Opening a file:



Files Commands

- Opening a file:

```
infile = open('data.txt', 'r')
```



Files Commands

- Opening a file:

```
infile = open('data.txt', 'r')  
outfile = open('log.txt', 'w')
```



Files Commands

- Opening a file:

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infile = open('data.txt', 'r')  
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```

- Reading from a file:



Files Commands

- Opening a file:

```
infile = open('data.txt', 'r')  
outfile = open('log.txt', 'w')
```

- Reading from a file:

- ▶ `infile.read()`: reads the entire file into a single string.



Files Commands

- Opening a file:

```
infile = open('data.txt', 'r')  
outfile = open('log.txt', 'w')
```

- Reading from a file:

- ▶ `infile.read()`: reads the entire file into a single string.
- ▶ `infile.readline()`: read the next line of the file.



Files Commands

- Opening a file:

```
infile = open('data.txt', 'r')  
outfile = open('log.txt', 'w')
```

- Reading from a file:

- ▶ `infile.read()`: reads the entire file into a single string.
- ▶ `infile.readline()`: read the next line of the file.
- ▶ `infile.readlines()`: read the file into a list of strings.



Files Commands



- Opening a file:

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infile = open('data.txt', 'r')  
outfile = open('log.txt', 'w')
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- Reading from a file:

- ▶ `infile.read()`: reads the entire file into a single string.
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- Closing a file:

Files Commands



- Opening a file:

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infile = open('data.txt', 'r')  
outfile = open('log.txt', 'w')
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- Reading from a file:

- ▶ `infile.read()`: reads the entire file into a single string.
- ▶ `infile.readline()`: read the next line of the file.
- ▶ `infile.readlines()`: read the file into a list of strings.

- Closing a file:

```
infile.close()
```

- Writing to a file:

Files Commands



- Opening a file:

```
infile = open('data.txt', 'r')  
outfile = open('log.txt', 'w')
```

- Reading from a file:

- ▶ `infile.read()`: reads the entire file into a single string.
- ▶ `infile.readline()`: read the next line of the file.
- ▶ `infile.readlines()`: read the file into a list of strings.

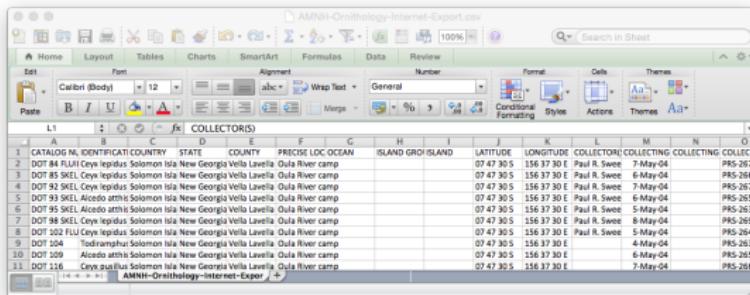
- Closing a file:

```
infile.close()
```

- Writing to a file:

```
outfile.write(s)
```

CSV Files

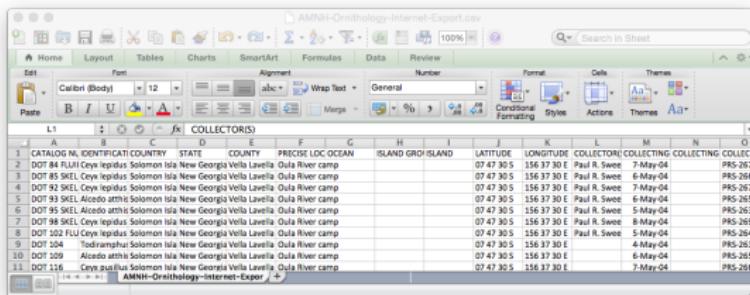


The screenshot shows a Microsoft Excel spreadsheet with the title bar 'AMNH-Ornithology-Internet-Export.csv'. The data is organized into 13 rows and 14 columns. The columns are labeled: CATALOG NR., IDENTIFICATION, COUNTRY, STATE, COUNTY, PRECISE LOC/OCEAN, ISLAND, GRID, ISLAND, LATITUDE, LONGITUDE, COLLECTOR/1, COLLECTING, COLLECTOR/2, and COLLECTOR/3. The data entries are as follows:

L1	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	CATALOG NR.	IDENTIFICATION	COUNTRY	STATE	COUNTY	PRECISE LOC/OCEAN	ISLAND	GRID	ISLAND	LATITUDE	LONGITUDE	COLLECTOR/1	COLLECTING	COLLECTOR/2	COLLECTOR/3
2	DOT 84	FLU Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp		07°47'30"S	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2672			
3	DOT 85	FLU Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp		07°47'30"S	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2674			
4	DOT 92	SKEL Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp		07°47'30"S	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2677			
5	DOT 93	SKEL Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp		07°47'30"S	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2655			
6	DOT 95	SKEL Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp		07°47'30"S	156°37'30"E	Paul R. Sweet	5-May-04	PRS-2637			
7	DOT 98	SKEL Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp		07°47'30"S	156°37'30"E	Paul R. Sweet	8-May-04	PRS-2692			
8	DOT 102	FLU Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp		07°47'30"S	156°37'30"E	Paul R. Sweet	5-May-04	PRS-2647			
9	DOT 103	FLU Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp		07°47'30"S	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2648			
10	DOT 209	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp		07°47'30"S	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2612			
11	DOT 216	Ceyx guillimoni	Solomon Isla	New Georgia	Vella Lavella	Oula River camp		07°47'30"S	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2671			

- Very structured– the columns and rows matter.

CSV Files



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O			
	COLLECTOR(S)																	
1	CATALOG	NR.	IDENTIFICATION	COUNTRY	STATE	COUNTY	PRECISE LOC	OCEAN	ISLAND	GROU	ISLAND	LATITUDE	LONGITUDE	COLLECTOR(S)	COLLECTING			
2	DOT	84	FLU	Ceyx	Ilegatus	Solomon	Island	New	Georgia	Vella	Laevata	Oula	River	camp	7	May-04	PRS-2672	
3	DOT	90	FLU	Ceyx	Ilegatus	Solomon	Island	New	Georgia	Vella	Laevata	Oula	River	camp	8	May-04	PRS-2674	
4	DOT	92	SKEL	Ceyx	Ilegatus	Solomon	Island	New	Georgia	Vella	Laevata	Oula	River	camp	9	May-04	PRS-2675	
5	DOT	93	SKEL	Alcedo	atthis	Solomon	Island	New	Georgia	Vella	Laevata	Oula	River	camp	10	May-04	PRS-2655	
6	DOT	95	SKEL	Alcedo	atthis	Solomon	Island	New	Georgia	Vella	Laevata	Oula	River	camp	11	May-04	PRS-2637	
7	DOT	98	SKEL	Ceyx	Ilegatus	Solomon	Island	New	Georgia	Vella	Laevata	Oula	River	camp	12	May-04	PRS-2692	
8	DOT	102	FLU	Ceyx	Ilegatus	Solomon	Island	New	Georgia	Vella	Laevata	Oula	River	camp	13	May-04	PRS-2647	
9	DOT	103	FLU	Ceyx	Ilegatus	Solomon	Island	New	Georgia	Vella	Laevata	Oula	River	camp	14	May-04	PRS-2648	
10	DOT	209		Alcedo	atthis	Solomon	Island	New	Georgia	Vella	Laevata	Oula	River	camp	15	May-04	PRS-2612	
11	DOT	216		Ceyx	gu	Ilegatus	Solomon	Island	New	Georgia	Vella	Laevata	Oula	River	camp	16	May-04	PRS-2657

- Very structured– the columns and rows matter.
- To keep that format as a text file:

CSV Files

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	COLLECTORS														
1	CATALOG#	NAME	IDENTIFICATION	COUNTRY	STATE	COUNTY	PRECISE LOC/OCEAN	ISLAND	GROUP/ISLAND	LATITUDE	LONGITUDE	COLLECTOR	COLLECTING_DATE	COLLECTING_CODE	
2	DOT 84	FLU Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30 S	156 37 30 E	Paul R. Sweet	7-May-04	PRS-2672	
3	DOT 85	FLU Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30 S	156 37 30 E	Paul R. Sweet	6-May-04	PRS-2674	
4	DOT 92	SKEL Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30 S	156 37 30 E	Paul R. Sweet	7-May-04	PRS-2677	
5	DOT 93	SKEL Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30 S	156 37 30 E	Paul R. Sweet	6-May-04	PRS-2655	
6	DOT 95	SKEL Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30 S	156 37 30 E	Paul R. Sweet	5-May-04	PRS-2637	
7	DOT 97	SKEL Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30 S	156 37 30 E	Paul R. Sweet	8-May-04	PRS-2692	
8	DOT 102	FLU Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30 S	156 37 30 E	Paul R. Sweet	5-May-04	PRS-2647	
9	DOT 103	FLU Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30 S	156 37 30 E	Paul R. Sweet	7-May-04	PRS-2648	
10	DOT 209	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30 S	156 37 30 E	Paul R. Sweet	6-May-04	PRS-2612	
11	DOT 216	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30 S	156 37 30 E	Paul R. Sweet	7-May-04	PRS-2671	

- Very structured– the columns and rows matter.
- To keep that format as a text file:
 - columns separated by commas (',')

CSV Files

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	COLLECTOR(S)														
1	CATALOG NR.	IDENTIFICATION	COUNTRY	STATE	COUNTY	PRECISE LOC/OCEAN	ISLAND GROUP	ISLAND	LATITUDE	LONGITUDE	COLLECTOR/NAME	COLLECTING DATE	COLLECTING NUMBER		
2	DOT 84	FLU Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30"S	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2672		
3	DOT 85	FLU Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30"S	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2674		
4	DOT 92	SKEL Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30"S	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2677		
5	DOT 93	SKEL Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30"S	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2655		
6	DOT 95	SKEL Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30"S	156°37'30"E	Paul R. Sweet	5-May-04	PRS-2637		
7	DOT 98	SKEL Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30"S	156°37'30"E	Paul R. Sweet	8-May-04	PRS-2692		
8	DOT 102	FLU Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30"S	156°37'30"E	Paul R. Sweet	5-May-04	PRS-2647		
9	DOT 103	FLU Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30"S	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2648		
10	DOT 209	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30"S	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2612		
11	DOT 216	Ceyx guilleni	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30"S	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2657		

- Very structured– the columns and rows matter.
- To keep that format as a text file:
 - columns separated by commas (',')
 - rows separated by new lines ('\n')

CSV Files

L1	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	CATALOG N.	IDENTIFICATION	COUNTRY	STATE	COUNTY	PRECISE LOC	OCEAN	ISLAND	GROUPLAND	LATITUDE	LONGITUDE	COLLECTOR/	COLLECTING	COLLECTING	COLLECT
2	DOT 84	FLUID	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07 47 30 S	156 37 30 E	Paul R. Sweet	7-May-04		PRS-2672
3	DOT 85	FLUID	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07 47 30 S	156 37 30 E	Paul R. Sweet	6-May-04		PRS-2654
4	DOT 92	SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07 47 30 S	156 37 30 E	Paul R. Sweet	7-May-04		PRS-2673
5	DOT 93	SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07 47 30 S	156 37 30 E	Paul R. Sweet	6-May-04		PRS-2655
6	DOT 95	SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07 47 30 S	156 37 30 E	Paul R. Sweet	5-May-04		PRS-2633
7	DOT 98	SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07 47 30 S	156 37 30 E	Paul R. Sweet	8-May-04		PRS-2692
8	DOT 102	FLUID	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07 47 30 S	156 37 30 E	Paul R. Sweet	5-May-04		PRS-2641
9	DOT 103	FLUID	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07 47 30 S	156 37 30 E	Paul R. Sweet	7-May-04		PRS-2642
10	DOT 209		Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07 47 30 S	156 37 30 E	Paul R. Sweet	6-May-04		PRS-2612
11	DOT 216		Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07 47 30 S	156 37 30 E	Paul R. Sweet	7-May-04		PRS-2657

- Very structured– the columns and rows matter.
- To keep that format as a text file:
 - columns separated by commas (',')
 - rows separated by new lines ('\n')
- Rows look like:

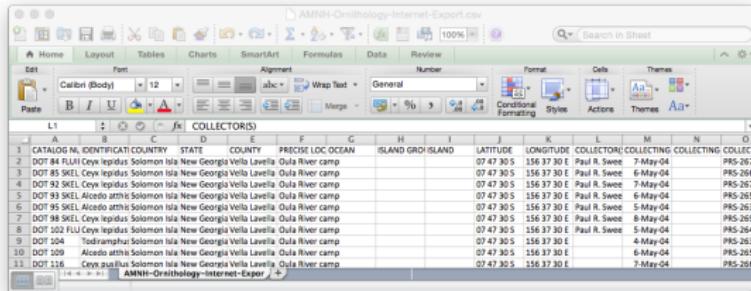
"DOT 84 FLUID 11383",Ceyx lepidus collectoris,Solomon Islands,New Georgia Group,Vella Lavella Island,Oula River camp,,,07 47 30 S,156 37 30 E,Paul R. Sweet,7-May-04,,PRS-2672,,"Tissue Fluid "

CSV Files

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	COLLECTOR(S)														
1.	CATALOG NO.	IDENTIFICATION	COUNTRY	STATE	COUNTY	PRECISE LOC	OCEAN	ISLAND GROUP	ISLAND	LATITUDE	LONGITUDE	COLLECTOR(S)	COLLECTING DATE	COLLECTOR ID	
2.	DOT 84	FLU	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2672	
3.	DOT 85	SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2663	
4.	DOT 92	SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2673	
5.	DOT 93	SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2655	
6.	DOT 95	SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	5-May-04	PRS-2657	
7.	DOT 98	SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	8-May-04	PRS-2662	
8.	DOT 102	FLU	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	5-May-04	PRS-2647	
9.	DOT 104	Todiramphus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E		4-May-04	PRS-2630	
10.	DOT 109		Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E		6-May-04	PRS-2657	
11.	DOT 116		Ceyx pusillus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E		7-May-04	PRS-2667	

- Built-in package for reading CSV files. To use it:

CSV Files



The screenshot shows a Microsoft Excel spreadsheet titled "AMNH-Ornithology-Internet-Expert.csv". The data is organized into columns labeled A through N. Column A contains row numbers from 1 to 11. Columns B through D represent categorical data: COLLECTOR#, COUNTRY, STATE, and COUNTY. Columns E through H represent precise location details: PRECISE LOC, OCEAN, ISLAND, and GRID/ISLAND. Columns I through N represent geographic coordinates: LATITUDE, LONGITUDE, and two sets of COLLECTING data (COLLECTOR#, DATE, and ID). The data entries are as follows:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	CATALOG	NR.	IDENTIFICATION	COUNTRY	STATE	COUNTY	PRECISE LOC	OCEAN	ISLAND	GRID/ISLAND	LATITUDE	LONGITUDE	COLLECTOR#	COLLECTING	COLLECTING
2	DOT 84	FLU	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2672
3	DOT 85	SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2663
4	DOT 92	SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2673
5	DOT 93	SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2655
6	DOT 95	SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	5-May-04	PRS-2657
7	DOT 98	SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	8-May-04	PRS-2662
8	DOT 102	FLU	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	5-May-04	PRS-2647
9	DOT 104	Todiramphus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp								4-May-04	PRS-2630
10	DOT 109		Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E		6-May-04	PRS-2657
11	DOT 116		Ceyx pusillus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E		7-May-04	PRS-2667

- Built-in package for reading CSV files. To use it:
 - ▶ At top of file, include: `import csv`

CSV Files

The screenshot shows a Microsoft Excel spreadsheet titled 'AMNH-Ornithology-Internet-Expert.csv'. The active sheet is 'COLLECTORS'. The data consists of 11 rows of information, each representing a record. The columns are labeled: CATALOG NO., IDENTIFICATION, COUNTRY, STATE, COUNTY, PRECISE LOC, OCEAN, ISLAND GROUP, ISLAND, LATITUDE, LONGITUDE, COLLECTOR(S), COLLECTING DATE, and COLLECTOR ID. The data includes various bird species names like 'Ceyx lepidus', 'Alcedo atthis', and 'Todiramphus solomonis' from locations such as New Georgia, Vella Lavella, and Oula River camp, with collection dates ranging from May 2004 to May 2005.

CATALOG NO.	IDENTIFICATION	COUNTRY	STATE	COUNTY	PRECISE LOC	OCEAN	ISLAND GROUP	ISLAND	LATITUDE	LONGITUDE	COLLECTOR(S)	COLLECTING DATE	COLLECTOR ID	
1	CATALOG NO.	IDENTIFICATION	COUNTRY	STATE	COUNTY	PRECISE LOC	OCEAN	ISLAND GROUP	ISLAND	LATITUDE	LONGITUDE	COLLECTOR(S)	COLLECTING DATE	COLLECTOR ID
2	DOT 84	<i>FLU</i> <i>Ceyx lepidus</i>	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2672	
3	DOT 85	<i>SKEL</i> <i>Ceyx lepidus</i>	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2663	
4	DOT 92	<i>SKEL</i> <i>Ceyx lepidus</i>	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2673	
5	DOT 93	<i>SKEL</i> <i>Alcedo atthis</i>	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2655	
6	DOT 95	<i>SKEL</i> <i>Ceyx lepidus</i>	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	5-May-04	PRS-2657	
7	DOT 98	<i>SKEL</i> <i>Ceyx lepidus</i>	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	8-May-04	PRS-2662	
8	DOT 102	<i>FLU</i> <i>Ceyx lepidus</i>	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	5-May-04	PRS-2647	
9	DOT 104	<i>Todiramphus solomonis</i>	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E		4-May-04	PRS-2630	
10	DOT 109	<i>Alcedo atthis</i>	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E		6-May-04	PRS-2657	
11	DOT 116	<i>Ceyx pusillus</i>	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E		7-May-04	PRS-2667	

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CSV Files

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2	DOT 84 FUJI	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	7-May-04		PRS-2672
3	DOT 85 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04		PRS-2663
4	DOT 92 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	7-May-04		PRS-2673
5	DOT 93 SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04		PRS-2655
6	DOT 95 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	5-May-04		PRS-2657
7	DOT 98 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	8-May-04		PRS-2662
8	DOT 102 FUJI	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	5-May-04		PRS-2642
9	DOT 104	Todiramphus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E		4-May-04		PRS-2630
10	DOT 109	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E		6-May-04		PRS-2657
11	DOT 116	Ceyx pusillus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E		7-May-04		PRS-2667

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CSV Files

1	2	3	4	5	6	7	8	9	10	11	12	13	14	
CATALOG NO.	IDENTIFICATION	COUNTRY	STATE	COUNTY	PRECISE LOC	OCEAN	ISLAND GROUP	ISLAND	LATITUDE	LONGITUDE	COLLECTOR(1)	COLLECTING DATE	COLLECTOR(2)	COLLECTING DATE
1	DOT 84 FUJI	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oulu River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	7-May-04		PRS-2672
2	DOT 85 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oulu River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04		PRS-2663
3	DOT 92 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oulu River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	7-May-04		PRS-2673
4	DOT 93 SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oulu River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04		PRS-2655
5	DOT 95 SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oulu River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04		PRS-2657
6	DOT 96 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oulu River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04		PRS-2658
7	DOT 98 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oulu River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04		PRS-2660
8	DOT 102 FUJI	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oulu River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	5-May-04		PRS-2647
9	DOT 104	Todiramphus	Solomon Isla	New Georgia	Vella Lavella	Oulu River camp			07°47'30.5"	156°37'30"E		4-May-04		PRS-2630
10	DOT 109	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oulu River camp			07°47'30.5"	156°37'30"E		6-May-04		PRS-2657
11	DOT 116	Ceyx pusillus	Solomon Isla	New Georgia	Vella Lavella	Oulu River camp			07°47'30.5"	156°37'30"E		7-May-04		PRS-2667

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CSV Files

	CATALOG NO.	IDENTIFICATION	COUNTRY	STATE	COUNTY	PRECISE LOC	OCEAN	ISLAND GROUP	ISLAND	LATITUDE	LONGITUDE	COLLECTOR(S)	COLLECTING DATE	COLLECTOR(S)
1	DOT 84 FLU	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2063
2	DOT 85 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2063
3	DOT 92 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2073
4	DOT 93 SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2055
5	DOT 95 SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2057
6	DOT 96 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2058
7	DOT 98 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2060
8	DOT 102 FLU	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E	Paul R. Sweet	5-May-04	PRS-2047
9	DOT 104	Todiramphus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E		4-May-04	PRS-2030
10	DOT 109	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E		6-May-04	PRS-2057
11	DOT 116	Ceyx pusillus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E		7-May-04	PRS-2067

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CSV Files

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	COLLECTOR(S)														
1	CATALOG NO.	IDENTIFICATION	COUNTRY	STATE	COUNTY	PRECISE LOC	OCEAN	ISLAND GROUP	ISLAND	LATITUDE	LONGITUDE	COLLECTOR(S)	COLLECTING DATE	COLLECTING NUMBER	
2	DOT 84	FLJU	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2063	
3	DOT 85	SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2063	
4	DOT 92	SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	7-May-04	PRS-2073	
5	DOT 93	SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	6-May-04	PRS-2055	
6	DOT 95	SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	5-May-04	PRS-2057	
7	DOT 98	SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	8-May-04	PRS-2062	
8	DOT 102	FLJU	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp			07°47'30.5"	156°37'30"E	Paul R. Sweet	5-May-04	PRS-2042	
9	DOT 104	Todiramphus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E		4-May-04	PRS-2032	
10	DOT 109	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E		6-May-04	PRS-2057	
11	DOT 116	Ceyx pusillus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07°47'30.5"	156°37'30"E		7-May-04	PRS-2067	

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 - ▶ Read in lines from reader:

CSV Files

	CATALOG NO.	IDENTIFICATION	COUNTRY	STATE	COUNTY	PRECISE LOC	OCEAN	ISLAND GROUP	ISLAND	LATITUDE	LONGITUDE	COLLECTOR(S)	COLLECTING DATE	COLLECTING NUMBER
1														
2	DOT 84 FLU	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	7-May-04	PRS-2063
3	DOT 85 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	6-May-04	PRS-2063
4	DOT 92 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	7-May-04	PRS-2073
5	DOT 93 SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	6-May-04	PRS-2055
6	DOT 95 SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	5-May-04	PRS-2057
7	DOT 98 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	8-May-04	PRS-2062
8	DOT 102 FLU	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	5-May-04	PRS-2047
9	DOT 104	Todiramphus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E		4-May-04	PRS-2032
10	DOT 109	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E		6-May-04	PRS-2057
11	DOT 116	Ceyx pusillus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E		7-May-04	PRS-2067

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CSV Files

COLLECTOR(S)	CATALOG NO.	IDENTIFICATION	COUNTRY	STATE	COUNTY	PRECISE LOC	OCEAN	ISLAND GROUP	ISLAND	LATITUDE	LONGITUDE	COLLECTOR(S)	COLLECTING DATE	COLLECTOR(S)
	DOT 84 FUJI	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	7-May-04	PRS-2063
	DOT 85 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	6-May-04	PRS-2063
	DOT 92 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	7-May-04	PRS-2073
	DOT 93 SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	6-May-04	PRS-2055
	DOT 95 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	5-May-04	PRS-2057
	DOT 98 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	8-May-04	PRS-2060
	DOT 102 FUJI	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	5-May-04	PRS-2047
	DOT 104	Todiramphus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E		4-May-04	PRS-2030
	DOT 105	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E		6-May-04	PRS-2057
	DOT 116	Ceyx pusillus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E		7-May-04	PRS-2067

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CSV Files

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2	DOT 84 FUJI	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	7-May-04		PRS-2063
3	DOT 85 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	6-May-04		PRS-2063
4	DOT 92 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	7-May-04		PRS-2073
5	DOT 93 SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	6-May-04		PRS-2055
6	DOT 95 SKEL	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	5-May-04		PRS-2057
7	DOT 98 SKEL	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	8-May-04		PRS-2069
8	DOT 102 FUJI	Ceyx lepidus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E	Paul R. Sweet	5-May-04		PRS-2047
9	DOT 104	Todiramphus	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E		4-May-04		PRS-2032
10	DOT 109	Alcedo atthis	Solomon Isla	New Georgia	Vella Lavella	Oula River camp				07 47 30.5	156 37 30 E		6-May-04		PRS-2057
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 - ▶ Read in lines from reader: `for row in reader:`
 - ▶ To access individual entries in a row:
`if "Malaysia" in row['COUNTRY']:` ...

Structured Data Files

- CSV: comma separated values



Structured Data Files



- CSV: comma separated values

- FASTA: sequence data

```
> Rosalind.1289
ACGTTAACCGGGGGGAA
> Rosalind.1988
GCGAAGGTATTGGSAAAA
GCGCGCGCGCCCTTATAT
```

Structured Data Files



- CSV: comma separated values
- FASTA: sequence data
 - > Rosalind.1289
ACGTTAATTATATATAAAA
 - > Rosalind.1988
GCGAAGGTATTGGSAAAA
 - GCGCGCGCGCCCTTATAT
- Portable Network Graphics (PNG): stores images pixel by pixel.

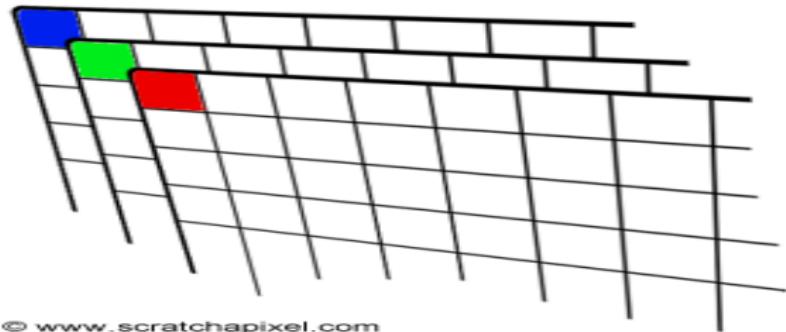
Structured Data Files



- CSV: comma separated values
- FASTA: sequence data

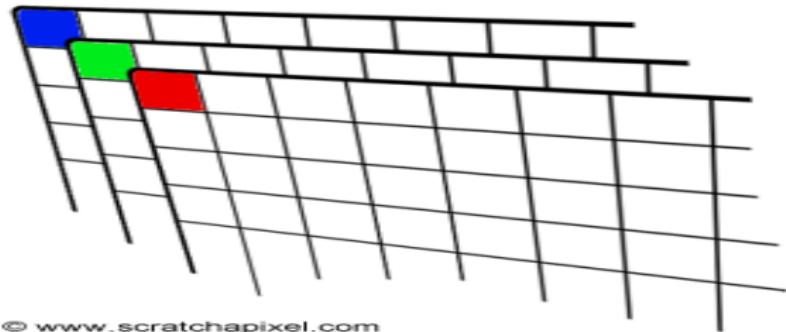
```
> Rosalind.1289
ACGTTAACCCATATATAAAAA
> Rosalind.1988
GCGAAGGTATTGGSAAAA
GCGCGCGCGCCCCCTTATAT
```
- Portable Network Graphics (PNG): stores images pixel by pixel.
- Structured Query Language (SQL): used to access/modify relational databases.

Color By Numbers...



- Images are a grid of pixels.

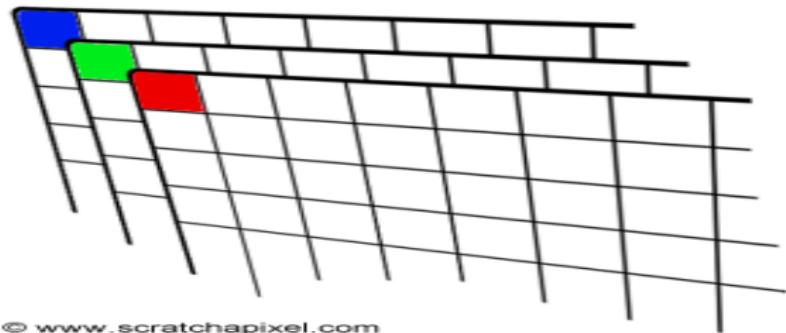
Color By Numbers...



- Images are a grid of pixels.
- Can access color value for pixel (row, col):

```
print "Red:  ", img[row,col,0]
print "Green:", img[row,col,1]
print "Blue:  ", img[row,col,2]
```

Color By Numbers...



- Images are a grid of pixels.
- Can access color value for pixel (row, col):

```
print "Red: ", img[row,col,0]
print "Green:", img[row,col,1]
print "Blue:  ", img[row,col,2]
```
- Challenges: manipulate images, pixel by pixel.

Code Review



```
*filterimage.py - /Users/stjohn/git-lab/bridgeUp-STEM-Miscellanea/ImageProcessing/filterimage.py (2.7.9)*
#Sample image processing file for BridgeUp: STEM
#Assumes a input file called: bfl.png is in the same directory

import matplotlib.pyplot as plt      #Import plotting and numbers libraries
import numpy as np

img = plt.imread('bfl.png')          #Read in first butterfly image
plt.imshow(img)                     #Load image into matplotlib
plt.show()                          #Open window to show image (close to continue)

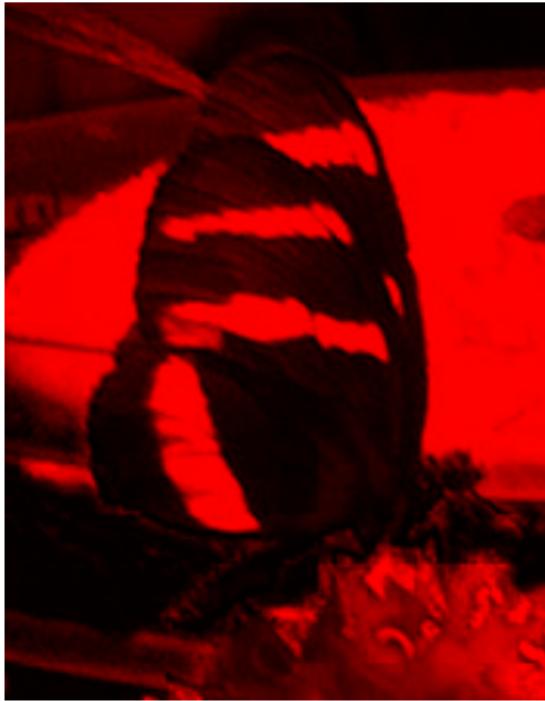
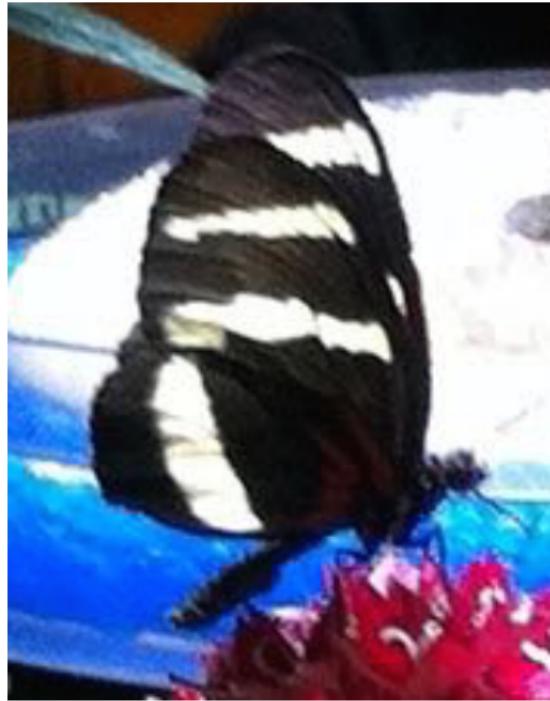
height = img.shape[0]
width = img.shape[1]
newImg = np.zeros((height,width,3))

for i in range(height):
    for j in range(width):
        newImg[i,j,0] = img[i,j,0]      #Line to change!
        newImg[i,j,1] = 0
        newImg[i,j,2] = 0

plt.imshow(newImg)
plt.show()
plt.imsave('rogue.png',newImg)
```

Ln: 24 Col: 0

Code Review



Challenges



- Display the green channel, the blue channel, and in black and white.

Challenges



- Display the green channel, the blue channel, and in black and white.
- Starting with a monochromatic butterfly (e.g. `bflyBlue.png`), display only the butterfly.

Challenges



- Display the green channel, the blue channel, and in black and white.
- Starting with a monochromatic butterfly (e.g. `bflyBlue.png`), display only the butterfly.
- Make a white butterfly appear purple (e.g. `bflyGreen.png`).

Challenges



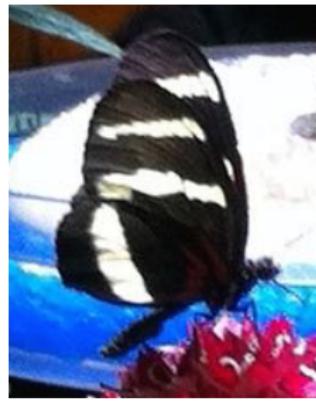
- Display the green channel, the blue channel, and in black and white.
- Starting with a monochromatic butterfly (e.g. `bflyBlue.png`), display only the butterfly.
- Make a white butterfly appear purple (e.g. `bflyGreen.png`).
- Display the image upside down.

Challenges



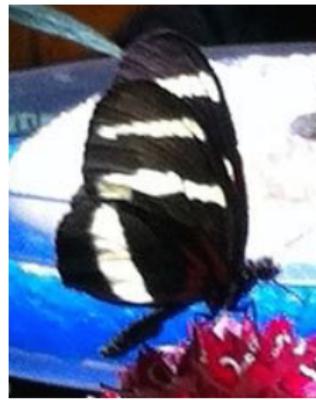
- Display the green channel, the blue channel, and in black and white.
- Starting with a monochromatic butterfly (e.g. `bflyBlue.png`), display only the butterfly.
- Make a white butterfly appear purple (e.g. `bflyGreen.png`).
- Display the image upside down.
- Subtract two similar images and display pixels that differ by more than 30%.

Recap



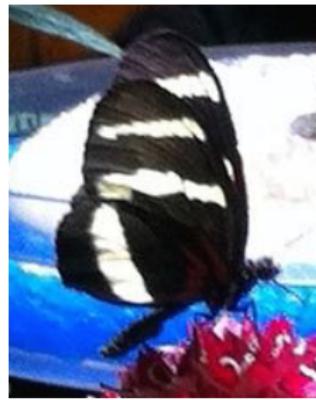
- Using matplotlib & numpy in lab today.

Recap



- Using matplotlib & numpy in lab today.
- Email lab reports to kstjohn@amnh.org

Recap



- Using matplotlib & numpy in lab today.
- Email lab reports to kstjohn@amnh.org
- Challenges available at rosalind.info