GG606

Data transformations and wrangling

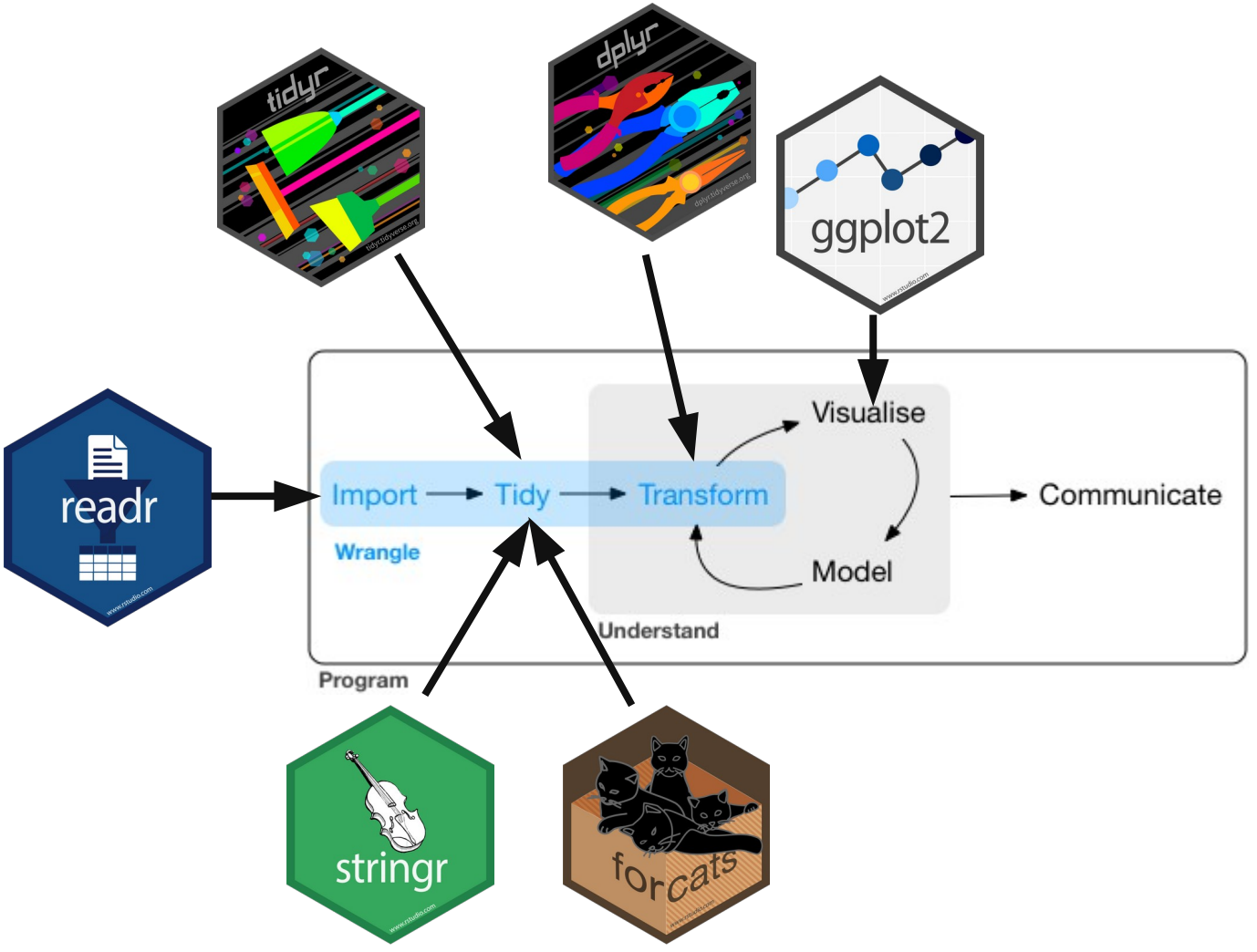
Homework

- folder structure for the workflow
  - we spoke about keeping raw data separate from processed data and keeping figures and/or tables together)
- use the `here` package and function
- R script to load data from pangaea.de or www.frdr-dfdr.ca
  - example, `read_csv(here("folder", "file"))`
- create and save a figure to an appropriate folder
  - hint, use the `ggsave` and `here` functions
- Put a screenshot of your success on discord

Homework

Transformations

- Organisation
- Reproducible
- Inputs & Outputs
- R-Script vs R-Markdown/Quarto vs Function


tidyr
dplyr
ggplot2
readr
Import
Tidy
Transform
Visualise
Model
Communicate
Wrangle
Understand
Program
stringr
forcats

Intro

- `vector, matrix, data.frame, tibble`
- import -> tidy -> save?
- So many data types

- MATLAB array: `[1 2 3 4]` (row vector)
- MATLAB vector: `[1 2 3; 4 5 6; 7 8 9]`
-
-
-
-

- MATLAB array: `[1 2 3 4]` (row vector)
- MATLAB vector: `[1 2 3; 4 5 6; 7 8 9]`
- R array: `array(1, 2, 3)` (⩾1 dimensions)
- R vector: `c(1, 2, 3)` (fixed size, same type)
-
-

- MATLAB array: `[1 2 3 4]` (row vector)
- MATLAB vector: `[1 2 3; 4 5 6; 7 8 9]`
- R array: `array(1, 2, 3)` (⩾1 dimensions)
- R vector: c(1, 2, 3) (fixed size, same type)
- R matrix: 2-dimensional vector
- R data.frame (table): (1 type per column, header names)
  `data.frame(a=1:3, b=4:6)`

tibbles

- `data.frame(a=1:3, b=4:6)`

```
> data.frame(a=1:3, b=4:6)
  a b
1 1 4
2 2 5
3 3 6
```

- `tibble(a=1:3, b=4:6)`

```
> tibble(a=1:3, b=4:6)
# A tibble: 3 x 2
      a     b
  <int> <int>
1     1     4
2     2     5
3     3     6
```

tibbles

- Prints 10 rows
- Column type
- (default options can be changed)
- Strict(er) behaviour can be useful
- Tools for identifying data types
- Can easily convert:

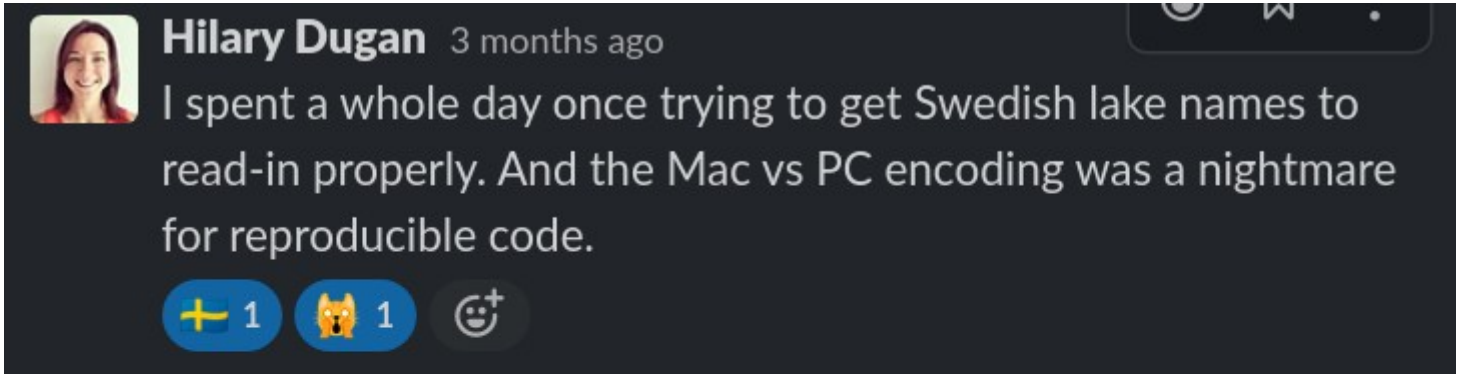
tibbles

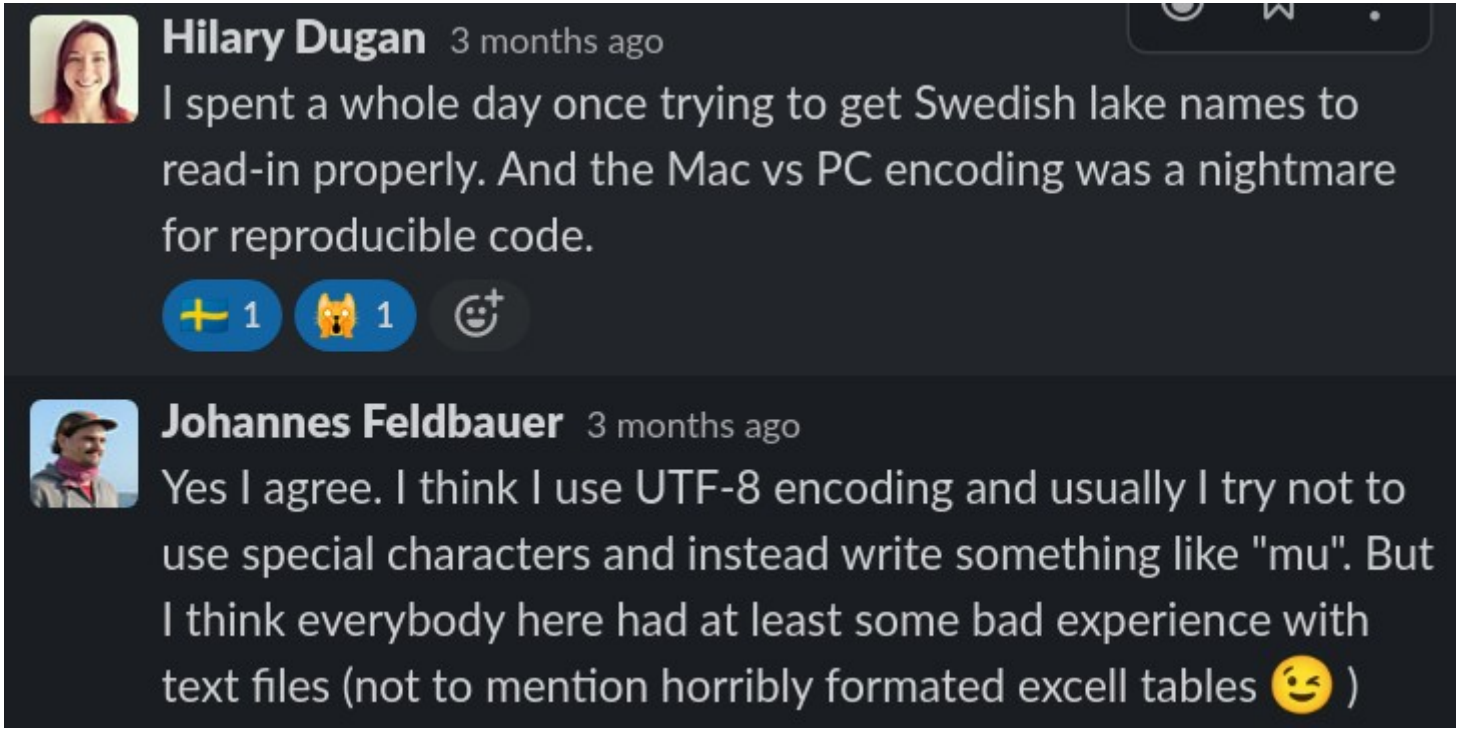
- Can easily convert:

```
x ← tibble(a=1:3, b=4:6)
y ← as.data.frame(x)
y
```

Data import

- `read_csv` vs `read.csv`
- Your examples
- A few examples


Hilary Dugan 3 months ago
I spent a whole day once trying to get Swedish lake names to read-in properly. And the Mac vs PC encoding was a nightmare for reproducible code.
1
1


Hilary Dugan 3 months ago
I spent a whole day once trying to get Swedish lake names to read-in properly. And the Mac vs PC encoding was a nightmare for reproducible code.
1
1
Johannes Feldbauer 3 months ago
Yes I agree. I think I use UTF-8 encoding and usually I try not to use special characters and instead write something like "mu". But I think everybody here had at least some bad experience with text files (not to mention horribly formated excell tables)

Parsing

- `parse_` functions
  - `parse_logical()` `parse_integer()`
  - `parse_double()` `parse_number()`
  - `parse_character()`
  - `parse_factor()`
  - `parse_datetime()` `parse_date()` `parse_time()`
  - `guess_parser()`

Parsing Numbers

- `parse_double("1.23")`
- `parse_double("1,23", locale = locale(decimal_mark = ","))`
-
-

Parsing Numbers

- `parse_double("1.23")`
- `parse_double("1,23", locale = locale(decimal_mark = ","))`
- `parse_number("$100")`
- `parse_number("123.456.789", locale = locale(grouping_mark = "."))`

Parsing Dates

- `parse_datetime("2021-01-01T0001")`
- ISO8601 by default
- What if no time?
- `hms` & `lubridate` packages

Parsing Dates

- `parse_date("01/02/15", "%m/%d/%y")`
- `parse_date("01/02/15", "%d/%m/%y")`
- `parse_date("01/02/15", "%y/%m/%d")`
- Can be infuriating

Parsing Dates

- `parse_date("1 janvier 2015", "%d %B %Y", locale = locale("fr"))`
-
- Can be infuriating
- Also time zones

Ziemann *et al. Genome Biology* (2016) 17:177
DOI 10.1186/s13059-016-1044-7

Genome Biology

COMMENT Open Access

Gene name errors are widespread in the scientific literature

Mark Ziemann[1], Yotam Eren[1,2] and Assam El-Osta[1,3*]

Abstract

The spreadsheet software Microsoft Excel, when used with default settings, is known to convert gene names to dates and floating-point numbers. A programmatic scan of leading genomics journals reveals that approximately one-fifth of papers with supplementary Excel gene lists contain erroneous gene name conversions.

Keywords: Microsoft Excel, Gene symbol, Supplementary data

Abbreviations: GEO, Gene Expression Omnibus; JIF, journal impact factor

Economic Policy

An alarming number of scientific papers contain Excel errors

By **Christopher Ingraham**
Reporter

August 26, 2016 at 6:17 a.m. EDT

What you type	What you see	How Excel stores it
MARCH1	1-MAR	42430
SEPT2	2-SEP	42615

BMC Bioinformatics

BioMed Central

Correspondence

Open Access

Mistaken Identifiers: Gene name errors can be introduced inadvertently when using Excel in bioinformatics

Barry R Zeeberg[†1], Joseph Riss[†2], David W Kane[3], Kimberly J Bussey[1], Edward Uchio[4], W Marston Linehan[4], J Carl Barrett[2] and John N Weinstein[*1]

Address: [1]Genomics & Bioinformatics Group, Laboratory of Molecular Pharmacology, Center for Cancer Research (CCR), National Cancer Institute (NCI), National Institutes of Health (NIH), Bldg 37 Rm 5041, NIH, 9000 Rockville Pike, Bethesda, MD 20892 USA, [2]Laboratory of Biosystems and Cancer, CCR, Bldg 37 Rm 5032, NIH, 9000 Rockville Pike, Bethesda, MD 20892 USA, [3]SRA International, 4300 Fair Lakes CT, Fairfax, VA 22033 USA and [4]Urologic Oncology Branch, Bldg 10 Rm 2B47, National Institutes of Health, Bethesda, MD 20892 USA

Email: Barry R Zeeberg - barry@discover.nci.nih.gov; Joseph Riss - rissj@helix.nih.gov; David W Kane - david_kane@sra.com; Kimberly J Bussey - busseyk@mail.nih.gov; Edward Uchio - eu8v@nih.gov; W Marston Linehan - linehanm@mail.nih.gov; J Carl Barrett - barrett@mail.nih.gov; John N Weinstein* - weinstein@dtpvx2.ncifcrf.gov

* Corresponding author †Equal contributors

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Received: 05 March 2004
Accepted: 23 June 2004

This article is available from: http://www.biomedcentral.com/1471-2105/5/80

BMC Bioinf

BioMed Central

Correspondence

Mistaken Identifiers … duced inadvertently when …

Barry R Zeeberg[†1], Jose… Bussey[1], Edward Uchio[4], W Ma… n N Weinstein[*1]

Address: [1]Genomics & Bioinformatics Gro… h (CCR), National Cancer Institute (NCI), National Institutes of Hea… 20892 USA, [2]Laboratory of Biosystems and Cancer, CCR, Bldg 37 Rm … rnational, 4300 Fair Lakes CT, Fairfax, VA 22033 USA and [4]Urologic Onc… da, MD 20892 USA

Email: Barry R Zeeberg - barry@discover.n… ne@sra.com; Kimberly J Bussey - busseyk@mail.nih.gov… ail.nih.gov; Carl Barrett - barrett@mail.nih.gov; John …

* Corresponding author †Equal contribu…

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This article is available from: http://www.bion…

Open Access

LocusLink Report

Back Forward Stop Refresh Home AutoFill Print Mail

Address: http://www.ncbi.nlm.nih.gov/LocusLink/LocRpt.cgi?l=4735

Live Home Page Apple Apple Support Apple Store iTools Mac OS X Microsoft MacTopia

NCBI LocusLink

PubMed Entrez BLAST OMIM Taxonomy Structure

Search LocusLink Display Brief Organism: All

Query: Go Clear

View Hs NEDD5 One of 1 Loci Save All Loci

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Click to Display mRNA-Genomic Alignments (spanning 38716 bps)

PUB OMIM REVIEW UNIGENE MAP VAR HOMOL GDB e! UCSC

Homo sapiens Official Gene Symbol and Name (HGNC)

NEDD5: neural precursor cell expressed, developmentally down-regulated 5

LocusID: 4735

Overview Submit GeneRIF ?

Locus Type:	gene with protein product, function known or inferred
Product:	neural precursor cell expressed, developmentally down-regulated 5
Alternate Symbols:	DIFF6, SEPT2, hNedd5, KIAA0158

Relationships ?

Mouse Homology Maps:

NCBI vs. MGD	1 cM	2-Sep	Hs Mm
UCSC vs. MGD	1 cM	Sept2	Hs Mm
UCSC vs. Hudson et al.	1 1319.34 cR	AW208991	Hs Mm

Map Information ?

Chromosome:	2			mv
Cytogenetic:	2q37		RefSeq	
Markers:	Chr. 2;	D2S2576	D2S2576	
	Chr. 2	G19712		mv
	Chr. 2	A001W20		mv
	Chr. 2	D2S2850	D2S2850	mv
	Chr. 2	D2S2704	D2S2704	mv
	Chr. 2	G62117		mv
	Chr. -	D15S949	D15S949	

NCBI Reference Sequences (RefSeq) ?

Category: PROVISIONAL

mRNA: NM_004404

LocusLink Home

NEDD5 Index:

Top of Page Nomenclature Overview Relationships Map RefSeq GenBank Links

LocusLink:

Collaborators Download FAQ Help Statistics

RefSeq:

About

Favorites History Search Scrapbook Page Holder

Internet zone

Ziemann et al. Genome Biology (2016) 17:177
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Genome Biology

COMMENT Open Access

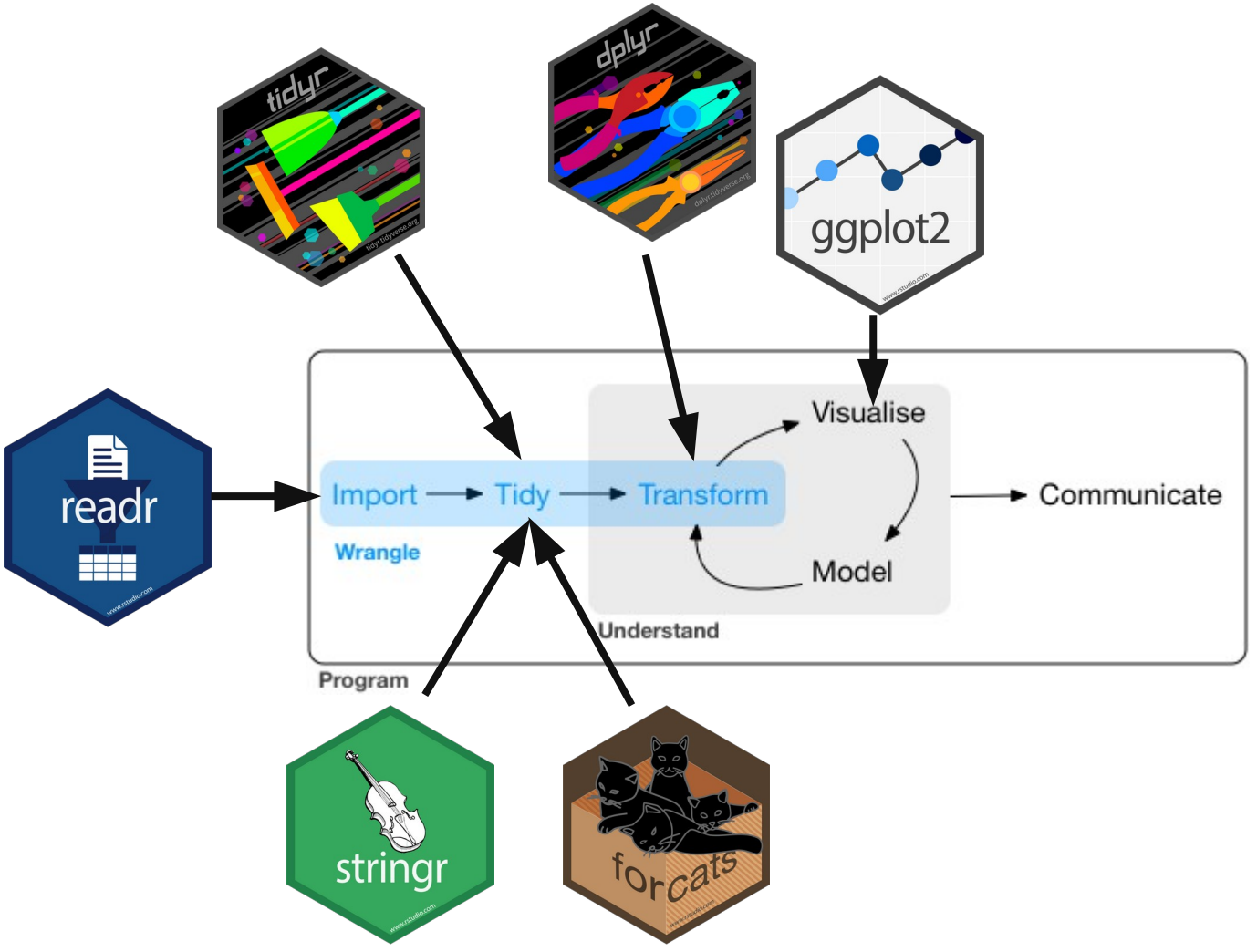
Gene name errors are widespread in the scientific literature

Mark Ziemann[1], Yotam Eren[1,2] and Assam El-Osta[1,3*]

The problem of Excel software (Microsoft Corp., Redmond, WA, USA) inadvertently converting gene symbols to dates and floating-point numbers was originally described in 2004 [1]. For example, gene symbols such as *SEPT2* (Septin 2) and *MARCH1* [Membrane-Associated Ring Finger (C3HC4) 1, E3 Ubiquitin Protein Ligase] are converted by default to '2-Sep' and '1-Mar', respectively. Furthermore, RIKEN identifiers were described to be automatically converted to floating point numbers (i.e. from accession '2310009E13' to '2.31E+13'). Since that report, we have uncovered further instances where gene symbols were converted to dates in supplementary data of recently published papers (e.g. '*SEPT2*' converted to '2006/09/02'). This suggests that gene name errors continue to be a problem in supplementary files accompanying articles. Inadvertent gene symbol conversion is problematic because these supplementary files are an important resource in the genomics community that are

Strategies

- readr used to uses heuristic over first 1000 rows – now uses periodic rows + 1st and last
- `guess_parser()`


tidyr
dplyr
ggplot2
readr
Import
Tidy
Transform
Visualise
Model
Communicate
Wrangle
Understand
Program
stringr
forcats

Save

- Import
- Tidy
- Save `write_csv()` or `write_rds()`
- How would you organise multiple R scripts to:
  import, tidy, save &
  load, continue

12 Points

- Karl W. Broman & Kara H. Woo (2018) Data Organization in Spreadsheets, The American Statistician, 72:1, 2-10, https://doi.org/10.1080/00031305.2017.1375989

Be Consistent

- Names
- Codes
- Identifiers
- Extra spaces

Good Names

- Avoid spaces
- No special characters or symbols

Table 1. Examples of good and bad variable names.

good name	good alternative	avoid
Max_temp_C	MaxTemp	Maximum Temp (°C)
Precipitation_mm	Precipitation	precmm
Mean_year_growth	MeanYearGrowth	Mean growth/year
sex	sex	M/F
weight	weight	w.
cell_type	CellType	Cell type
Observation_01	first_observation	1st Obs.

Dates

- YYYY-MM-DD ISO8601

	A	B	C
1	Date	Assay date	Weight
2		12/9/05	54.9
3		12/9/05	45.3
4	12/6/2005	e	47
5		e	45.7
6		e	52.9
7		1/11/2006	46.1
8		1/11/2006	38.6

Figure 1. A spreadsheet with inconsistent date formats. This spreadsheet does not adhere to our recommendations for consistency of date format.

No Empty Cells

- Empty vs NA

A

	A	B	C
1	id	date	glucose
2	101	2015–06–14	149.3
3	102		95.3
4	103	2015–06–18	97.5
5	104		117.0
6	105		108.0
7	106	2015–06–20	149.0
8	107		169.4

B

	A	B	C	D	E	F	G	H	I
1		1 min				5 min			
2	strain	normal		mutant		normal		mutant	
3	A	147	139	166	179	334	354	451	474
4	B	246	240	178	172	514	611	412	447

One Thing Per Cell

- a place for everything and everything in its place

Finally, do not merge cells. It might look pretty, but you end up breaking the rule of *no empty cells*.

Rectangle

A

	A	B	C	D	E	F
1						
2		101	102	103	104	105
3	sex	Male	Female	Male	Male	Male
4						
5		101	102	103	104	105
6	glucose	134.1	120.0	124.8	83.1	105.2
7						
8		101	102	103	104	105
9	insulin	0.60	1.18	1.23	1.16	0.73

B

	A	B	C	D	E	F	G
1	1MIN						
2			Normal			Mutant	
3	B6	146.6	138.6	155.6	166	179.3	186.9
4	BTBR	245.7	240	243.1	177.8	171.6	188.1
5							
6	5MIN						
7			Normal			Mutant	
8	B6	333.6	353.6	408.8	450.6	474.4	423.8
9	BTBR	514.4	610.6	597.9	412.1	447.4	446.5

C

	A	B	C	D	E	F	G
1							
2	Date	11/3/14					
3	Days on diet	126					
4	Mouse #	43					
5	sex	f					
6	experiment		values			mean	SD
7	control		0.186	0.191	1.081	0.49	0.52
8	treatment A		7.414	1.468	2.254	3.71	3.23
9	treatment B		9.811	9.259	11.296	10.12	1.05
10							
11	fold change		values			mean	SD
12	treatment A		15.26	3.02	4.64	7.64	6.65
13	treatment B		20.19	19.05	23.24	20.83	2.17

D

	A	B	C	D	E	F
1		GTT date	GTT weight	time	glucose mg/dl	insulin ng/ml
2	321	2/9/15	24.5	0	99.2	lo off curve
3				5	349.3	0.205
4				15	286.1	0.129
5				30	312	0.175
6				60	99.9	0.122
7				120	217.9	lo off curve
8	322	2/9/15	18.9	0	185.8	0.251
9				5	297.4	2.228
10				15	439	2.078
11				30	362.3	0.775
12				60	232.7	0.5
13				120	260.7	0.523
14	323	2/9/15	24.7	0	198.5	0.151
15				5	530.6	off curve lo

Figure 5. Examples of spreadsheets with nonrectangular layouts. These layouts are likely to cause problems in analysis.

Data Dictionary

- Metadata

	A	B	C	D
1	name	plot_name	group	description
2	mouse	Mouse	demographic	Animal identifier
3	sex	Sex	demographic	Male (M) or Female (F)
4	sac_date	Date of sac	demographic	Date mouse was sacrificed
5	partial_inflation	Partial inflation	clinical	Indicates if mouse showed partial pancreatic inflation
6	coat_color	Coat color	demographic	Coat color, by visual inspection
7	crumblers	Crumblers	clinical	Indicates if mouse stored food in their bedding
8	diet_days	Days on diet	clinical	Number of days on high–fat diet

Figure 9. An example data dictionary.

No Calcs in Data Files

- Really
- This will be difficult for some people

(Has this happened to you? You open an Excel file and start typing and nothing happens, and then you select a cell and you can start typing. Where did all of that initial text go? Well, sometimes it got entered into some random cell, to be discovered later during data analysis.)

Your primary data file should be a pristine store of data. Write-protect it, back it up, and do not touch it.

Colour & Highlights Are Not Data

A

	A	B	C
1	id	date	glucose
2	101	2015–06–14	149.3
3	102	2015–06–14	95.3
4	103	2015–06–18	97.5
5	104	2015–06–18	1.1
6	105	2015–06–18	108.0
7	106	2015–06–20	149.0
8	107	2015–06–20	169.4

B

	A	B	C	D
1	id	date	glucose	outlier
2	101	2015–06–14	149.3	FALSE
3	102	2015–06–14	95.3	FALSE
4	103	2015–06–18	97.5	FALSE
5	104	2015–06–18	1.1	TRUE
6	105	2015–06–18	108.0	FALSE
7	106	2015–06–20	149.0	FALSE
8	107	2015–06–20	169.4	FALSE

Figure 10. Highlighting in spreadsheets. (a) A potential outlier indicated by highlighting the cell. (b) The preferred method for indicating outliers, via an additional column.

Backups

- March 31 is World Backup Day
- http://www.worldbackupday.com

Data Validation

- Feature in spreadsheets
  to help with data entry

Save Plain Text

- Good test

A

	A	B	C	D	E
1	id	sex	glucose	insulin	triglyc
2	101	Male	134.1	0.60	273.4
3	102	Female	120.0	1.18	243.6
4	103	Male	124.8	1.23	297.6
5	104	Male	83.1	1.16	142.4
6	105	Male	105.2	0.73	215.7

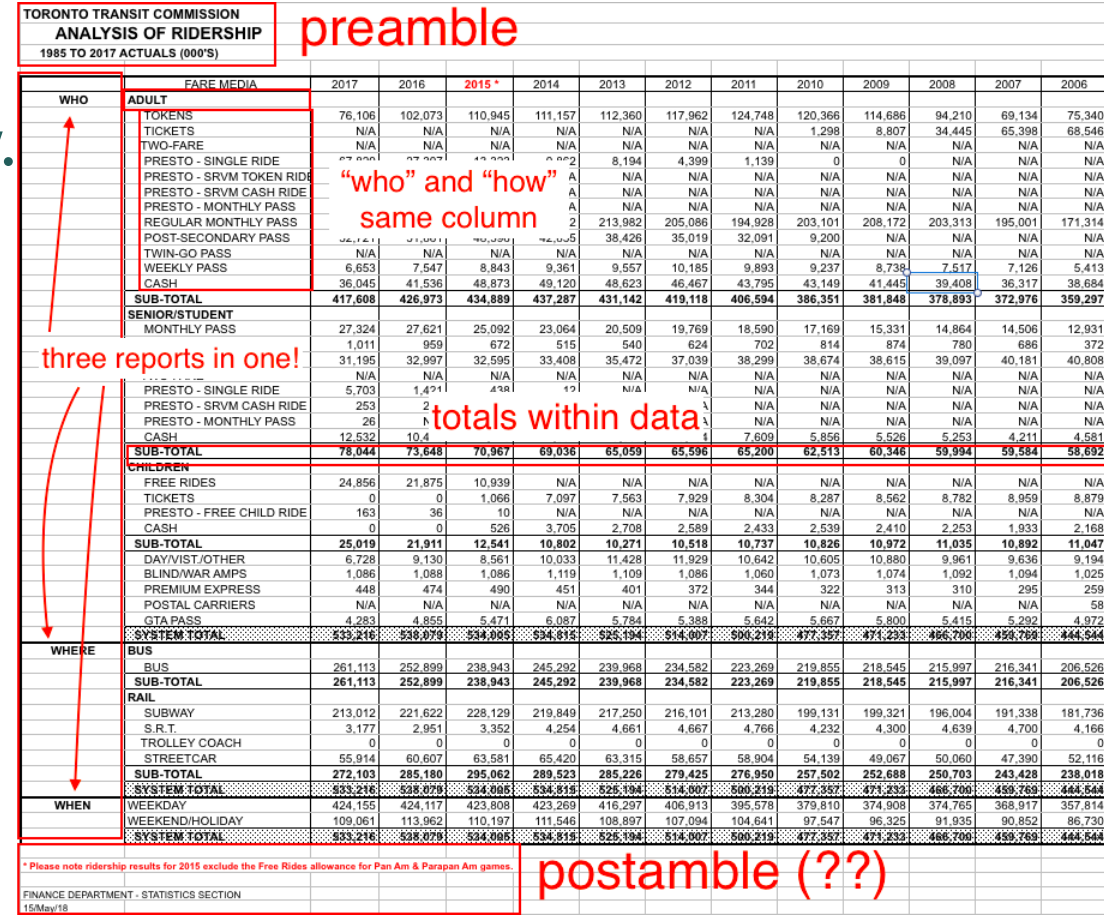
B

```
id,sex,glucose,insulin,triglyc
101,Male,134.1,0.60,273.4
102,Female,120.0,1.18,243.6
103,Male,124.8,1.23,297.6
104,Male,83.1,1.16,142.4
105,Male,105.2,0.73,215.7
```

Figure 11. (a) An example spreadsheet. (b) The same data as a plain text file in CSV format.

A TTC Example

- Sharla Gelfand
  https://sharlagelfand.netlify.app/posts/tidy-ttc/
- https://open.toronto.ca/dataset/ttc-ridership-analysis/



TORONTO TRANSIT COMMISSION
ANALYSIS OF RIDERSHIP
1985 TO 2017 ACTUALS (000'S)

preamble

	FARE MEDIA	2017	2016	2015 *	2014	2013	2012	2011	2010	2009	2008	2007	2006
WHO	ADULT												
	TOKENS	76,106	102,073	110,945	111,157	112,360	117,962	124,748	120,366	114,686	94,210	69,134	75,340
	TICKETS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,298	8,807	34,445	65,398	68,546
	TWO-FARE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PRESTO - SINGLE RIDE				2	8,194	4,399	1,139	0	0	N/A	N/A	N/A
	PRESTO - SRVM TOKEN RIDE				A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PRESTO - SRVM CASH RIDE				A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PRESTO - MONTHLY PASS				A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	REGULAR MONTHLY PASS				2	213,982	205,086	194,928	203,101	208,172	203,313	195,001	171,314
	POST-SECONDARY PASS					38,426	35,019	32,091	9,200	N/A	N/A	N/A	N/A
	TWIN-GO PASS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	WEEKLY PASS	6,653	7,547	8,843	9,361	9,557	10,185	9,893	9,237	8,738	7,517	7,126	5,413
	CASH	36,045	41,536	48,873	49,120	48,623	46,467	43,795	43,149	41,445	39,408	36,317	38,684
	SUB-TOTAL	**417,608**	**426,973**	**434,889**	**437,287**	**431,142**	**419,118**	**406,594**	**386,351**	**381,848**	**378,893**	**372,976**	**359,297**
	SENIOR/STUDENT												
	MONTHLY PASS	27,324	27,621	25,092	23,064	20,509	19,769	18,590	17,169	15,331	14,864	14,506	12,931
		1,011	959	672	515	540	624	702	814	874	780	686	372
		31,195	32,997	32,595	33,408	35,472	37,039	38,299	38,674	38,615	39,097	40,181	40,808
		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PRESTO - SINGLE RIDE	5,703	1,421	438	12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PRESTO - SRVM CASH RIDE	253	2					N/A	N/A	N/A	N/A	N/A	N/A
	PRESTO - MONTHLY PASS	26	N					N/A	N/A	N/A	N/A	N/A	N/A
	CASH	12,532	10,4				1	7,609	5,856	5,526	5,253	4,211	4,581
	SUB-TOTAL	**78,044**	**73,648**	**70,967**	**69,036**	**65,059**	**65,596**	**65,200**	**62,513**	**60,346**	**59,994**	**59,584**	**58,692**
	CHILDREN												
	FREE RIDES	24,856	21,875	10,939	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	TICKETS	0	0	1,066	7,097	7,563	7,929	8,304	8,287	8,562	8,782	8,959	8,879
	PRESTO - FREE CHILD RIDE	163	36	10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	CASH	0	0	526	3,705	2,708	2,589	2,433	2,539	2,410	2,253	1,933	2,168
	SUB-TOTAL	**25,019**	**21,911**	**12,541**	**10,802**	**10,271**	**10,518**	**10,737**	**10,826**	**10,972**	**11,035**	**10,892**	**11,047**
	DAY/VIST./OTHER	6,728	9,130	8,561	10,033	11,428	11,929	10,642	10,605	10,880	9,961	9,636	9,194
	BLIND/WAR AMPS	1,086	1,088	1,086	1,119	1,109	1,086	1,060	1,073	1,074	1,092	1,094	1,025
	PREMIUM EXPRESS	448	474	490	451	401	372	344	322	313	310	295	259
	POSTAL CARRIERS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	58
	GTA PASS	4,283	4,855	5,471	6,087	5,784	5,388	5,642	5,667	5,800	5,415	5,292	4,972
	SYSTEM TOTAL	533,216	528,079	534,005	534,815	525,194	514,007	500,219	477,357	471,233	466,700	459,769	444,544
WHERE	BUS												
	BUS	261,113	252,899	238,943	245,292	239,968	234,582	223,269	219,855	218,545	215,997	216,341	206,526
	SUB-TOTAL	**261,113**	**252,899**	**238,943**	**245,292**	**239,968**	**234,582**	**223,269**	**219,855**	**218,545**	**215,997**	**216,341**	**206,526**
	RAIL												
	SUBWAY	213,012	221,622	228,129	219,849	217,250	216,101	213,280	199,131	199,321	196,004	191,338	181,736
	S.R.T.	3,177	2,951	3,352	4,254	4,661	4,667	4,766	4,232	4,300	4,639	4,700	4,166
	TROLLEY COACH	0	0	0	0	0	0	0	0	0	0	0	0
	STREETCAR	55,914	60,607	63,581	65,420	63,315	58,657	58,904	54,139	49,067	50,060	47,390	52,116
	SUB-TOTAL	**272,103**	**285,180**	**295,062**	**289,523**	**285,226**	**279,425**	**276,950**	**257,502**	**252,688**	**250,703**	**243,428**	**238,018**
	SYSTEM TOTAL	533,216	528,079	534,005	534,815	525,194	514,007	500,219	477,357	471,233	466,700	459,769	444,544
WHEN	WEEKDAY	424,155	424,117	423,808	423,269	416,297	406,913	395,578	379,810	374,908	374,765	368,917	357,814
	WEEKEND/HOLIDAY	109,061	113,962	110,197	111,546	108,897	107,094	104,641	97,547	96,325	91,935	90,852	86,730
	SYSTEM TOTAL	533,216	528,079	534,005	534,815	525,194	514,007	500,219	477,357	471,233	466,700	459,769	444,544

"who" and "how" same column

three reports in one!

totals within data

* Please note ridership results for 2015 exclude the Free Rides allowance for Pan Am & Parapan Am games.

FINANCE DEPARTMENT - STATISTICS SECTION
15/May/18

postamble (??)

Homework

- Pick a year: https://doi.org/10.5683/SP3/OUWVZ3 (physical, chemical, biological)
- Use this: https://doi.org/10.5683/SP2/TNYTQL
  “NW-20-C2-Chronology-Dspec50-2019-with-self-attenuation-SimpleView.xlsx”
  “NW-50-Chronology-Dspec649-2019-withdensity-SIMPLEVIEW with graphs v3.tab”