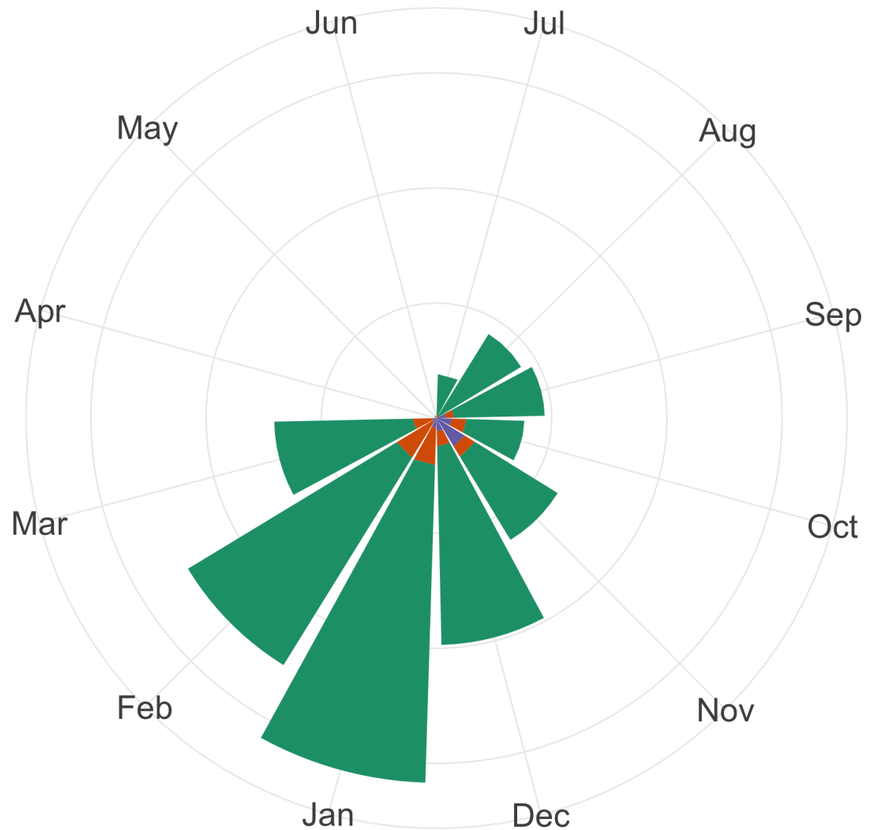
Scientific Data Visualizations

CORH 203

Mathew Vis-Dunbar

October, 2022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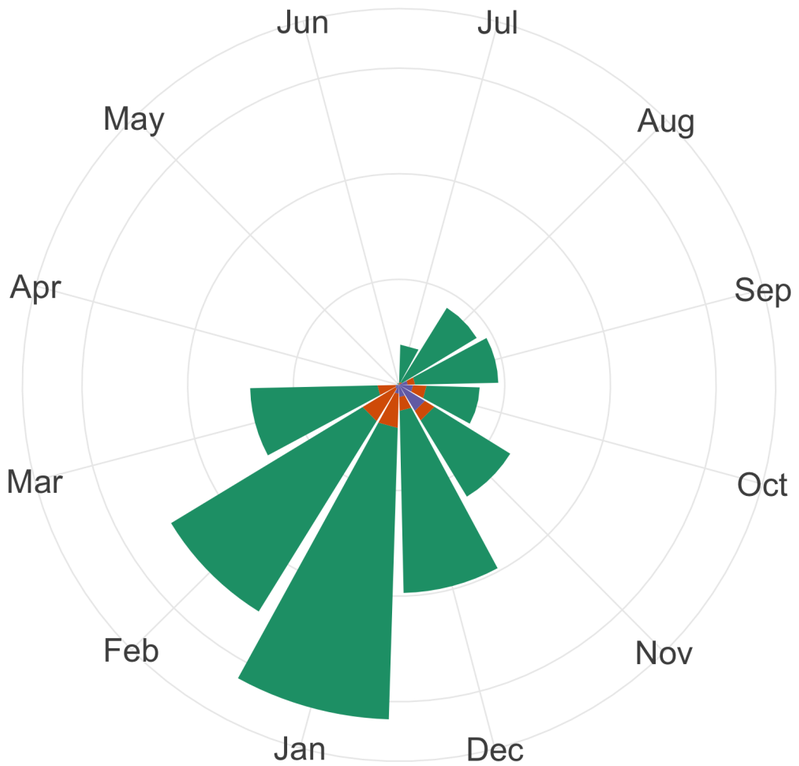
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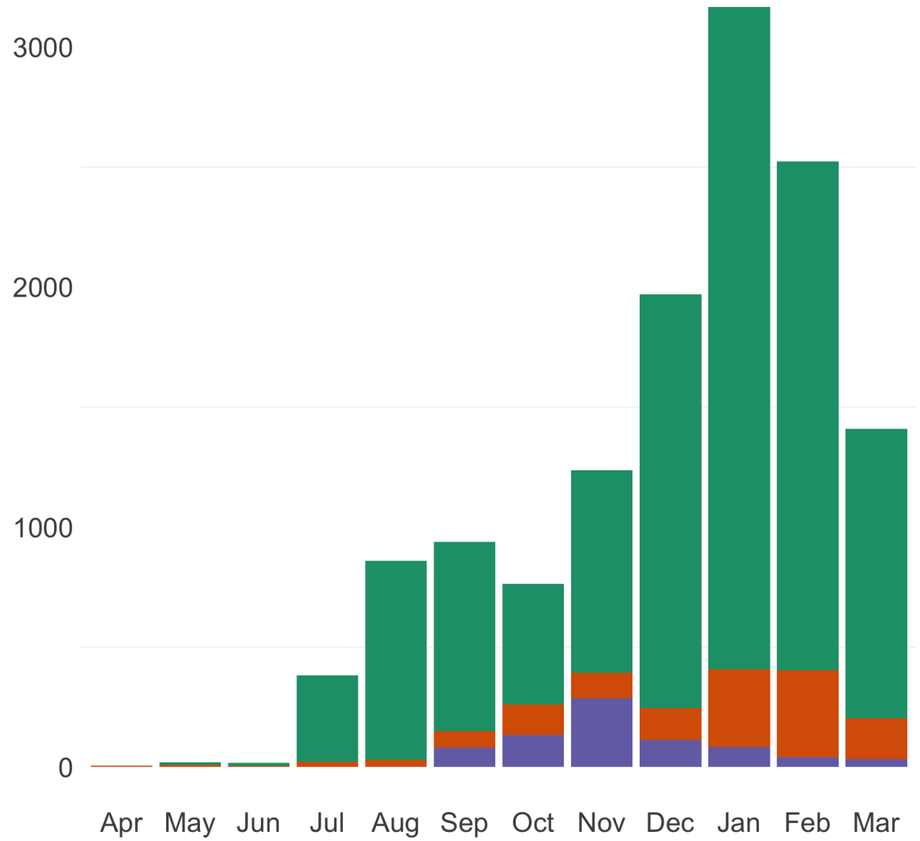
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135 202 210 210 215 217 230 230 233 237 246 250 250 250 255 259 260 260 265 268 270 276 280 280 280 281 286 290 291 300 300 300 301 306 310 310 314 315 320 325 327 329 330 332 336 338 340 350 350 350 350 352 360 360 360 360 375 377 380 380 383 390 390 392 407 410 411 420 420 424 425 430 431 435 444 445 450 460 460 465 470 490 500 500 505 524 525 525 529 538 540 545 560 570 600 600 600 605 610 618 620 625 630 652 671 680 696 710 720 720 730 735 735 760 780 800 840 850 870 890 900 900 906 981 1000 1038 1054 1100 1171 1205 1243 1270 1306 1450 1459 1770 1885 2315 2348 2533 3710

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Show 10 entries Search:

River Length	Count
135	1
202	1
210	2
215	1
217	1
230	2
233	1
237	1
246	1
250	3

Showing 1 to 10 of 114 entries

Previous 1 2 3 4 5 … 12 Next

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##    3 | 000011112233333444555556666888889999
##    4 | 111222333445566779
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##   34 |
##   35 |
##   36 |
##   37 | 1
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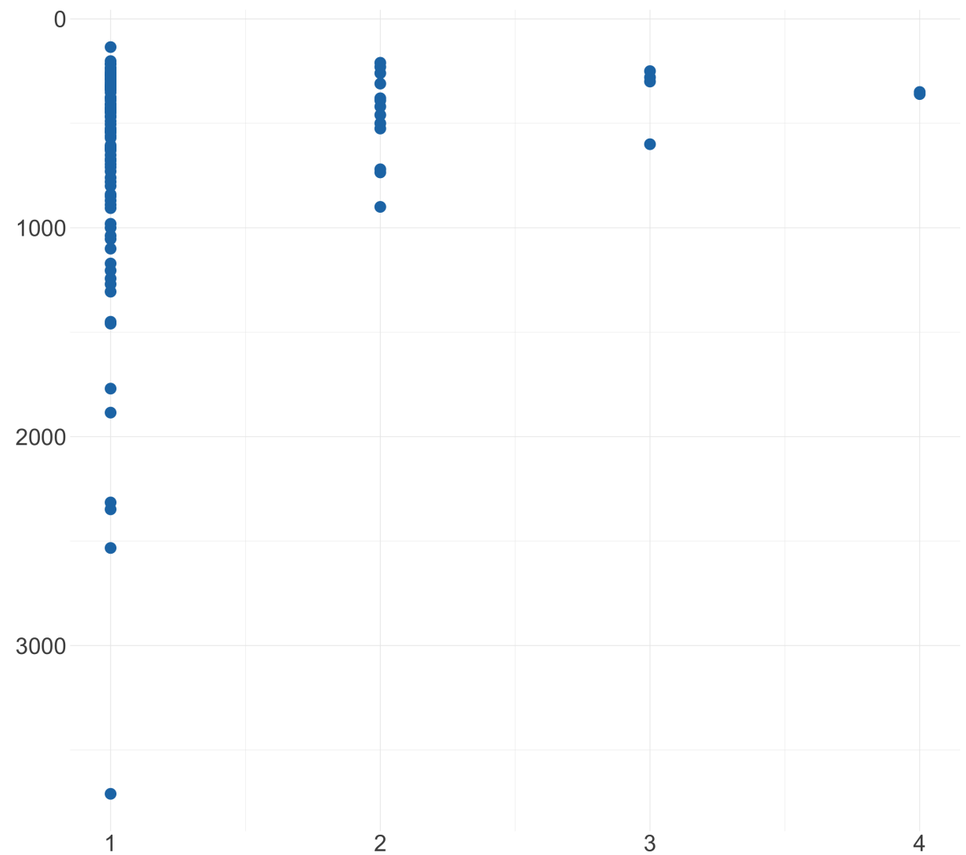

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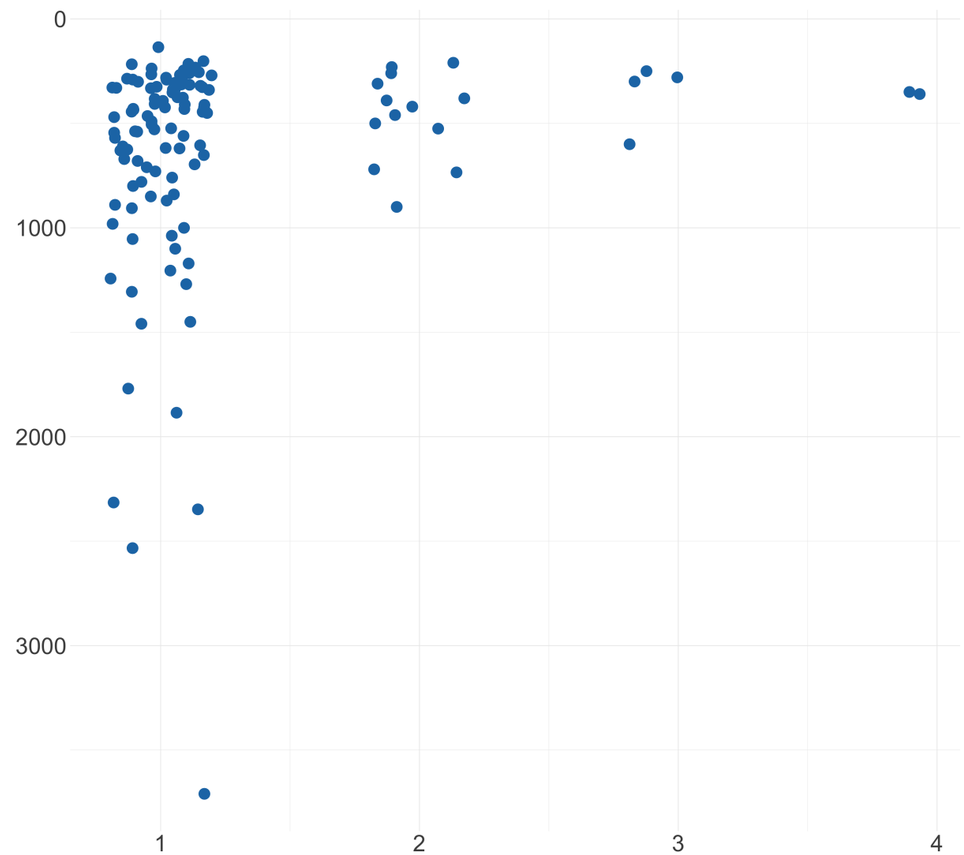

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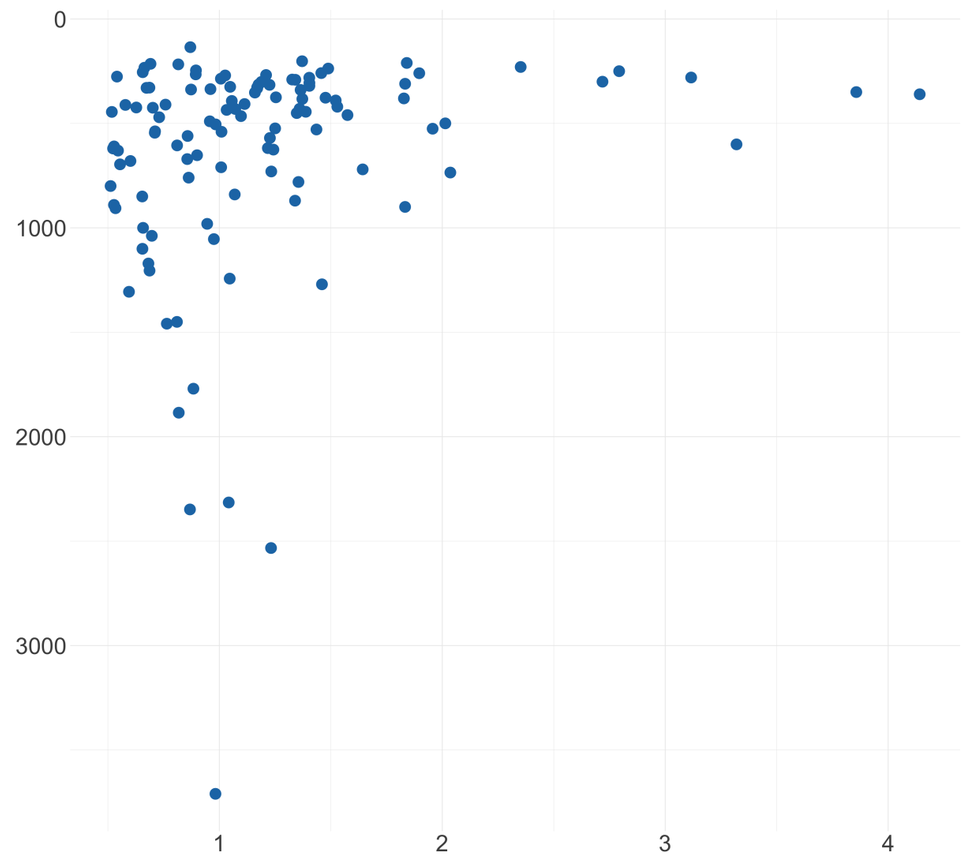

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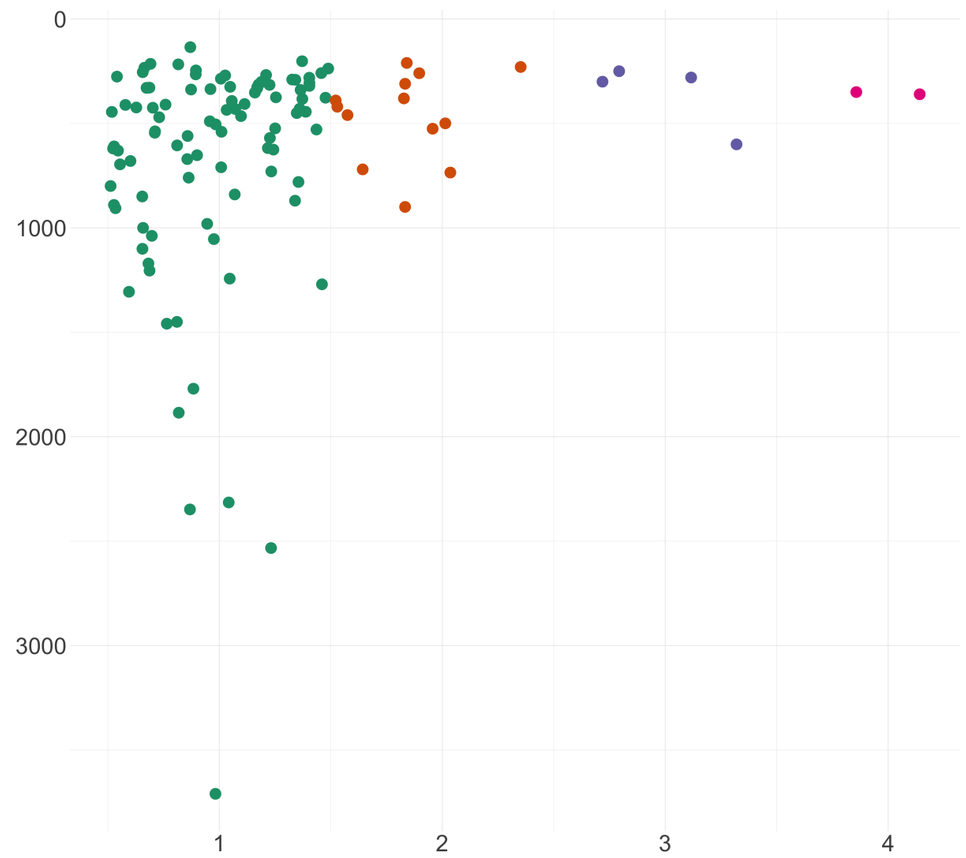

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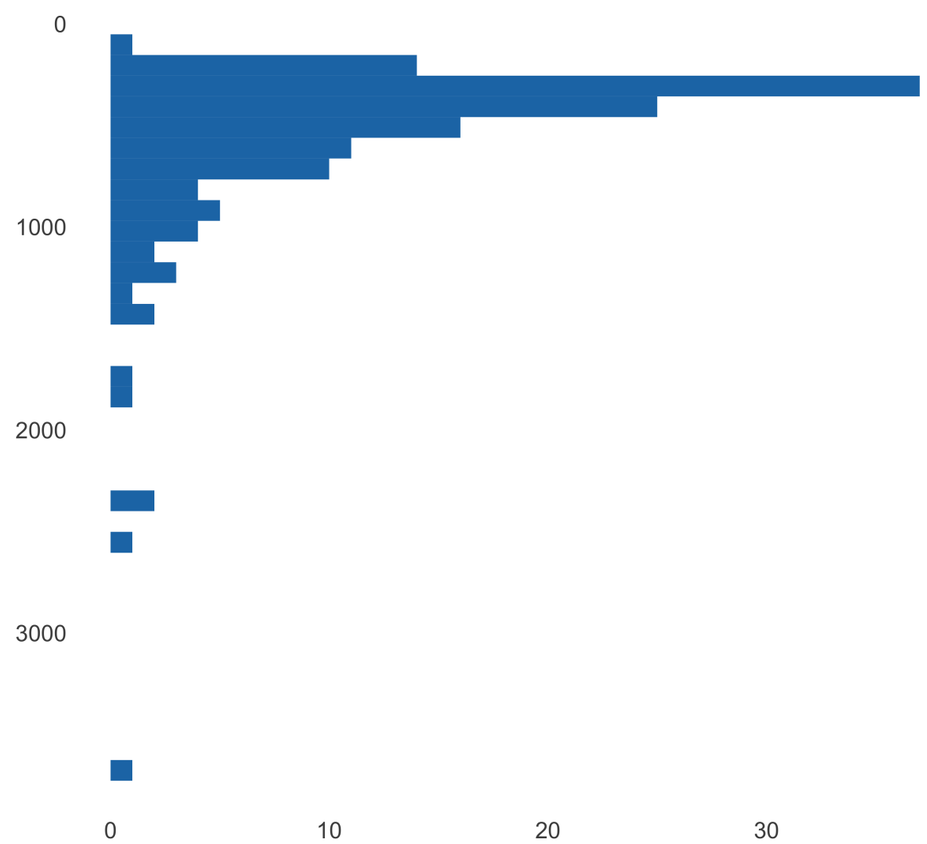

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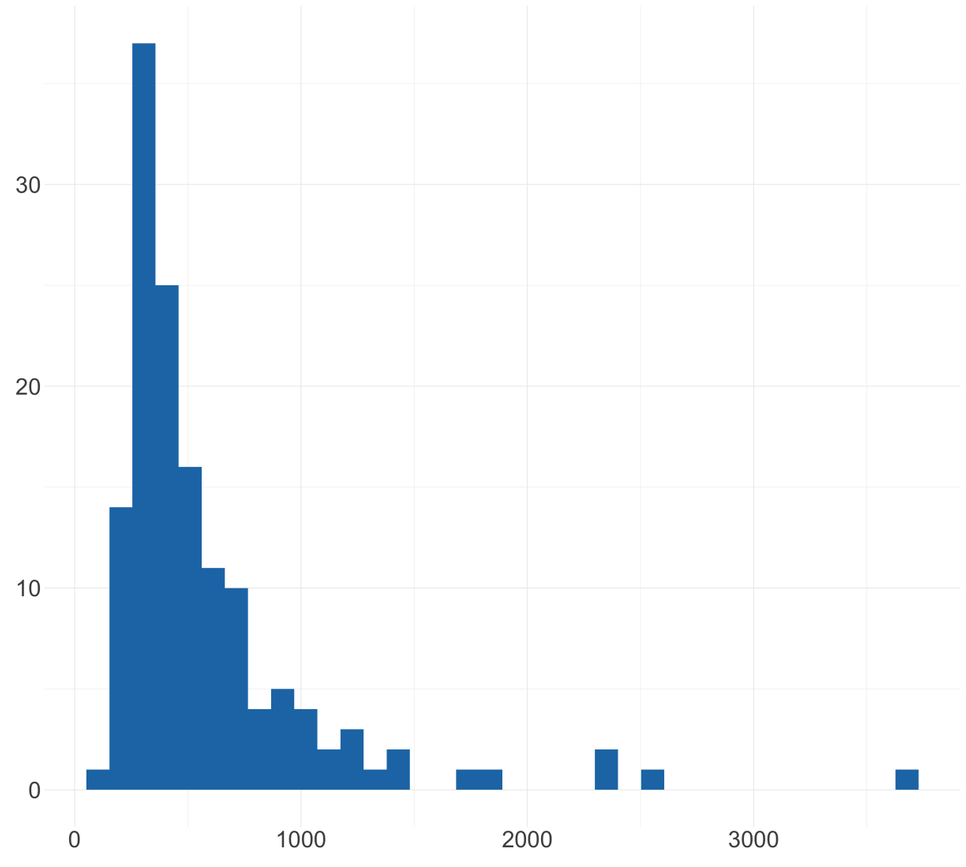

Overview

- What we're not talking about
- What is data visualization
- Why we visualize data
- Visual attributes & perception
- Data types & graphs
- Visual layering of content
- Questionable approaches to graphing
- Scientific data, transparency, and reproducibility

What We're Not Talking About

- 3D visualizations
- Info graphics

What is Data Visualization?

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Data visualization turns data into visual information. We could turn data into auditory or tactile information as well.

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This involves abstraction as shapes, colours etc are used represent the data.

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Data visualization turns data into visual information. We could turn data into auditory or tactile information as well.

This involves abstraction as shapes, colours etc which are used represent the data.

Visual and data literacies are needed to interpret both the data and the abstraction.

Why Do We Visualize Data?

A Defintion

Data visualization is the graphical display of abstract information for two purposes: sense-making (also called data analysis) and communication.

Stephen Few. Data Visualization for Human Perception.

Attributes & Perception

Even though an object as a whole might take some conscious effort to identify, the basic visual attributes that combine to make up that object are perceived without any conscious effort.

Stephen Few (2004). Tapping the Power of Visual Perception.

An Example

3	9	7	9	9	1	9	5	3	5
3	9	5	2	4	2	7	5	8	6
2	9	7	5	6	4	3	8	3	8
6	3	9	8	8	5	8	3	8	4
3	8	9	2	6	6	9	2	1	7
4	7	7	1	6	3	3	2	7	4
6	9	5	9	7	9	7	6	7	3
9	3	7	9	1	4	3	4	7	9
2	4	5	6	6	6	7	1	6	7
3	1	6	5	2	9	6	6	7	6

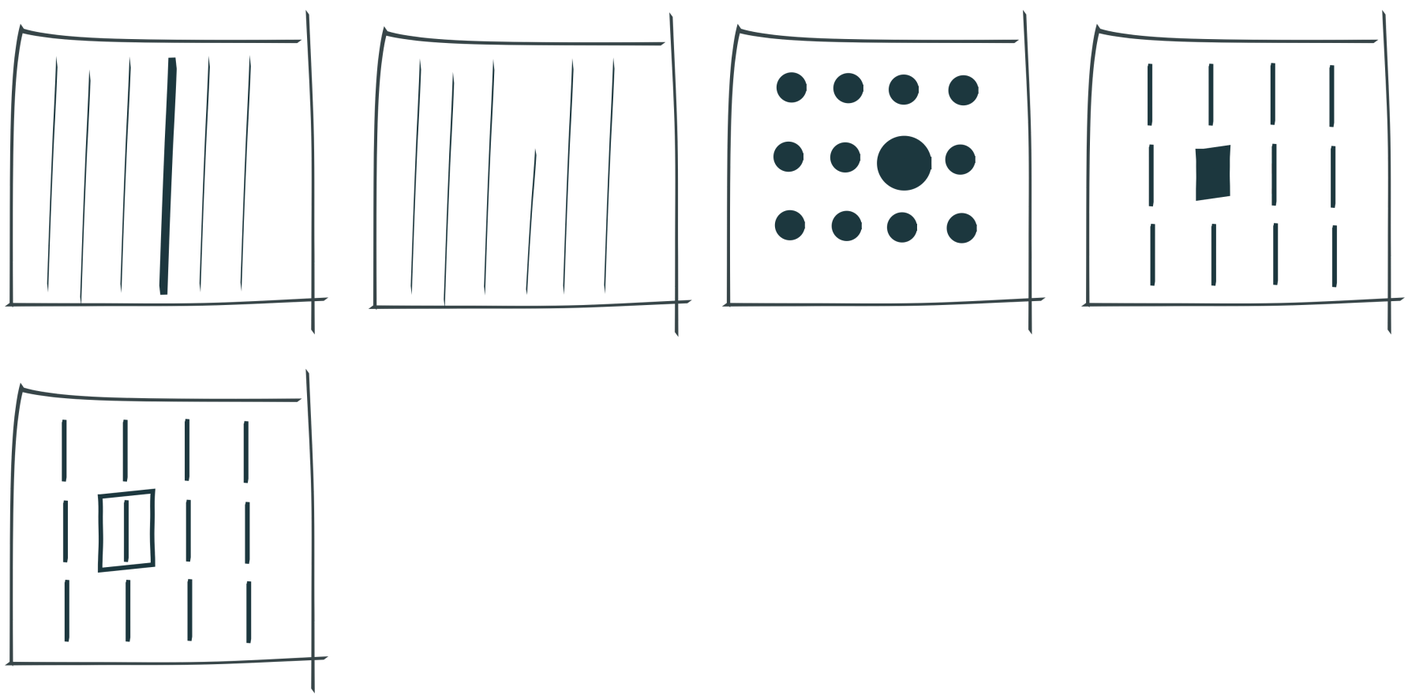
An Example

3	9	7	9	9	1	9	**5**	3	**5**
3	9	**5**	2	4	2	7	**5**	8	6
2	9	7	**5**	6	4	3	8	3	8
6	3	9	8	8	**5**	8	3	8	4
3	8	9	2	6	6	9	2	1	7
4	7	7	1	6	3	3	2	7	4
6	9	**5**	9	7	9	7	6	7	3
9	3	7	9	1	4	3	4	7	9
2	4	**5**	6	6	6	7	1	6	7
3	1	6	**5**	2	9	6	6	7	6

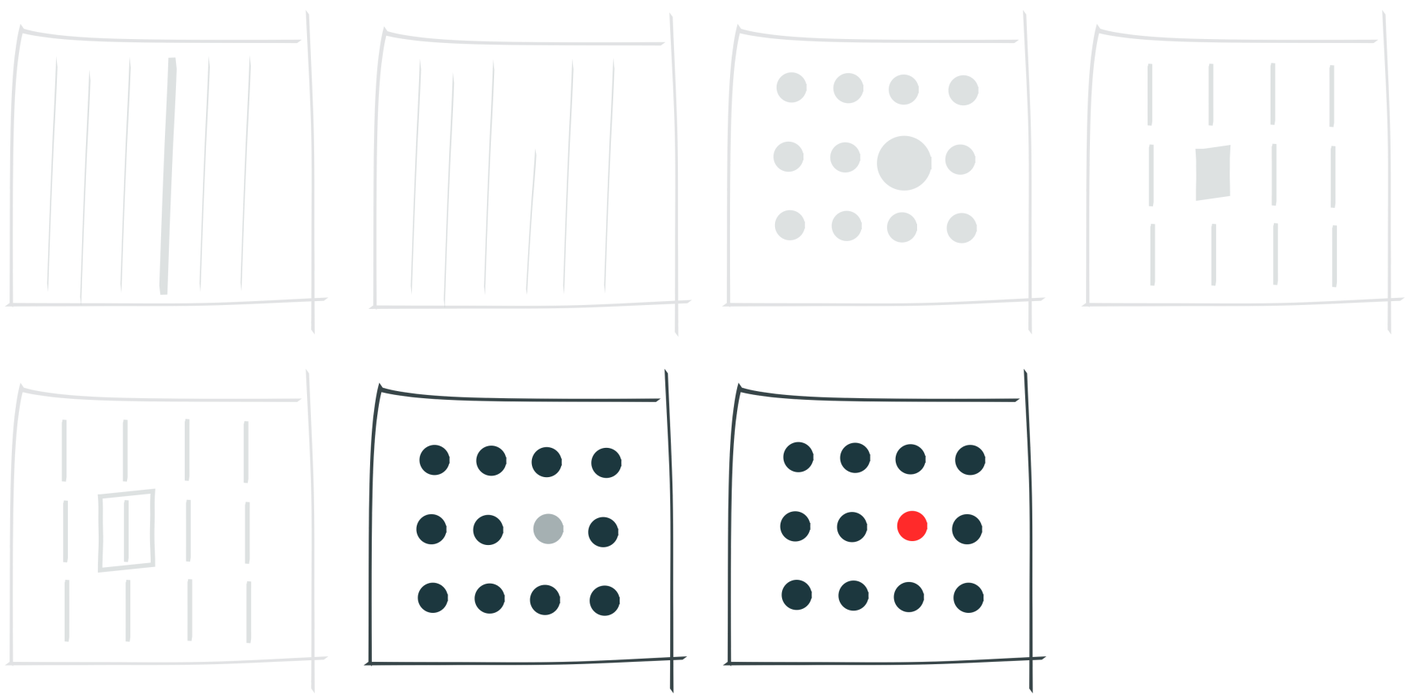
Preattentive Attributes

- Form
- Colour
- Position

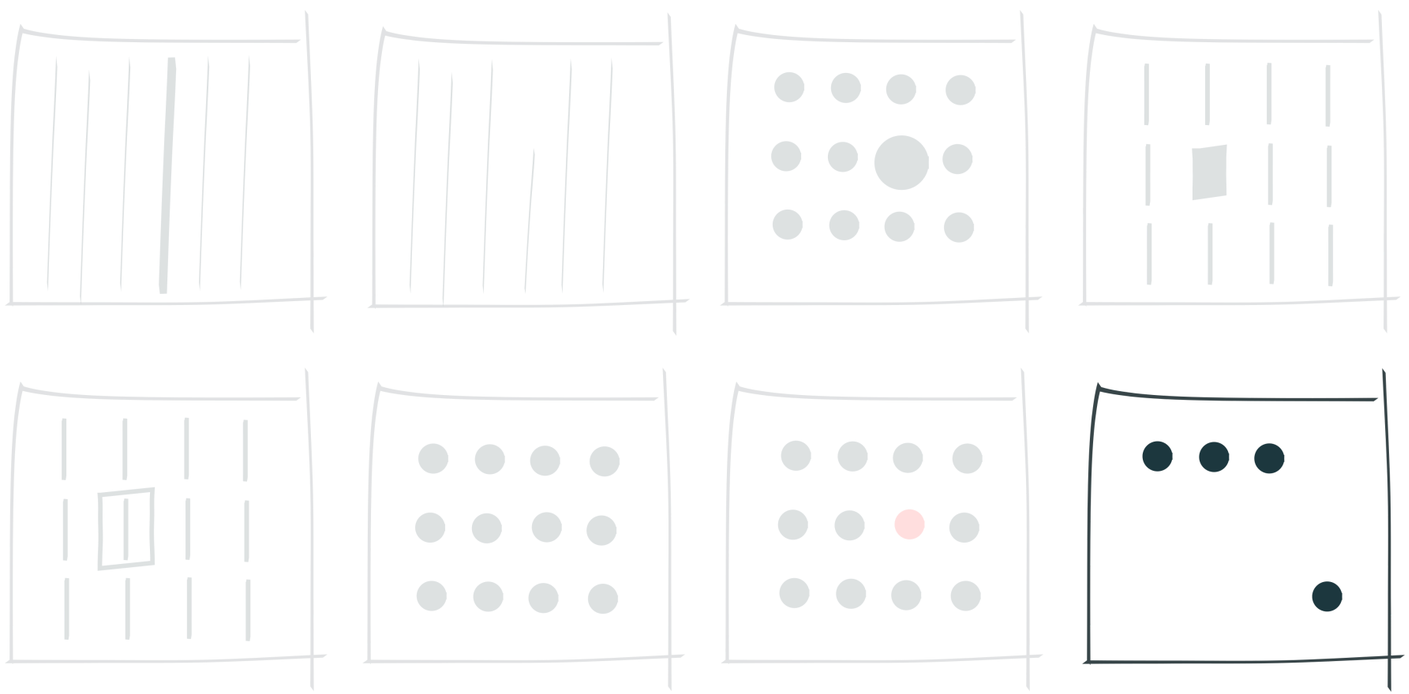
Form



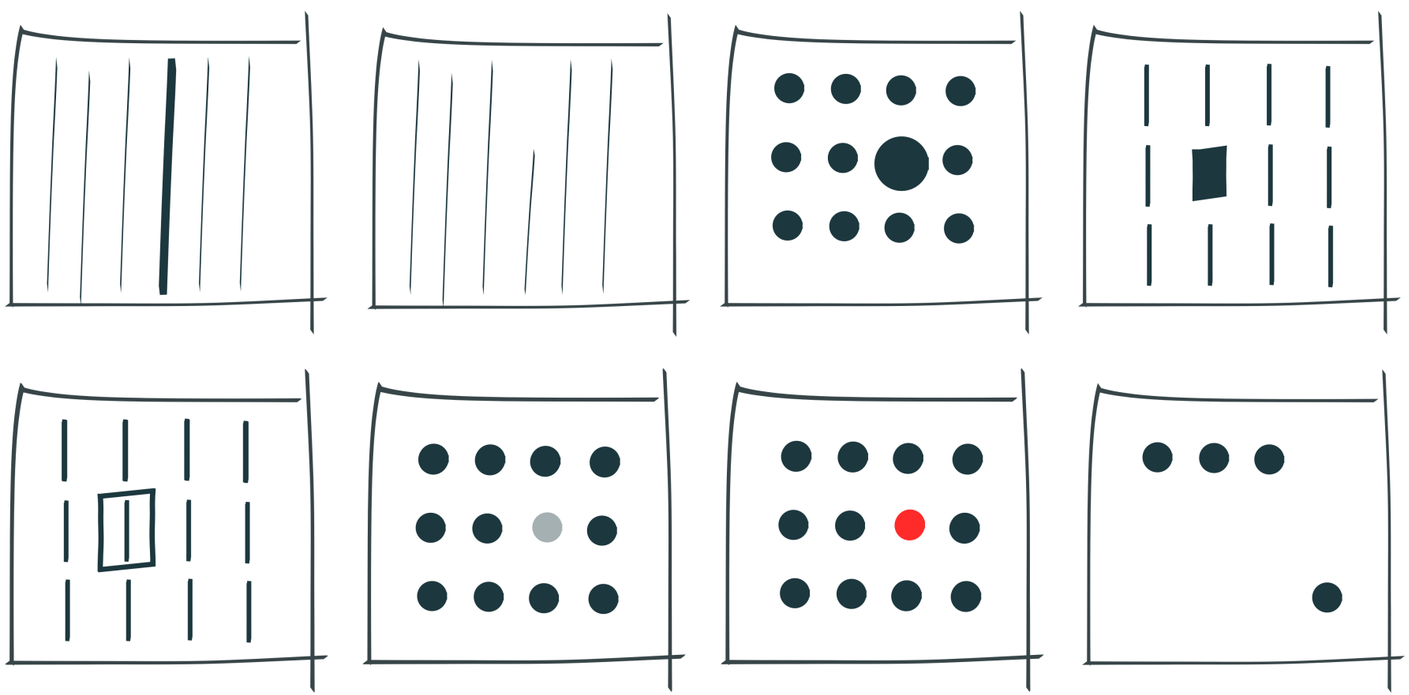
Colour



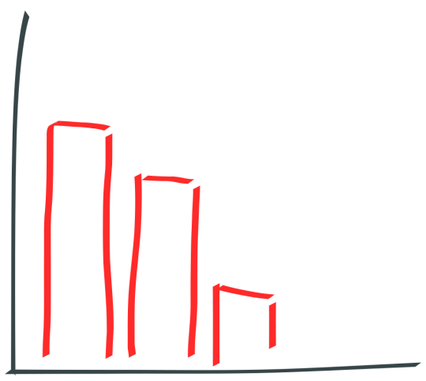
Position

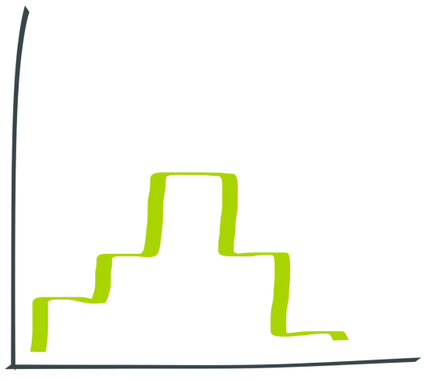


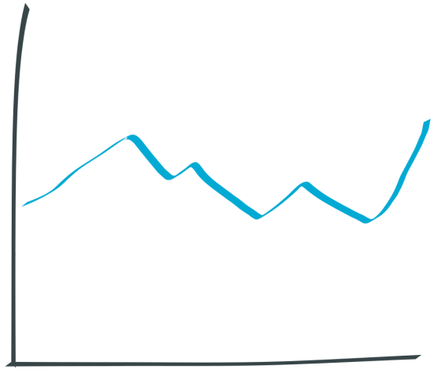
Preattentive Attributes

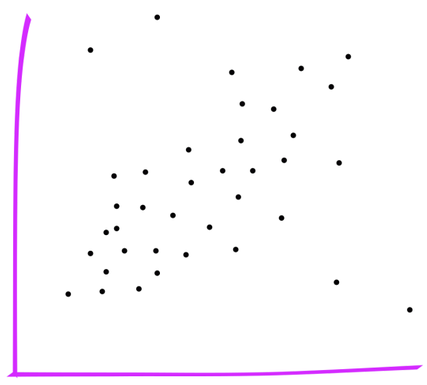


Common Visualizations

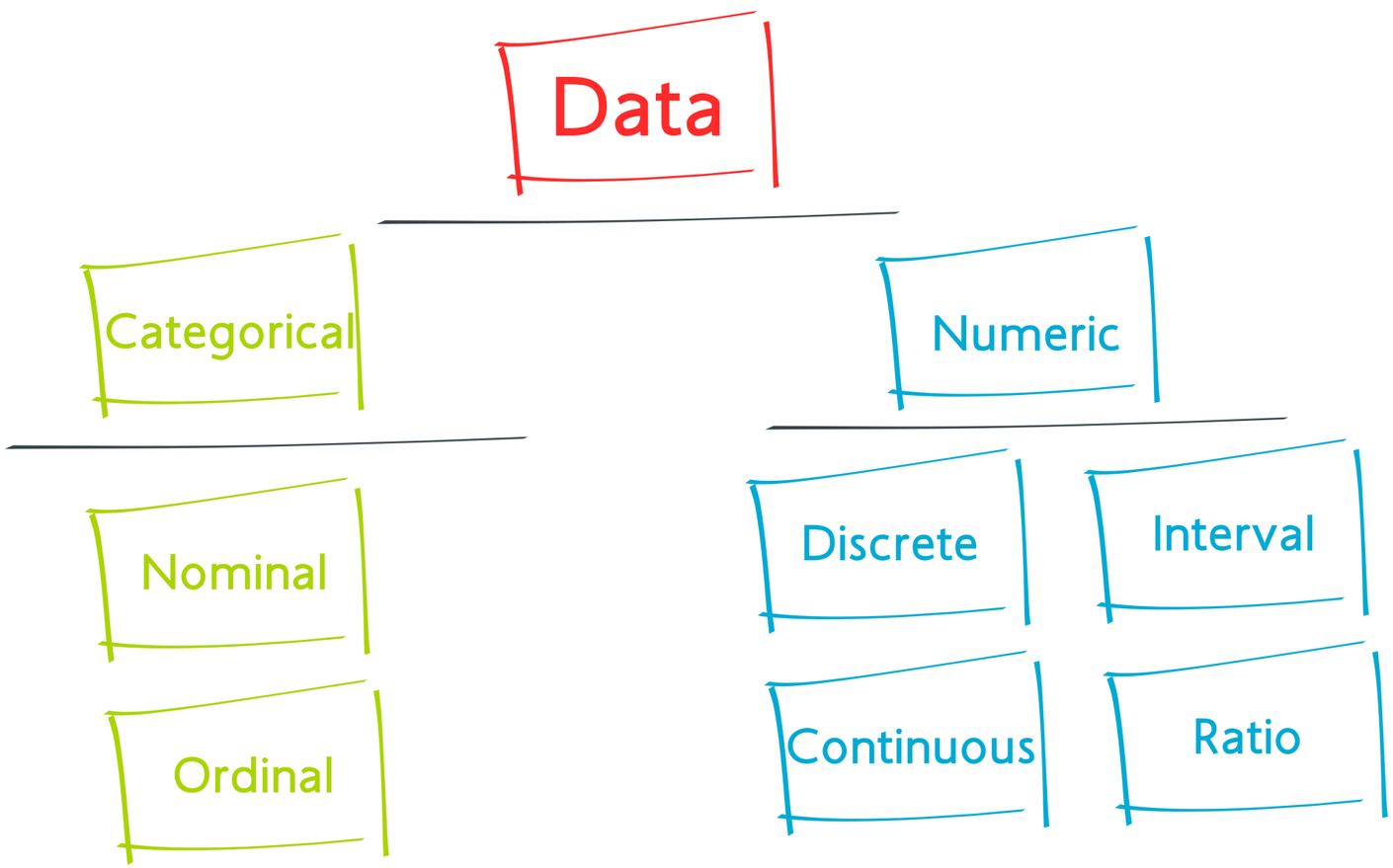








Basic Data Types



Categorical Data

Nominal data

No order

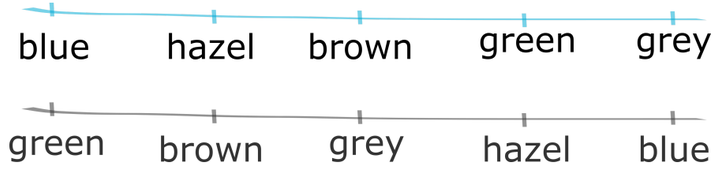
Ordinal data

Intrinsic order

Categorical Data

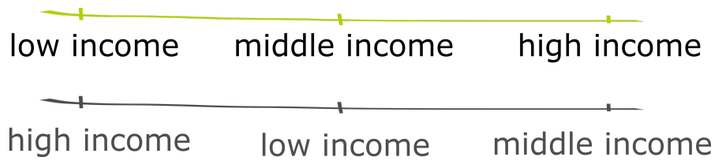
Nominal data

No order



Ordinal data

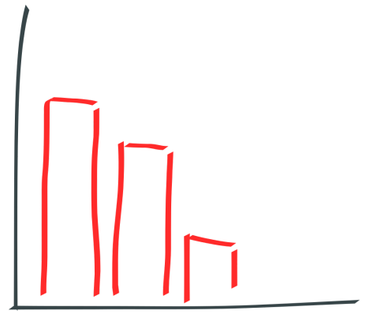
Intrinsic order



Bar Plots

Visualization tool

Frequency plots with bar charts



species	island	bill_length_mm	bill_depth_mm	flipper_length_mm	body_mass_g	sex	year
Chinstrap	Dream	43.5	18.1	202	3400	female	2009
Gentoo	Biscoe	43.6	13.9	217	4900	female	2008
Gentoo	Biscoe	48.1	15.1	209	5500	male	2009
Gentoo	Biscoe	46.8	14.3	215	4850	female	2009
Gentoo	Biscoe	48.5	14.1	220	5300	male	2008
Chinstrap	Dream	42.4	17.3	181	3600	female	2007
Gentoo	Biscoe	46.1	15.1	215	5100	male	2007
Adelie	Torgersen	35.5	17.5	190	3700	female	2008
Adelie	Torgersen	38.5	17.9	190	3325	female	2009
Chinstrap	Dream	52.8	20.0	205	4550	male	2008
Chinstrap	Dream	49.7	18.6	195	3600	male	2008
Adelie	Biscoe	37.6	17.0	185	3600	female	2008
Adelie	Dream	41.1	17.5	190	3900	male	2009
Gentoo	Biscoe	45.2	13.8	215	4750	female	2008
Chinstrap	Dream	47.0	17.3	185	3700	female	2007
Adelie	Biscoe	42.0	19.5	200	4050	male	2008
Adelie	Biscoe	45.6	20.3	191	4600	male	2009
Gentoo	Biscoe	46.2	14.5	209	4800	female	2007
Adelie	Dream	42.2	18.5	180	3550	female	2007
Adelie	Biscoe	43.2	19.0	197	4775	male	2009

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Gentoo	Biscoe	48.1	15.1	209	5500	male	2009
Gentoo	Biscoe	46.8	14.3	215	4850	female	2009
Gentoo	Biscoe	48.5	14.1	220	5300	male	2008
Chinstrap	Dream	42.4	17.3	181	3600	female	2007
Gentoo	Biscoe	46.1	15.1	215	5100	male	2007
Adelie	Torgersen	35.5	17.5	190	3700	female	2008
Adelie	Torgersen	38.5	17.9	190	3325	female	2009
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Chinstrap	Dream	49.7	18.6	195	3600	male	2008
Adelie	Biscoe	37.6	17.0	185	3600	female	2008
Adelie	Dream	41.1	17.5	190	3900	male	2009
Gentoo	Biscoe	45.2	13.8	215	4750	female	2008
Chinstrap	Dream	47.0	17.3	185	3700	female	2007
Adelie	Biscoe	42.0	19.5	200	4050	male	2008
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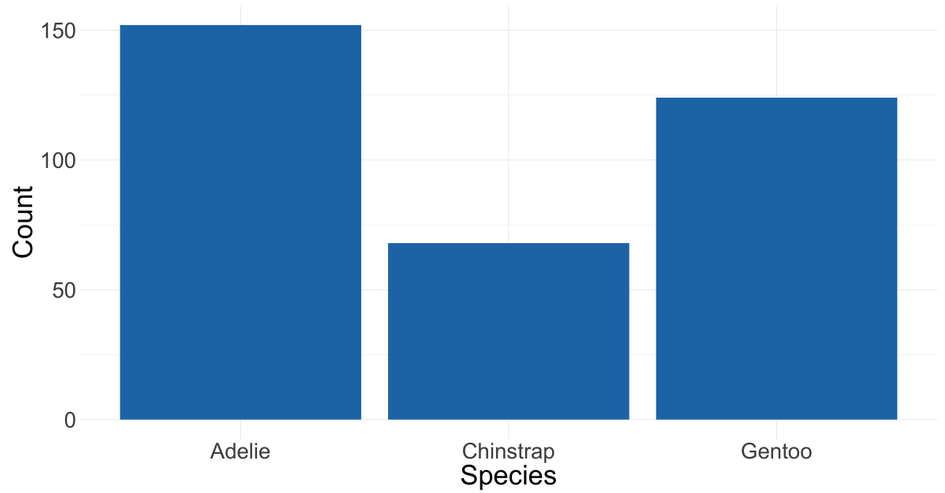
Gentoo	Biscoe	46.2	14.5	209	4800	female	2007
Adelie	Dream	42.2	18.5	180	3550	female	2007
Adelie	Biscoe	43.2	19.0	197	4775	male	2009


150
100
50
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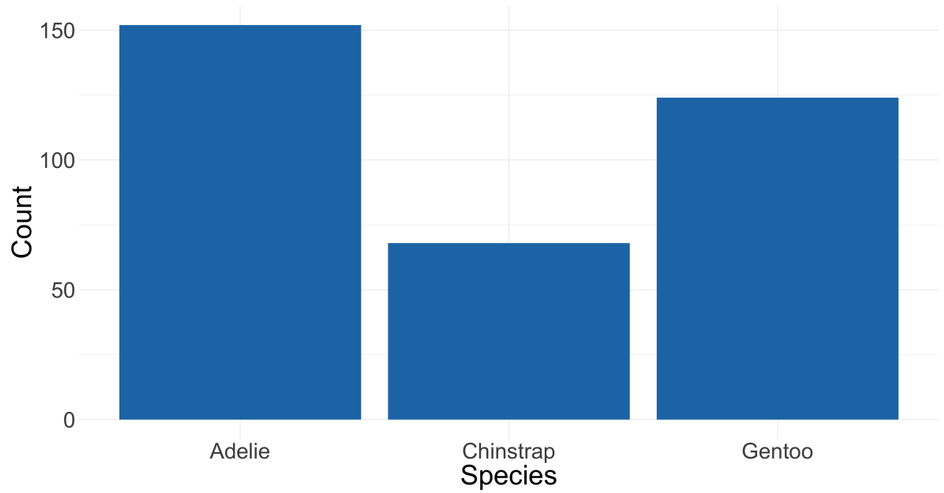
Count
Adelie
Chinstrap
Gentoo
Species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100
50
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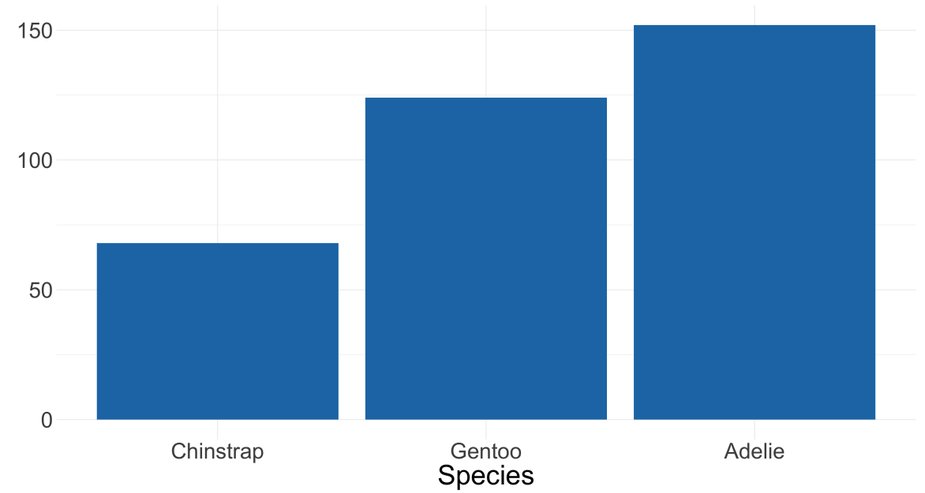
Count
Adelie
Chinstrap
Gentoo
Species


150
100
50
0
Chinstrap
Gentoo
Adelie
Species

carat	cut	color	clarity	depth	table	price	x	y	z
0.57	Ideal	G	VS2	61.6	57.0	1728	5.36	5.32	3.29
1.01	Ideal	D	SI2	61.3	54.0	4916	6.47	6.52	3.99
0.45	Fair	F	VS2	67.0	56.0	923	4.77	4.70	3.17
1.04	Premium	H	VVS2	59.1	60.0	6278	6.66	6.60	3.92
0.90	Very Good	G	VVS2	59.8	60.0	5102	6.23	6.28	3.74
1.20	Very Good	I	VS2	62.3	56.0	5955	6.76	6.81	4.23
1.25	Premium	F	I1	58.0	59.0	3724	7.12	7.05	4.11
1.52	Premium	G	VVS2	62.1	58.0	14105	7.40	7.31	4.57
1.03	Very Good	D	SI2	61.3	61.0	4679	6.46	6.49	3.97
0.44	Premium	E	SI1	62.3	58.0	778	4.85	4.88	3.03
1.13	Ideal	E	VVS2	60.1	59.0	11387	6.77	6.81	4.08
1.11	Good	H	SI2	63.5	60.3	4456	6.49	6.58	4.15
1.00	Fair	H	VS2	64.8	62.0	4861	6.22	6.13	4.00
0.44	Very Good	H	IF	61.1	57.0	1194	4.91	4.94	3.01
1.12	Ideal	G	VS1	61.0	56.0	7632	6.76	6.72	4.11
0.91	Ideal	H	VS2	62.4	56.0	4678	6.20	6.14	3.85
1.50	Premium	D	SI2	62.6	59.0	8108	7.20	7.23	4.52
1.03	Premium	E	SI2	61.8	59.0	4845	6.47	6.42	3.98
0.71	Fair	F	SI1	59.8	70.0	2458	5.89	5.72	3.48
1.32	Ideal	E	VS2	62.0	56.0	10919	7.02	7.07	4.37

carat	cut	color	clarity	depth	table	price	x	y	z
0.57	Ideal	G	VS2	61.6	57.0	1728	5.36	5.32	3.29
1.01	Ideal	D	SI2	61.3	54.0	4916	6.47	6.52	3.99
0.45	Fair	F	VS2	67.0	56.0	923	4.77	4.70	3.17
1.04	Premium	H	VVS2	59.1	60.0	6278	6.66	6.60	3.92
0.90	Very Good	G	VVS2	59.8	60.0	5102	6.23	6.28	3.74
1.20	Very Good	I	VS2	62.3	56.0	5955	6.76	6.81	4.23
1.25	Premium	F	I1	58.0	59.0	3724	7.12	7.05	4.11
1.52	Premium	G	VVS2	62.1	58.0	14105	7.40	7.31	4.57
1.03	Very Good	D	SI2	61.3	61.0	4679	6.46	6.49	3.97
0.44	Premium	E	SI1	62.3	58.0	778	4.85	4.88	3.03
1.13	Ideal	E	VVS2	60.1	59.0	11387	6.77	6.81	4.08
1.11	Good	H	SI2	63.5	60.3	4456	6.49	6.58	4.15
1.00	Fair	H	VS2	64.8	62.0	4861	6.22	6.13	4.00
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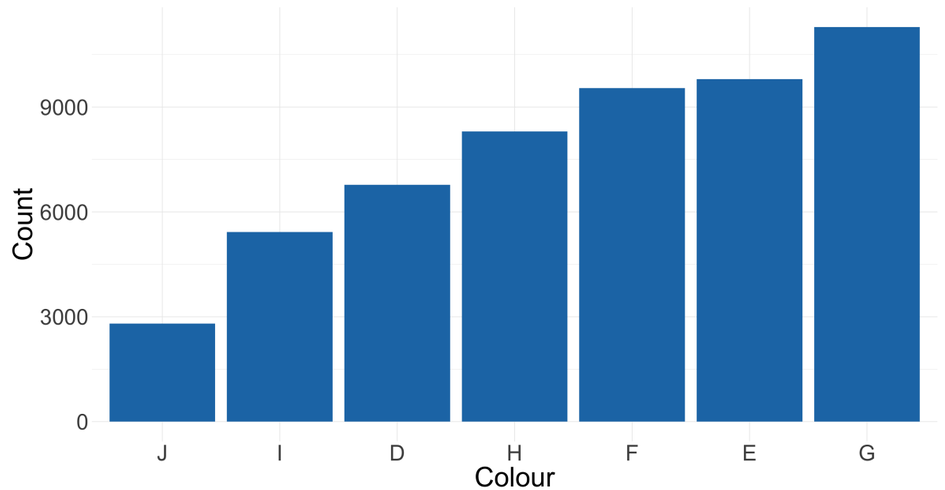
1.50	Premium	D	SI2	62.6	59.0	8108	7.20	7.23	4.52
1.03	Premium	E	SI2	61.8	59.0	4845	6.47	6.42	3.98
0.71	Fair	F	SI1	59.8	70.0	2458	5.89	5.72	3.48
1.32	Ideal	E	VS2	62.0	56.0	10919	7.02	7.07	4.37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6000
3000
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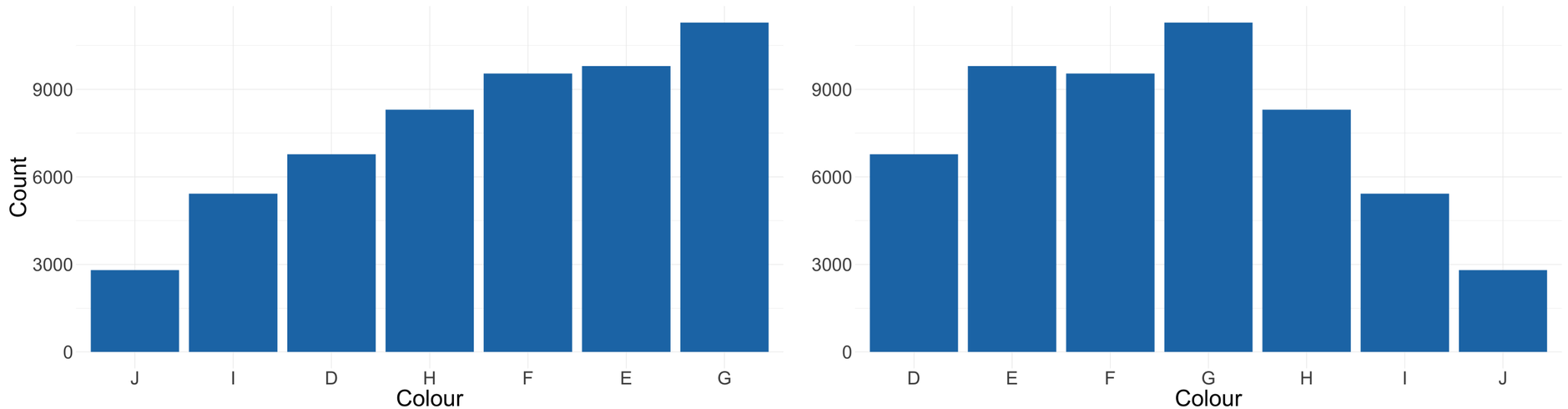
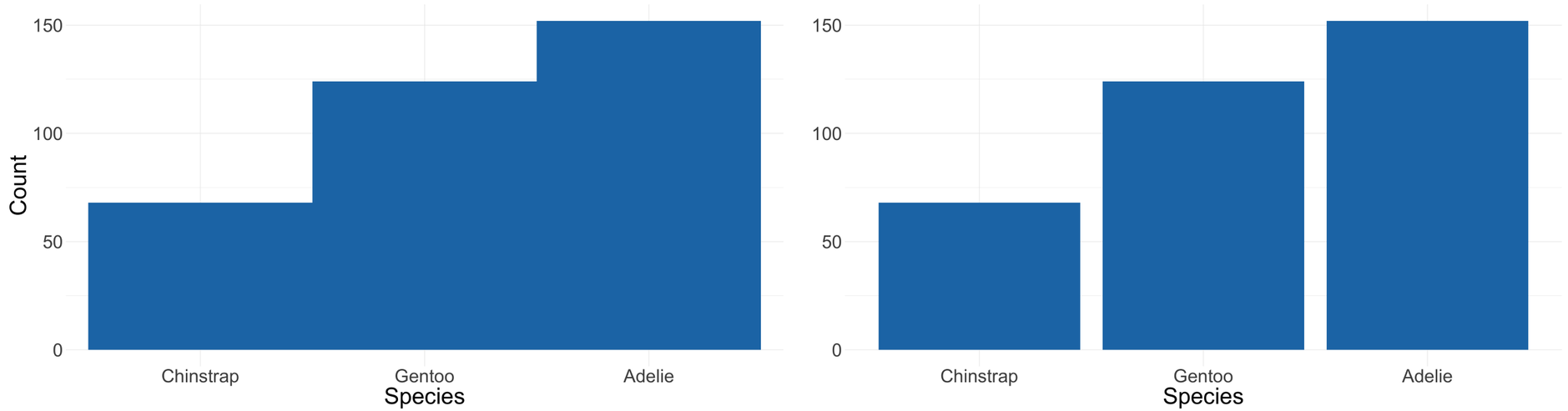
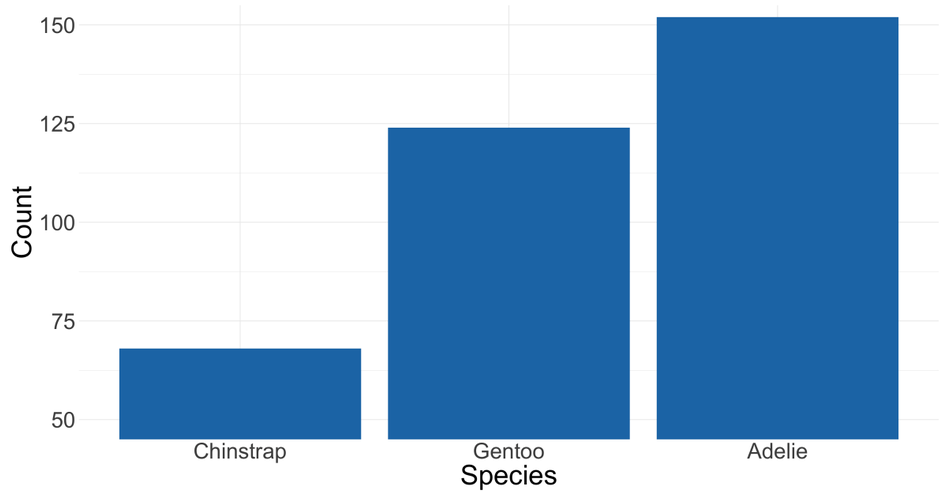
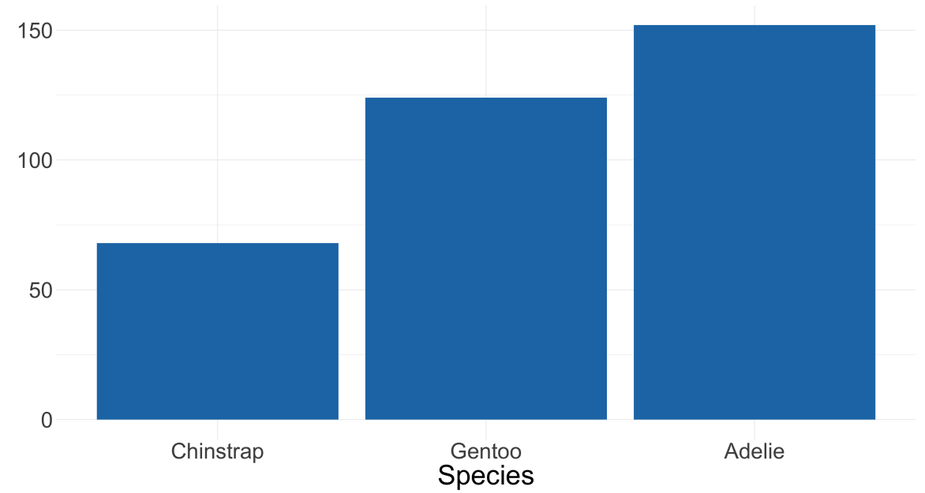
Count
J
I
D
H
F
E
G
Colour

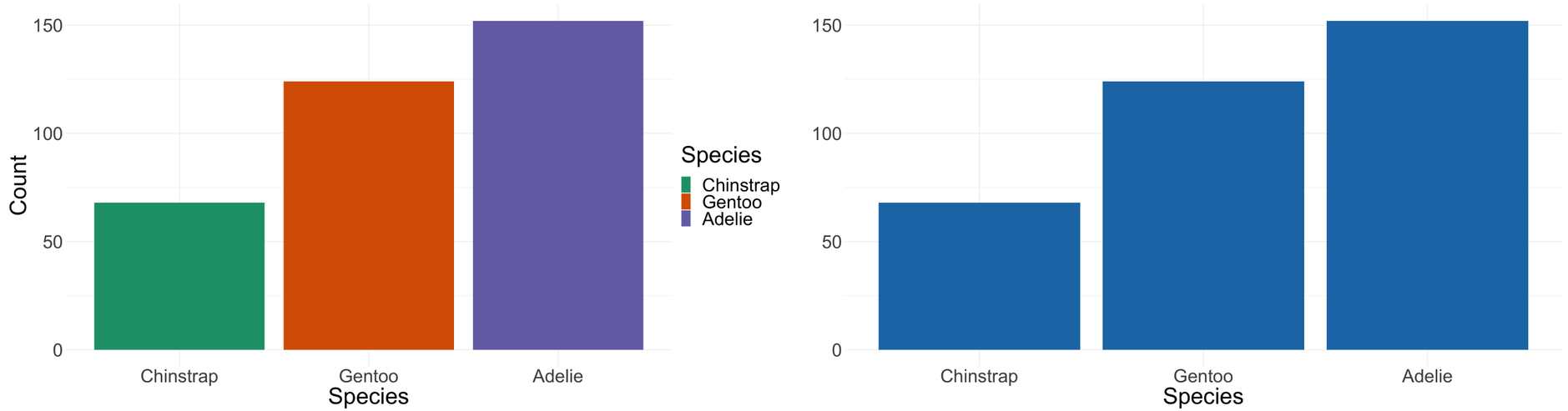

Count
9000
6000
3000
0
J
I
D
H
F
E
G
Colour
9000
6000
3000
0
D
E
F
G
H
I
J
Colour

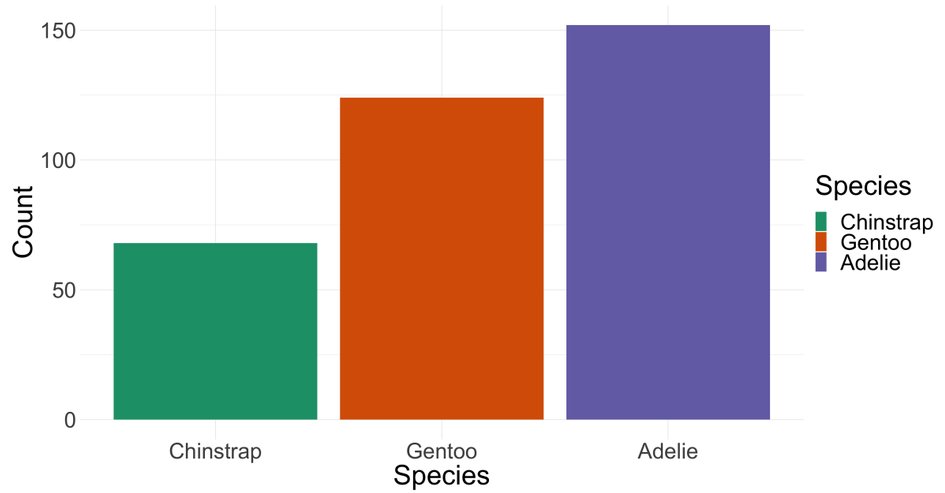
Things to Consider


150
100
50
0
Count
Chinstrap
Gentoo
Adelie
Species
150
100
50
0
Chinstrap
Gentoo
Adelie
Species


150
125
100
75
50
Count
Chinstrap
Gentoo
Adelie
Species


150
100
50
0
Chinstrap
Gentoo
Adelie
Species


150
100
50
0
Count
Chinstrap
Gentoo
Adelie
Species
Species
Chinstrap
Gentoo
Adelie
150
100
50
0
Chinstrap
Gentoo
Adelie
Species



Summary count of Penguins by species. *n* = 344

Bar Charts with more than one Categorical Variable

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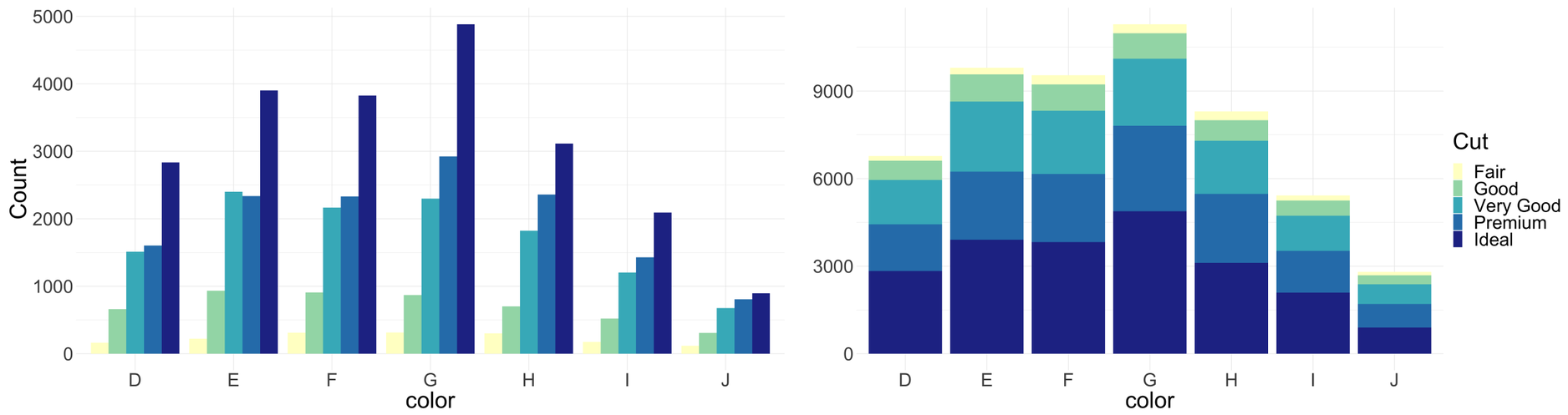

5000
4000
3000
2000
1000
0
Count
D
E
F
G
H
I
J
color
9000
6000
3000
0
D
E
F
G
H
I
J
color
Cut
Fair
Good
Very Good
Premium
Ideal

Numeric Data

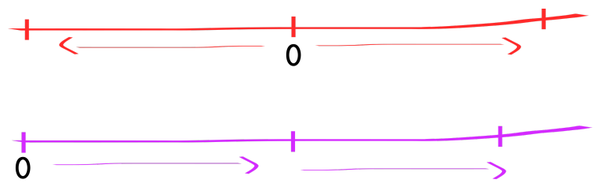
Discrete = **Counted**

Continuous = **Measured**

Numeric Data

Interval = **Greater or less than**

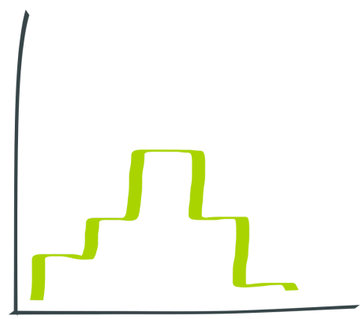
Ratio = **Percentage more or less**



Counts of Numeric Data

Visualization tool

Frequency plots with histograms



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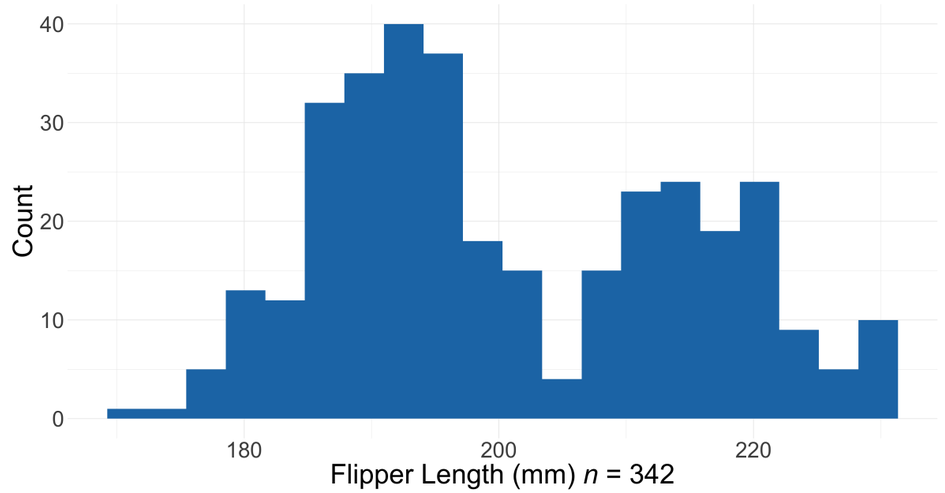
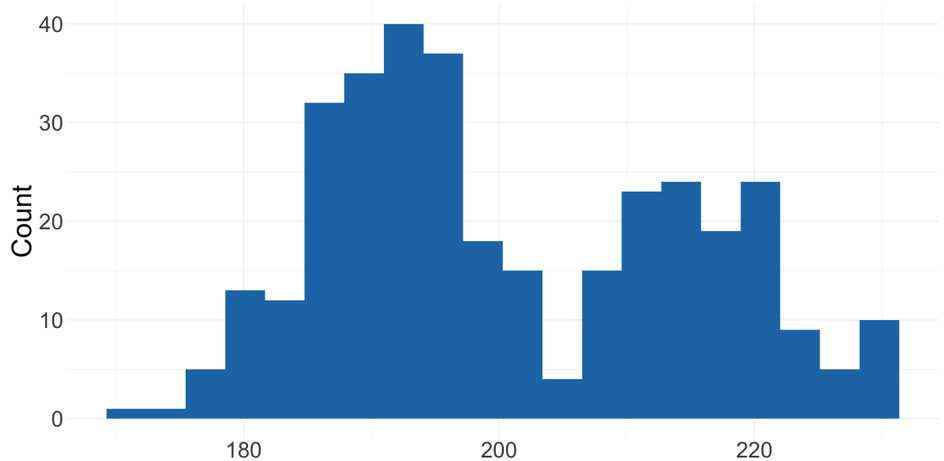
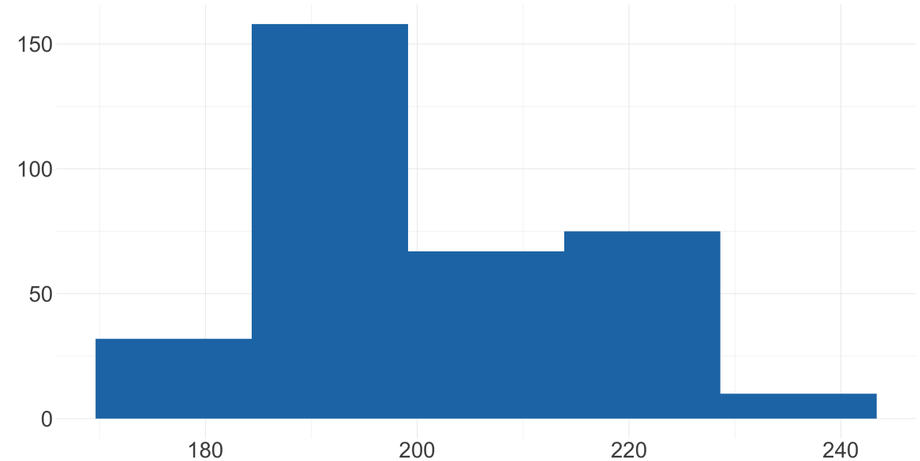
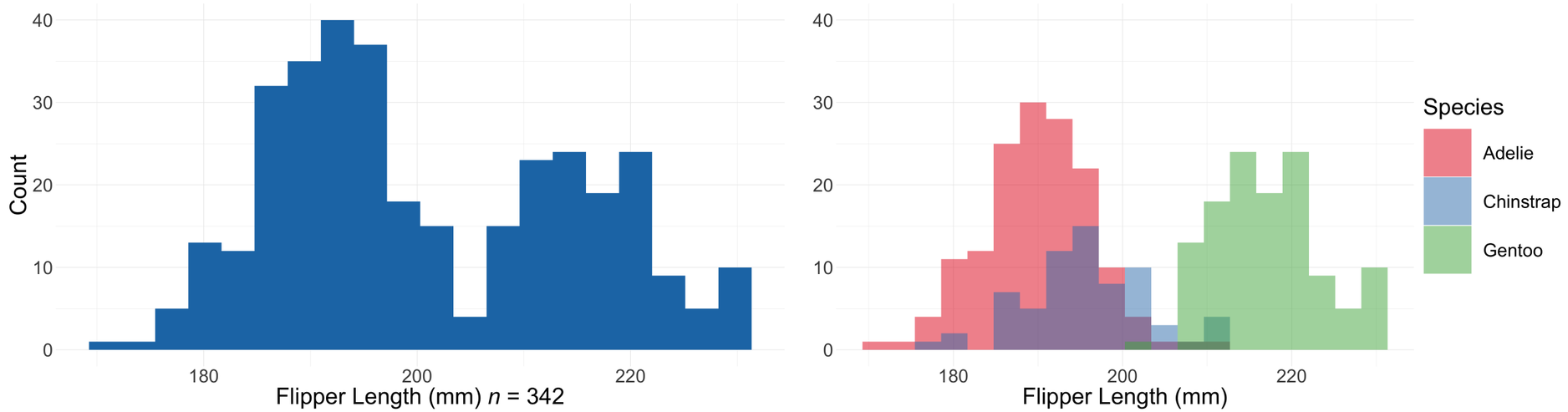
Adelie	Biscoe	45.6	20.3	191	4600	male	2009
Gentoo	Biscoe	46.2	14.5	209	4800	female	2007
Adelie	Dream	42.2	18.5	180	3550	female	2007
Adelie	Biscoe	43.2	19.0	197	4775	male	2009


40
30
20
10
0
Count
180
200
220
Flipper Length (mm) n = 342

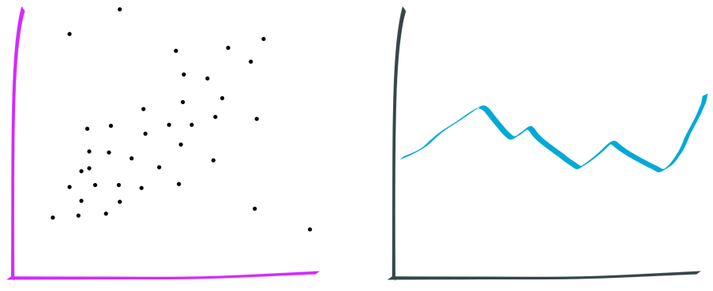

Count
40
30
20
10
0
180
200
220
Flipper Length (mm) n = 342


150
100
50
0
180
200
220
240
Flipper Length (mm) n = 342


Count
40
30
20
10
0
180
200
220
Flipper Length (mm) n = 342
Flipper Length (mm)
Species
Adelie
Chinstrap
Gentoo

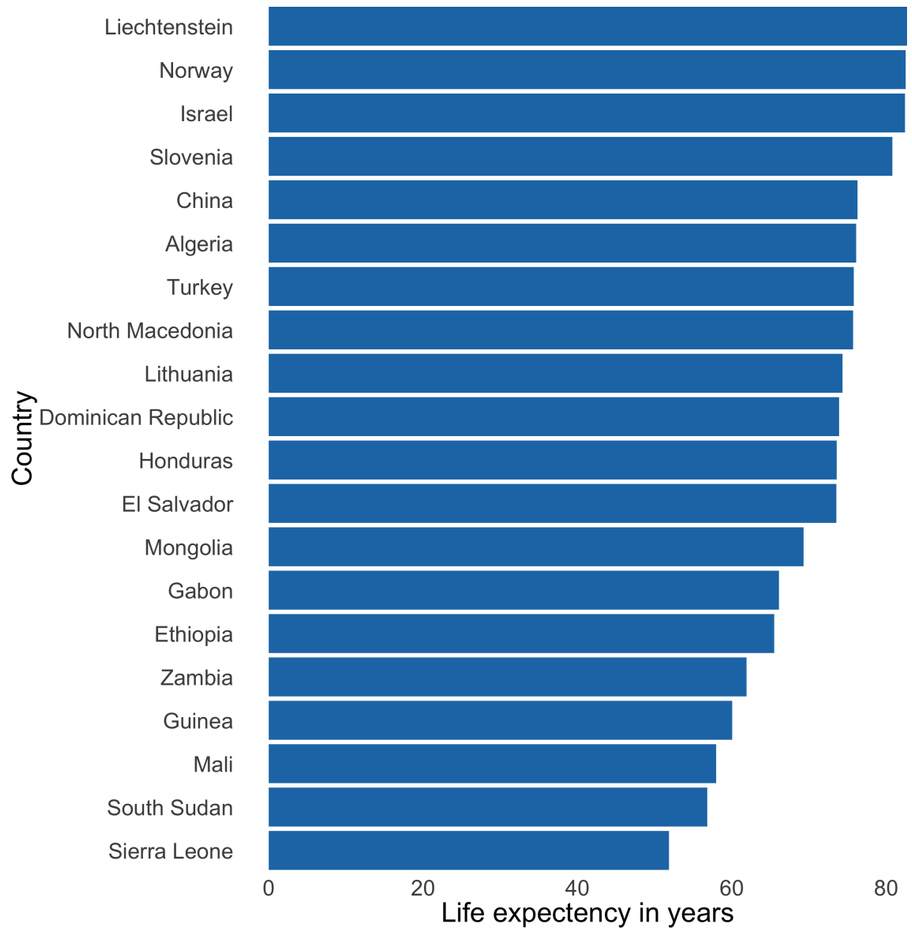
Comparing Variables

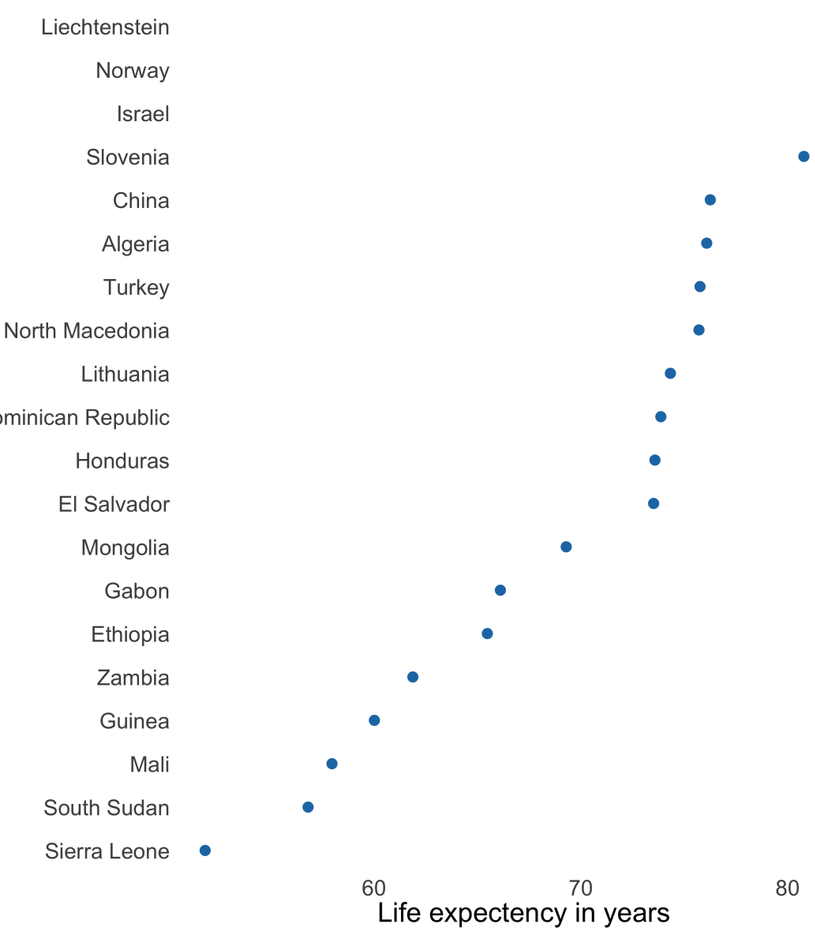
Dot Plots, Line Graphs & Scatter Plots

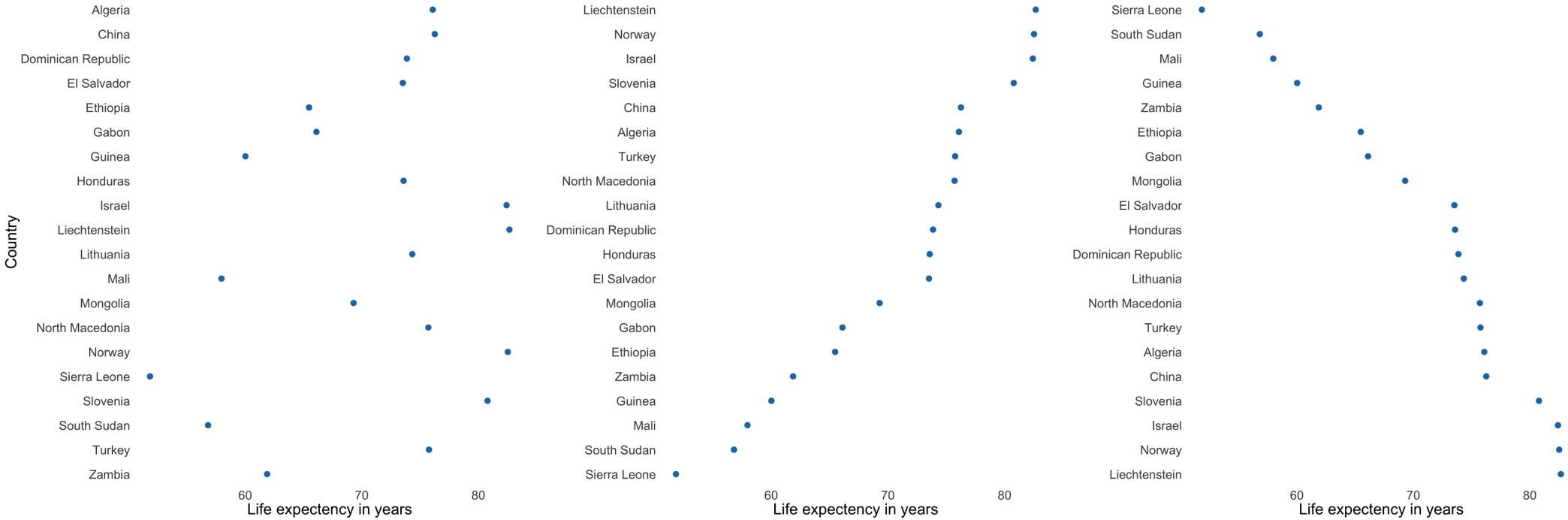


Country	Country_Code	Year	Life_Expectency
Honduras	HND	2016	73.57500
El Salvador	SLV	2016	73.51200
Algeria	DZA	2016	76.07800
Guinea	GIN	2016	60.01500
Turkey	TUR	2016	75.75500
Mongolia	MNG	2016	69.28700
Zambia	ZMB	2016	61.87400
Ethiopia	ETH	2016	65.47500
South Sudan	SSD	2016	56.81100
Gabon	GAB	2016	66.10500
Lithuania	LTU	2016	74.32195
Norway	NOR	2016	82.50976
Sierra Leone	SLE	2016	51.83500
North Macedonia	MKD	2016	75.70300
Israel	ISR	2016	82.40732
China	CHN	2016	76.25200
Slovenia	SVN	2016	80.77561
Mali	MLI	2016	57.96600
Dominican Republic	DOM	2016	73.86100
Liechtenstein	LIE	2016	82.65610

Country	Country_Code	Year	Life_Expectency
Honduras	HND	2016	73.57500
El Salvador	SLV	2016	73.51200
Algeria	DZA	2016	76.07800
Guinea	GIN	2016	60.01500
Turkey	TUR	2016	75.75500
Mongolia	MNG	2016	69.28700
Zambia	ZMB	2016	61.87400
Ethiopia	ETH	2016	65.47500
South Sudan	SSD	2016	56.81100
Gabon	GAB	2016	66.10500
Lithuania	LTU	2016	74.32195
Norway	NOR	2016	82.50976
Sierra Leone	SLE	2016	51.83500
North Macedonia	MKD	2016	75.70300
Israel	ISR	2016	82.40732
China	CHN	2016	76.25200
Slovenia	SVN	2016	80.77561
Mali	MLI	2016	57.96600
Dominican Republic	DOM	2016	73.86100
Liechtenstein	LIE	2016	82.65610


Liechtenstein
Norway
Israel
Slovenia
China
Algeria
Turkey
North Macedonia
Lithuania
Dominican Republic
Honduras
El Salvador
Mongolia
Gabon
Ethiopia
Zambia
Guinea
Mali
South Sudan
Sierra Leone
Country
0
20
40
60
80
Life expectency in years


Liechtenstein
Norway
Israel
Slovenia
China
Algeria
Turkey
North Macedonia
Lithuania
Dominican Republic
Honduras
El Salvador
Mongolia
Gabon
Ethiopia
Zambia
Guinea
Mali
South Sudan
Sierra Leone
60
70
80
Life expectency in years


Country
Algeria
China
Dominican Republic
El Salvador
Ethiopia
Gabon
Guinea
Honduras
Israel
Liechtenstein
Lithuania
Mali
Mongolia
North Macedonia
Norway
Sierra Leone
Slovenia
South Sudan
Turkey
Zambia
60
70
80
Life expectency in years
Liechtenstein
Norway
Israel
Slovenia
China
Algeria
Turkey
North Macedonia
Lithuania
Dominican Republic
Honduras
El Salvador
Mongolia
Gabon
Ethiopia
Zambia
Guinea
Mali
South Sudan
Sierra Leone
60
70
80
Life expectency in years
Sierra Leone
South Sudan
Mali
Guinea
Zambia
Ethiopia
Gabon
Mongolia
El Salvador
Honduras
Dominican Republic
Lithuania
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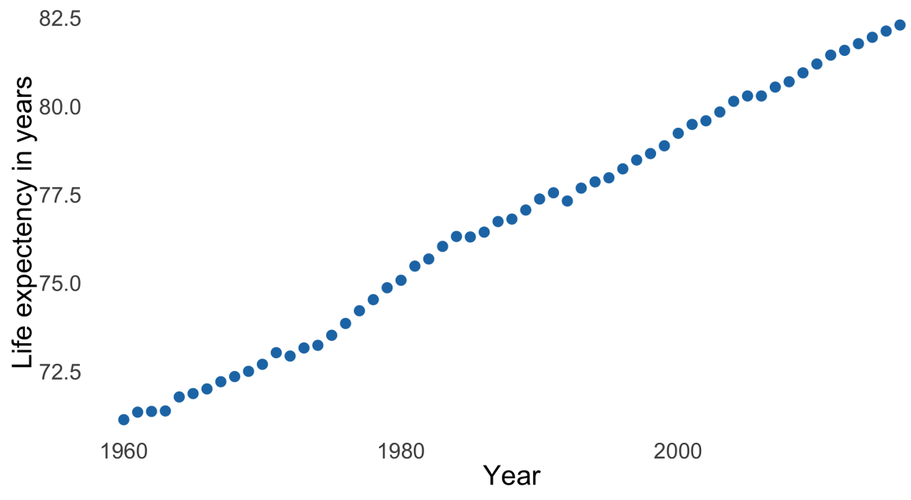
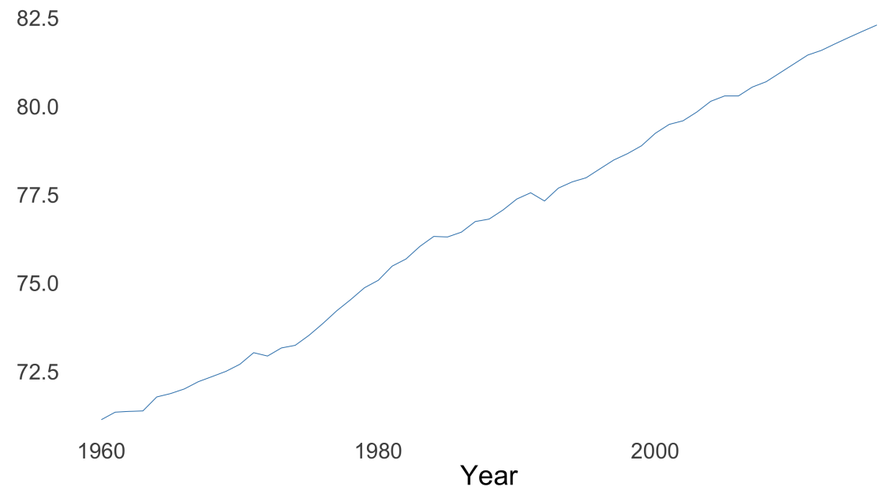
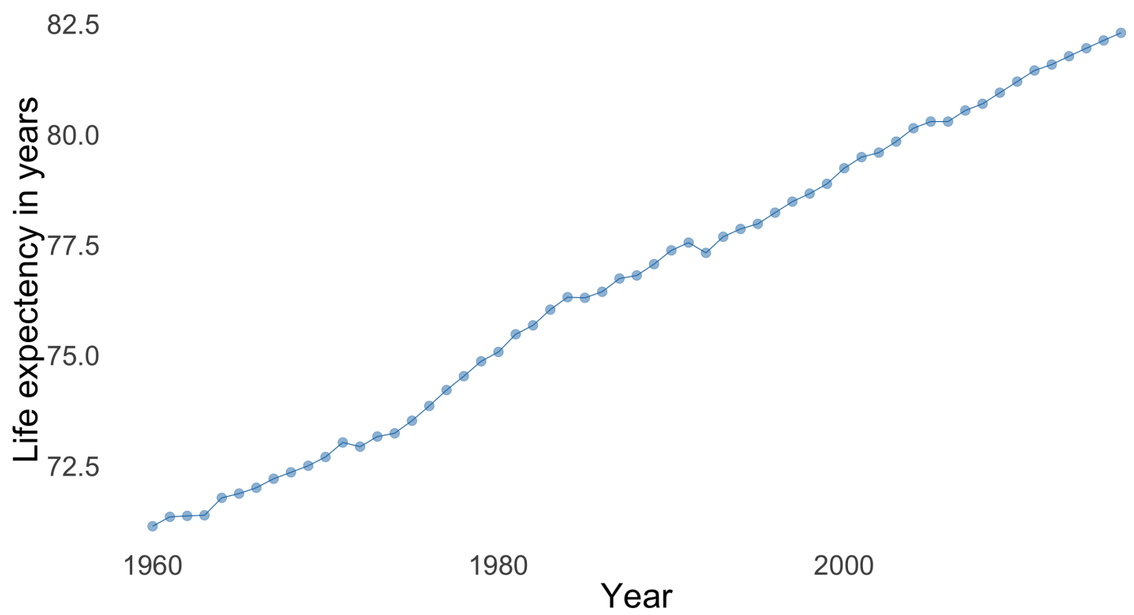
Turkey
Algeria
China
Slovenia
Israel
Norway
Liechtenstein
60
70
80
Life expectency in years


82.5
80.0
77.5
75.0
72.5
Life expectency in years
1960
1980
2000
Year

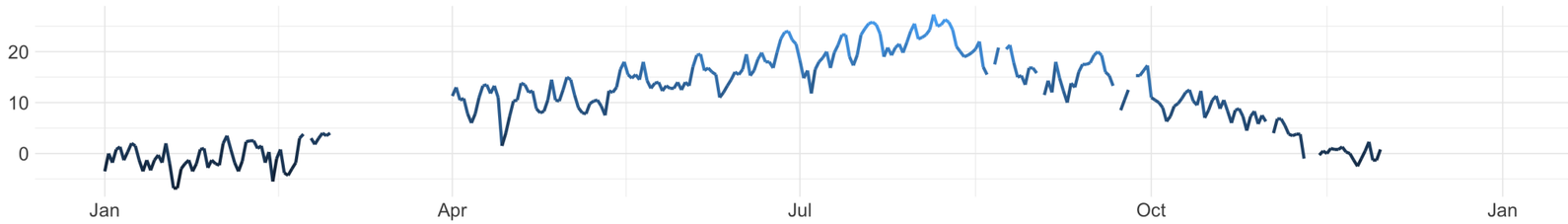

82.5
80.0
77.5
75.0
72.5
1960
1980
2000
Year

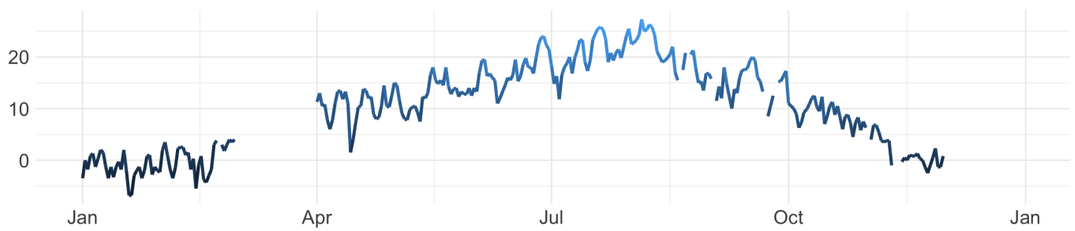

82.5
80.0
77.5
75.0
72.5
Life expectency in years
1960
1980
2000
Year

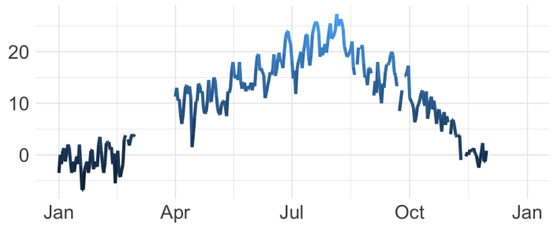
Aspect Ratio & Colour

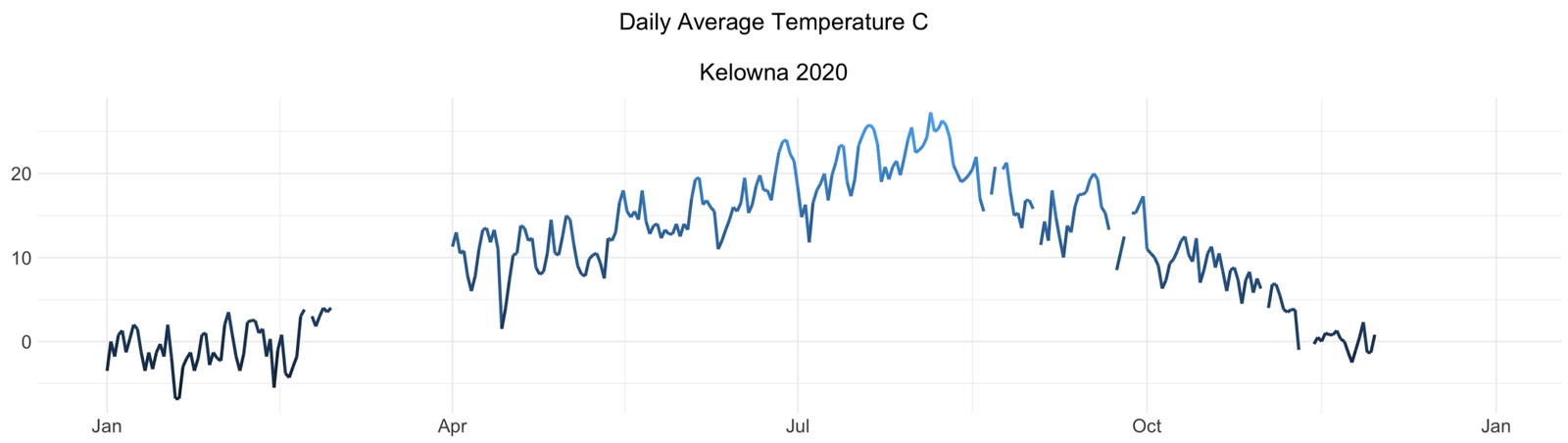
Daily Average Temperature C

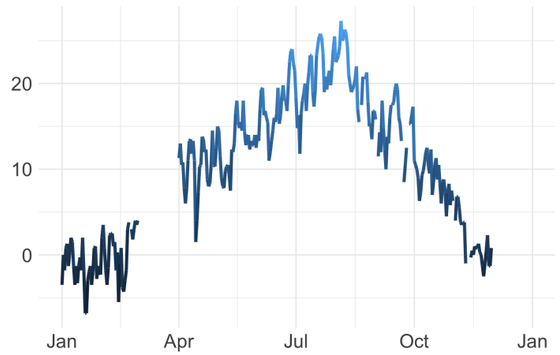
Kelowna 2020

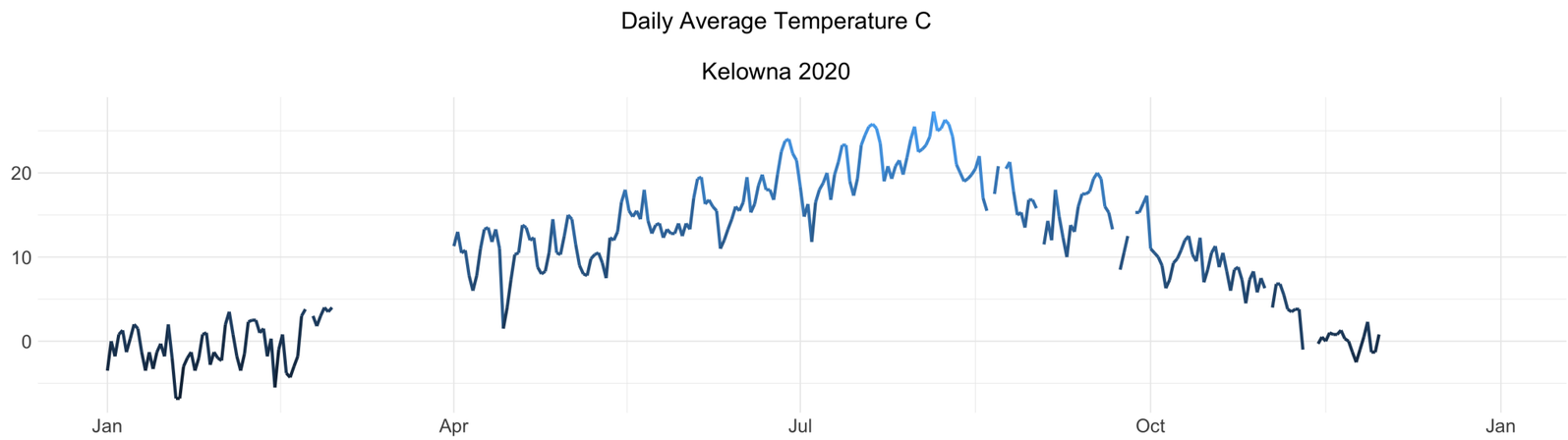


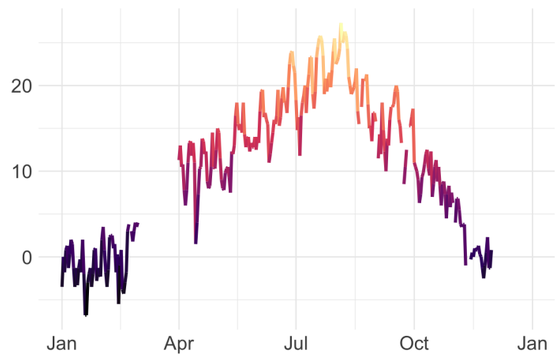





Daily Average Temperature C
Kelowna 2020
20
10
0
Jan
Apr
Jul
Oct
Jan


20
10
0
Jan
Apr
Jul
Oct
Jan


Daily Average Temperature C
Kelowna 2020
20
10
0
Jan
Apr
Jul
Oct
Jan


20
10
0
Jan
Apr
Jul
Oct
Jan

Layering Data and Statistics

Country	Code	Year	Population	Continent	Life.Expectency	GDP
Lesotho	LSO	2015	2059000	Africa	51.038	2954
Armenia	ARM	2015	2926000	Asia	74.467	9552
Uruguay	URY	2015	3412000	South America	77.369	19668
Slovakia	SVK	2015	5436000	Europe	76.827	25896
Bosnia and Herzegovina	BIH	2015	3429000	Europe	76.865	10305
Mali	MLI	2015	17439000	Africa	57.509	1563
Romania	ROU	2015	19925000	Europe	75.476	20549
Denmark	DNK	2015	5689000	Europe	80.475	44939
Jamaica	JAM	2015	2891000	North America	74.098	7115
Senegal	SEN	2015	14578000	Africa	66.747	2446
Eswatini	SWZ	2015	1104000	Africa	55.359	7726
Pakistan	PAK	2015	199427008	Asia	66.577	5056
Gambia	GMB	2015	2086000	Africa	60.910	1948
Haiti	HTI	2015	10696000	North America	62.485	1649
Vietnam	VNM	2015	92677000	Asia	75.110	5733
Congo	COG	2015	4856000	Africa	63.097	4526
Gabon	GAB	2015	1948000	Africa	64.913	14315
Nepal	NPL	2015	27015000	Asia	69.515	2607
North Macedonia	MKD	2015	2079000	Europe	75.406	13586
Cyprus	CYP	2015	1161000	Europe	80.350	25903

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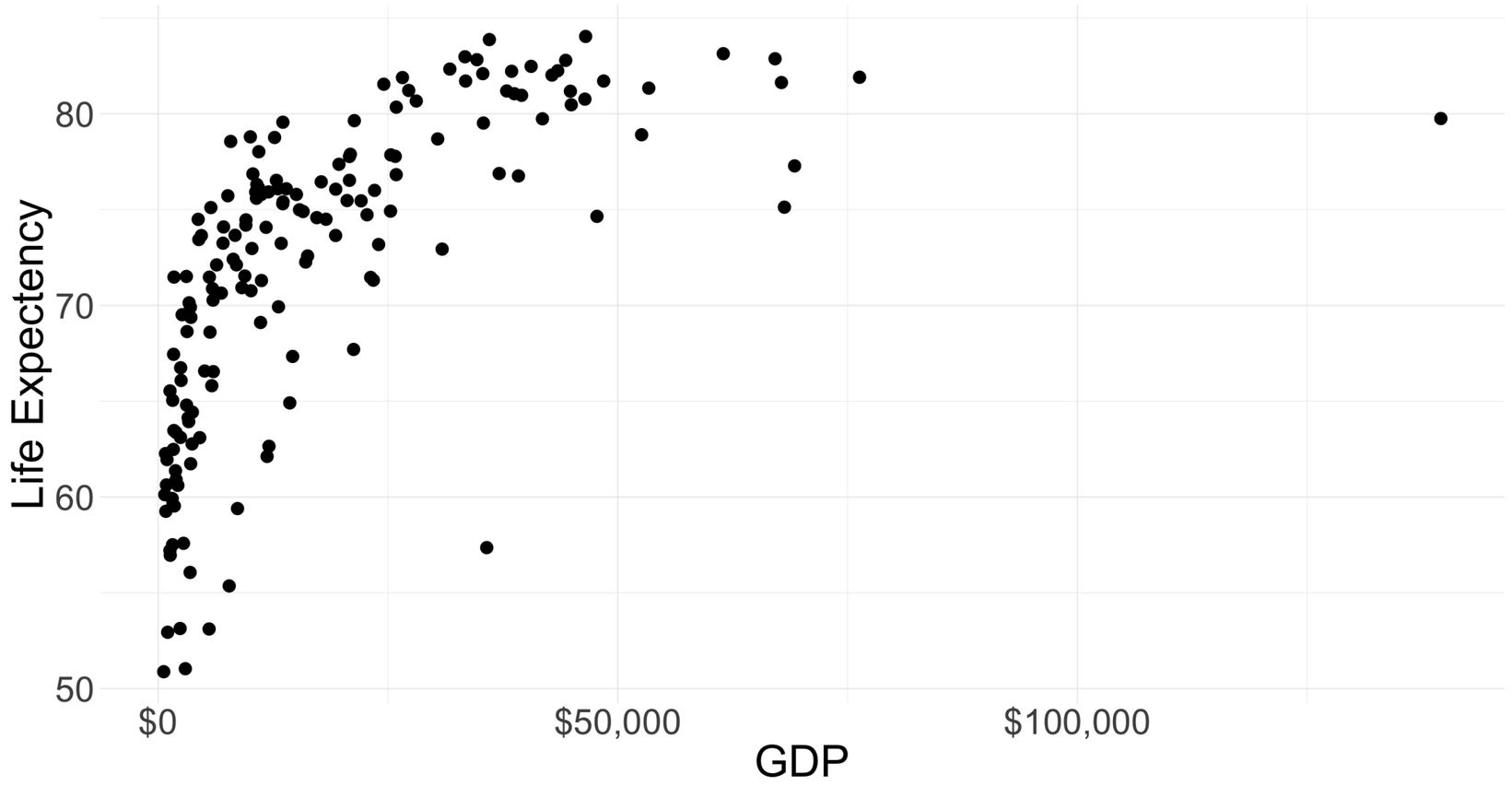
Cyprus	CYP	2015	1161000	Europe	80.350	25903


80
70
60
50
Life Expectency
$0
$50,000
$100,000
GDP

Country	Code	Year	Population	Continent	Life.Expectency	GDP
Lesotho	LSO	2015	2059000	Africa	51.038	2954
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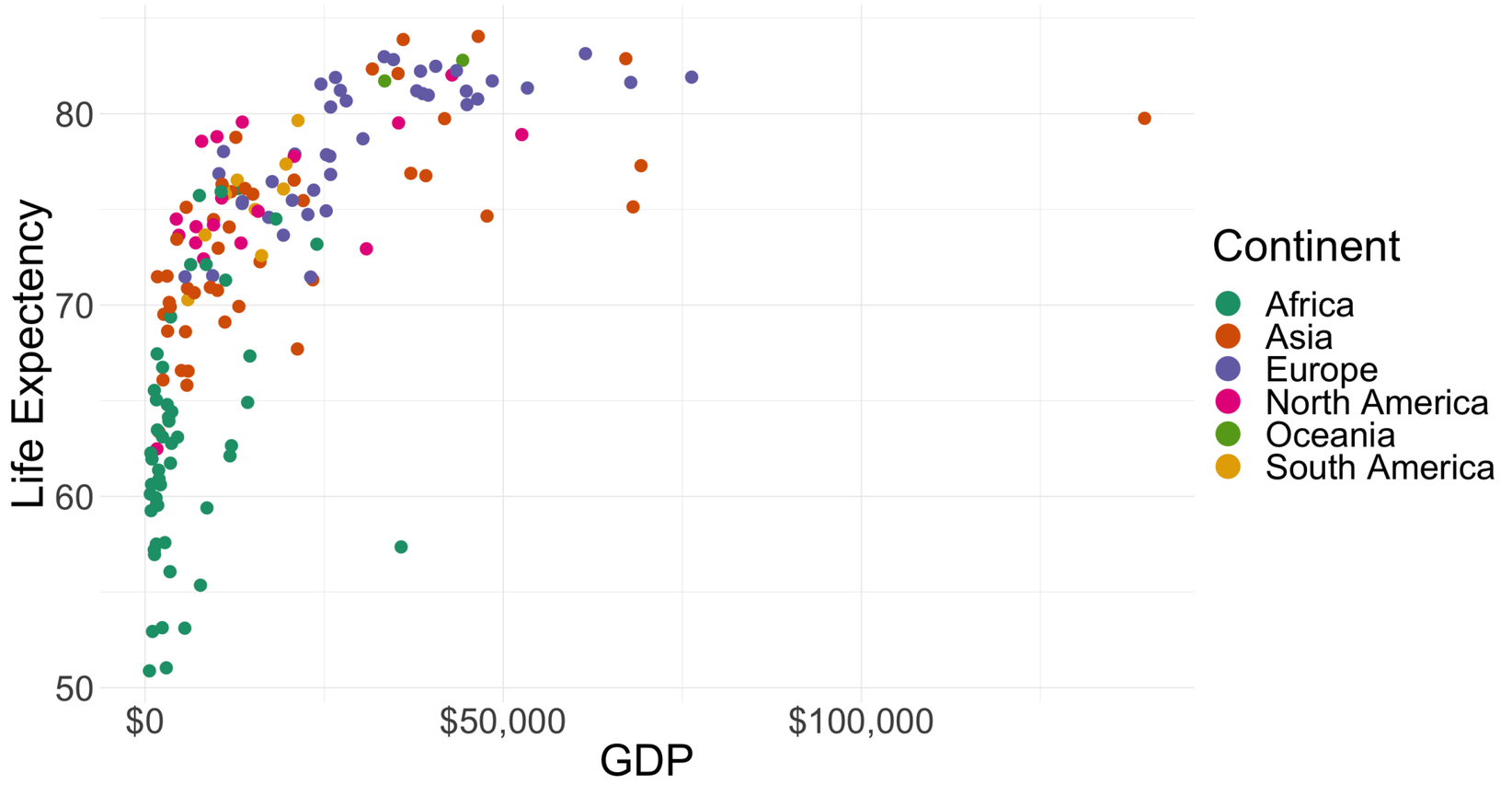
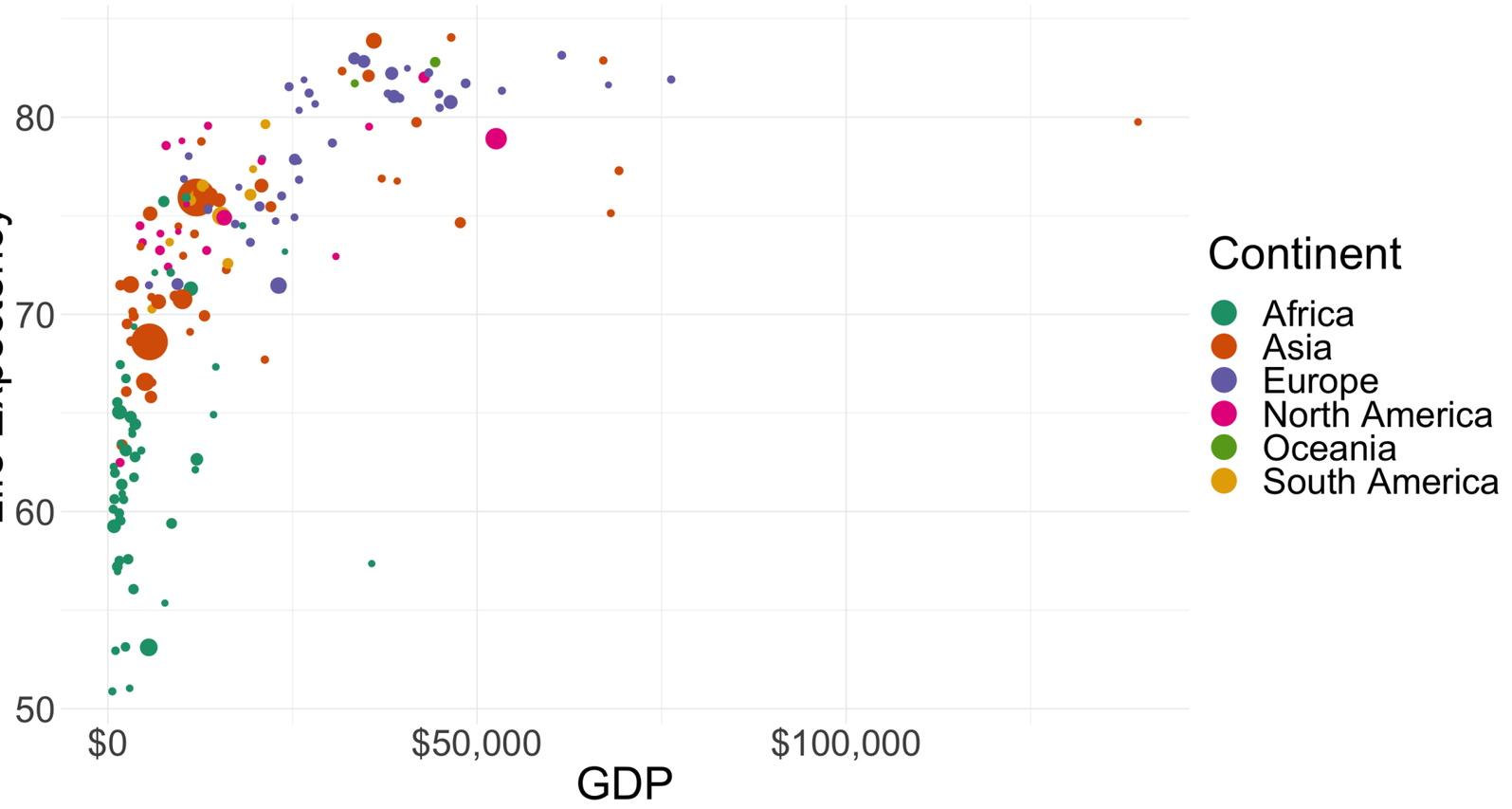
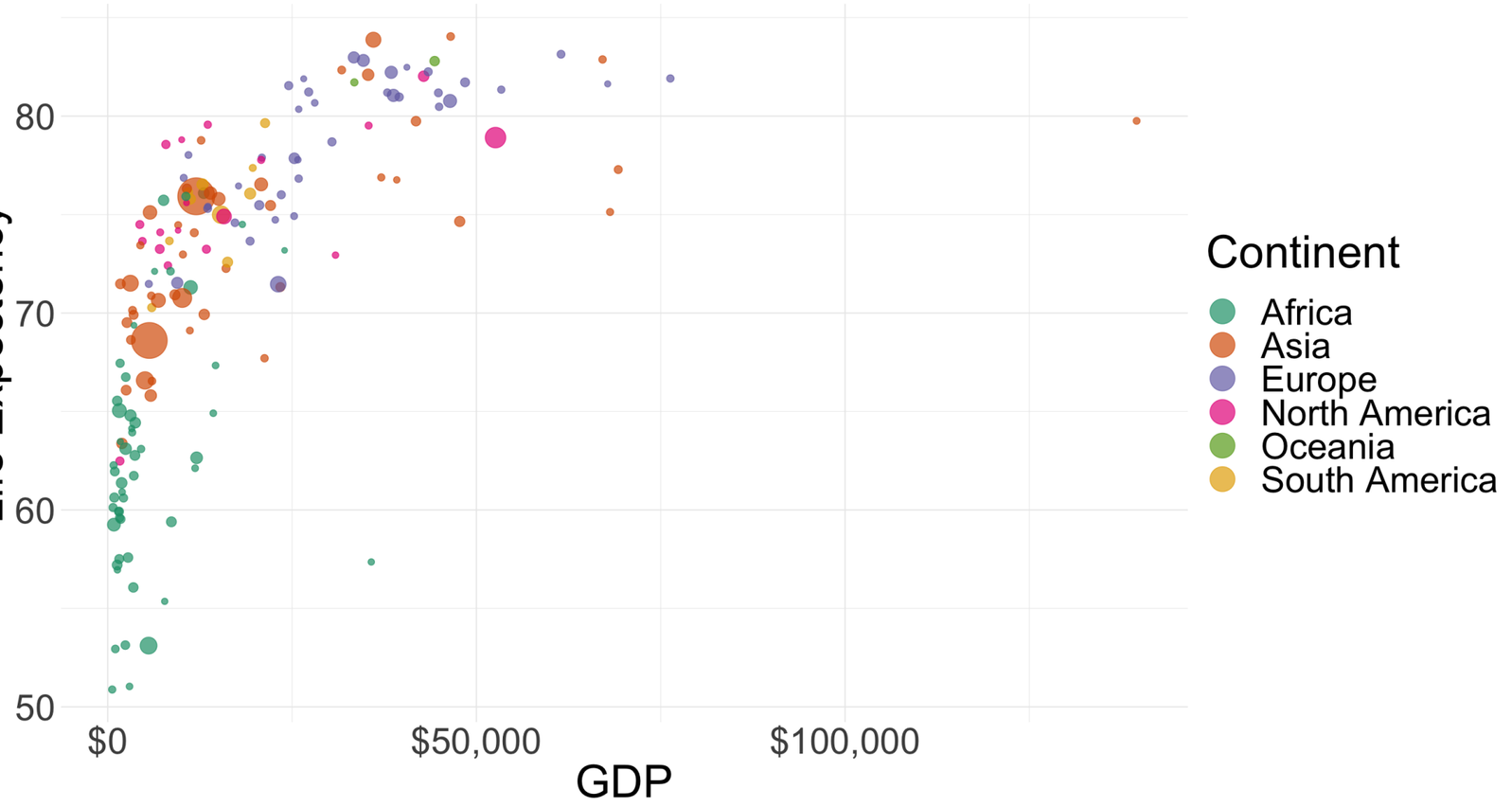
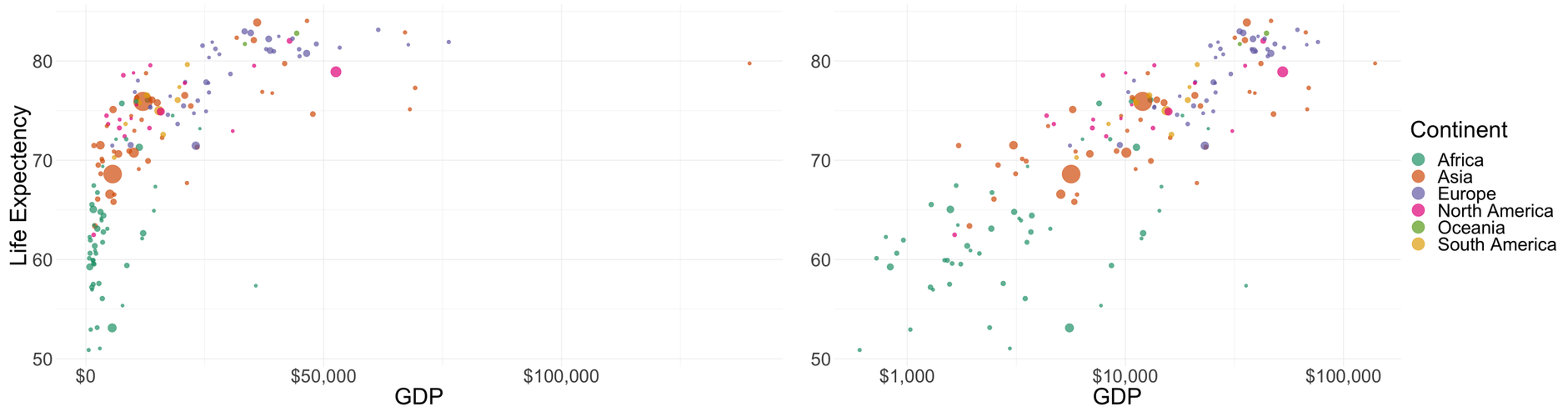
Nepal	NPL	2015	27015000	Asia	69.515	2607
North Macedonia	MKD	2015	2079000	Europe	75.406	13586
Cyprus	CYP	2015	1161000	Europe	80.350	25903


Life Expectency
80
70
60
50
$0
$50,000
$100,000
GDP
Continent
Africa
Asia
Europe
North America
Oceania
South America


Life Expectency
80
70
60
50
$0
$50,000
$100,000
GDP
Continent
Africa
Asia
Europe
North America
Oceania
South America


Life Expectency
80
70
60
50
$0
$50,000
$100,000
GDP
Continent
Africa
Asia
Europe
North America
Oceania
South America


Life Expectency
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60
50
$0
$50,000
$100,000
GDP
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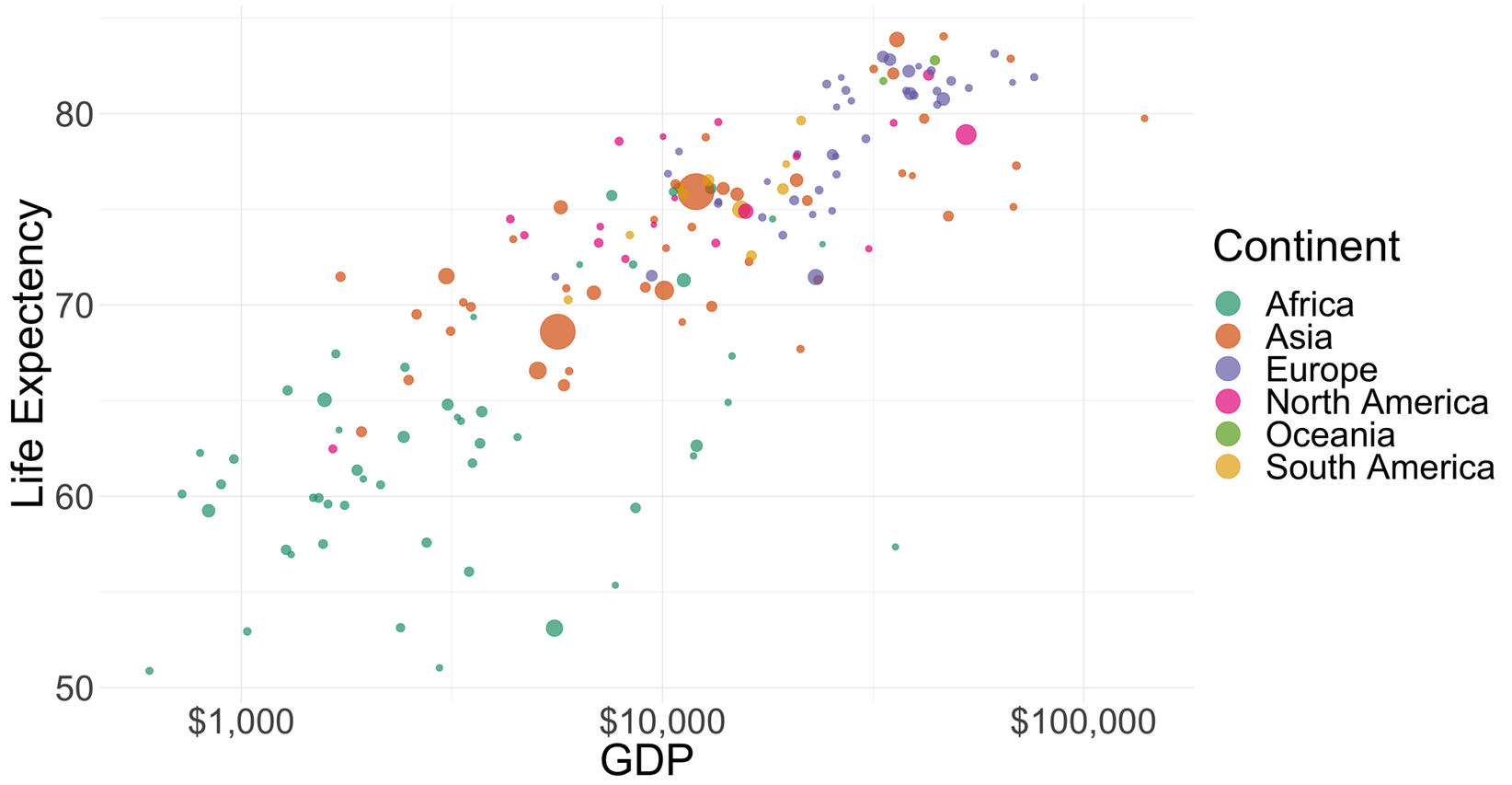
70
60
50
$1,000
$10,000
$100,000
GDP
Continent
Africa
Asia
Europe
North America
Oceania
South America


Life Expectency
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$1,000
$10,000
$100,000
GDP
Continent
Africa
Asia
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North America
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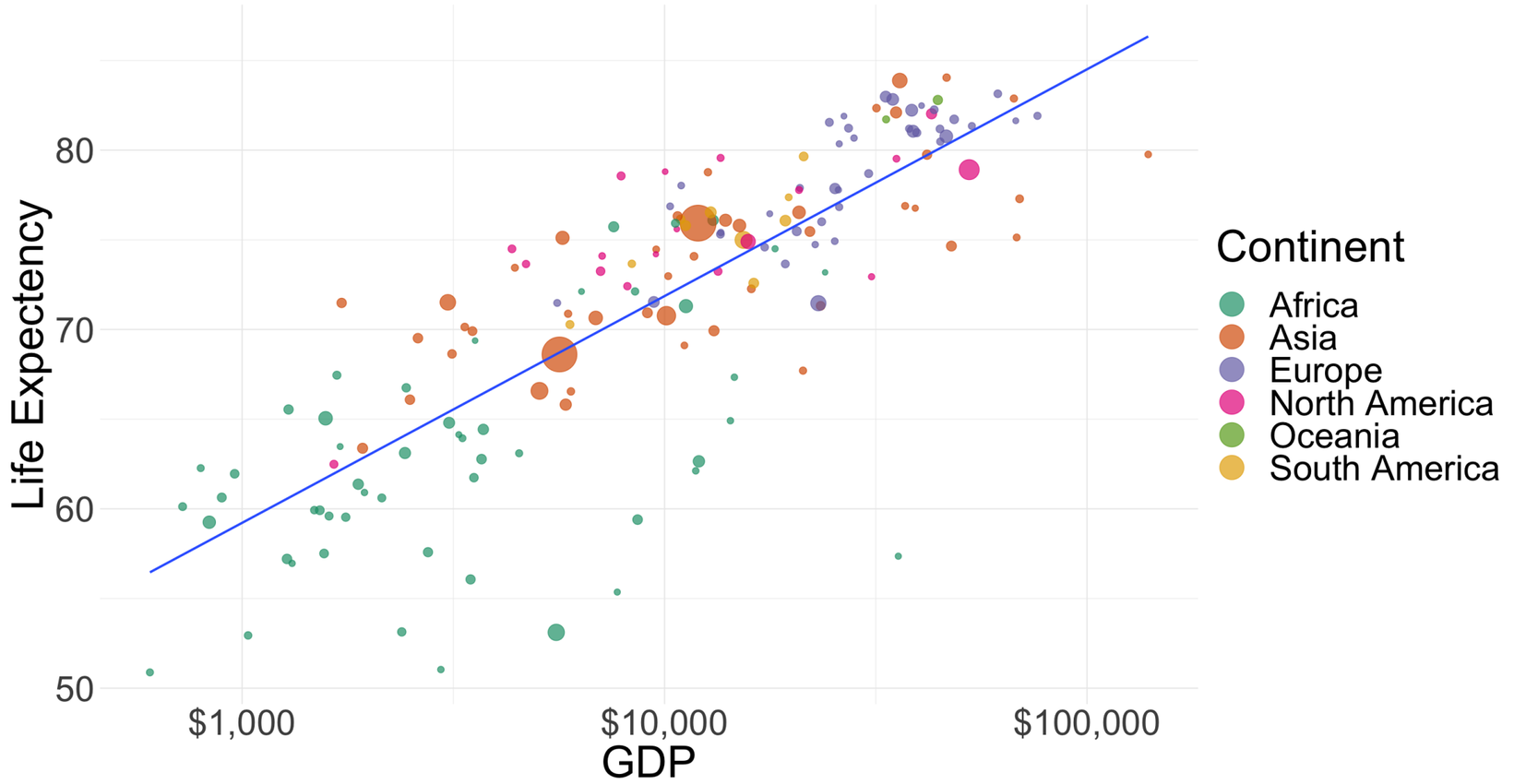
South America


Life Expectency
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70
60
50
$1,000
$10,000
$100,000
GDP
Continent
Africa
Asia
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North America
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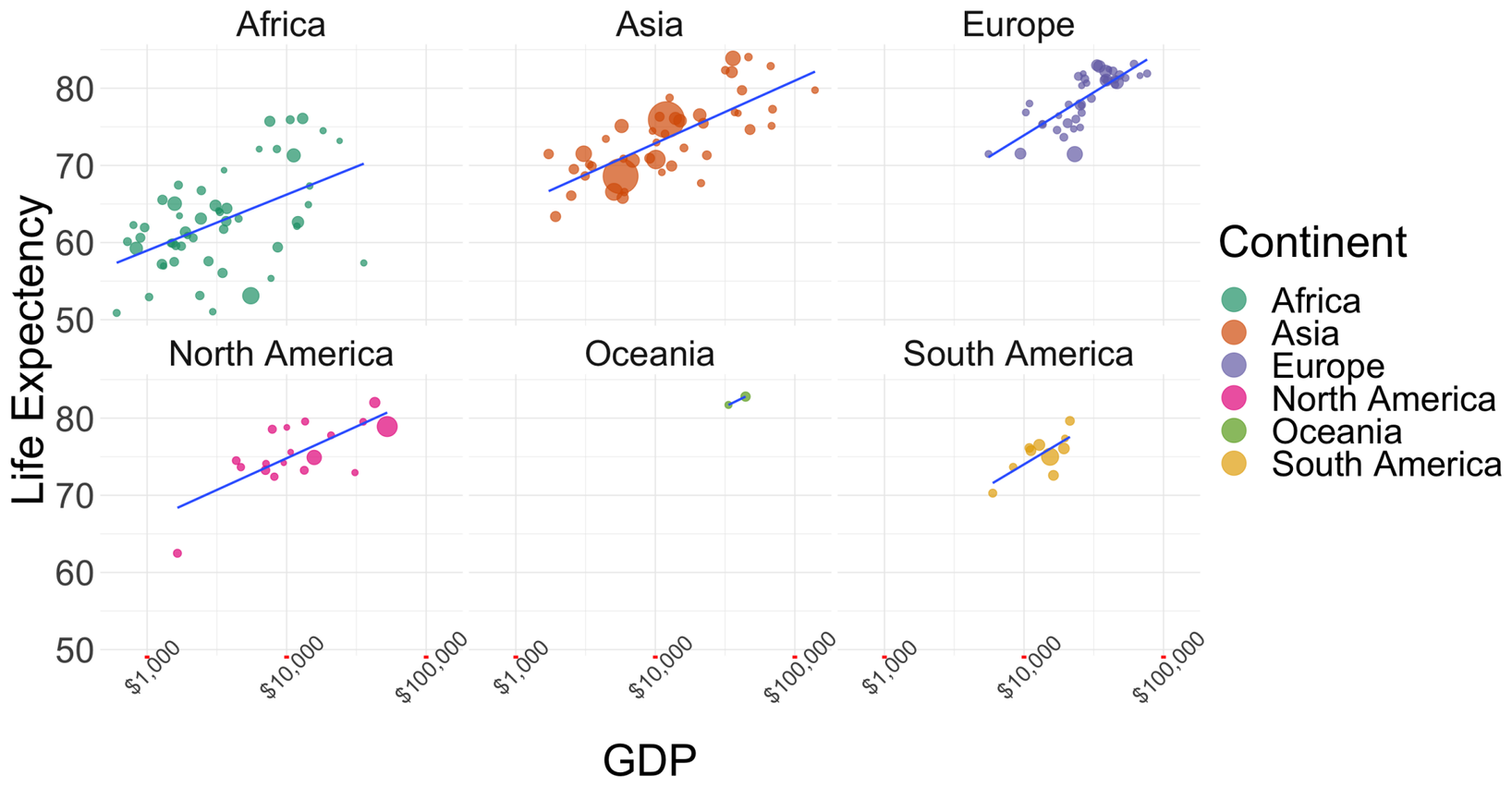
South America


Africa
Asia
Europe
North America
Oceania
South America
Life Expectency
80
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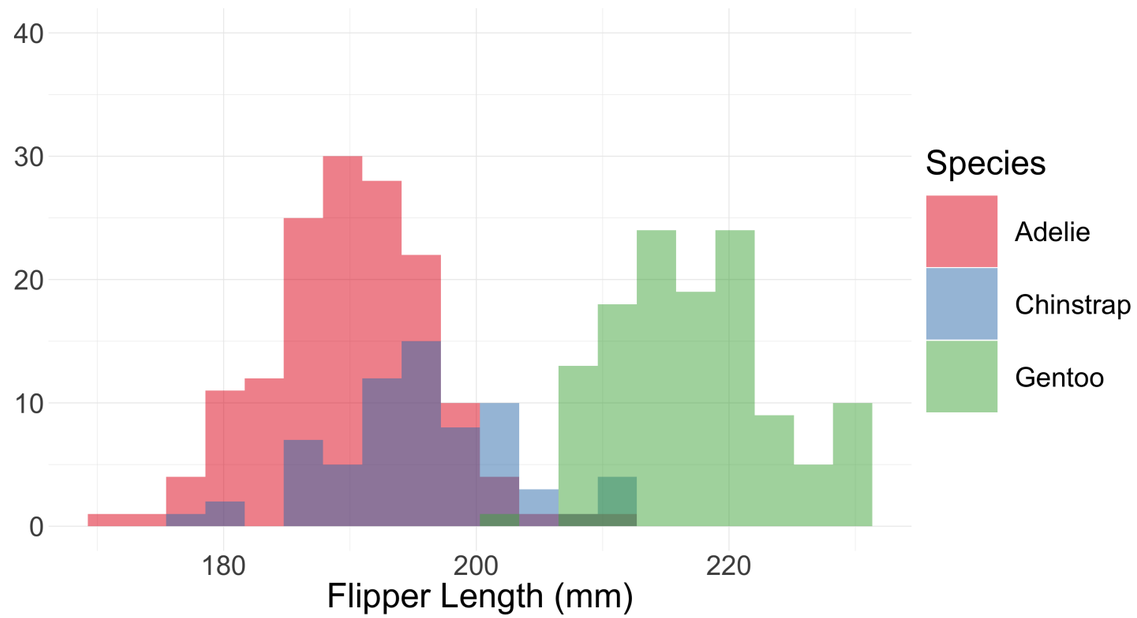
60
50
$1,000
$10,000
$100,000
GDP
Continent
Africa
Asia
Europe
North America
Oceania
South America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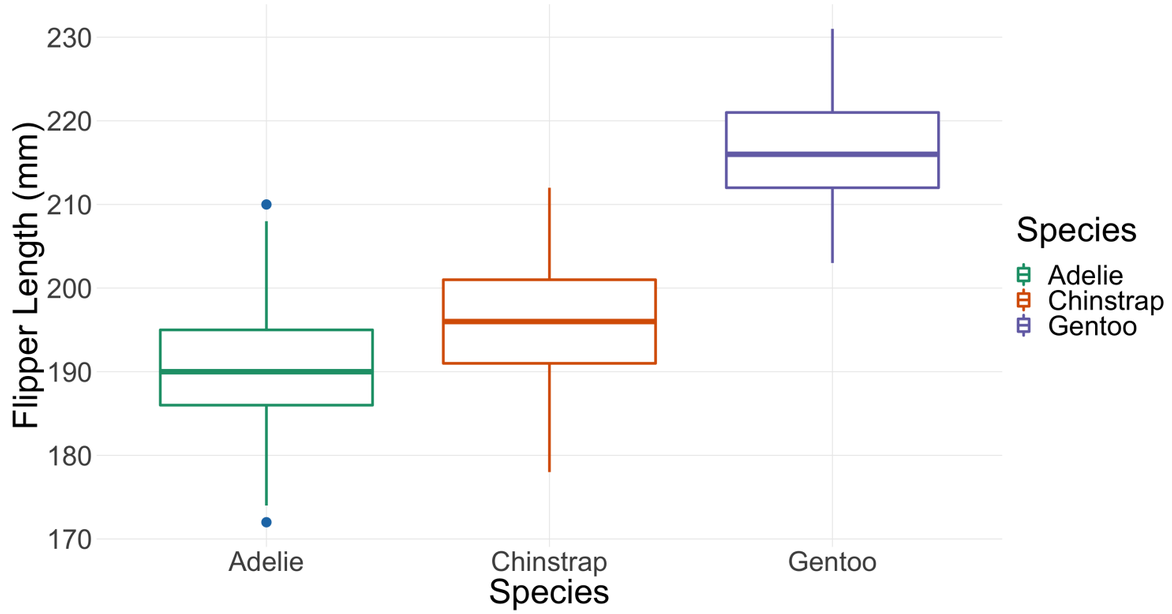
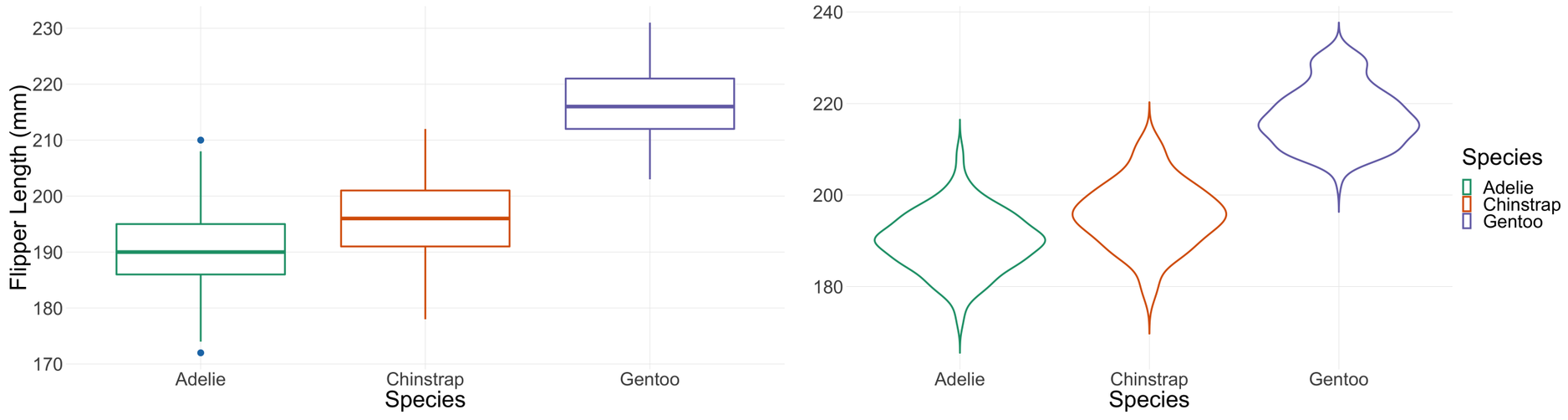
30
20
10
0
180
200
220
Flipper Length (mm)
Species
Adelie
Chinstrap
Gentoo


Flipper Length (mm)
230
220
210
200
190
180
170
Adelie
Chinstrap
Gentoo
Species
Species
Adelie
Chinstrap
Gentoo


Flipper Length (mm)
230
220
210
200
190
180
170
Adelie
Chinstrap
Gentoo
Species
240
220
200
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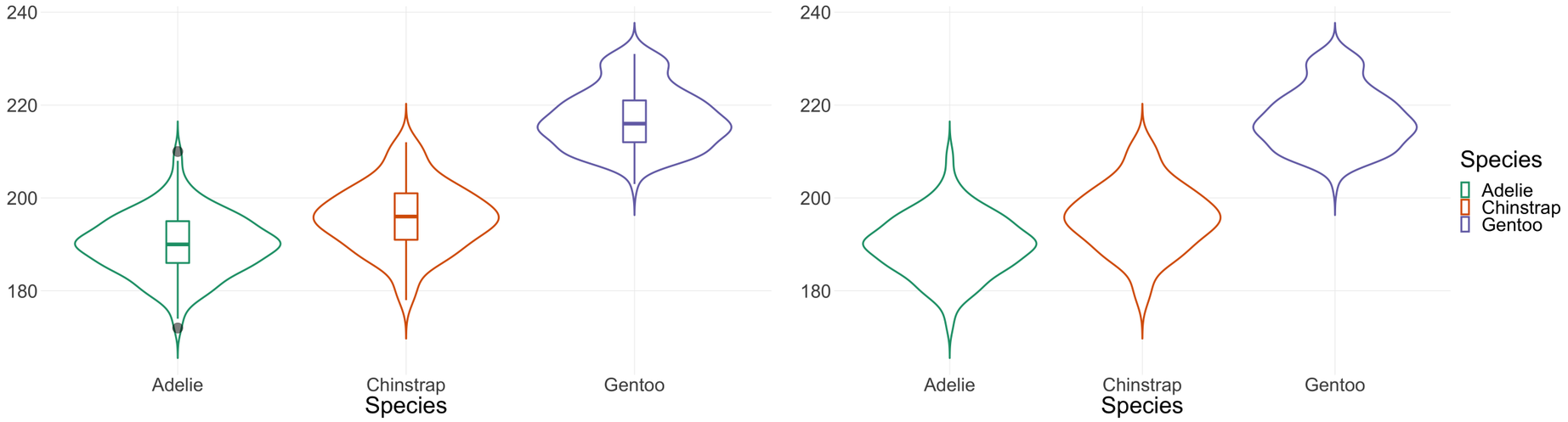
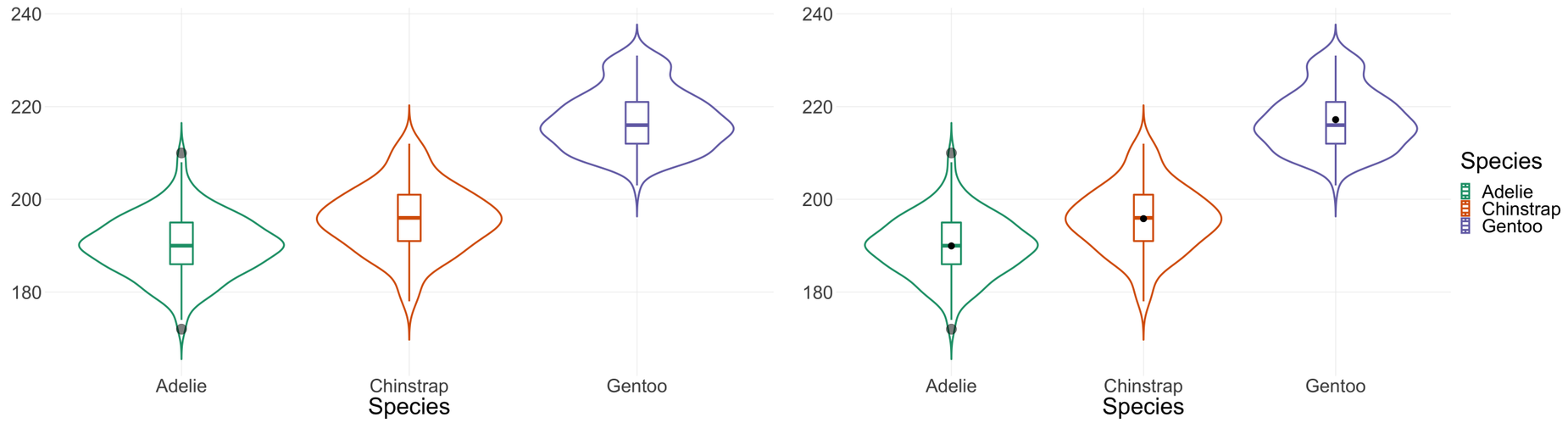
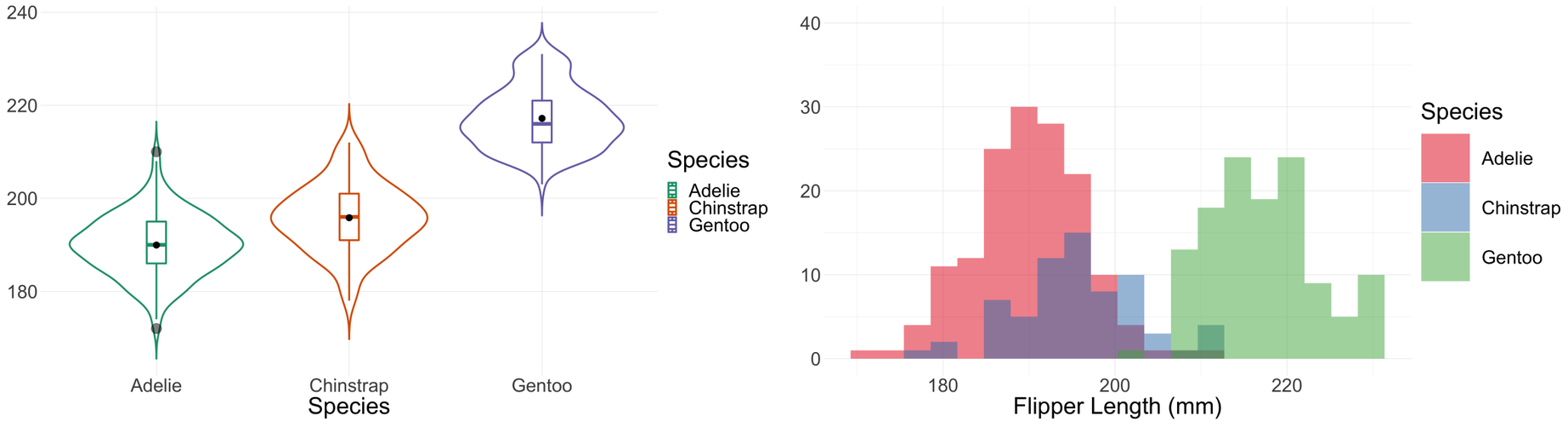
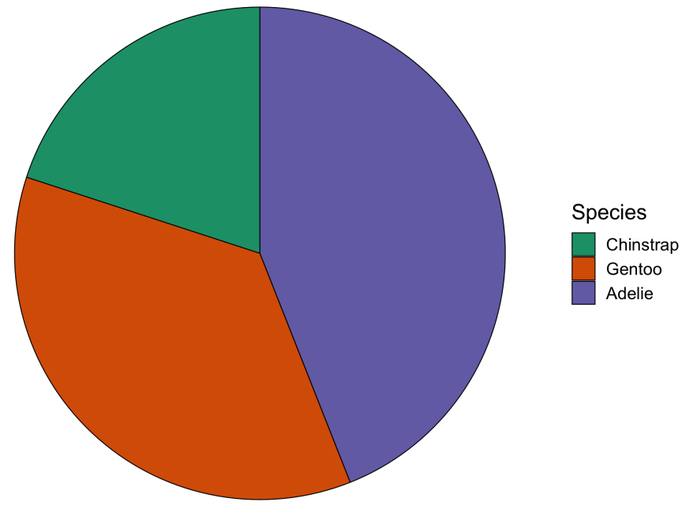
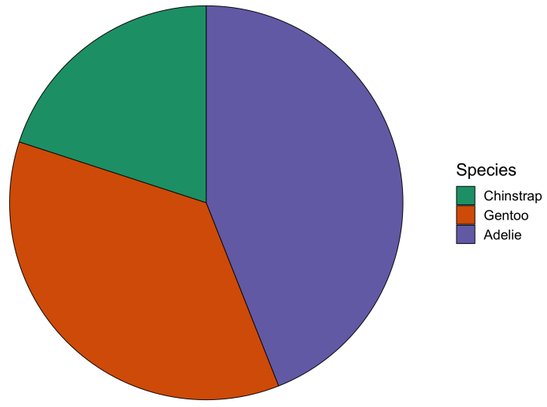
Adelie
Chinstrap
Gentoo
Species
Species
Adelie
Chinstrap
Gentoo

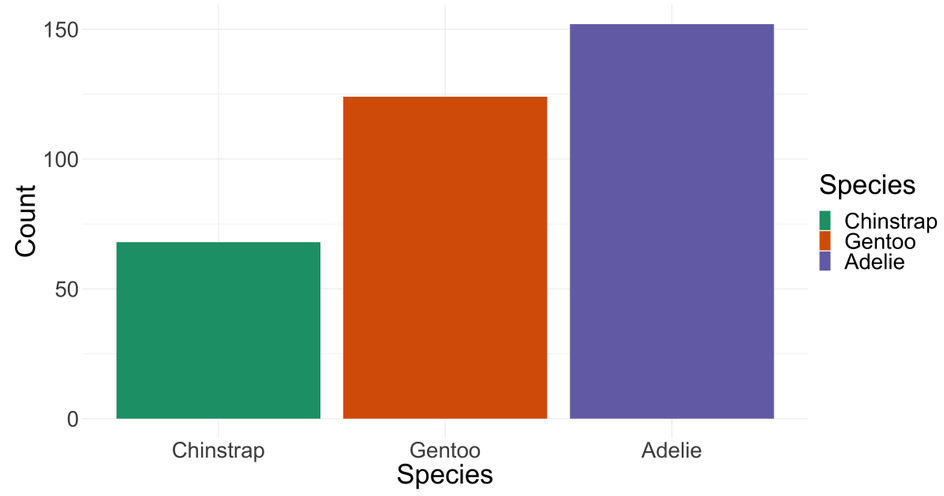

240
220
200
180
Adelie
Chinstrap
Gentoo
Species
Species
Adelie
Chinstrap
Gentoo


240
220
200
180
Adelie
Chinstrap
Gentoo
Species
240
220
200
180
Adelie
Chinstrap
Gentoo
Species
Species
Adelie
Chinstrap
Gentoo


240
220
200
180
Adelie
Chinstrap
Gentoo
Species
Species
Adelie
Chinstrap
Gentoo
40
30
20
10
0
180
200
220
Flipper Length (mm)
Species
Adelie
Chinstrap
Gentoo


Species
Chinstrap
Gentoo
Adelie

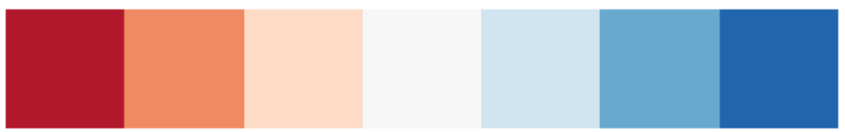

Species
Chinstrap
Gentoo
Adelie


150
100
50
0
Count
Chinstrap
Gentoo
Adelie
Species
Species
Chinstrap
Gentoo
Adelie

Colour should be meaningful and take into account the nature of the data being graphed. It should also be attune to colour blindness.

Sequential

Diverging



Qualitative

ColorBrewer https://colorbrewer2.org/