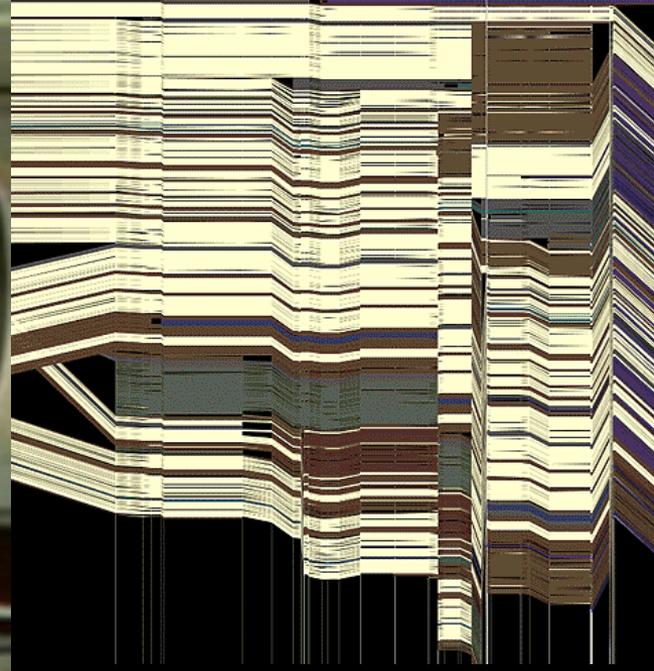
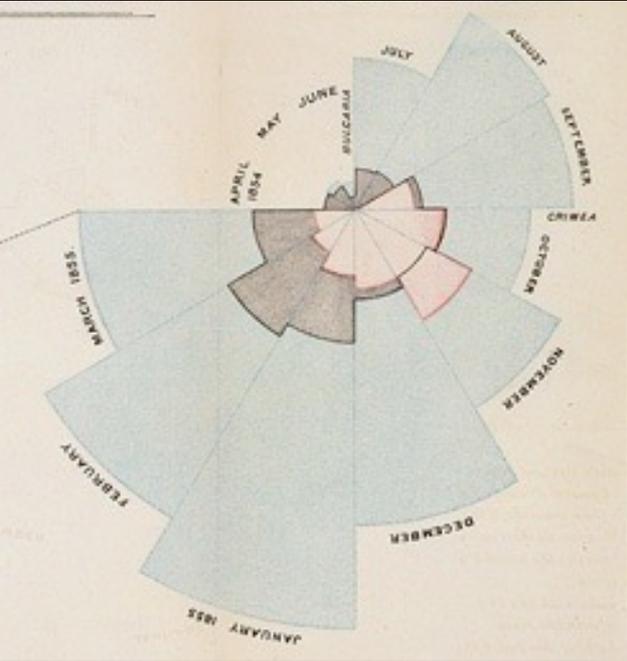


CSE 512 - Data Visualization

Design & Re-Design



Jeffrey Heer University of Washington

Last Time:
Data & Image Models

The Big Picture

task

questions, goals
assumptions

data

physical data type
conceptual data type

domain

metadata
semantics
conventions

processing
algorithms

mapping
visual encoding

image

visual channel
graphical marks



Nominal, Ordinal & Quantitative

N - Nominal (labels or categories)

- Operations: =, ≠

O - Ordered

- Operations: =, ≠, <, >

Q - Interval (location of zero arbitrary)

- Operations: =, ≠, <, >, -
- Can measure distances or spans

Q - Ratio (zero fixed)

- Operations: =, ≠, <, >, -, %
- Can measure ratios or proportions

Visual Encoding Variables

Position (x 2)

Size

Value

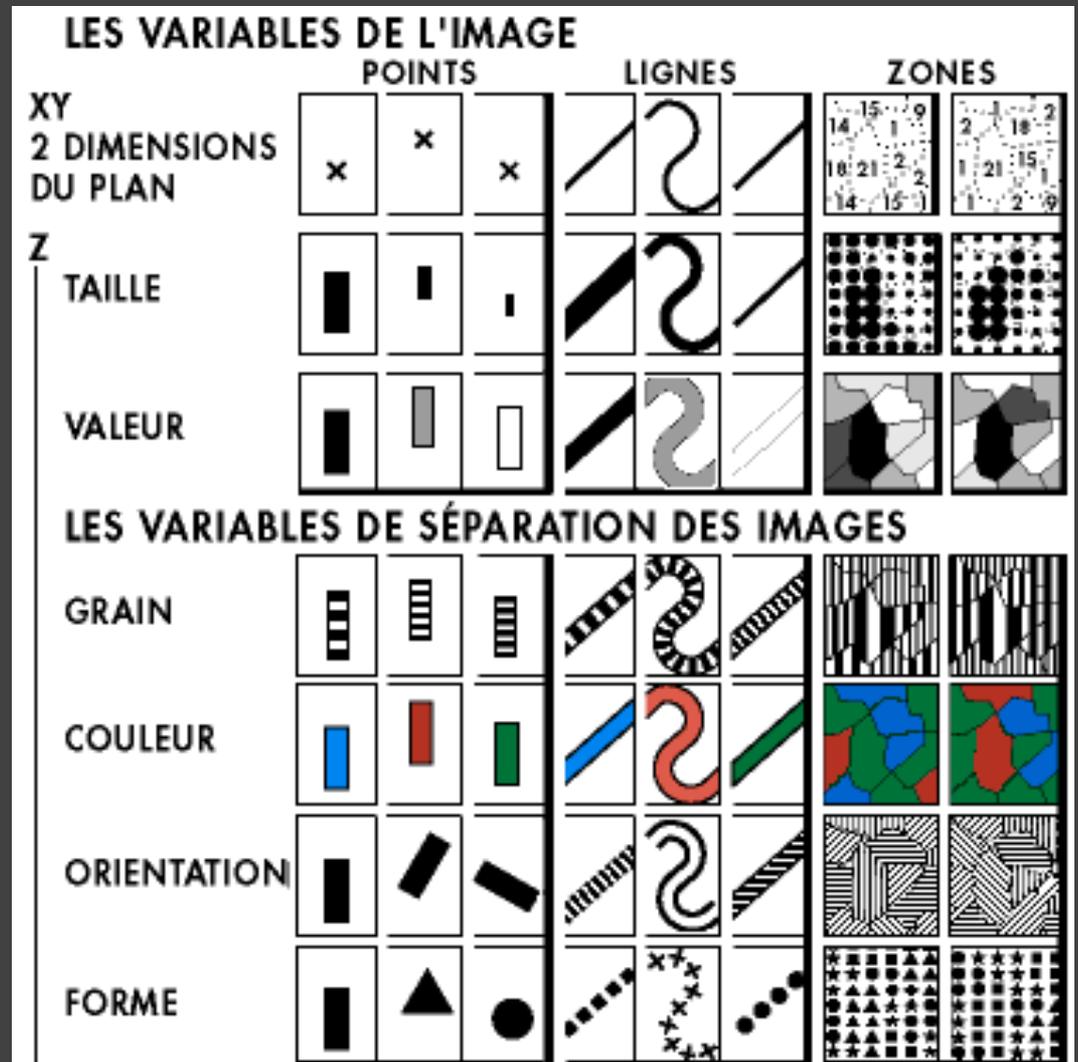
Texture

Color

Orientation

Shape

Others?



Bertin's "Levels of Organization"

Position

N	O	Q
---	---	---

Nominal

Size

N	O	Q
---	---	---

Ordinal

Value

N	O	Q
---	---	---

Quantitative

Note: $Q \subset O \subset N$

Texture

N	o	
---	---	--

Color

N		
---	--	--

Orientation

N		
---	--	--

Shape

N		
---	--	--

Choosing Visual Encodings

Assume k visual encodings and n data attributes. We would like to pick the “best” encoding among a combinatorial set of possibilities of size $(n+1)^k$

Principle of Consistency

The properties of the image (visual variables) should match the properties of the data.

Principle of Importance Ordering

Encode the most important information in the most effective way.

Design Criteria [Mackinlay 86]

Expressiveness

A set of facts is *expressible* in a visual language if the sentences (i.e. the visualizations) in the language express all the facts in the set of data, and only the facts in the data.

Effectiveness

A visualization is more *effective* than another visualization if the information conveyed by one visualization is more readily perceived than the information in the other visualization.

Design Criteria *Translated*

Tell the truth and nothing but the truth
(don't lie, and don't lie by omission)

Use encodings that people decode better
(where better = faster and/or more accurate)

Effectiveness Rankings [Mackinlay 86]

QUANTITATIVE

Position
Length
Angle
Slope
Area (Size)
Volume
Density (Value)
Color Sat
Color Hue
Texture
Connection
Containment
Shape

ORDINAL

Position
Density (Value)
Color Sat
Color Hue
Texture
Connection
Containment
Length
Angle
Slope
Area (Size)
Volume
Shape

NOMINAL

Position
Color Hue
Texture
Connection
Containment
Density (Value)
Color Sat
Shape
Length
Angle
Slope
Area
Volume

Effectiveness Rankings [Mackinlay 86]

QUANTITATIVE

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Containment
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Slope
Area (Size)
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Shape

NOMINAL

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Color Hue
Texture
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Containment
Density (Value)
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Effectiveness Rankings [Mackinlay 86]

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Angle
Slope
Area (Size)
Volume
Shape

NOMINAL

Position
Color Hue
Texture
Connection
Containment
Density (Value)
Color Sat
Shape
Length
Angle
Slope
Area
Volume

A1 Review

Design Considerations

Title, labels, legend, captions, source!

Expressiveness and Effectiveness

Avoid unexpressive marks (lines? gradients?)

Use perceptually effective encodings

Don't distract: faint gridlines, pastel highlights/fills

The "elimination diet" approach - start minimal

Support comparison and pattern perception

Between elements, to a reference line, or to totals

Design Considerations

Transform data (e.g., invert, log, normalize)

Are model choices (regression lines) appropriate?

Group / sort data by meaningful dimensions

Reduce cognitive overhead

Minimize visual search, minimize ambiguity

Avoid legend lookups if direct labeling works

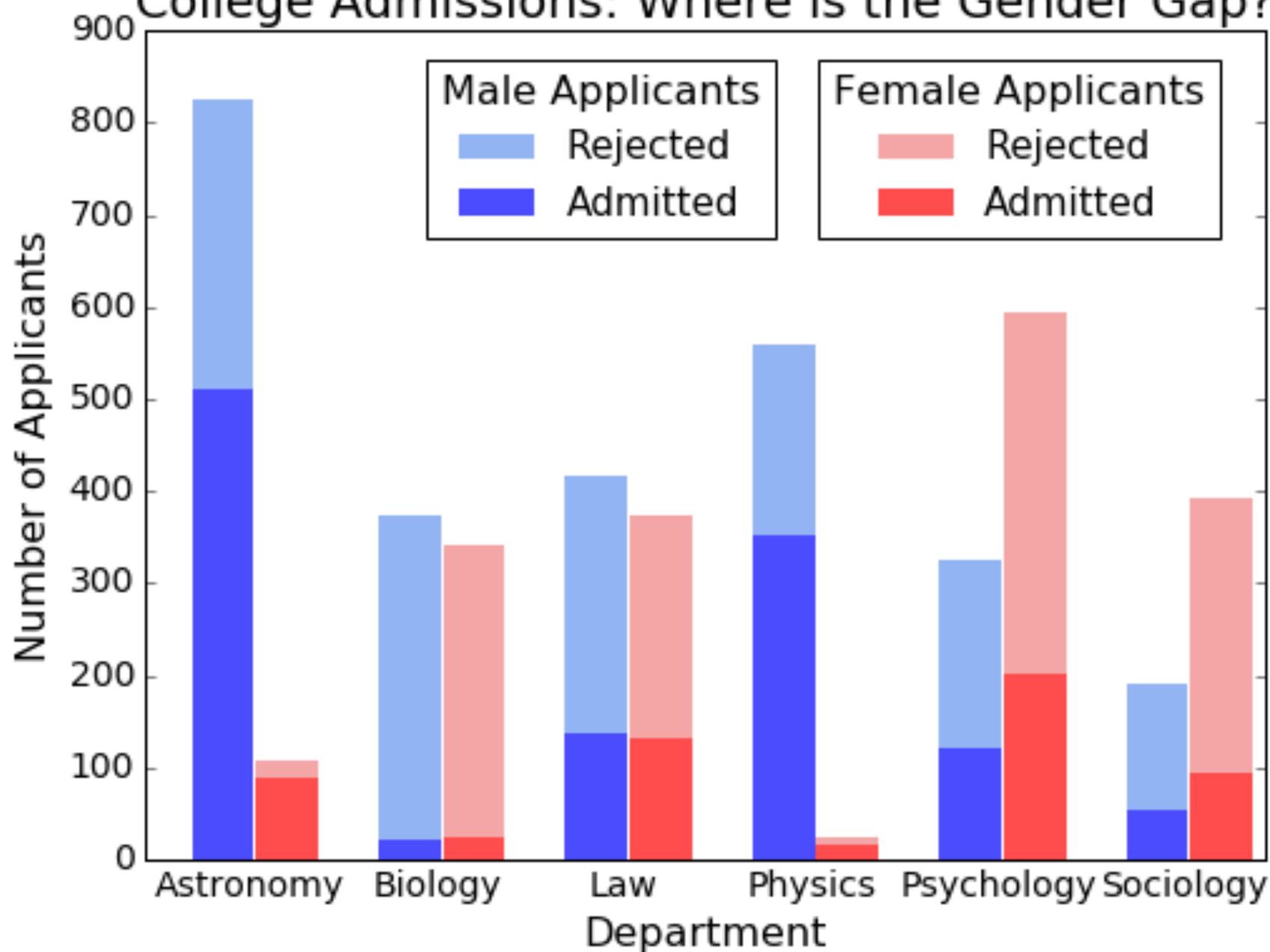
Avoid color mappings with indiscernible colors

Be consistent! Visual inferences should consistently support data inferences.

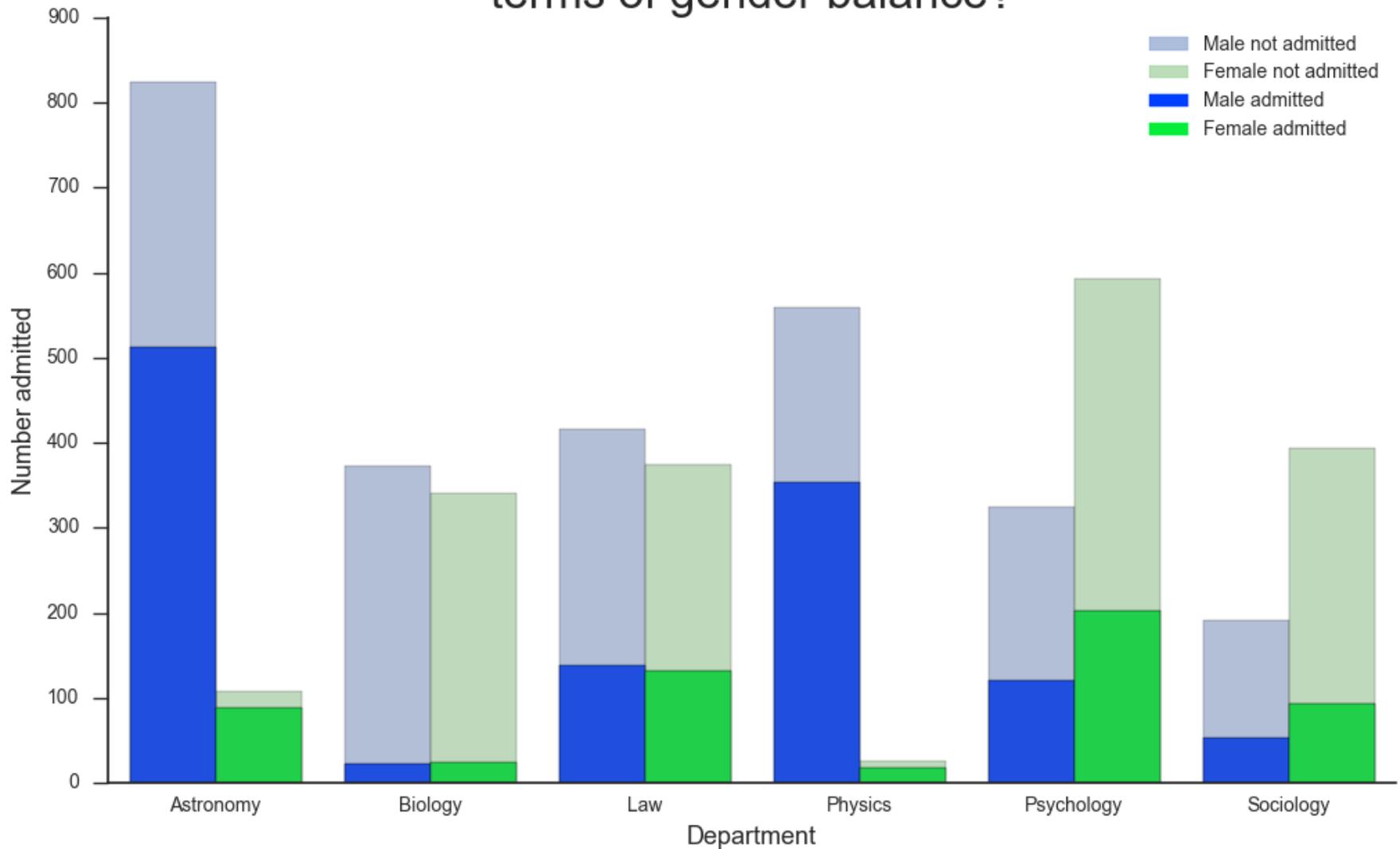
Bar Charts

Counts

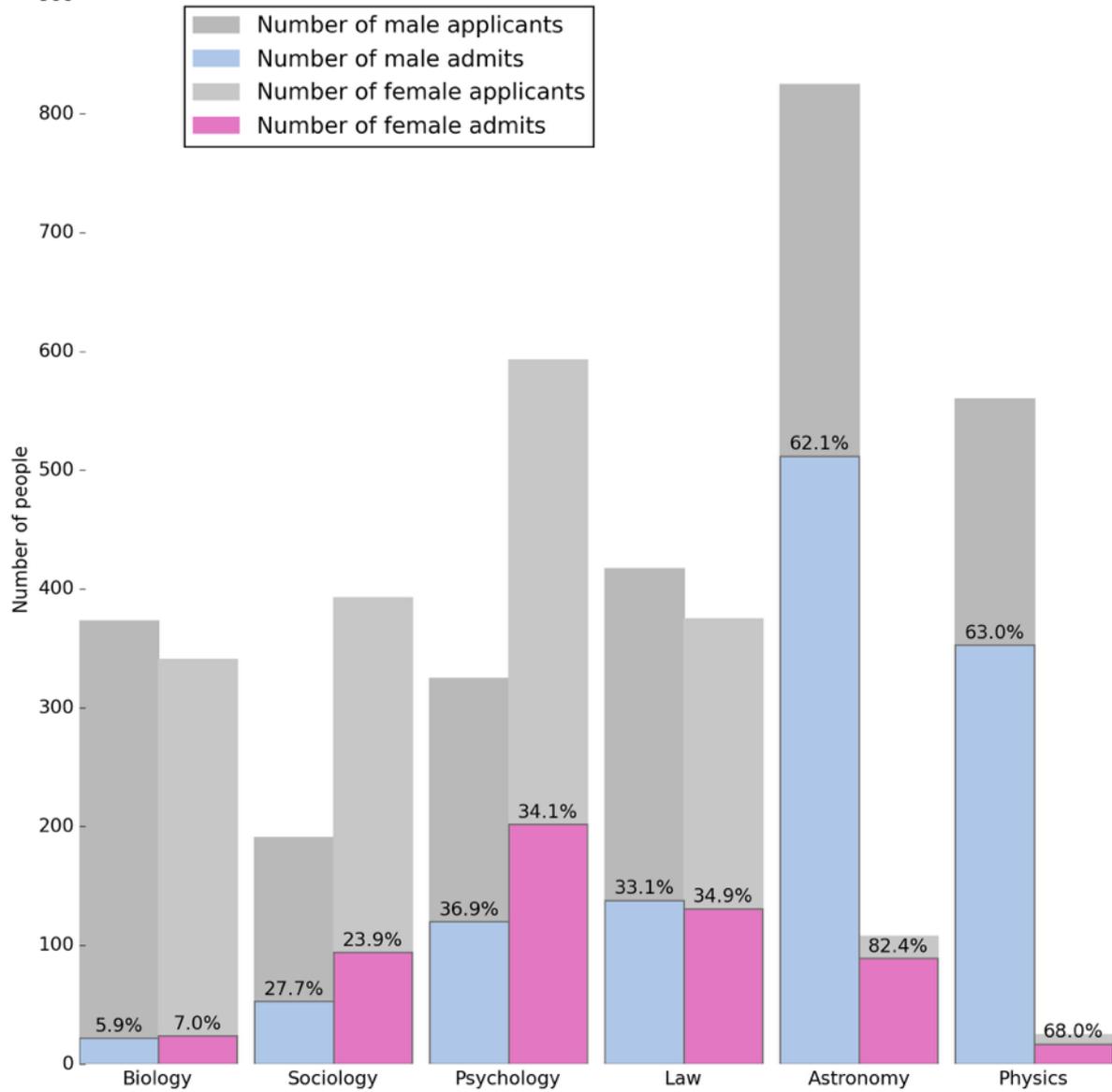
College Admissions: Where is the Gender Gap?



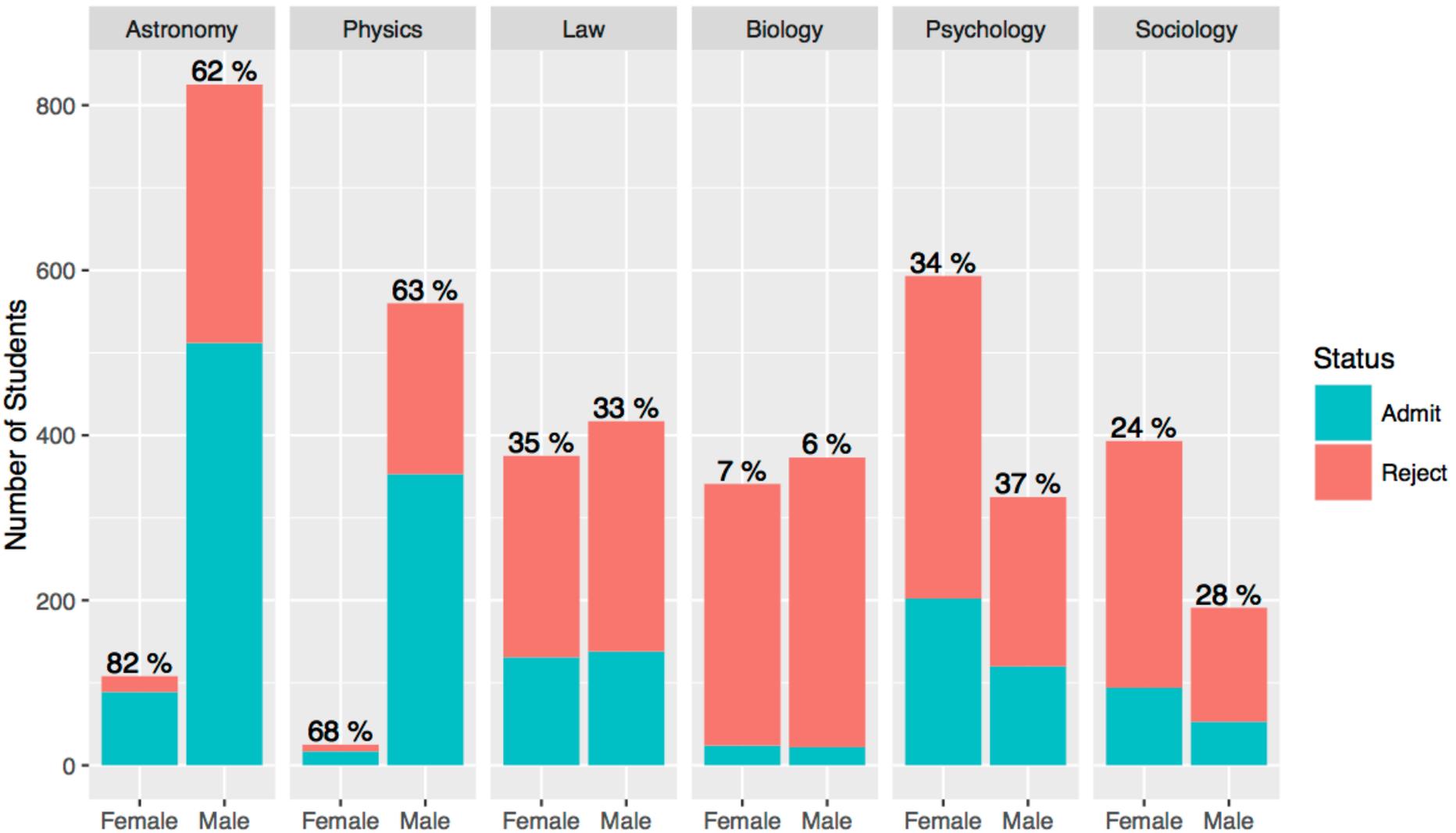
How do the admissions to different departments compare in terms of gender balance?



How do admission rates for each gender vary by department?

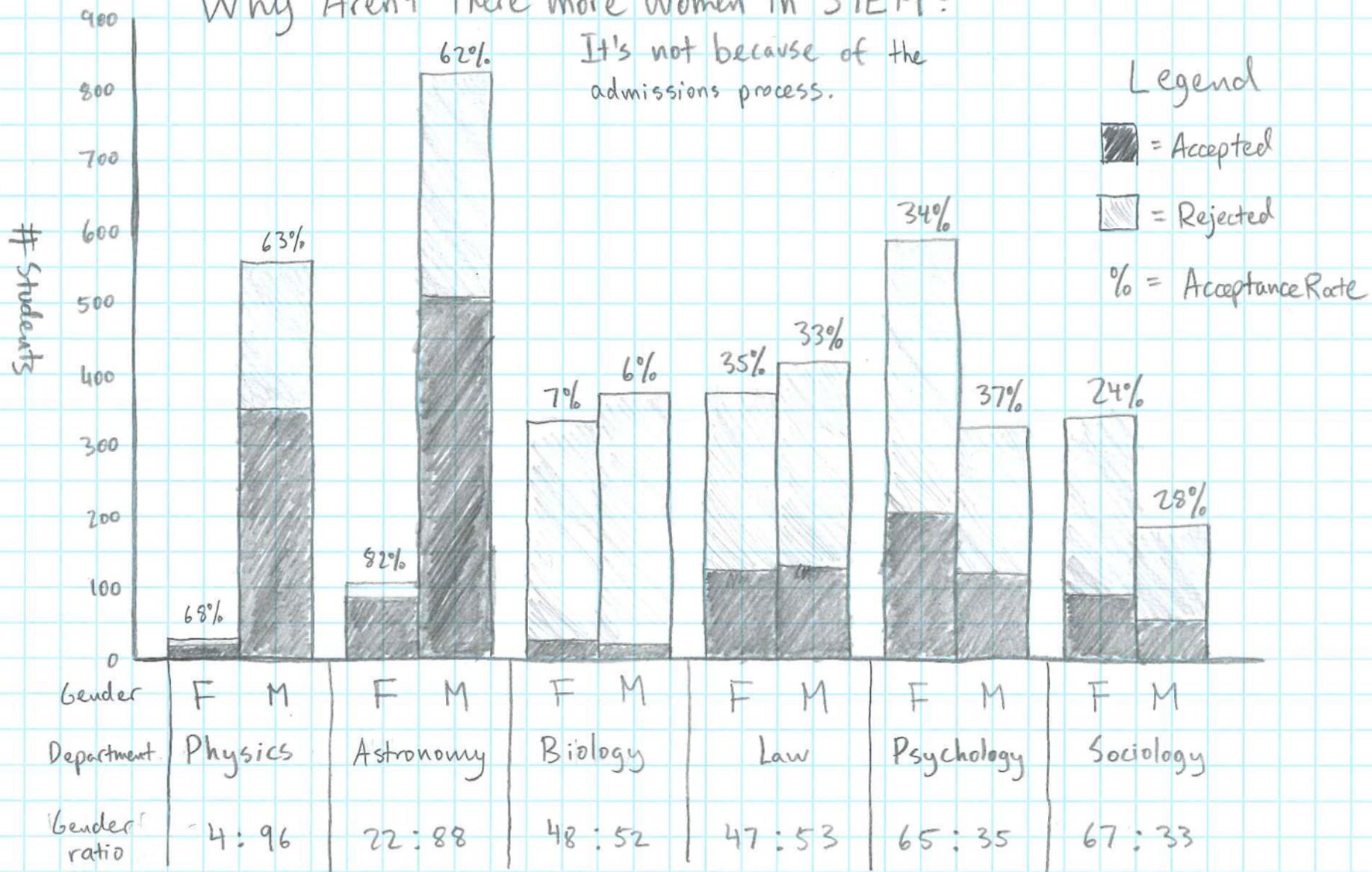


Does gender bias exist in college admissions?

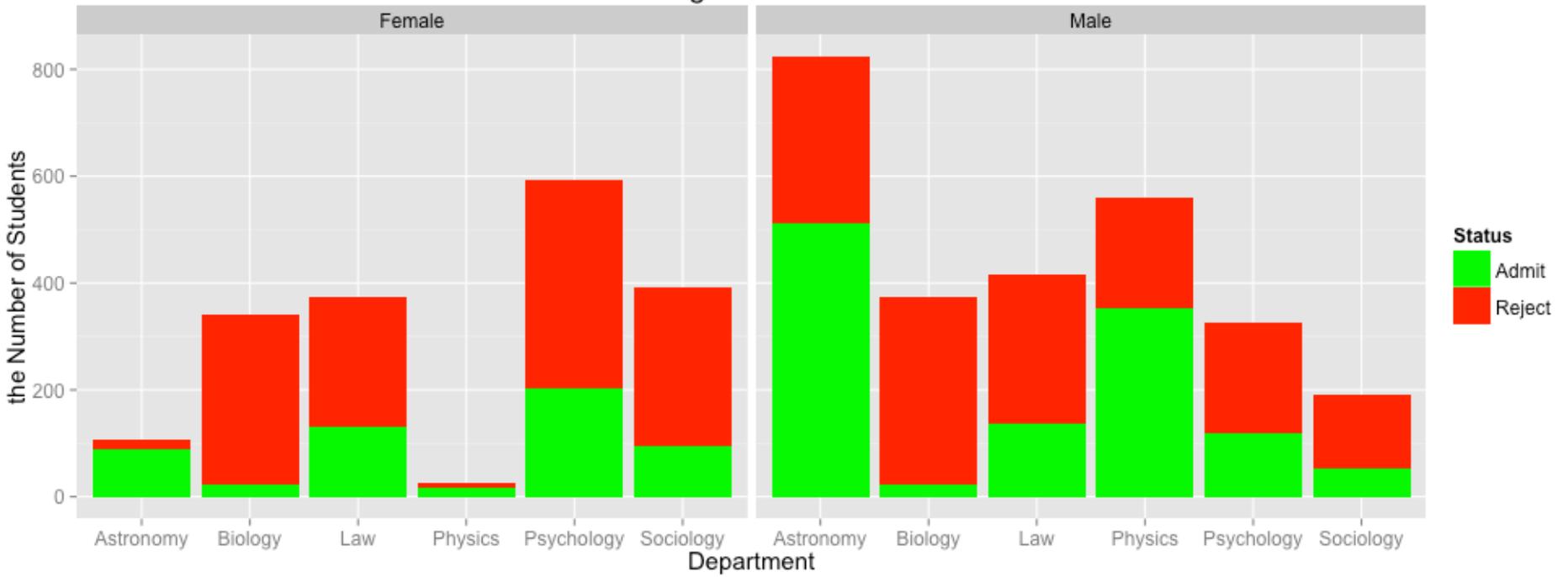


Why Aren't There more Women in STEM?

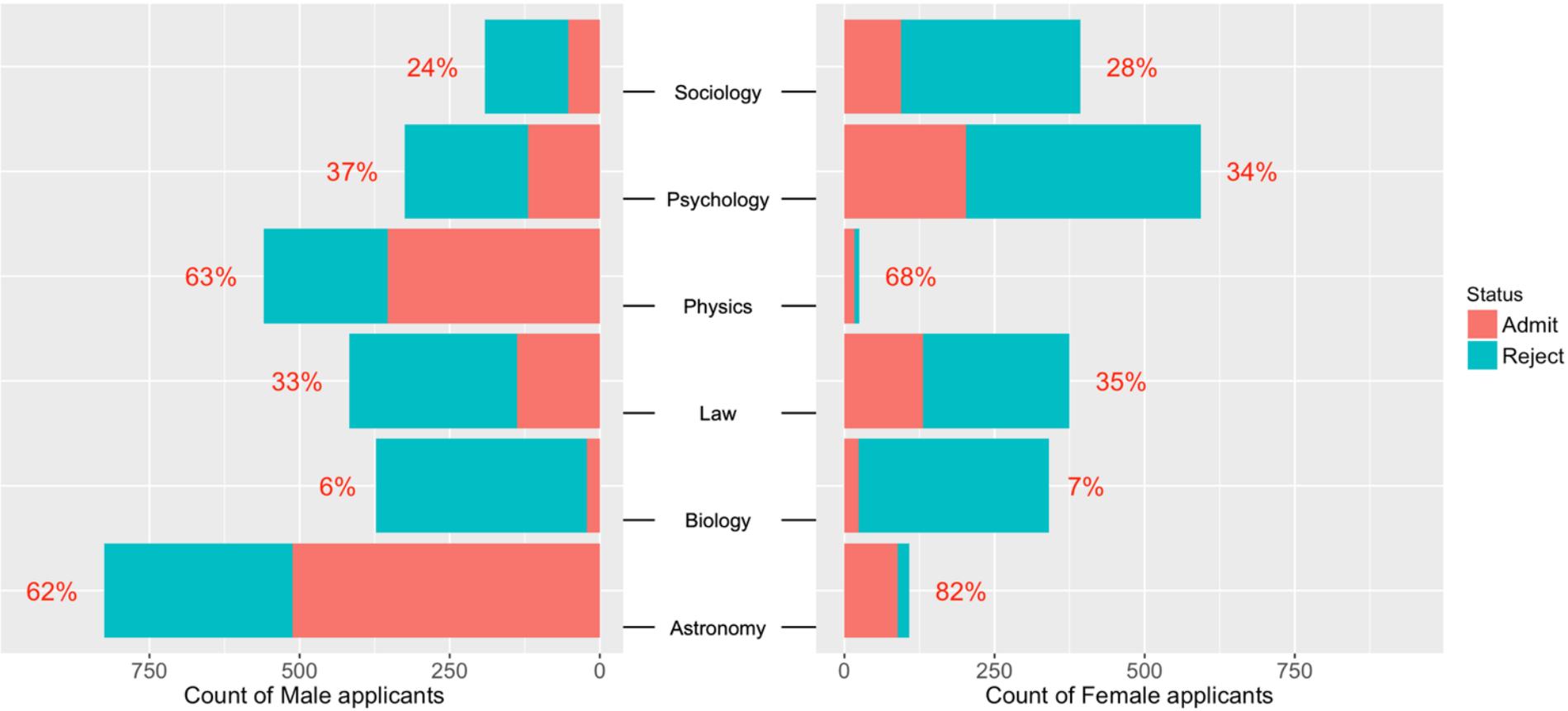
It's not because of the admissions process.



College Admissions



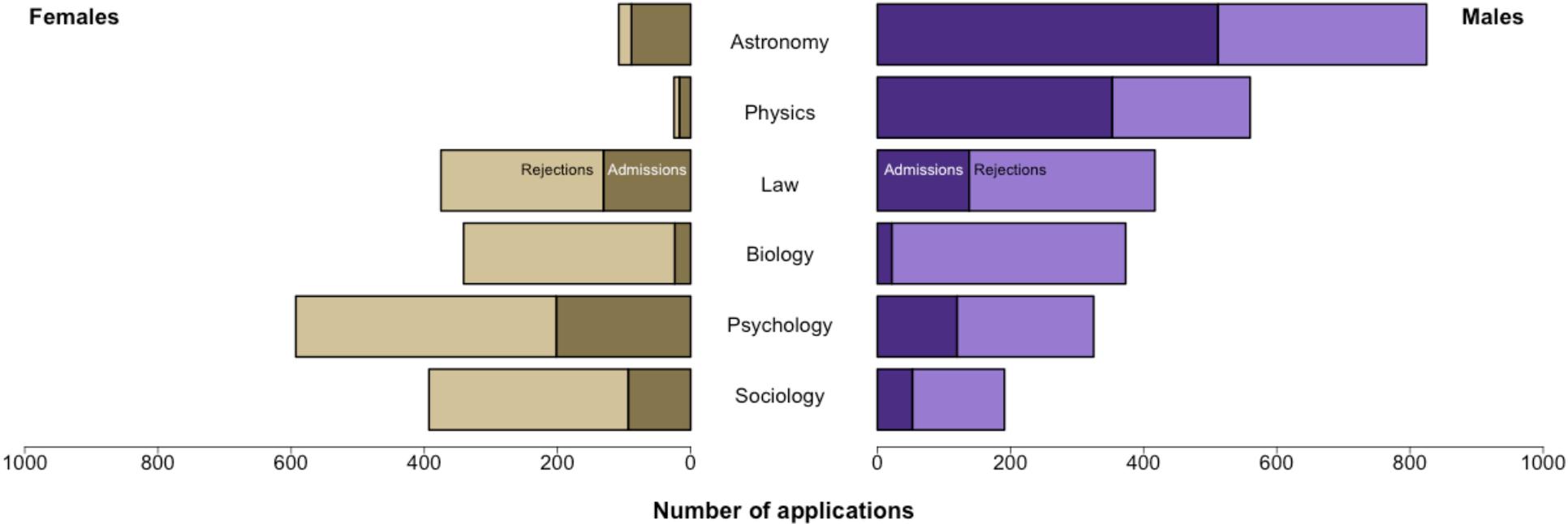
Are there any gender differences regarding number of applicants and admission rates for each department?



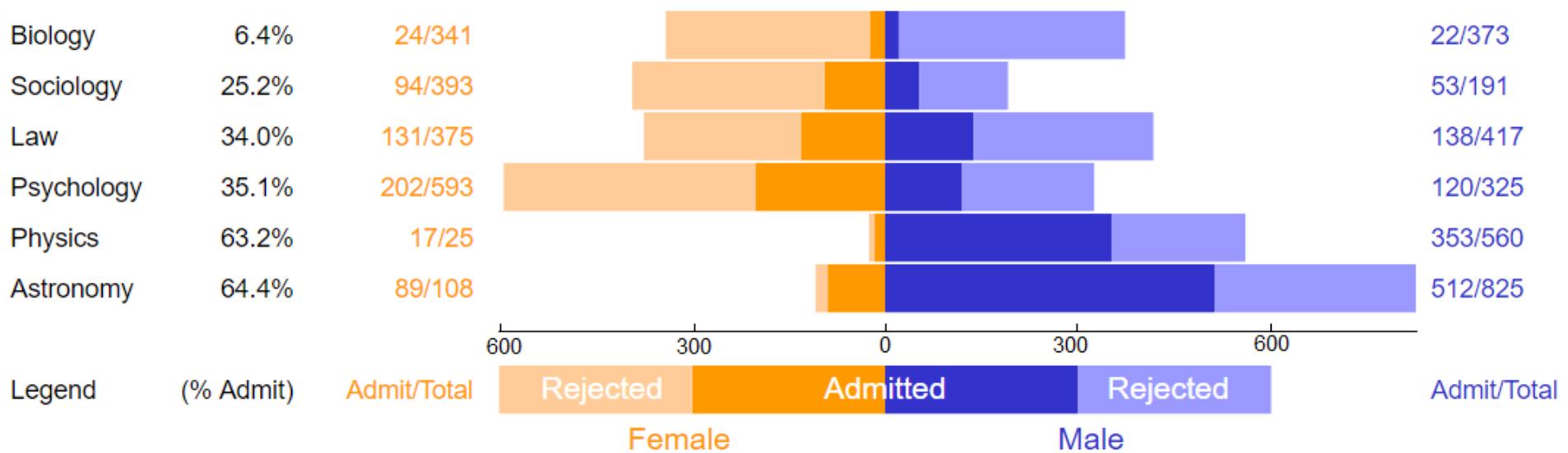
Is there a gender bias in college applications?

Females

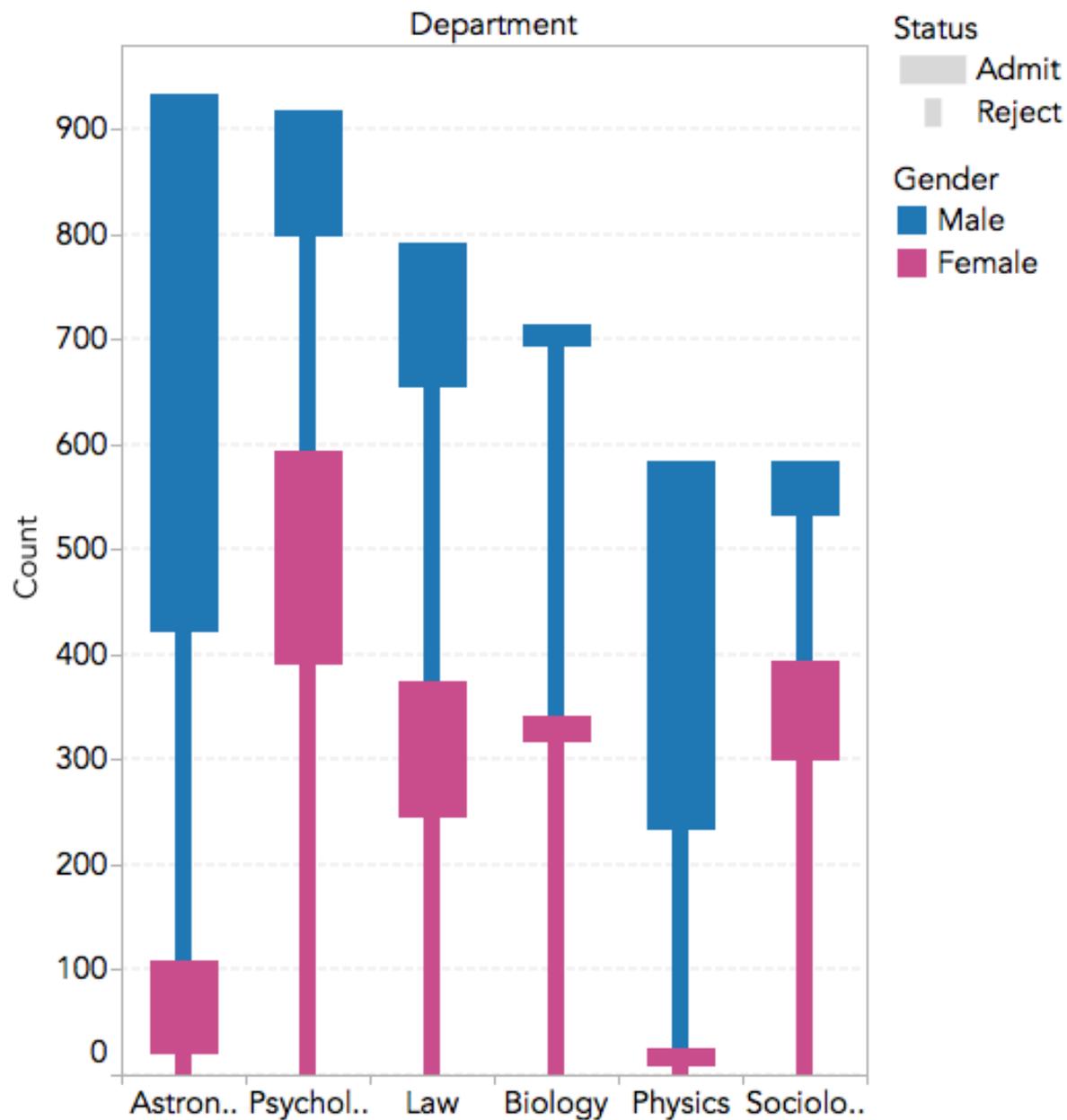
Males



Admissions by Department and Gender

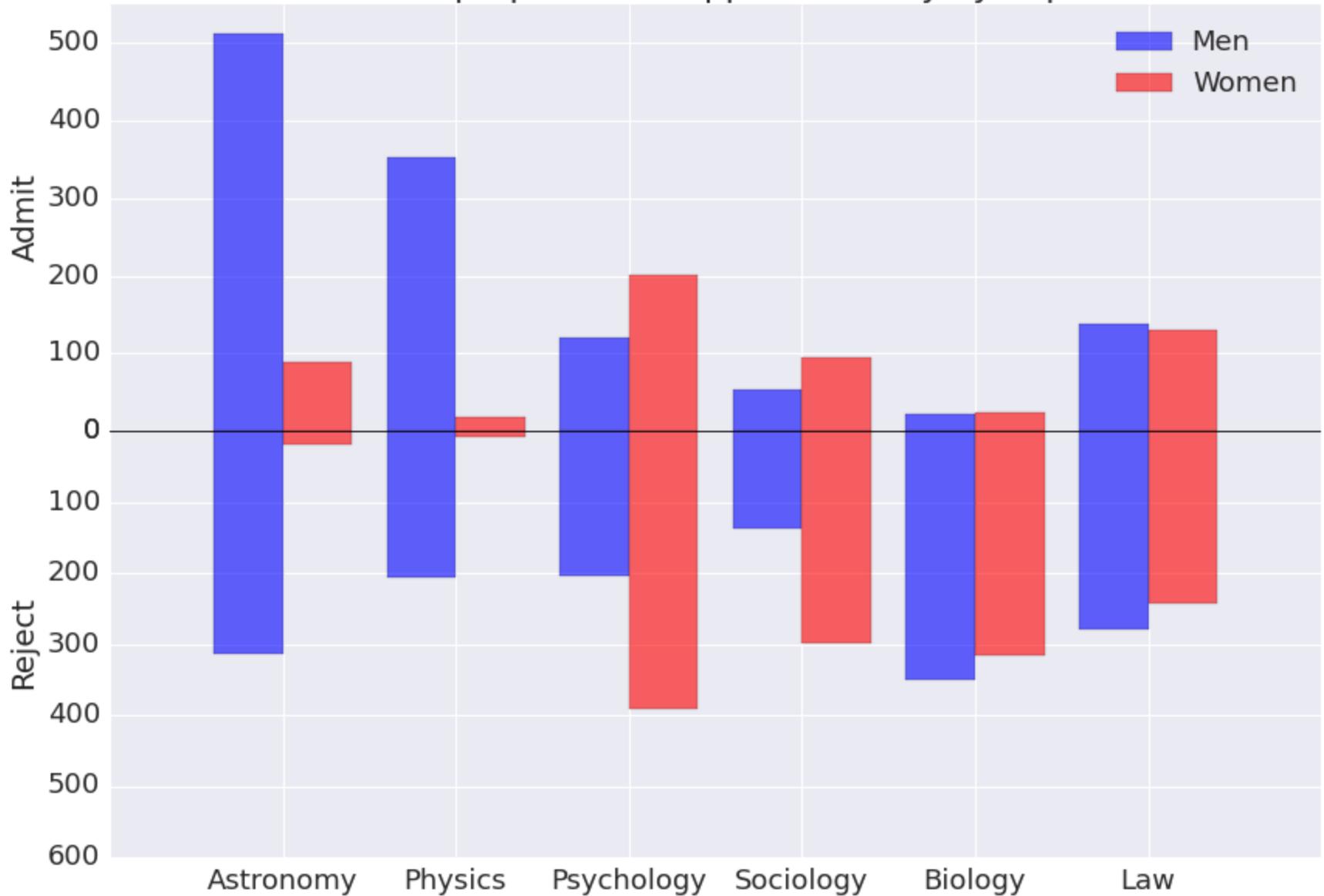


Admissions Data Analysis

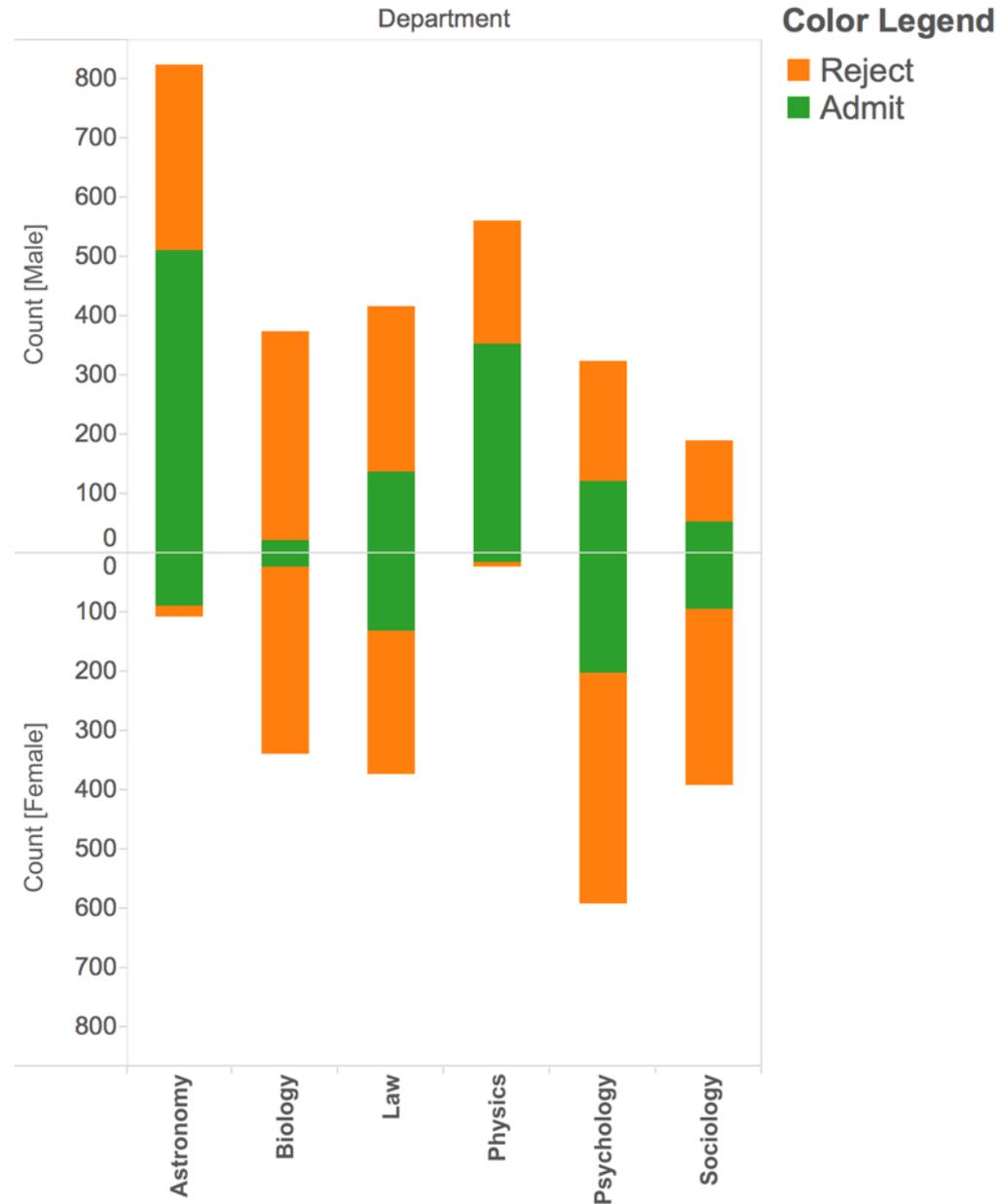


Sum of Count for each Department. Color shows details about Gender. Size shows details about Status.

How does the proportion of applicants vary by department?



Compare college admission for different department across gender



Sum of Male and sum of Female for each Department. Color shows details about Status.

University Admission Infographics



Total Applicants



2691 male
60%



1835 female
40%

Department

Male

Female



Astronomy



Biology



Law



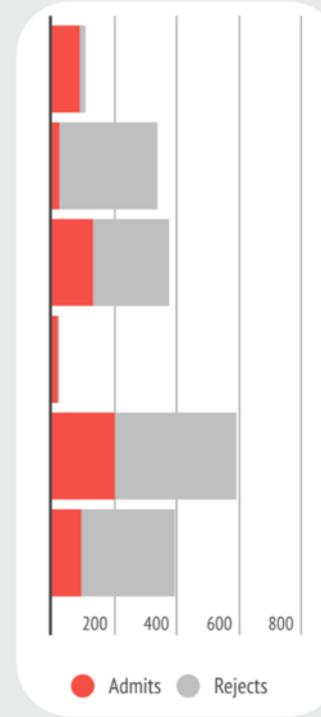
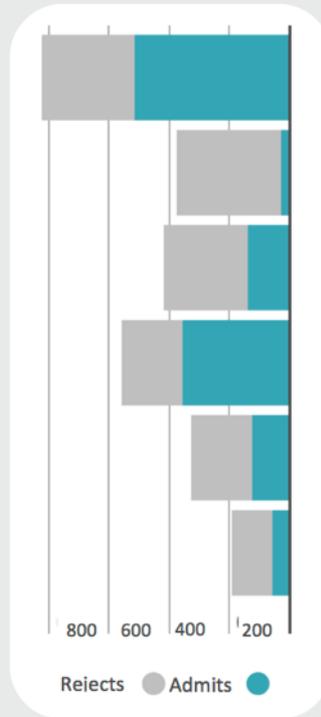
Physics



Psychology



Sociology

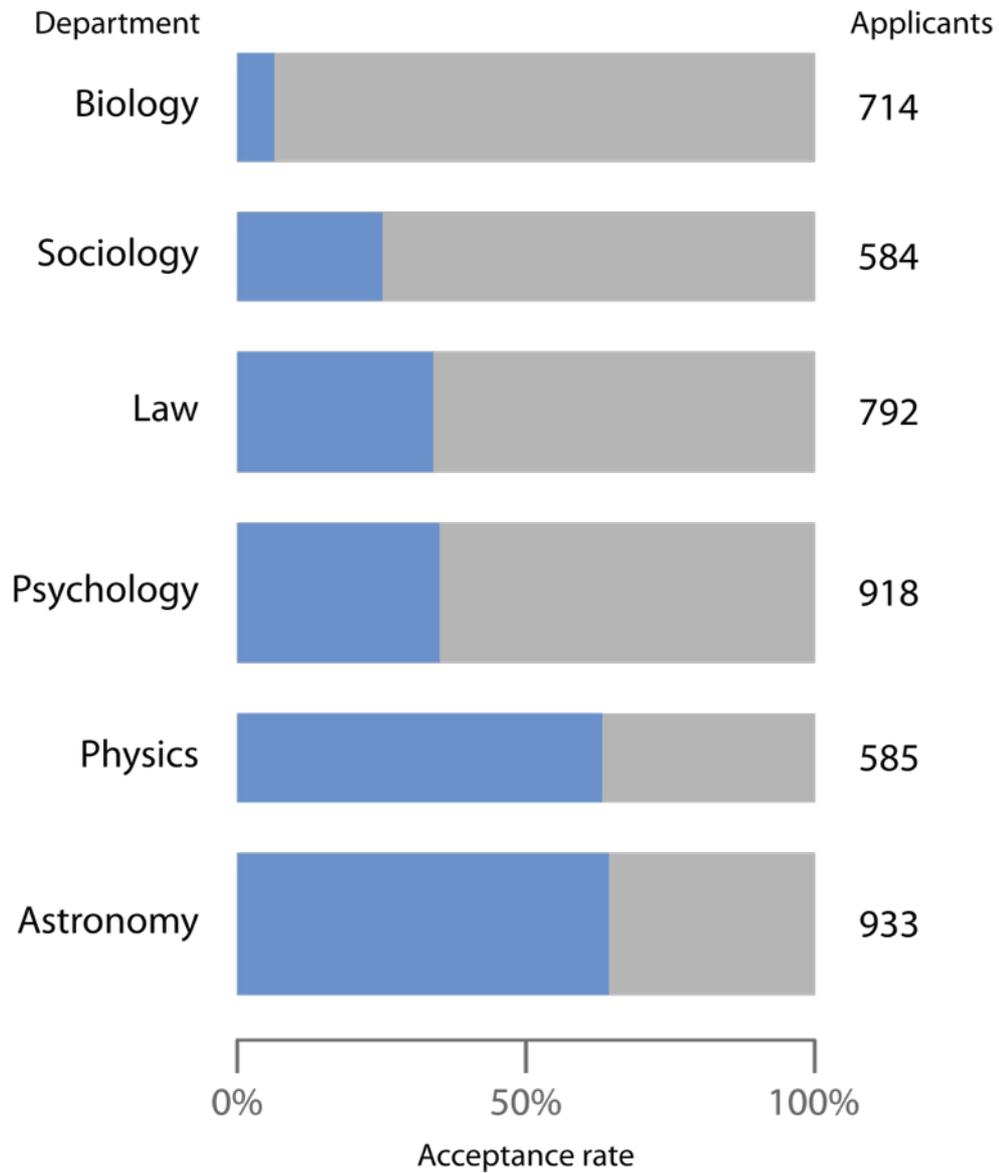


Rejects Admits

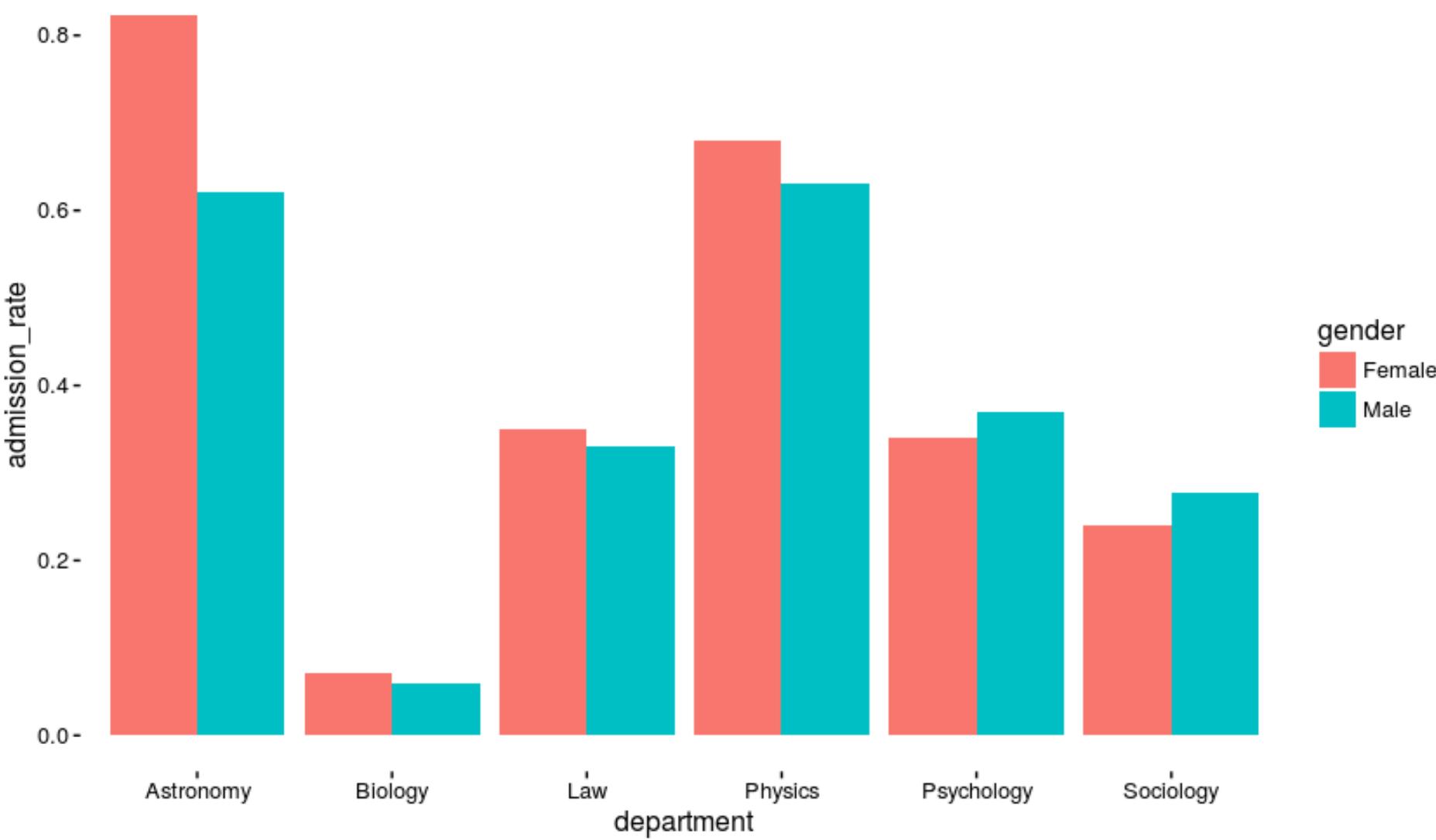
Admits Rejects

Rates

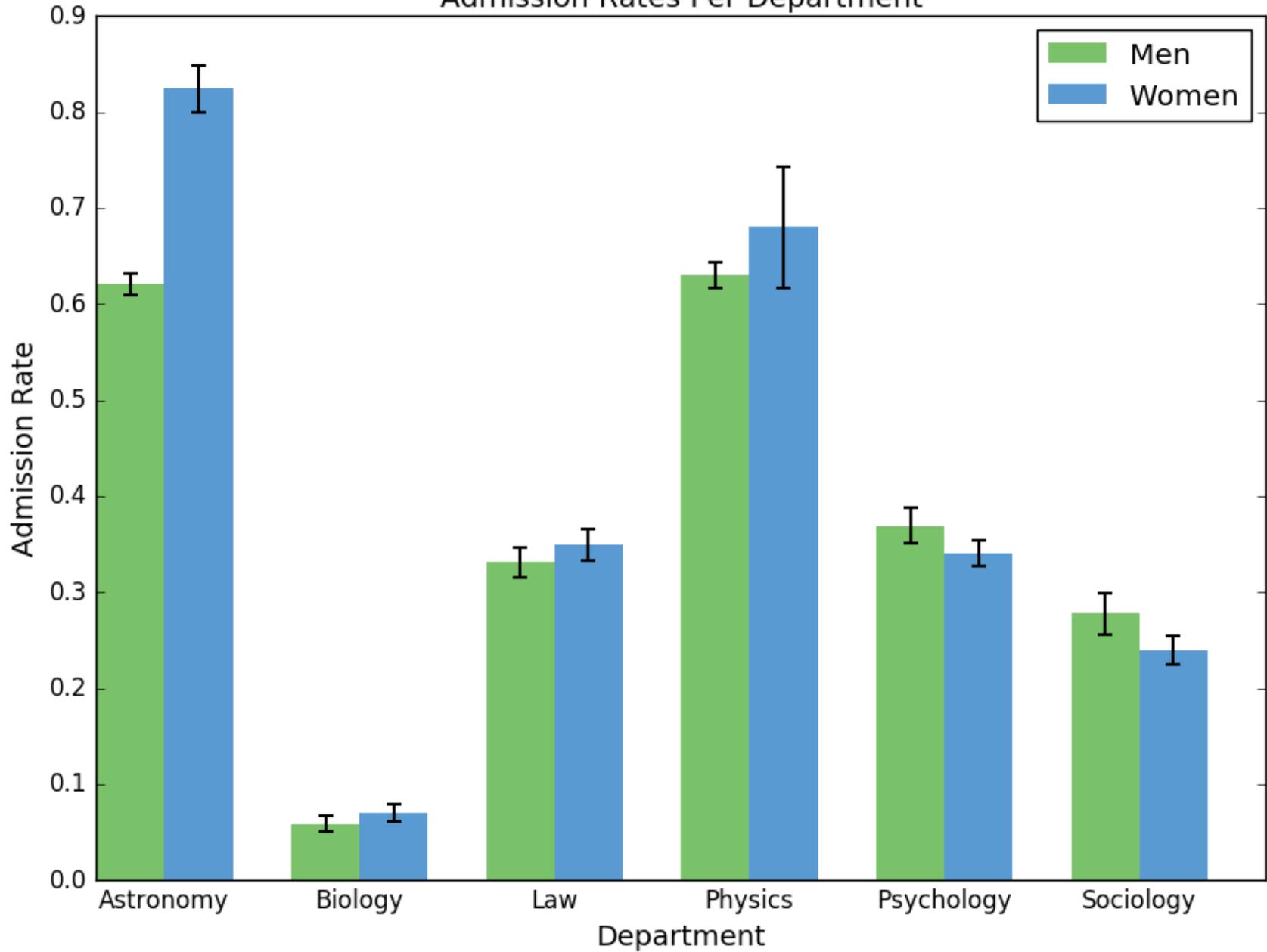
Popularity and Selectiveness of Departments



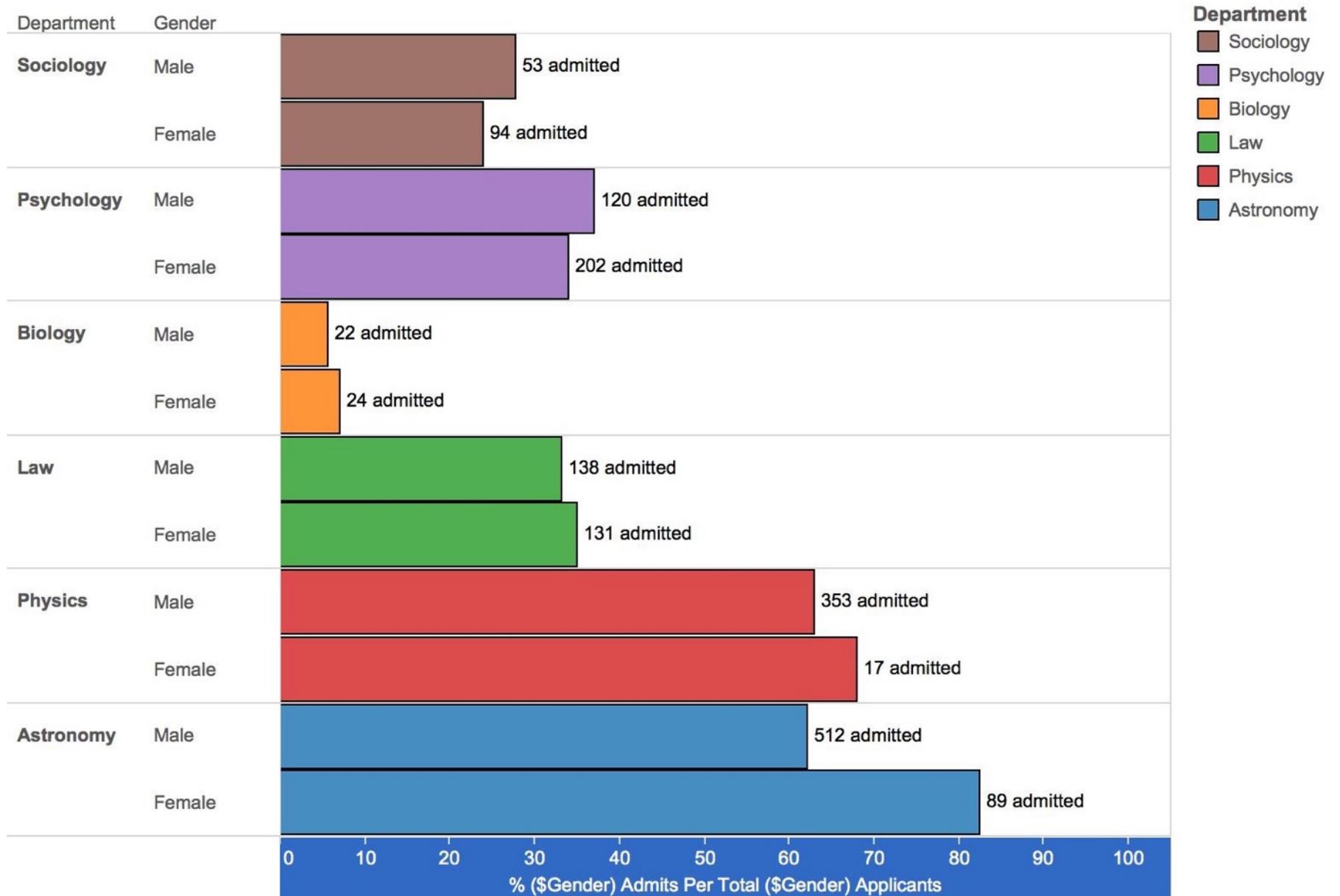
Male or female has higher admission rate in different departments?



Admission Rates Per Department

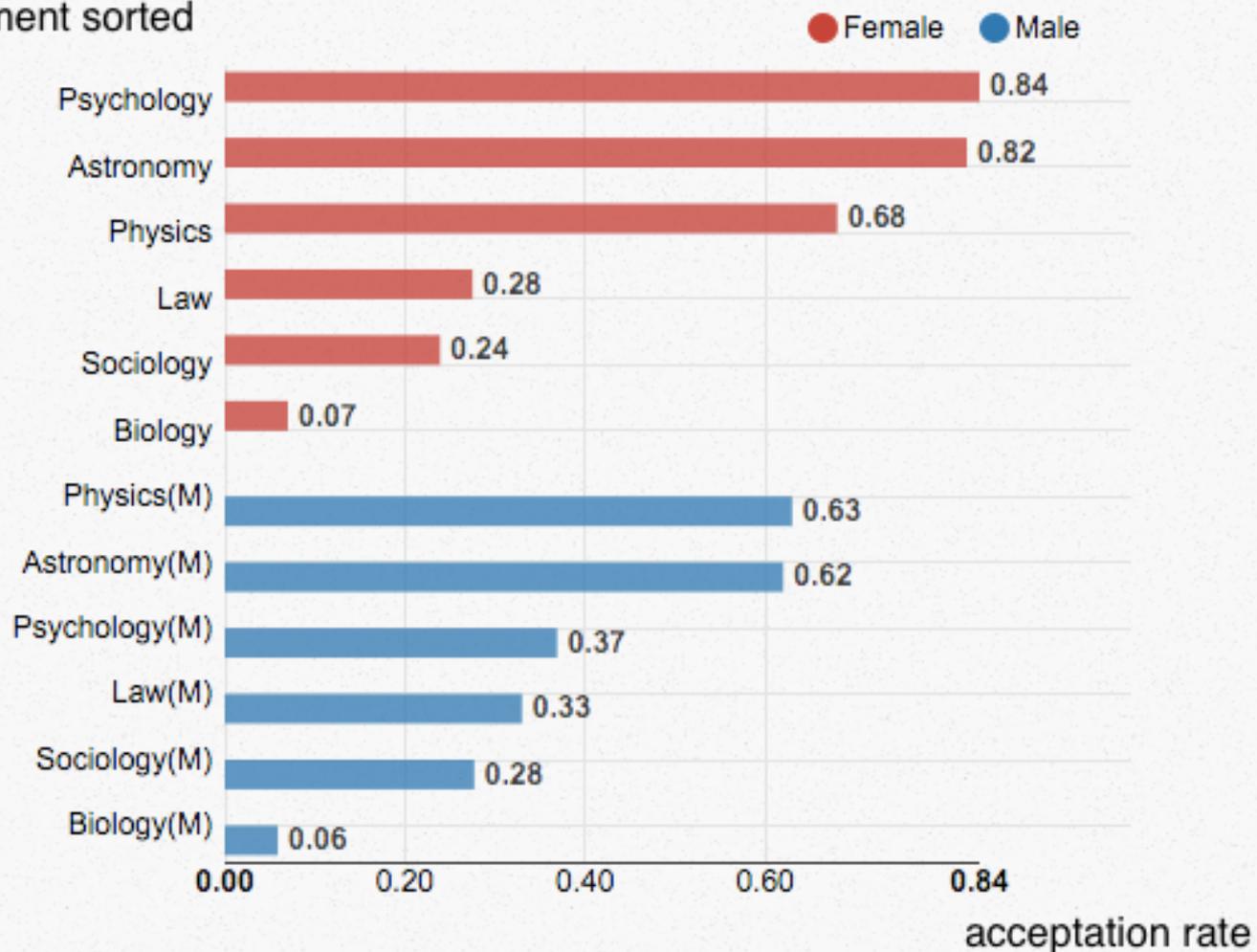


Percent of applicants offered admission



What is the sorting of acceptance rate between departments for males and females separately?

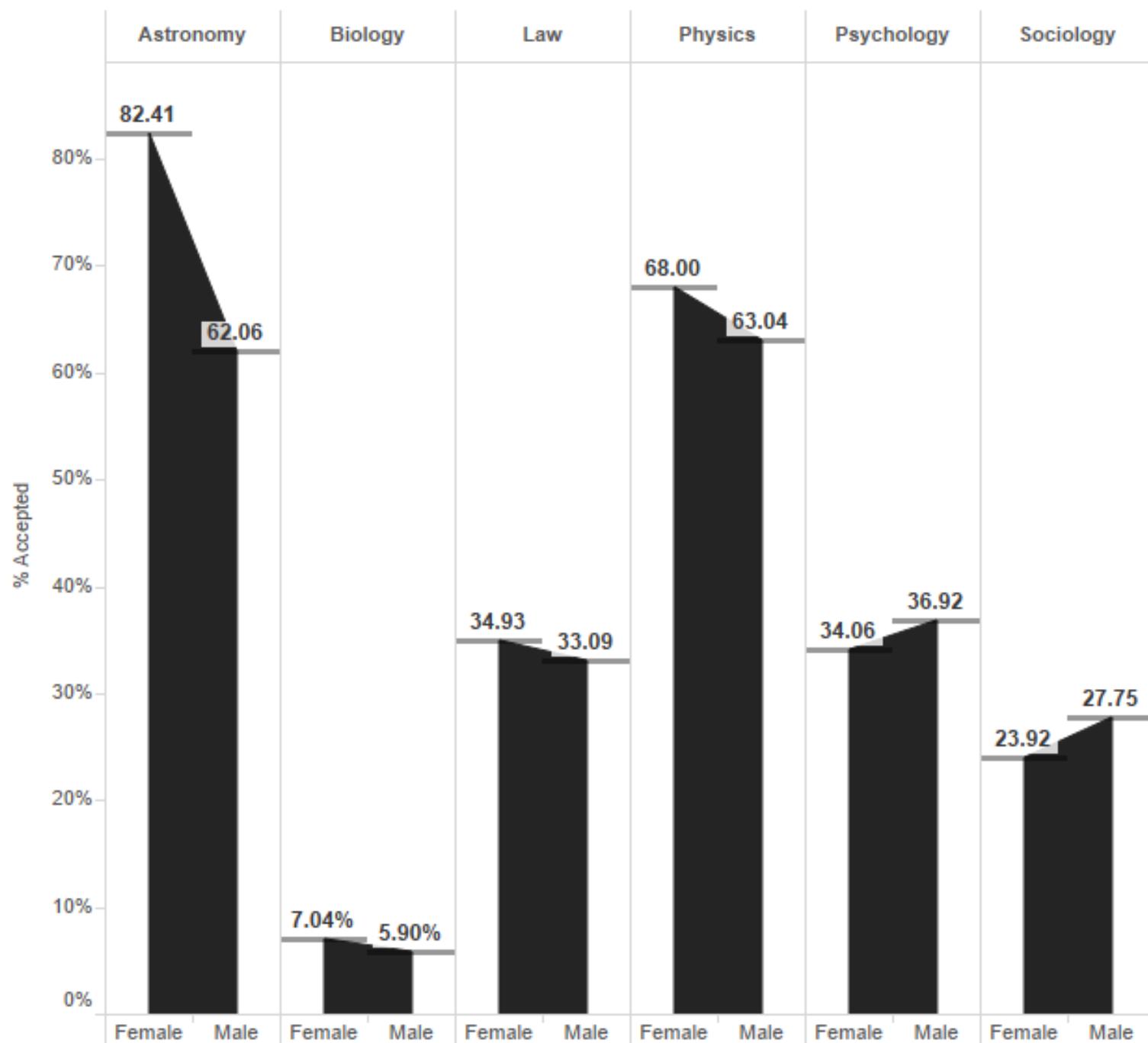
department sorted



What is the sorting of acceptance rate between departments for males and females separately?

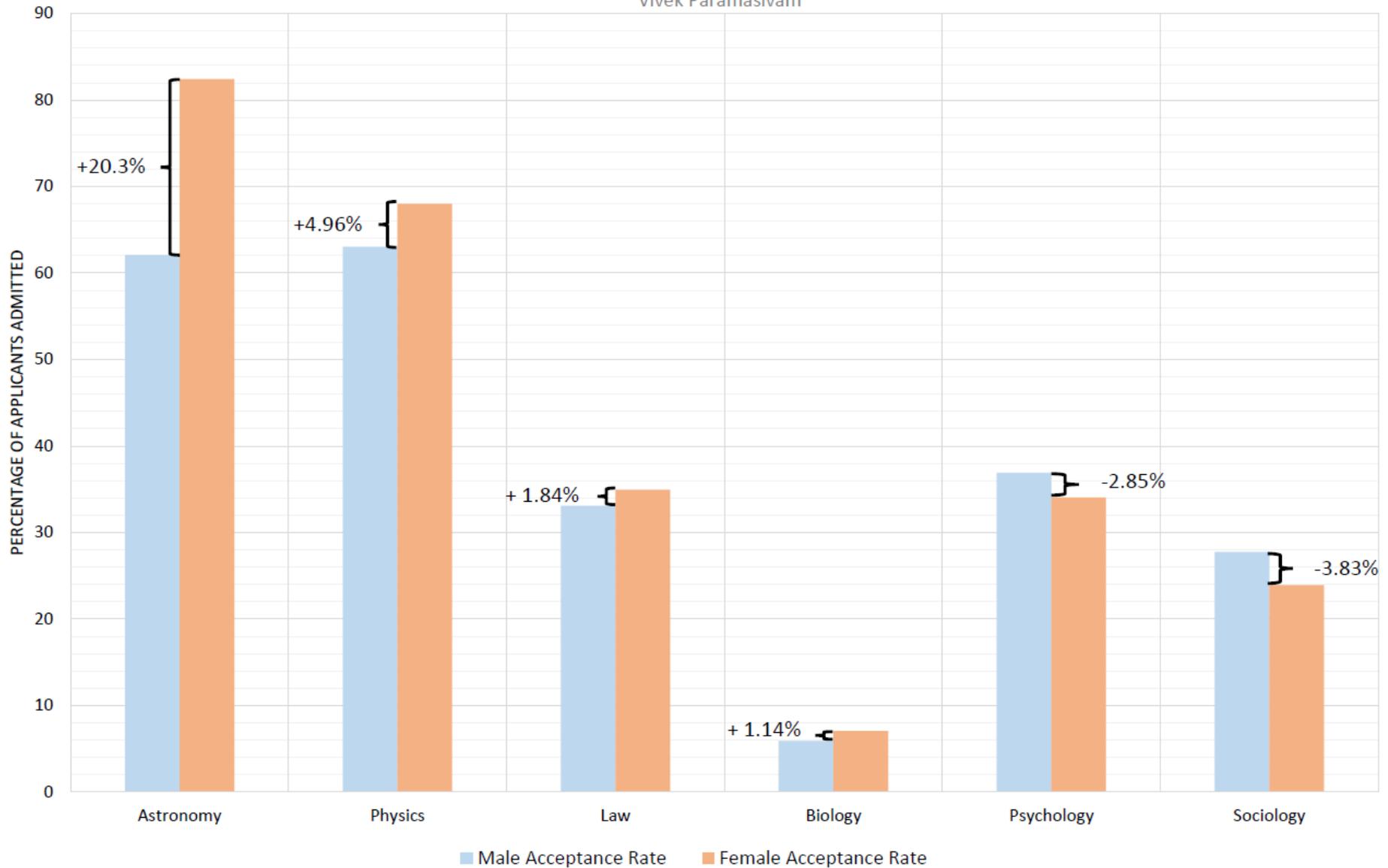
Rank	department	gender	acceptation rate
1	Psychology	female	high
2	Astronomy	female	
3	Physics	female	
4	Law	female	
5	Sociology	female	
6	Biology	female	low
1	Physics	male	high
2	Astronomy	male	
3	Psychology	male	
4	Law	male	
5	Sociology	male	
6	Biology	male	low

What are the acceptance rates for each department in regards to gender?

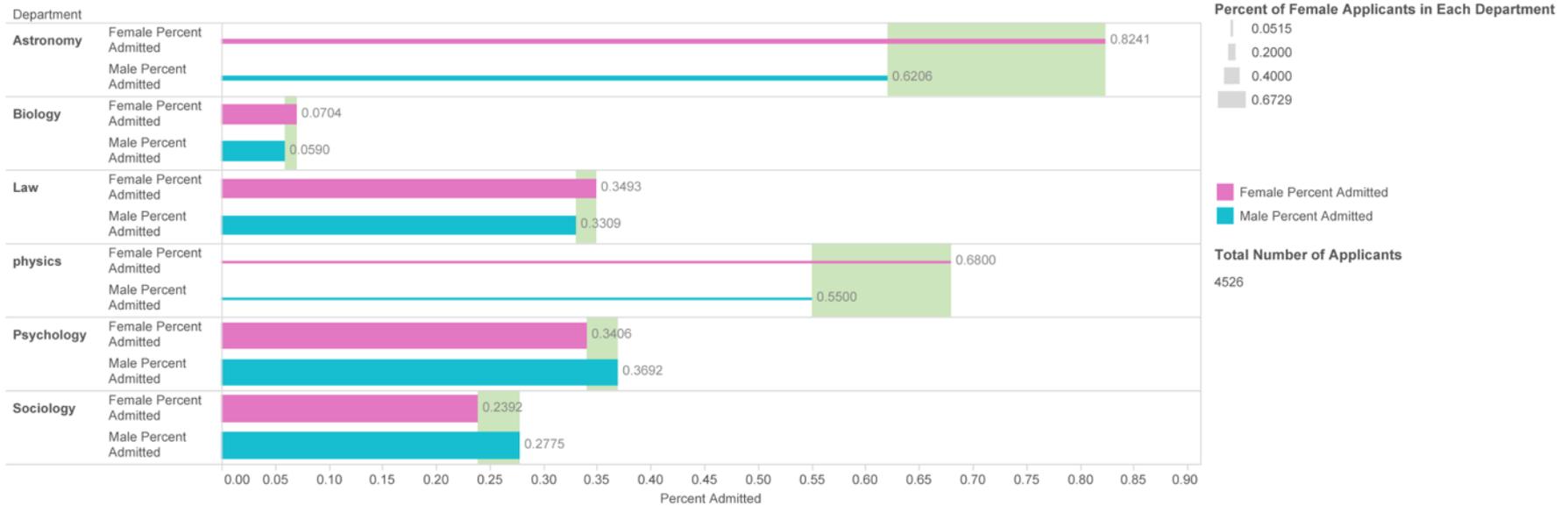


Which departments have the highest disparity in acceptance rates between men and women?

Vivek Paramasivam

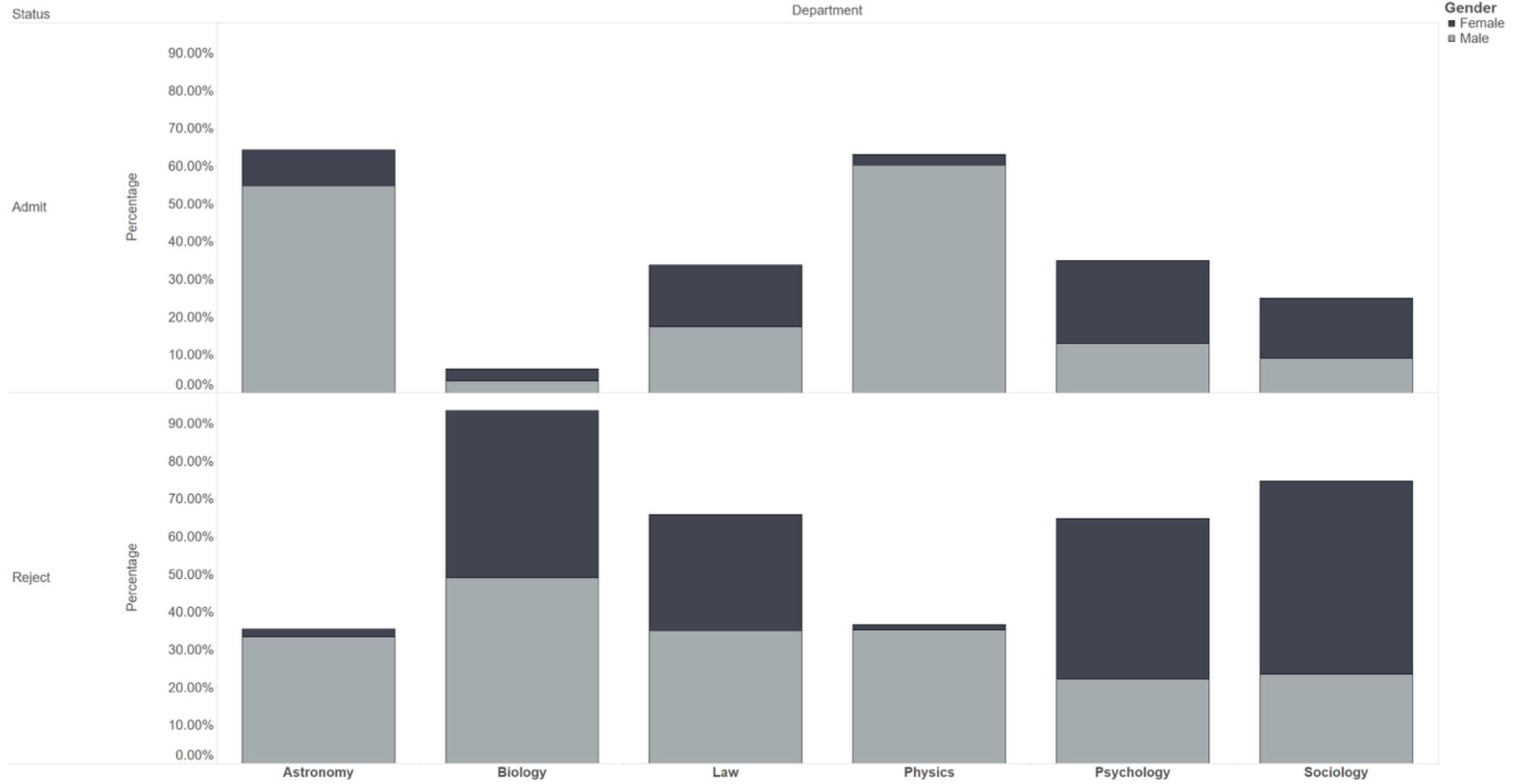


Do female have a higher acceptance rate than male when there is fewer percent of female applicants?



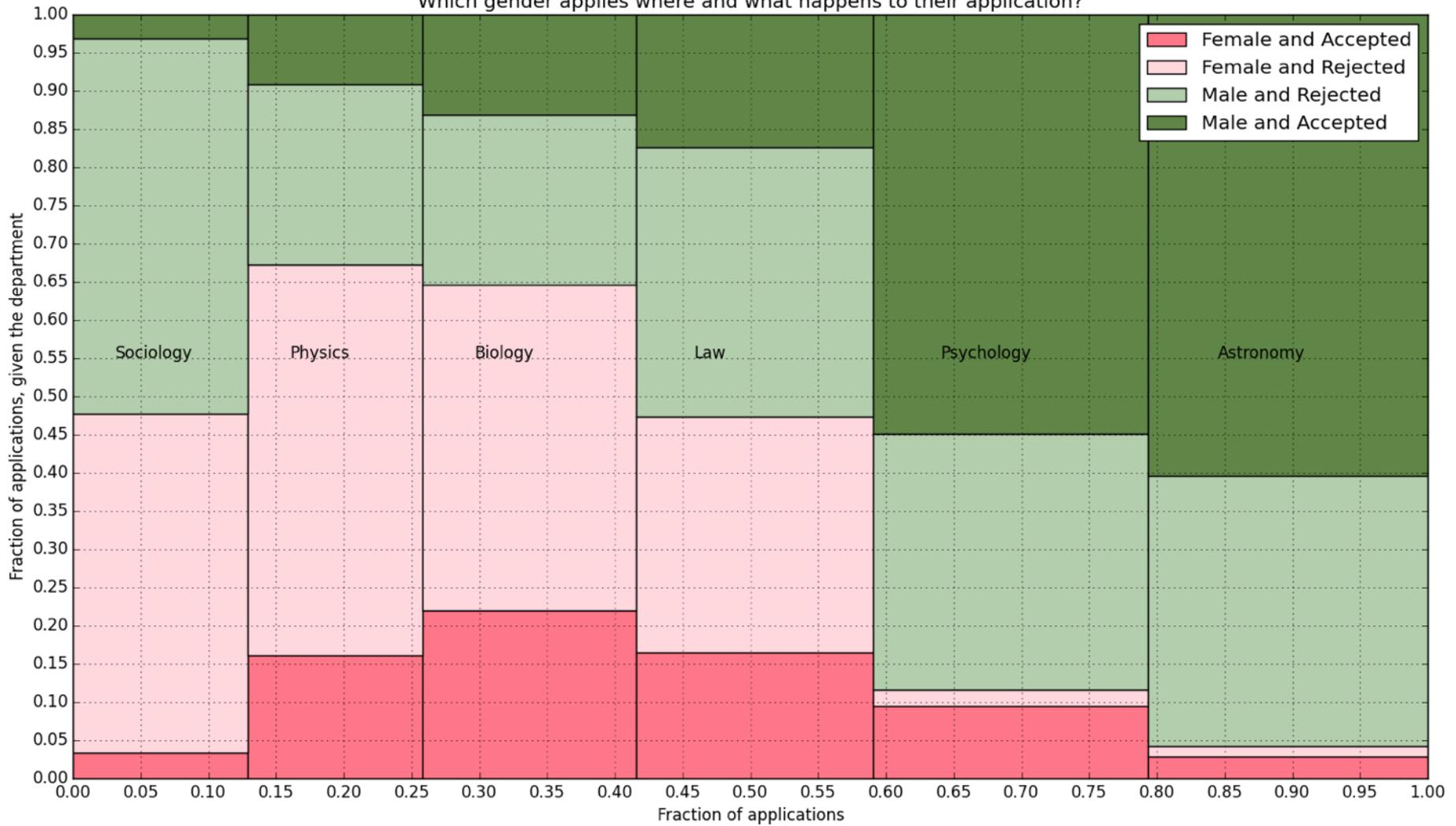
Female Percent Admitted and Male Percent Admitted for each Department. Color shows details about Female Percent Admitted and Male Percent Admitted. Size shows sum of Percent of Female Applicants in Each Department.

Assignment 1: Visualizing the acceptance and rejection rates of each department broken down by gender



Percentage for each Department broken down by Status. Color shows details about Gender.

Which gender applies where and what happens to their application?



How Does Gender Play Roles In Admission?



Status
■ Admit
■ Reject

Gender
■ Female
■ Male

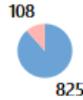
Admission Rate

Applicant Num.

Admission Rate



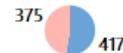
Astronomy



Biology



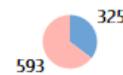
Law



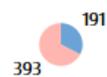
Physics



Psychology



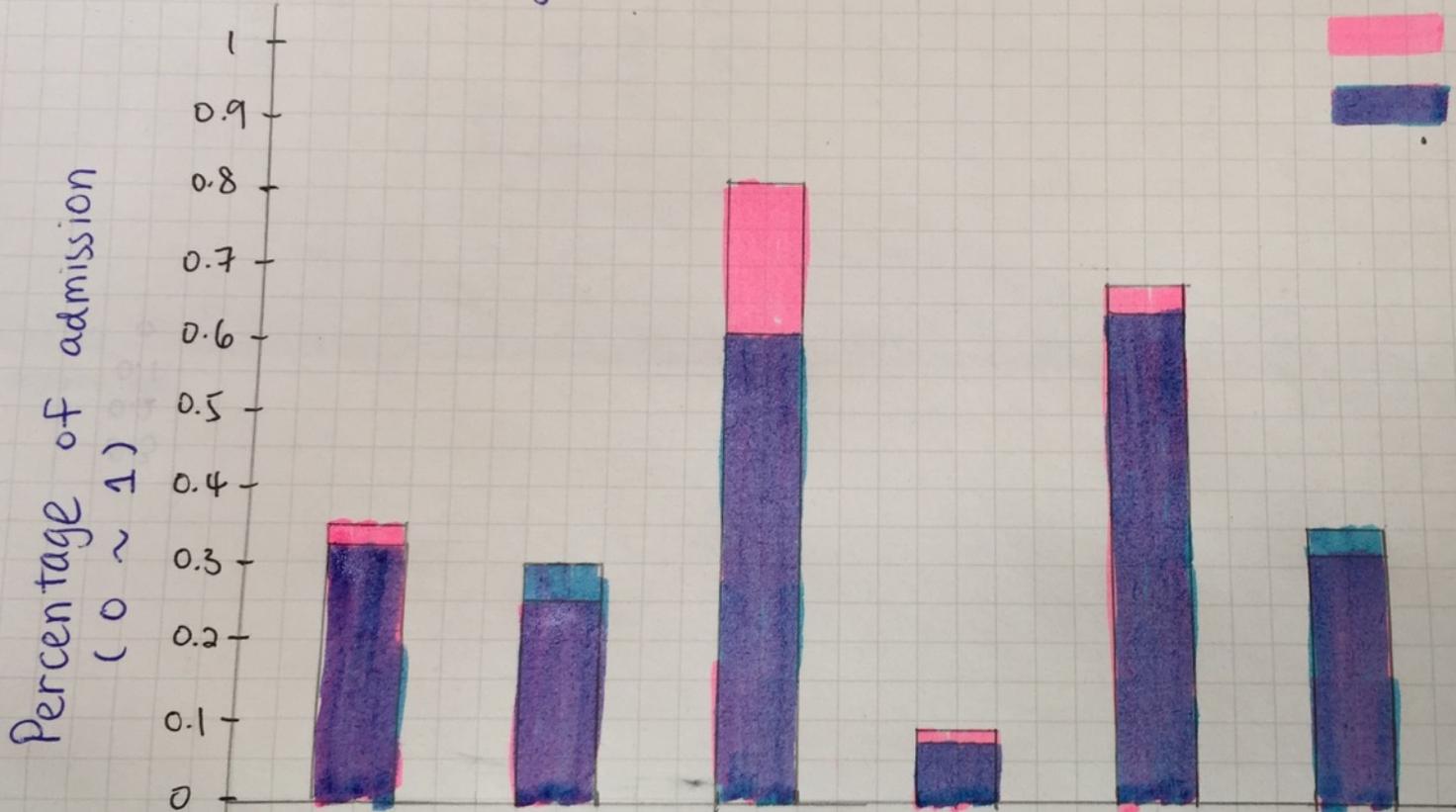
Sociology



Difference

Are female applicants more likely to get in STEM majors?

Male
Female
Overlapped



Is STEM (Y/N)

Major

Law

Sociology

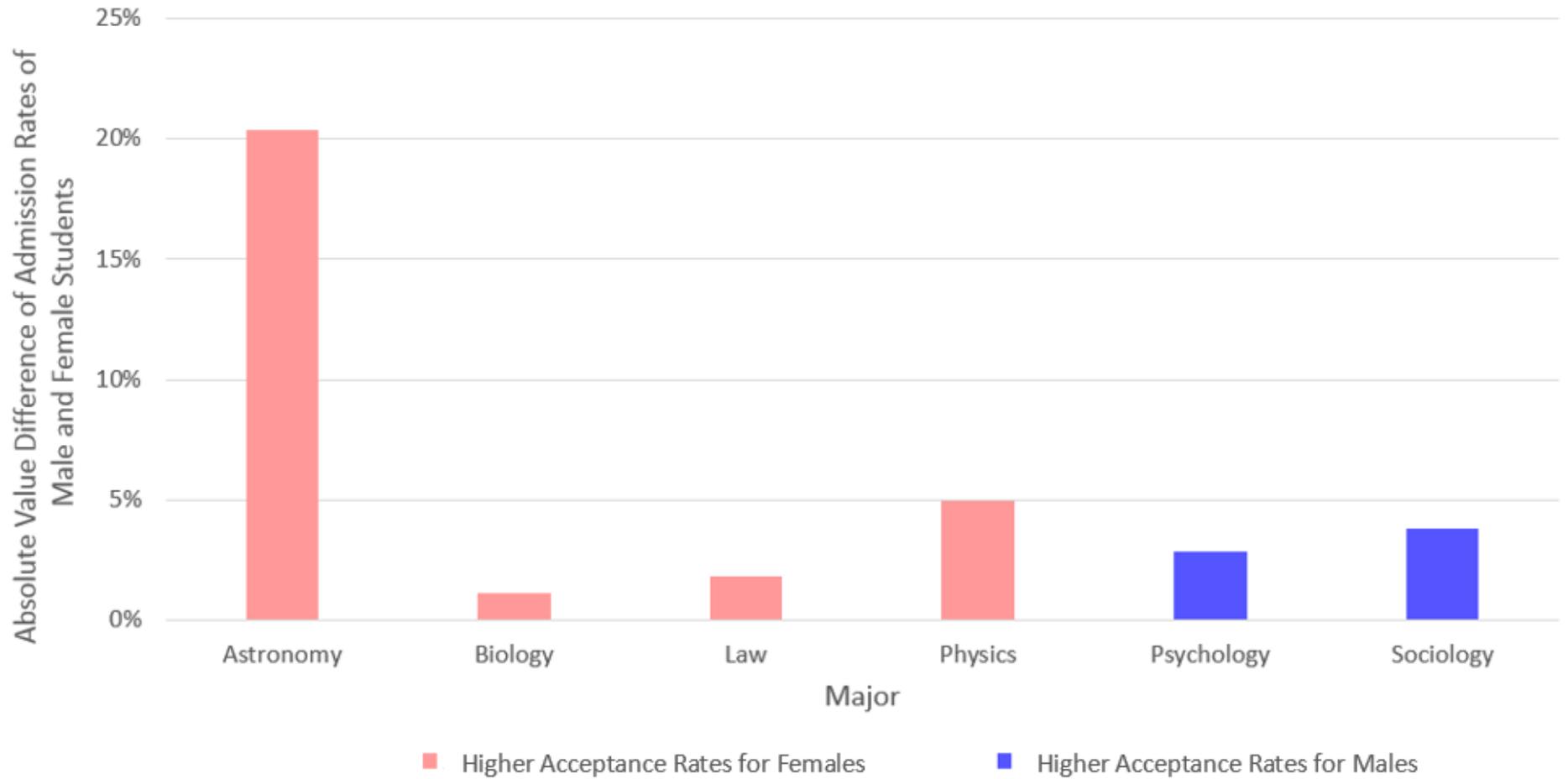
Astronomy

Biology

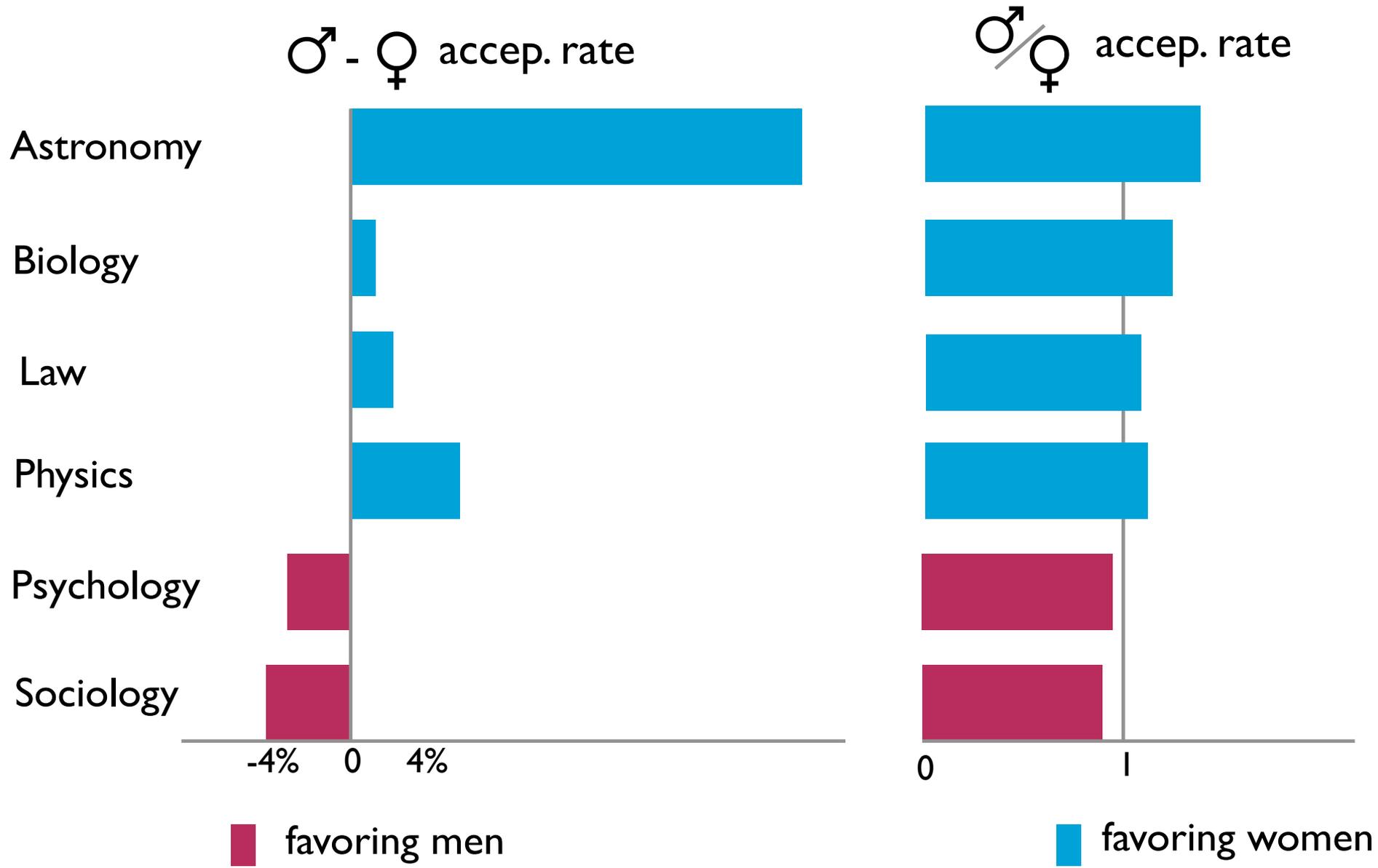
Physics

Psychology

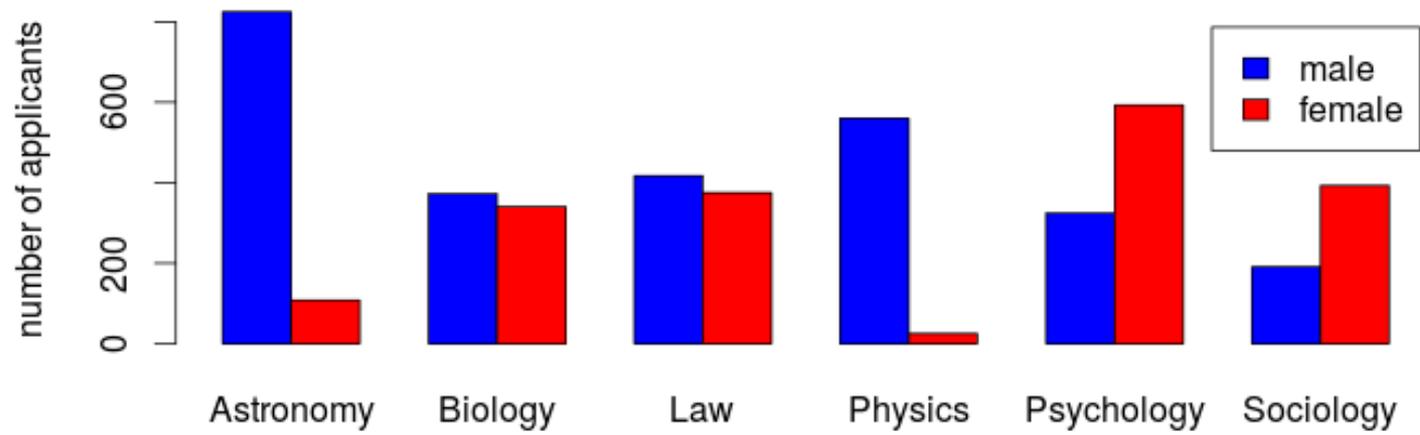
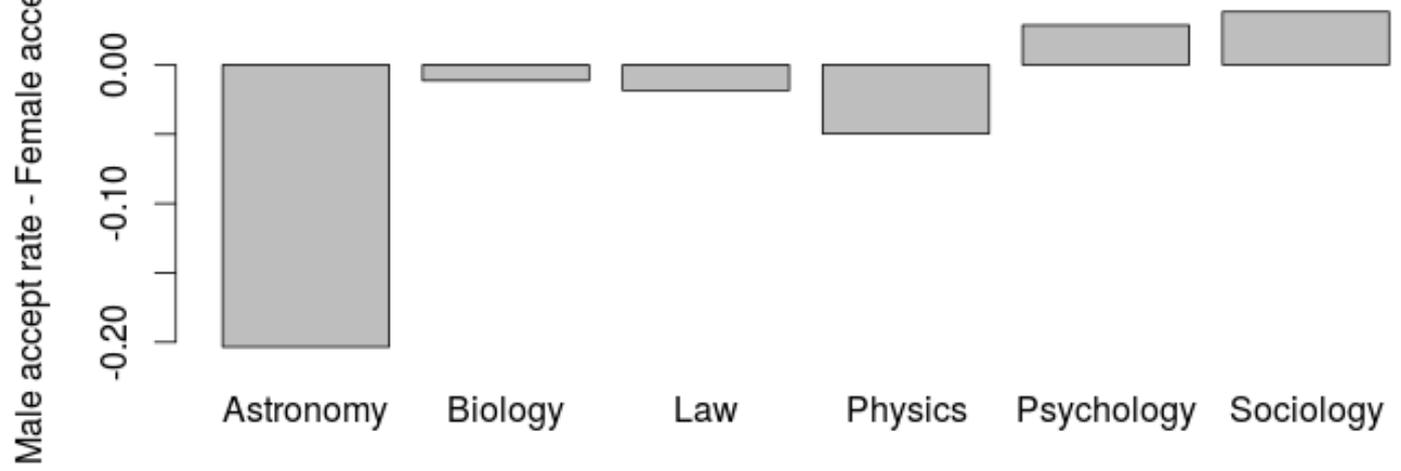
What Is the Difference in Admission Rates of Male and Female Students Across a Set of Majors?



Gender Gaps in Graduate Acceptance

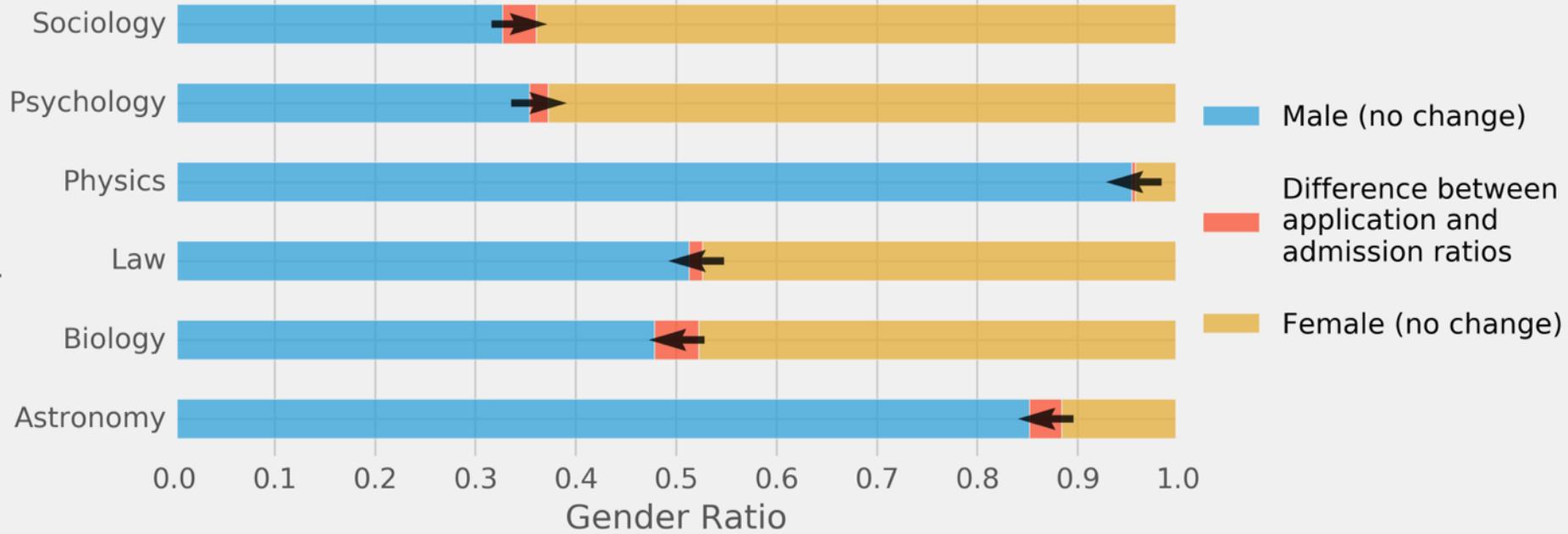


Are there preference of a gender throughout different department when accepting students?

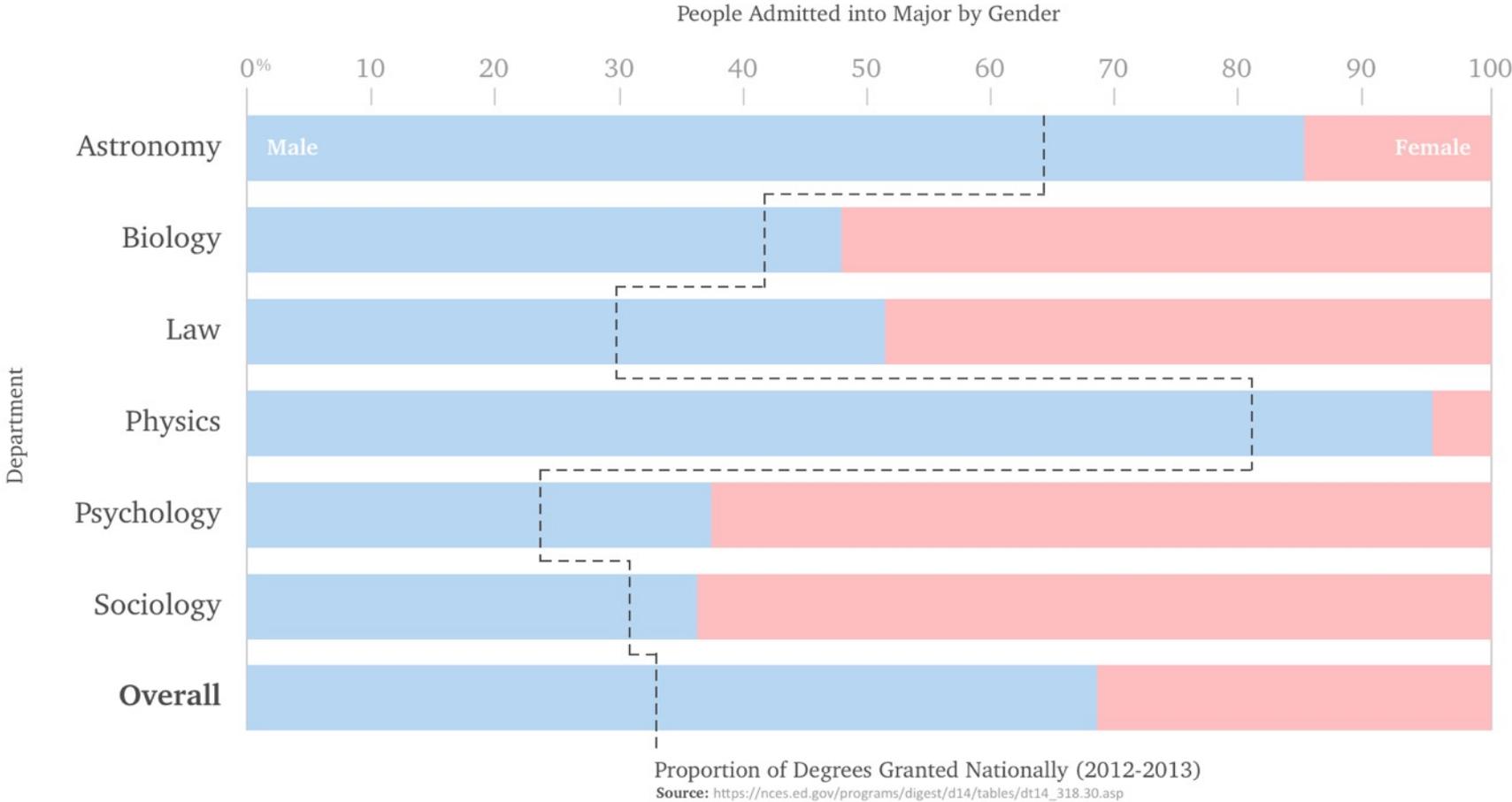


Do admitted cohorts have greater gender parity than applicant pools?

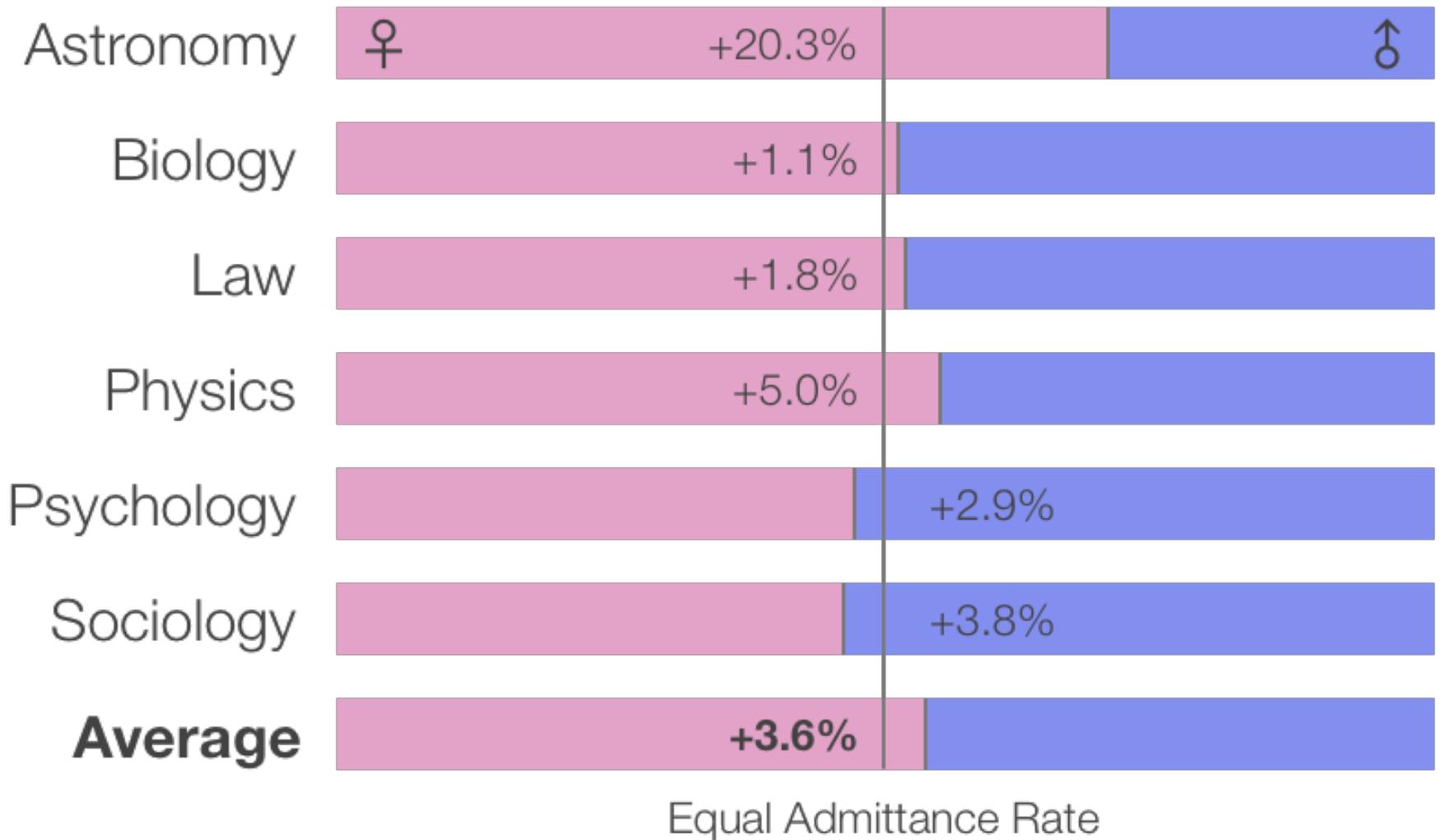
Arrows indicate direction of change from application to admission.



Q: How do the rates of admission per gender at this university differ, how equitable are they, and how do they compare to the proportion of degrees granted nationally?

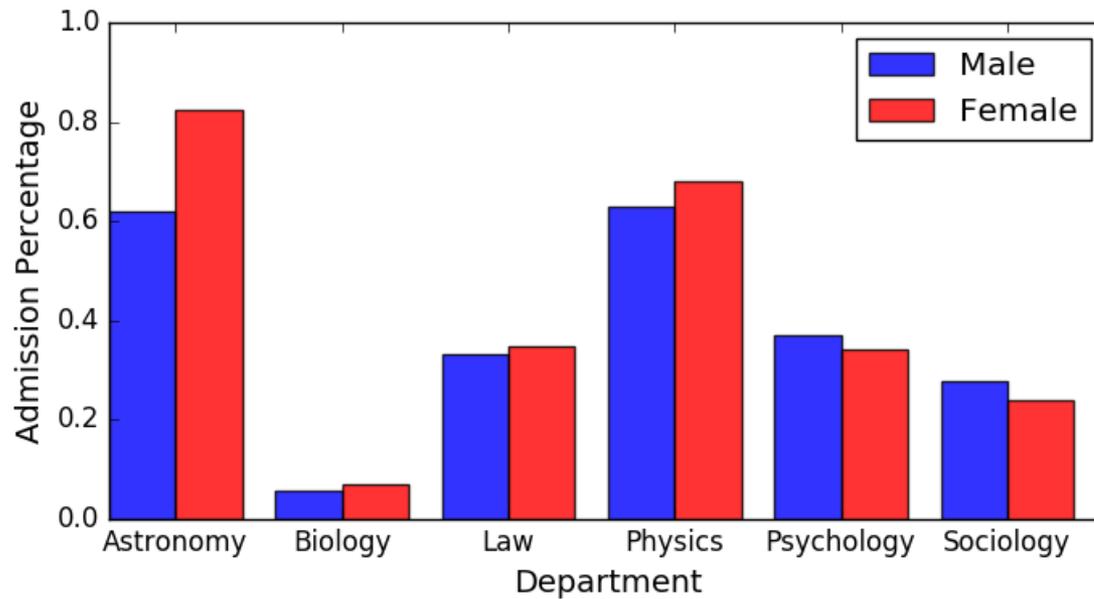
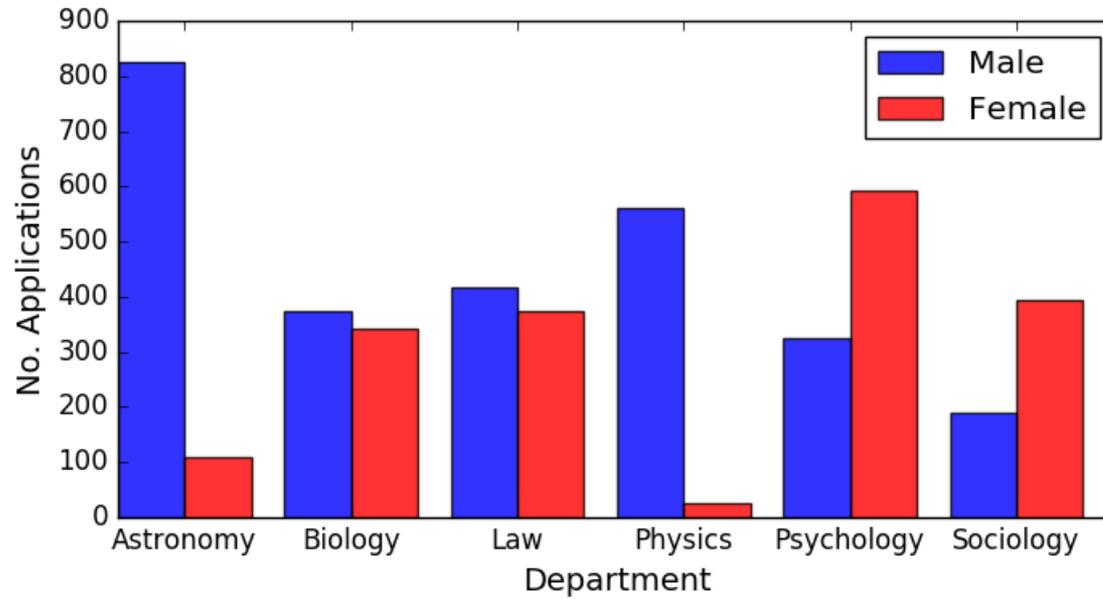


Gender Difference in Admittance Rates

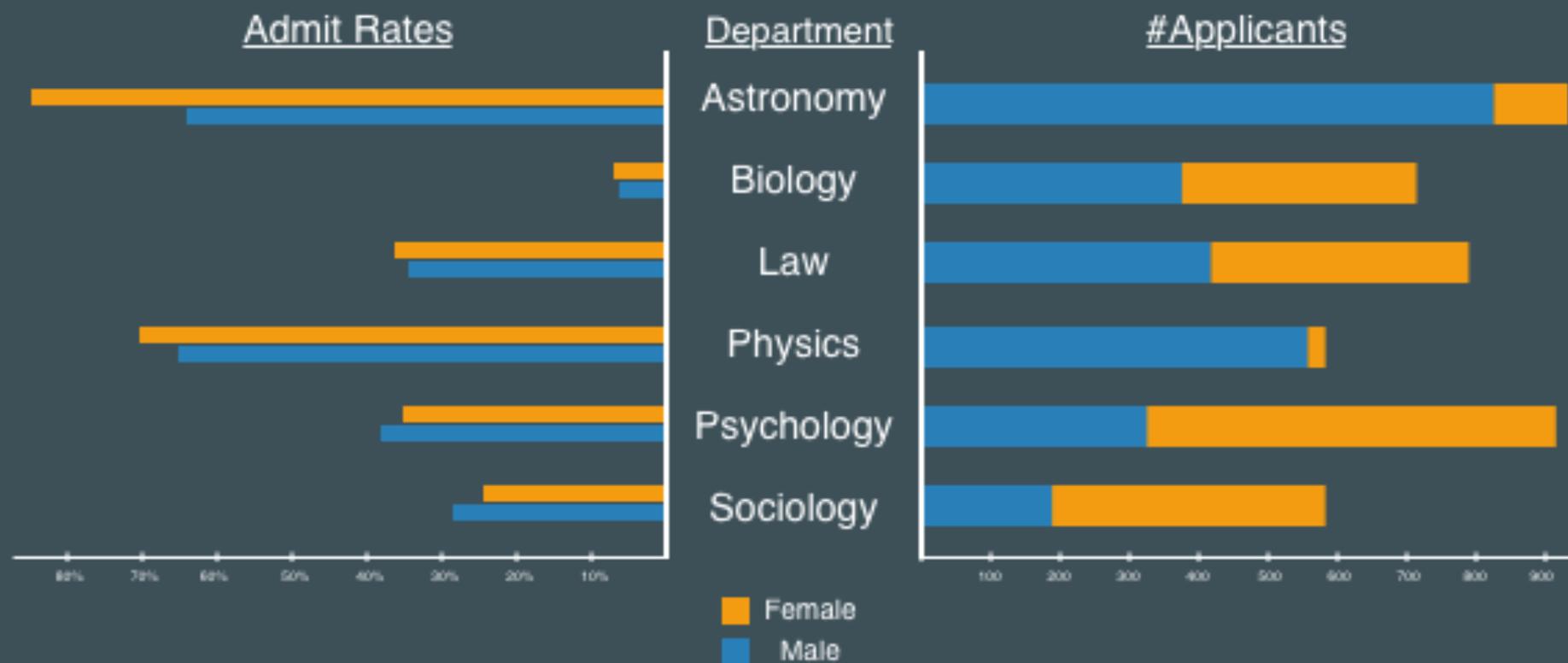


Hybrids

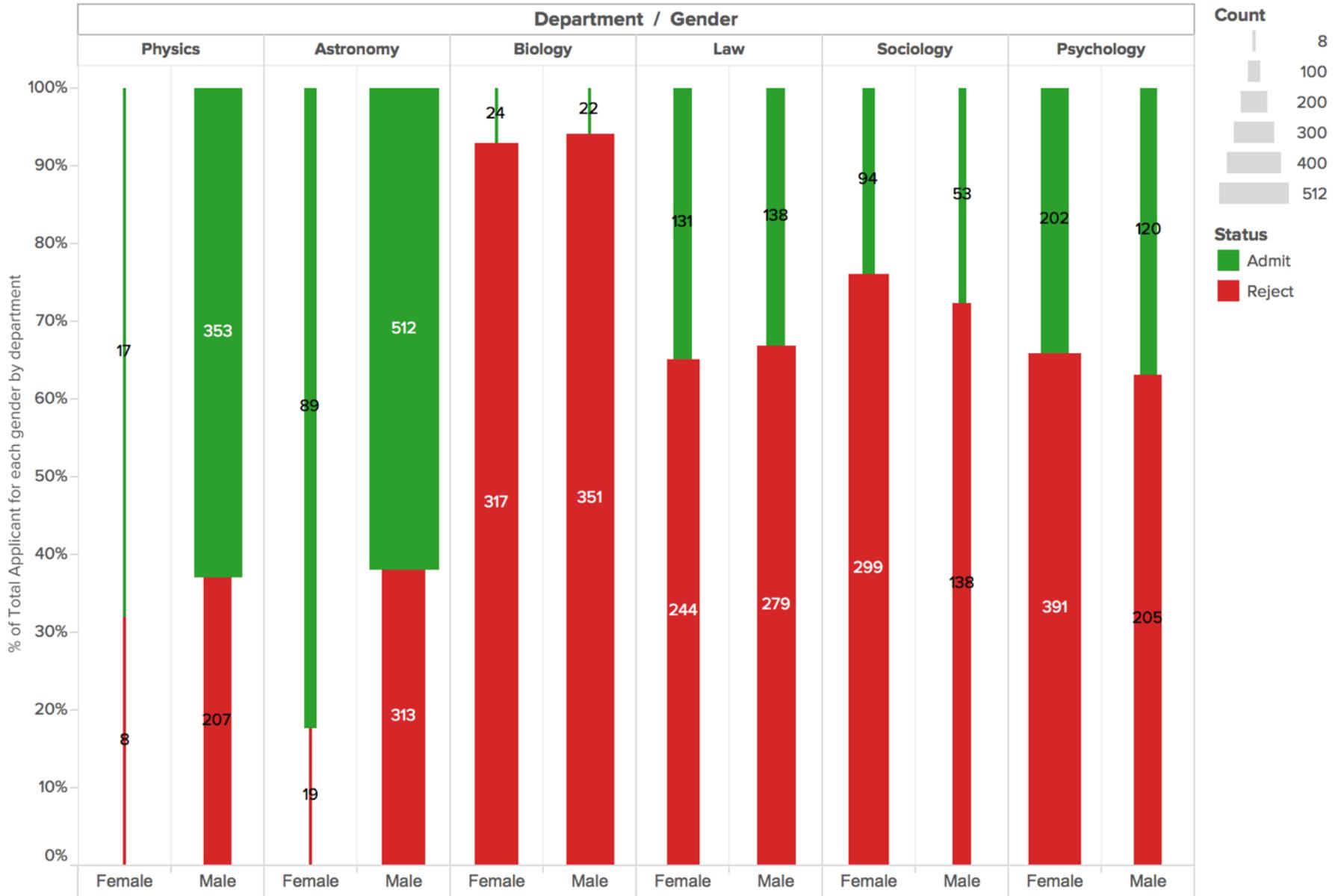
What Causes Gender Imbalances In Academic Departments?



GENDER BIAS IN ADMISSION IN VARIOUS DEPARTMENTS & CORELATION WITH POPULARITY OF DEPARTMENTS IN BOTH GENDERS



Is there a relationship between gender and their acceptance result to a certain department?



% of Total Applicants for each Gender broken down by Department. Color shows details about Status. Size shows sum of Count. The marks are labeled by sum of Count.

Are college admissions by department equally competitive for men and women?

Biology

Sociology

Psychology

Male

Female

Admitted
Rejected

Law

Physics

Astronomy

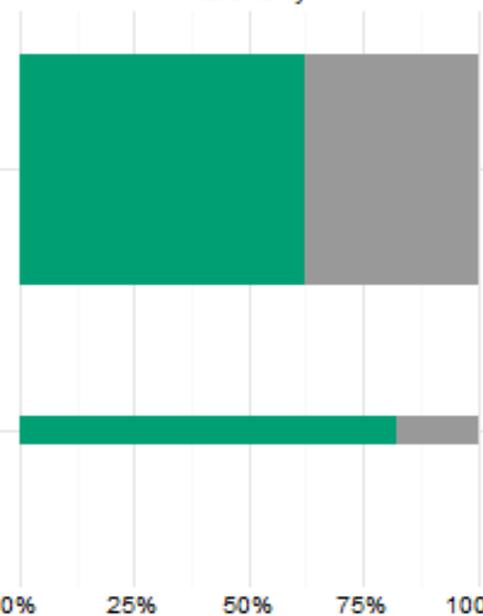
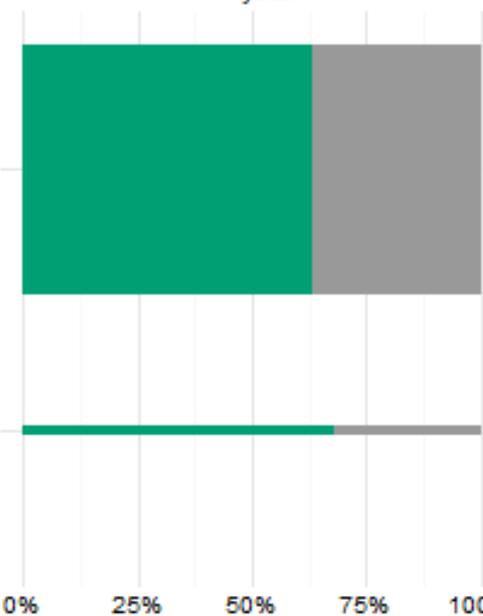
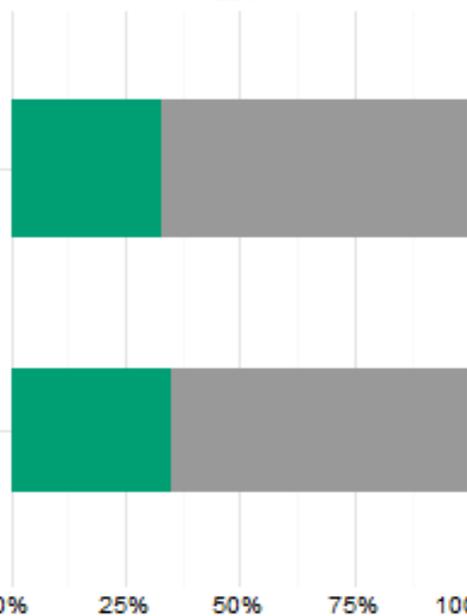
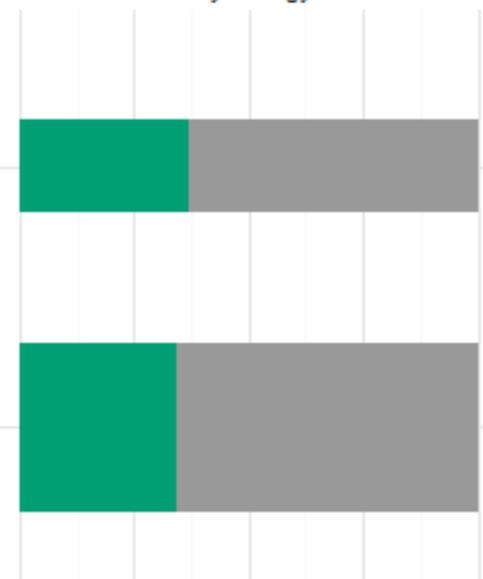
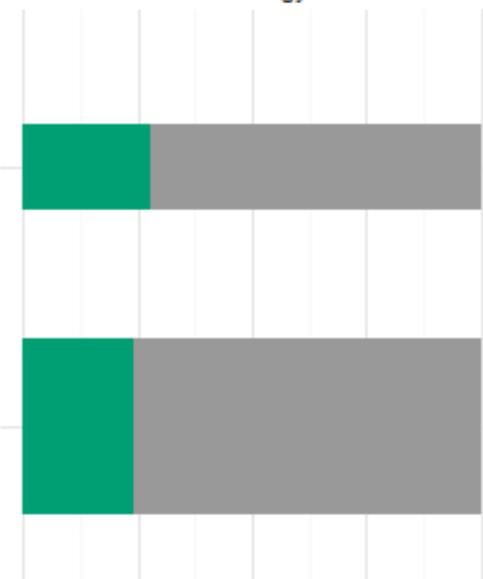
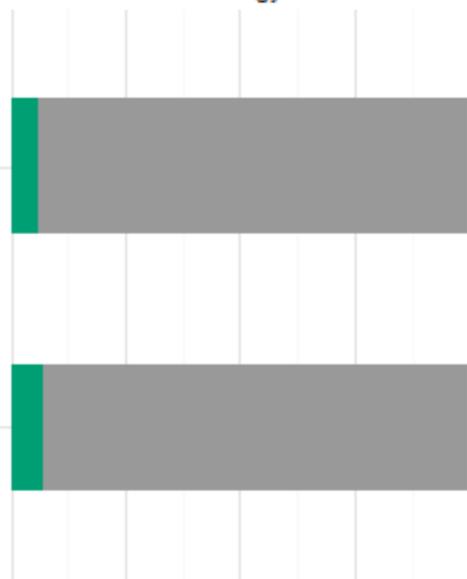
Male

Female

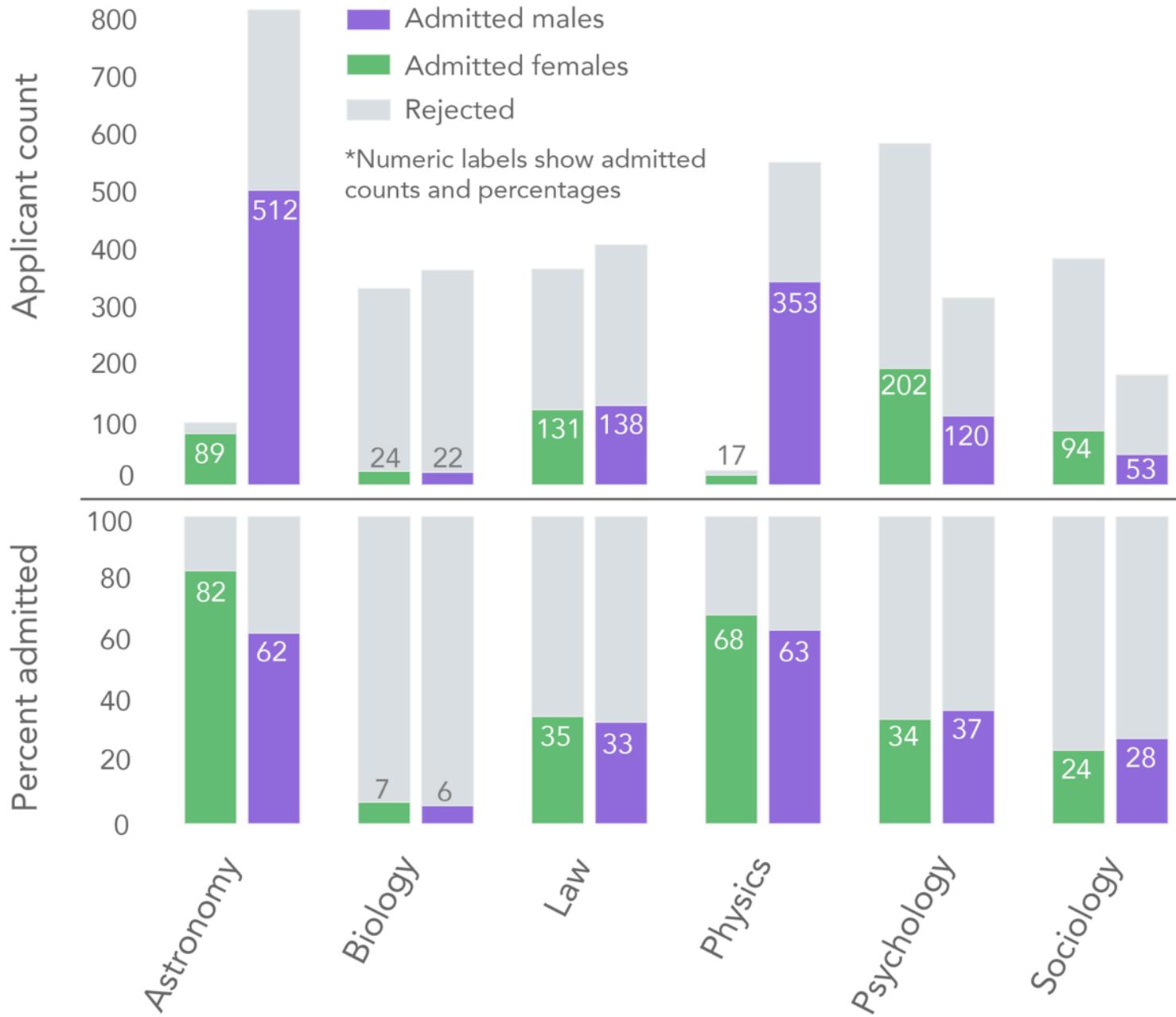
0% 25% 50% 75% 100% 0% 25% 50% 75% 100% 0% 25% 50% 75% 100%

Percent of applicants admitted
(width of bars is within department percentage of applications)

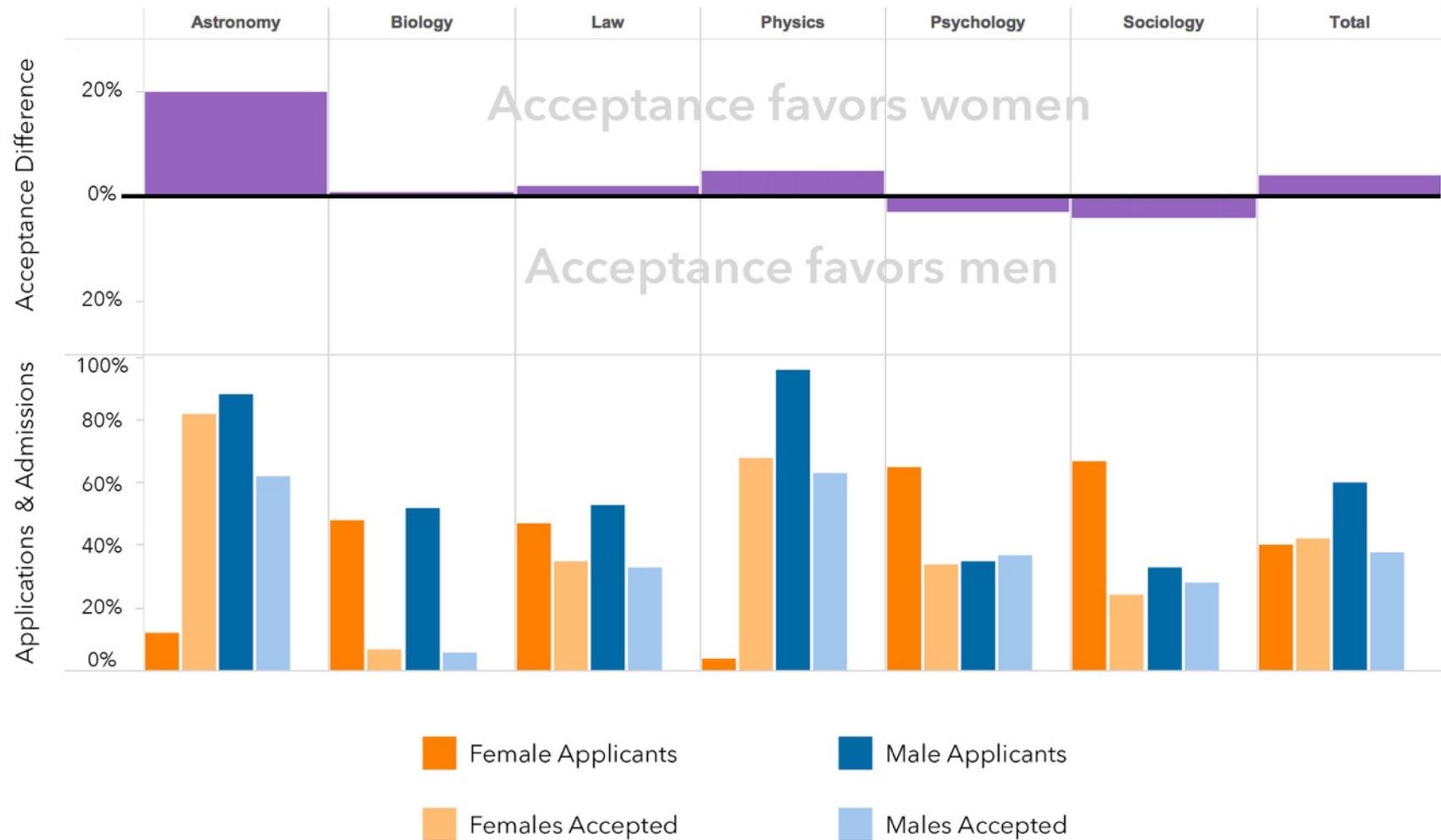
Gender



Is there evidence of gender bias in college admissions?

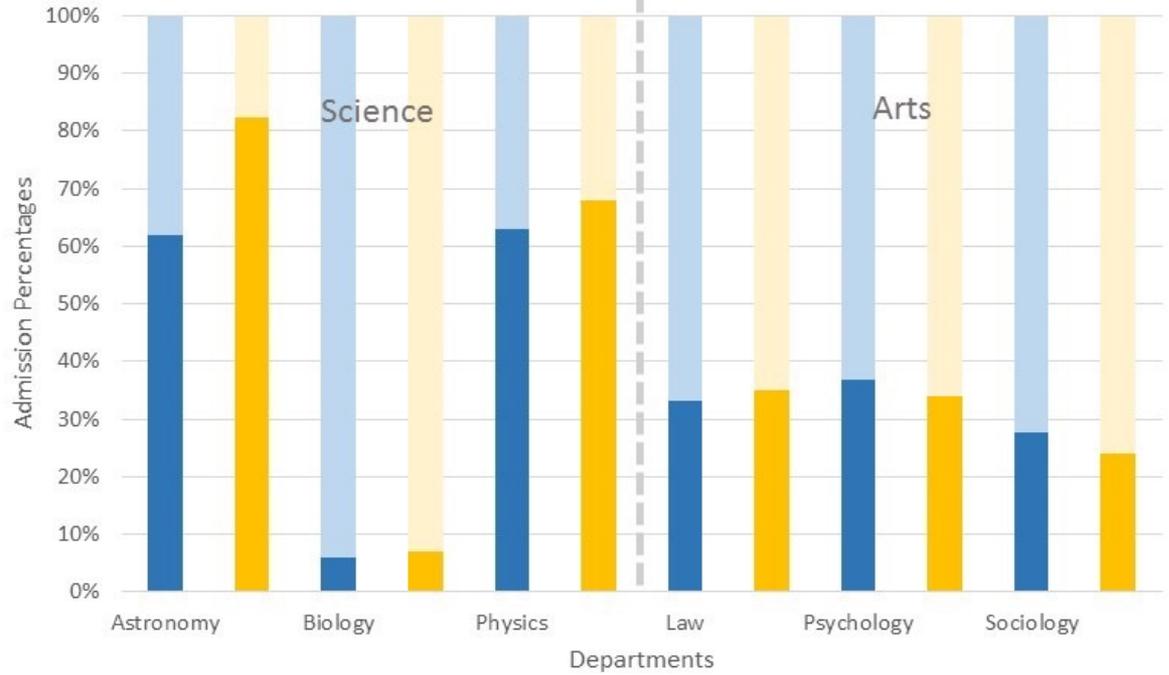
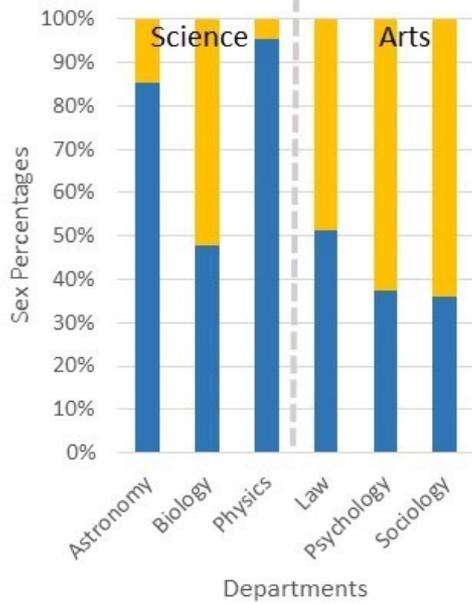


Do departments attempt to balance gender during admissions?



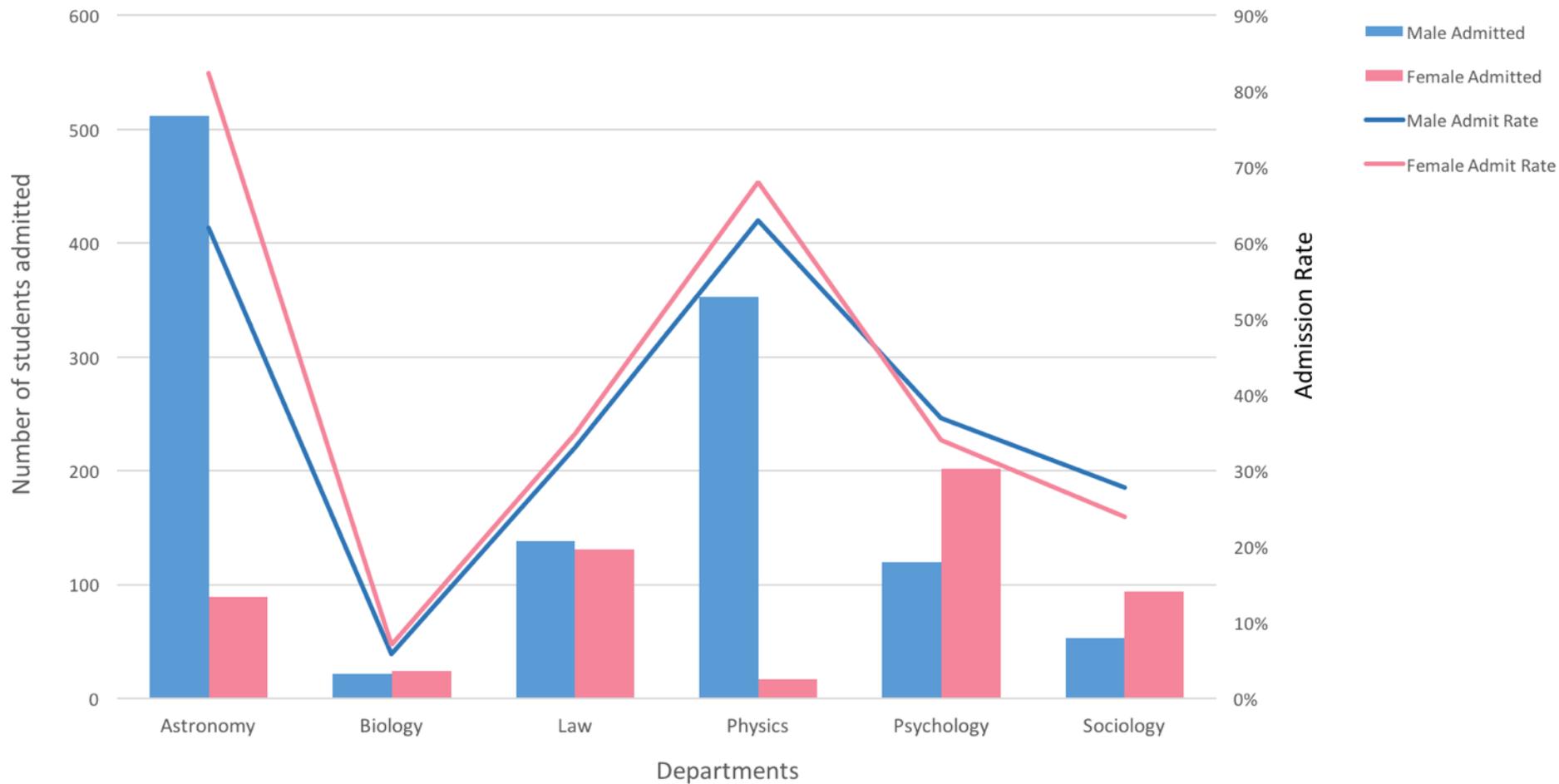
Do Science Departments Favor Male Students and Arts Departments Favor Female Students?

Male vs. Female Students across Departments

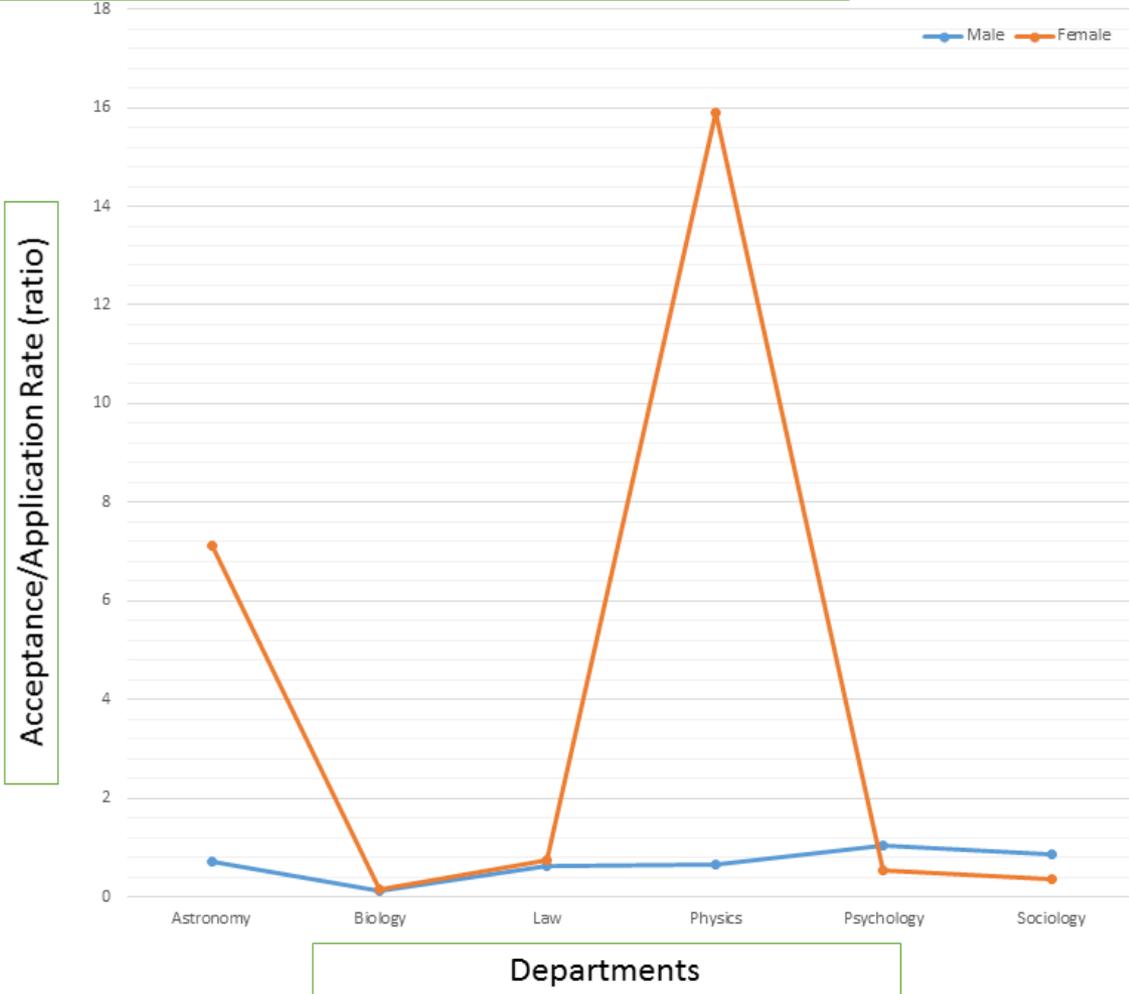
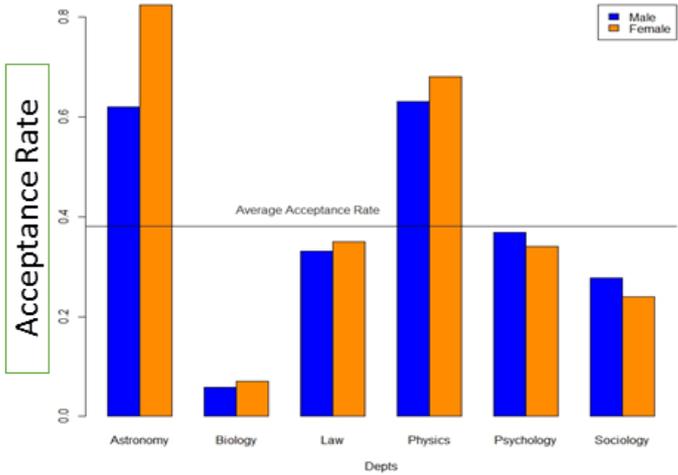
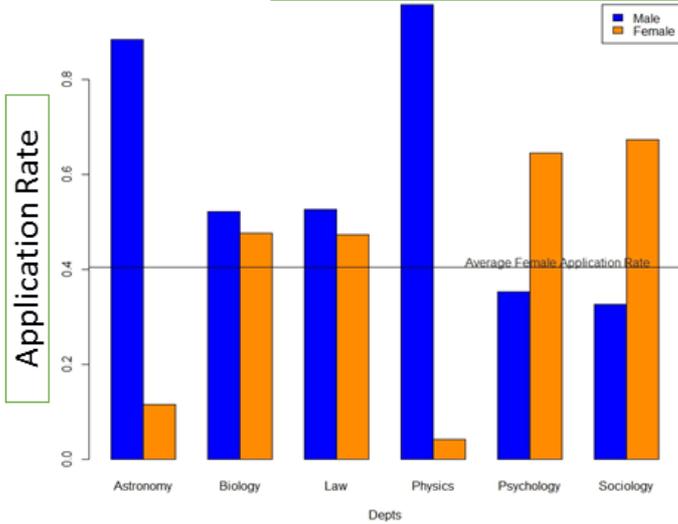


■ Admitted Male
 ■ Rejected Male
 ■ Admitted Female
 ■ Rejected Female

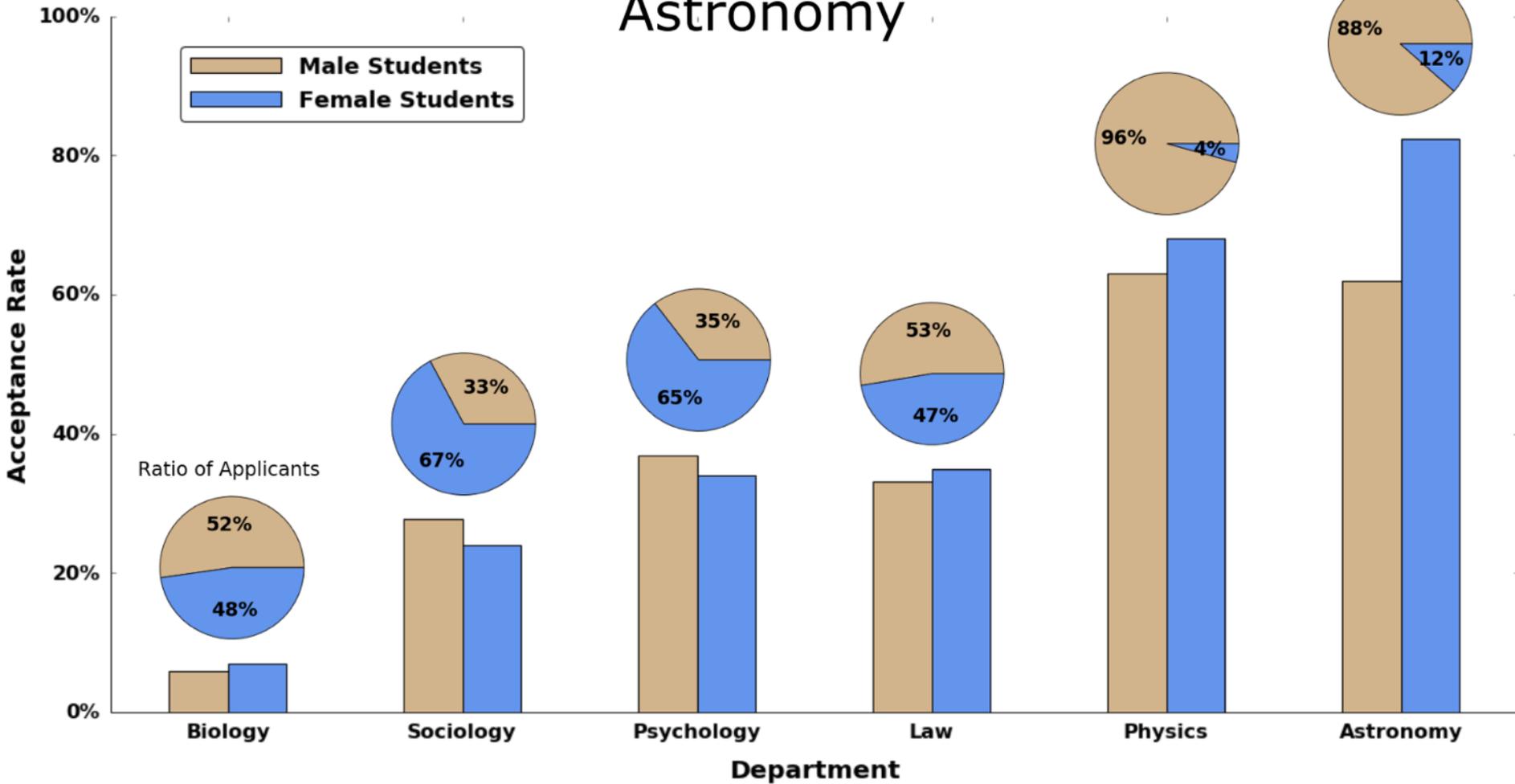
How many applicants are admitted in different departments and how does admission rate differ in terms of gender?



Which Department has the highest Likelihood of Admission for women?



The Missing Applicants in Physics and Astronomy

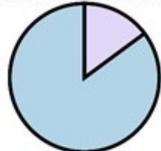


Do Department Admissions Differ by Gender?

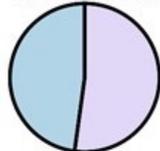
■ Males ■ Females

Gender Composition of Admits

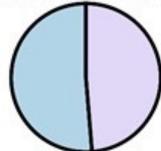
85% 15%



48% 52%



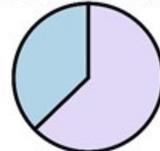
51% 49%



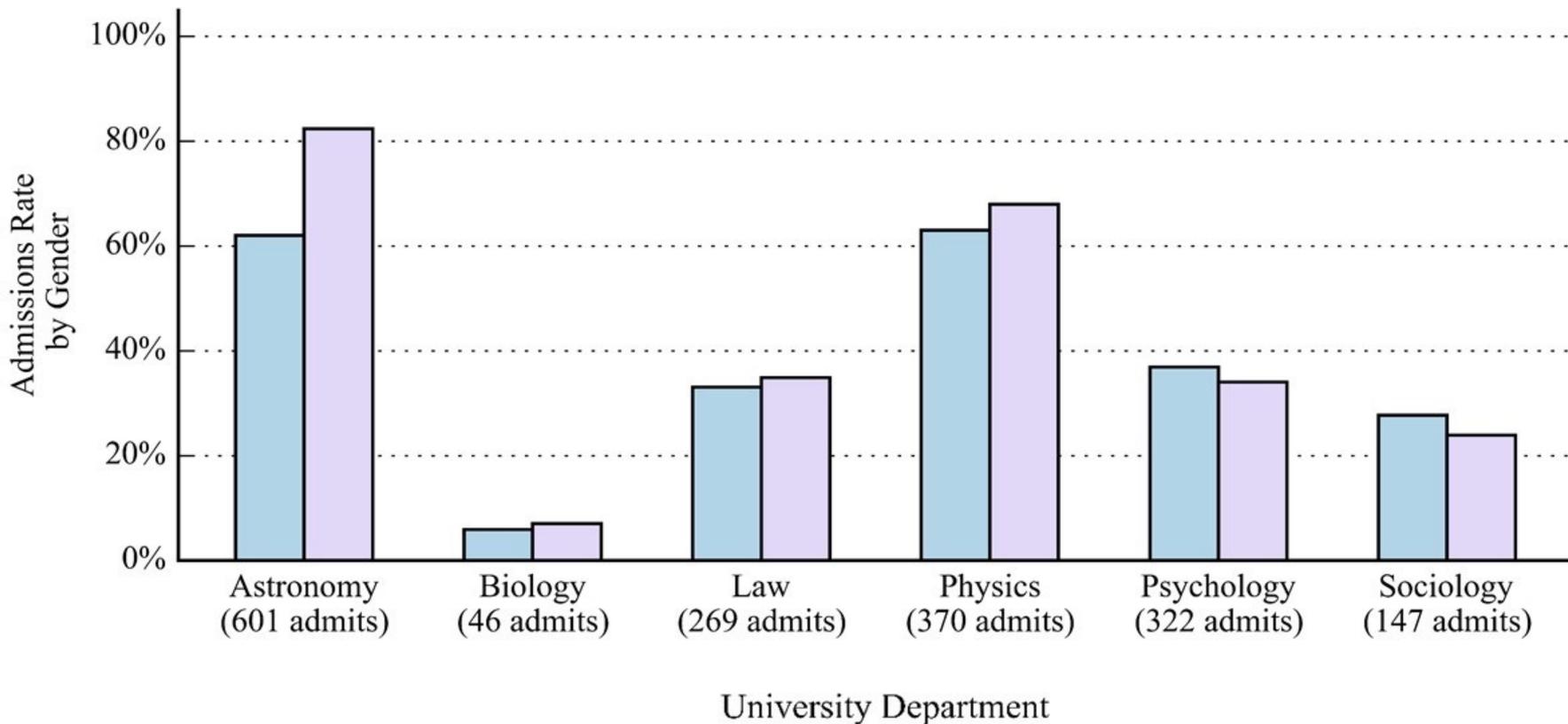
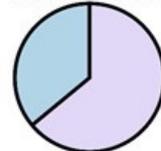
95% 5%



37% 63%

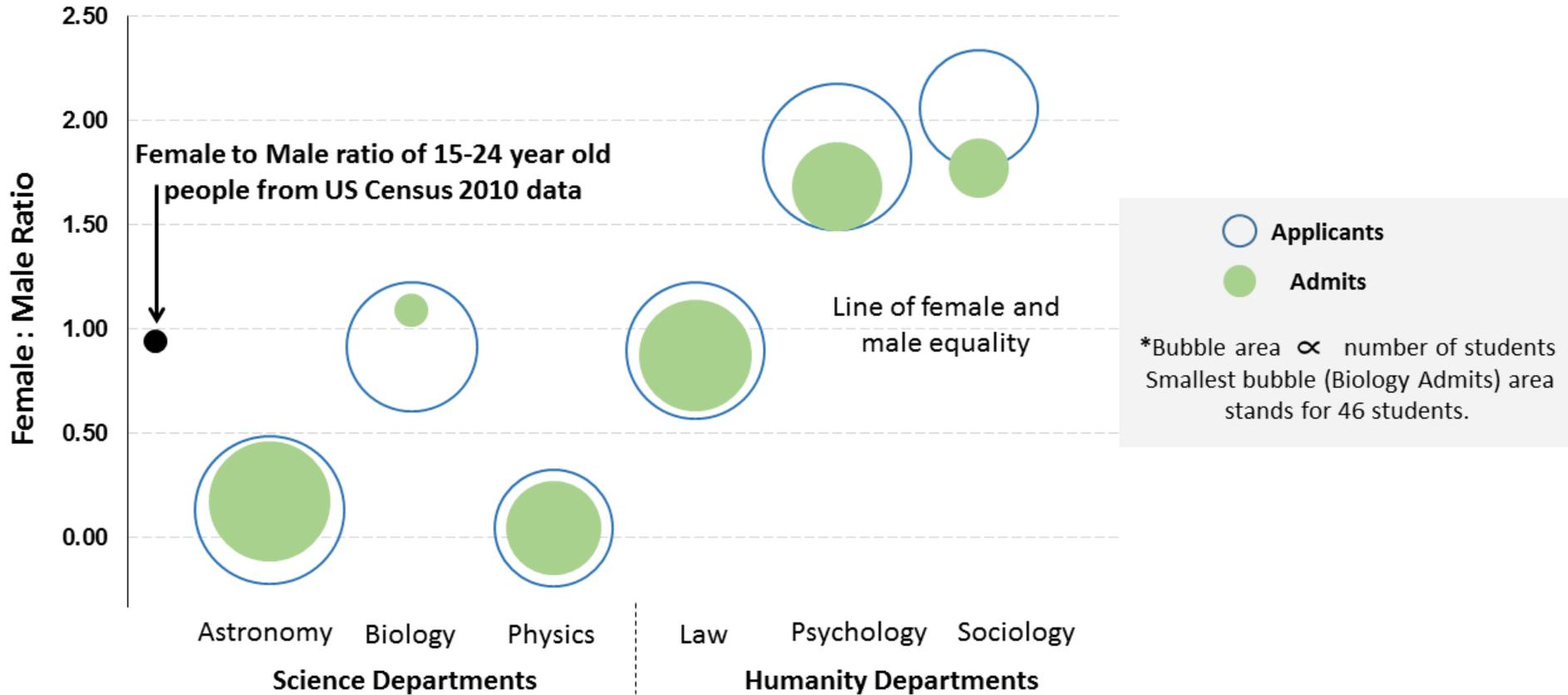


36% 64%

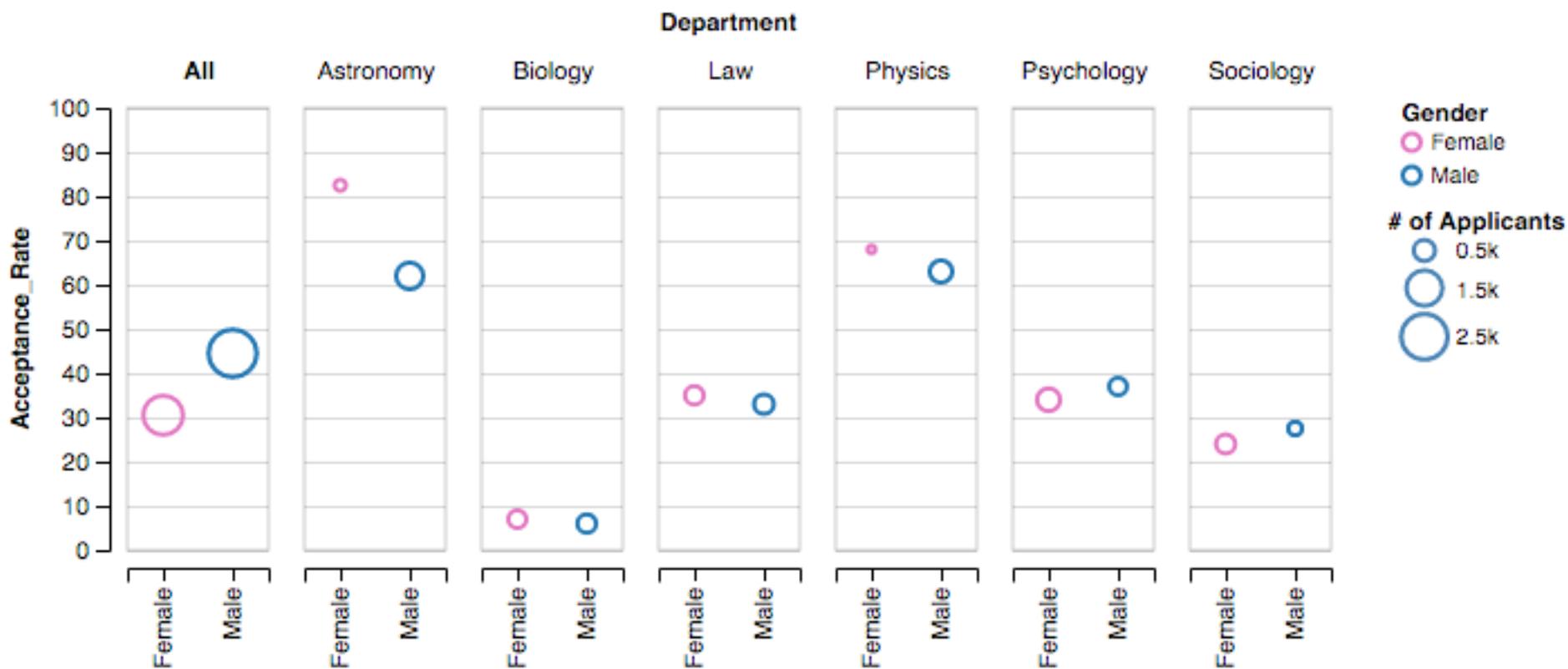


Dot Plots

How well are both genders represented across departments? Where in the application process is the difference greatest?



Is Acceptance Rate Different between Gender?



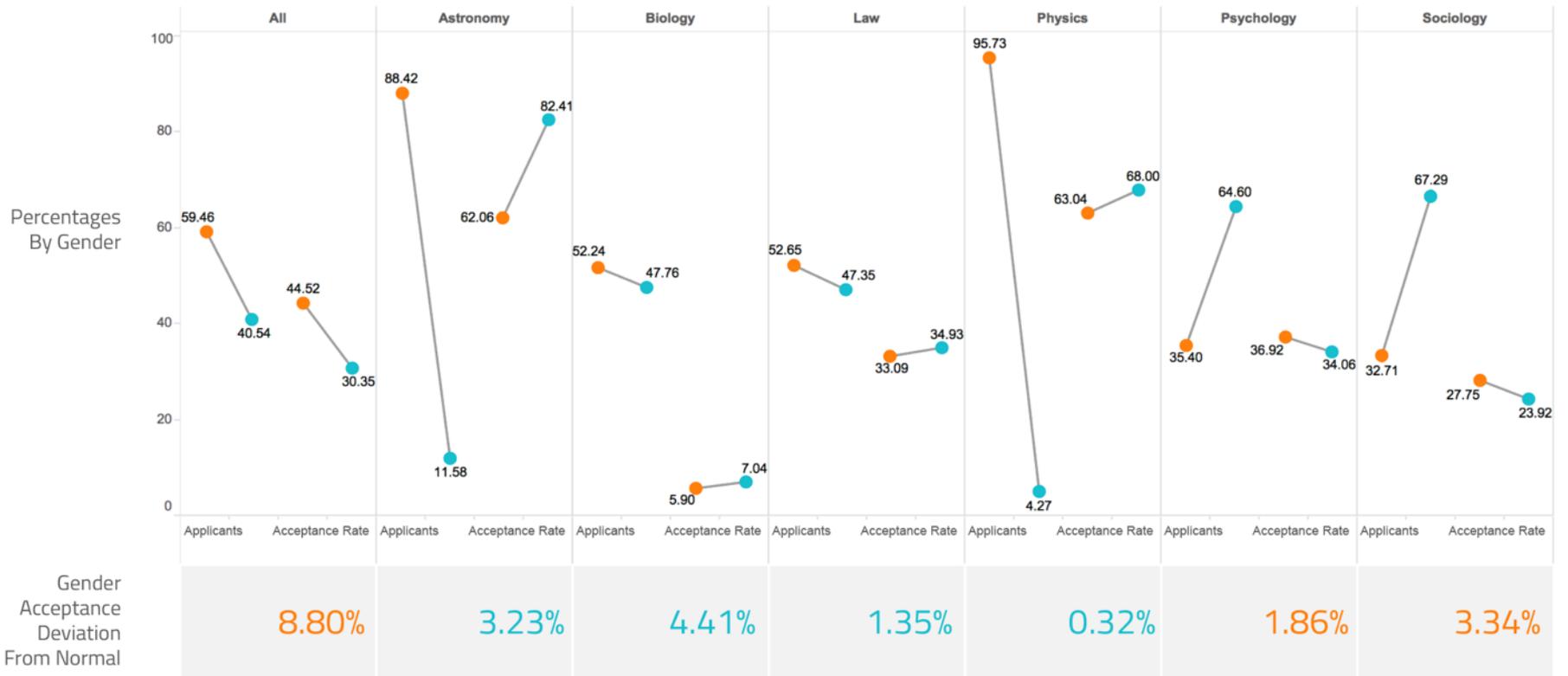
How does department choice affect admission?



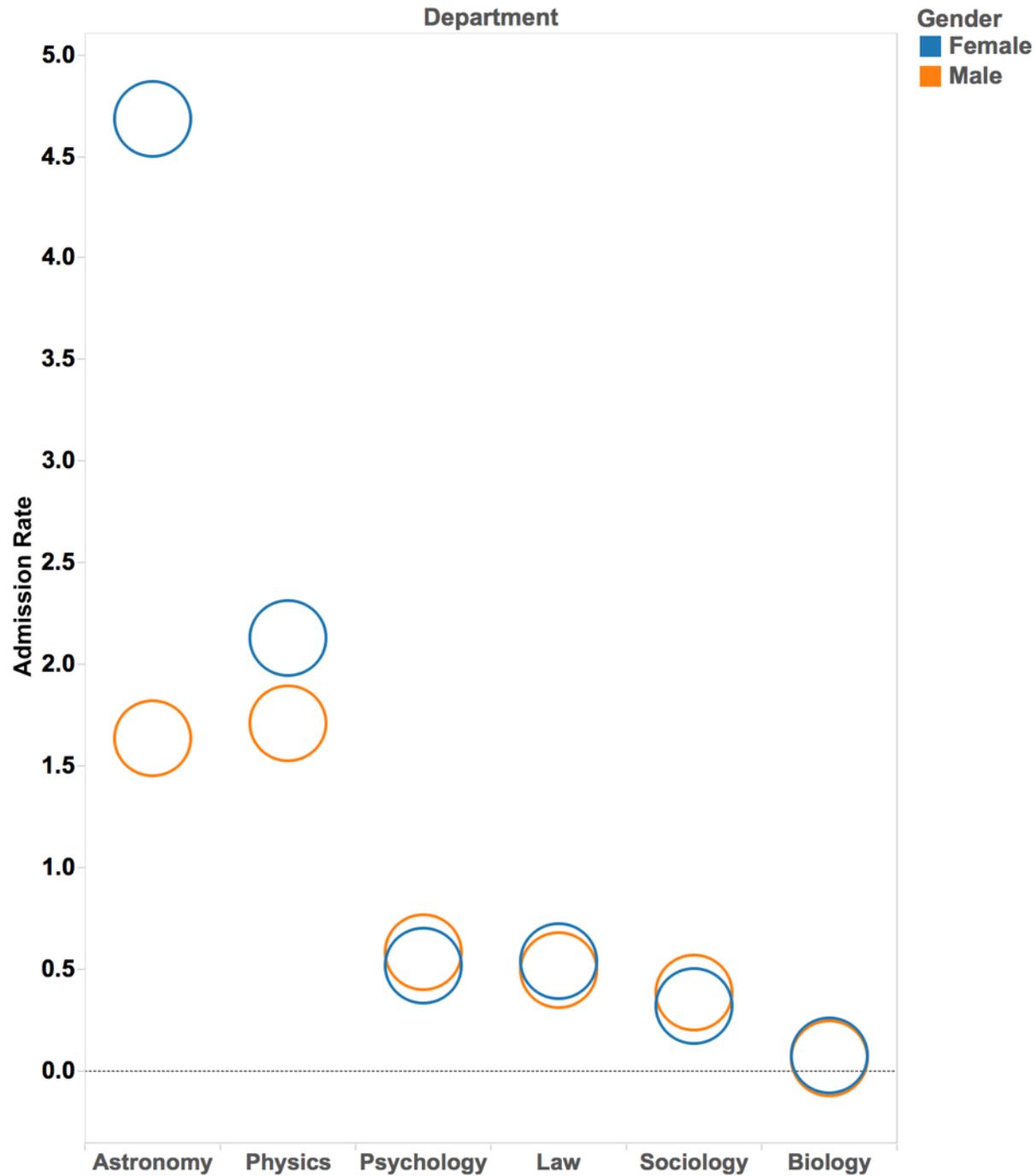
Do Departments Correct for Application Gender Ratio?

- Male Applicants
- Female Applicants

Departments

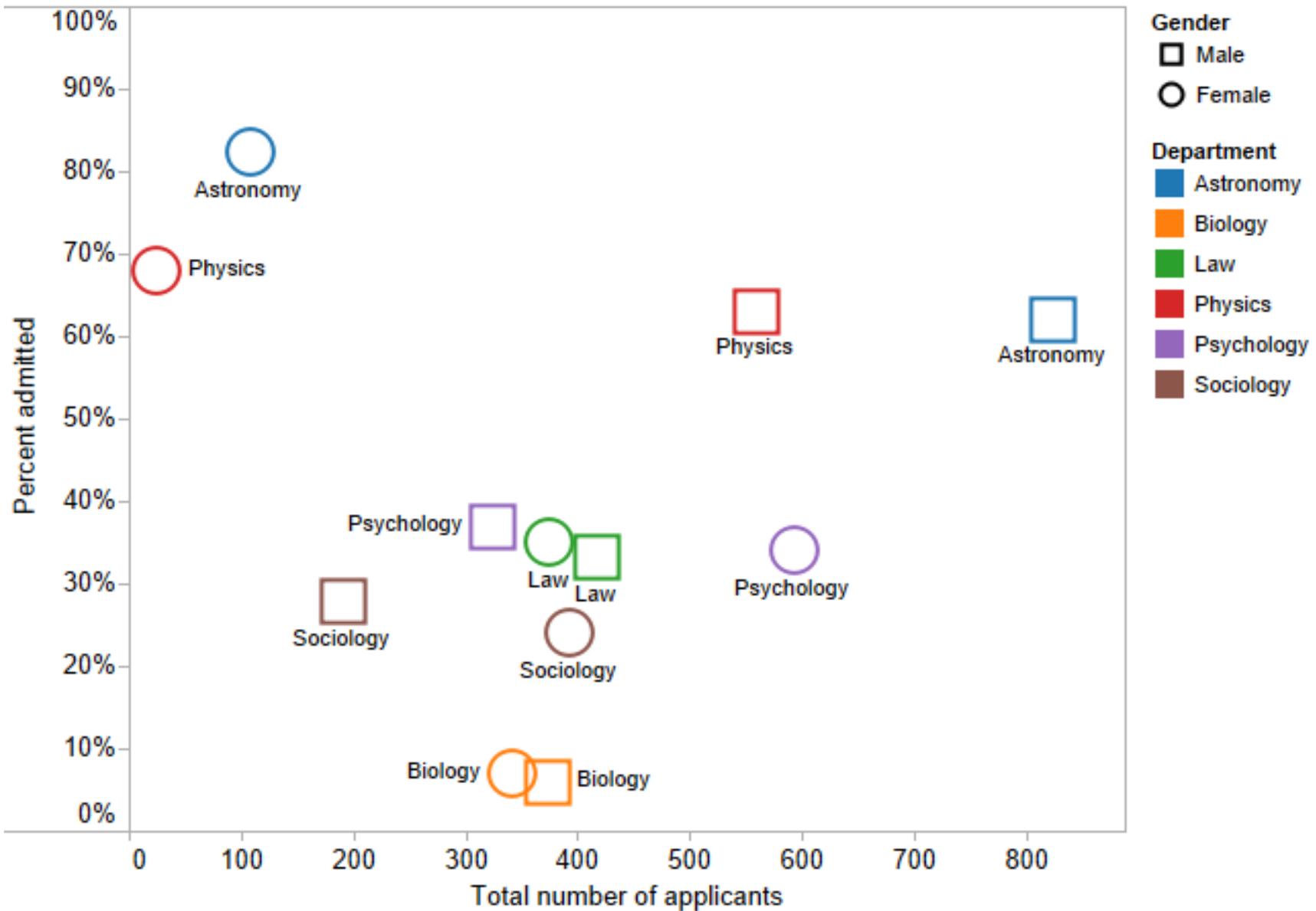


Will gender affect admission rate?



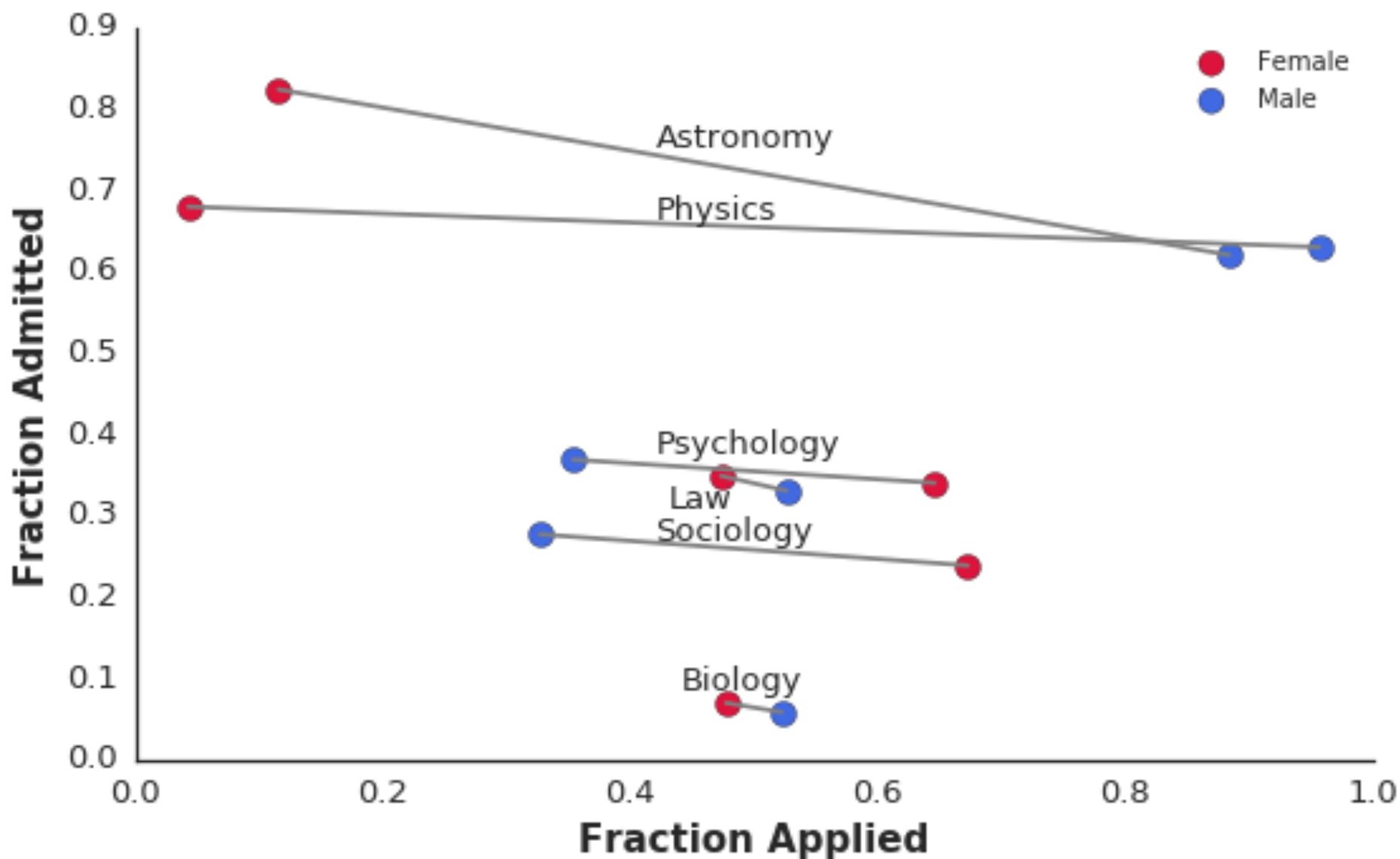
Scatter Plots

What are the differences in popularity and selectivity of various academic departments by gender?

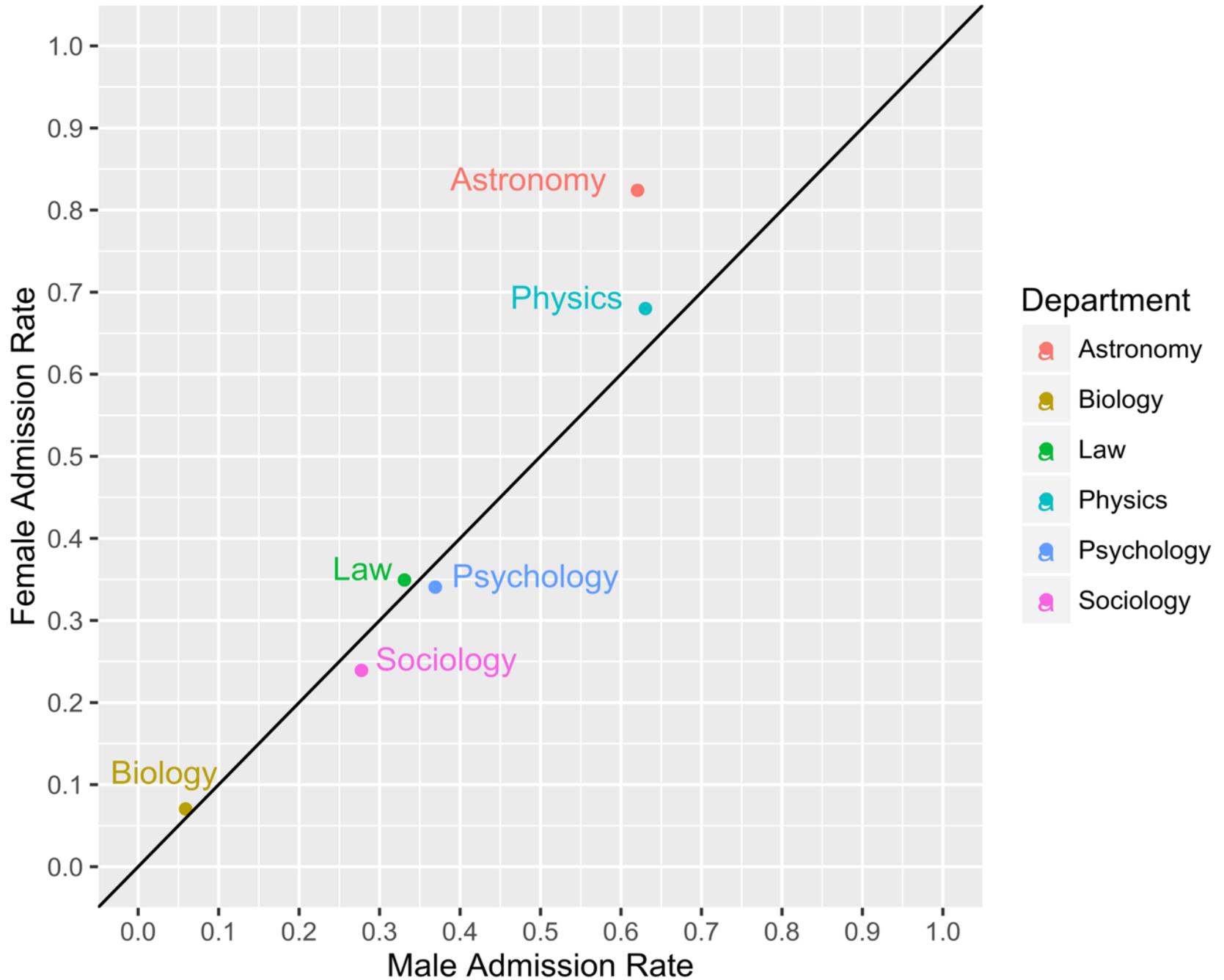


Scatterplot of percent admitted to each department by gender compared to the total applications to each department by gender. Gender is distinguished by shape, and department by color.

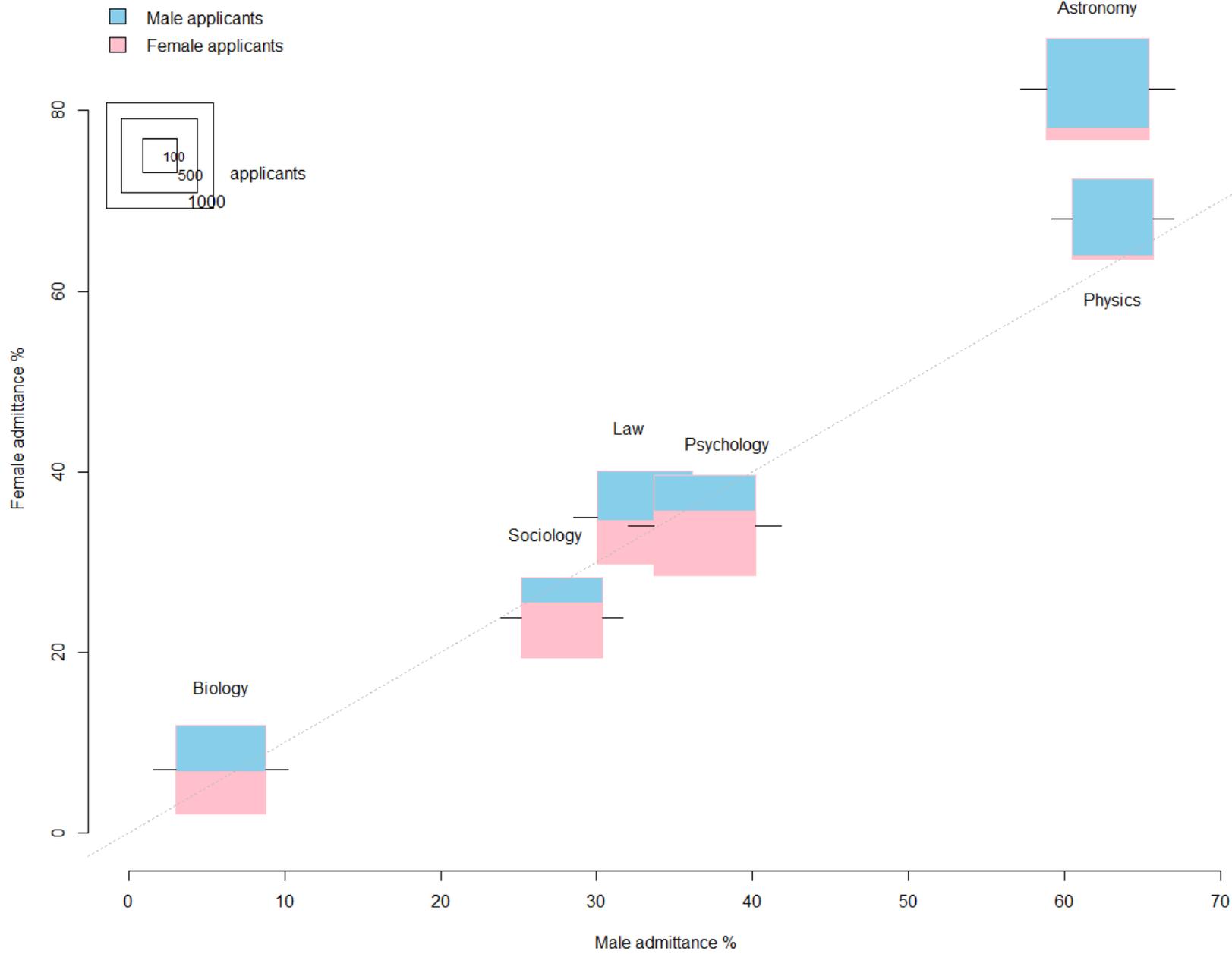
Acceptance vs Admission Rates by Gender



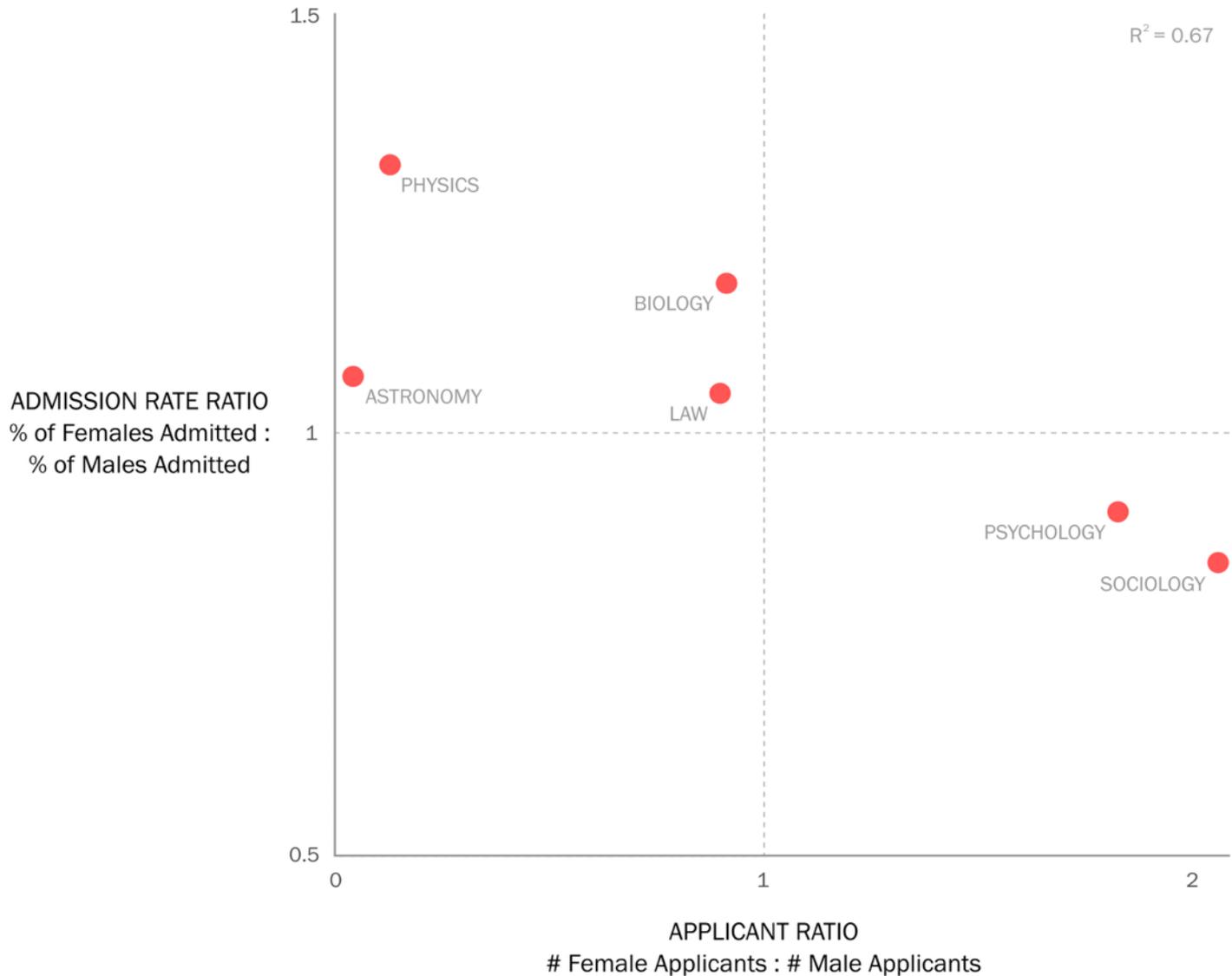
What's the difference in admission rate by gender among departments?



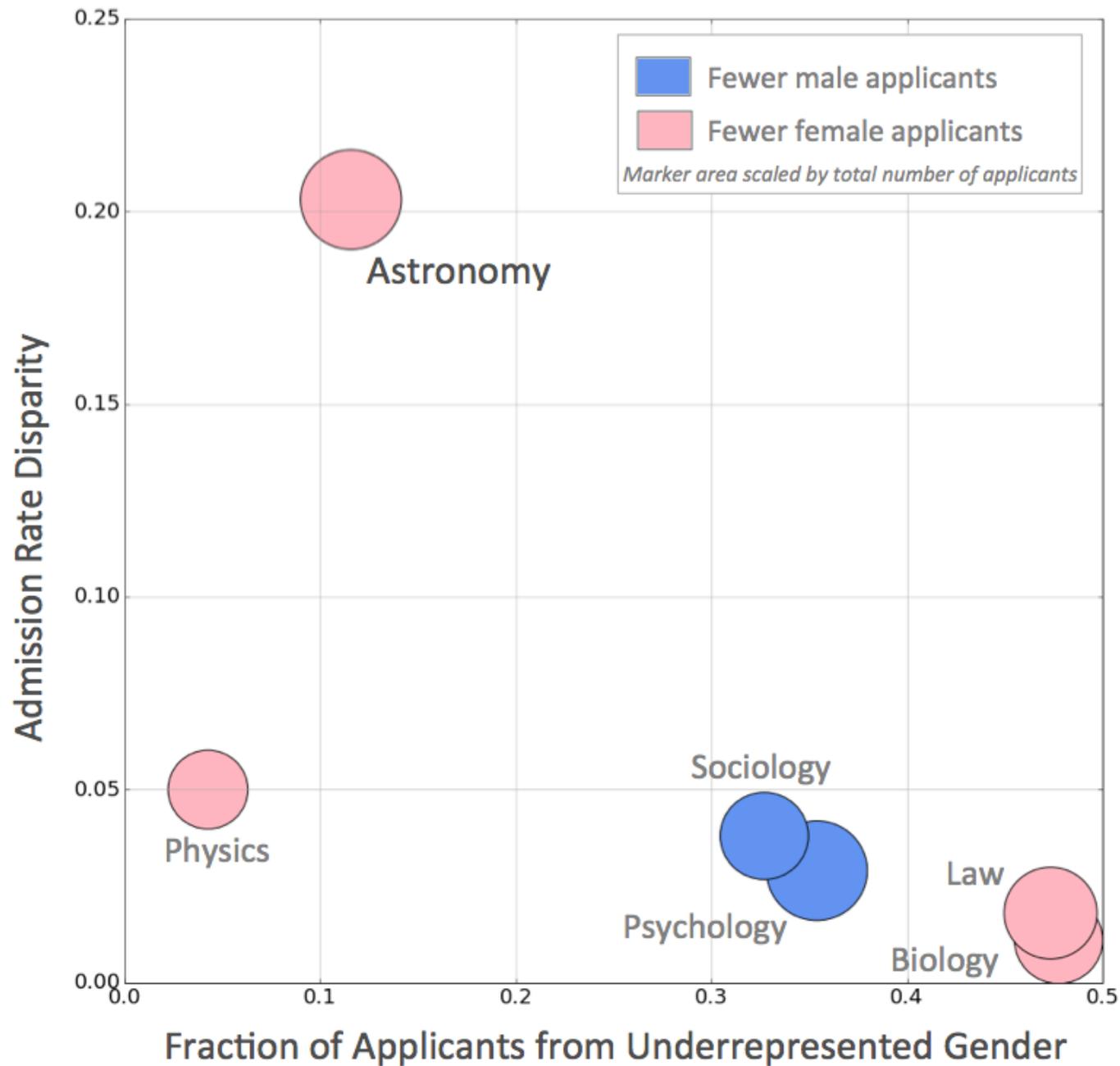
Male/Female Admittance and Application Proportions



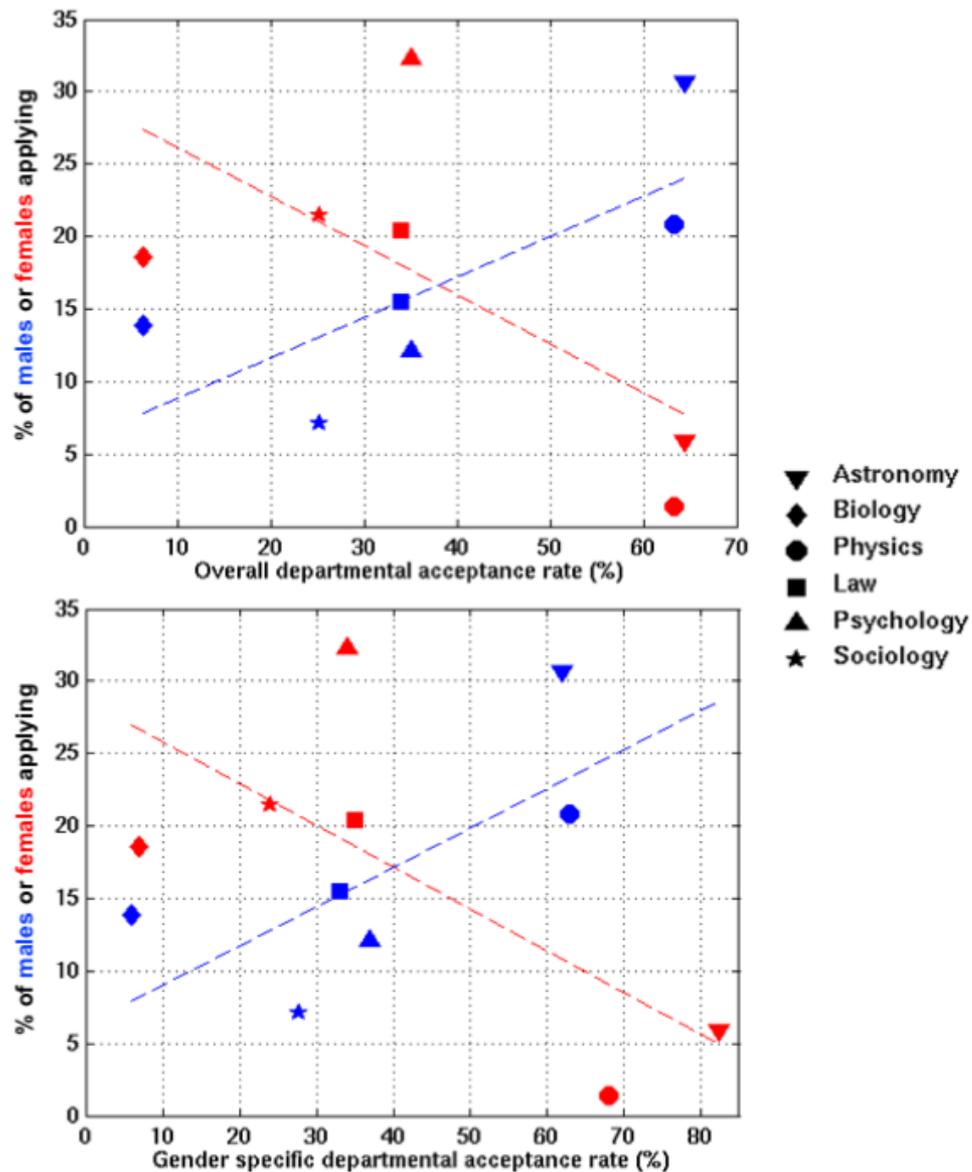
Does the proportion of women applicants affect admission rates within each gender?



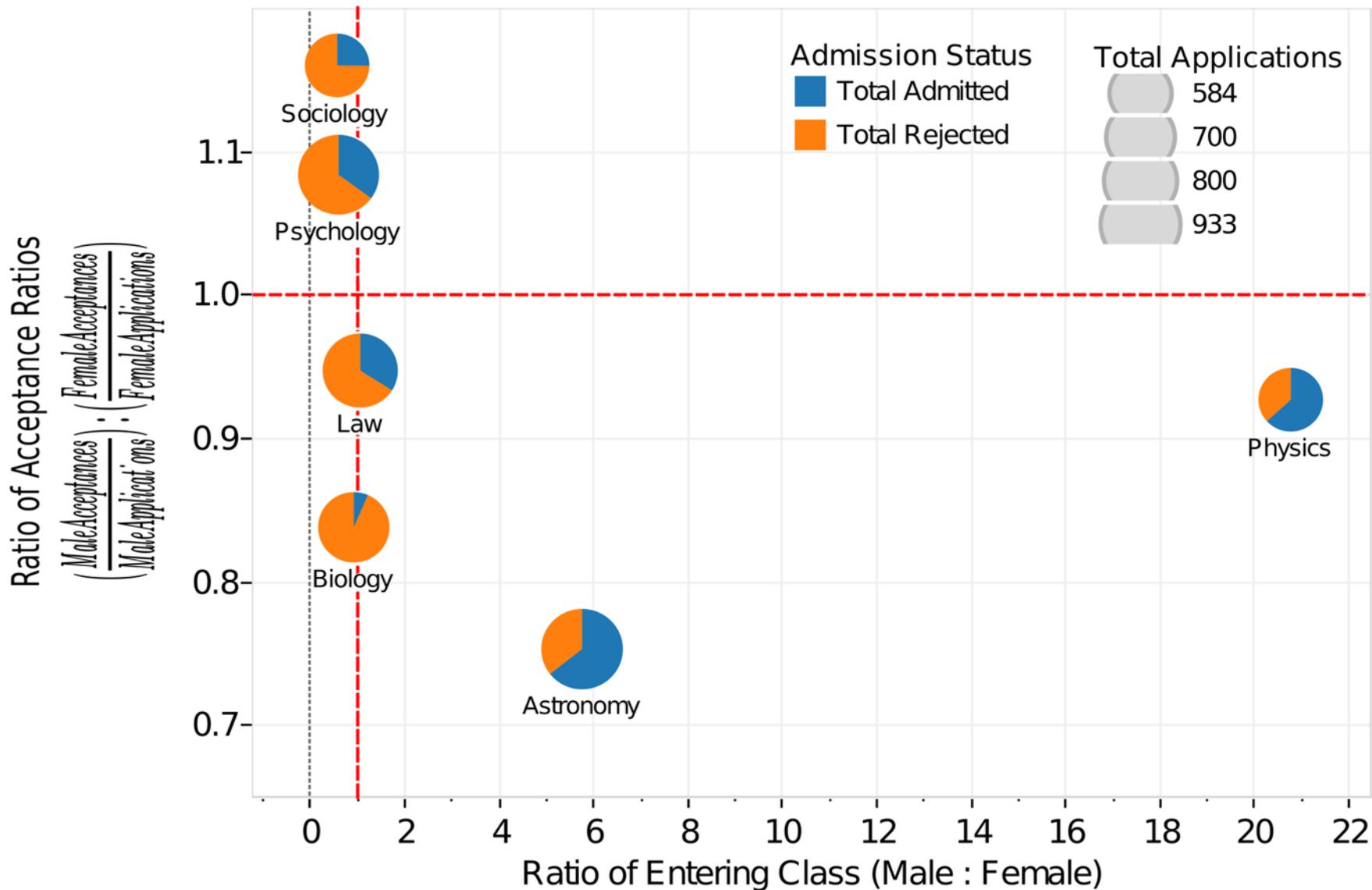
Is admission gender bias conserved across departments?



Are **females** more likely to apply to departments that are easier to get into? What about **males**?

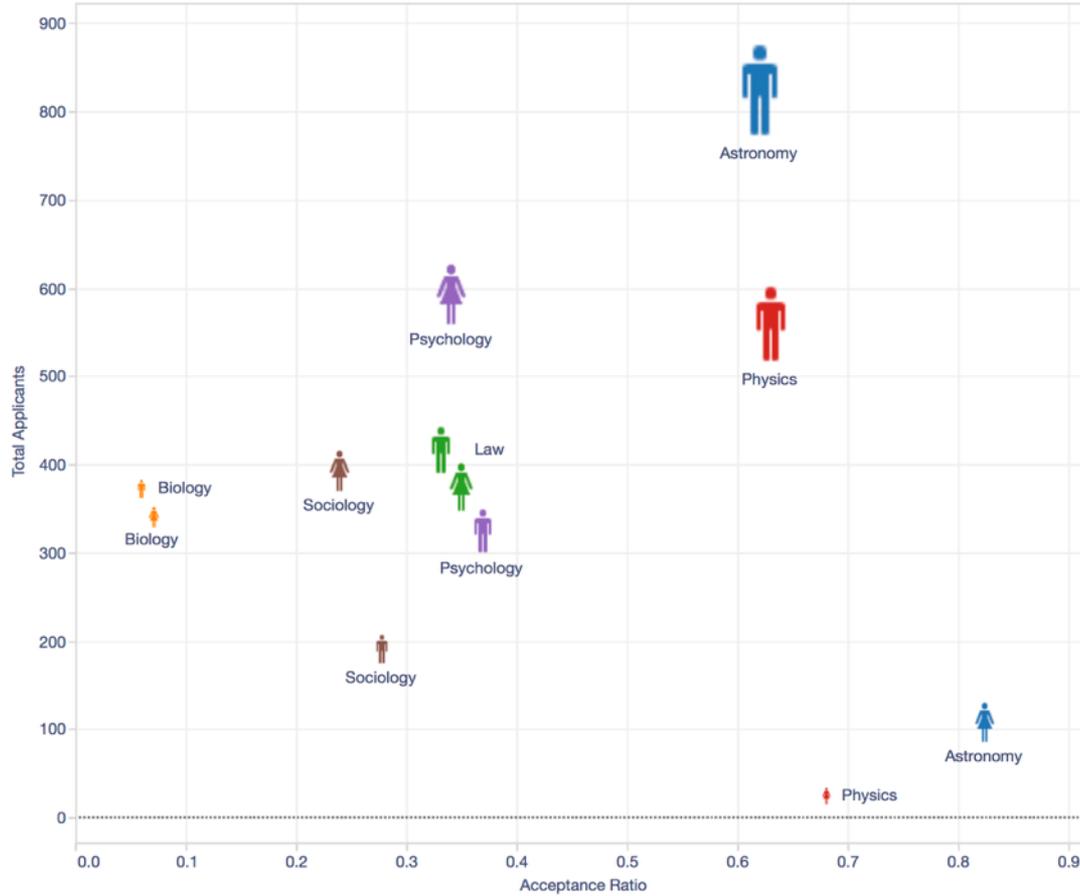


Admissions are biased toward the underrepresented gender in some departments and less selective departments are heavily dominated by males

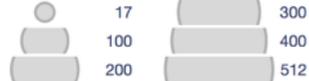


Education: Is it still a man's man's man's world?

Who's leading?



Size = Total Admitted



Gender



Department

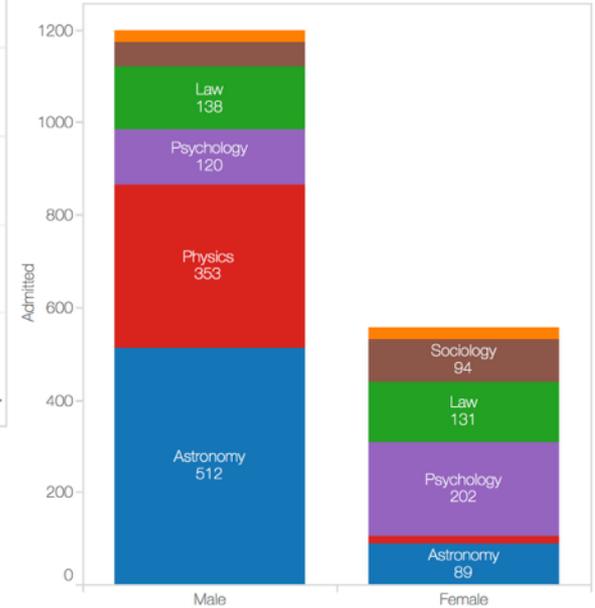


Daniel Kristiyanto
CSE 512
University of Washington

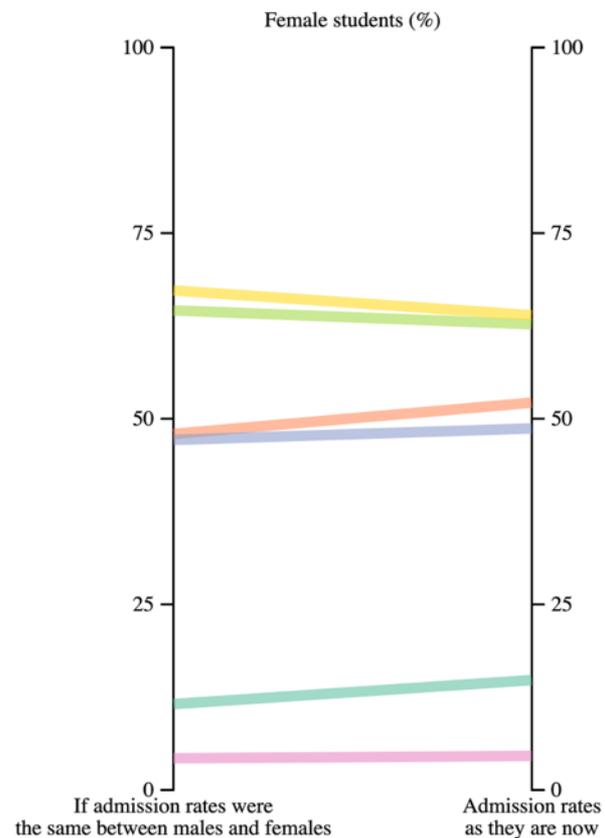
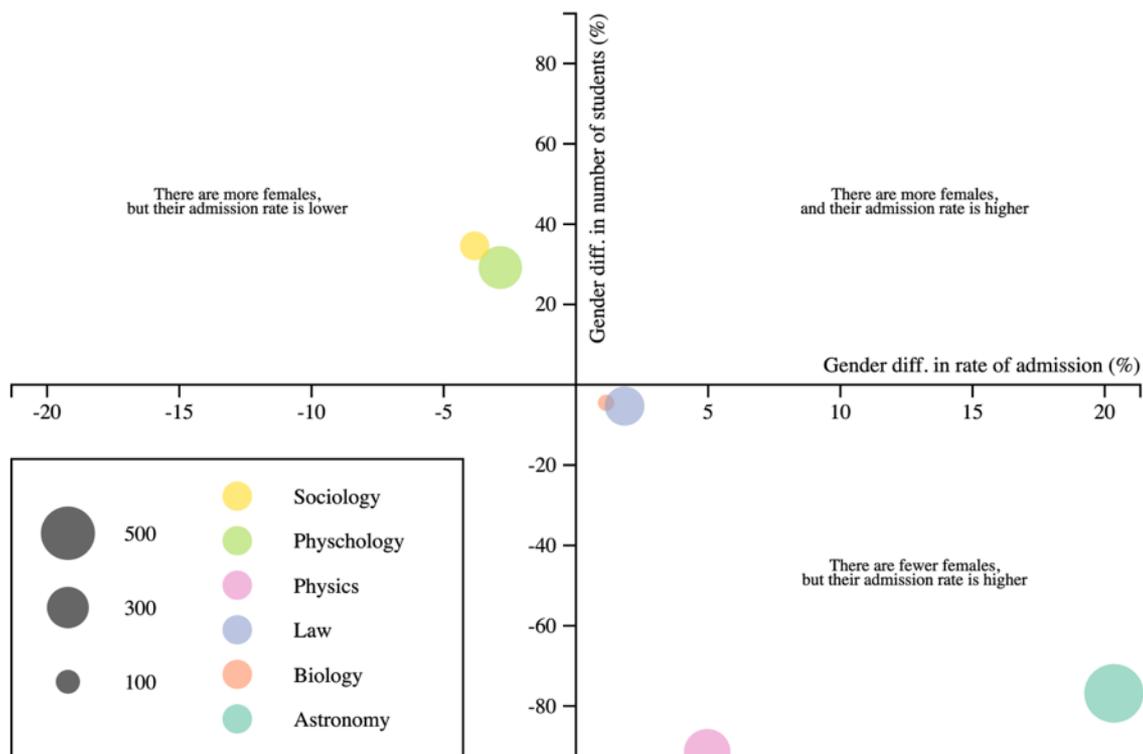
What are the most popular departments?



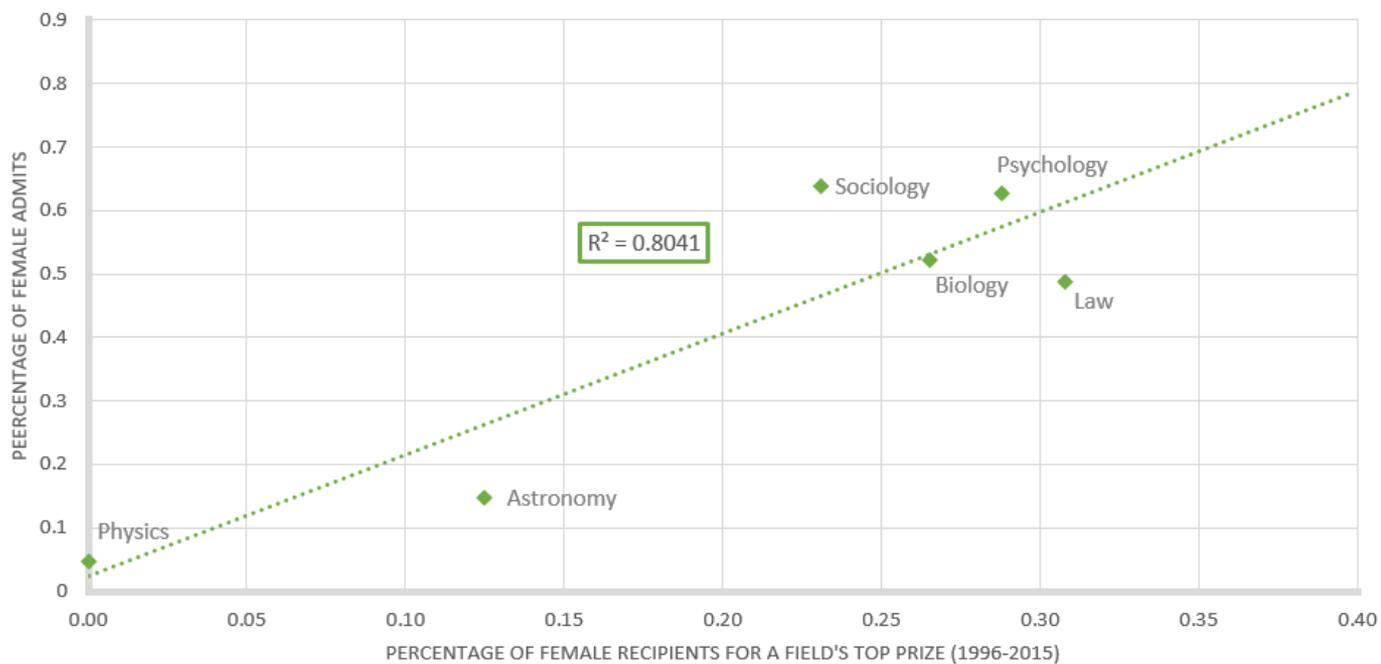
Who would more likely be your classmates?



Are universities' admission practices closing the gender gap?

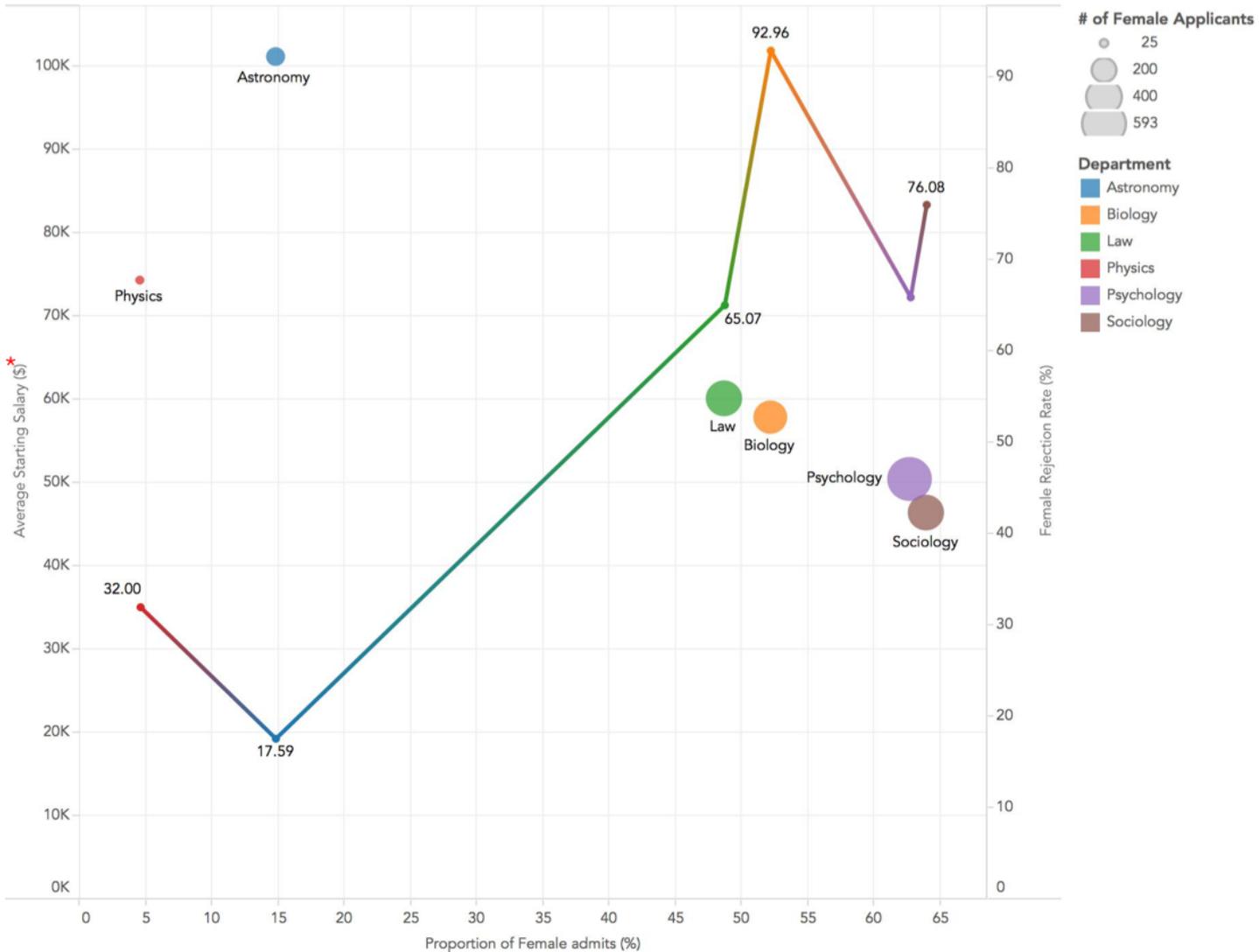


CORRELATING A FIELD'S PERCENT OF FEMALE TOP PRIZE WINNERS (1996-2015) AND ITS PERCENTAGE OF FEMALE ADMITS



Field	Prize
Astronomy	Crafoord Prize
Biology	National Medal of Science--Biology
Law	Supreme Court Justice
Physics	Nobel Prize--Physics
Psychology	APA Award for Distinguished Scientific Contributions
Sociology	Holberg Prize

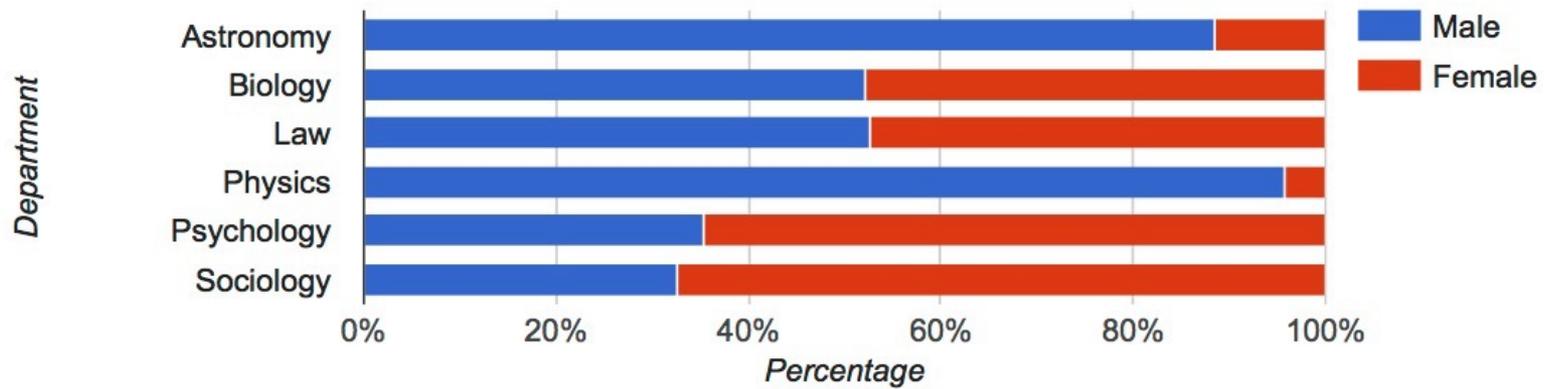
Are female students rejected from the high paying majors or just not interested?



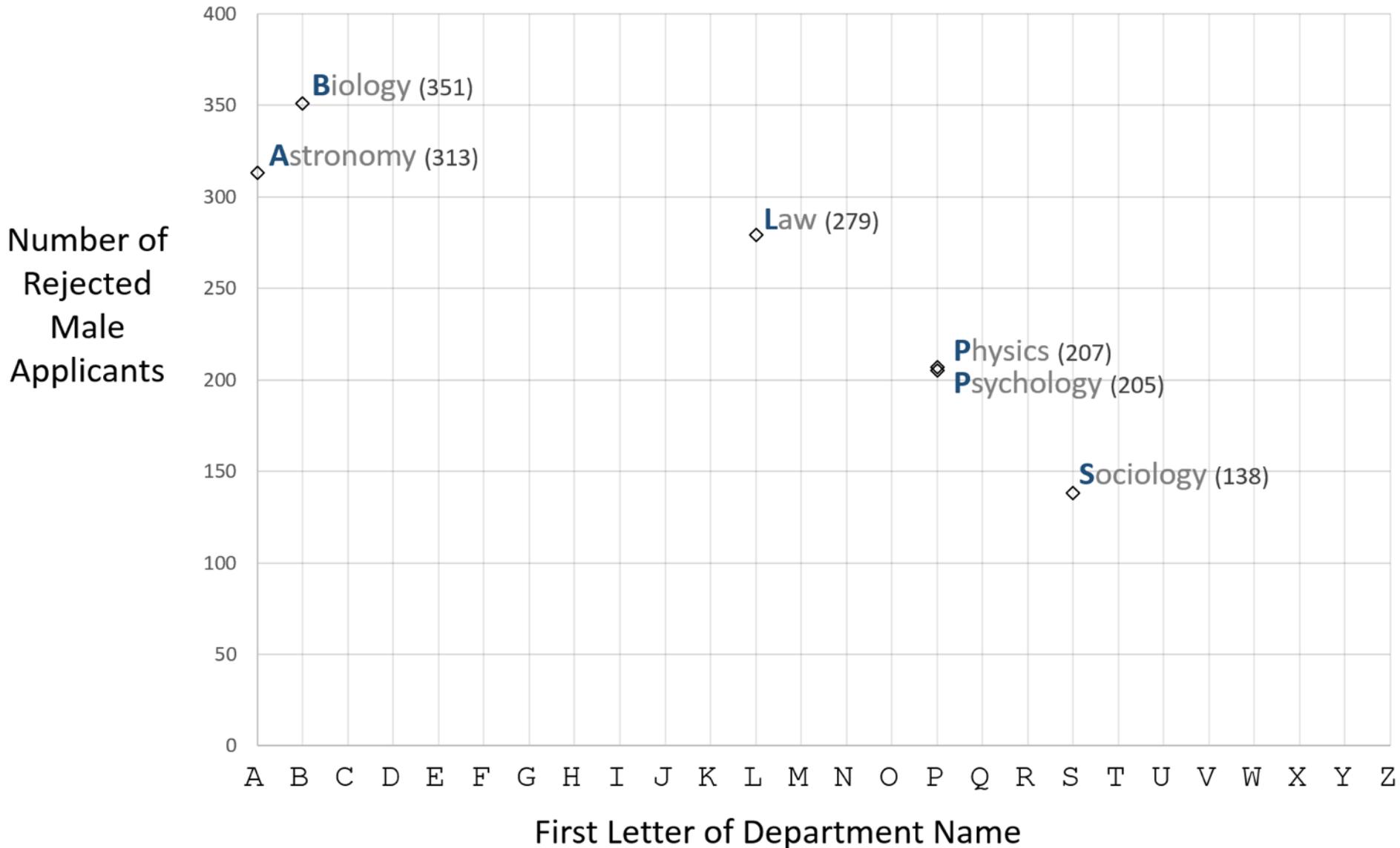
Average Salary vs. Gender Ratio



Gender Breakdown by Department

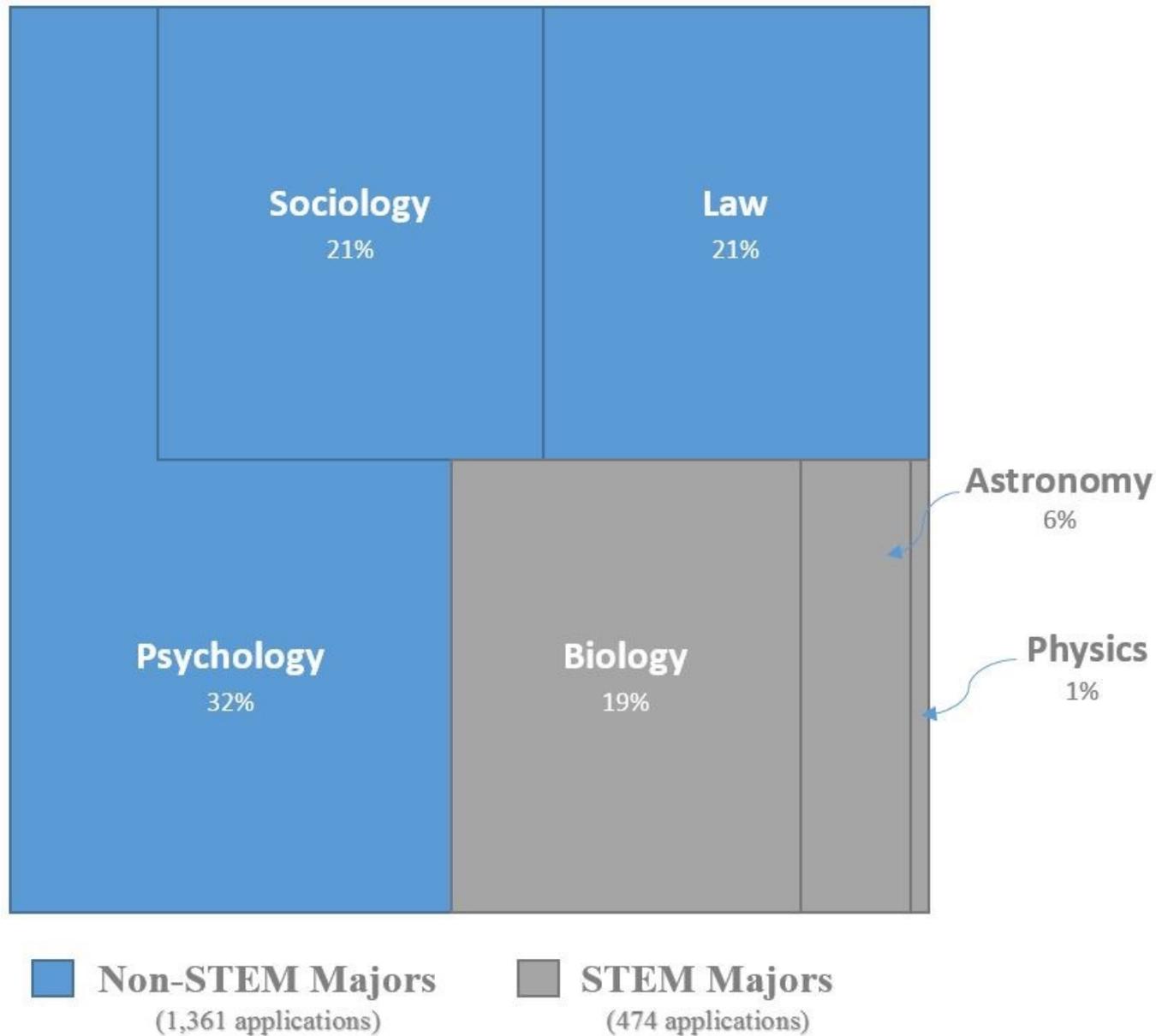


Do Departments With Earlier First Letters In Their Names Reject More Male Applicants?



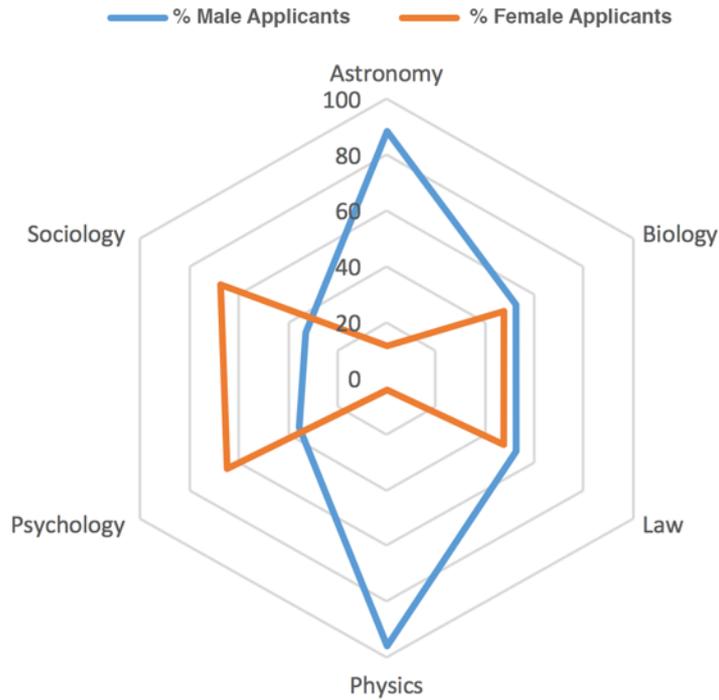
Misc

What is the distribution of interest between STEM and Non-STEM majors across female applicants?

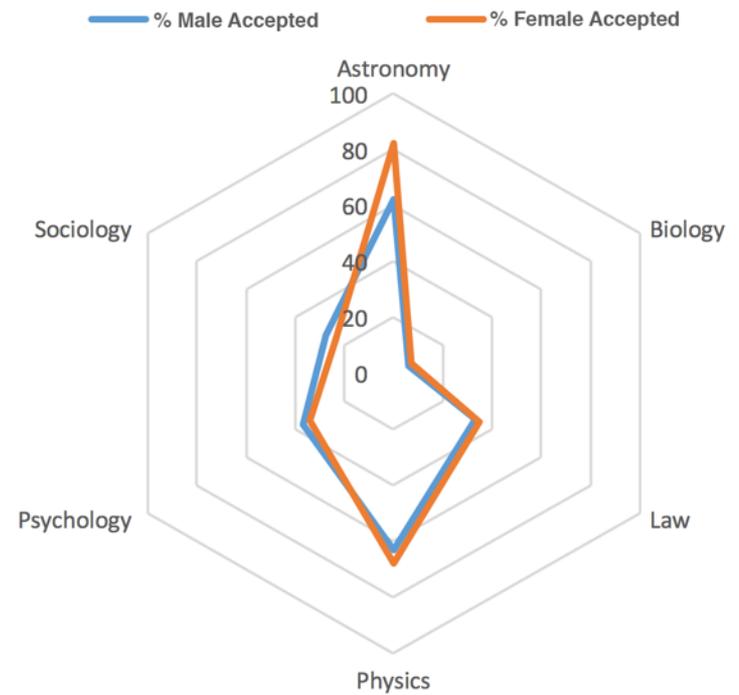


Is gender a parameter in selection of candidates?

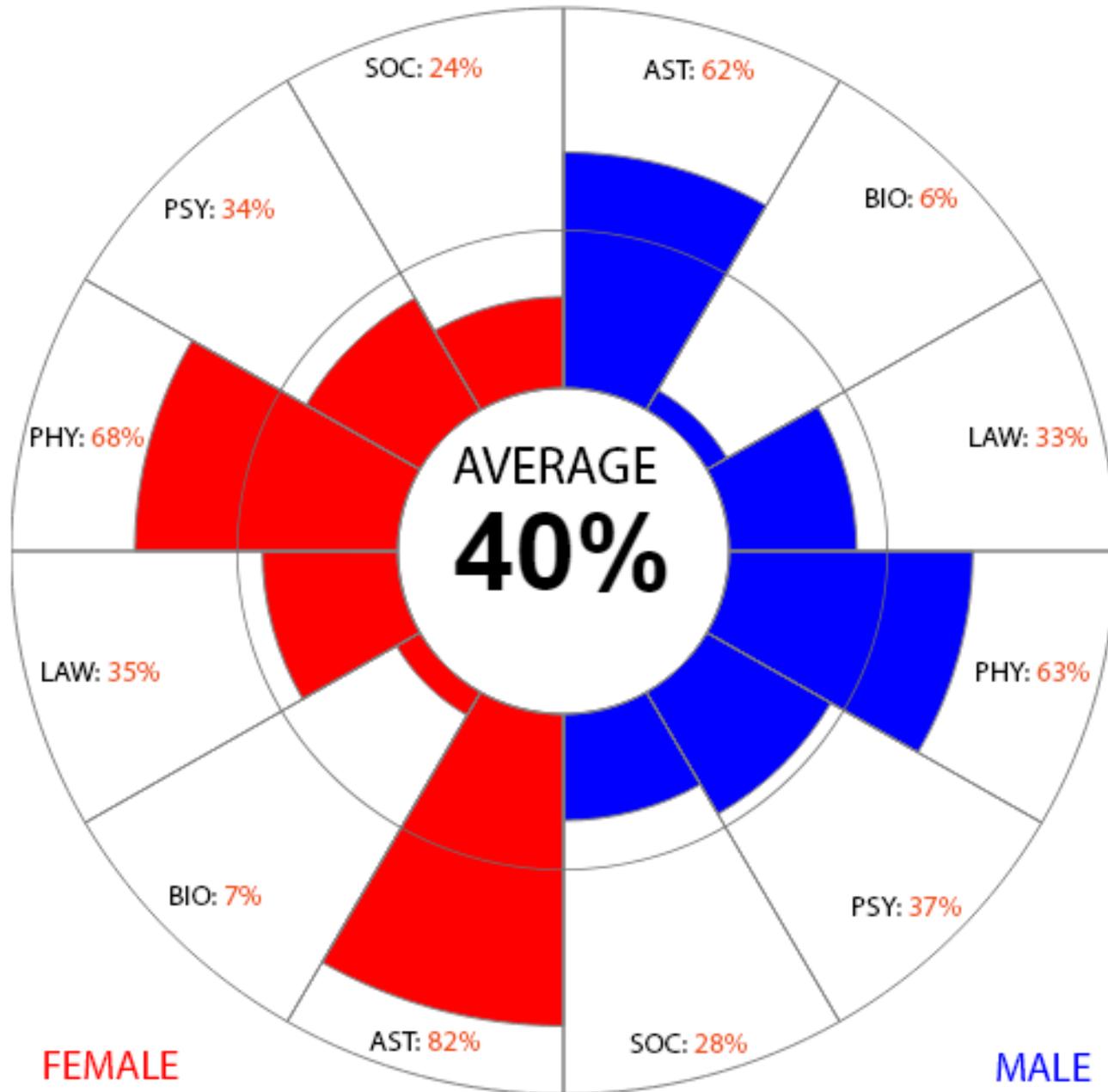
Proportion of applicants by gender

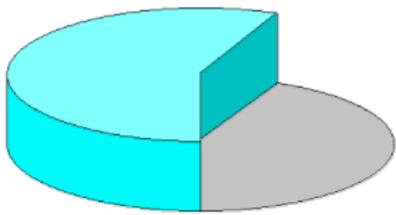


Proportion of successful applicants by gender



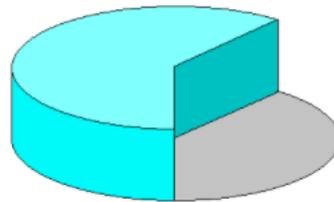
What Majors vs Genders have the Highest College Acceptance Rates?





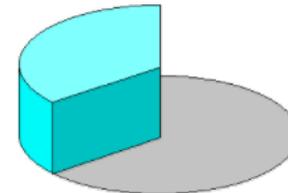
62.06% (512/825) **82.41%** (89/108)

Astronomy



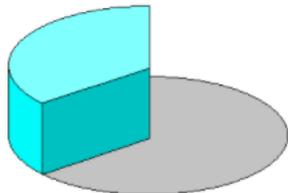
63.34% (353/560) **68.00%** (17/25)

Physics



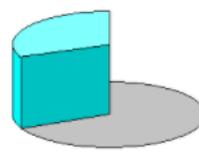
36.92% (120/325) **34.06%** (202/593)

Psychology



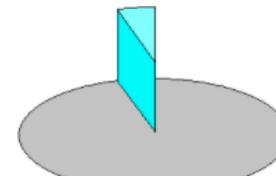
33.09% (138/417) **34.93%** (131/375)

Law



27.75% (53/191) **23.92%** (94/393)

Sociology



5.90% (22/373) **7.04%** (24/341)

Biology

 Accepted Male Applicants vs. Total Male Applicants

 Accepted Female Applicants vs. Total Female Applicants

Which Departments Are the Easiest to Get Admitted To?

Simpson's Paradox

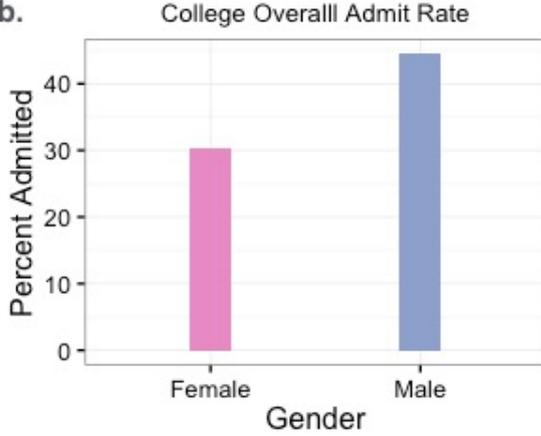
Is there any Gender bias in admissions at DG College ?

Admissions Dashboard

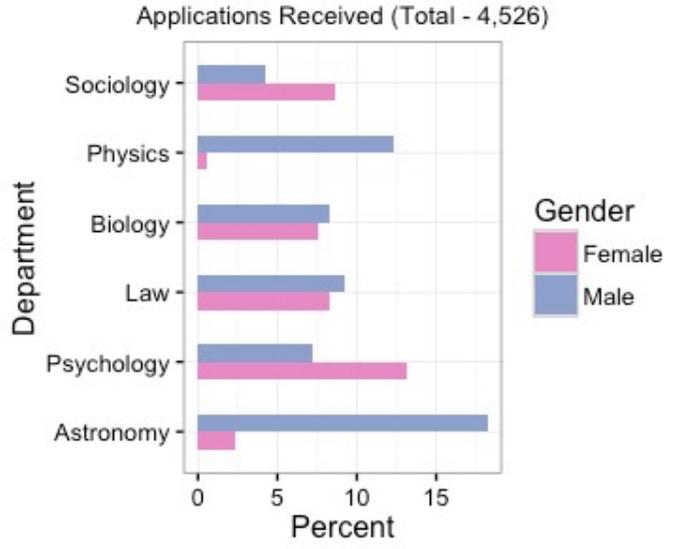
a.

Total Applications: 4526		
	#Accept	#Reject
Male	1198	1493
Female	557	1278

b.



c.



d.

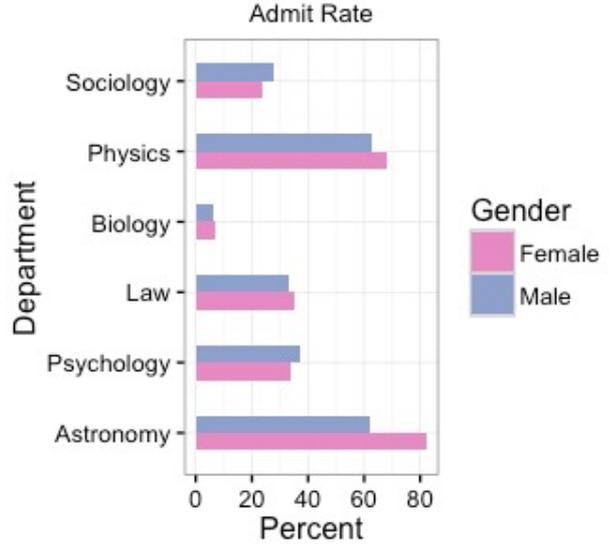
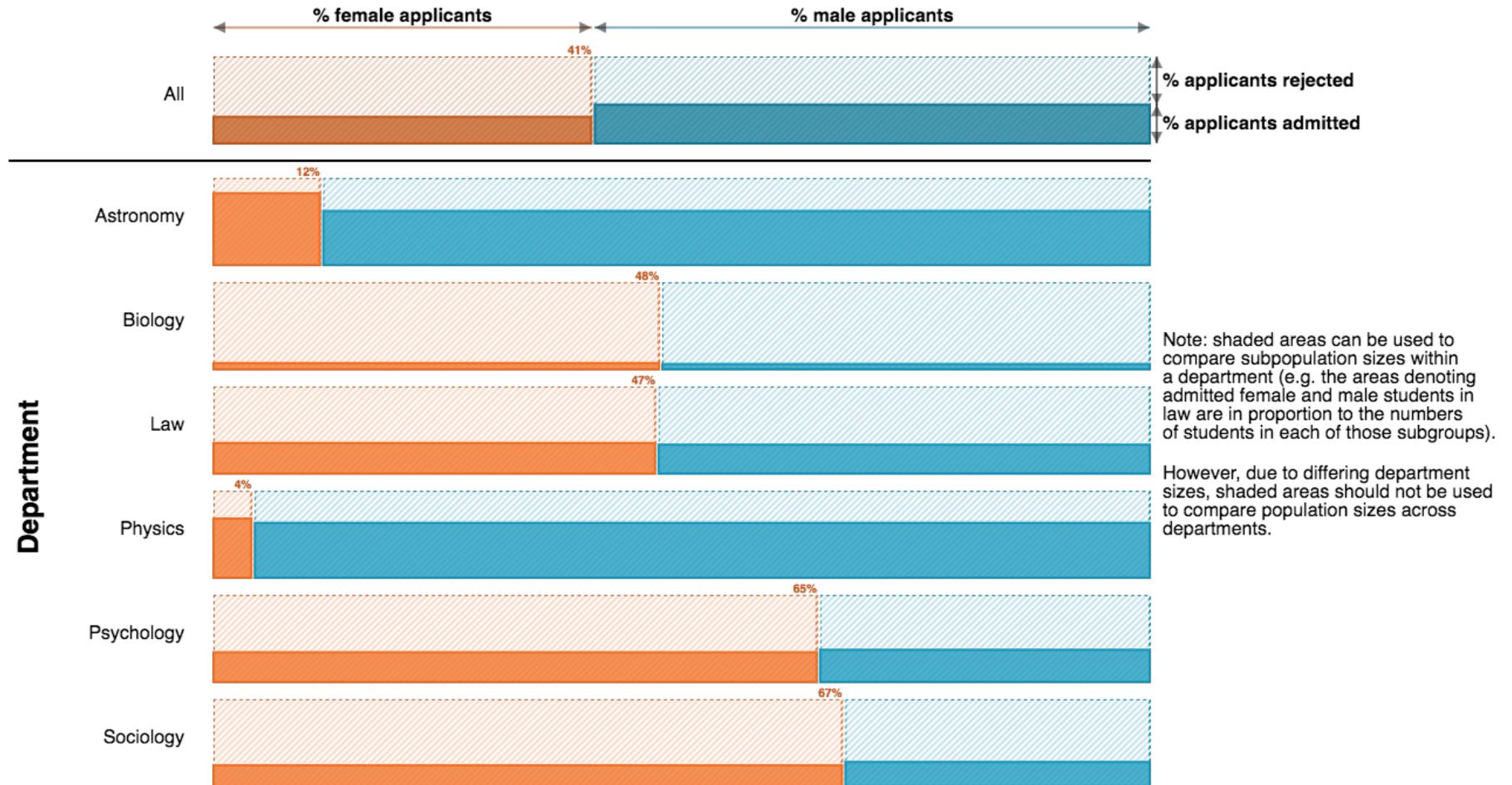
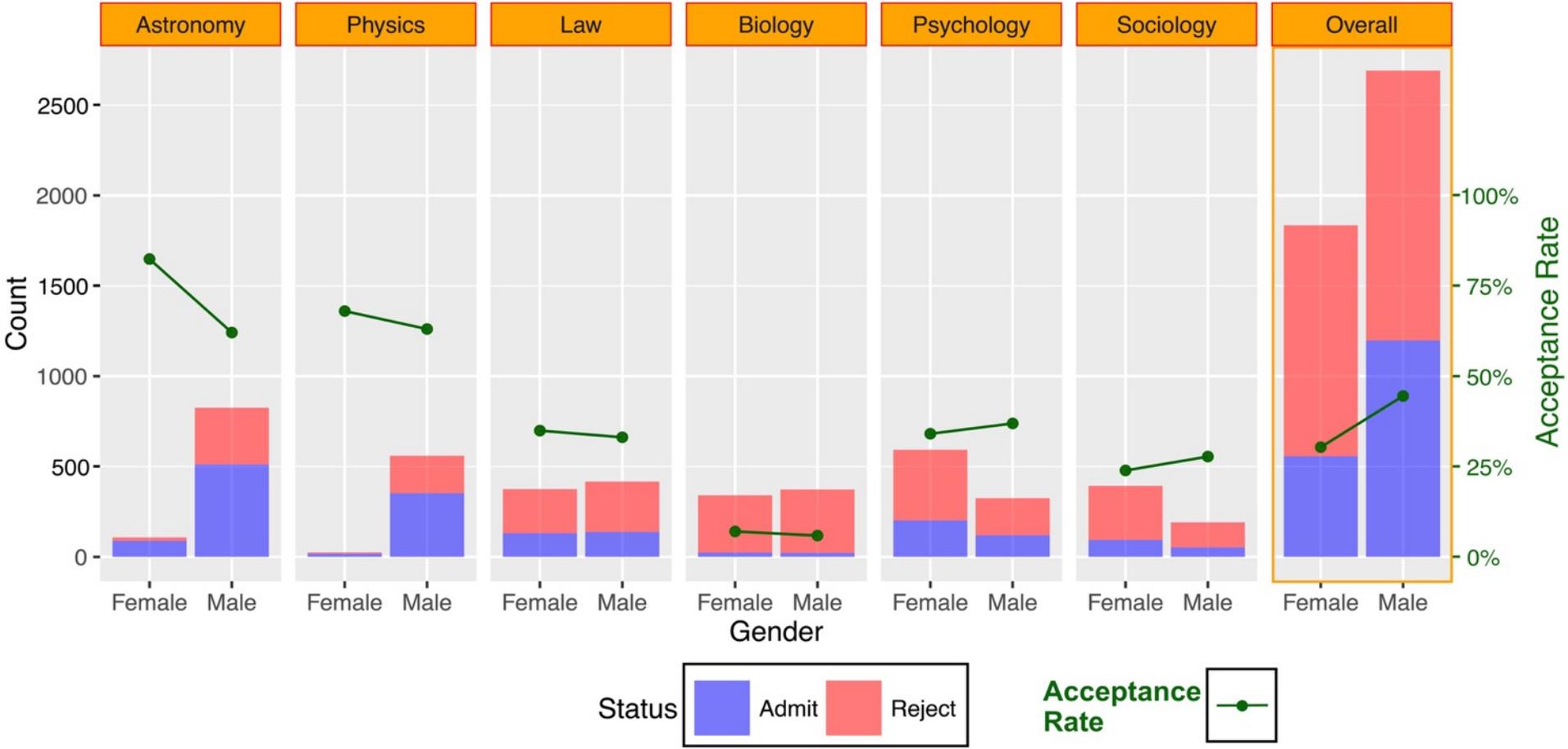


Figure 1. a.) Admissions application statistics. Comparing figure 1.b and 1.d one can see the confounding pattern in admissions data. While overall admission rates show significant difference for females and males (chi-squared p-val <.001) (1.b), department wise number of females and males admitted are seen to be more balanced. Physics and Astronomy departments receives the least amount of applications by females(1.c) yet admit more percent of females than males (1.d). More males are applying to easier to get-in departments.

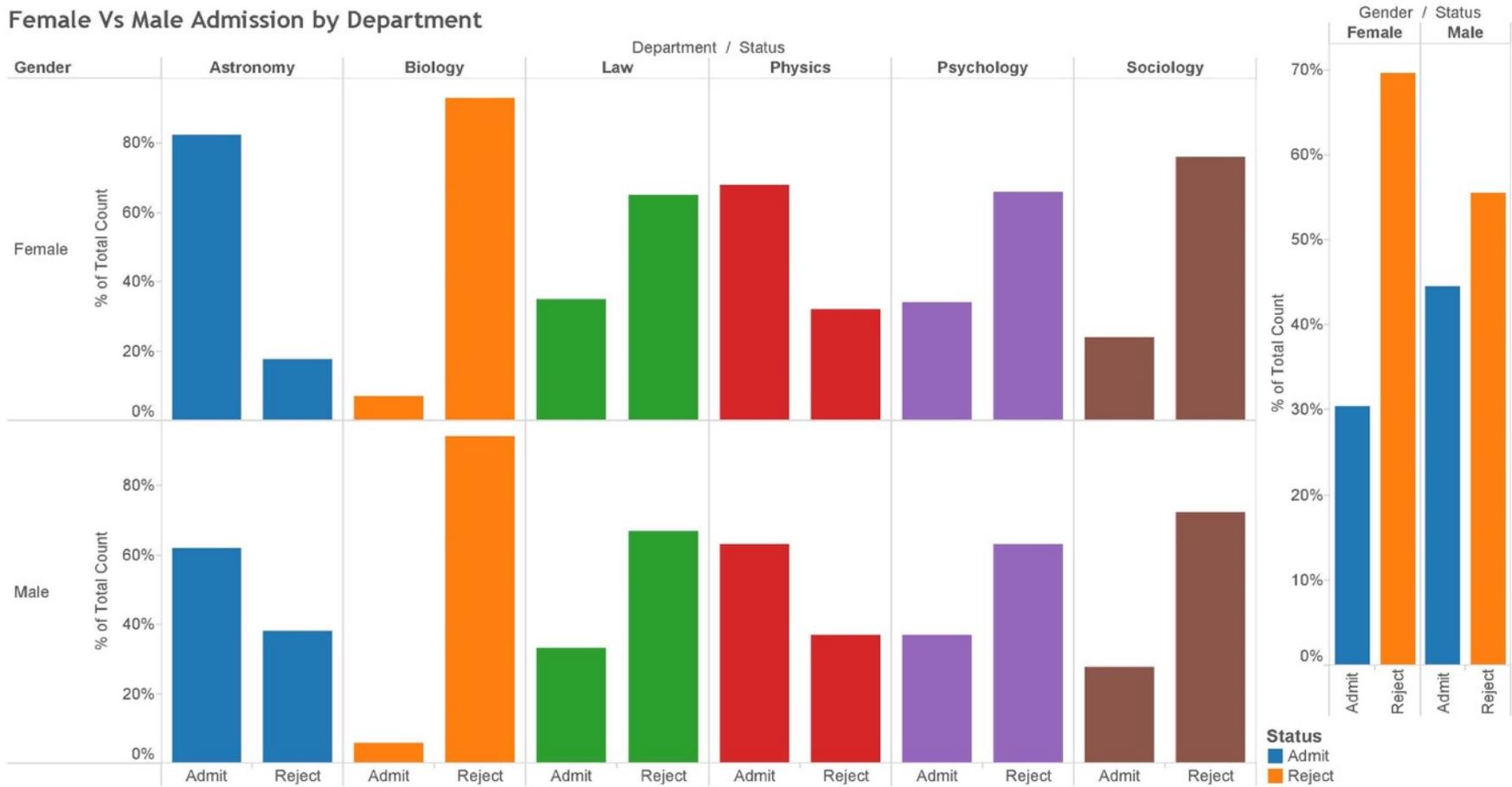
Application & acceptance rates by gender across departments



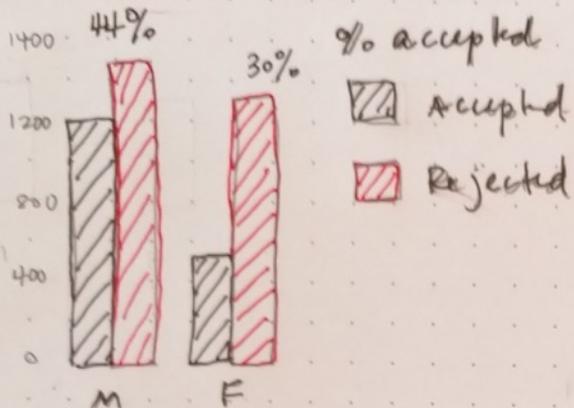
Are College Admission Acceptance Rates for Female Applicants Higher Than That for Male Applicants?



Female Vs Male Admission by Department

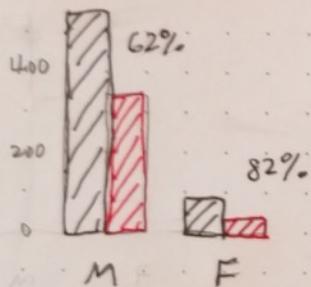


ALL DEPARTMENTS

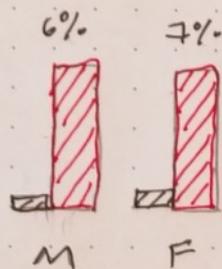


COLLEGE ADMISSIONS BY DEPARTMENT AND GENDER

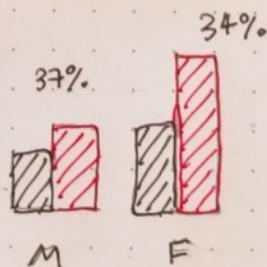
ASTRONOMY



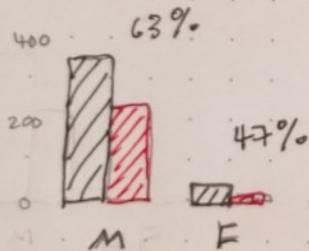
BIOLOGY



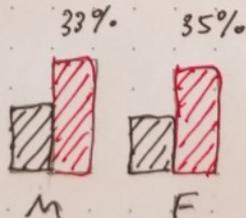
PSYCHOLOGY



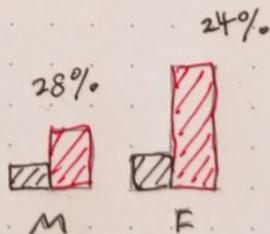
PHYSICS



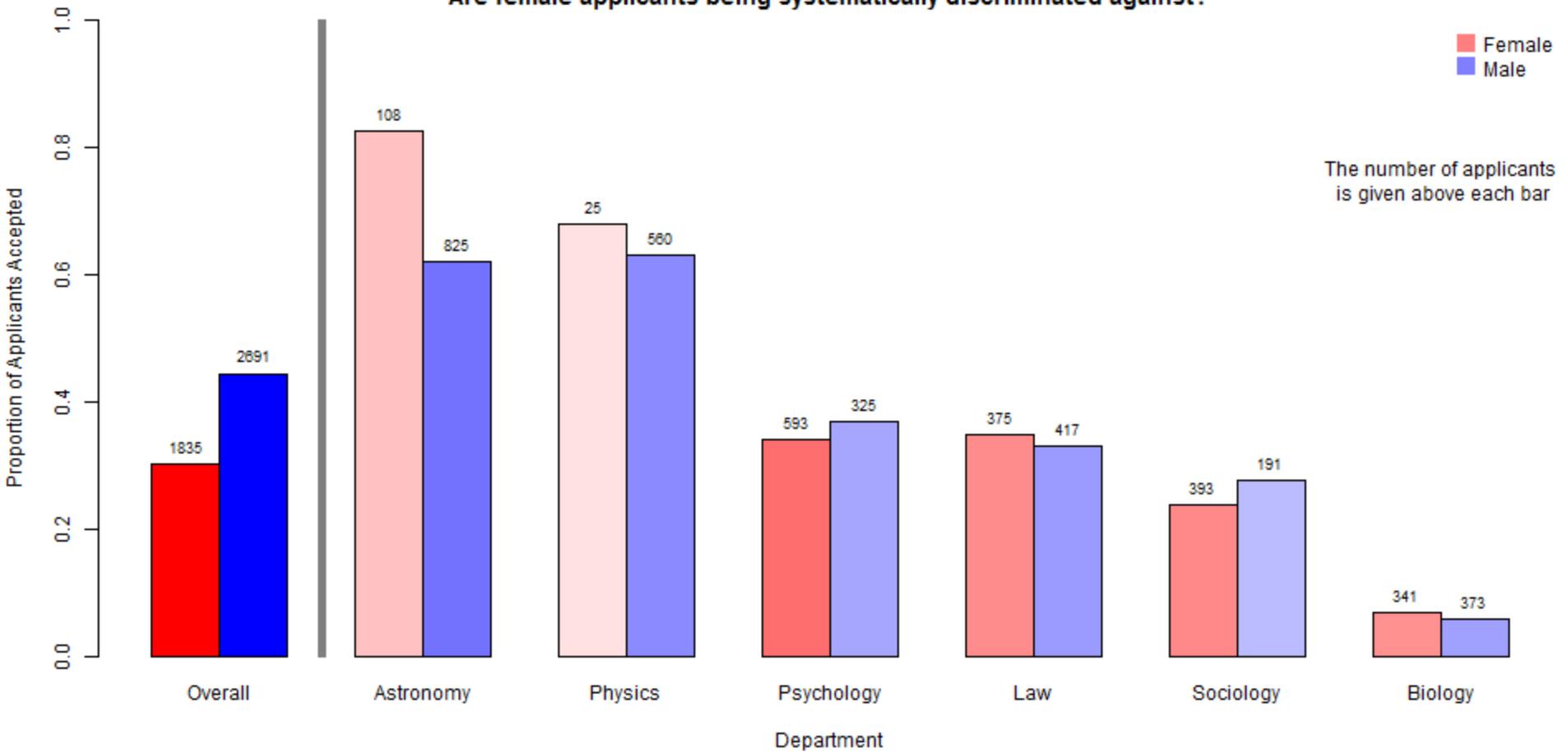
LAW



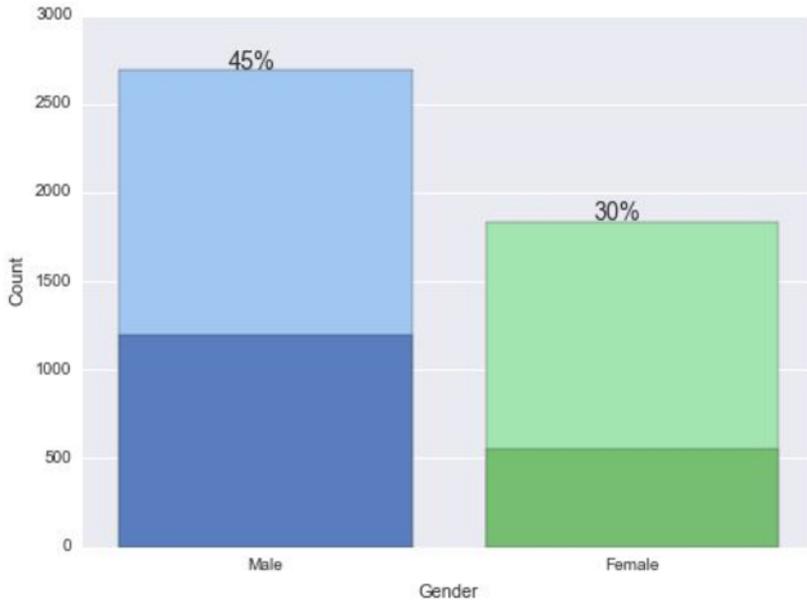
SOCIOLOGY



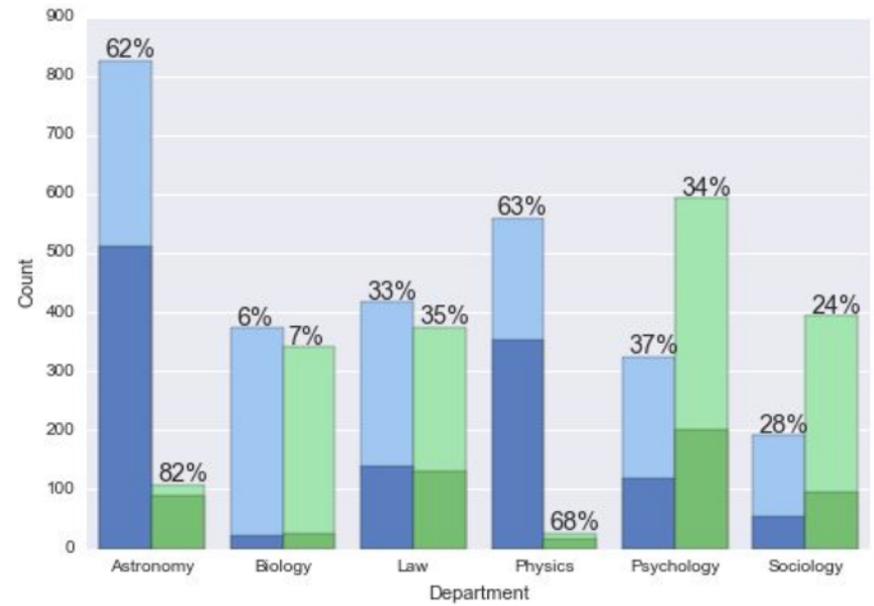
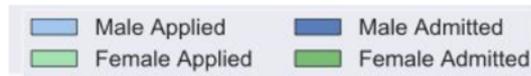
Are female applicants being systematically discriminated against?



College Admissions Paradox



Overall admission statistics



Admission statistics *by department*

Re-Design Exercise

Re-Design Exercise

Task: Analyze and Re-design visualization

Identify data variables (N/O/Q) and encodings

Critique the design: what works, what doesn't

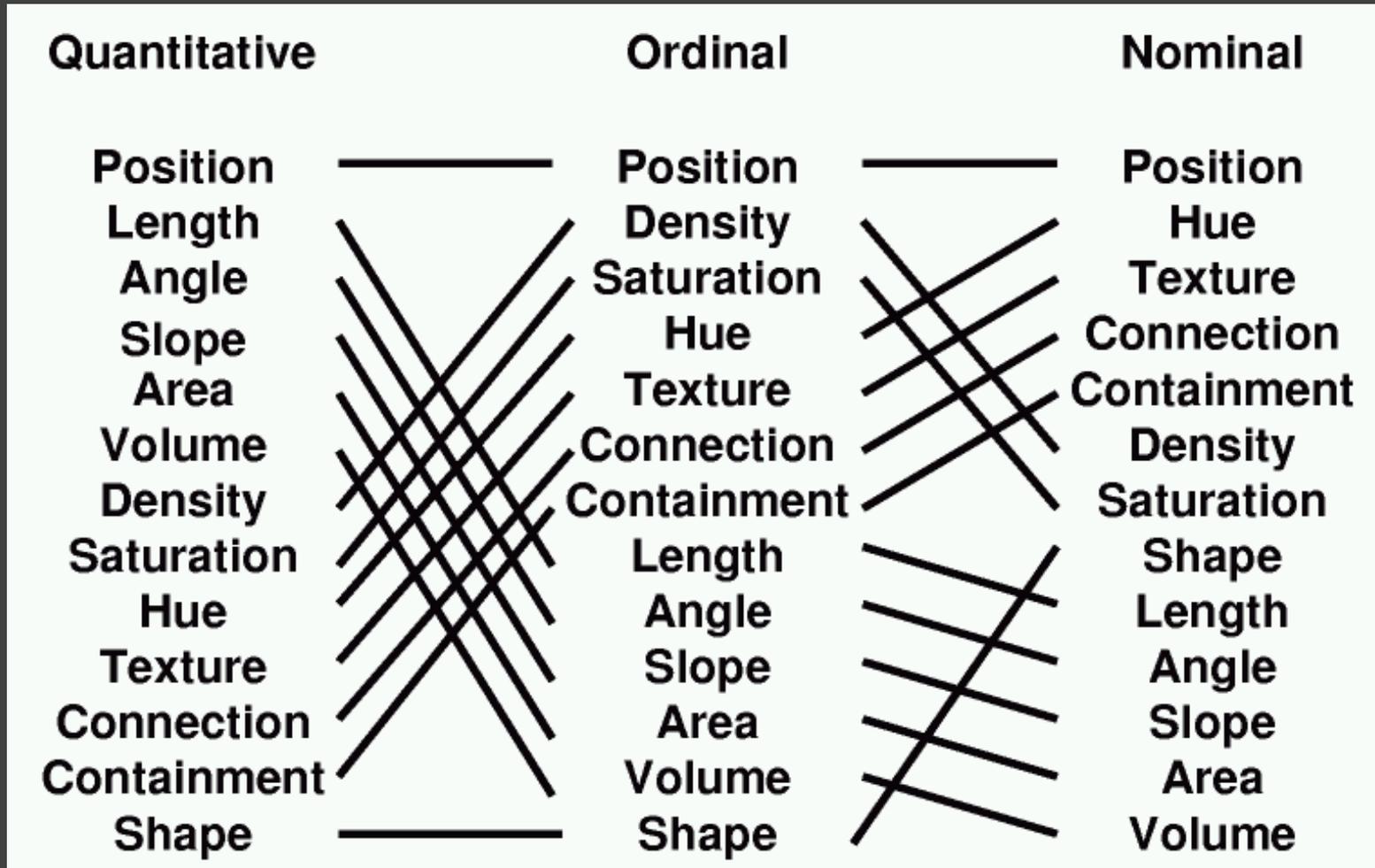
Sketch a re-design to improve communication

Be ready to share your thoughts with the class

Break into groups with those sitting near you

(~4 people per group)

Mackinlay's Ranking



Conjectured *effectiveness* of encodings by data type

Teacher Salaries: Is It Really That Bad?

National and State averages for K-12 Public-School Teachers



UNITED STATES

AVG. SALARY: \$47,674

Avg. vacation days: 63

HOURLY

Hours per week on-site: 36.5
 Public-School Teacher: \$34.06
 Private-School Teacher: \$21.08
 Average Worker: \$25.08
 Police: \$22.64
 Fire: \$17.91

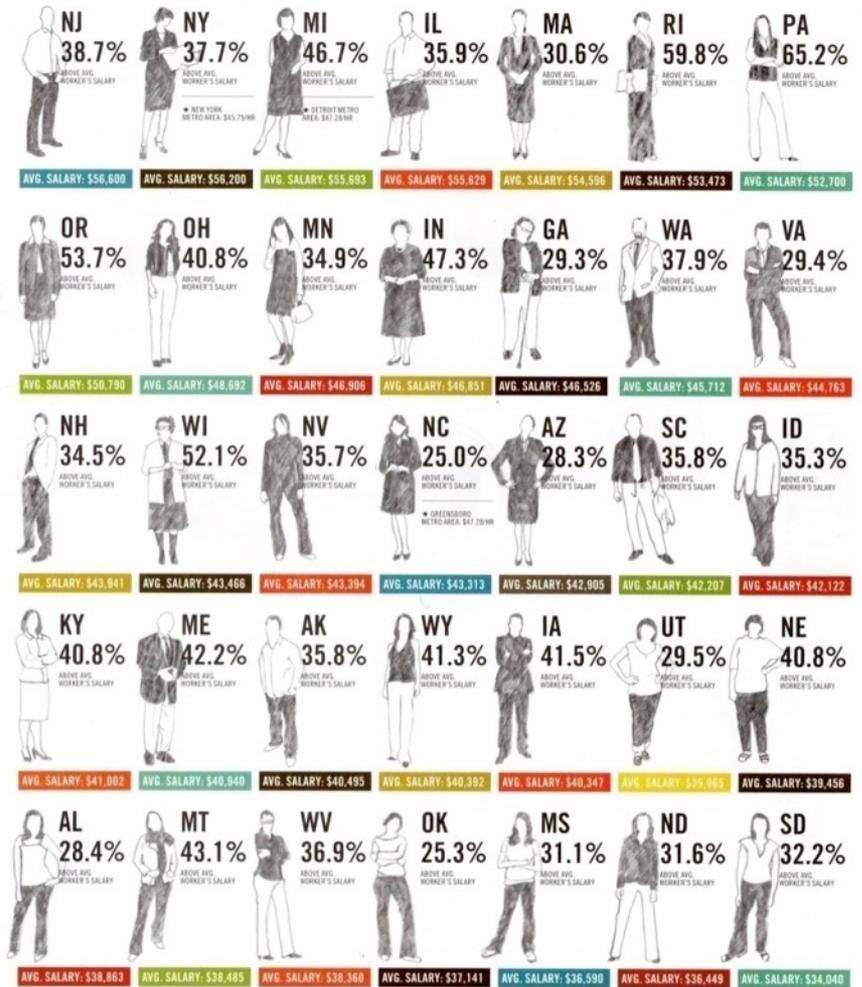
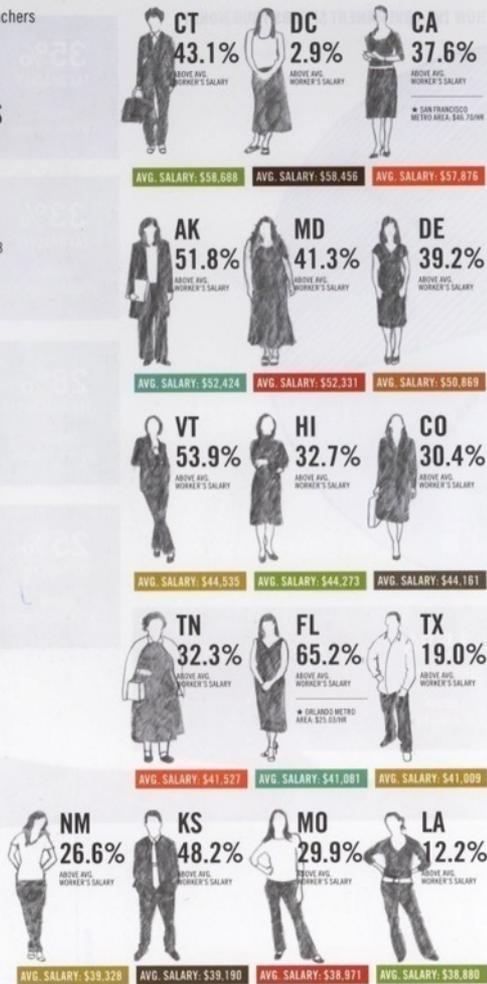


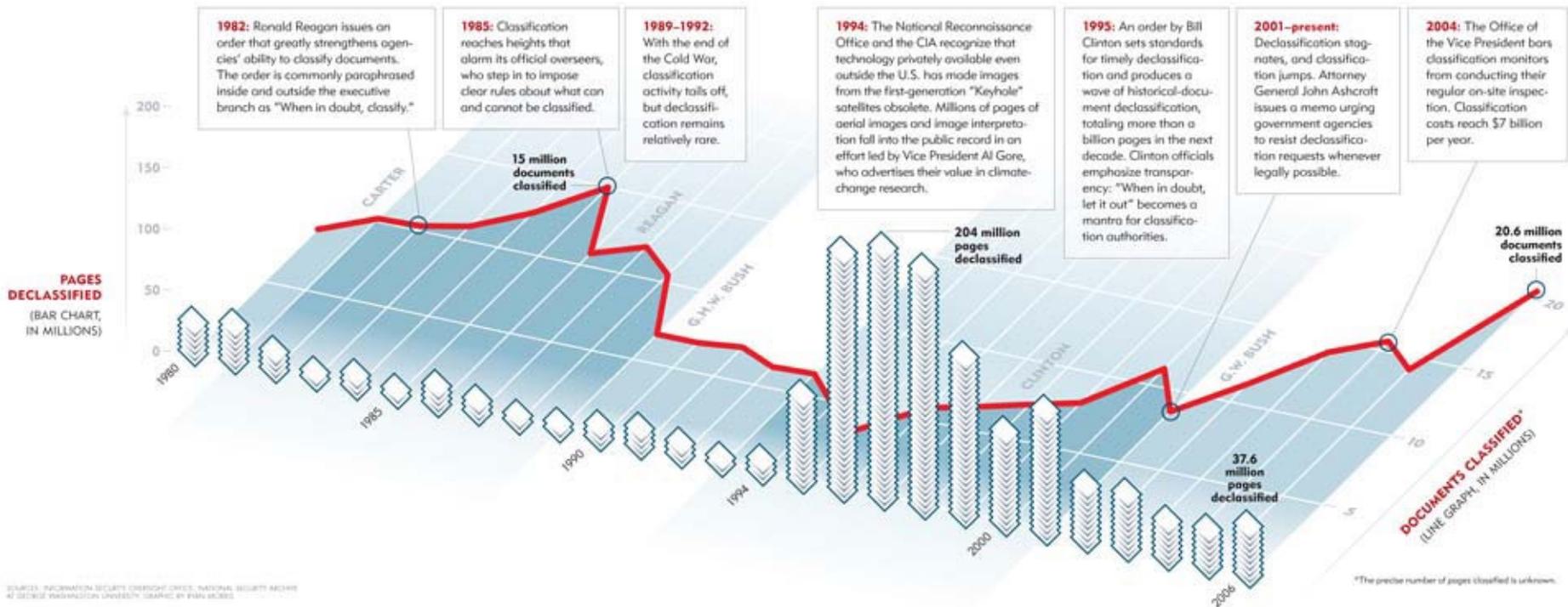
CANADA

AVG. SALARY: \$43,000

Avg. vacation days: 50

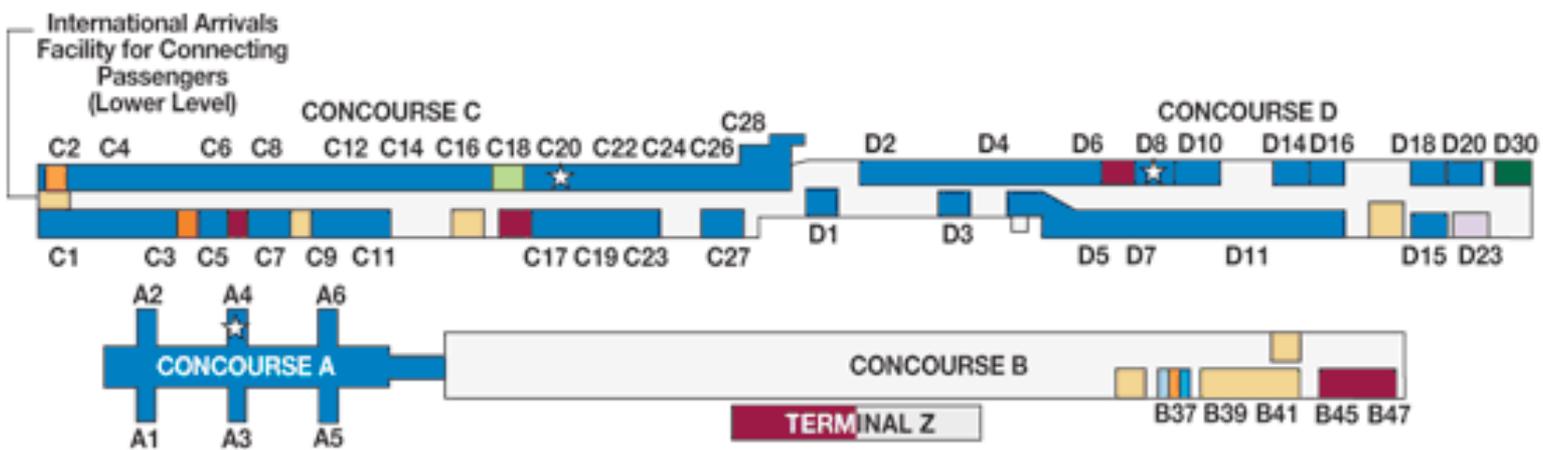
HOURLY: \$30.18
 Hours per week on-site: 55.6



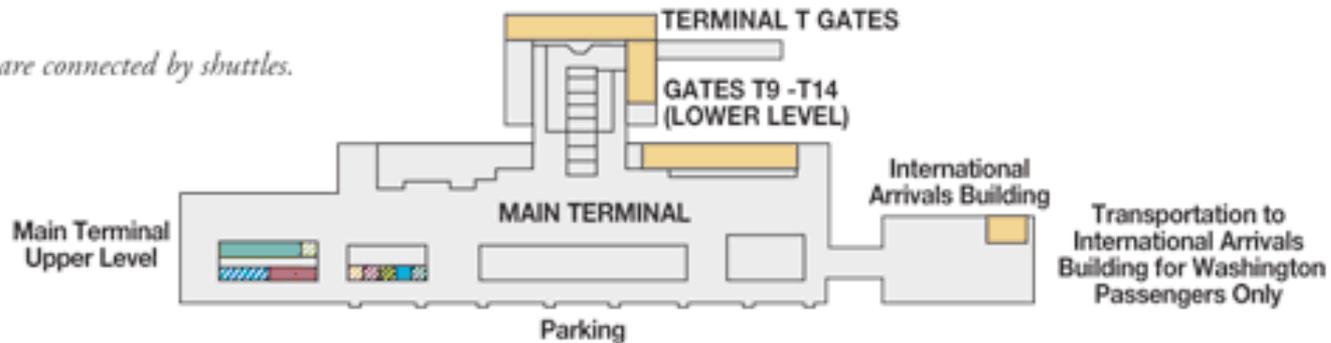


Source: *The Atlantic* 300 no. 2 (September 2007)

Number of Classified U.S. Documents



* Terminals are connected by shuttles.



- | | | |
|-----------------------------------|----------------------------|-----------------------------|
| United / TED Gate Area | Lufthansa Check-in | Austrian Airlines Gate Area |
| United Premier Check-in | Air Canada Gate Area | SAS Gate Area |
| United Check-in | Air Canada Check-in | BWIA Gate |
| United International Check-in | Mobile Lounge Dock | South African Airways |
| United Red Carpet Club | ANA Check-in | US Airways Gates |
| United First International Lounge | ANA Fuji Lounge/Gate Area | United EasyCheck-in |
| Lufthansa Gate Area | Austrian Airlines Check-in | US Airways Check-in |

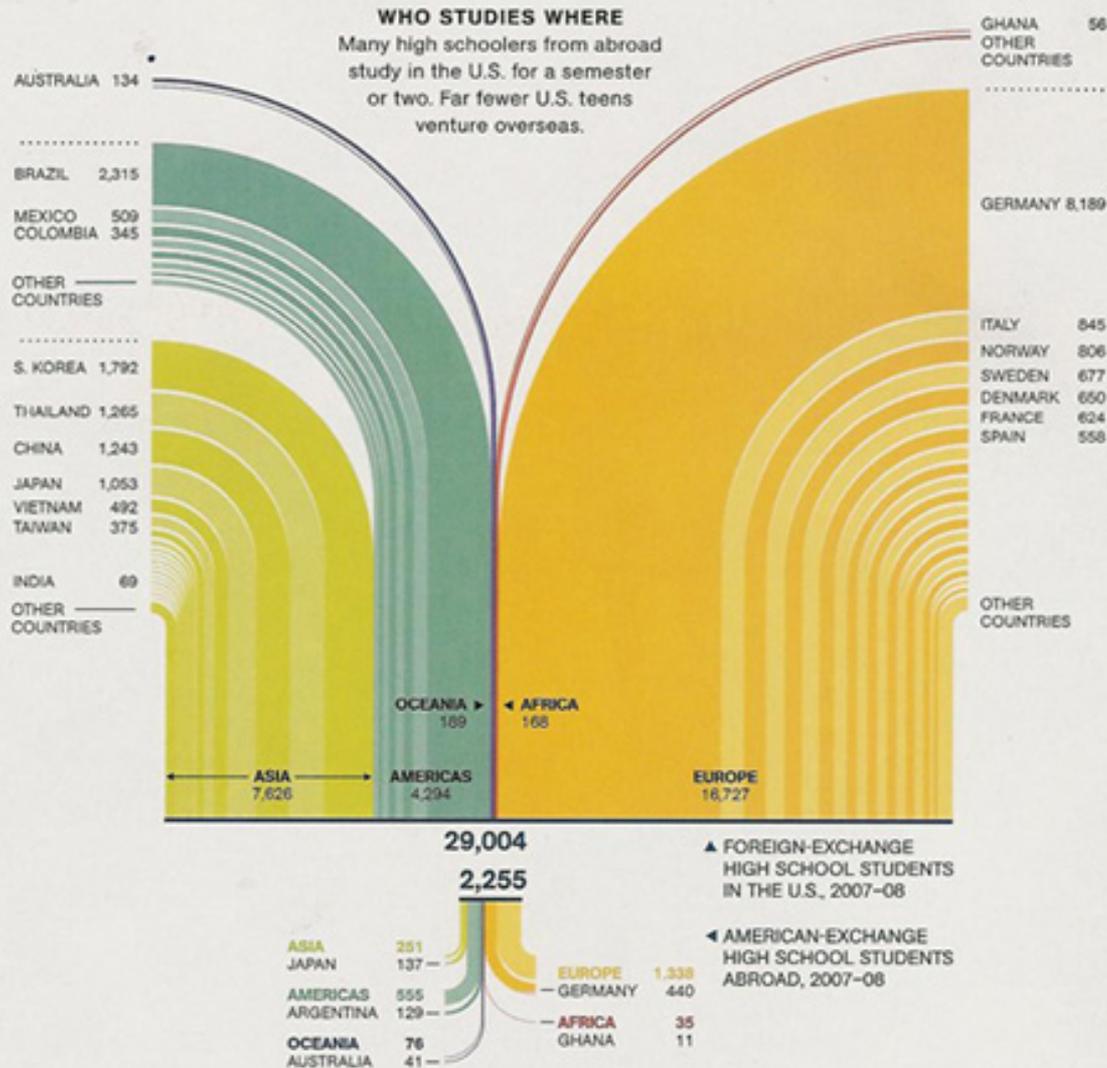
EasyCheck-in is available at this airport.



11 2006

Washington Dulles Airport Map

Source: United Airlines Hemispheres

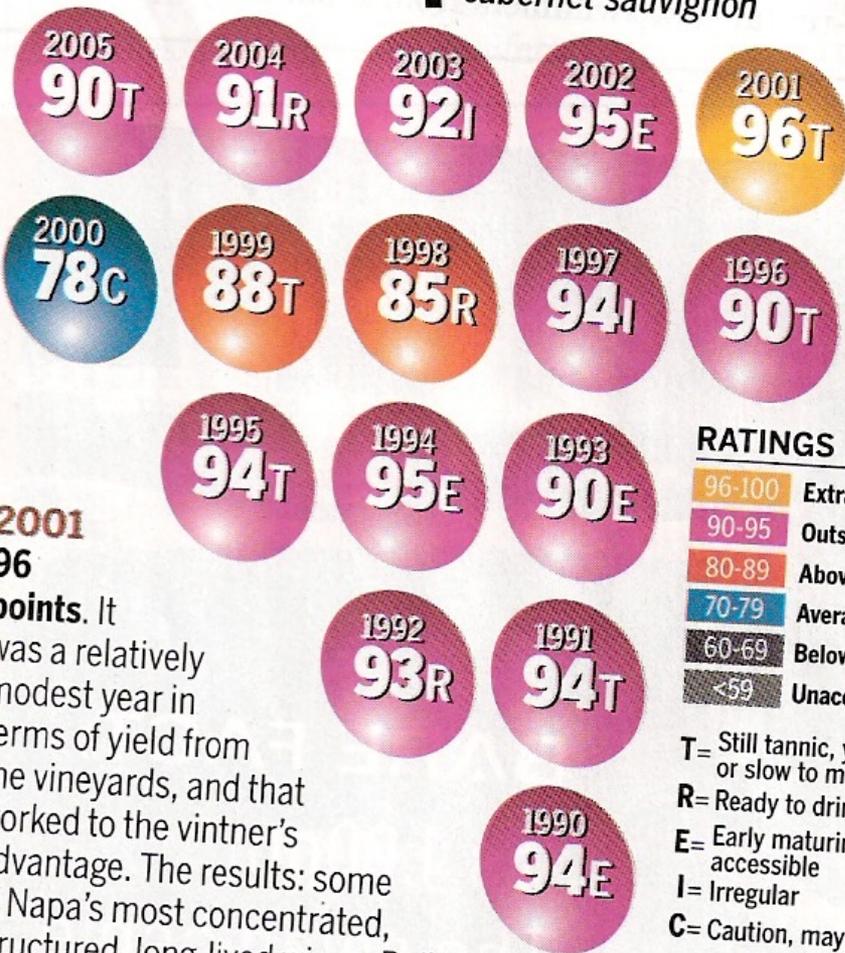


Source: *National Geographic*, September, 2008, p. 22.
 Silver, Mark. "High School Give-and-Take."

IT WAS A VERY GOOD YEAR?

Robert Parker's ratings for vintages of Napa Valley cabernet sauvignon

%,



2001
96

points. It was a relatively modest year in terms of yield from the vineyards, and that worked to the vintner's advantage. The results: some of Napa's most concentrated, structured, long-lived wines. Built for aging, they are rich, densely colored,

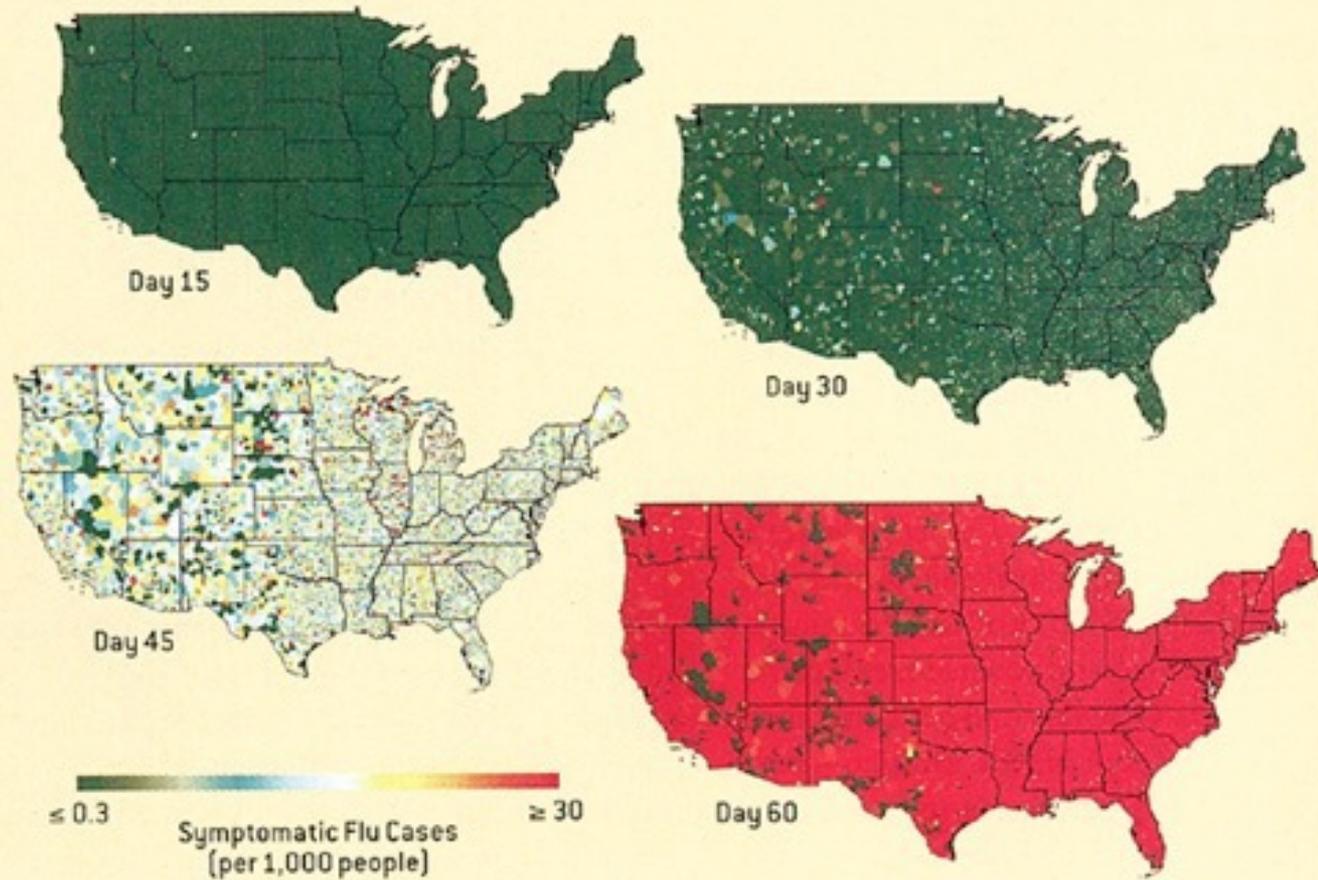
RATINGS

96-100	Extraordinary
90-95	Outstanding
80-89	Above average
70-79	Average
60-69	Below average
<59	Unacceptable

T= Still tannic, youthful, or slow to mature
 R= Ready to drink
 E= Early maturing and accessible
 I= Irregular
 C= Caution, may be too old

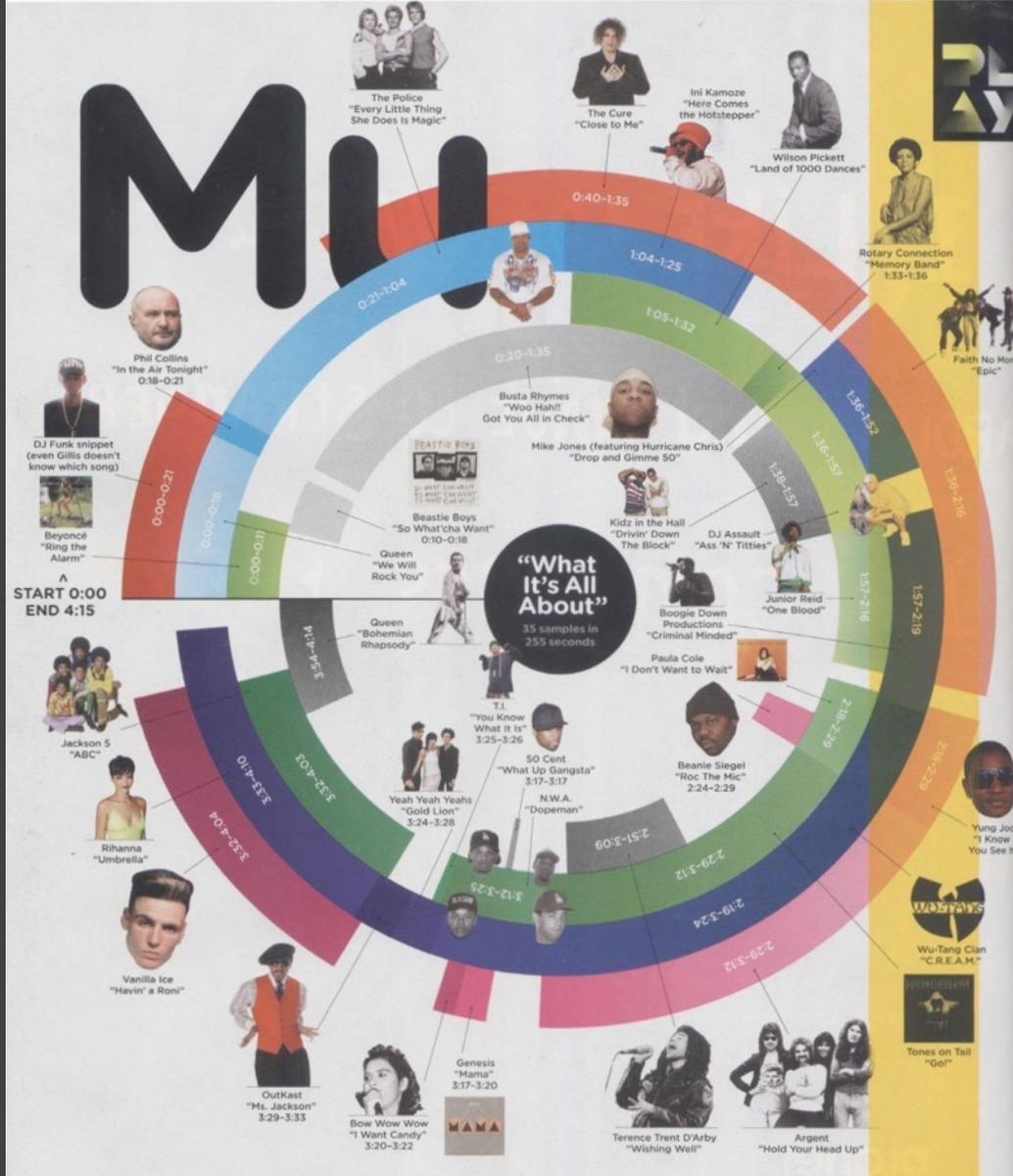
Pandemic Flu Hits the U.S.

A simulation created by researchers from Los Alamos National Laboratory and Emory University shows the first wave of a pandemic spreading rapidly with no vaccine or antiviral drugs employed to slow it down. Colors represent the number of symptomatic flu cases per 1,000 people (see scale). Starting with 40 infected people on the first day, nationwide cases peak around day 60, and the wave subsides after four months with 33 percent of the population having become sick. The scientists are also modeling potential interventions with drugs and vaccines to learn if travel restrictions, quarantines and other disruptive disease-control strategies could be avoided.



Preparing for a Pandemic

Source: *Scientific American*, 293(5). November, 2005, p. 50



Source: *Wired Magazine*, September 2008 Edition
 Music: Super Cuts (page 92)