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Research focus on gastrointestinal and respiratory cancers as well as meta-analysis.

9 years of SAS programming experience focusing on macros, graphics, SQL and reports.

PharmaSUG 2018
Paper #DV14

Welcome to the Three Ring %CIRCOS: An Example of Creating a Circular Graph without a Polar Axis

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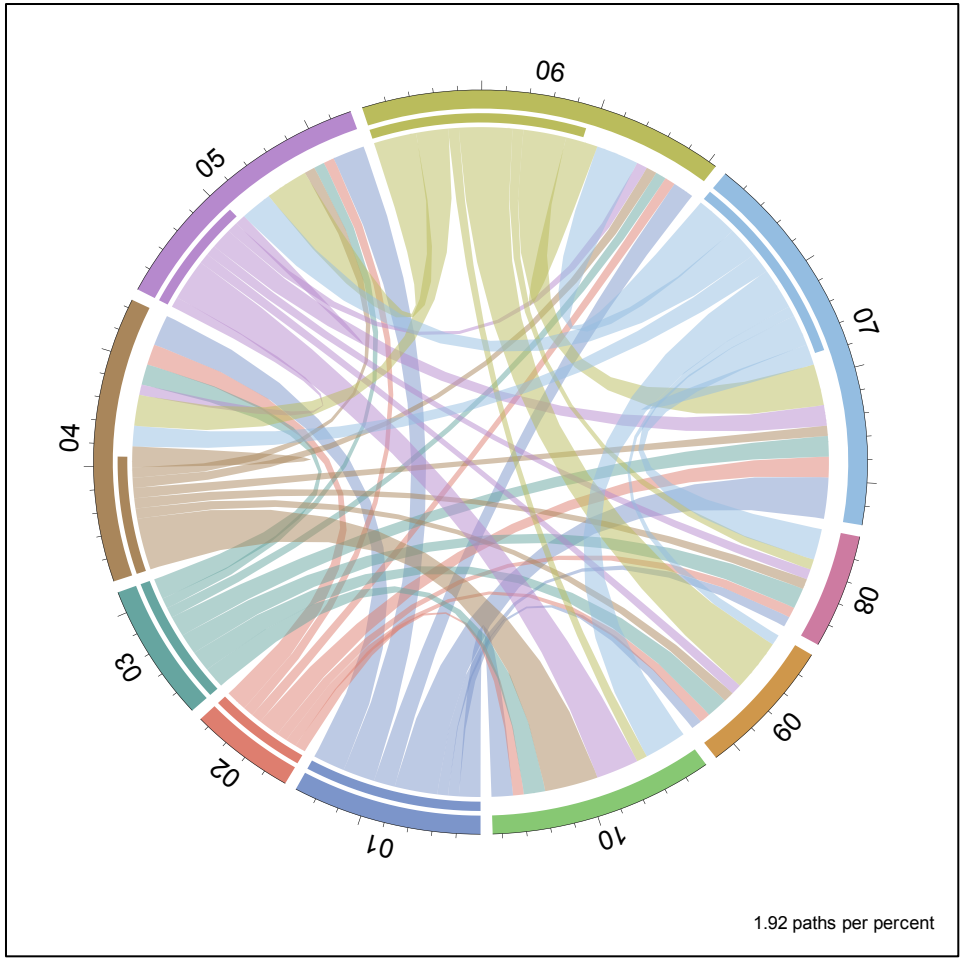
Section 1:
What is a CIRCOS Graph?

CIRCOS Graph

- Visual depiction of connections between groups
- Commonly used in genomics
- Four main components
  - Outer Circle (OC)
  - Inner Circle (IC)
  - Bezier Curves (BC)
  - Axes/Labels



Outer Circle

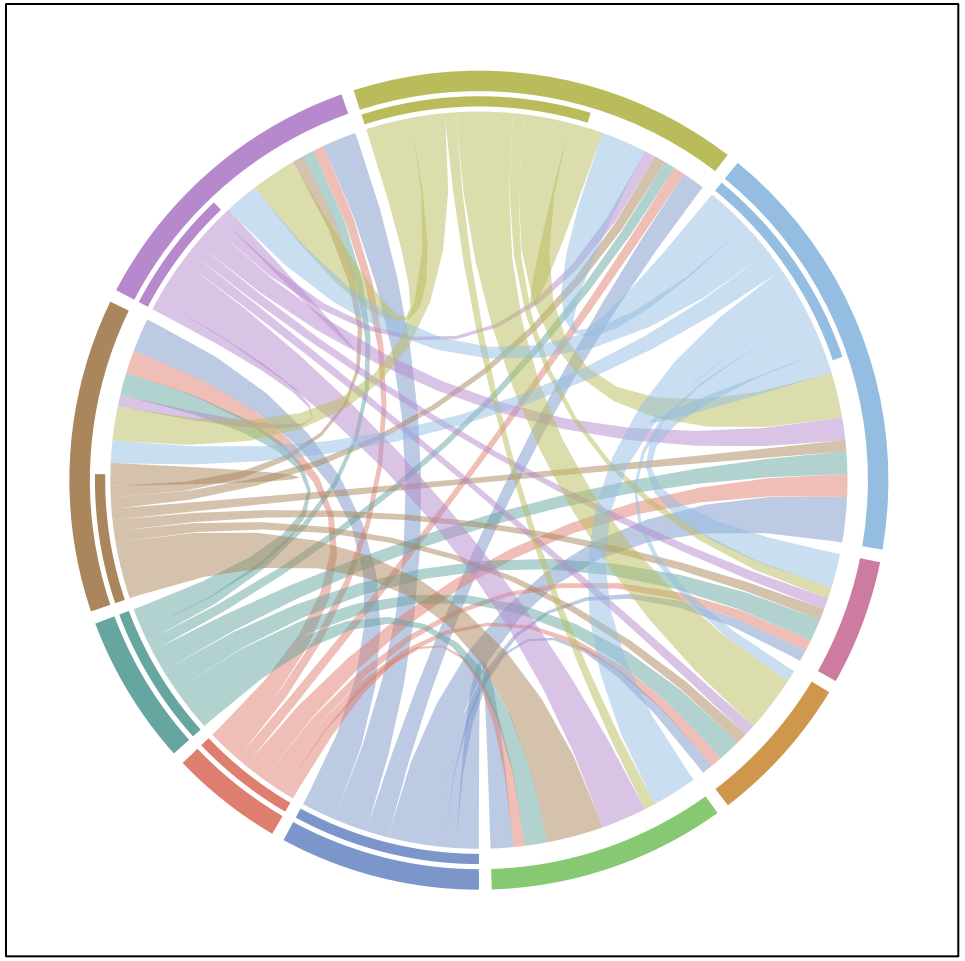
- Length of rectangle proportionate to sample size

Inner Circle

- Length of rectangles is proportionate to the number of paths leaving group

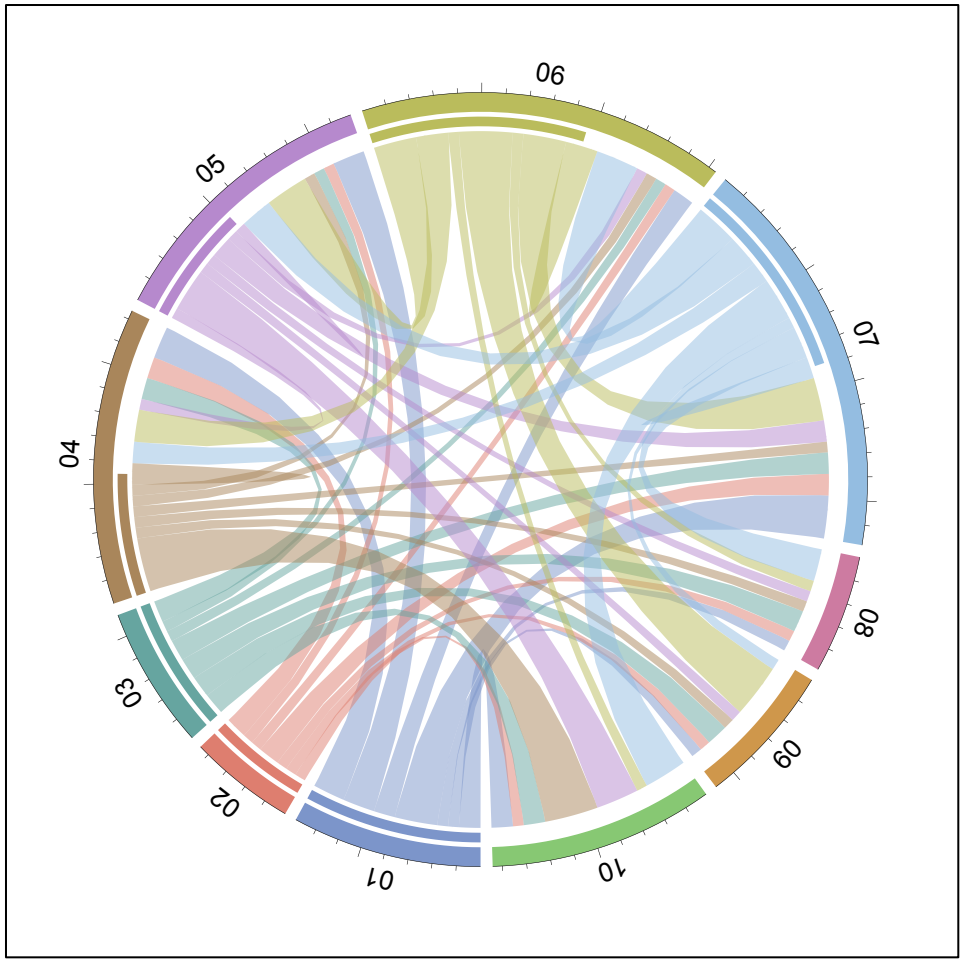
Bezier Curves

- Connects one group to another
- Width of each end is different
- Color is the same as the group the Bezier curve is leaving
- Curves are “pulled” towards the center of the circle



Axes and Labels

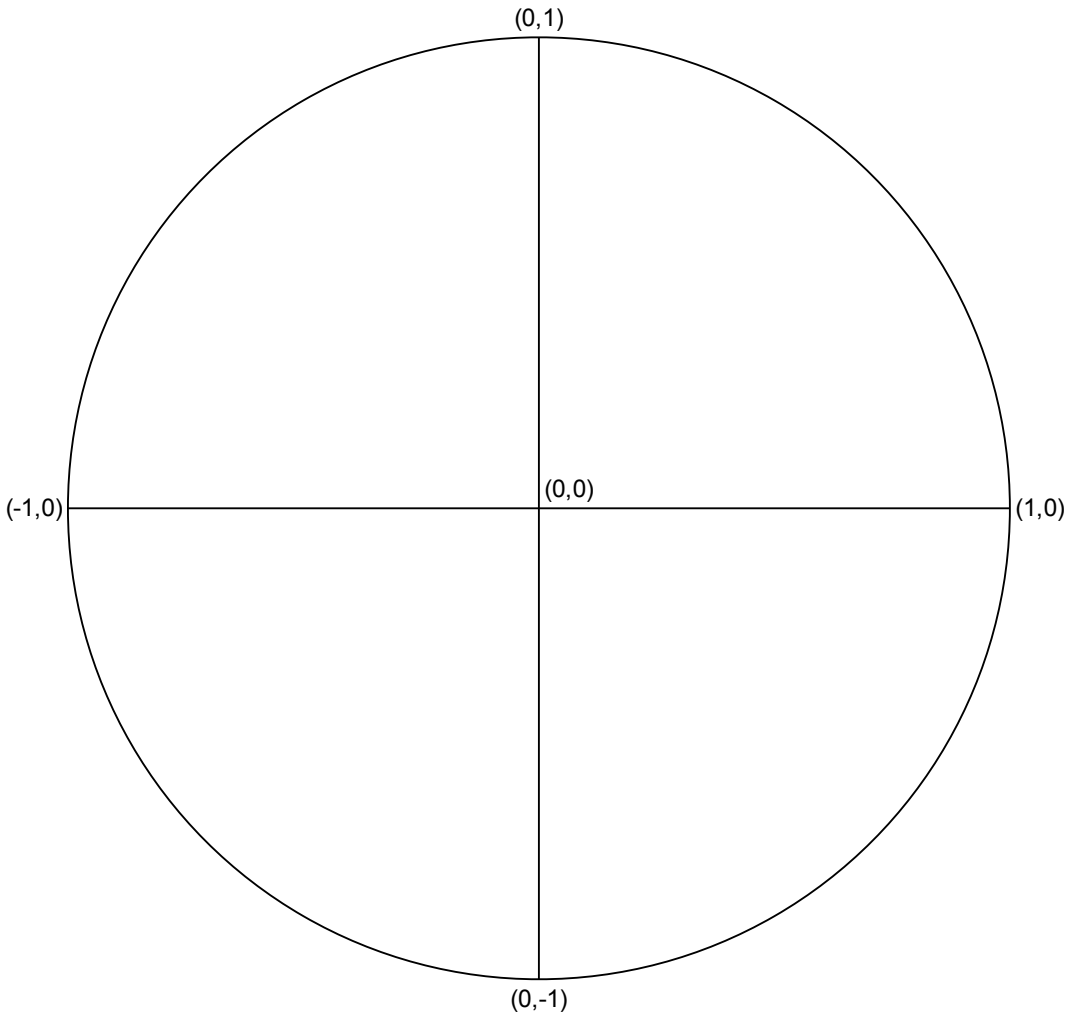
- Axes have major and minor tick marks
  - Major tick marks represent 5% intervals
  - Minor tick marks represent 1% intervals
- Labels are rotated to face the center



Section 2: Methods

Unit Circle

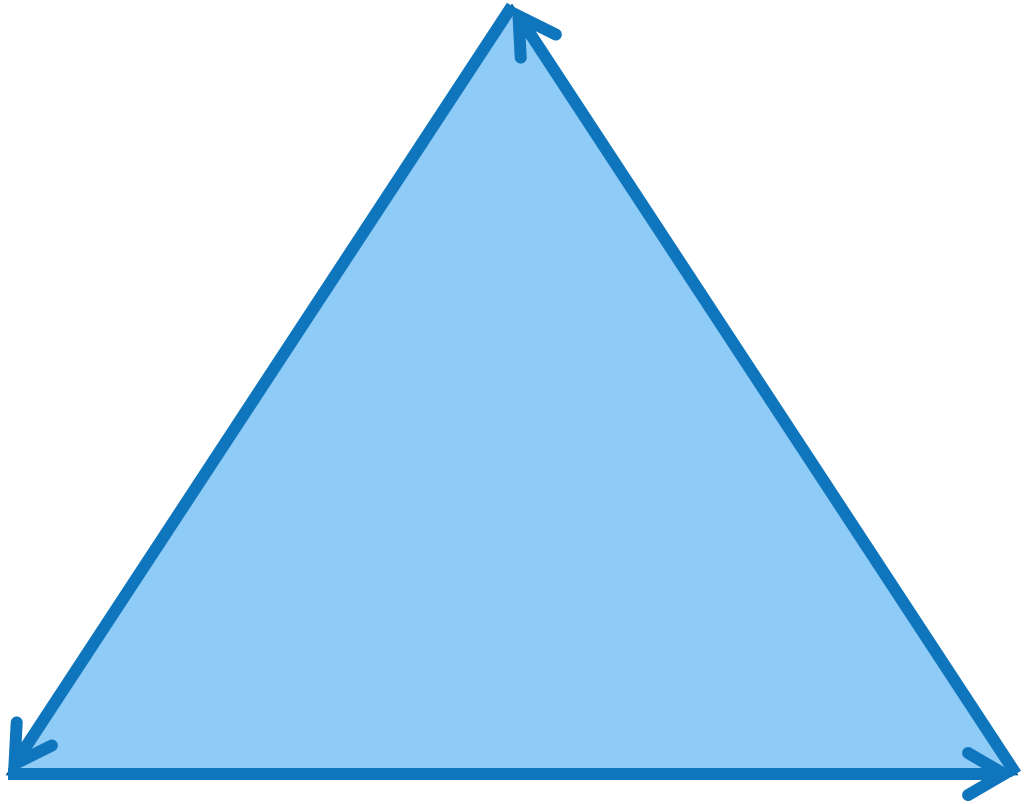
- Circle of Radius 1 centered on the (0, 0) coordinates
- Easy to calculate distances with SINE and COSINE functions
- Full rotation around the circle is 360° or 2π radians
  - Positive x-axis used as reference



Polygon Plot

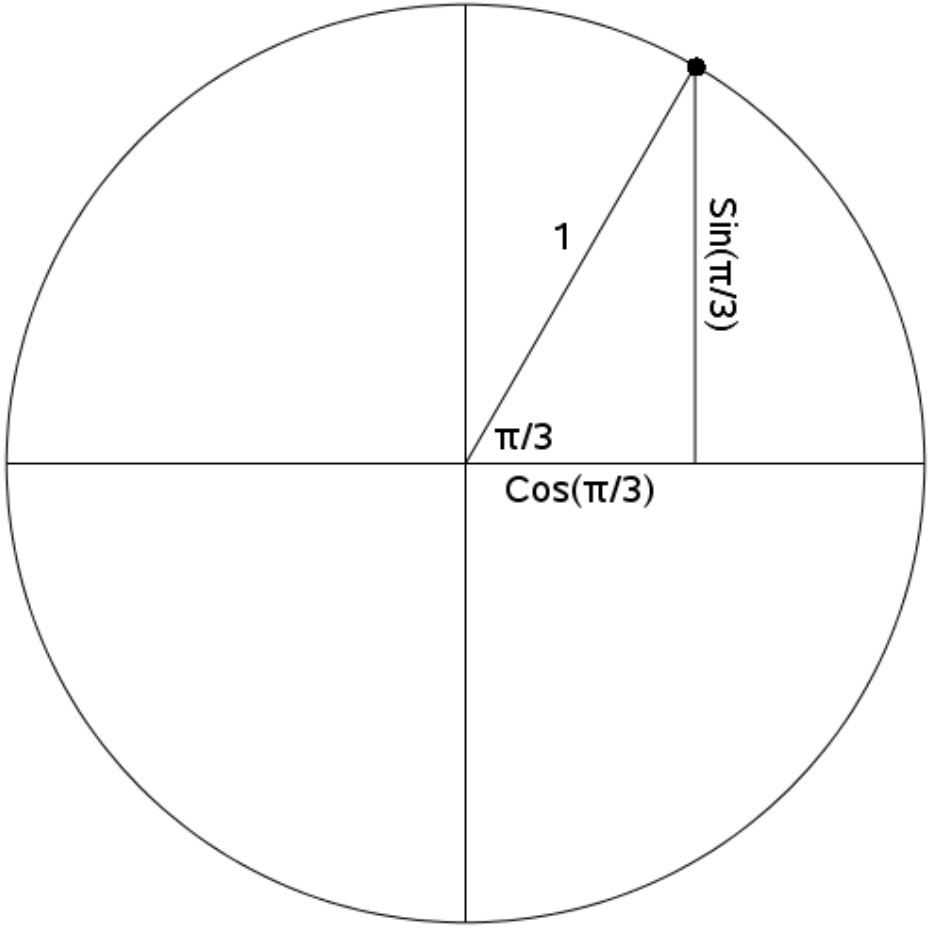
- polygonplot x=x y=y id=id;

- X: x-coordinate
- Y: y-coordinate
- ID: distinguish unique objects



Trigonometry Functions

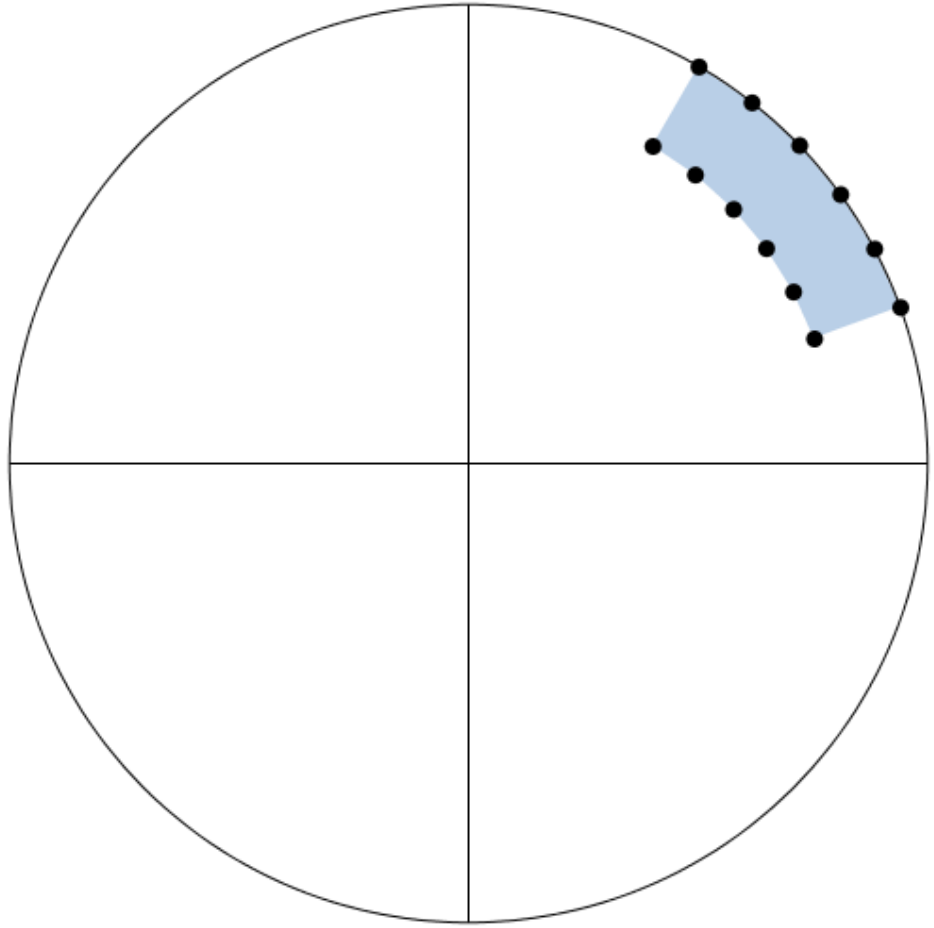
- X = d * cos(θ)
- Y = d * sin(θ)



Drawing a Curved Rectangle

```
/*Draw Outside of Rectangle*/
do i = π/3 to π/9 by (π/9- π/3)/5;
      x=1*cos(i); y=1*sin(i);output;
   end;


/*Draw Inside of Rectangle*/
do i = π/9 to π/3 by (π/3- π/9)/5;
      x=0.8*cos(i);y=0.8*sin(i);output;
   end;
```



Drawing a Bezier Curve

Quadratic Bezier formula:

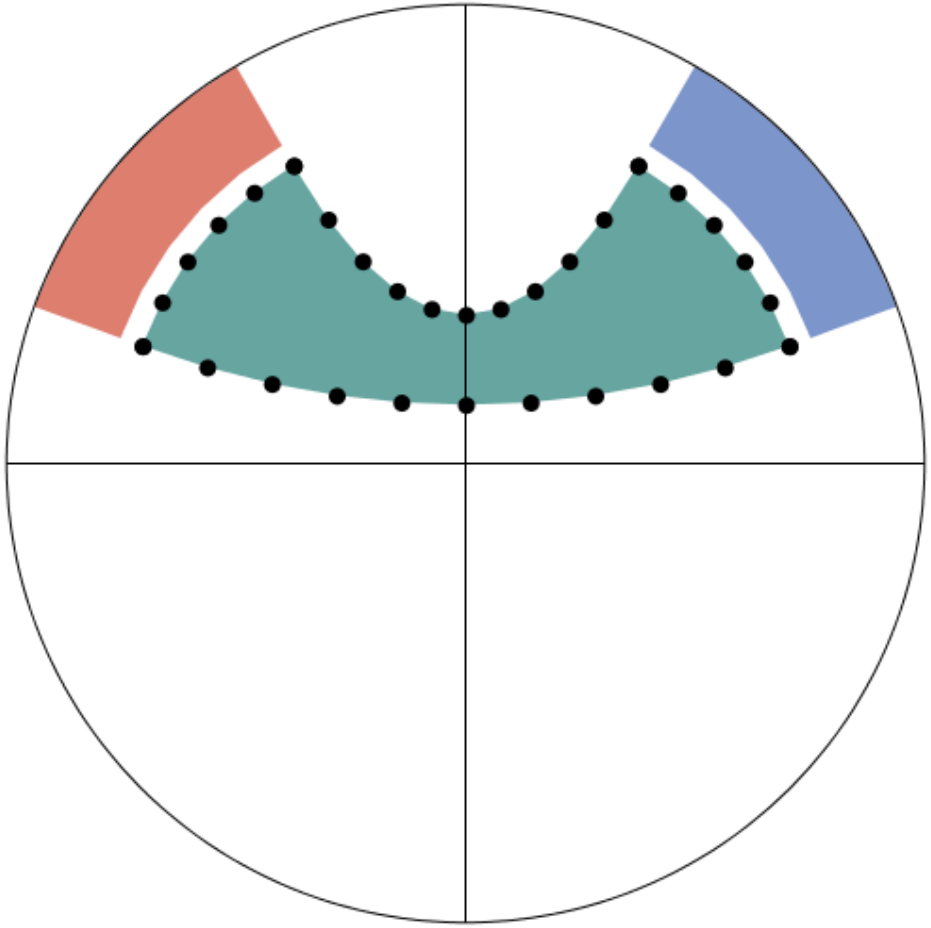
$$\mathbf{B}(t) = (1-t)^2\mathbf{P}_0 + 2(1-t)t\mathbf{P}_1 + t^2\mathbf{P}_2,\ 0 \le t \le 1$$

Connects three points: P_0, P_1, P_2

P_1 is always the center (0, 0) which reduces the equation to:

$$\mathbf{B}(t) = (1-t)^2\mathbf{P}_0 + t^2\mathbf{P}_2,\ 0 \le t \le 1$$

```
do t = 0 to 1 by 1/10;
   x=(1-t)**2*0.75*cos(π*2/3)+t**2*0.75*cos(π*1/3);
   y=(1-t)**2*0.75*sin(π*2/3)+ t**2*0.75*sin(π*1/3);
   output;
end;
```



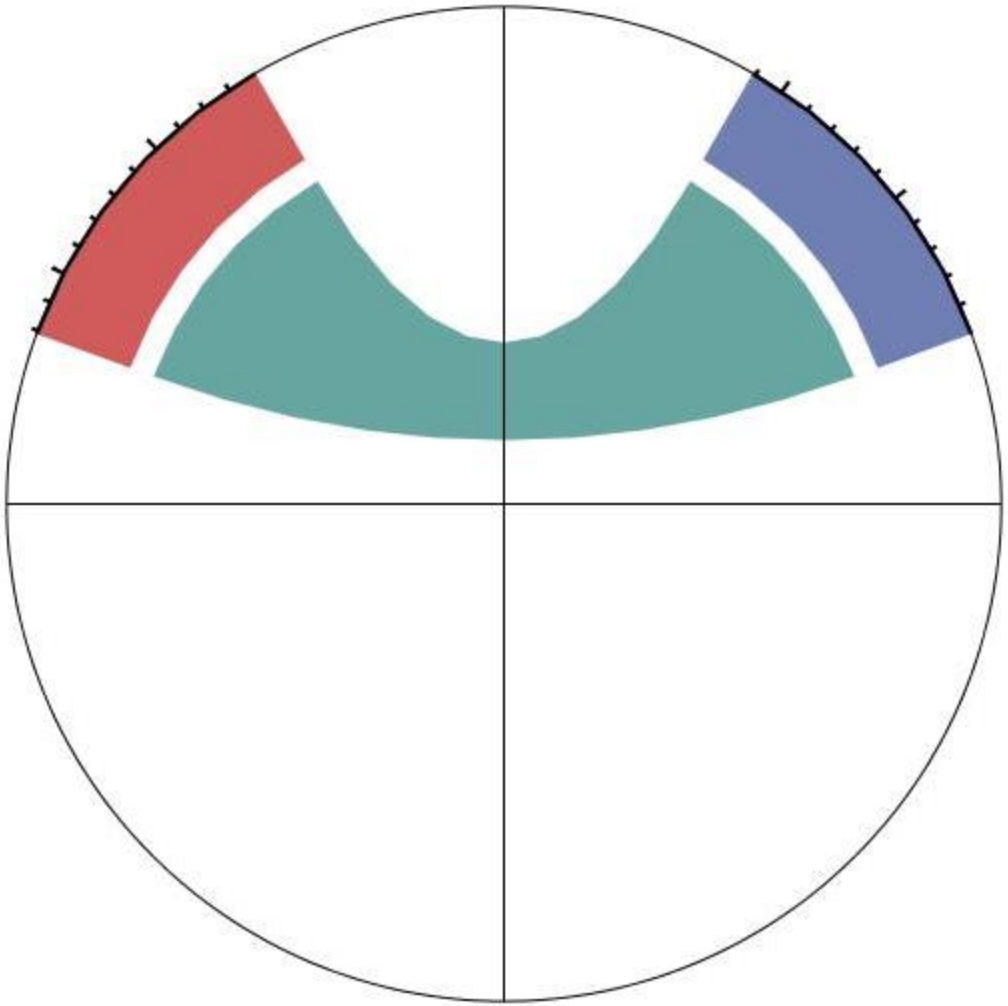
Drawing a Curved Axis

- Axis line
  - Uses curved rectangles outer edge
  - Drawn with a SERIESPLOT statement

```
seriesplot x=eval(ifn(axis=1,x,.)) y=y / group=id;
```

- Tick marks
  - Drawn with SERIESPLOT statement
  - GROUP option distinguishes between ticks

```
seriesplot x=xtick y=ytick / group=tick;
```

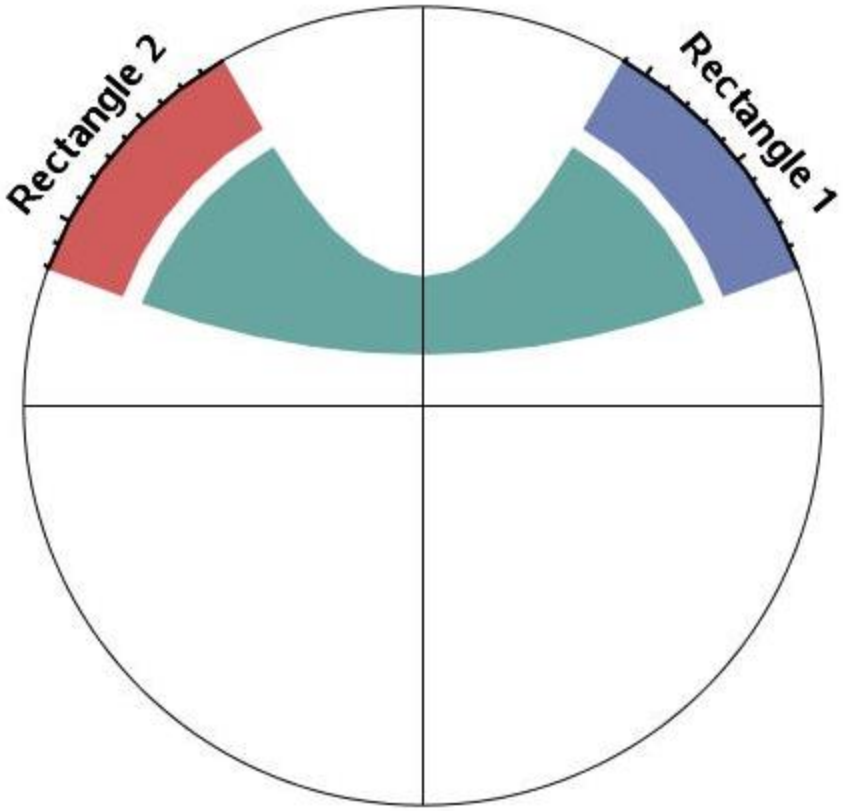


Drawing Rotated Labels

- Labels are drawn with TEXTPLOT
- Rotated to face the center of the circle

```
xlab=1.1*cos(π*2/9);
ylab=1.1*sin(π*2/9);
rotate=0-arcos(ylab/1.1)*360/(2π);
text='Rectangle 1';

textplot text=text x=xlab y=ylab / rotate=rotate;
```



Section 3: Examples

%CIRCOS Macro Call

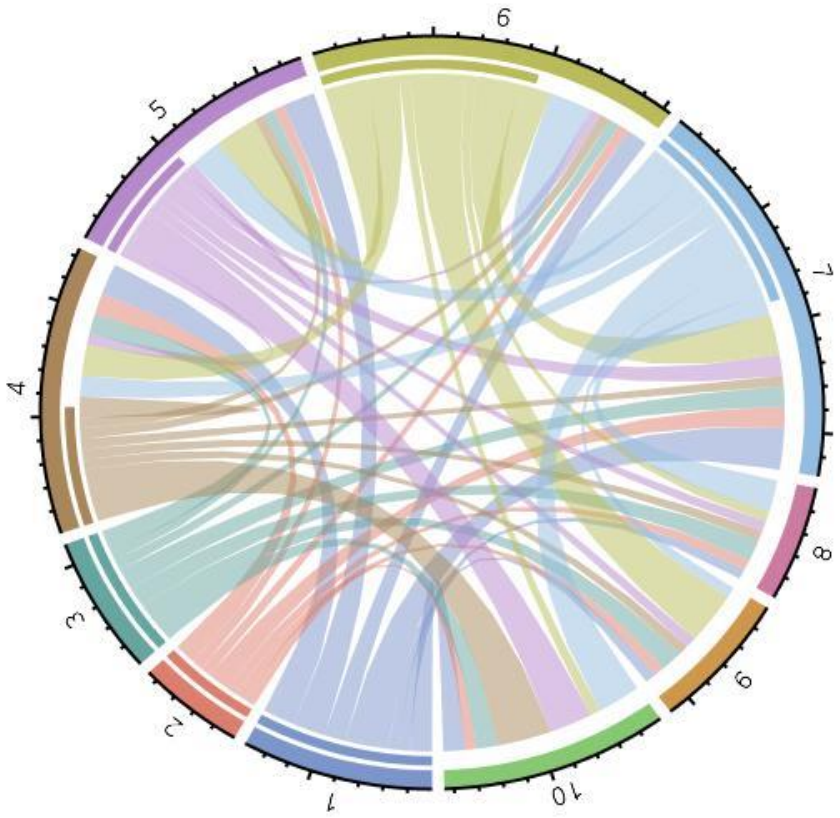
- Required Parameters:
  - DATA: Input dataset
  - BEFORE: Starting Group
  - AFTER: Ending Group

- Image Options
  - Image height and width
  - Image type and name
  - Antialiasing and transparency
  - Document type
  - DPI

- Appearance Options
  - GROUPGAP: Gap between rectangles
  - BARWIDTH: Width of rectangles
  - INNERGAP: Gap between IC and OC
  - START: Starting point on the unit circle
  - DIRECTION: Which way the rectangles rotate
  - POINTS: How many points draw each side of the rectangles
  - Font sizes, colors, weights
  - Order of groups
  - Color of groups

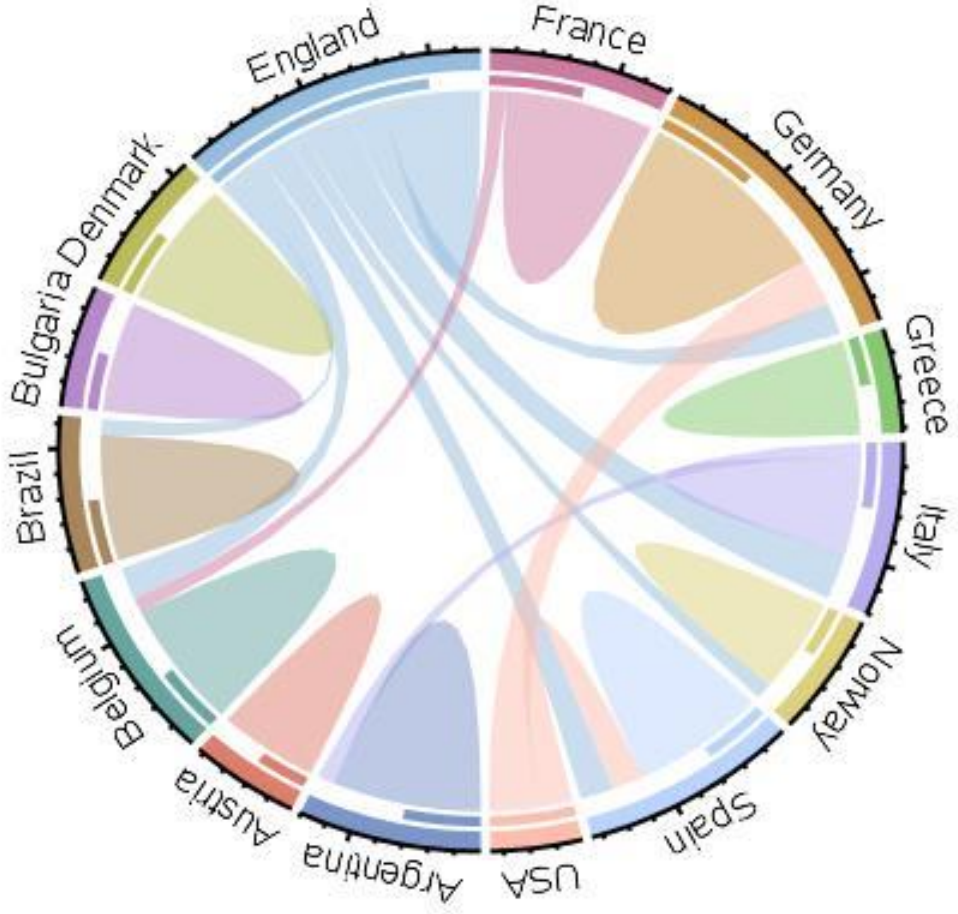
%CIRCOS Example

```
data random;
    call streaminit(123);
    do i = 1 to 100;
        u = rand("Uniform");
        u2 = rand("Uniform");
        before = 1 + floor(7*u);
        after = 4 + floor(7*u2);
        output;
    end;
run;
%CIRCOS(DATA=random,
       BEFORE=before, AFTER=after);
```



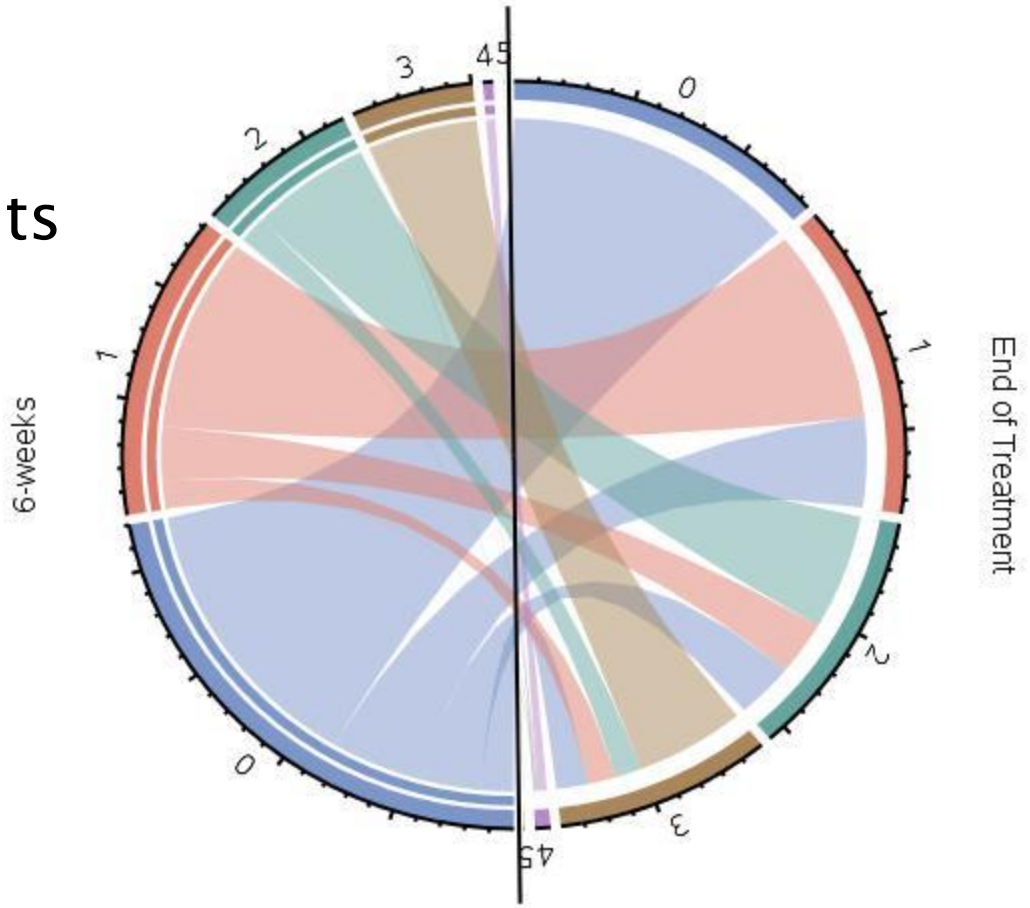
Soccer Players Changing Teams

- 10-27-2016 Graphically Speaking
- Example dataset by Sanjay Matange
- Shows Soccer players changing teams within certain regions



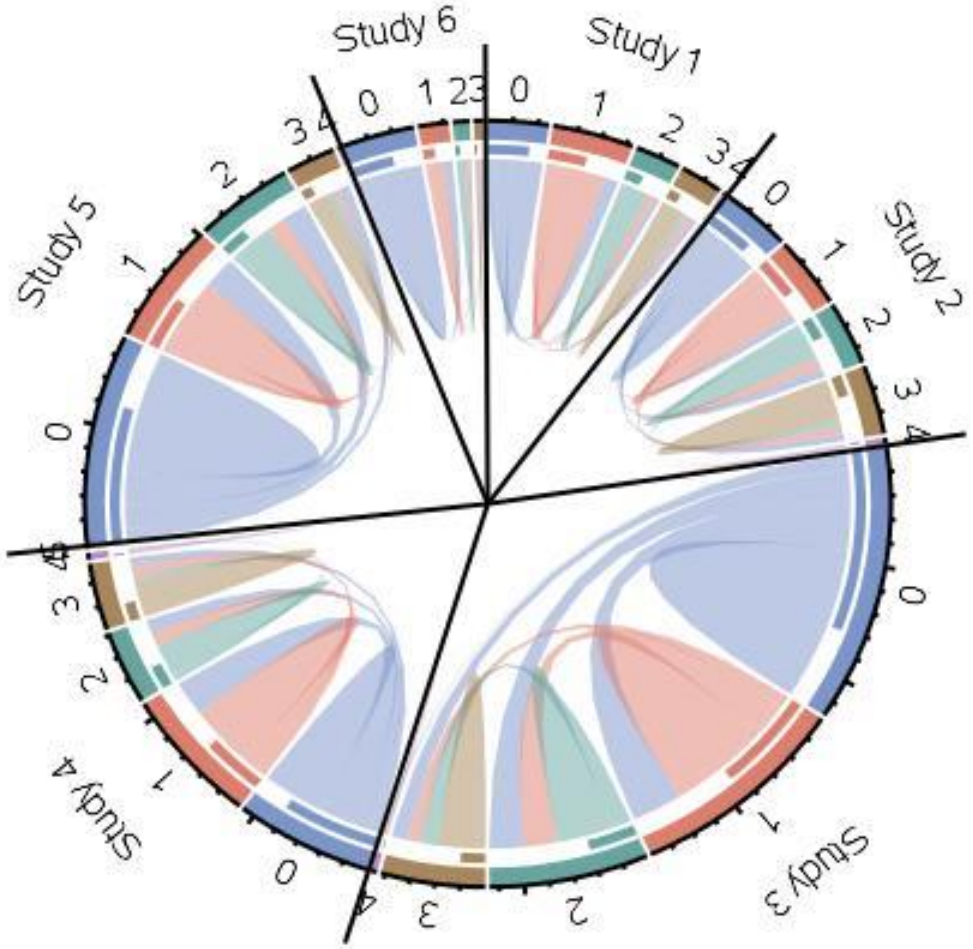
Comparing AE Grades Between Time-points

- Maximum grade AE for diarrhea at 6-weeks and at the end of treatment
- See distributions at these time-points
- See where patients at each grade finish at the end of study



Comparing AE Grades Between Time-points by Study

- Paths can be placed into subgroups such as study or arm
- Colors can be unique to groups or allow the same levels to be the same color
- Sections of the circle are sized by each subgroups proportion



Conclusion

- Generating circular plots is possible with trigonometry functions
  - Current methods are highly inefficient
  - Would be improved with the addition of a polar axis type

- CIRCOS plots are a powerful visual tool
  - Not meant to be quantitative
  - Versatile to situations outside of genomics

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