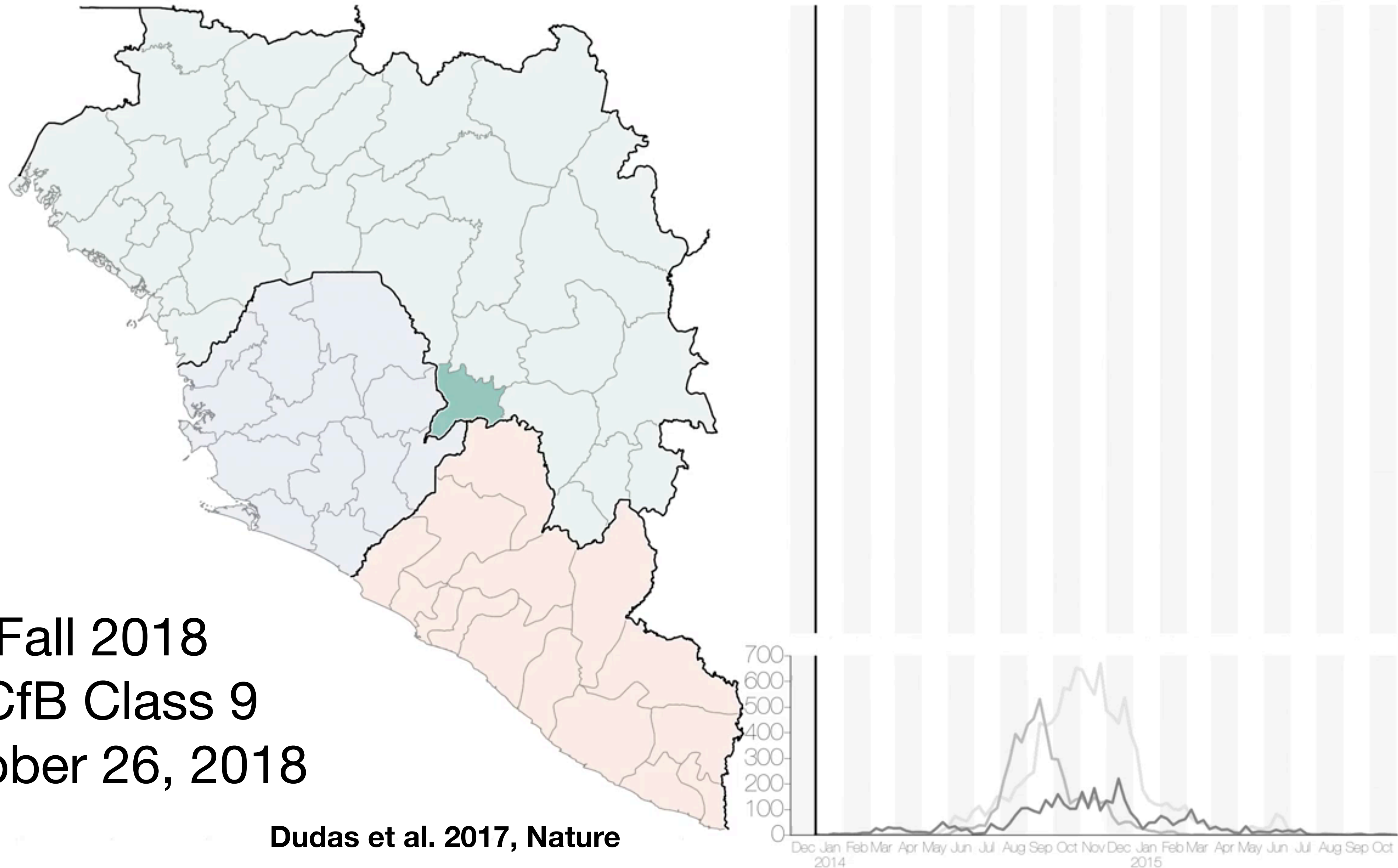


# Making figures with Python

Fall 2018  
PCfB Class 9  
October 26, 2018

Dudas et al. 2017, Nature



# Objectives

- Benefits of Python for figures
- Intro to Matplotlib module

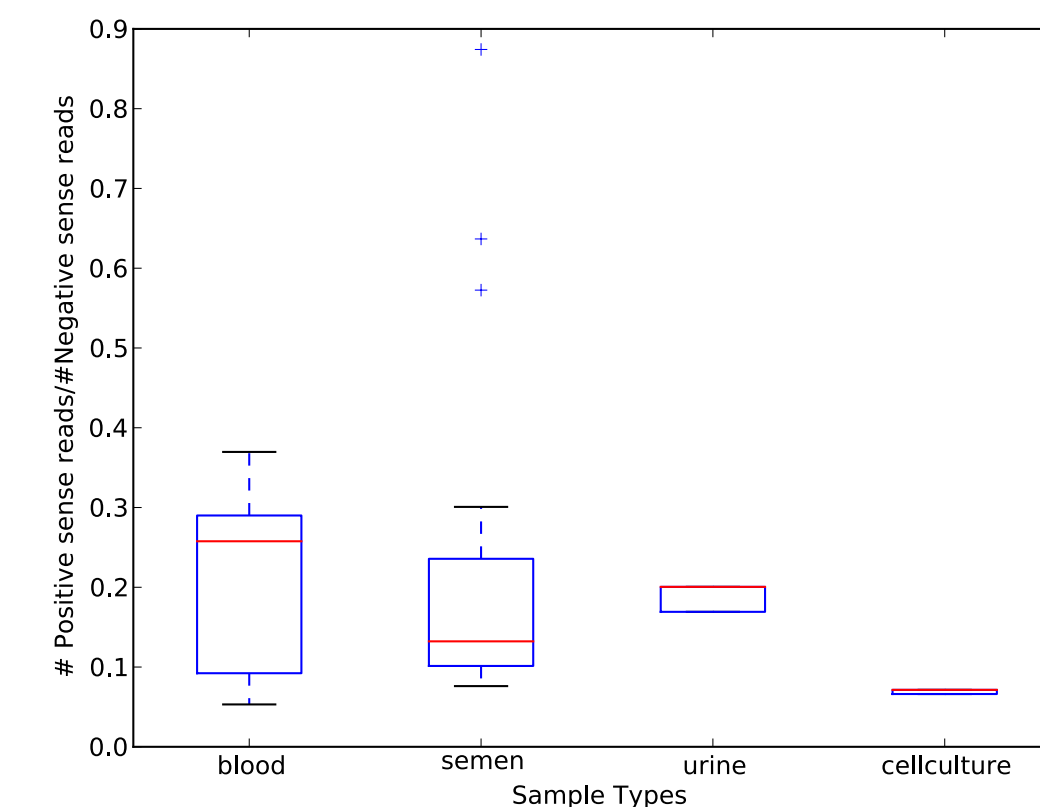
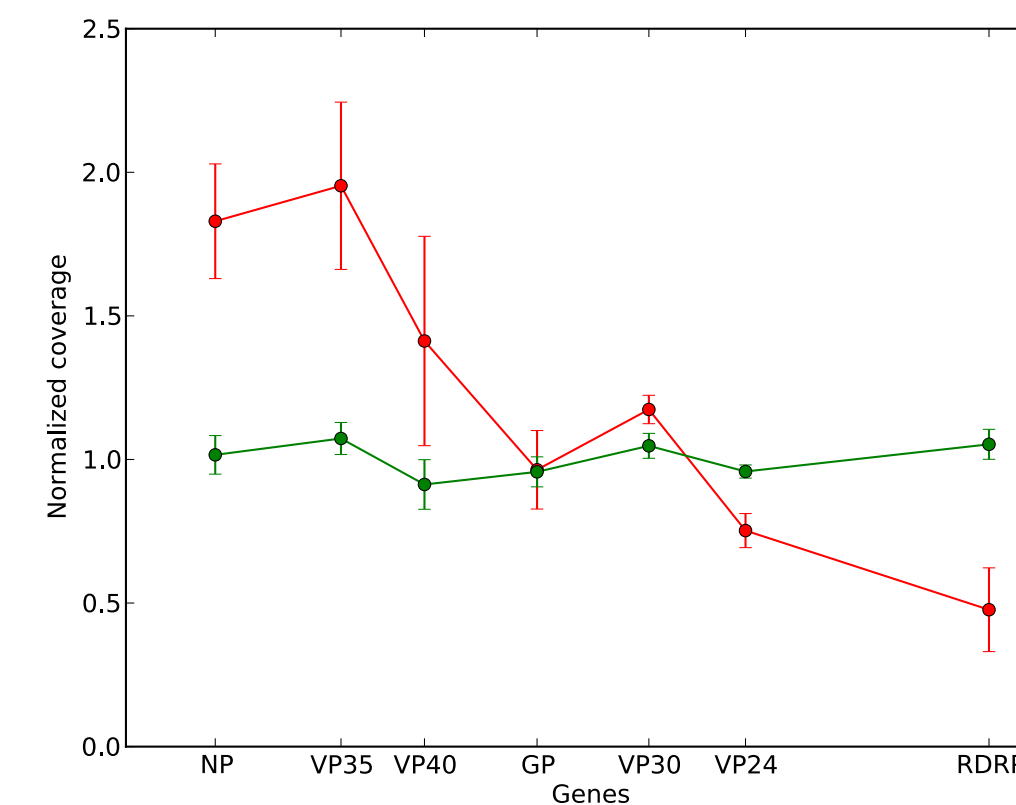
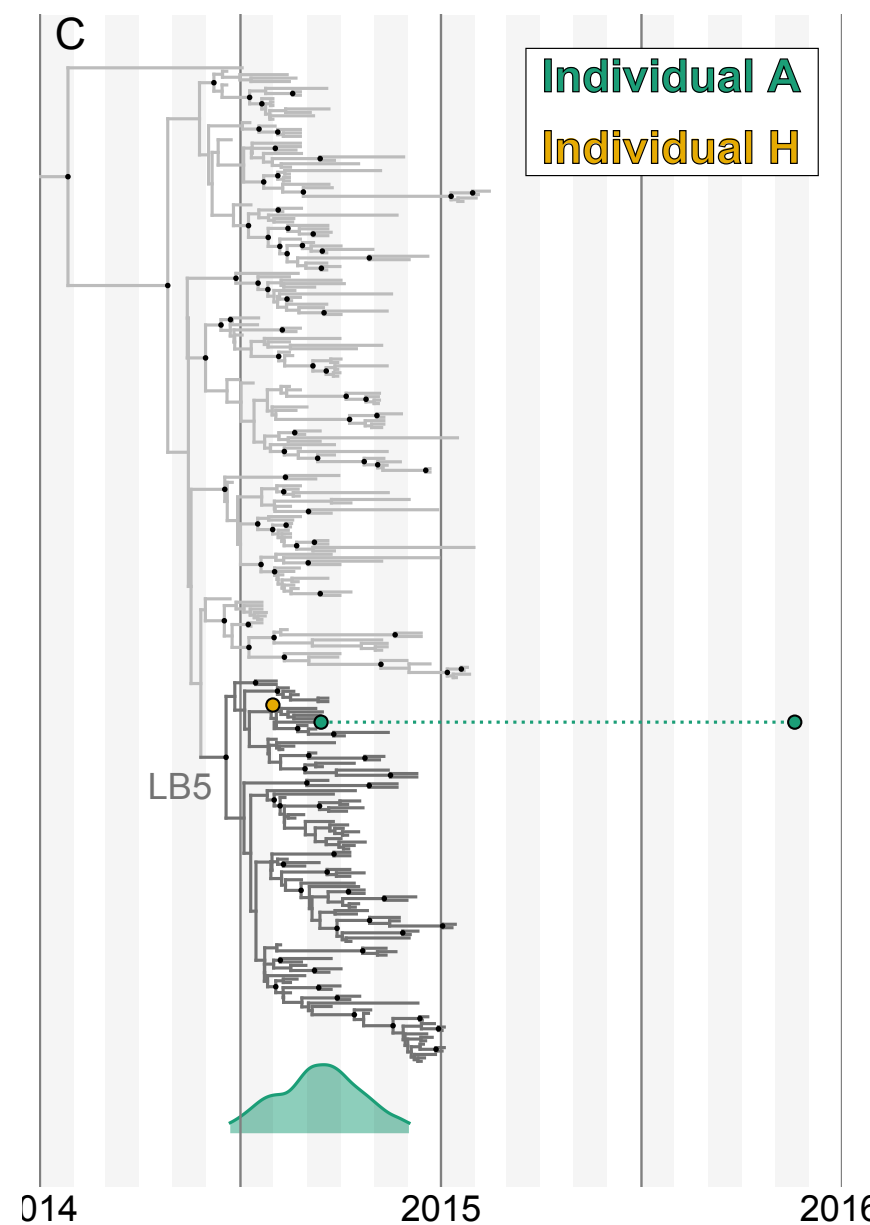
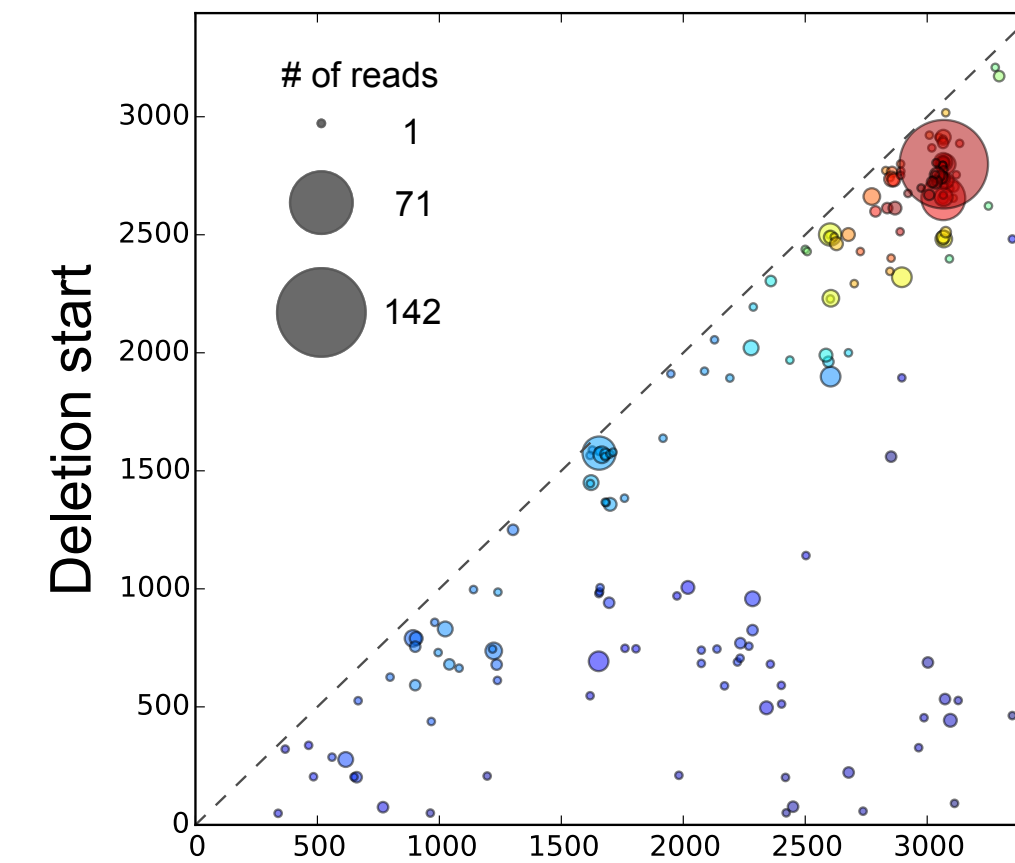
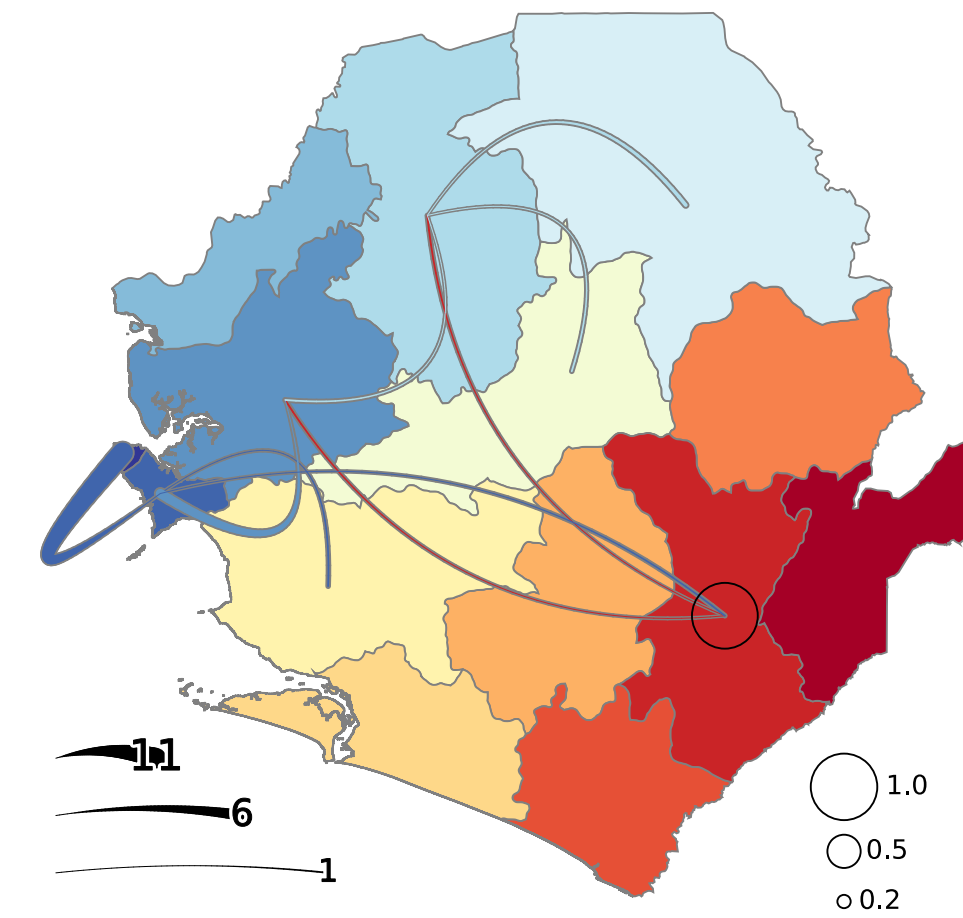
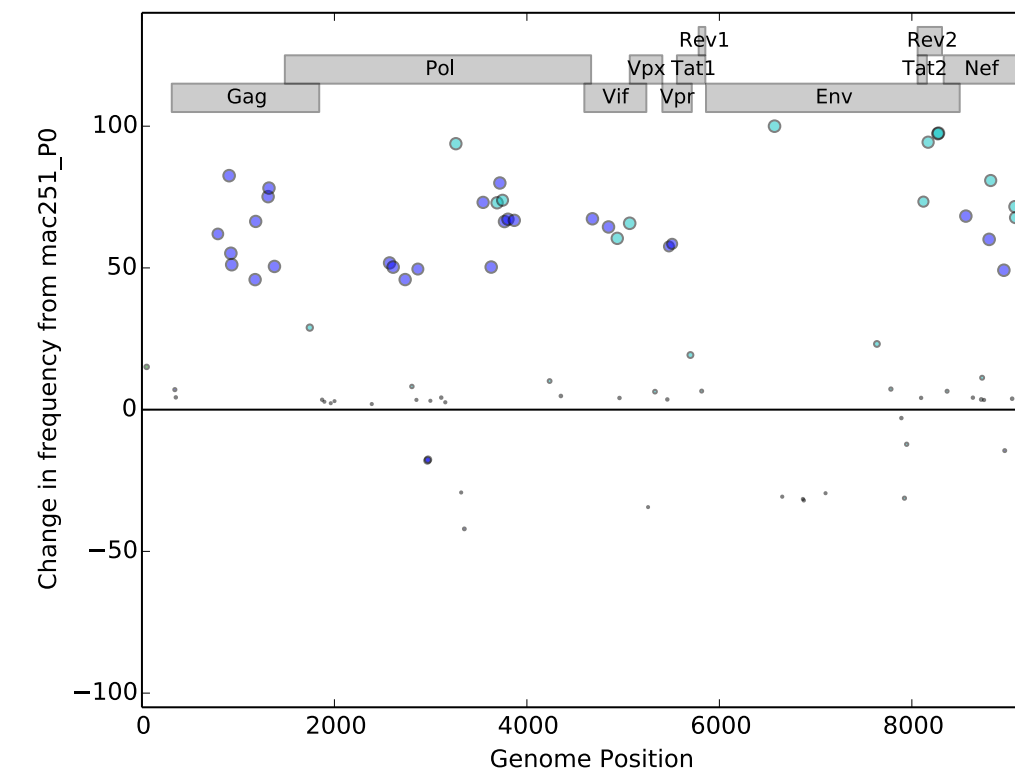
# Why use Python?

- Highly customizable
- Automated, easy to rerun
- Integrate into analysis
- Open science compatible



- Powerful plotting module

- Preloaded in Anaconda installations



# Using Matplotlib

- `import matplotlib.pyplot as plt`
- Each command adds/modify plot
- Recommended ways to use Matplotlib:
  - Stand-alone scripts
  - Jupyter notebook

# Plot Objects

- **Figure objects**
  - Top-level container for plot elements
  - Can contain multiple Axes objects (i.e. plots)
- **Axes objects**
  - One per graph/plot
  - Contains most figure elements

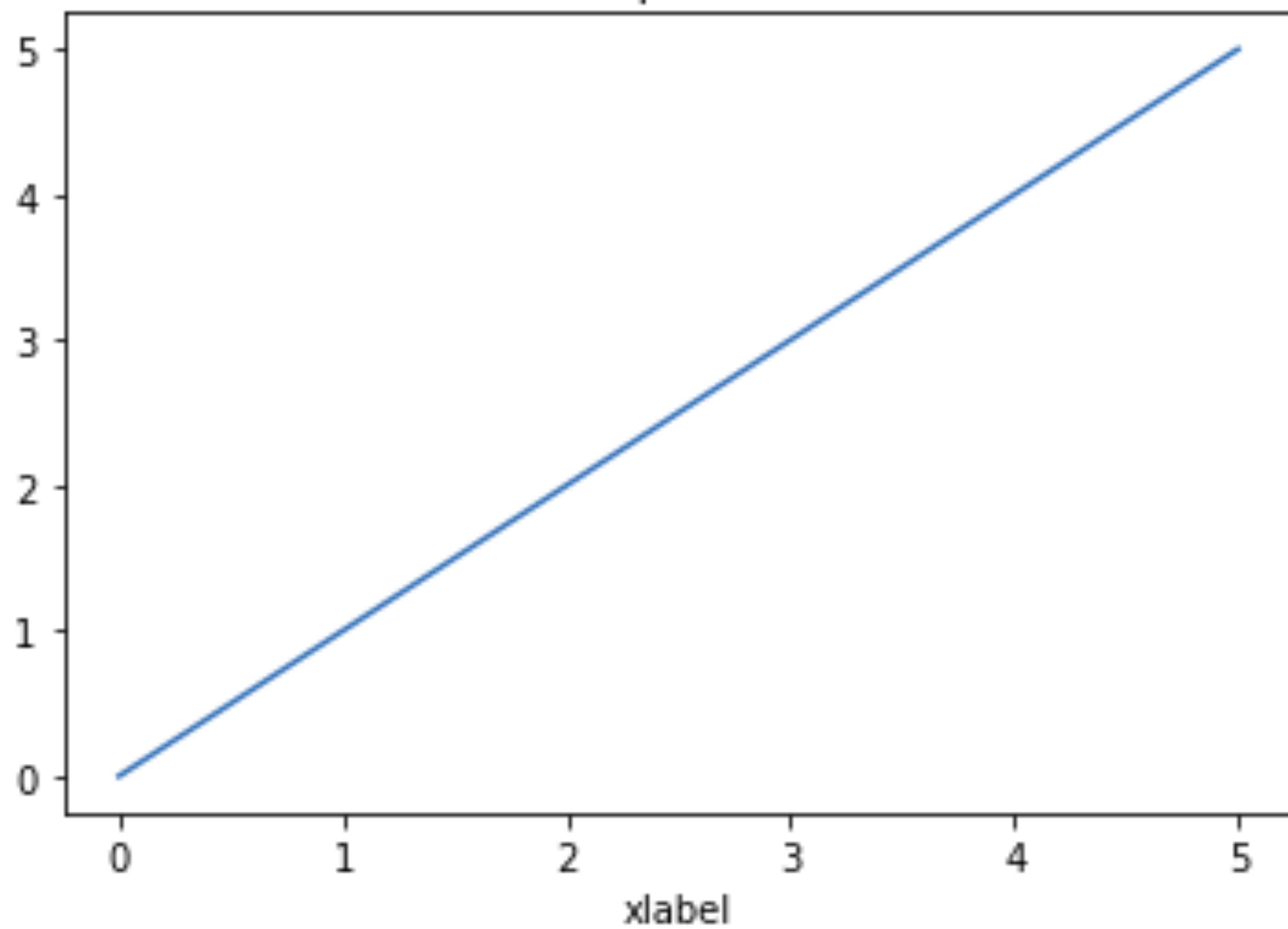
# Two approaches

## state-machine interface

```
plt.plot([0,5], [0,5])  
plt.xlabel('xlabel')  
plt.title('Simple Plot')
```



Simple Plot





# Two approaches

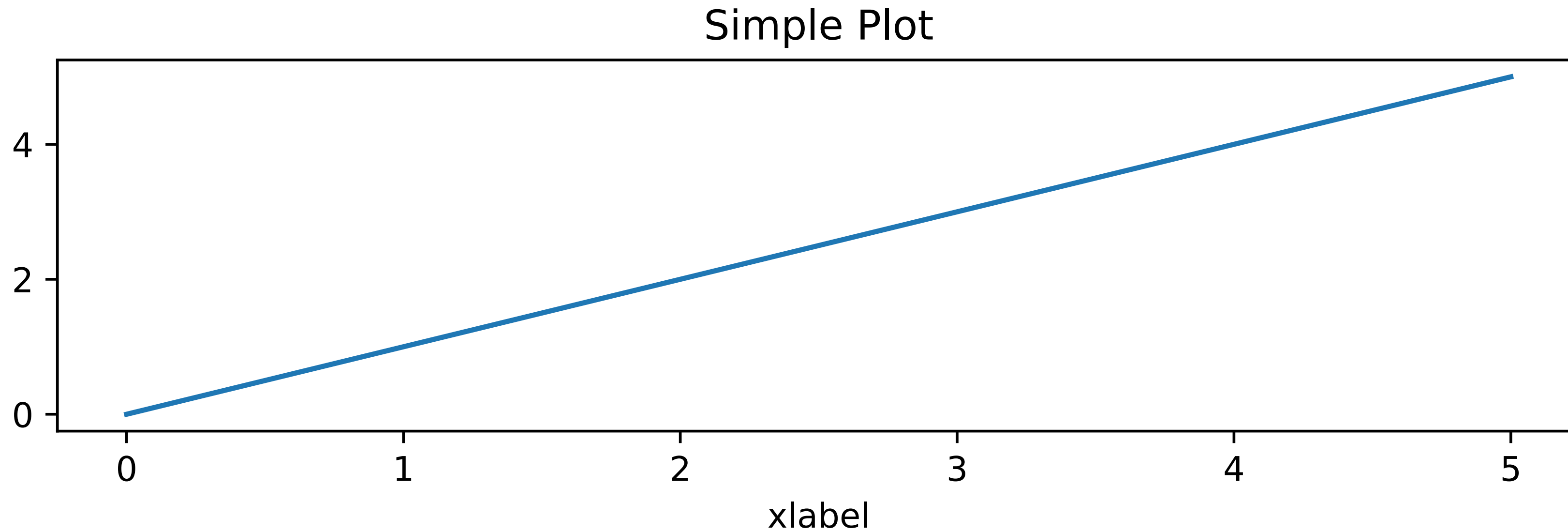
## state-machine interface

```
plt.plot([0,5], [0,5])  
plt.xlabel('xlabel')  
plt.title('Simple Plot')
```

## object-oriented approach

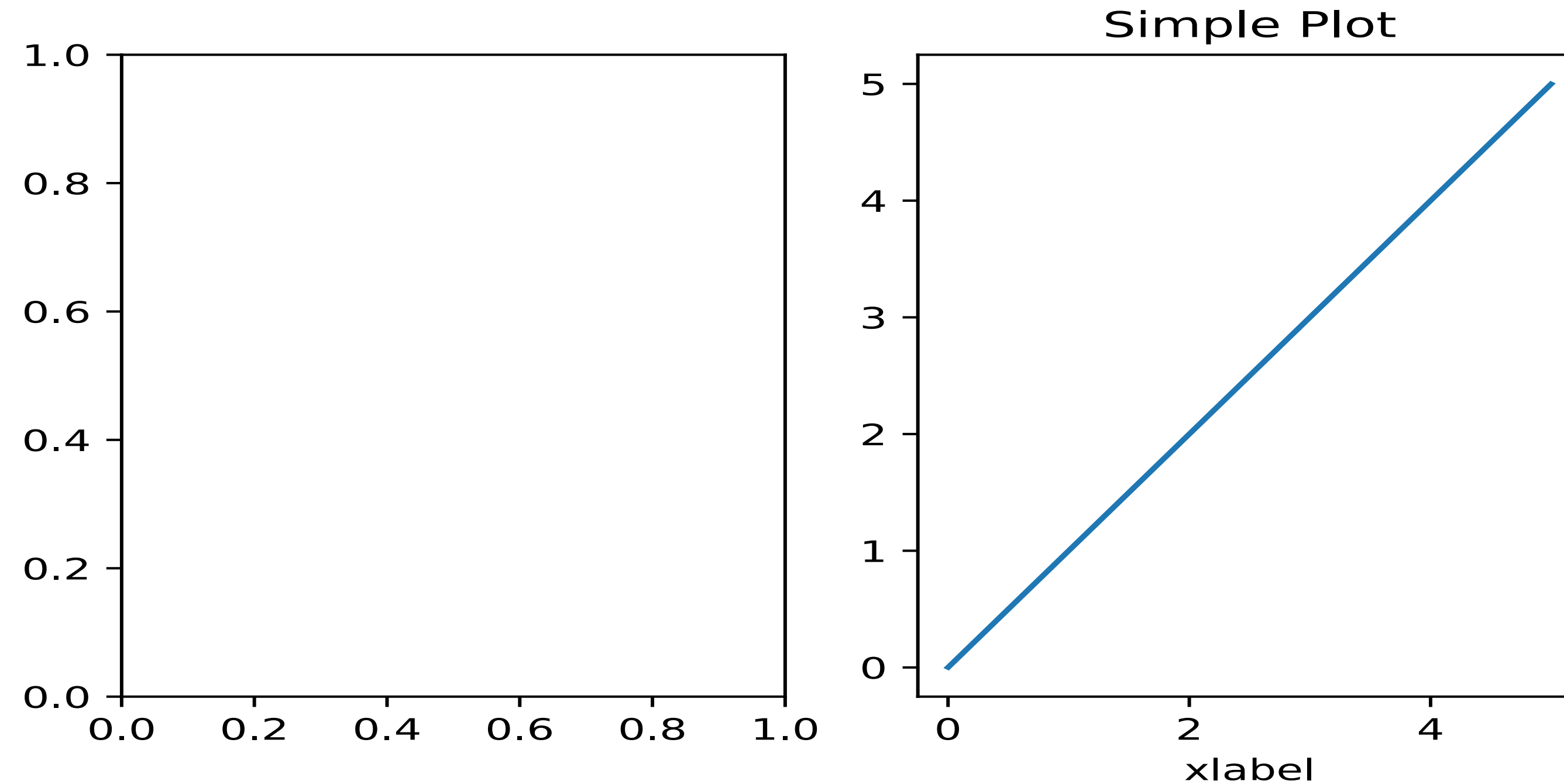
```
fig, ax = plt.subplots()  
ax.plot([0,5], [0,5])  
ax.set_xlabel('xlabel')  
ax.set_title('Simple Plot')
```

# Control figure size



```
fig, ax = plt.subplots(figsize=(8,2))  
    ax.plot([0,5], [0,5])  
    ax.set_xlabel('xlabel')  
    ax.set_title('Simple Plot')
```

# Multiple axes per figure



```
fig, axes = plt.subplots(1, 2)
    axes[1].plot([0, 5], [0, 5])
    axes[1].set_xlabel('xlabel')
axes[1].set_title('Simple Plot')
```

# Axes object methods

```
['acorr', 'add_artist', 'add_callback', 'add_collection', 'add_container', 'add_line', 'add_patch', 'add_table', 'aname', 'annotate', 'apply_aspect', 'arrow', 'artists',
'autoscale', 'autoscale_view', 'axes', 'axesPatch', 'axhline', 'axhspan', 'axis', 'axison', 'axvline', 'axvspan', 'bar', 'barbs', 'barh', 'bbox', 'boxplot', 'broken_barh',
'callbacks', 'can_pan', 'can_zoom', 'change_geometry', 'cla', 'clabel', 'clear', 'clipboard', 'cohere', 'colNum', 'collections', 'containers', 'contains', 'contains_point',
'contour', 'contourf', 'convert_xunits', 'convert_yunits', 'csd', 'dataLim', 'drag_pan', 'draw', 'draw_artist', 'end_pan', 'errorbar', 'eventplot', 'eventson', 'figbox',
'figure', 'fill', 'fill_between', 'fill_betweenx', 'findobj', 'fmt_xdata', 'fmt_ydata', 'format_coord', 'format_xdata', 'format_ydata', 'get_adjustable', 'get_agg_filter',
'get_alpha', 'get_anchor', 'get_animated', 'get_aspect', 'get_autoscale_on', 'get_autoscalex_on', 'get_autoscaley_on', 'get_axes', 'get_axes_locator',
'get_axis_bgcolor', 'get_axisbelow', 'get_children', 'get_clip_box', 'get_clip_on', 'get_clip_path', 'get_contains', 'get_cursor_props', 'get_data_ratio',
'get_data_ratio_log', 'get_default_bbox_extra_artists', 'get_figure', 'get_frame_on', 'get_geometry', 'get_gid', 'get_images', 'get_label', 'get_legend',
'get_legend_handles_labels', 'get_lines', 'get_navigate', 'get_navigate_mode', 'get_path_effects', 'get_picker', 'get_position', 'get_rasterization_zorder',
'get_rasterized', 'get_renderer_cache', 'get_shared_x_axes', 'get_shared_y_axes', 'get_sketch_params', 'get_snap', 'get_subplotspec', 'get_tightbbox', 'get_title',
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'invert_xaxis', 'invert_yaxis', 'is_figure_set', 'is_first_col', 'is_first_row', 'is_last_col', 'is_last_row', 'is_transform_set', 'ishold', 'label_outer', 'legend', 'legend_',
'lines', 'locator_params', 'loglog', 'margins', 'matshow', 'minorticks_off', 'minorticks_on', 'name', 'numCols', 'numRows', 'patch', 'patches', 'pchanged', 'pcolor',
'pcolorfast', 'pcolormesh', 'pick', 'pickable', 'pie', 'plot', 'plot_date', 'properties', 'psd', 'quiver', 'quiverkey', 'redraw_in_frame', 'relim', 'remove',
'remove_callback', 'reset_position', 'rowNum', 'scatter', 'semilogx', 'semilogy', 'set', 'set_adjustable', 'set_agg_filter', 'set_alpha', 'set_anchor', 'set_animated',
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'update_datalim_bounds', 'update_datalim_numerix', 'update_from', 'update_params', 'viewLim', 'vlines', 'xaxis', 'xaxis_date', 'xaxis_inverted', 'xcorr', 'yaxis',
'yaxis_date', 'yaxis_inverted', 'zorder']
```

# Great potential for customization

['acorr', 'add\_artist', 'add\_callback', 'add\_collection', 'add\_container', 'add\_line', 'add\_patch', 'add\_table', 'aname', 'annotate', 'apply\_aspect', 'arrow', 'artists', 'autoscale', 'autoscale\_view', 'axes', 'axesPatch', 'axhline', 'axhspan', 'axis', 'axison', 'axvline', 'axvspan', 'bar', 'barbs', 'barh', 'bbox', 'boxplot', 'broken\_barh', 'callbacks', 'can\_pan', 'can\_zoom', 'change\_geometry', 'cla', 'clabel', 'clear', 'clipboard', 'cohere', 'colNum', 'collections', 'containers', 'contains', 'contains\_point', 'contour', 'contourf', 'convert\_xunits', 'convert\_yunits', 'csd', 'dataLim', 'drag\_pan', 'draw', 'draw\_artist', 'end\_pan', 'errorbar', 'eventplot', 'eventson', 'figbox', 'figure', 'fill', 'fill\_between', 'fill\_betweenx', 'findobj', 'fmt\_xdata', 'fmt\_ydata', 'format\_coord', 'format\_xdata', 'format\_ydata', 'get\_adjustable', 'get\_agg\_filter', 'get\_alpha', 'get\_anchor', 'get\_animated', 'get\_aspect', 'get\_autoscale\_on', 'get\_autoscalex\_on', 'get\_autoscaley\_on', 'get\_axes', 'get\_axes\_locator', 'get\_axis\_bgcolor', 'get\_axisbelow', 'get\_children', 'get\_clip\_box', 'get\_clip\_on', 'get\_clip\_path', 'get\_contains', 'get\_cursor\_props', 'get\_data\_ratio', 'get\_data\_ratio\_log', 'get\_default\_bbox\_extra\_artists', 'get\_figure', 'get\_frame\_on', 'get\_geometry', 'get\_gid', 'get\_images', 'get\_label', 'get\_legend', 'get\_legend\_handles\_labels', 'get\_lines', 'get\_navigate', 'get\_navigate\_mode', 'get\_path\_effects', 'get\_picker', 'get\_position', 'get\_rasterization\_zorder', 'get\_rasterized', 'get\_renderer\_cache', 'get\_shared\_x\_axes', 'get\_shared\_y\_axes', 'get\_sketch\_params', 'get\_snap', 'get\_subplotspec', 'get\_tightbbox', 'get\_title', 'get\_transform', 'get\_transformed\_clip\_path\_and\_affine', 'get\_url', 'get\_visible', 'get\_window\_extent', 'get\_xaxis', 'get\_xaxis\_text1\_transform', 'get\_xaxis\_text2\_transform', 'get\_xaxis\_transform', 'get\_xbound', 'get\_xgridlines', 'get\_xlabel', 'get\_xlim', 'get\_xmajorticklabels', 'get\_xminorticklabels', 'get\_xscale', 'get\_xticklabels', 'get\_xticklines', 'get\_xticks', 'get\_yaxis', 'get\_yaxis\_text1\_transform', 'get\_yaxis\_text2\_transform', 'get\_yaxis\_transform', 'get\_ybound', 'get\_ygridlines', 'get\_ylabel', 'get\_ylim', 'get\_ymajorticklabels', 'get\_yminorticklabels', 'get\_yscale', 'get\_yticklabels', 'get\_yticklines', 'get\_yticks', 'get\_zorder', 'grid', 'has\_data', 'have\_units', 'hexbin', 'hist', 'hist2d', 'hitlist', 'hlines', 'hold', 'ignore\_existing\_data\_limits', 'images', 'imshow', 'in\_axes', 'invert\_xaxis', 'invert\_yaxis', 'is\_figure\_set', 'is\_first\_col', 'is\_first\_row', 'is\_last\_col', 'is\_last\_row', 'is\_transform\_set', 'ishold', 'label\_outer', 'legend', 'legend\_', 'lines', 'locator\_params', 'loglog', 'margins', 'matshow', 'minorticks\_off', 'minorticks\_on', 'name', 'numCols', 'numRows', 'patch', 'patches', 'pchanged', 'pcolor', 'pcolorfast', 'pcolormesh', 'pick', 'pickable', 'pie', 'plot', 'plot\_date', 'properties', 'psd', 'quiver', 'quiverkey', 'redraw\_in\_frame', 'relim', 'remove', 'remove\_callback', 'reset\_position', 'rowNum', 'scatter', 'semilogx', 'semilogy', 'set', 'set\_adjustable', 'set\_agg\_filter', 'set\_alpha', 'set\_anchor', 'set\_animated', 'set\_aspect', 'set\_autoscale\_on', 'set\_autoscalex\_on', 'set\_autoscaley\_on', 'set\_axes', 'set\_axes\_locator', 'set\_axis\_bgcolor', 'set\_axis\_off', 'set\_axis\_on', 'set\_axisbelow', 'set\_clip\_box', 'set\_clip\_on', 'set\_clip\_path', 'set\_color\_cycle', 'set\_contains', 'set\_cursor\_props', 'set\_figure', 'set\_frame\_on', 'set\_gid', 'set\_label', 'set\_lod', 'set\_navigate', 'set\_navigate\_mode', 'set\_path\_effects', 'set\_picker', 'set\_position', 'set\_rasterization\_zorder', 'set\_rasterized', 'set\_sketch\_params', 'set\_snap', 'set\_subplotspec', 'set\_title', 'set\_transform', 'set\_url', 'set\_visible', 'set\_xbound', 'set\_xlabel', 'set\_xlim', 'set\_xmargin', 'set\_xscale', 'set\_xticklabels', 'set\_xticks', 'set\_ybound', 'set\_ylabel', 'set\_ylim', 'set\_ymargin', 'set\_yscale', 'set\_yticklabels', 'set\_yticks', 'set\_zorder', 'specgram', 'spines', 'spy', 'stackplot', 'start\_pan', 'stem', 'step', 'streamplot', 'table', 'tables', 'text', 'texts', 'tick\_params', 'ticklabel\_format', 'title', 'titleOffsetTrans', 'transAxes', 'transData', 'transLimits', 'transScale', 'tricontour', 'tricontourf', 'tripcolor', 'tripplot', 'twinx', 'twiny', 'update', 'update\_datalim', 'update\_datalim\_bounds', 'update\_datalim\_numerix', 'update\_from', 'update\_params', 'viewLim', 'vlines', 'xaxis', 'xaxis\_date', 'xaxis\_inverted', 'xcorr', 'yaxis', 'yaxis\_date', 'yaxis\_inverted', 'zorder']

# Viewing your plots

**Stand-alone script, interactive**

state-machine interface: `plt.show()`

object-oriented approach: `fig.show()`

**Jupyter Notebook**

1st line in notebook: `%matplotlib inline`

# Saving your plots

```
plt.savefig('name.pdf')
```

```
fig.savefig('name.pdf')
```

```
fig.savefig('name.pdf', bbox_inches='tight')
```

```
fig.savefig('name.png', dpi=200)
```



# Exercises

- DataCamp Tutorial
- Interactive Jupyter Notebook