# Data Analysis with Python

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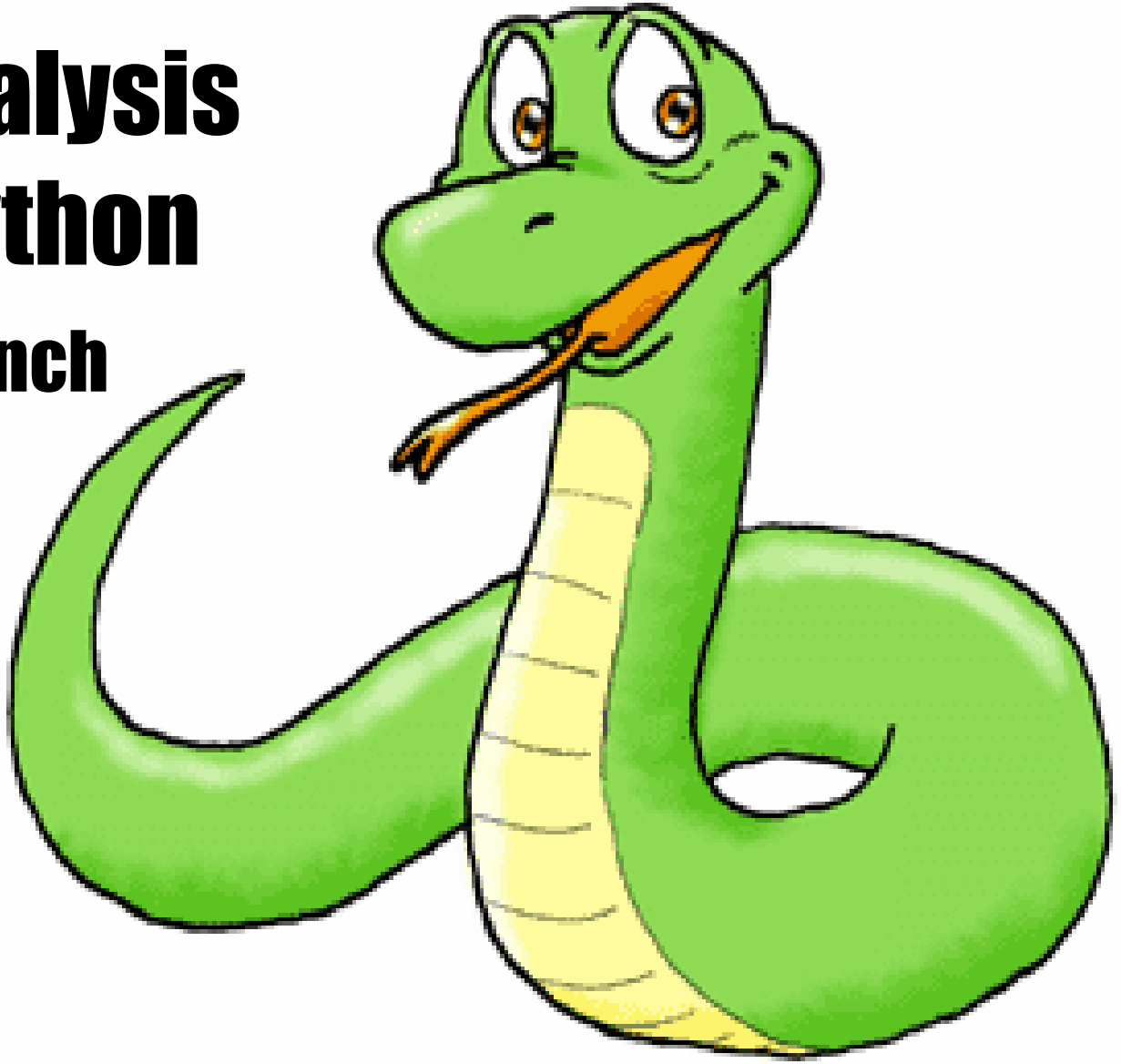


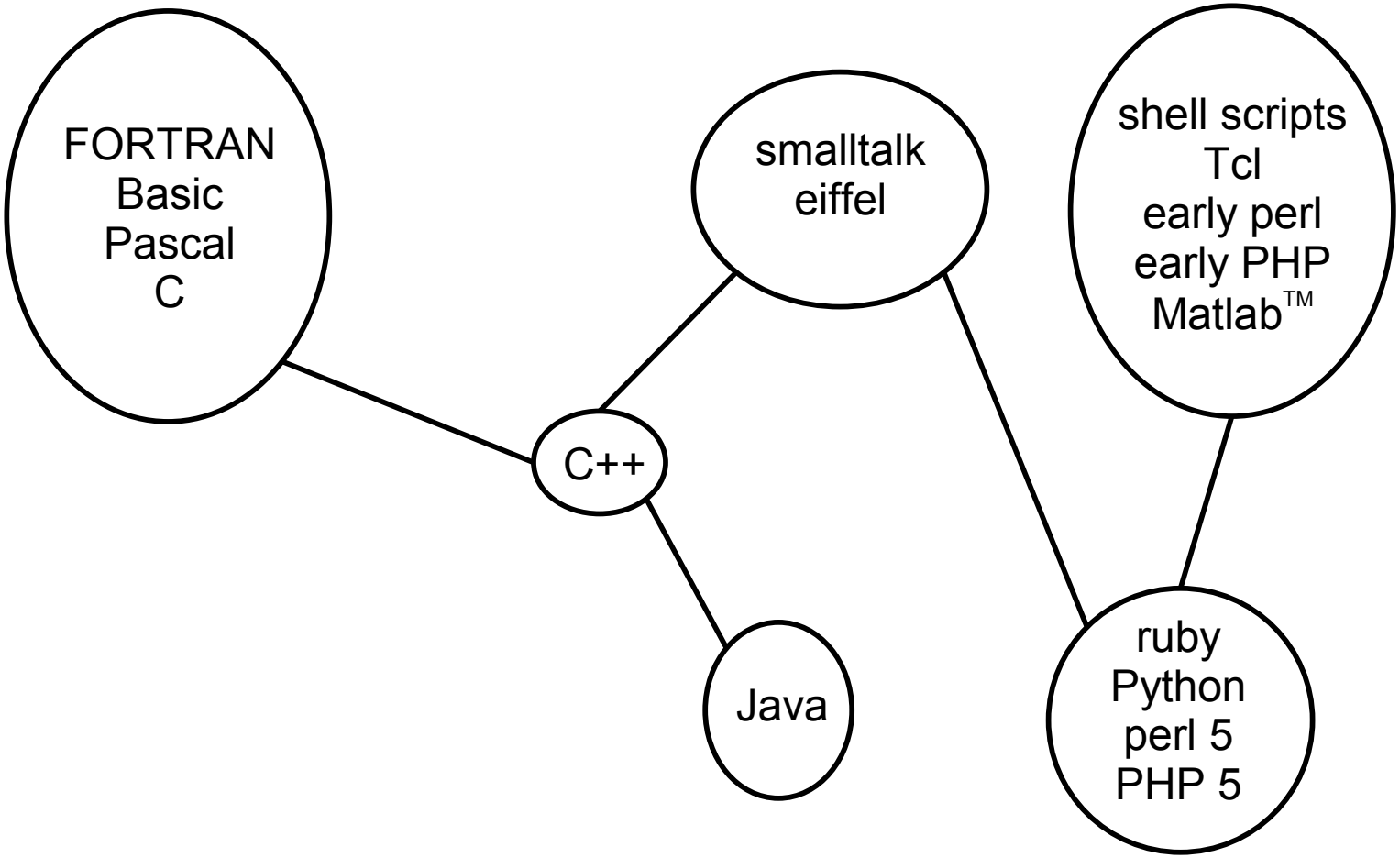
Barcamp Orlando 2008

# About me

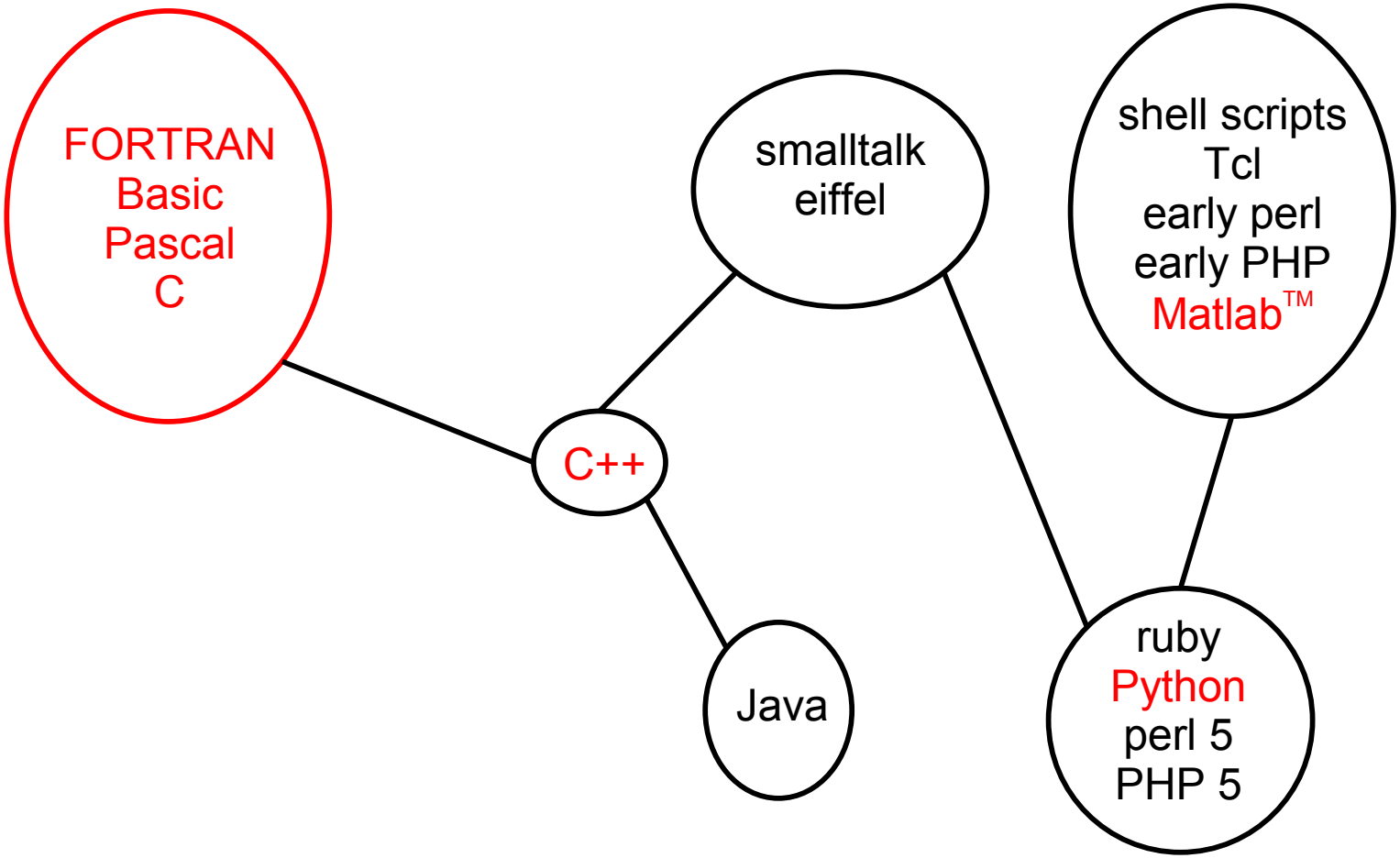
- An engineer by training—currently a PhD candidate in Modeling and Simulation at UCF
- Started coding in Apple Basic around 1987
- Moved on to Basic and Pascal on Macs
- Then to C on DOS/Windows
- Started using Unix around 1993
- Linux since 1998

# Part I: Quick Overview

# Programming languages: a family tree



# Programming languages: a family tree



# Quick description

- Object oriented (since Day One)
- Automatic memory management
- Minimal language, large standard library
- Can be used on the command line
- Implementations:
  - CPython (most common interpreter)
  - Stackless Python
  - Jython (Python implementation on JVM)
  - IronPython (Python implementation on .NET)

# Types

- Types
  - strong
  - safe
  - dynamic
- For example:

```
In [1]: x = 5
In [2]: y = “37”
In [3]: x + y

TypeError: unsupported operand type(s)
for +: ‘int’ and ‘str’
```

# What it looks like

```
# --------------- Function to extract sample times-------------
def getTime(table):
    ## Access data in table ##
    time = [x['time'] for x in table.iterrows()
                if x['label'][0] =='s' and x['cumEnzymeLost'] < 50.0 ]

    # convert to hours for plotting
    for i in range(len(time)):
        time[i] = time[i]/60./60.
#    print time
    return time
####
```

- Minimal amount of symbols
- Indent levels are used to denote code blocks, in place of { } or BEGIN END

# Part II: Handling Ridiculous Amounts of Data

# HDF and the PyTables package

- Hierarchical Data Format
- HDF is comprised of
  - A data model
  - A portable file format
  - A software library
- PyTables is a Pythonic interface to HDF
- HDF/PyTables deal with arbitrarily large datasets (ie larger than memory)


# NumPy package

- A powerful, n-dimensional array class
- Highly optimized for numerical computing
- Also useful as a multi-dimensional container for generic data
- Includes basic linear algebra functions

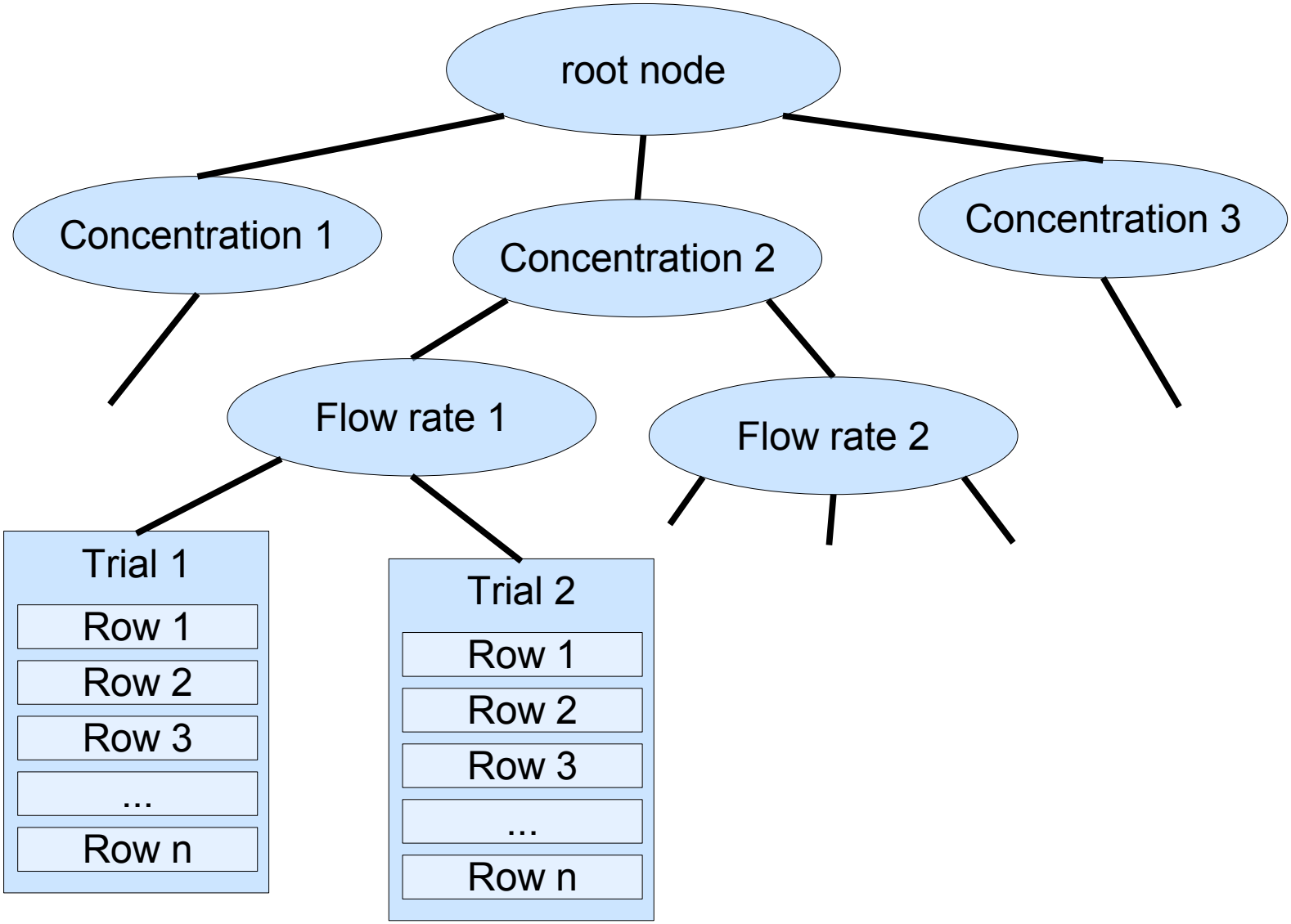
- Gives Python capabilities similar to Matlab™


http://numpy.scipy.org/

# Defining the data structure

```
# ---------- Define HDF5 file structure ----------
from tables import *

# root node
file = openFile("AP_PEG.h5", mode = "w", title = "AP on PEG Capillary")

# concentrations: three groups branching from root node
conc90 = file.createGroup("/", 'conc90', '90 ng/ml')
conc300 = file.createGroup("/", 'conc180', '180 ng/ml')
conc300 = file.createGroup("/", 'conc300', '300 ng/ml')

# flow rates: two groups branching from each concentration node
file.createGroup("/conc90", 'flow60', 'Flow Rate 60 microliters/hour')
file.createGroup("/conc90", 'flow100', 'Flow Rate 100 microliters/hour')

file.createGroup("/conc180", 'flow60', 'Flow Rate 60 microliters/hour')
file.createGroup("/conc180", 'flow100', 'Flow Rate 100 microliters/hour')

file.createGroup("/conc300", 'flow60', 'Flow Rate 60 microliters/hour')
file.createGroup("/conc300", 'flow100', 'Flow Rate 100 microliters/hour')
```

# HDF data structure



# From flatfiles to HDF

```
## Opening the file
textFile = open( textFileName, 'r' )

# First line--the important data is concentration
words = textFile.readline().split('\t')
concentration = float(words[0])
print concentration

# Next line--headers
words = textFile.readline().split('\t')
print words

# Data lines
isData = True
while isData:
    words = textFile.readline().split('\t')
    if words[0] == '':
        isData = False
    else:
        print words
        data = table.row
```

# Part III: Data Processing

# Accessing data with PyTables

- List comprehensions
  - A nice shorthand for creating lists

```
newList = [ expression for-statement
            if-statement ]
```

- Dictionaries
  - Associative arrays that are indexed by keys rather than integers

```
delegates = {'clinton':1486 , 'obama':
             1629}
delegates['obama'] = 1486
```

# Accessing data with PyTables

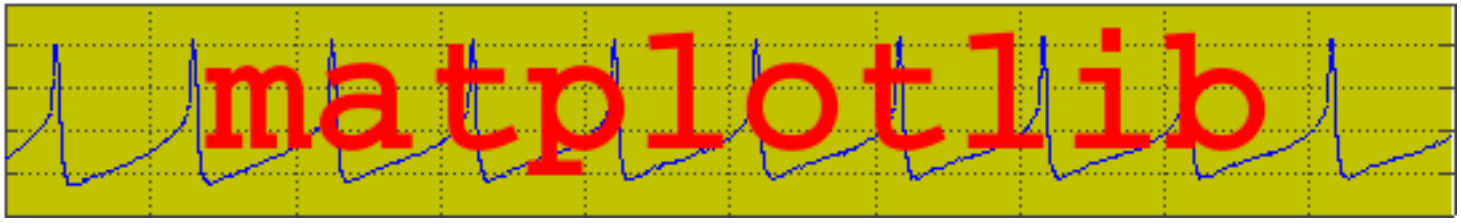
- The code:

```
# --------------- Function to extract sample times------------
def getTime(table):
    ## Access data in table ##
    time = [x['time'] for x in table.iterrows()
                if x['label'][0] =='s' and x['cumEnzymeLost'] < 50.0 ]

    # convert to hours for plotting
    for i in range(len(time)):
        time[i] = time[i]/60./60.
    return time
####
```

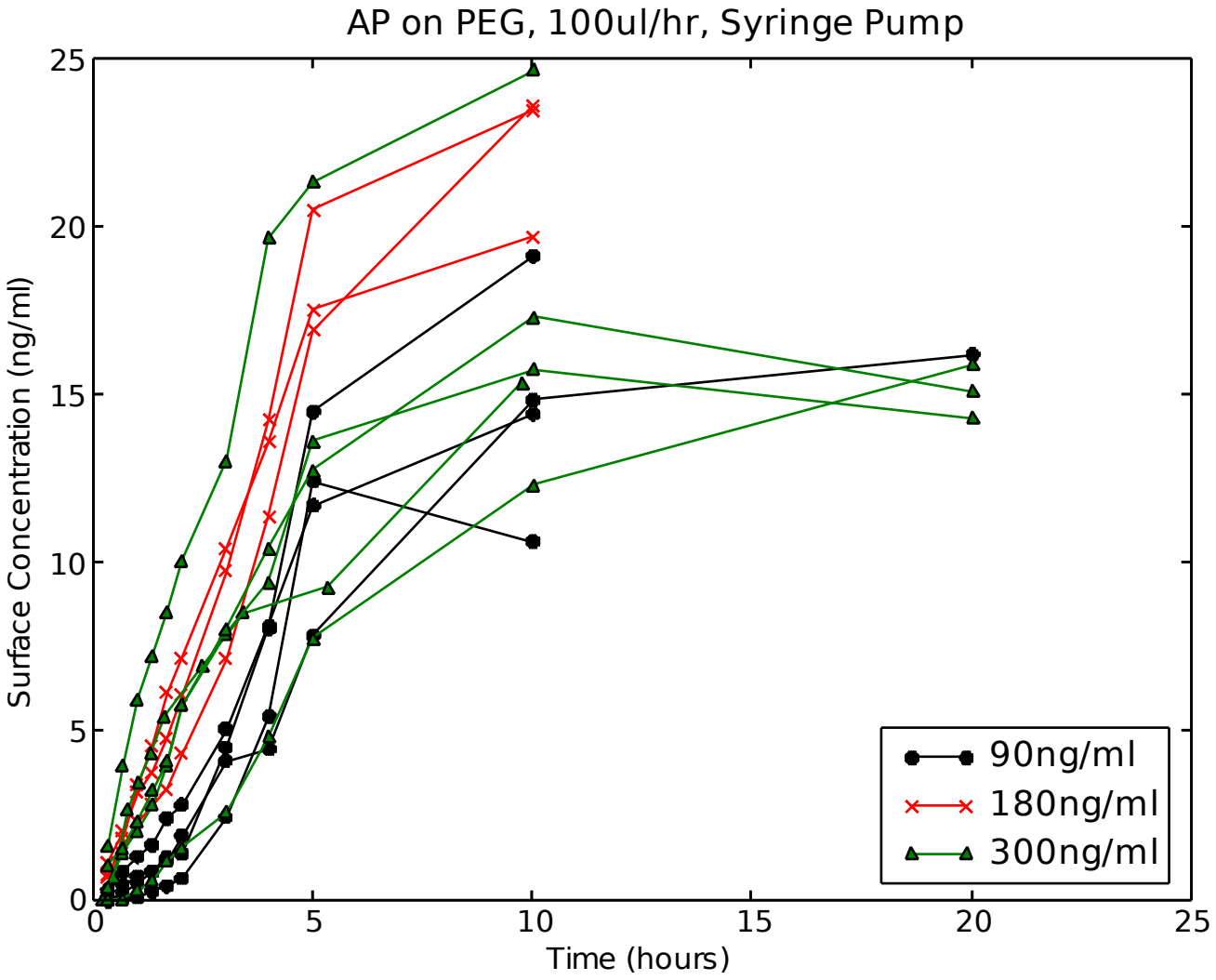
# Plotting with matplotlib

- Matplotlib: a package with plotting functions that are highly compatible with Matlab™
- Publication-quality 2D graphics

http://matplotlib.sourceforge.net



# Plotting all the data



# Data reduction

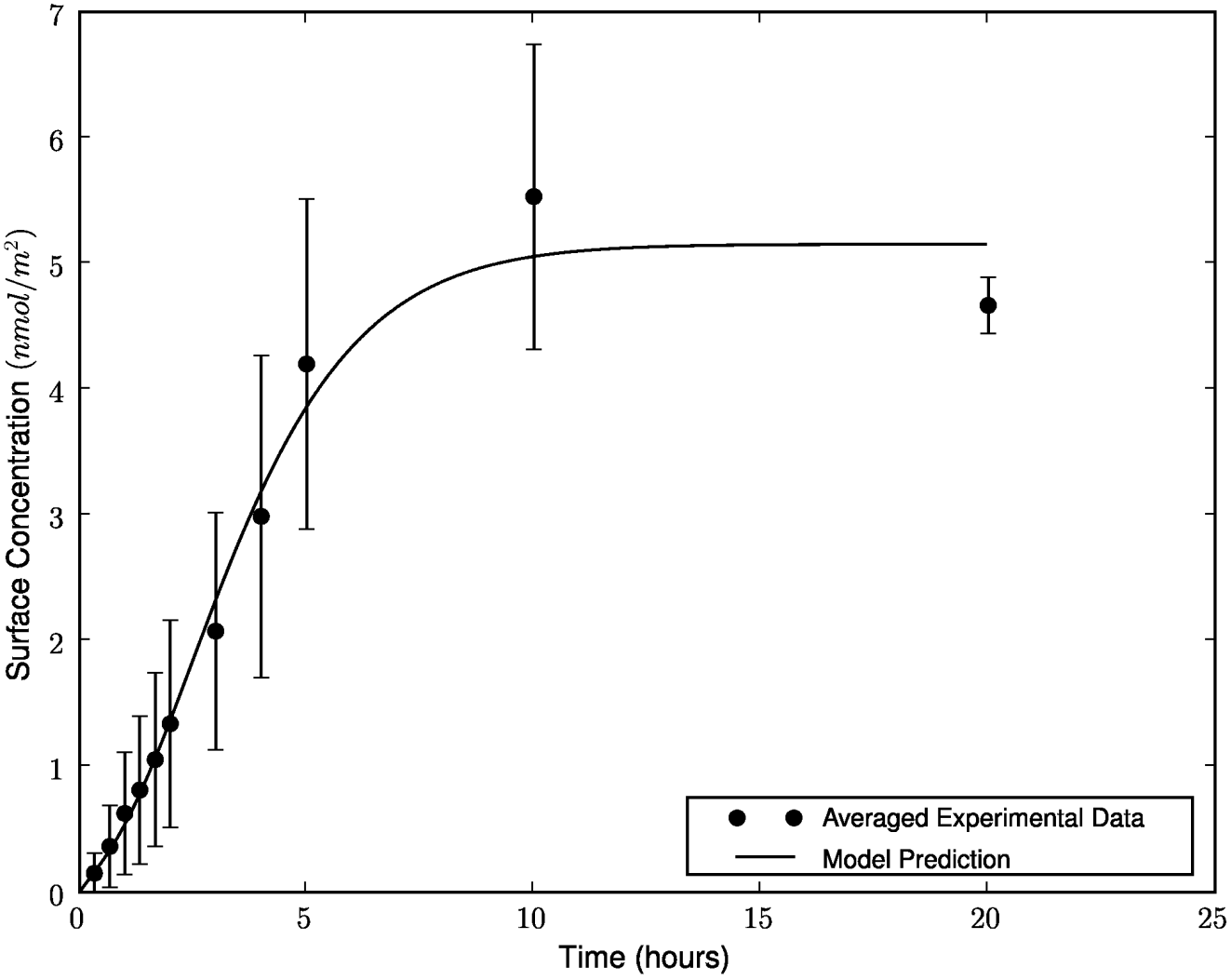
- Combine multiple runs into a single data set: mean and standard deviation

```
if len(values) > 1:
    stdevSurfConc.append(pylab.std(values))
else:
    stdevSurfConc.append(0.0)
```

- Could have also used exceptions

```
try:
    stdevSurfConc.append(pylab.std(values))
except DivideByZeroError:
    stdevSurfConc.append(0.0)
```

# Plotting the final data



# Plotting code

```
# ----- Overall Mean Plot -----
pylab.figure()
pylab.errorbar(times_all, average_all, fmt='ko', xerr=None,
        yerr=stdev_all, label='Averaged Experimental Data')
pylab.hold(True)

pylab.plot(modelTimes, optimalPrediction[0], 'k-', label='Model Prediction')

# Scale and decorate
#pylab.title('AP on PEG, 90, 180, and 300ng/ml, 100ul/hr')
pylab.xlabel(r'Time (hours)', size='medium')
pylab.ylabel(r'Surface Concentration $(nmol/m^2)$', size='medium')
pylab.legend(loc="lower right", numpoints=2, pad=0.2, handletextsep = 0.025, prop=fontprop)
pylab.axis([0., 25., 0., 7.])
pylab.savefig('SyringePump_AP_PEG_fitted_100ulhr.eps')

# Show plots and close files
pylab.show()
```

# Conclusion

- What I need in a language:
  - Rapid development
  - Highest possible level of abstraction
  - Clean, readable code for easy maintenance
  - Extensive open-source libraries
- What I don't need:
  - Blinding fast execution
  - Licensing fees and proprietary source
- Python meets my needs—consider whether it will meet yours!

# Further Reading

- Why Eric S. Raymond likes Python (over Perl)

  http://www.linuxjournal.com/article/3882

- http://www.prescod.net/python/why.html