Info Session: Virtual Environments

By Nadia Blostein

Interpreted vs Compiled Programming Languages: What's the Difference?

“ Every program is a set of instructions, whether it’s to add two numbers or send a request over the internet. Compilers and interpreters take human-readable code and convert it to computer-readable machine code.”

About Python...

- “Python is an **interpreted**, **high-level** and **general-purpose** programming language” (Wiki)
  - **Interpreted**: executed line-by-line
  - **High-level**: human readable (as opposed to machine readable)
  - **General purpose**: designed for variety of applications
- Python interpreter:
  - “The Python interpreter is a *virtual machine*, meaning that it is software that emulates a physical computer.” (https://www.aosabook.org/en/500L/a-python-interpreter-written-in-python.html)
  - Thus, when you install a version of Python on your computer, you are installing a version of a Python interpreter
  - The Python interpreter can read and execute Python code line-by-line
  - Practise (from your command line):
    - *$ python test_script.py*
    - you are asking your Python interpreter to read and execute each line in test_script.py
- **Python installation:** https://wiki.python.org/moin/BeginnersGuide/Download

NOTATION. $ some_text_here: some_text_here is a command-line argument (you can just copy-paste it into your terminal!)

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- Python installation: https://wiki.python.org/moin/BeginnersGuide/Download
- **Great! Now that your computer has a Python interpreter, all you’re just missing is...**

MODULES, LIBRARIES AND PACKAGES

module < library < packages.
(*https://stackoverflow.com/questions/16997950/whats-the-difference-between-module-package-and-library-in-haskell*)

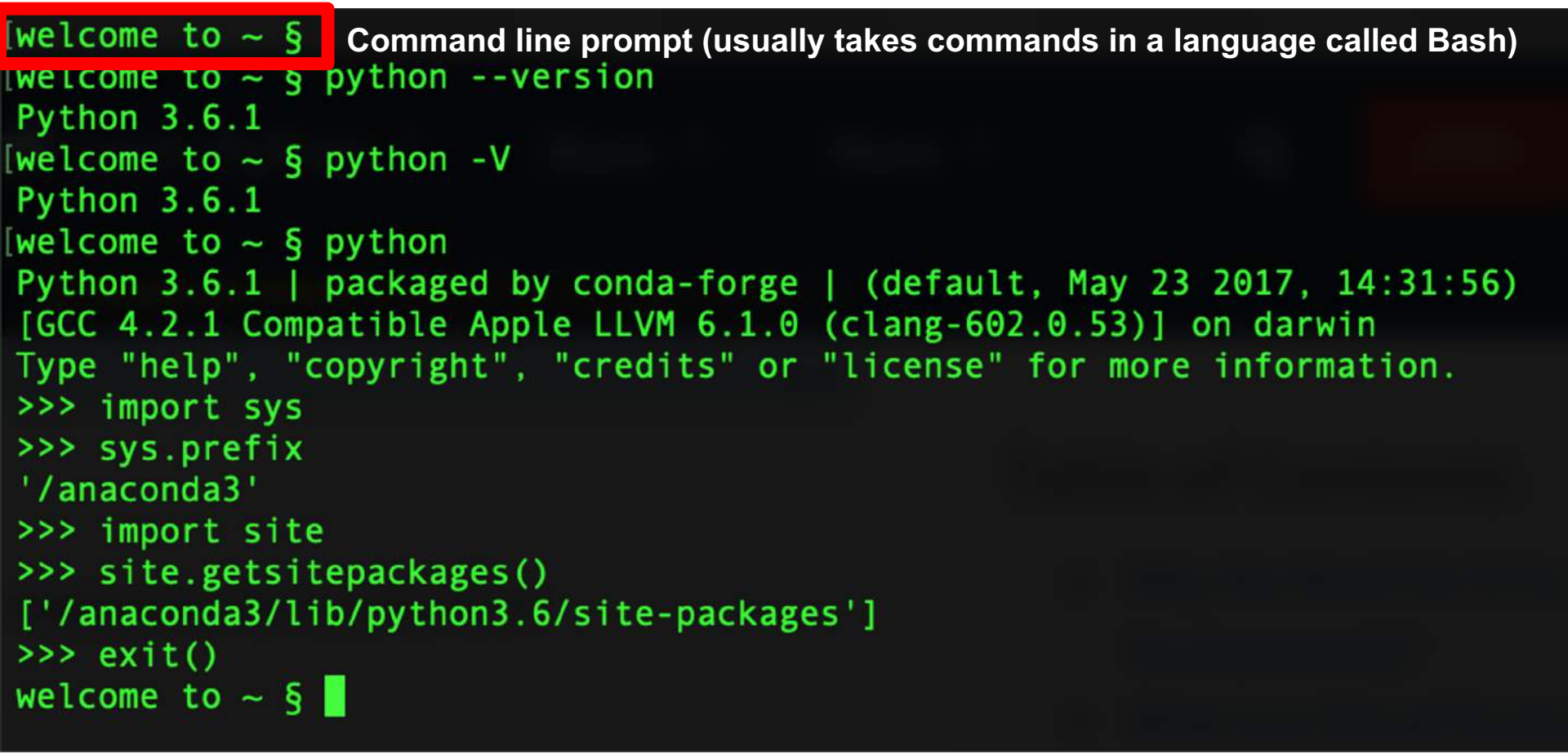
- "A **module** is a set of functions, types, classes, ... put together in a common namespace.
- A **library** is a set of modules which makes sense to put together and that can be used in a program or another library.
- A **package** is a unit of distribution that can contain a library or an executable or both. It's a way to share your code with the community."

Cool… But how does Python download, store and resolve packages?

How does Python download, store and resolve packages?

1. **System packages**: packages that are part of the standard Python library (automatically downloaded when you download your interpreter)
2. **Site Packages:** 3rd party packages, usually installed using pip or easy_install commands
   - **PyPI (Python Package Index)**: 3rd party software repository for Python (Wiki)
   - **Pip**: standard package-management system used to install and manage software packages written in Python. Many packages can be found in the default source for packages and their dependencies — Python Package Index (Wiki)

How does Python download, store and resolve packages?



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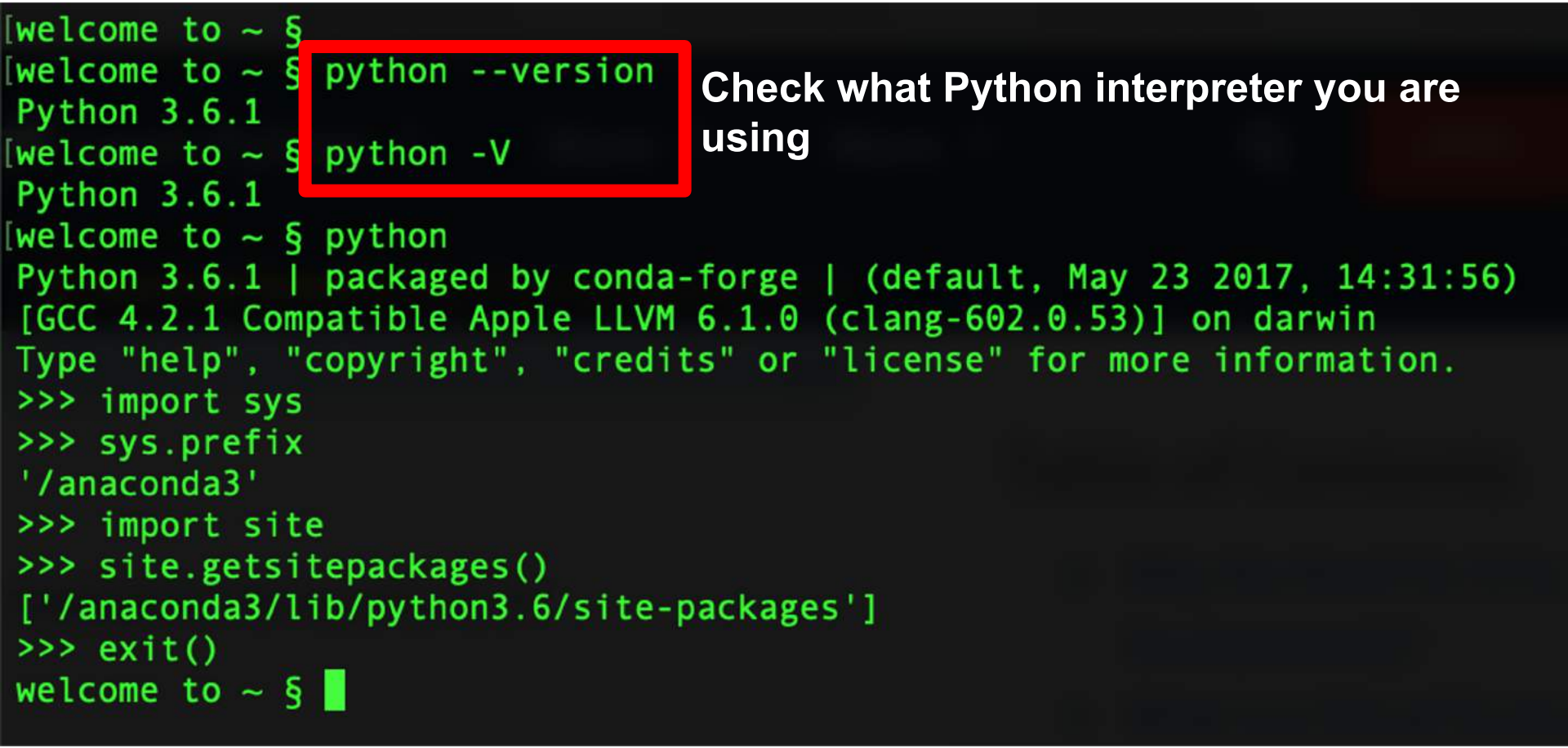

Check what Python interpreter you are using

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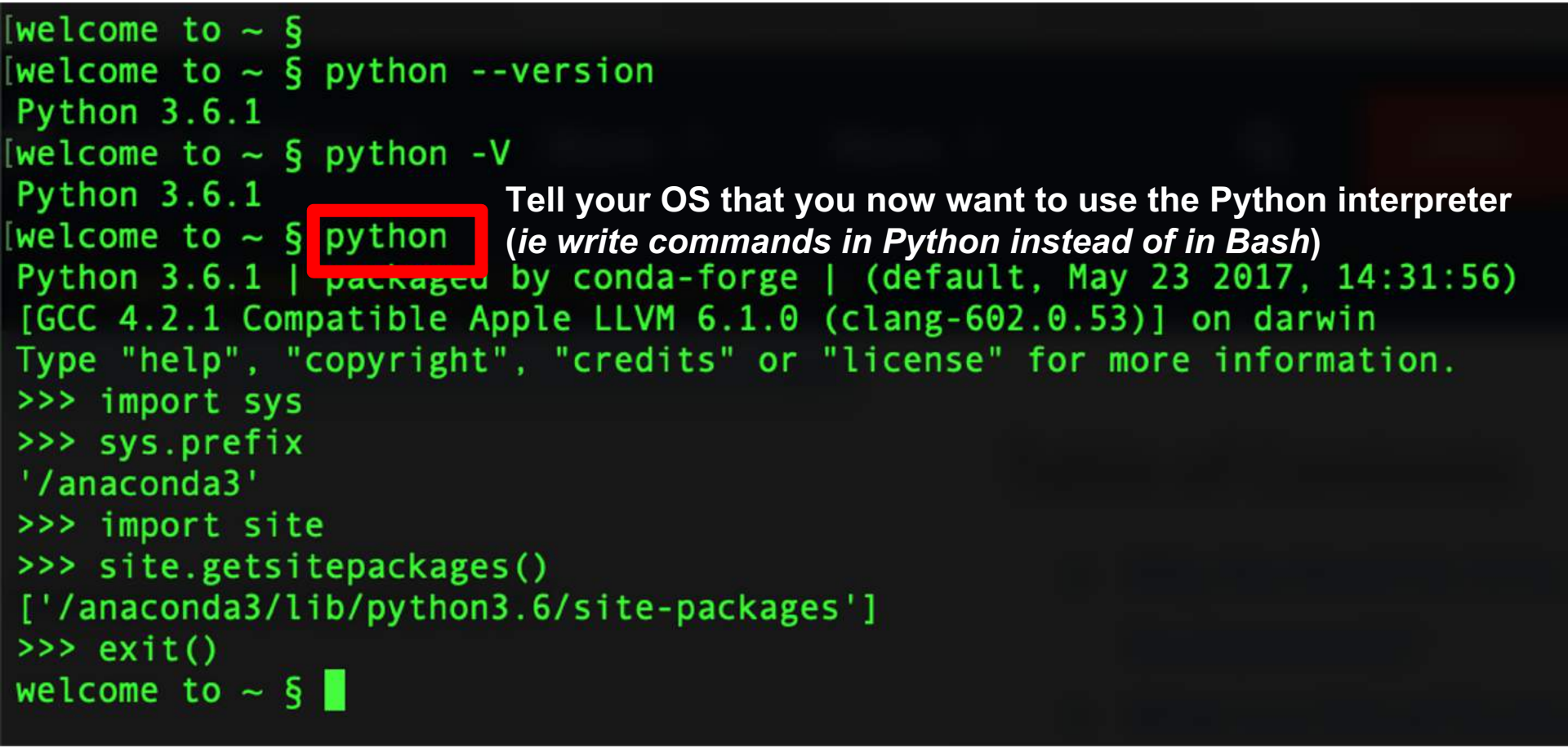

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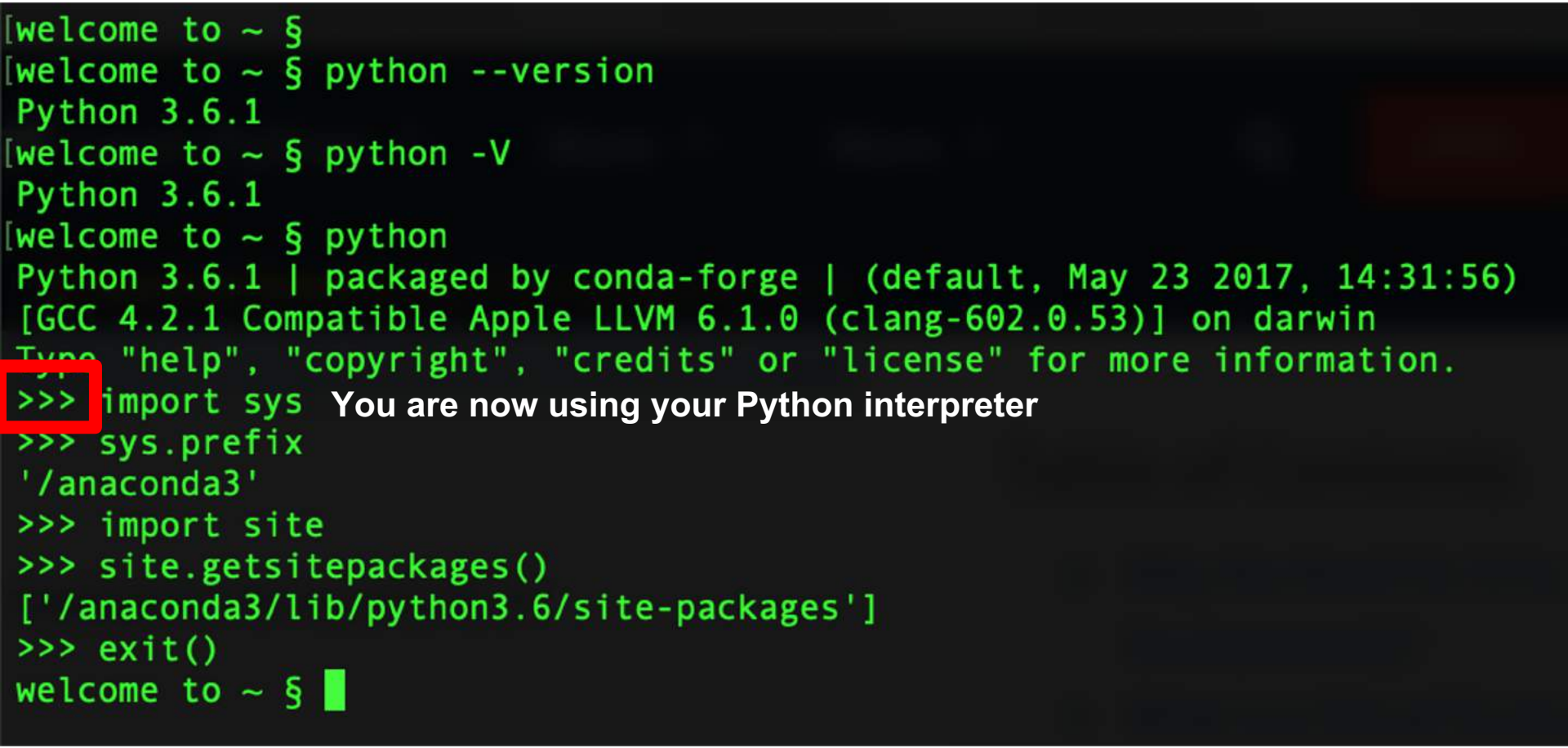

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RECALL:

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Find out where your system packages are stored!

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>>> import sys
>>> sys.prefix
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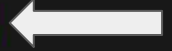

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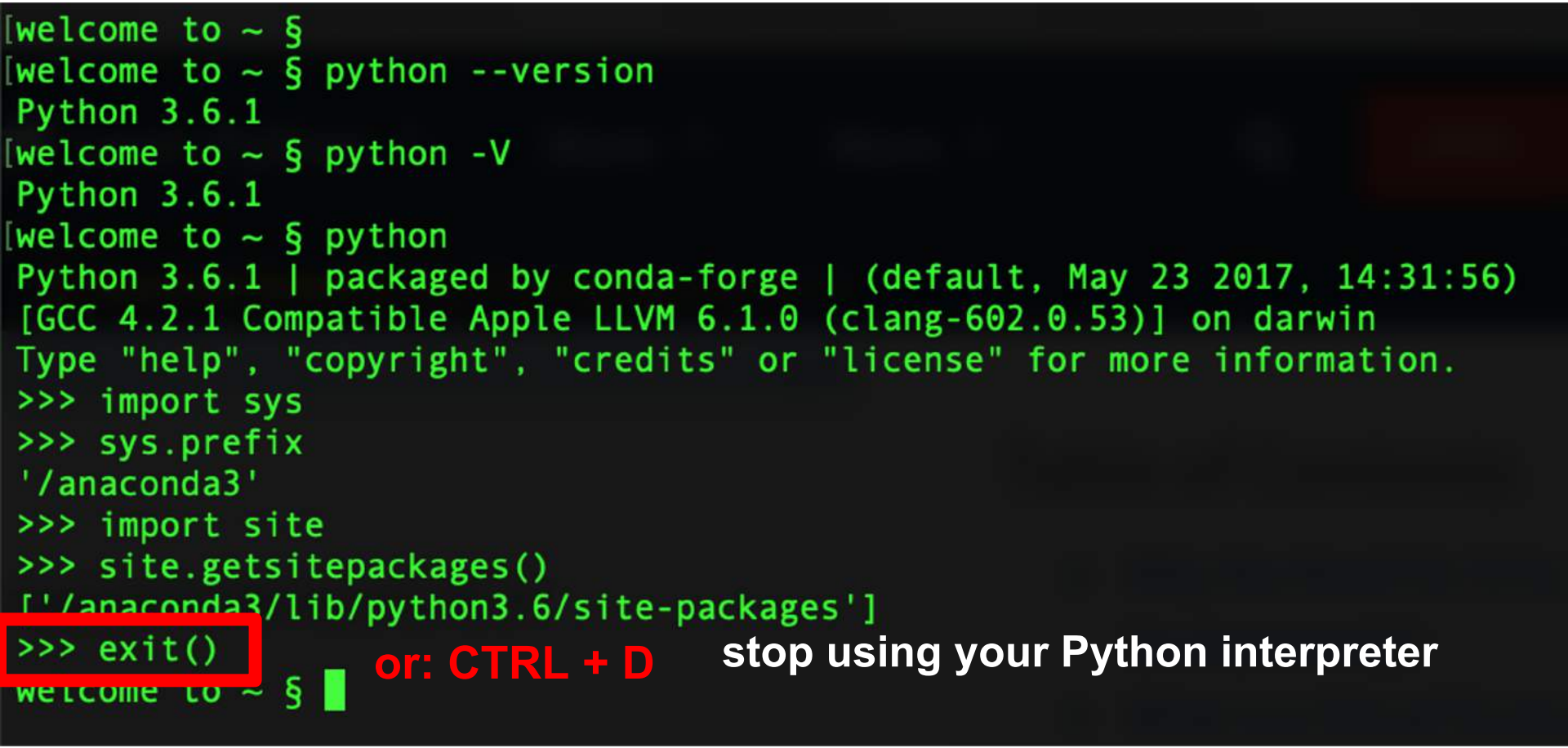

How does Python download, store and resolve packages?

1. **System packages**: packages that are part of the standard Python library
2. **Site Packages:** 3rd party packages
3. **Virtual Environments:**
   - Python tool for package management and project isolation
   - Allow for site packages (3rd party packages) to be installed in a local directory (ex: specific project) instead of globally
     - ie create a “local” (project-specific) site-packages directory that can use its own version of Python!
   - Why? https://towardsdatascience.com/virtual-environments-104c62d48c54#ee81
     - **“Resolve dependency issues** by allowing you to use different versions of a package for different projects.
     - Make your project **self-contained** and **reproducible** by capturing all package dependencies in a requirements file.
     - Install packages on a host on which you do not have admin privileges.
     - Keep your global `site-packages/` system site-packages directory tidy by removing the need to install packages system-wide which you might only need for one project.”

Virtual Environments: Motivation

- Project B examines the relationship between TBV and age in a *new* dataset
  - *project_B.py* (script) loads & analyzes *new_dataset.csv* (data file)
  - Dependencies:
    - **numpy v 1.19**
    - **pandas v 1.1.2**
    - **matplotlib 3.3.1**
- Project A examines the relationship between TBV and age in an *old* dataset
  - *project_A.py* (script) loads & analyzes *dataset.csv* (data file)
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    - **numpy v 1.15**
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    - **matplotlib 3.3.1**,
    - **linearmodels**
- **Alert!** Different package dependencies → store in separate virtual environments

Build Your Own Venv

Example from: [Python Virtual Environments: A Primer – Real Python]

Note: this example assumes that you are using Python 3

```
[welcome to ~/Downloads § mkdir python_test_env && cd python_test_env
[welcome to ~/Downloads/python_test_env § python3 -m venv test_env
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Build Your Own Venv

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Make a directory and cd into it

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```
/Users/nadiablostein/Downloads/python_test_env
└── test_env
    ├── bin
    │   ├── activate
    │   ├── activate.csh
    │   ├── activate.fish
    │   ├── easy_install
    │   ├── easy_install-3.7
    │   ├── pip
    │   ├── pip3
    │   ├── pip3.7
    │   ├── python -> python3
    │   └── python3 -> /Library/Frameworks/Python.framework/Versions/3.7/bin/python3
    ├── include
    ├── lib
    │   └── python3.7
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```

contains script that allows you to switch from global venv to local venv

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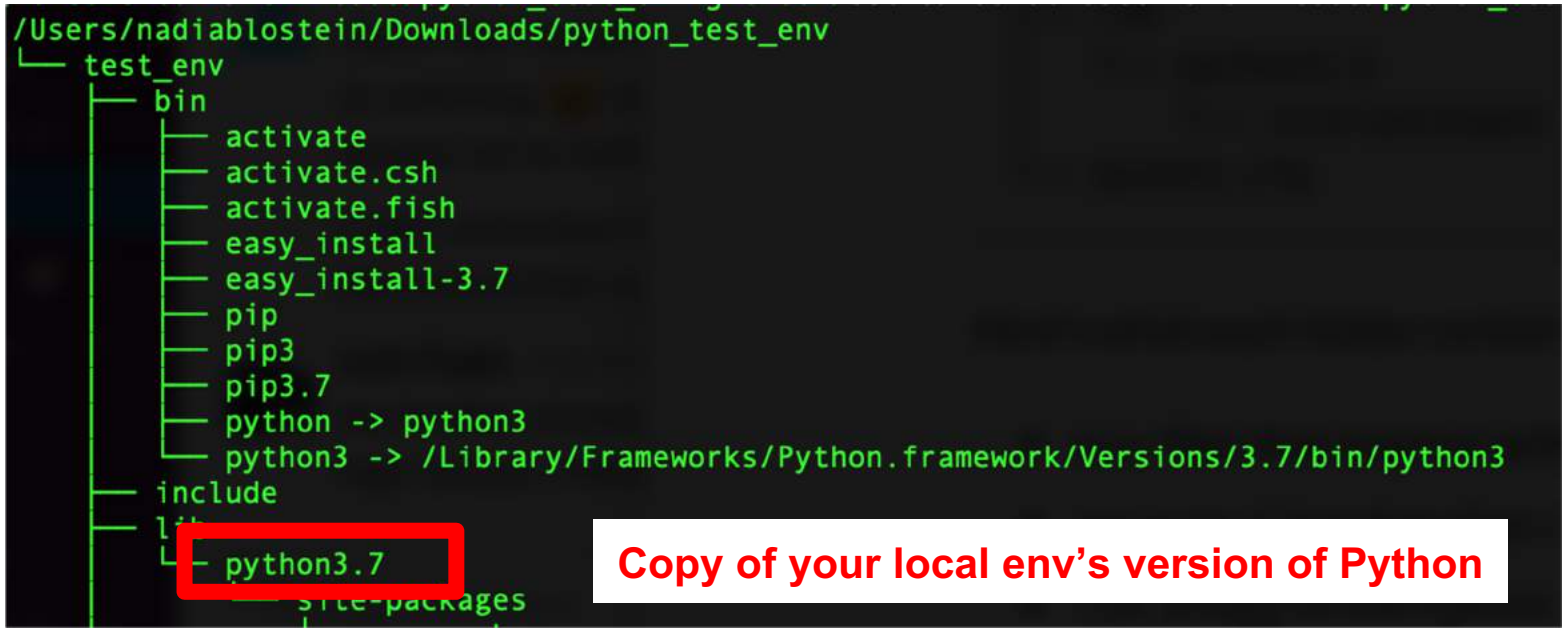

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Where the 3rd party packages of the local venv are stored

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Switch from global to local venv

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Install 3rd party package in global site-packages directory

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Use bcrypt to hash a password

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hashpw('password'.encode('utf-8'), bcrypt.gensalt()))"
Traceback (most recent call last):
  File "<string>", line 1, in <module>
[ModuleNotFoundError: No module named 'bcrypt'
(test_env) welcome to ~/Downloads/python_test_env § deactivate
welcome to ~/Downloads/python_test_env §
```

Build Your Own Venv

Example from: [Python Virtual Environments: A Primer – Real Python]

Switch back to your local venv

```
[welcome to ~/Downloads § mkdir python_test_env && cd python_test_env
[welcome to ~/Downloads/python_test_env § python3 -m venv test_env
[welcome to ~/Downloads/python_test_env § source test_env/bin/activate
[(test_env) welcome to ~/Downloads/python_test_env § deactivate
[welcome to ~/Downloads/python_test_env § pip -q install bcrypt
[welcome to ~/Downloads/python_test_env § python -c "import bcrypt; print(bcrypt.hashpw('pas
 sword'.encode('utf-8'), bcrypt.gensalt()))"
[b'$2b$12$u/6wZBvKRooOcJ5LICtobeWh18YF.deYF.3xNVqFJfLGNyyDbEAbG'
[welcome to ~/Downloads/python_test_env § source test_env/bin/activate
 (test_env) welcome to ~/Downloads/python_test_env § python -c "import bcrypt; print(bcrypt.
 hashpw('password'.encode('utf-8'), bcrypt.gensalt()))"
 Traceback (most recent call last):
   File "<string>", line 1, in <module>
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 (test_env) welcome to ~/Downloads/python_test_env § deactivate
 welcome to ~/Downloads/python_test_env §
```

Build Your Own Venv

Example from: [Python Virtual Environments: A Primer – Real Python]

Switch back to your local venv

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[welcome to ~/Downloads § mkdir python_test_env && cd python_test_env
[welcome to ~/Downloads/python_test_env § python3 -m venv test_env
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 sword'.encode('utf-8'), bcrypt.gensalt()))"
[b'$2b$12$u/6wZBvKRooOcJ5LICtobeWh18YF.deYF.3xNVqFJfLGNvyDbEAbG'
[welcome to ~/Downloads/python_test_env § source test_env/bin/activate
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hashpw('password'.encode('utf-8'), bcrypt.gensalt()))"
Traceback (most recent call last):
  File "<string>", line 1, in <module>
[ModuleNotFoundError: No module named 'bcrypt'
(test_env) welcome to ~/Downloads/python_test_env § deactivate
welcome to ~/Downloads/python_test_env §
```

Build Your Own Venv

Example from: [Python Virtual Environments: A Primer – Real Python]

Use bcrypt to hash a password

```
[welcome to ~/Downloads § mkdir python_test_env && cd python_test_env
[welcome to ~/Downloads/python_test_env § python3 -m venv test_env
[welcome to ~/Downloads/python_test_env § source test_env/bin/activate
[(test_env) welcome to ~/Downloads/python_test_env § deactivate
[welcome to ~/Downloads/python_test_env § pip -q install bcrypt
[welcome to ~/Downloads/python_test_env § python -c "import bcrypt; print(bcrypt.hashpw('pas
 sword'.encode('utf-8'), bcrypt.gensalt()))"
[b'$2b$12$u/6wZBvKRooOcJ5LICtobeWh18YF.deYF.3xNVqFJfLGNvyDbEAbG'
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hashpw('password'.encode('utf-8'), bcrypt.gensalt()))"
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(test_env) welcome to ~/Downloads/python_test_env § deactivate
welcome to ~/Downloads/python_test_env §
```

Build Your Own Venv

Example from: [Python Virtual Environments: A Primer – Real Python]

ModuleNotFoundError !

```
[welcome to ~/Downloads § mkdir python_test_env && cd python_test_env
[welcome to ~/Downloads/python_test_env § python3 -m venv test_env
[welcome to ~/Downloads/python_test_env § source test_env/bin/activate
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[welcome to ~/Downloads/python_test_env § source test_env/bin/activate
 (test_env) welcome to ~/Downloads/python_test_env § python -c "import bcrypt; print(bcrypt.
                                                    t()))"
Traceback (most recent call last):
  File "<string>", line 1, in <module>
[ModuleNotFoundError: No module named 'bcrypt'
                                                    § deactivate
welcome to ~/Downloads/python_test_env §
```

Anaconda and Miniconda

- **Pip**: package manager
- **Virtualenv**: environment manager
- **Conda:** both!
  - Packaging tool and installer (like pip!) → packages from Anaconda Repository and Anaconda Cloud (instead of PyPI)
  - Creates a virtual environment (like virtualenv!)
  - **Command line tool**: does not require a Python interpreter
  - Conda Cheat Sheet
- **Anaconda:** Python and R distribution, “aims to simplify package management and deployment” (Wiki)
  - **Python interpreter** (*any version you chose*) + **Conda** + **“meta-packages anaconda”** (predetermined set of Python packages)
- **Miniconda:**
  - **Python interpreter** (*any version you chose*) + **Conda**
  - manually install any packages/dependencies you need
  - ⊕: less space, quicker to install, customizable
  - ⊖: requires a better understanding of venvs as well as what your project requires
- **READ MORE:**
  - **Anaconda vs. Miniconda vs. Virtualenv**
  - **Understanding Conda and Pip**

Build your own Conda Virtual Environment!

(1) Download the correct files from the CobraLab Google Drive: CobraLab → PRESENTATIONS → LAB MEETINGS → Info_Session_2020 → 2020-09-16-virtual-environments → test_conda_env.tar.gz: https://drive.google.com/drive/folders/1Ngtmwn-ePr-8Kt5ai8CluKVG93E3qupI?usp=sharing

(2) Unzip the .tar file and cd into through your terminal!

NOTATION

$ some_text_here: some_text_here is a command-line argument (you can just copy-paste it into your terminal!)

Build your own Conda Virtual Environment!

OPTION 1 (2nd option later):

(3) Create your conda environment:

```
$ conda create --name my_conda_env python=3.8.3
```

(2) Activate your condal environment:

```
$ source activate my_conda_env
```

(5) Download all of the right packages and dependencies to be able to run HCP_interactive_plot.ipynb:

```
$ conda install numpy
$ conda install pandas
$ conda install plotly
$ conda install dash
$ conda install -c conda-forge -c plotly jupyter-dash
$ conda install jupyter
$ conda install nb_conda_kernels
```

(6) Launch Jupyter Notebook!

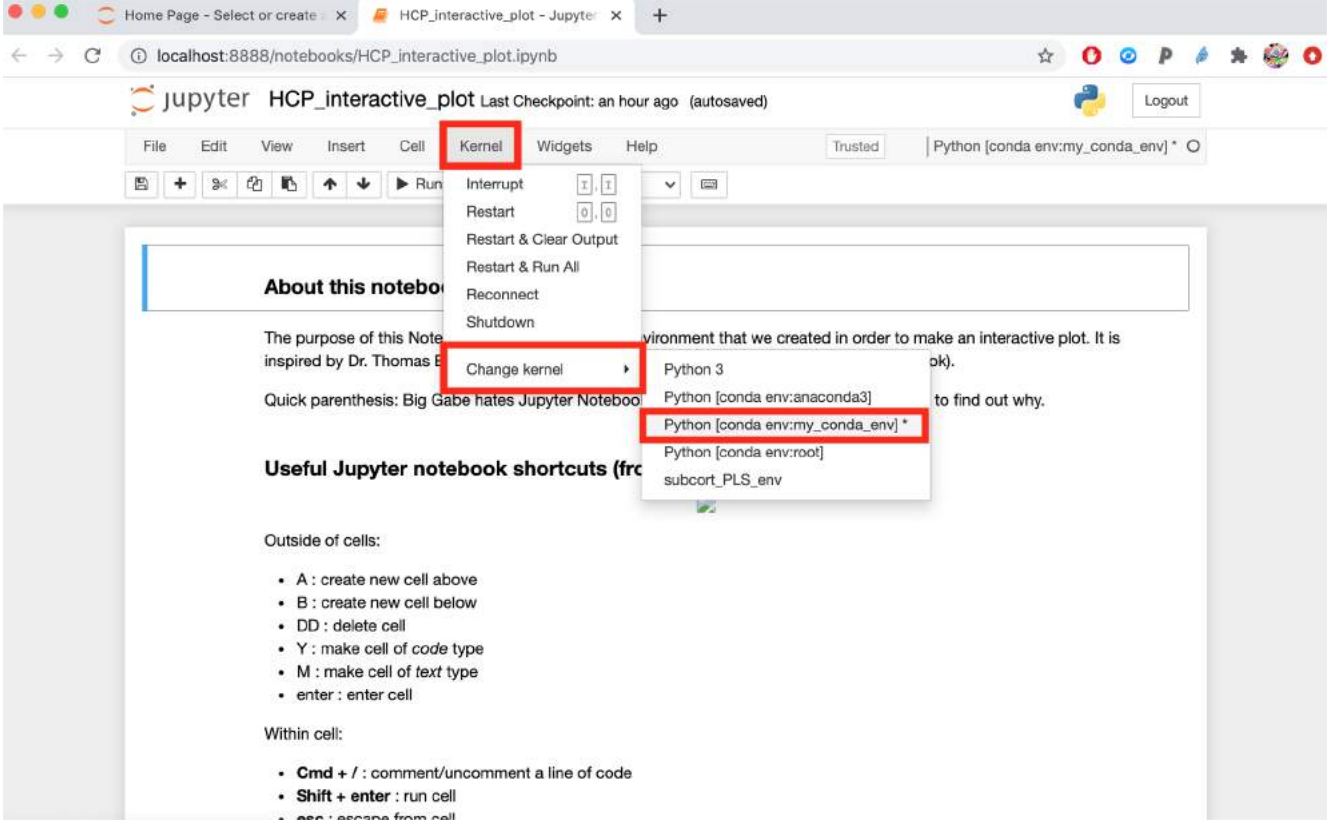
```
$ jupyter notebook
```

Build your own Conda Virtual Environment!

(8) Open the Jupyter Notebook:

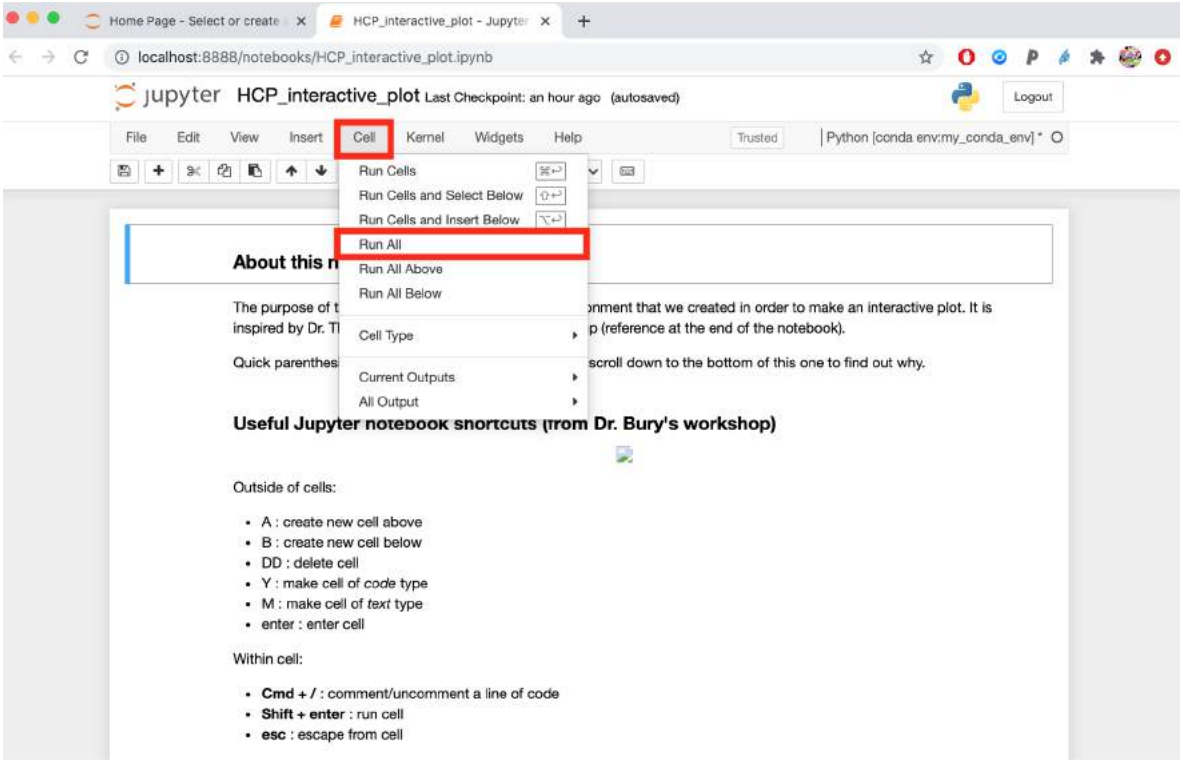
Build your own Conda Virtual Environment!

(9) Make sure you are using the right kernel



Build your own Conda Virtual Environment!

(10) Run all of the cells



Maintaining good habits

Your **final goa**l is for anybody (including yourself) to be able **reproduce** your results **whenever** and as **seamlessly** as possible, whilst minimizing the steps required to do so.

Maintaining good habits… save dependencies

(1) pip freeze: virtual environments (venv)
- List all packages in the current environment:
  - $ pip freeze -l
- Save packages for future use:
  - $ PATH_TO_ENV_1/bin/pip pip freeze > requirements.txt
- Reinstall packages from an export file:
  - $ PATH_TO_ENV_2/bin/pip install -r requirements.txt

(2) conda list: conda environments
- List all packages in the current environment:
  - $ conda list
- List all packages installed into the environment 'myenv':
  - $ conda list -n myenv
- Save packages for future use:
  - $ conda list --explicit > package-list.txt
- Reinstall packages from an export file:
  - $ conda create -n myenv --file package-list.txt

(3) Makefiles
- Deploying software, sharing projects

OPTION 2: **package list**

(3) Create your conda environment:

$ conda create --name my_conda_env python=3.8.3 --file=package-list.txt

(4) Activate your condal environment:

$ source activate my_conda_env

(5) Launch Jupyter Notebook!

$ jupyter notebook or $ python HCP_interactive_plot.py

Build your own Conda Virtual Environment!

OPTION 3: makefile

```
install: # create your virtual environment
	@echo "Creating virtual environment"
	conda create --prefix ./my_temp_conda_env python=3.8.3 --file=package-list.txt

plot: # generate interactive plot
	echo "generating interactive plot (.html file)"
	./my_temp_conda_env/bin/python HCP_interactive_plot.py

clean: # delete your virtual environment
	@echo "Cleaning up"
	rm -rf ./my_temp_conda_env
```

makefile anatomy

Build your own Conda Virtual Environment!

OPTION 3: makefile

(3) $ make install

```
install: # create your virtual environment
	@echo "Creating virtual environment
	conda create --prefix ./my_temp_conda_env python=3.8.3 --file=package-list.txt

plot: # generate interactive plot
	echo "generating interactive plot (.html file)"
	./my_temp_conda_env/bin/python HCP_interactive_plot.py

clean: # delete your virtual environment
	@echo "Cleaning up"
	rm -rf ./my_temp_conda_env
```

makefile anatomy

Build your own Conda Virtual Environment!

OPTION 3: makefile

(3) $ make install

(4) $ make plot

```
install: # create your virtual environment
	@echo "Creating virtual environment"
	conda create --prefix ./my_temp_conda_env python=3.8.3 --file=package-list.txt

plot: # generate interactive plot
	echo "generating interactive plot ( html file)"
	./my_temp_conda_env/bin/python HCP nteractive_plot.py

clean: # delete your virtual environment
	@echo "Cleaning up"
	rm -rf ./my_temp_conda_env
```

makefile anatomy

Build your own Conda Virtual Environment!

OPTION 3: makefile

(3) $ make install
(4) $ make plot
(5) $ make clean

```
install: # create your virtual environment
	@echo "Creating virtual environment"
	conda create --prefix ./my_temp_conda_env python=3.8.3 --file=package-list.txt

plot: # generate interactive plot
	echo "generating interactive plot (.html file)"
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clean: # delete your virtual environment
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	rm -rf ./my_temp_conda_env
```

makefile anatomy

Thank you!