



Cold
Spring
Harbor
Laboratory

Introduction to cloud computing

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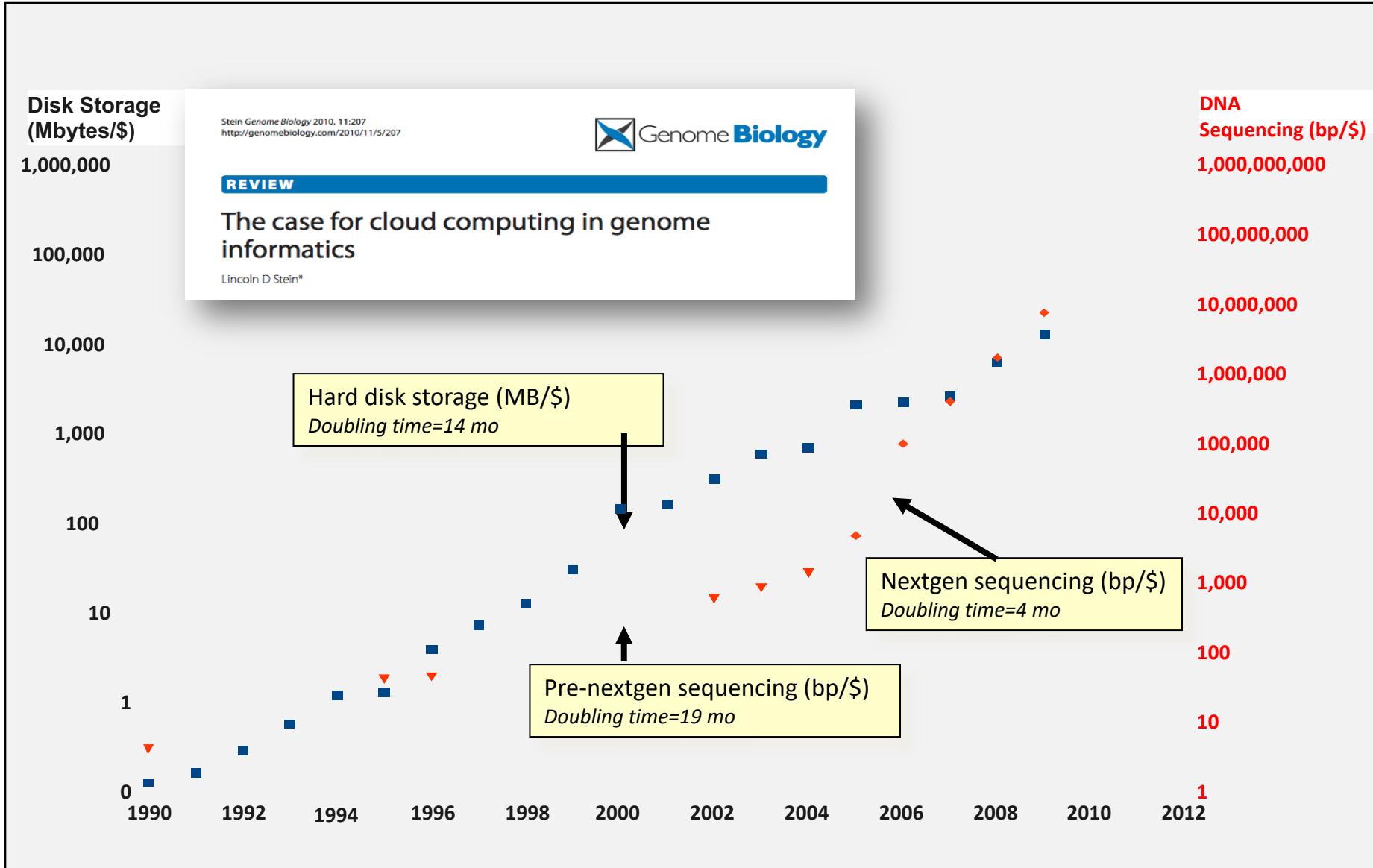
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Learning Objectives

- Introduction to cloud computing concepts
- Introduction to cloud computing providers
- Use the Amazon EC2 console to create an instance for each student
 - Will be used for many hands-on tutorials throughout the course
- How to log into your cloud instance

Disk Capacity vs Sequencing Capacity, 1990-2012



About DNA and computers

- We hit the \$1000 genome* in ~2016
 - Need to think about the \$100 genome
- The doubling time of sequencing has been ~5-6 months.
- The doubling time of storage and network bandwidth is ~12 months.
- The doubling time of CPU speed is ~18 months.
- The cost of sequencing a base pair will eventually equal the cost of storing a base pair

What is the general biomedical scientist to do?

- Lots of data
- Poor IT infrastructure in many labs
- Where do they go?
- Get bigger hardware?
- Write more grants?

Cloud computing providers

- Amazon AWS
 - <https://aws.amazon.com/>
- Google cloud
 - <https://cloud.google.com/>
- Microsoft Azure
 - <https://azure.microsoft.com/en-us/>
- More...

Amazon Web Services (AWS)

- Infinite storage (scalable): S3 (simple storage service)
- Compute per hour: EC2 (elastic cloud computing)
- Ready when you are High Performance Computing
- Multiple football fields of HPC throughout the world



Some of the challenges of cloud computing:

- Not cheap
- Getting files to and from there
- Standardization can be a challenge if you don't control hardware
- PHI: personal health information & security concerns
 - In the USA: HIPAA act, PSQIA act, HITECH act, Patriot act, CLIA and CAP programs, etc.
 - <http://www.biostars.org/p/70204/>

Some of the advantages of cloud computing:

- We received a grant from Amazon, so supported by ‘AWS in Education grant award’.
- There are better ways of transferring large files, and now AWS makes it free to upload files.
- A number of datasets exist on AWS (e.g. 1000 genome data).
- Many useful bioinformatics AMI’s (Amazon Machine Images) exist on AWS: e.g. cloudbiolinux & CloudMan (Galaxy) – now one for this course!
- Many flavors of cloud available, not just AWS

Key AWS concepts and terminology

- **AWS** - Amazon Web Services. A collection of cloud computing services provided by Amazon.
- **EC2** - Elastic Compute. An AWS service that allows you to configure and rent computers to meet your compute needs on an as needed basis.
- **EBS** - Elastic Block Storage. A data storage solution that allows you to rent disk storage and associate that storage with your compute resources. EBS volumes are generally backed by SSD devices.

Key AWS concepts and terminology

- **S3** - Simple storage service. Cheaper than EBS and allows for storage of larger amounts of data with some drawbacks compared to EBS. S3 volumes store data as objects that are accessed by an API or command line interface or other application designed to work with S3. EBS volumes on the other hand can be mounted as if they were a local disk drive associated with the Instance.
- **SSD** - Solid state drive. A particular type of storage hardware that is generally faster and more expensive than traditional hard drives.

What is difference between the 'Start', 'Stop', 'Reboot', and 'Terminate' (Instance States)?

- Start – turn on an EC2 instance that you have previously created
- Stop – turn off an EC2 instance that you have previously created
- Reboot – restart an EC2 instance
- Terminate – permanently stop and destroy an EC2 instance. Any associated EBS volumes may also be destroyed at this time depending on configuration

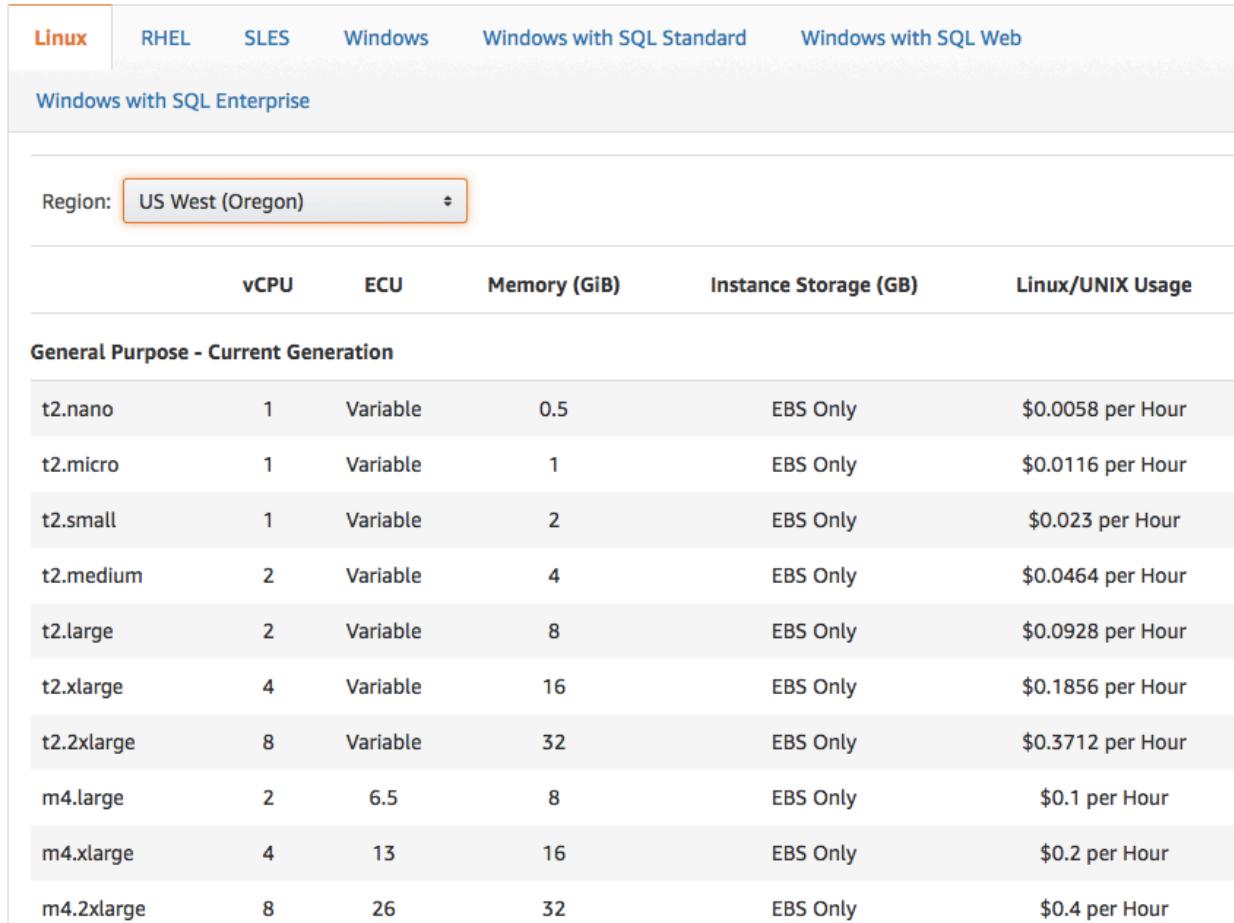
What is an AMI/snapshot?

- AMI (Amazon Machine Image) – a template that specifies how to launch EC2 instances
 - Root volume with operating system (OS), pre-installed applications, etc
 - Launch permissions determine who can use the AMI
 - Specification of (data) volumes to attach when launched
- You can create an AMI for any instance you have created/configured
- AMI can be made public for sharing (region-specific)
- Creating an AMI involves creating a snapshot of the root and any attached volumes. You will be charged to store this snapshot.

I can not log into my EC2 instance, what might have gone wrong?

- Is your instance running?
- Are you providing the correct path to your key file?
- Is it the correct key file?
- Have you set the permissions for your key file correctly?
- Did you specify a valid user for your AMI (e.g., ubuntu)?
- Did you specify the correct IP address?
- Does the Security Group for the instance allow access for your connection protocol (e.g., SSH) and location?

How much does it cost to use AWS EC2 resources?



The screenshot shows the AWS CloudWatch Metrics Insights search interface. At the top, there are tabs for Linux, RHEL, SLES, Windows, Windows with SQL Standard, and Windows with SQL Web. Below these tabs, the Windows with SQL Enterprise tab is selected. A dropdown menu labeled "Region:" shows "US West (Oregon)" with an orange border. The main area displays a table of AWS Lambda metrics. The table has columns for vCPU, ECU, Memory (GiB), Instance Storage (GB), and Linux/UNIX Usage. The rows are grouped under "General Purpose - Current Generation".

	vCPU	ECU	Memory (GiB)	Instance Storage (GB)	Linux/UNIX Usage
General Purpose - Current Generation					
t2.nano	1	Variable	0.5	EBS Only	\$0.0058 per Hour
t2.micro	1	Variable	1	EBS Only	\$0.0116 per Hour
t2.small	1	Variable	2	EBS Only	\$0.023 per Hour
t2.medium	2	Variable	4	EBS Only	\$0.0464 per Hour
t2.large	2	Variable	8	EBS Only	\$0.0928 per Hour
t2.xlarge	4	Variable	16	EBS Only	\$0.1856 per Hour
t2.2xlarge	8	Variable	32	EBS Only	\$0.3712 per Hour
m4.large	2	6.5	8	EBS Only	\$0.1 per Hour
m4.xlarge	4	13	16	EBS Only	\$0.2 per Hour
m4.2xlarge	8	26	32	EBS Only	\$0.4 per Hour

Data transfer (GB): In: free or \$0.01; Out: free, \$0.01 or \$0.02

EBS storage (GB/Month): \$0.10

S3 storage (GB/Month): \$0.023 standard, \$0.0125 infrequent access, or
\$0.004 glacier

Why am I still getting a monthly bill?

- Generally you get an accounting of usage and cost on a 30 day cycle
 - Pricing is per instance-hour (now instance-second!) consumed for each instance type.
 - Also charges for storage, transfers, etc
- Be aware of regions!
- Even when an instance is stopped, storage for root or other EBS volumes persist
- Creating AMIs/snapshots requires storage
- Explore the billing and cost management tools of AWS to track your spending, set warnings, etc

Amazon AWS documentation

https://rnabio.org/module-00-setup/0000/06/01/Intro_to_AWS/

<http://aws.amazon.com/console/>

In this workshop:

- Some tools (data) are
 - on your computer
 - on the web
 - on the cloud.
- You will become efficient at traversing these various spaces, and finding resources you need, and using what is best for you.
- There are different ways of using the cloud:
 1. Command line (like your own very powerful Unix box)
 2. With a web-browser (e.g. Galaxy): not in this workshop

Things we have set up:

- Loaded data files to a web server
- We brought up an Ubuntu (Linux) instance, and loaded a whole bunch of software for NGS analysis.
- We will clone this and create separate instances for everybody in the class.
- We've simplified the security: you basically all have the same login and file access, and opened ports. In your own world you would be more secure.

Logging into Amazon AWS

Go to course wiki, “Log into AWS” page



Log into AWS

[« Introduction to AWS](#)

[Course](#)

[Unix »](#)

Using cloud computing to complete this course involves two major components: (1) Launching an instance on the cloud (essentially renting a virtual computer by the hour and turning it on) and (2) logging into that instance).

Covered in this section: logging into AWS EC2 console, starting an instance from the course AMI, configuring it in the console (select instance AMI, instance type, instance details, storage volumes, tags, security group, and key pairs).



https://rnabio.org/module-00-setup/0000/07/01/Log_into_AWS/

Login to AWS console



Account ID or alias

cshlworkshops

IAM user name

cshl.student

Password

.....

Sign In



[Sign-in using root account credentials](#)

[Forgot password?](#)

<https://cshlworkshops.signin.aws.amazon.com/console>

Select "EC2" service

AWS Management Console

N. Virginia

Stay connected to your resources

Download the AWS Console Mobile App to your iOS or Android mobile device. [Learn more](#)

Explore AWS

Amazon SageMaker Autopilot

Get hands-on with AutoML. [Learn more](#)

AWS Storage Gateway

Get on-premises low latency access to virtually unlimited cloud storage with this hybrid cloud storage service. [Learn more](#)

AWS services

Find Services
You can enter names, keywords or acronyms

EC2

Search for EC2

Recently visited services

- EC2
- Billing
- IAM

All services

Build a solution

Get started with simple wizards and automated workflows.

The screenshot shows the AWS Management Console homepage. A red arrow points to the 'N. Virginia' region selector in the top right corner. Another red arrow points to the search bar where 'EC2' has been typed, with the text 'Search for EC2' overlaid. The 'Recently visited services' section includes links for EC2, Billing, and IAM. The 'Explore AWS' sidebar features links for Amazon SageMaker Autopilot and AWS Storage Gateway.

Launch a new Instance

The screenshot shows the AWS EC2 Dashboard. On the left, there's a sidebar with navigation links like 'EC2 Dashboard', 'Instances', 'Images', and 'Elastic Block Store'. The main area is titled 'Resources' and shows various EC2 metrics: Instances (running) 2, Dedicated Hosts 0, Elastic IPs 0, Instances (all states) 2, Key pairs 5, Load balancers 0, Placement groups 0, Security groups 4, Snapshots 4, and Volumes 3. Below these metrics is a callout box with text about launching Microsoft SQL Server Always On availability groups. At the bottom of the dashboard, there's a section titled 'Launch instance' with a large orange 'Launch instance' button. A red arrow points to this button. A note at the bottom states: 'Note: Your instances will launch in the US East (N. Virginia) Region'.

aws Services ▾

New EC2 Experience Tell us what you think X

EC2 Dashboard New

Events New

Tags

Limits

Instances

- Instances New
- Instance Types
- Launch Templates
- Spot Requests
- Savings Plans
- Reserved Instances
- Dedicated Hosts New
- Scheduled Instances
- Capacity Reservations

Images

- AMIs

Elastic Block Store

Resources

You are using the following Amazon EC2 resources in the US East (N. Virginia) Region:

Instances (running)	2	Dedicated Hosts	0
Elastic IPs	0	Instances (all states)	2
Key pairs	5	Load balancers	0
Placement groups	0	Security groups	4
Snapshots	4	Volumes	3

i Easily size, configure, and deploy Microsoft SQL Server Always On availability groups on AWS using the AWS Launch Wizard for SQL Server. [Learn more](#) X

Launch instance

To get started, launch an Amazon EC2 instance, which is a virtual server in the cloud.

Launch instance ▾

Note: Your instances will launch in the US East (N. Virginia) Region

Account attributes

Supported platforms

- VPC

Default VPC vpc-ad2c8fd7

Settings

EBS encryption

Zones

Default credit specification

Console experiments

Additional information

Getting started guide

Documentation

All EC2 resources

Forums

Choose an AMI – Find the CSHL SEQTEC 2020 AMI in the My AMIs

The screenshot shows the AWS Step 1: Choose an Amazon Machine Image (AMI) interface. The top navigation bar includes the AWS logo, Services dropdown, user information (cshl.student @ cshlworkshops), region (N. Virginia), and Support. Below the navigation, a progress bar shows steps 1 through 7. Step 1 is highlighted with an orange underline.

Step 1: Choose an Amazon Machine Image (AMI)

An AMI is a template that contains the software configuration (operating system, application server, and applications) required to launch your instance. You can select an AMI provided by AWS, our user community, or the AWS Marketplace; or you can select one of your own AMIs.

Search for an AMI by entering a search term e.g. "Windows" X

Search by Systems Manager parameter |< < 1 to 2 of 2 AMIs > >|

Quick Start

My AMIs ←

AWS Marketplace

Community AMIs

Ownership

Owned by me Shared with me

Architecture

32-bit (x86) 64-bit (x86)

AMI Name	AMI ID	Root device type	Virtualization type	Owner	ENA Enabled	Architecture
cshl-seqtec-2019 - ami-018b3bf40f9926ac5	ami-018b3bf40f9926ac5	ebs	hvm	577255725291	Yes	64-bit (x86)
cshl-seqtech-2020 - ami-0cdaba7e6f983f943	ami-0cdaba7e6f983f943	ebs	hvm	577255725291	Yes	64-bit (x86)

Select ←

Choose “m5.2xlarge” instance type, then “Next: Configure Instance Details”.

The screenshot shows the AWS CloudFormation console interface. The top navigation bar includes the AWS logo, Services dropdown, and user information (cshl.student @ cshlworkshops, N. Virginia, Support). Below the navigation is a progress bar with steps 1 through 7. Step 2, "Choose Instance Type", is currently active and underlined. The main content area is titled "Step 2: Choose an Instance Type". A table lists various instance types with their details: name, type, vCPUs, memory, storage, networking, and EBS support. The "m5.2xlarge" row is highlighted with a blue background and has a red arrow pointing to its "EBS only" column. At the bottom are buttons for Cancel, Previous, Review and Launch (which is highlighted in blue), and Next: Configure Instance Details (which is also highlighted in a red box).

<input type="checkbox"/>	m5	m5.large	2	8	EBS only	Yes	Up to 10 Gigabit	Yes
<input type="checkbox"/>	m5	m5.xlarge	4	16	EBS only	Yes	Up to 10 Gigabit	Yes
<input checked="" type="checkbox"/>	m5	m5.2xlarge	8	32	EBS only	Yes	Up to 10 Gigabit	Yes
<input type="checkbox"/>	m5	m5.4xlarge	16	64	EBS only	Yes	Up to 10 Gigabit	Yes
<input type="checkbox"/>	m5	m5.8xlarge	32	128	EBS only	Yes	10 Gigabit	Yes
<input type="checkbox"/>	m5	m5.12xlarge	48	192	EBS only	Yes	10 Gigabit	Yes
<input type="checkbox"/>	m5	m5.16xlarge	64	256	EBS only	Yes	20 Gigabit	Yes
<input type="checkbox"/>	m5	m5.24xlarge	96	384	EBS only	Yes	25 Gigabit	Yes
<input type="checkbox"/>	m5	m5.metal	96	384	EBS only	Yes	25 Gigabit	Yes
<input type="checkbox"/>	m5a	m5a.large	2	8	EBS only	Yes	Up to 10 Gigabit	Yes
<input type="checkbox"/>	m5a	m5a.xlarge	4	16	EBS only	Yes	Up to 10 Gigabit	Yes

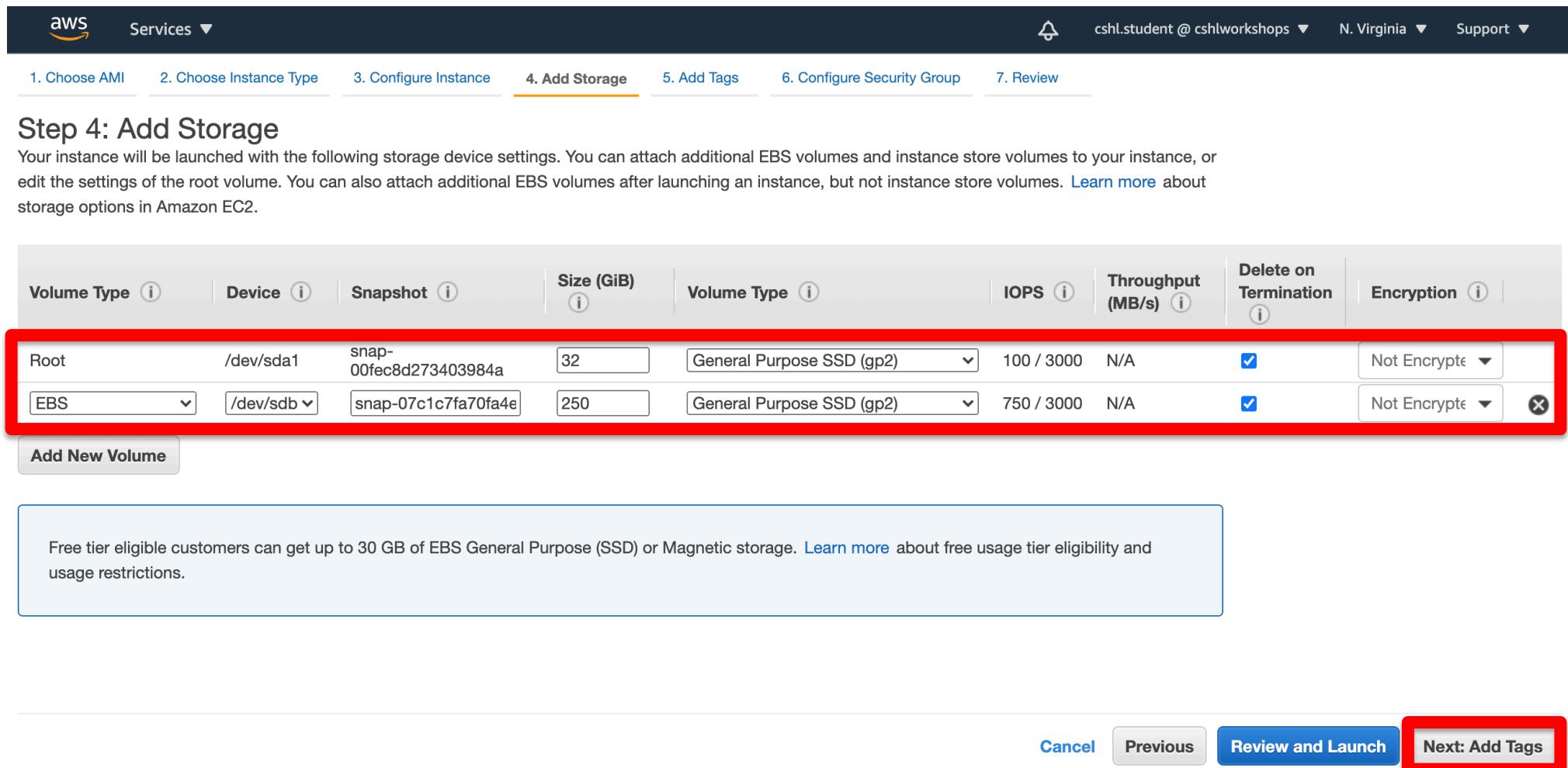
Select "Protect against accidental termination", then "Next: Add Storage".

The screenshot shows the AWS CloudFormation console during the 'Step 3: Configure Instance Details' phase of a new stack creation. The top navigation bar includes the AWS logo, 'Services ▾', a user dropdown ('cshl.student @ cshlworkshops'), a region dropdown ('N. Virginia'), and a 'Support ▾' link. Below the navigation, a progress bar indicates steps 1 through 7: '1. Choose AMI', '2. Choose Instance Type', '3. Configure Instance' (which is active and highlighted in orange), '4. Add Storage', '5. Add Tags', '6. Configure Security Group', and '7. Review'. The main content area is titled 'Step 3: Configure Instance Details'. It contains several configuration sections:

- Auto-assign Public IP:** Set to 'Use subnet setting (Enable)'.
- Placement group:** Has an unchecked checkbox for 'Add instance to placement group'.
- Capacity Reservation:** Set to 'Open'.
- Domain join directory:** Set to 'No directory' with a 'Create new directory' button.
- IAM role:** Set to 'None' with a 'Create new IAM role' button. A red box surrounds this section, and a red warning message at the bottom states: '⚠ You do not have permissions to list instance profiles. Contact your administrator, or check your IAM permissions.'
- CPU options:** Has an unchecked checkbox for 'Specify CPU options'.
- Shutdown behavior:** Set to 'Stop'.
- Stop - Hibernate behavior:** Has an unchecked checkbox for 'Enable hibernation as an additional stop behavior'.
- Enable termination protection:** Has a checked checkbox for 'Protect against accidental termination'. A large red arrow points to this checkbox.
- Monitoring:** Has an unchecked checkbox for 'Enable CloudWatch detailed monitoring' with a note: 'Additional charges apply.'
- EBS-optimized instance:** Has a checked checkbox for 'Launch as EBS-optimized instance'.

At the bottom right, there are four buttons: 'Cancel', 'Previous', 'Review and Launch' (which is highlighted in blue), and 'Next: Add Storage' (which is also highlighted with a red box).

You should see "snap-xxxxxxx" (32GB) and "snap-xxxxxxx" (250GB) as the two storage volumes selected. Then, "Next: Tag Instance"



The screenshot shows the AWS EC2 instance creation wizard at Step 4: Add Storage. The top navigation bar includes the AWS logo, Services dropdown, user account (cshl.student @ cshlworkshops), region (N. Virginia), and Support. Below the navigation is a progress bar with steps 1 through 7. The current step, 4. Add Storage, is highlighted with an orange underline.

Step 4: Add Storage

Your instance will be launched with the following storage device settings. You can attach additional EBS volumes and instance store volumes to your instance, or edit the settings of the root volume. You can also attach additional EBS volumes after launching an instance, but not instance store volumes. [Learn more](#) about storage options in Amazon EC2.

The main table lists storage volumes:

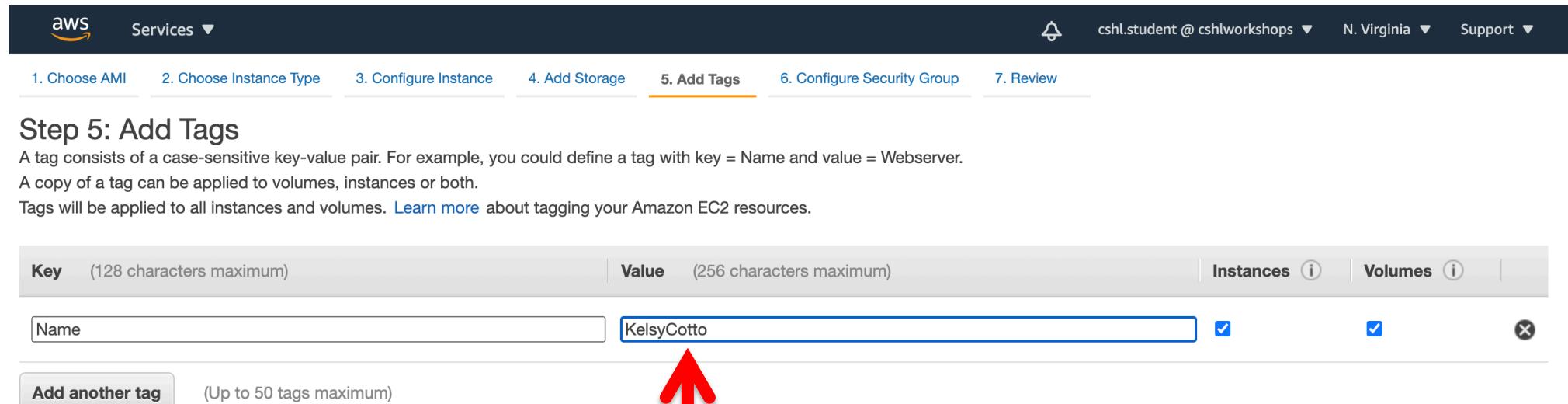
Volume Type	Device	Snapshot	Size (GiB)	Volume Type	IOPS	Throughput (MB/s)	Delete on Termination	Encryption
Root	/dev/sda1	snap-00fec8d273403984a	32	General Purpose SSD (gp2)	100 / 3000	N/A	<input checked="" type="checkbox"/>	Not Encrypted
EBS	/dev/sdb	snap-07c1c7fa70fa4e	250	General Purpose SSD (gp2)	750 / 3000	N/A	<input checked="" type="checkbox"/>	Not Encrypted

A red box highlights the second row (EBS volume). Below the table is a button labeled "Add New Volume".

Note: Free tier eligible customers can get up to 30 GB of EBS General Purpose (SSD) or Magnetic storage. [Learn more](#) about free usage tier eligibility and usage restrictions.

At the bottom right are buttons: Cancel, Previous, Review and Launch (blue), and Next: Add Tags (red).

Create a tag like “Name=KelsyCotto” [use your own name]. Then hit “Next: Configure Security Group”.



The screenshot shows the AWS EC2 instance creation wizard at Step 5: Add Tags. The navigation bar includes links for Choose AMI, Choose Instance Type, Configure Instance, Add Storage, Add Tags (which is highlighted), Configure Security Group, and Review. The main section is titled "Step 5: Add Tags" with instructions about tag keys and values. It shows a table with one tag entry: Key "Name" and Value "KelsyCotto". Buttons for adding more tags and reviewing the launch configuration are visible. A large red arrow points to the Value input field.

Step 5: Add Tags

A tag consists of a case-sensitive key-value pair. For example, you could define a tag with key = Name and value = Webserver.

A copy of a tag can be applied to volumes, instances or both.

Tags will be applied to all instances and volumes. [Learn more](#) about tagging your Amazon EC2 resources.

Key	(128 characters maximum)	Value	(256 characters maximum)	Instances	Volumes	
Name		KelsyCotto		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="button" value="X"/>

Add another tag (Up to 50 tags maximum)

Important: Don't forget to name your instance! (FirstnameLastname)

Cancel Previous Review and Launch Next: Configure Security Group

Select an Existing Security Group, choose "SSH_HTTP". Then hit "Review and Launch".

The screenshot shows the AWS EC2 instance creation wizard at Step 6: Configure Security Group. The navigation bar includes links for Choose AMI, Choose Instance Type, Configure Instance, Add Storage, Add Tags, Configure Security Group (which is highlighted), and Review. The main content area is titled "Step 6: Configure Security Group" and describes security groups as sets of firewall rules. It mentions creating a new security group or selecting an existing one. Below this, there's a table showing existing security groups:

Security Group ID	Name	Description	Actions
sg-384f5b79	default	default VPC security group	Copy to new
sg-0087dc3a8b6e37a2d	SSH and HTTP	created 2019-11-08T09:43:29.293-05:00	Copy to new

A red arrow points to the radio button labeled "Select an existing security group". Another red arrow points to the row for the "SSH and HTTP" security group, which has a blue selection box next to its ID.

Below the table, it says "Inbound rules for sg-0087dc3a8b6e37a2d (Selected security groups: sg-0087dc3a8b6e37a2d)". The inbound rules table shows:

Type	Protocol	Port Range	Source	Description
HTTP	TCP	80	0.0.0.0/0	
HTTP	TCP	80	::/0	
SSH	TCP	22	0.0.0.0/0	

At the bottom right, there are buttons for Cancel, Previous, and Review and Launch, with the latter being highlighted by a red box.

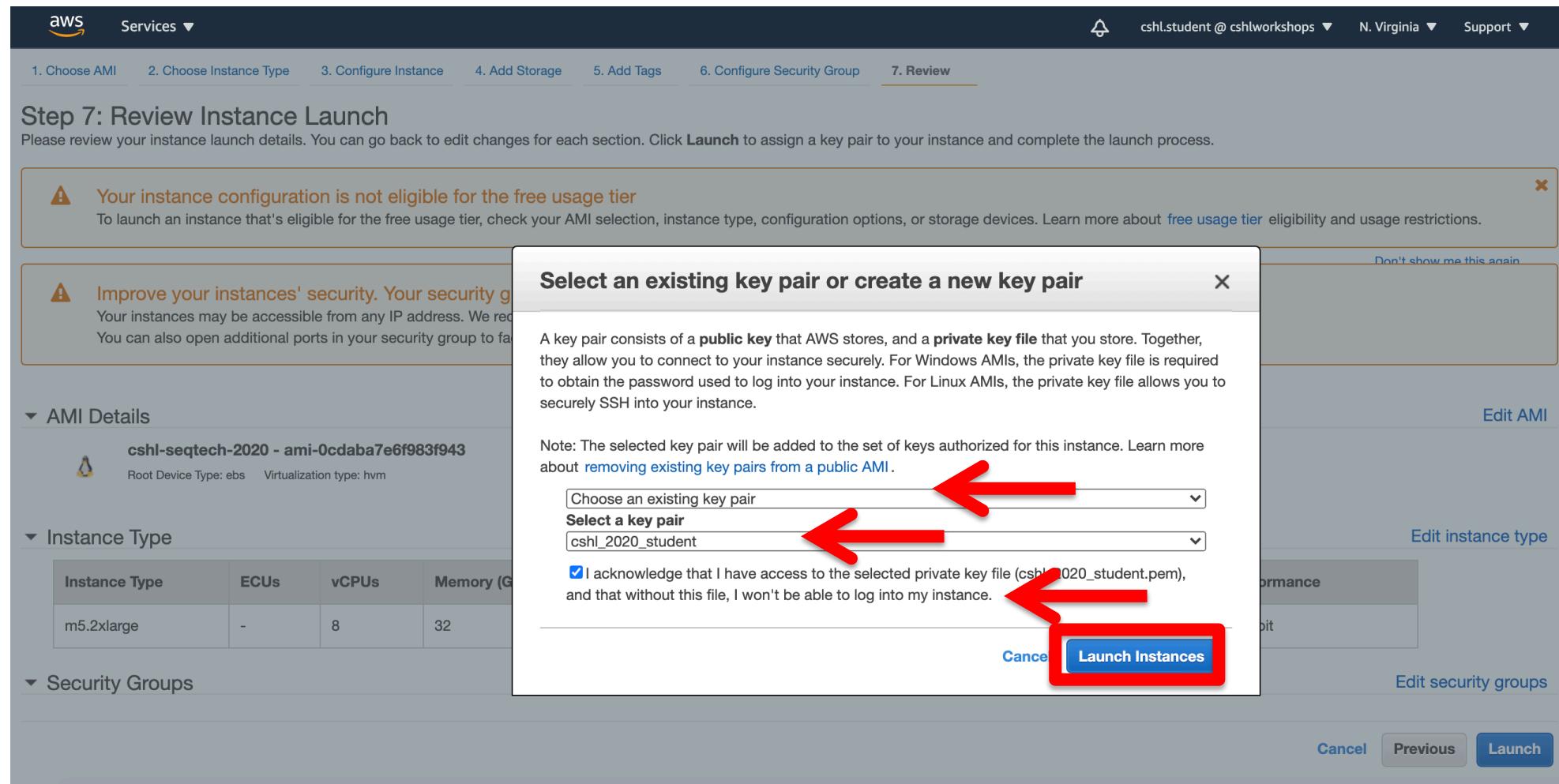
Review the details of your instance, note the warnings, then hit Launch

The screenshot shows the AWS Step 7: Review Instance Launch page. At the top, a navigation bar includes the AWS logo, Services dropdown, and user information (cshl.student @ cshlworkshops, N. Virginia, Support). Below the navigation, a progress bar shows steps 1 through 7, with step 7 highlighted. The main content area is titled "Step 7: Review Instance Launch" and contains instructions: "Please review your instance launch details. You can go back to edit changes for each section. Click **Launch** to assign a key pair to your instance and complete the launch process." Two warning messages are displayed in red-bordered boxes:

- Your instance configuration is not eligible for the free usage tier**
To launch an instance that's eligible for the free usage tier, check your AMI selection, instance type, configuration options, or storage devices. Learn more about [free usage tier](#) eligibility and usage restrictions.
- Improve your instances' security. Your security group, SSH and HTTP, is open to the world.**
Your instances may be accessible from any IP address. We recommend that you update your security group rules to allow access from known IP addresses only.
You can also open additional ports in your security group to facilitate access to the application or service you're running, e.g., HTTP (80) for web servers. [Edit security groups](#)

Below the warnings, the "AMI Details" section is expanded, showing the AMI selected: "cshl-seqtech-2020 - ami-0cdaba7e6f983f943". A red arrow points to this section. The "Instance Type" section is also expanded, showing the configuration for an "m5.2xlarge" instance. A red arrow points to this section. The "Security Groups" section shows a single group named "SSH and HTTP" with a description of "created 2019-11-08T09:43:29.293-05:00". The bottom right corner features three buttons: "Cancel", "Previous", and a large blue "Launch" button, which is also highlighted with a red border.

Choose an existing key pair: "cshl_2020_student" and then Launch.



View Instances to see your new instance spinning up!

The screenshot shows the AWS Launch Status page. At the top, there's a navigation bar with the AWS logo, 'Services' dropdown, 'Resource Groups' dropdown, a star icon, a bell icon, user information 'cshl.student @ cshlworkshops', location 'N. Virginia', and a 'Support' dropdown.

The main content area is titled 'Launch Status'. It contains a green box with a checkmark icon and the text 'Your instances are now launching'. Below this, it says 'The following instance launches have been initiated: i-08e73e43f17783273' and a 'View launch log' link.

Below this is a blue box with an info icon and the text 'Get notified of estimated charges'. It includes a link to 'Create billing alerts' and a descriptive text about receiving email notifications for estimated charges.

A section titled 'How to connect to your instances' follows. It explains that instances are launching and may take a few minutes to reach the 'running' state. It suggests clicking 'View Instances' to monitor status and provides a link to find out how to connect.

Under 'Helpful resources', there are two columns of links:

- How to connect to your Linux instance
- Learn about AWS Free Usage Tier
- Amazon EC2: User Guide
- Amazon EC2: Discussion Forum

At the bottom, there are links for creating status check alarms, attaching EBS volumes, managing security groups, and a prominent red 'View Instances' button.

Find YOUR instance, select it, and then hit connect for instructions on how to connect (It may take some time for your instance to be ready)

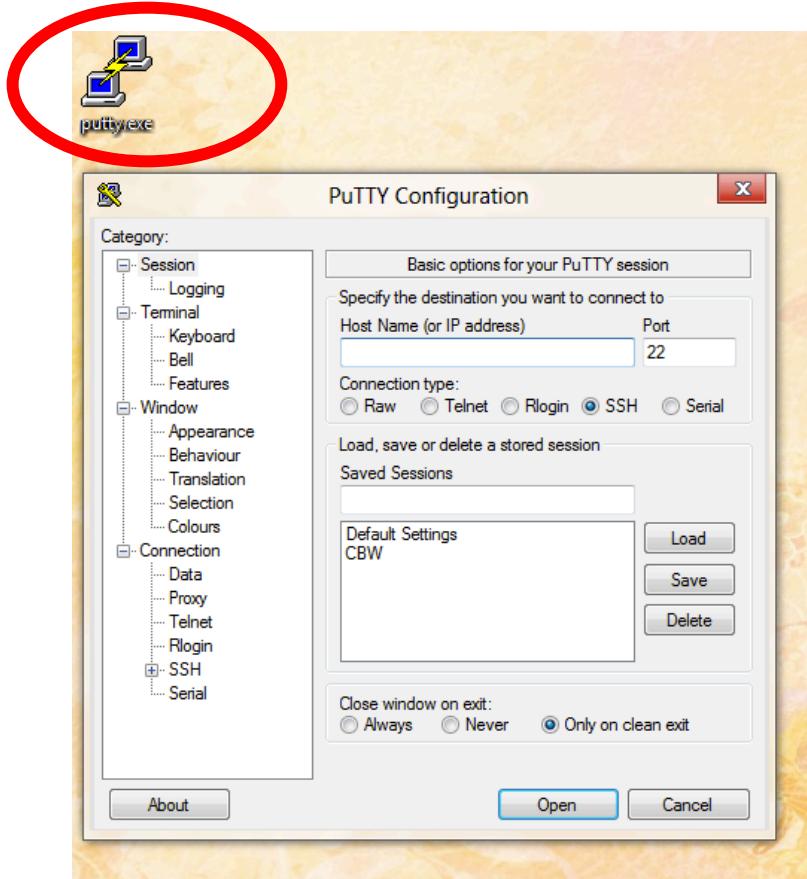
The screenshot shows the AWS EC2 Instances page. On the left, there's a navigation sidebar with various links like EC2 Dashboard, Events, Tags, Limits, Instances, Images, and Elastic Block Store. The 'Instances' link is underlined, indicating it's selected. The main content area shows a table of instances with columns: Name, Instance ID, Instance state, Instance type, Status check, Alarm status, Availability Zone, and Public IPv4 DNS. Three instances are listed: 'test_login_in...', 'instructor_in...', and 'KelsyCotto'. The 'KelsyCotto' row is highlighted with a blue selection bar and has a red arrow pointing to it from the left. Above the table, there's a 'Connect' button with a red box around it. Below the table, there's a detailed view for the selected instance 'KelsyCotto' (i-0b012943b3ce51aee). This view includes tabs for Details, Security, Networking, Storage, Status Checks, Monitoring, and Tags. The 'Details' tab is active. Under 'Instance summary', there are sections for Instance ID (i-0b012943b3ce51aee), Instance state (Running), and Instance type (m5.2xlarge). To the right, there are sections for Public IPv4 address (100.24.122.188), Public IPv4 DNS (ec2-100-24-122-188.compute-1.amazonaws.com), Private IPv4 addresses (172.31.72.162), Private IPv4 DNS (ip-172-31-72-162.ec2.internal), and VPC ID (vpc-ad2c8fd7). A red arrow points to the '100.24.122.188 | open address' link.

Take note of your Public DNS/IP and the instructions on changing permissions for the key file (Note, we will login as ubuntu NOT root)

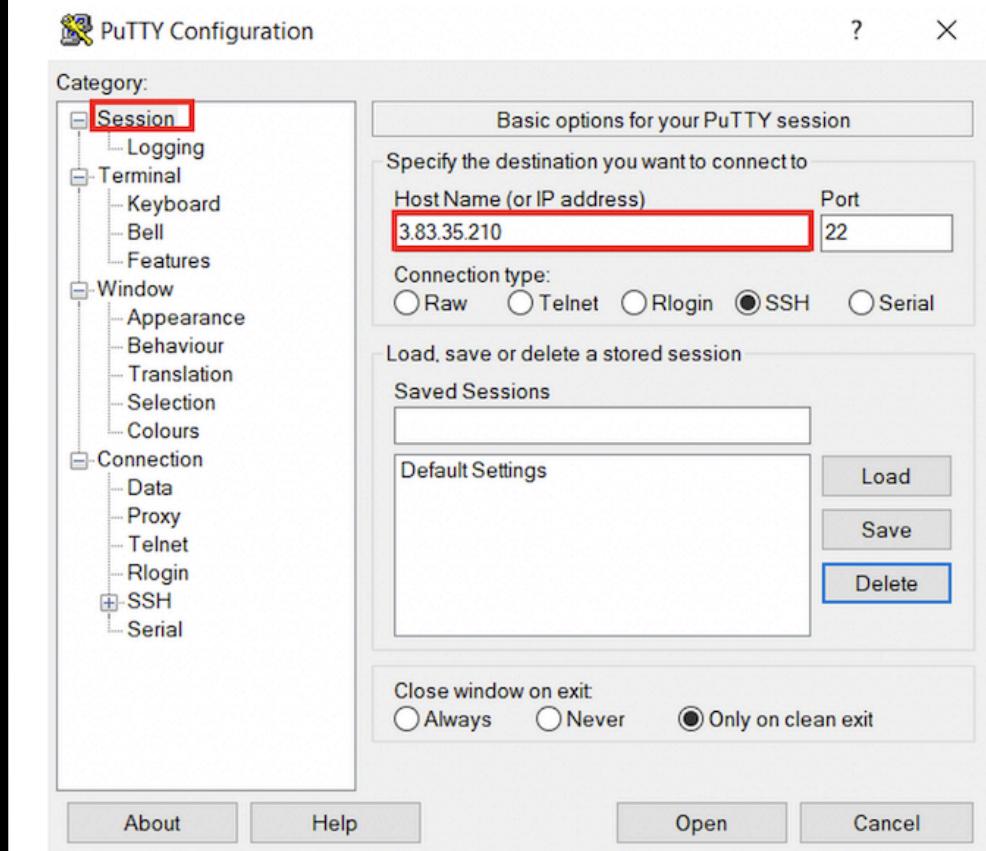
The screenshot shows the AWS EC2 'Connect to instance' interface. At the top, there's a navigation bar with the AWS logo, 'Services ▾', a bell icon, 'cshl.student @ cshlworkshops ▾', 'N. Virginia ▾', and 'Support ▾'. Below the navigation, the path 'EC2 > Instances > i-0b012943b3ce51aee > Connect to instance' is visible. The main section is titled 'Connect to instance' with a blue 'Info' link. It says 'Connect to your instance i-0b012943b3ce51aee (KelsyCotto) using any of these options'. There are three tabs: 'EC2 Instance Connect', 'Session Manager', and 'SSH client', with 'SSH client' highlighted in orange and a red arrow pointing to it. Below the tabs, the 'Instance ID' is listed as 'i-0b012943b3ce51aee (KelsyCotto)'. A numbered list provides instructions: 1. Open an SSH client. 2. Locate your private key file. The key used to launch this instance is 'cshl_2020_student.pem'. 3. Run this command, if necessary, to ensure your key is not publicly viewable. A checkbox is shown for 'chmod 400 cshl_2020_student.pem'. 4. Connect to your instance using its Public DNS. A checkbox is shown for 'ec2-3-237-46-215.compute-1.amazonaws.com'. An 'Example:' section shows the command: 'ssh -i "cshl_2020_student.pem" root@ec2-3-237-46-215.compute-1.amazonaws.com'. At the bottom right of the main window is a 'Cancel' button.

Logging into your instance (Windows)

Open PuTTY

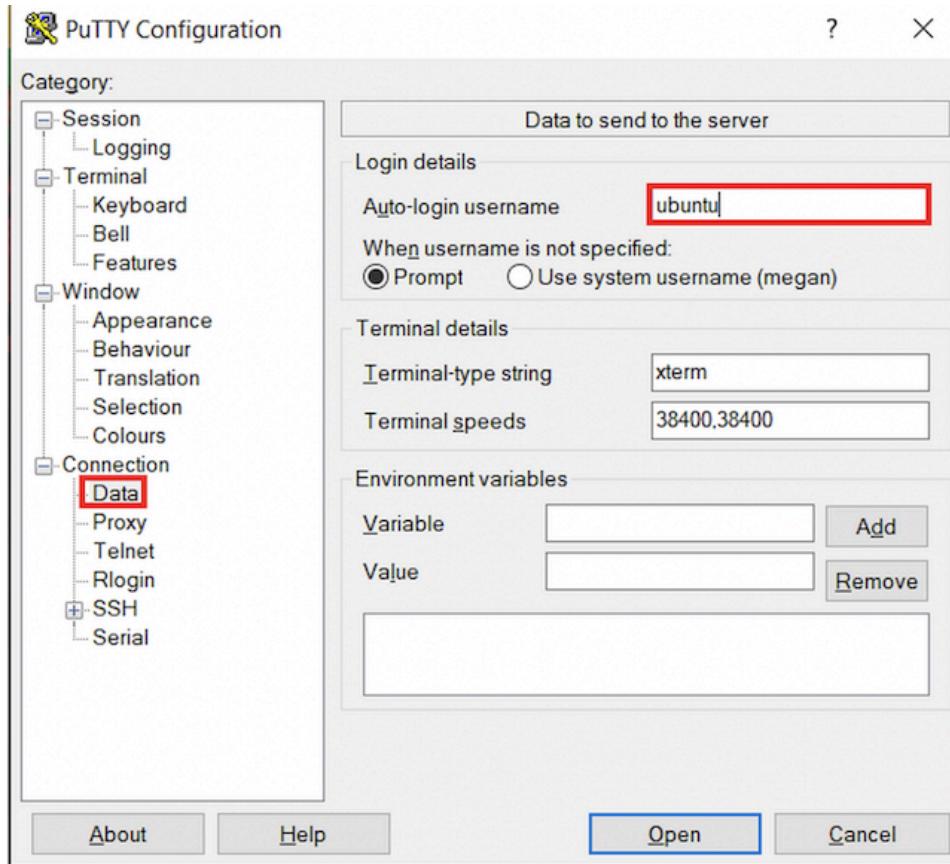


Enter the Host Name (IP address)

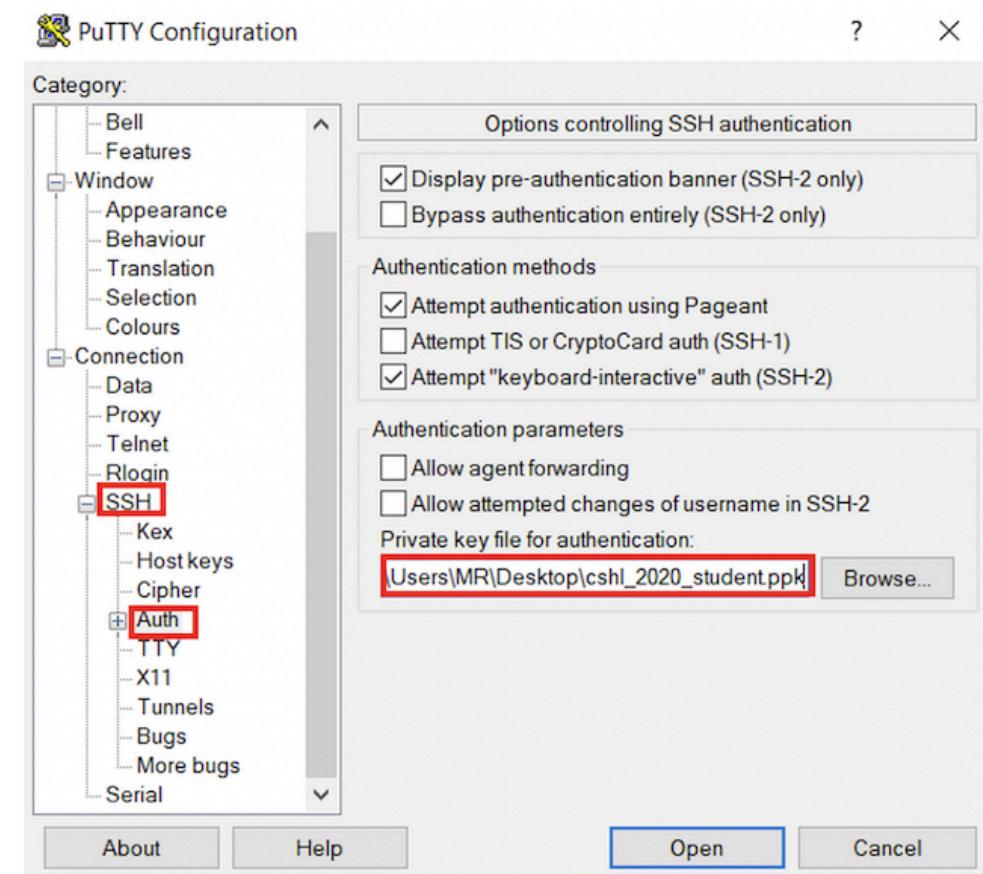


Logging into your instance (Windows)

Choose Connection -> Data
Enter the username 'ubuntu'



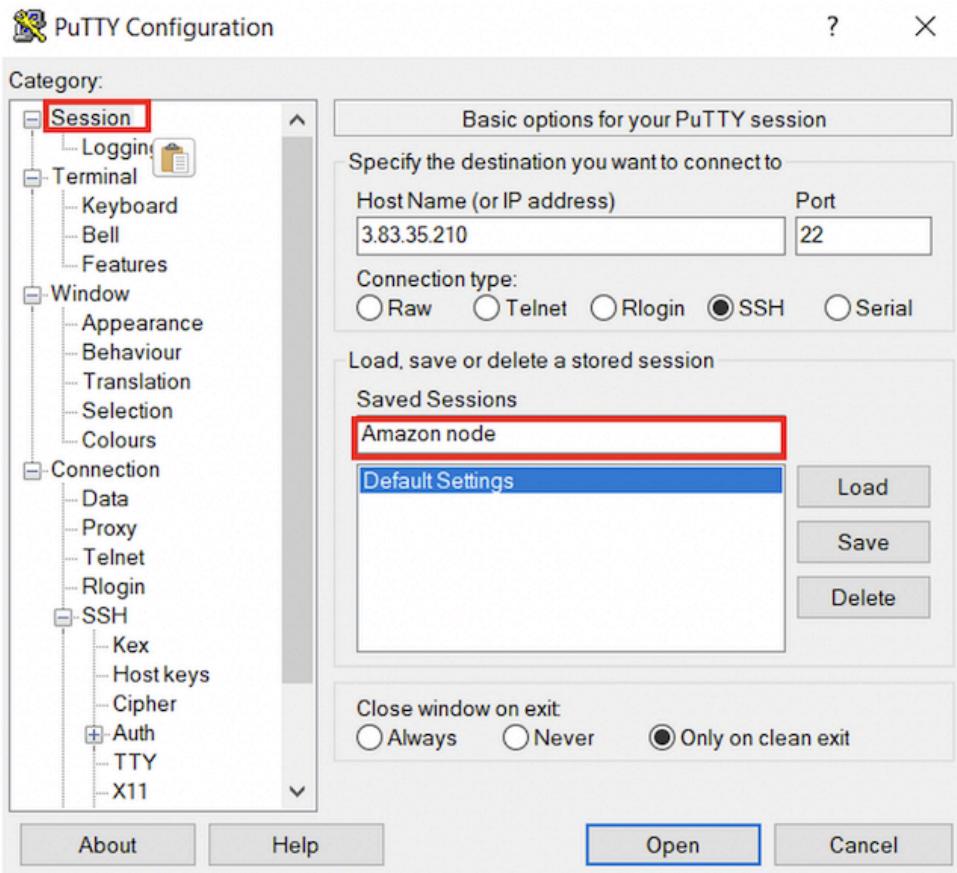
Choose SSH -> Auth
Browse to Private key (ppk) file



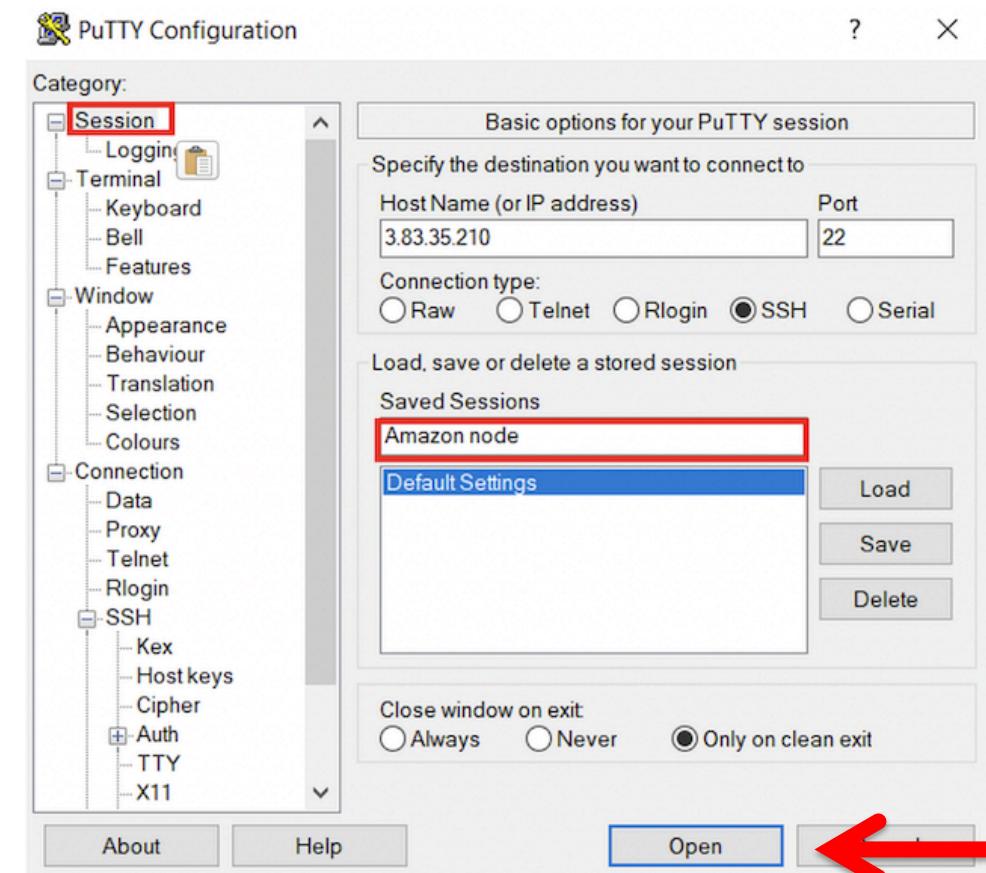
Logging into your instance (Windows)

Choose Session

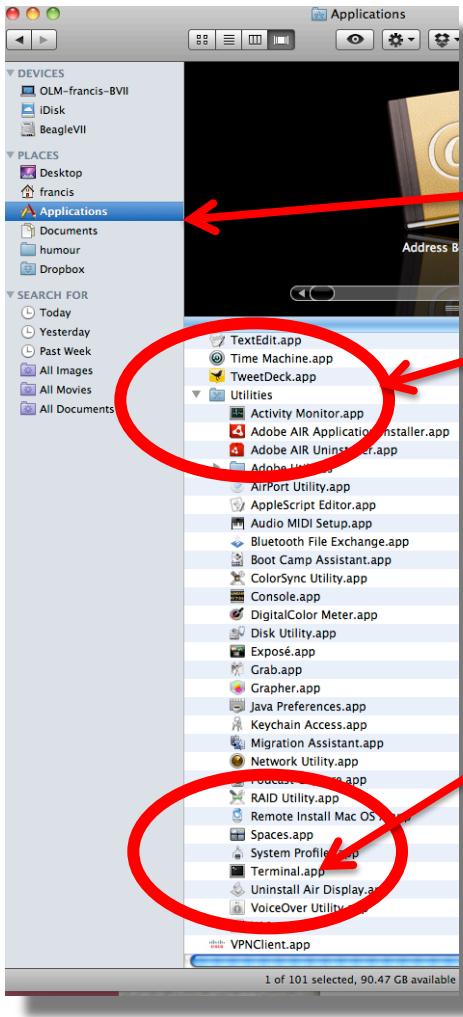
Save your session as "Amazon Node"



Double-click saved “Amazon Node” session OR
Select “Amazon Node” session and click Open



Logging into your instance (Mac)

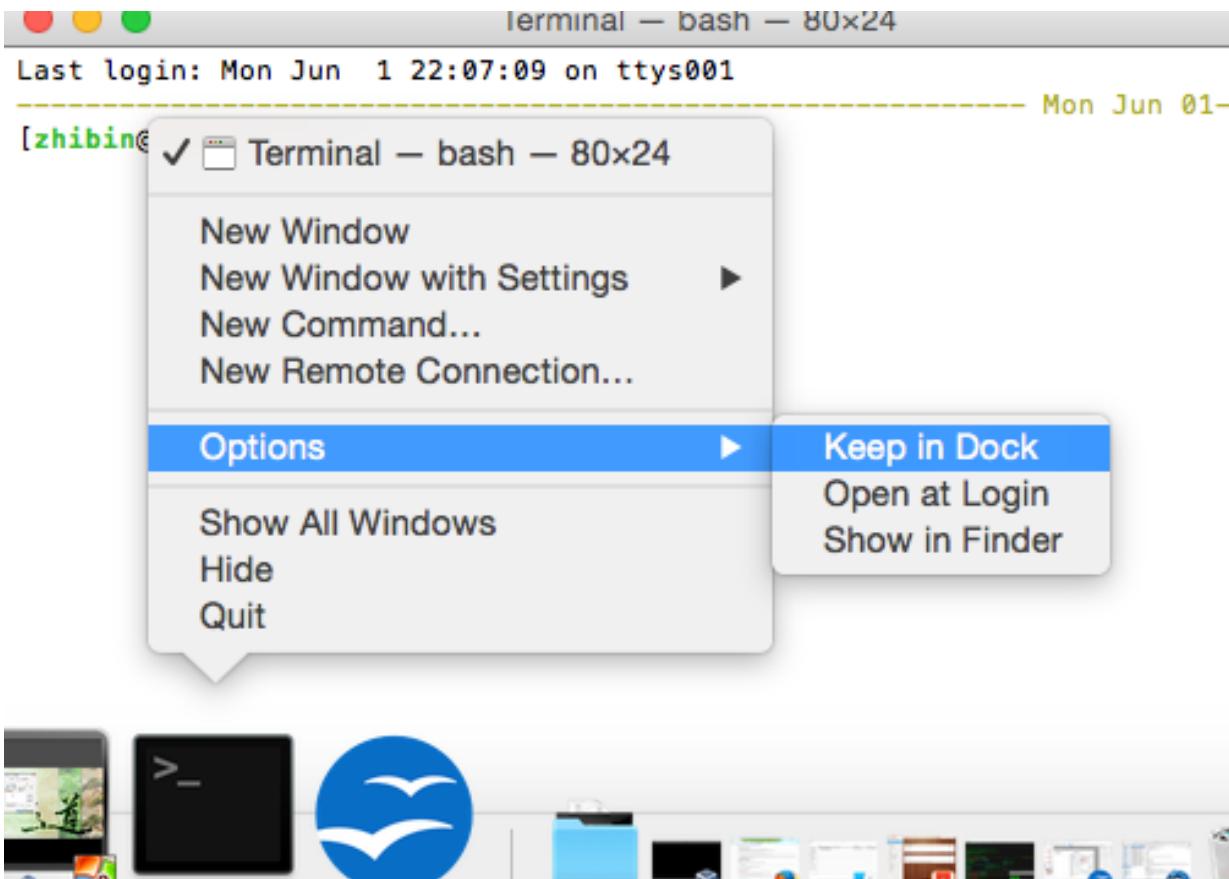


In a Finder window
'Applications' -> 'Utilities' -> 'Terminal'



Or on your dock

Add the terminal App to your dock



Creating a working directory on your Mac called ‘cshl’

```
obis-air:~ ogriffit$ pwd
/Users/ogriffit
obis-air:~ ogriffit$ ls
Applications   Desktop      Dropbox      Movies       Public      gittemp     temp
Attachments    Documents    Google Drive  Music        bin         igv
Box Sync       Downloads    Library      Pictures    git         ncbi
obis-air:~ ogriffit$ mkdir cshl
obis-air:~ ogriffit$ cd cshl
obis-air:cshl ogriffit$ ls -la
total 0
drwxr-xr-x  2 ogriffit  staff   68 Nov 13 22:18 .
drwxr-xr-x+ 58 ogriffit  staff  1972 Nov 13 22:18 ..
obis-air:cshl ogriffit$ █
```

mkdir cshl
cd cshl

Obtain the course SSH key file

- NOTE for Mac users. You will need to use a “.pem” file
- **NOTE for Windows Users.** You will need to use a “.ppk” file instead.
 - This is created from the “.pem” file.
 - <https://aws.amazon.com/premiumsupport/knowledge-center/convert-pem-file-into-ppk/>
- The SSH key file will be used to securely login to your student instance on the cloud

Save the pem/ppk file you received via email/slack to your new cshl folder

Viewing the ‘key’ file once downloaded

`cat cshl_2020_student.pem`

```
Kelsys-MacBook-Pro:keys kcotto$ cat cshl_2019_student.pem
-----BEGIN RSA PRIVATE KEY-----
MIIEpAIBAAKCAQEAgGtpnqERtEu/SCmeF2r1HMESMao0fEJiAwQwk2/SNXK8izr0IH0zTVvmE1D
VUwWq7pkvhjh05pDb+2U9HiZe3sxLv3S1NrkATYF/NsrpwB+q1vwqzGW9sQ6uj45RWrPkiZlsaj
TQZmyFRu+t1JTRU3hQDqA0MRWTx1Wxv0gFzuZy/qb+DALuFQsInrEKnijrwdLmd6usaBTvhc0gFS
B9oEelH0bZHJTZFW/wP+Z0uZq0Ujir7Qw0LTM45QH/L0dBdUl3k/mBeez00yvnKMwj8E4Xi0rQ0t
hHtQ7F9iSILK80W1rRH0qwxwt9ycEH1JtNMQmUTif0vE2XJ6l06chQIDAQABAoIBABG7P/FHu/Qp
WFgg+89myuqR6GvA2X55CFSzFyG0aQyrj5jDleFtdu2uXiISG8gUBZYvlzxx82aOC0P5j04SBq0
xD/qRlukY/jyXyPn77w/ExmaNoLJjl1W9RUSH0JYLIzVpFPGes3u5zGSGDTSDNh3sSdWhq1FX3l
7vY5b6UAQgahXf0dpGFxt6P6qb/BKFQFsThXk7GXMyS/kr4w7ZlhPWHRMSu2UBdS/a/beAVN76qU
E/10HR30oAuqghusZabpbX7MJl00VcviaQgeF8Z+xf2uugDEAKut1PxW0+yvGM4SpZZ0skFZz6YI
pBnX4ELWPhCeMzq4M18QY6ptR2UCgYEAc6YfNlymg24NJu8PANx8navTi50WYuXWXrj0mrLr3SR
/XY+w26cgipM+K5eQfxSr4Yb8BQKjRktMzBzf5nKdaX4pzYIquQH02B0HDhTooHAhkbTMTmKukv4
oEW06wcEE6RQi fw4xbMEnfQfHJBI21am+jwI8Xb7idwMG4pU/nsCgYEAtD0x4bNC1X3A5by50uY0
WXrtgQszCXycbkrpbjRET12f9hgz9MRMHY/xH/XGvMutZSFV2rCZRwd7lm+QWGadk/MQS0kouzW6
gSasyjFq+MKCkqYnS3/JTbx8yrLZmzl0LtX6pwmwg0Zy8aJjYHo9a2/EI8Tjh2d0SxeadIRVYP8C
gYAToiXww1Vdu+dj/7TDLqYCdHOVAxJX/utI9Q3yoIryuh+bWmFvEIvAmIGXyyQZRyoZwgIS4A
PNH03+bEa+69wbzlhksiK5g8GKgISVdLC4rZZXB5ehgTmWV7IgJ89y/SF4G/Ityo30K0ohALh597
NcvNEzzqrutja1IIMvTKMwKBgQCkM+QP1Tqc0TbVlfvClviXuJBLsiJLCImYeZL0nZVmIMusbhxX
b8ZQYGSyUz09nulXau1G1QDvXvf089CzWL1SomxBoHlFJQvGwa9FfYQRIVPHuqut8rs4oPGn0QzC
h7M7QCJcr00oAcrSLLkQmgz+phIw7BzFr039J4HFiRIInjQKBgQCtdEvcbtyk8Jh4WH3z0wpkc43f
U8DZhZwjRQpGWlD8CPj9RgRnE4+1PCH6s/RLQf7SiE1ZjX/0Ud0WPEvr0j5sVjy0IujohRbty0CM
oqWeSeUb1sLogRvMrTfCEpl/rz3GpoQ1SC/5s6XvjnnKK8RN8s7MseLuuJ63T/CRBpIs8A==
-----END RSA PRIVATE KEY-----Kelsys-MacBook-Pro:keys kcotto$
```

Changing file permissions of your ‘key’ file (Mac/Linux)

ls -l (long listing)

```
-rw-r--r--@ 1 kcotto staff 1696 Nov 9 09:19 cshl_2020_student.pem
```

 rwx : owner

 rwx : group

 rwx: world

 r read (4)

 w write (2)

 x execute (1)

Which ever way you add these 3 numbers, you know which integers were used (6 is always 4+2, 5 is 4+1, 4 is by itself, 0 is none of them etc ...)

So, when you have:

chmod 400 <file name>

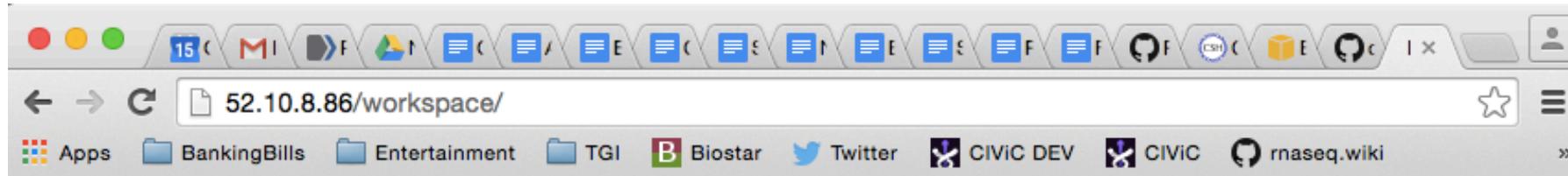
It is “r” for the the file owner **only**

Logging into your instance

Mac/Linux

```
cd ~/cshl  
chmod 400 cshl_2020_student.pem  
ssh -i cshl_2020_student.pem ubuntu@[YOUR PUBLIC IP]
```

Copying files from AWS to your computer (using a web browser)



Index of /workspace

<u>Name</u>	<u>Last modified</u>	<u>Size</u>	<u>Description</u>
Parent Directory		-	
Homo_sapiens/	2015-11-13 06:45	-	
README.txt	2014-06-17 23:53	5.3K	
bam-demo/	2015-11-14 21:03	-	
data/	2015-11-13 01:39	-	
scratch/	2015-11-13 19:43	-	
tools/	2015-11-13 01:54	-	

Apache/2.4.7 (Ubuntu) Server at 52.10.8.86 Port 80

[http://\[YOUR PUBLIC DNS OR IP\]/](http://[YOUR PUBLIC DNS OR IP]/)

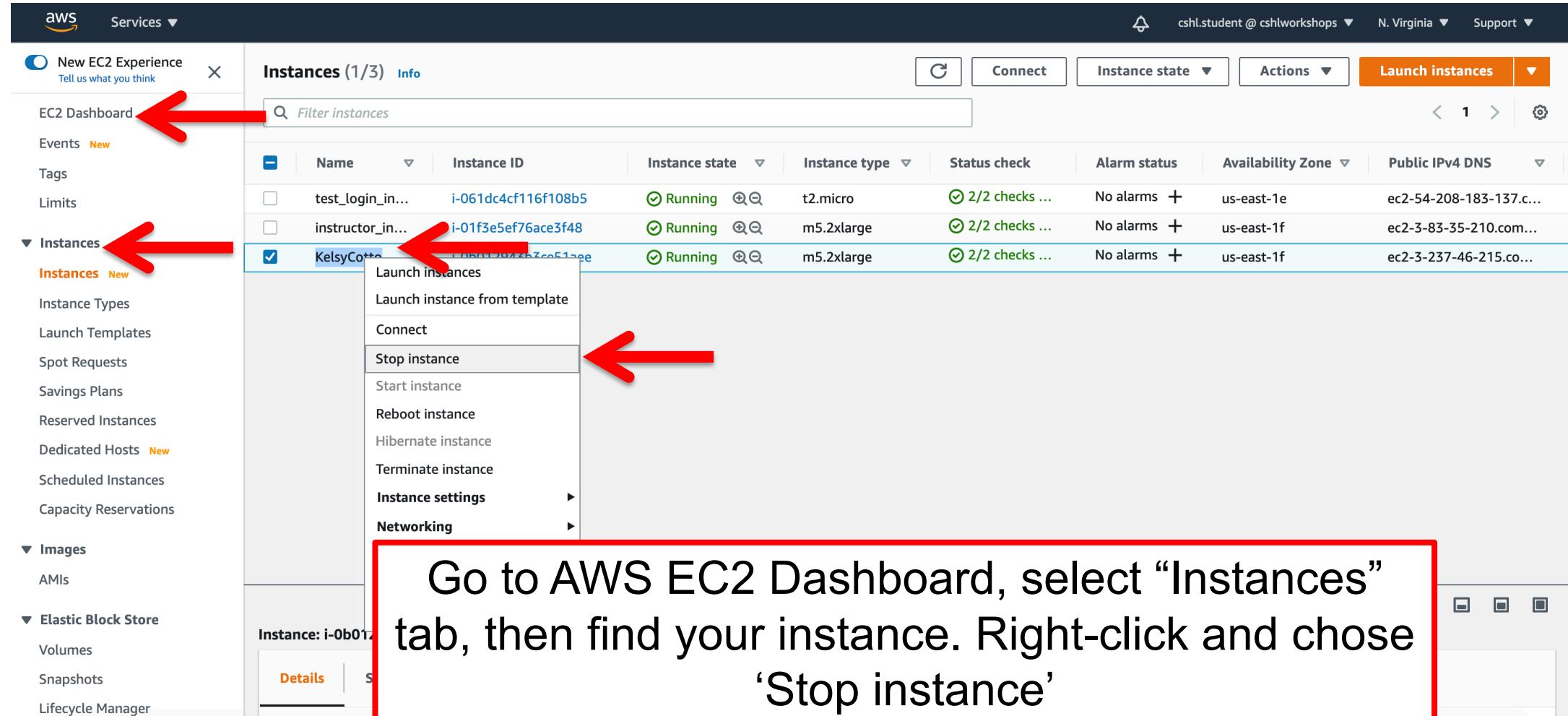
Logging out of your instance

Mac/Linux – simply type exit

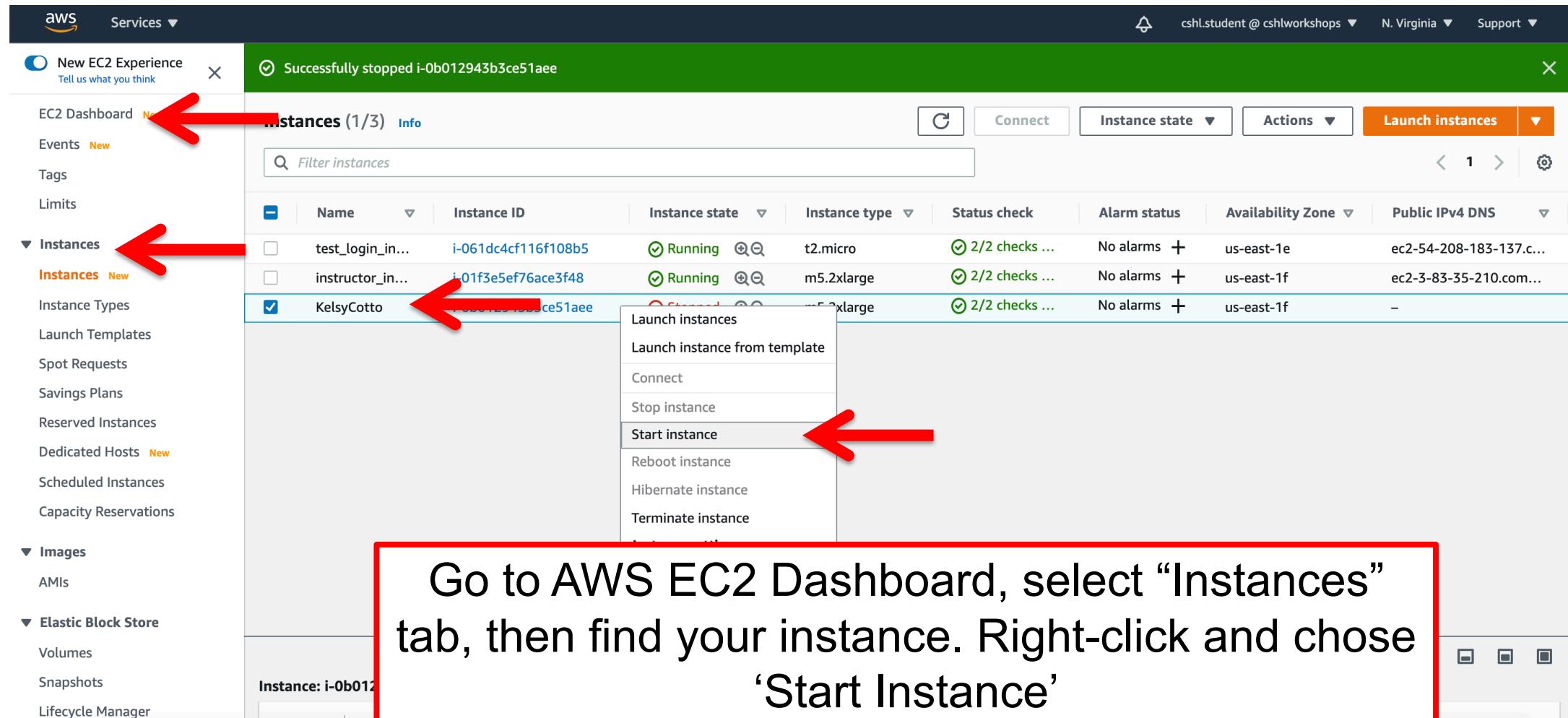
exit

Note, this disconnects the terminal session (ssh connection) to your cloud instance. But, your cloud instance is still running! See next slide for how to stop your instance.

When you are done for the day you can “Stop” your instance – Don’t Terminate!



Next morning, you can “Start” your instance again



When you restart your instance you will need to find your new Public DNS or IP address. Select your instance and “Connect” or look in Description tab. Then go back to instructions for “Logging into your instance”

The screenshot shows the AWS EC2 Instances page. On the left, there's a sidebar with various navigation links like EC2 Dashboard, Events, Tags, Limits, Instances, Images, and Elastic Block Store. The Instances section is expanded, showing sub-links for Instances, Instance Types, Launch Templates, Spot Requests, Savings Plans, Reserved Instances, Dedicated Hosts, Scheduled Instances, and Capacity Reservations. The main content area shows a table of instances with columns for Name, Instance ID, Instance state, Instance type, Status check, Alarm status, Availability Zone, and Public IPv4 DNS. One instance, 'KelsyCotto' (Instance ID i-0b012943b3ce51aee), is selected and highlighted with a blue border. A red arrow points to the 'Connect' button in the top right of the instance row. Below the table, a detailed view for the selected instance is shown. This view includes tabs for Details, Security, Networking, Storage, Status Checks, Monitoring, and Tags. The Details tab is active. Under the Instance summary section, the Public IPv4 address is listed as 100.24.122.188 with a link to open the address. Another red arrow points to this link. Other details shown include Instance ID (i-0b012943b3ce51aee), Instance state (Running), Instance type (m5.2xlarge), and VPC ID (vpc-ad2c8fd7). To the right, Private IPv4 addresses (172.31.72.162) and Private IPv4 DNS (ip-172-31-72-162.ec2.internal) are listed.

So, at this point:

- Your laptop/pc is ready for the workshop
- If it is not, you know where to get the information you need
- You know how to login to AWS
- The next step is to login to your linux machine on AWS and learn the basics of a linux command line

Break

Key AWS concepts and terminology

- **HDD** - Hard disk drive. A particular type of storage hardware that is generally cheaper and larger but slower than SSD. HDD drives are traditional hard drives that access data on a spinning magnetic disk.
- **Ephemeral storage** - Also known as Instance Store storage. Data storage associated with an EC2 instance that is local to the host computer. This storage does not persist when the instance is stopped or terminated. In other words, anything you store in this way will be lost if the system is stopped or terminated. Instance store volumes may be backed by SSD or HDD devices.

What is a Region?

- An AWS Region is set of compute resources that Amazon maintains (like the Data Center image shown before)
- Each Region corresponds to a physical warehouse of compute hardware (computers, storage, networking, etc.).
- At the time of writing there are 22 regions: (US East (N.Virginia), US East (Ohio), US West (Oregon), US West (N. California), GovCloud (US-West), GovCloud (US-East), Canada (Montreal), EU (Ireland), EU (Frankfurt), EU (London), EU (Paris), EU (Milan), EU (Stockholm), Middle East (Bahrain), Asia Pacific (Singapore), Asia Pacific (Sydney), Asia Pacific (Seoul), Asia Pacific (Tokyo), Asia Pacific (Mumbai), Asia Pacific (Hong Kong), Asia Pacific (Beijing), and South America (Sao Paulo).
- When you are logged into the AWS EC2 console, you are always operating in one of these regions.

What is a Region?

- Current region shown in the upper right corner of console
- It is important to pay attention to what region you are using for several reasons.
 - When you create an EC2 instance (EBS volume, etc) in one region you won't see it in another region.
 - The cost to use many AWS resources varies by region.
 - The region may influence network performance when you are accessing the instance, especially if you need to transfer large amounts of data in or out.
 - Billing is tracked separately for each region
 - Generally you should choose a region that is close to you or your users. But cost is also a consideration.