



Cold  
Spring  
Harbor  
Laboratory

# Introduction to cloud computing

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Advanced Sequencing Technologies & Applications

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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

Disk Storage  
(Mbytes/\$)

Stein Genome Biology 2010, 11:207  
<http://genomebiology.com/2010/11/5/207>



DNA  
Sequencing (bp/\$)

1,000,000

100,000

10,000

1,000

100

10

1

1,000,000,000

100,000,000

10,000,000

1,000,000

100,000

10,000

1,000

100

1

REVIEW

The case for cloud computing in genome informatics

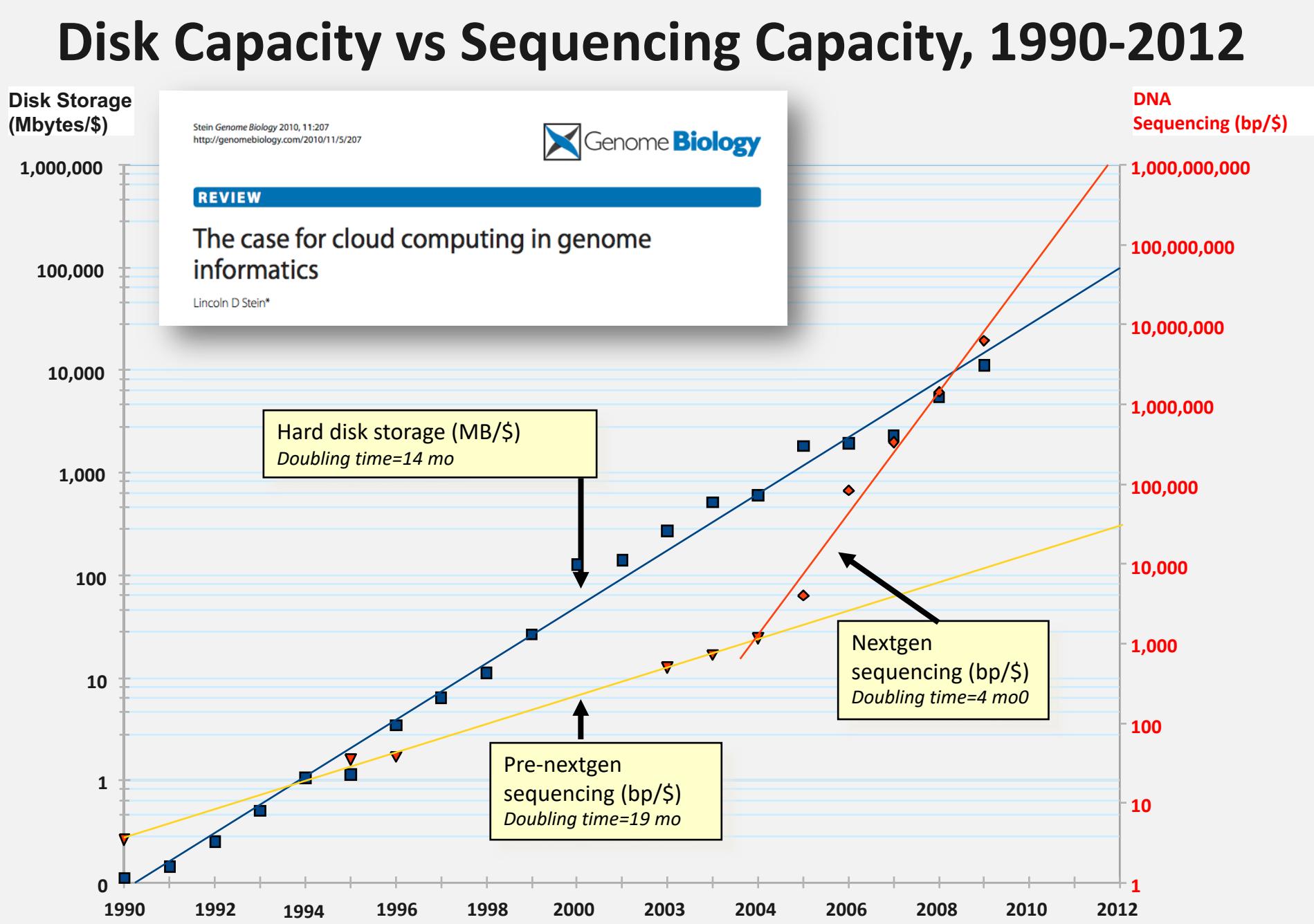
Lincoln D Stein\*

Hard disk storage (MB/\$)  
Doubling time=14 mo

Pre-nextgen sequencing (bp/\$)  
Doubling time=19 mo

Nextgen sequencing (bp/\$)  
Doubling time=4 mo

1990 1992 1994 1996 1998 2000 2002 2003 2004 2005 2006 2008 2010 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?
- Write more grants?
- Get bigger hardware?

# Cloud computing providers

- Amazon AWS
  - <https://aws.amazon.com/>
- Google cloud
  - <https://cloud.google.com/>
- Digital ocean
  - <https://www.digitalocean.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
- HPC are expanded at one container at a time:



# Some of the challenges of cloud computing:

- Not cheap!
- Getting files to and from there
- Not the best solution for everybody
- Standardization
- 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.

# 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 14 regions: (US East (N.Virginia), US East (Ohio), US West (Oregon), US West (N. California), Canada (Central), EU (Ireland), EU (Frankfurt), EU (London), Asia Pacific (Singapore), Asia Pacific (Sydney), Asia Pacific (Seoul), Asia Pacific (Tokyo), Asia Pacific (Mumbai) 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.

# 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?

Linux	RHEL	SLES	Windows	Windows with SQL Standard	Windows with SQL Web
Windows with SQL Enterprise					
Region:	US West (Oregon)				
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/0000/04/01/Intro\\_to\\_AWS/](https://rnabio.org/module-00-setup/0000/04/01/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, “Accessing the cloud” page

The screenshot shows a web browser window with the following details:

- Title Bar:** C-SEQTEC 2018: Wiki
- Toolbar:** Home, View, Edit, Info, History, Watch, Search: [empty input field], and icons for RSS and Print.
- Page Header:** Accessing The Cloud, Recently visited, and a link to Accessing The Cloud last modified by Malachi Griffith on November 9, 2018 8:55:29 AM EST.
- Section Header:** Instructions for students to access their AWC EC2 cloud instance
- Text:** Most hands on components of this workshop will be performed on Amazon AWS EC2 instances. Each student is assigned their own instance (instance type) running the Ubuntu operating system. Use the following instructions to log in.
- Text:** Visit AWS Console to create instance:
- List:**
  - AWS Console Signin: <https://cshlworkshops.signin.aws.amazon.com/console>
  - User Name: cshl.student
  - Password: seqtec2018
  - Zone: US West (Oregon)
  - Course AMI: cshl-seqtech-2018v2 (ami-0ee7d04a5b96e28c6)
- Text:** Download pem file (right-click and "Save Link As..."; take note of where you download it to):
- List:**
  - [cshl\\_2018\\_student.pem](#)
- Text:** Connect to AWS instance via Terminal:
- Text:**

```
chmod 400 cshl_2018_student.pem
ssh -i cshl_2018_student.pem ubuntu@YOUR_IP_ADDRESS
```

# Login to AWS console



Account ID or alias

IAM user name

Password

Sign In



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

[Forgot password?](#)

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

# Select "EC2" service

The screenshot shows the AWS Services menu. On the left, there's a sidebar with links like History, EC2, Console Home, S3, Billing, IAM, and Simple Queue Service. The main area has a search bar at the top. Below it, services are grouped into categories: Compute, Storage, Database, Robotics, Customer Enablement, Blockchain, Management & Governance, Analytics, Business Applications, Security, Identity, & Compliance, Internet Of Things, and Management. A red arrow points to the 'Compute' section, specifically the 'EC2' link. Another red arrow points to the 'Region' dropdown in the top right corner, which is set to 'N. Virginia'. A large text overlay on the right says 'Make sure you are in Virginia region'.

History

Services ▾

Resource Groups ▾

Find a service by name or feature (for example, EC2, S3 or VM, storage).

Group A-Z

Compute

- EC2
- Lightsail ↗
- ECR
- ECS
- EKS
- Lambda
- Batch
- Elastic Beanstalk
- Serverless Application Repository

Storage

- S3
- EFS
- FSx
- S3 Glacier
- Storage Gateway
- AWS Backup

Database

- RDS
- DynamoDB

Robotics

- AWS RoboMaker

Customer Enablement

- AWS IQ ↗
- Support
- Managed Services

Blockchain

- Amazon Managed Blockchain

Management & Governance

- AWS Organizations
- CloudWatch
- AWS Auto Scaling
- CloudFormation
- CloudTrail

Analytics

- Athena
- EMR
- CloudSearch
- Elasticsearch
- Kinesis
- QuickSight ↗
- Data Pipeline
- AWS Glue
- AWS Lake Formation
- MSK

Business Applications

- WorkSpaces
- AppStream 2.0
- WorkDocs
- WorkLink

Security, Identity, & Compliance

- IAM
- Resource Access Manager
- Cognito
- Secrets Manager
- GuardDuty
- Inspector
- Amazon Macie ↗
- AWS Single Sign-On
- Certificate Manager

Internet Of Things

- IoT Core
- Amazon FreeRTOS
- IoT 1-Click
- IoT Analytics
- IoT Device Defender
- IoT Device Management
- IoT Events
- IoT Greengrass
- IoT SiteWise
- IoT Things Graph

N. Virginia

Make sure you are in Virginia region

# Launch a new Instance

Screenshot of the AWS EC2 Dashboard showing the 'Create Instance' button highlighted with a red arrow.

The screenshot shows the AWS EC2 Dashboard with the following navigation bar:

- Services ▾
- Resource Groups ▾
- bell icon
- cshl.student @ cshlworkshops
- N. Virginia ▾
- Support ▾

The main content area includes:

- Resources**: You are using the following Amazon EC2 resources in the US East (N. Virginia) region:
  - 3 Running Instances
  - 0 Dedicated Hosts
  - 5 Volumes
  - 3 Key Pairs
  - 0 Placement Groups
  - 0 Elastic IPs
  - 4 Snapshots
  - 0 Load Balancers
  - 3 Security Groups
- A message box: Learn more about the latest in AWS Compute from AWS re:Invent by viewing the [EC2 Videos](#).
- Create Instance**: To start using Amazon EC2 you will want to launch a virtual server, known as an Amazon EC2 instance.  
[Launch Instance](#) (button with a dropdown arrow)
- Migrate a Machine**: Use CloudEndure Migration to simplify, expedite, and automate large-scale migrations from physical, virtual, and cloud-based infrastructure to AWS.  
[Get started with CloudEndure Migration](#)
- Service Health**: Service Status:  US East (N. Virginia):
- Scheduled Events**: US East (N. Virginia): No events
- Account Attributes**:
  - Supported Platforms: VPC
  - Default VPC: vpc-ad2c8fd7
  - Console experiments: Settings
- Additional Information**:
  - Getting Started Guide
  - Documentation
  - All EC2 Resources
  - Forums
  - Pricing
  - Contact Us
- AWS Marketplace**: Find free software trial products in the AWS Marketplace from the [EC2 Launch Wizard](#). Or try these popular software:  
[CloudEndure Migration](#)



# Choose an AMI – Find the CSHL SEQTEC 2019 AMI in the My AMIs

The screenshot shows the AWS Step Functions interface for choosing an Amazon Machine Image (AMI). The top navigation bar includes the AWS logo, Services dropdown, Resource Groups dropdown, a bell icon, user information (cshl.student @ cshlworkshops), location (N. Virginia), and Support dropdown.

The breadcrumb navigation shows the current step: 1. Choose AMI (highlighted in orange), 2. Choose Instance Type, 3. Configure Instance, 4. Add Storage, 5. Add Tags, 6. Configure Security Group, and 7. Review.

**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 bar: Search for an AMI by entering a search term e.g. "Windows"

Left sidebar filters:

- Quick Start
- My AMIs** (selected, indicated by a red arrow)
- AWS Marketplace
- Community AMIs
- Ownership
  - Owned by me
  - Shared with me
- Architecture
  - 32-bit (x86)
  - 64-bit (x86)
  - 64-bit (Arm)
- Root device type

Table of AMIs:

AMI Name	Root device type	Virtualization type	Owner	ENA Enabled	Action
cshl-seqtech-2019 - ami-0031e653e6b611b81	ebs	hvm	577255725291	Yes	Select (64-bit (x86))
cshl-seqtec-2019 - ami-018b3bf40f9926ac5	ebs	hvm	577255725291	Yes	Select (64-bit (x86))

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

Screenshot of the AWS CloudFormation console showing the "Step 2: Choose an Instance Type" step. The "m5.2xlarge" instance type is selected, indicated by a red arrow pointing to the "Yes" checkbox in the "Supported" column. The "Review and Launch" button is highlighted with a red box.

Step 2: Choose an Instance Type

	General purpose	m5.large	2	8	EBS only	Yes	Up to 10 Gigabit	Yes
<input type="checkbox"/>	General purpose	m5.xlarge	4	16	EBS only	Yes	Up to 10 Gigabit	Yes
<input checked="" type="checkbox"/>	General purpose	m5.2xlarge	8	32	EBS only	Yes	Up to 10 Gigabit	Yes
<input type="checkbox"/>	General purpose	m5.4xlarge	16	64	EBS only	Yes	Up to 10 Gigabit	Yes
<input type="checkbox"/>	General purpose	m5.8xlarge	32	128	EBS only	Yes	10 Gigabit	Yes
<input type="checkbox"/>	General purpose	m5.12xlarge	48	192	EBS only	Yes	10 Gigabit	Yes
<input type="checkbox"/>	General purpose	m5.16xlarge	64	256	EBS only	Yes	20 Gigabit	Yes
<input type="checkbox"/>	General purpose	m5.24xlarge	96	384	EBS only	Yes	25 Gigabit	Yes
<input type="checkbox"/>	General purpose	m5.metal	96	384	EBS only	Yes	25 Gigabit	Yes
<input type="checkbox"/>	General purpose	m4.large	2	8	EBS only	Yes	Moderate	Yes
<input type="checkbox"/>	General purpose	m4.xlarge	4	16	EBS only	Yes	High	Yes
<input type="checkbox"/>	General purpose	m4.2xlarge	8	32	EBS only	Yes	High	Yes
<input type="checkbox"/>	General purpose	m4.4xlarge	16	64	EBS only	Yes	High	Yes

Cancel Previous Review and Launch Next: Configure Instance Details

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

Screenshot of the AWS Launch Wizard Step 3: Configure Instance Details page. The page shows various configuration options for an instance, including IAM role, CPU options, shutdown behavior, and enable termination protection. A red arrow points to the 'Protect against accidental termination' checkbox under the 'Enable termination protection' section. A red box highlights the 'Next: Add Storage' button at the bottom right.

Step 3: Configure Instance Details

Auto-assign Public IP: Use subnet setting (Enable)

Placement group: Add instance to placement group

Capacity Reservation: Open, Create new Capacity Reservation

IAM role: None, Create new IAM role

You do not have permissions to list instance profiles. Contact your administrator, or check your IAM permissions.

CPU options: Specify CPU options

Shutdown behavior: Stop

Stop - Hibernate behavior: Enable hibernation as an additional stop behavior

Enable termination protection: Protect against accidental termination  (highlighted by a red arrow)

Monitoring: Enable CloudWatch detailed monitoring (Additional charges apply)

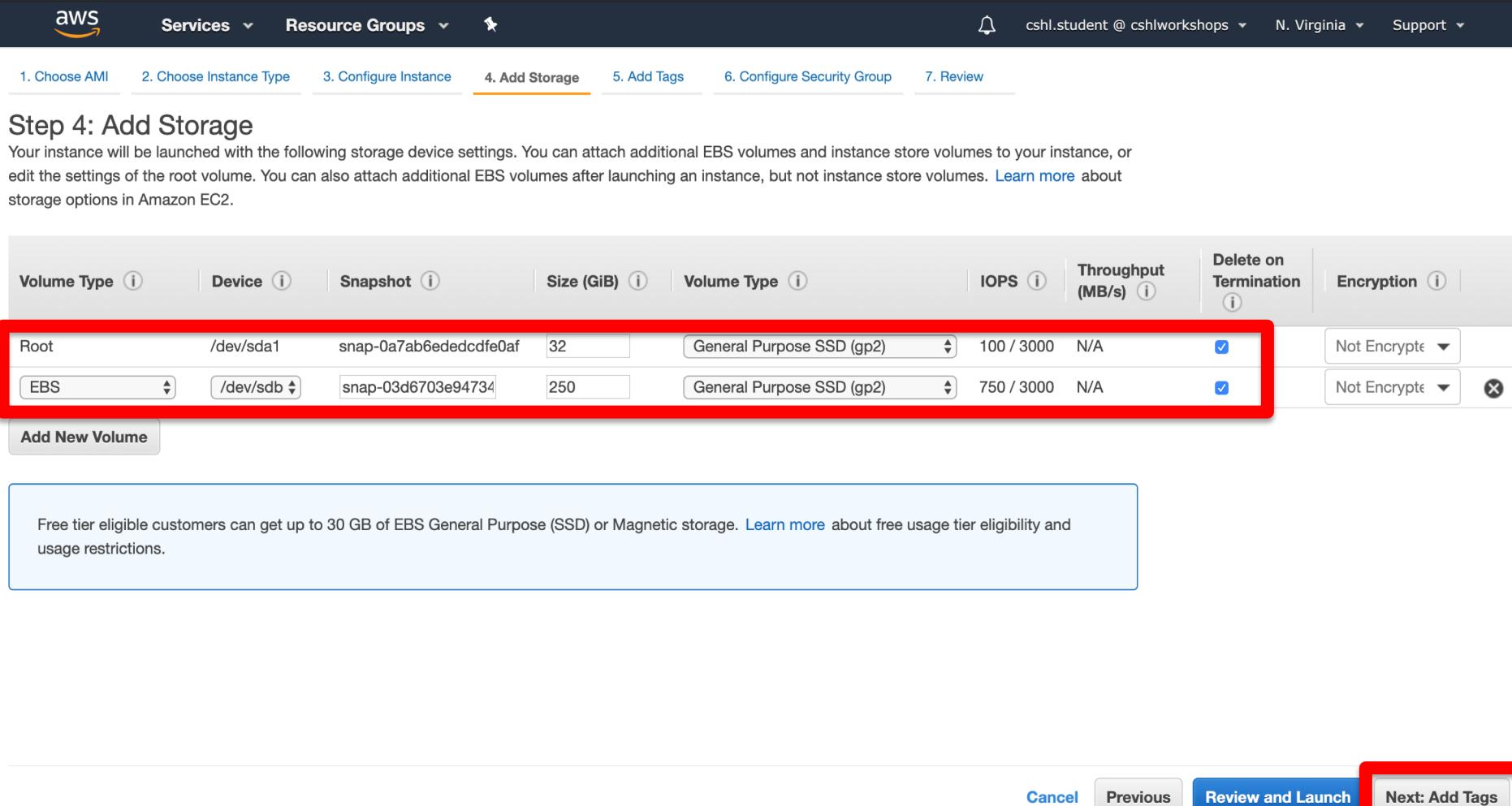
EBS-optimized instance: Launch as EBS-optimized instance

Tenancy: Shared - Run a shared hardware instance (Additional charges will apply for dedicated tenancy)

Elastic Inference: Add an Elastic Inference accelerator (Additional charges apply)

Cancel Previous Review and Launch Next: Add Storage

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 process at Step 4: Add Storage. The 'Root' volume is set to /dev/sda1, using snapshot snap-0a7ab6eddedcdfe0af, with a size of 32 GiB and a General Purpose SSD (gp2) type. An additional EBS volume is being added, with device /dev/sdb, snapshot snap-03d6703e94734, size 250 GiB, and gp2 type. Both volumes have 'Delete on Termination' checked and are not encrypted. A red box highlights the second volume row. At the bottom right, the 'Next: Add Tags' button is also highlighted with a red box.

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.

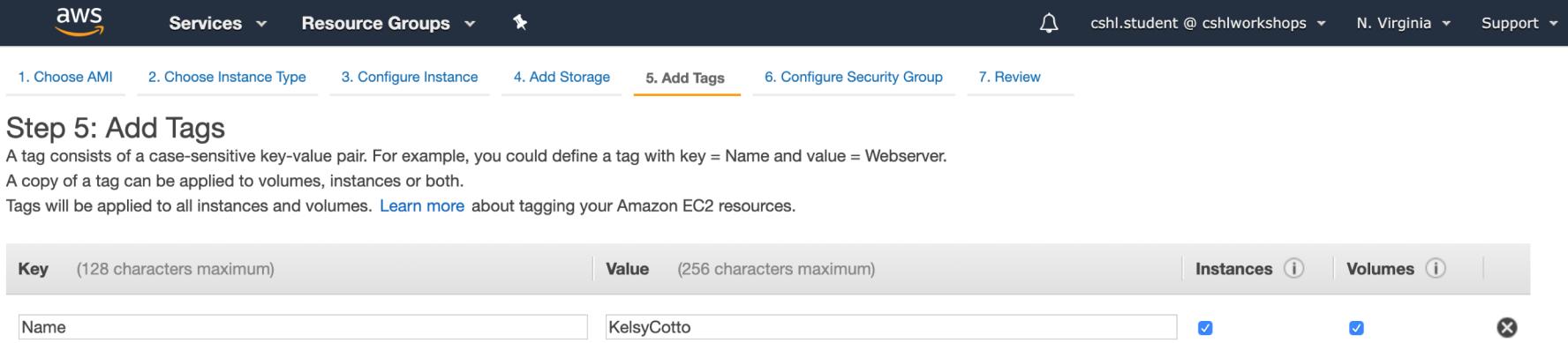
Volume Type	Device	Snapshot	Size (GiB)	Volume Type	IOPS	Throughput (MB/s)	Delete on Termination	Encryption
Root	/dev/sda1	snap-0a7ab6eddedcdfe0af	32	General Purpose SSD (gp2)	100 / 3000	N/A	<input checked="" type="checkbox"/>	Not Encrypted
EBS	/dev/sdb	snap-03d6703e94734	250	General Purpose SSD (gp2)	750 / 3000	N/A	<input checked="" type="checkbox"/>	Not Encrypted

Add New Volume

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.

Cancel Previous Review and Launch Next: Add Tags

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



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 (i)      Volumes (i)

Name

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".

AWS Services Resource Groups 1. Choose AMI 2. Choose Instance Type 3. Configure Instance 4. Add Storage 5. Add Tags 6. Configure Security Group 7. Review

## Step 6: Configure Security Group

A security group is a set of firewall rules that control the traffic for your instance. On this page, you can add rules to allow specific traffic to reach your instance. For example, if you want to set up a web server and allow Internet traffic to reach your instance, add rules that allow unrestricted access to the HTTP and HTTPS ports. You can create a new security group or select from an existing one below. [Learn more](#) about Amazon EC2 security groups.

Assign a security group:  Create a new security group  Select an existing security group

Security Group ID	Name	Description	Actions
sg-384f5b79	default	default VPC security group	<a href="#">Copy to new</a>
sg-06a8108faf3523284	launch-wizard-1	launch-wizard-1 created 2019-10-23T14:17:30.512-05:00	<a href="#">Copy to new</a>
sg-048f9a165ed38304a	launch-wizard-2	launch-wizard-2 created 2019-10-24T11:23:58.265-05:00	<a href="#">Copy to new</a>
sg-0087dc3a8b6e37a2d	SSH and HTTP	created 2019-11-08T09:43:29.293-05:00	<a href="#">Copy to new</a>

Inbound rules for sg-0087dc3a8b6e37a2d (Selected security groups: sg-0087dc3a8b6e37a2d)

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	

Cancel Previous **Review and Launch**

# 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, there's a navigation bar with links for Services, Resource Groups, and a user account. Below the navigation, a progress bar shows steps 1 through 7, with step 7 being the current one.

**Step 7: Review Instance Launch**

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.

**Warning:** 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](#)

**Warning:** 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.

**AMI Details**

cshl-seqtech-2019 - ami-0031e653e6b611b81

Root Device Type: ebs Virtualization type: hvm

**Instance Type**

Instance Type	ECUs	vCPUs	Memory (GiB)	Instance Storage (GB)	EBS-Optimized Available	Network Performance
m5.2xlarge	31	8	32	EBS only	Yes	Up to 10 Gigabit

**Security Groups**

[Edit security groups](#)

Cancel Previous **Launch**

# Choose an existing key pair: "cshl\_2019\_student" and then Launch.

AWS Services Resource Groups ★

1. Choose AMI 2. Choose Instance Type 3. Configure Instance 4. Add Storage 5. Add Tags 6. Configure Security Group 7. Review

cshl.student @ cshlworkshops N. Virginia Support

**Step 7: Review Instance Launch**

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.

**Select an existing key pair or create a new key pair**

A key pair consists of a **public key** that AWS stores, and a **private key file** that you store. Together, they allow you to connect to your instance securely. For Windows AMIs, the private key file is required to obtain the password used to log into your instance. For Linux AMIs, the private key file allows you to securely SSH into your instance.

Note: The selected key pair will be added to the set of keys authorized for this instance. Learn more about [removing existing key pairs from a public AMI](#).

Choose an existing key pair  
Select a key pair  
cshl\_2019\_student  
 I acknowledge that I have access to the selected private key file (cshl\_2019\_student.pem), and that without this file, I won't be able to log into my instance.

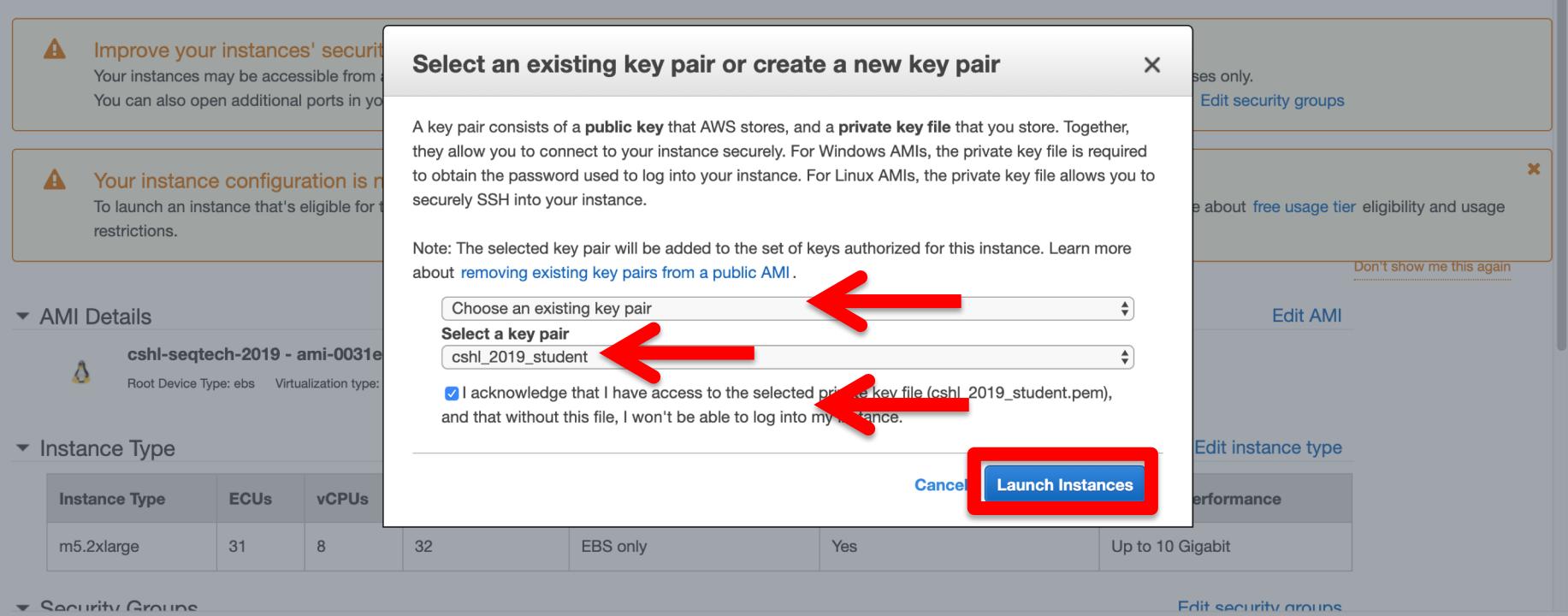
Cancel **Launch Instances**

AMI Details  
cshl-seqtech-2019 - ami-0031e  
Root Device Type: ebs Virtualization type:

Instance Type  
m5.2xlarge 31 8 32 EBS only Yes Up to 10 Gigabit

Security Groups Edit security groups

Cancel Previous Launch



# View Instances to see your new instance spinning up!



## Launch Status

### Your instances are now launching

The following instance launches have been initiated: [i-08e73e43f17783273](#) [View launch log](#)

### Get notified of estimated charges

[Create billing alerts](#) to get an email notification when estimated charges on your AWS bill exceed an amount you define (for example, if you exceed the free usage tier).

## How to connect to your instances

Your instances are launching, and it may take a few minutes until they are in the **running** state, when they will be ready for you to use. Usage hours on your new instances will start immediately and continue to accrue until you stop or terminate your instances.

Click [View Instances](#) to monitor your instances' status. Once your instances are in the **running** state, you can **connect** to them from the Instances screen. [Find out](#) how to connect to your instances.

### Here are some helpful resources to get you started

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

While your instances are launching you can also

[Create status check alarms](#) to be notified when these instances fail status checks. (Additional charges may apply)

[Create and attach additional EBS volumes](#) (Additional charges may apply)

[Manage security groups](#)

[View Instances](#)

# 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 Dashboard. On the left, there's a sidebar with navigation links: EC2 Dashboard, Events, Tags, Reports, Limits, INSTANCES (with Instances selected), Launch Templates, Spot Requests, Savings Plans, Reserved Instances, Dedicated Hosts, Scheduled Instances, Capacity Reservations, IMAGES, AMIs, and Bundle Tasks. The main content area has a header with 'Launch Instance', 'Connect' (which is highlighted with a red box), and 'Actions'. Below is a table titled 'Filter by tags and attributes or search by keyword' with columns: Name, Instance ID, Instance Type, Availability Zone, Instance State, Status Checks, Alarm Status, and Public DNS (IPv4). There are four instances listed: 'Instructor\_test\_inst...', 'command\_line\_boot...', 'developer\_instance', and 'KelsyCotto'. A red arrow points to the 'KelsyCotto' row, and another red box highlights the 'Connect' button in the header.

Name	Instance ID	Instance Type	Availability Zone	Instance State	Status Checks	Alarm Status	Public DNS (IPv4)
Instructor_test_inst...	i-06601eed1b1bfa657	m5.2xlarge	us-east-1c	running	2/2 checks ...	None	ec2-34-239-1-158.co...
command_line_boot...	i-00ebf20b2fb63ce3d	t2.xlarge	us-east-1b	terminated		None	ec2-34-239-1-158.co...
developer_instance	i-0088e20bb99bbbd...	m5.2xlarge	us-east-1c	running	2/2 checks ...	None	ec2-54-157-116-180.co...
KelsyCotto	i-0088e20bb99bbbd17783273	m5.2xlarge	us-east-1c	running	Initializing	None	ec2-3-219-34-153.co...

# 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 Dashboard with a modal window titled "Connect To Your Instance". The modal provides instructions for connecting to an instance using a standalone SSH client, EC2 Instance Connect, or a Java SSH Client. It details steps for opening an SSH client, locating the private key file (cshl\_2019\_student.pem), changing permissions with chmod 400, and connecting using the Public DNS. An example command is provided: ssh -i "cshl\_2019\_student.pem" root@ec2-3-219-34-153.compute-1.amazonaws.com. A note cautions users to ensure the AMI owner has not changed the default AMI username. A "Close" button is at the bottom right. In the background, the EC2 Instances page lists four instances with their Public DNS and status.

EC2 Dashboard

Events

Tags

Reports

Limits

INSTANCES

Instances

Launch Templates

Spot Requests

Savings Plans

Reserved Instances

Dedicated Hosts

Scheduled Instances

Capacity Reservations

IMAGES

AMIs

Bundle Tasks

ELASTIC BLOCK STORE

Volumes

Snapshots

Lifecycle Manager

NETWORK & SECURITY

Security Groups

Elastic IPs

Services ▾

Resource Groups ▾

Launch

Connect To Your Instance

I would like to connect with

- A standalone SSH client i
- EC2 Instance Connect (browser-based SSH connection) i
- A Java SSH Client directly from my browser (Java required) i

To access your instance:

1. Open an SSH client. (find out how to [connect using PuTTY](#))
2. Locate your private key file (cshl\_2019\_student.pem). The wizard automatically detects the key you used to launch the instance.
3. Your key must not be publicly viewable for SSH to work. Use this command if needed:  
`chmod 400 cshl_2019_student.pem`
4. Connect to your instance using its Public DNS:  
`ec2-3-219-34-153.compute-1.amazonaws.com`

Example:

```
ssh -i "cshl_2019_student.pem" root@ec2-3-219-34-153.compute-1.amazonaws.com
```

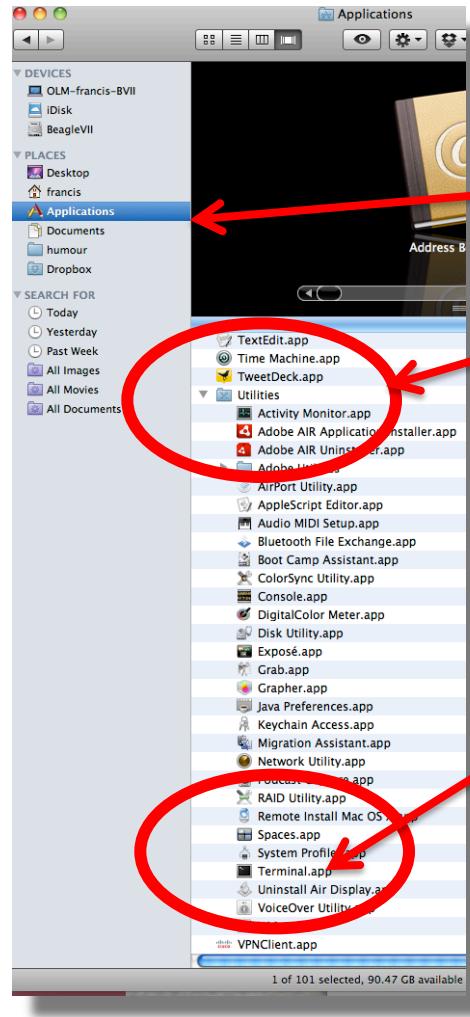
Please note that in most cases the username above will be correct, however please ensure that you read your AMI usage instructions to ensure that the AMI owner has not changed the default AMI username.

If you need any assistance connecting to your instance, please see our [connection documentation](#).

Close

	Alarm Status	Public DNS (IPv4)
None	None	ec2-34-239-1-158.co
None	None	ec2-54-157-116-180.co
None	None	ec2-3-219-34-153.co
None	None	ec2-3-219-34-153.co

# Opening a ‘terminal session’ on a Mac

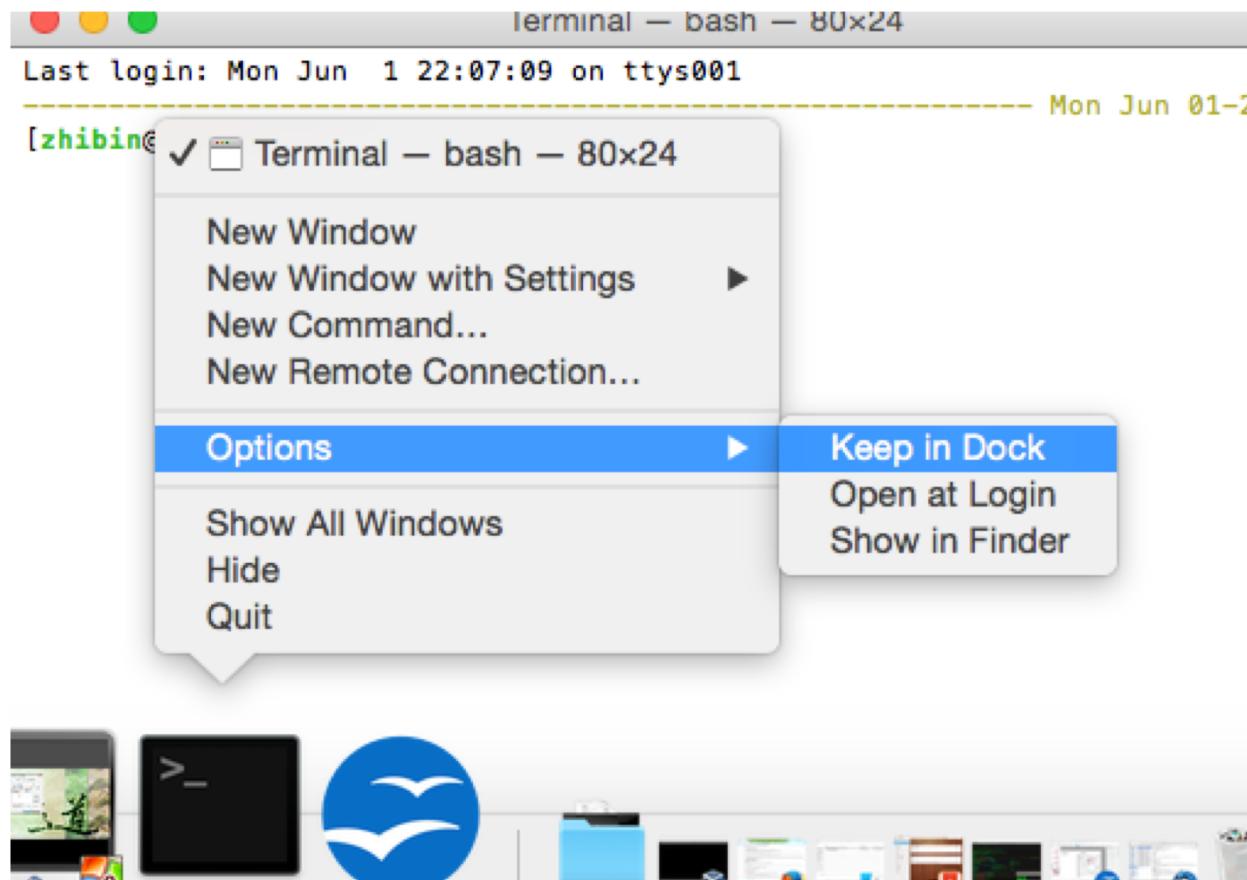


In a Finder window  
‘Applications’ -> ‘Utilities’ -> ‘Terminal’

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

# Download .pem file to cshl directory from course wiki

C-SEQTEC 2019: Wiki

Home View Edit Info History Watch Search:  RSS Print

Instructions For Students To Access Their Awc Ec2 Cloud Instance Recently visited

Instructions For Students To Access Their Awc Ec2 Cloud Instance last modified by Kelsy Cotto on November 8, 2019 9:42:52 AM EST

Most hands on components of this workshop will be performed on the cloud using Amazon AWS EC2 instances. Each student is assigned their own instance running the Ubuntu operating system. Use the following instructions to log in.

Visit AWS EC2 Console to create instance:

- AWS Console Signin: <https://cshlworkshops.signin.aws.amazon.com/console>
- User Name: cshl.student
- Password: seqtec2019
- Services -> Compute -> EC2
- Zone: US East (us-east-1) (N. Virginia)
- Course AMI: cshl-seqtec-2019 (ami-018b3bf40f9926ac5)
- Instance Type: m5.2xlarge

Download pem file (right-click and "Save Link As..."; take note of where you download it to):

- [cshl\\_2019\\_student.pem](#)

Connect to AWS instance via Terminal:

```
chmod 400 cshl_2019_student.pem
ssh -i cshl_2019_student.pem ubuntu@YOUR_IP_ADDRESS
```

# Viewing the ‘key’ file once downloaded

cat cshl\_2019\_student.pem

```
Kelsys-MacBook-Pro:keys kcotto$ cat cshl_2019_student.pem
-----BEGIN RSA PRIVATE KEY-----
MIIEpAIBAAKCAQEAgGtpnqERTEu/SCmeF2r1HMESEmo0fEJiAwQwk2/SNXK8izr0IH0zTVvmE1D
VUwWq7pkvhjh05pDb+2U9HiZe3sxLv3S1NrkATYF/NsrpwB+q1vwqzGW9sQ6uj45RWrPkiZlsaj
TQZmyFRu+t1JTRU3hQDqA0MRWTx1Wxv0gFzuZy/qb+DALuFQsInrEKnijrwdLmd6usaBTvhc0gFS
B9oEelH0bZHJTZFw/wP+Z0uZq0Ujir7Qw0LTM45QH/L0dBdUl3k/mBeez00yvnKMwj8E4Xi0rQ0t
hHtQ7F9iSILK80W1rRH0qwxwt9ycEH1JtNMQmUTif0vE2XJ6l06chQIDAQABAoIBABG7P/FHu/Qp
WFgg+89myuqR6GvA2X55CFSzFyG0aQyrj5jDleFtdu2uXiISG8gUBZYvlzxx82a0C0P5j04SBq0
xD/qR1ukY/jyXyPn77w/ExmaNoLjj1W9RUSH0JYLIZVpFPGes3u5zGSGDTSDNhw3sSdWhq1FX3l
7vY5b6UAQgahXf0dpGFxt6P6qb/BKFQFsThXk7GXMyS/kr4w7ZlhPWHRMSu2UBdS/a/beAVN76qU
E/10HR30oAuqghusZabpbX7MJl00VcvIAQgeF8Z+xf2uugDEAKut1PxW0+yvGM4SpZZ0skFZz6YI
pBnX4ELWPhCeMzq4Ml8QY6ptR2UCgYEAc6YfNlymg24NJU8PANx8navTi50WYuXWXrj0mrLr3SR
/XY+w26cgipM+K5eQFXSr4Yb8BQKjRktMzBzf5nKdaX4pzYIquQH02B0HDhTooHAhkbTMTmKukv4
oEW06wcEE6RQifw4xbMEnfQfHJBI21am+jwI8Xb7idwMG4pU/nsCgYEAtD0x4bNC1X3A5by50uY0
WXrtgQszCXYcbkrpbjRET12f9hgz9MRMHY/xH/XGvMutZSFV2rCZRwd7lm+QWGadk/MQS0kouzW6
gSasyjFq+MKCkqYnS3/JTbx8yrLzmz10LtX6pwmwg0Zy8aJjYHo9a2/EI8Tjh2d0SxeadIRVYP8C
gYAToiXww1Vdu+dj/7TDLqYCdHOVAXJX/utI9Q3yoIryuh+bWmFvEIvAmIGXyyQZRyoZwgIS4A
PNH03+bEa+69wbzlhksiK5g8GKgISVdlC4rZZXB5ehgTmWV7IgJ89y/SF4G/ITyo30K0ohALh597
NcvNEzzqruTja1IIMvTKMwKBgQClM+QP1Tqc0TbVlfvClviXuJBLsiJLCImYeZL0nZVmIMusbhxX
b8ZQYGSyUz09nu1Xau1G1QDvXvf089CzWL1SomxBoH1FJQvGwa9FfYQRIVPHuqut8rs4oPGn0QzC
h7M7QCJcr00oAcrSLLkQmgz+phIw7BzFr039J4HFiRInjQKBgQCtdEvcbyk8Jh4WH3z0wpkc43f
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_2019_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>**

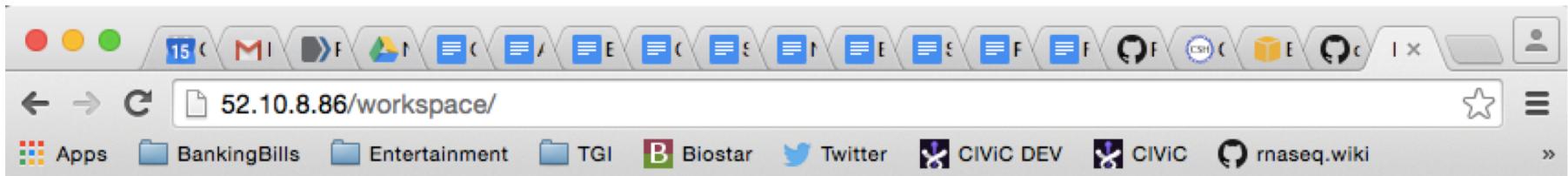
It is “r” for the the file owner **only**

# Logging into your instance

## Mac/Linux

```
cd ~/cshl  
chmod 400 cshl_2019_student.pem  
ssh -i cshl_2019_student.pem ubuntu@[YOUR PUBLIC IP]
```

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



## Index of /workspace

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

*Apache/2.4.7 (Ubuntu) Server at 52.10.8.86 Port 80*

**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!

The screenshot shows the AWS EC2 Dashboard. On the left, there's a sidebar with various navigation options like EC2 Dashboard, Events, Tags, Reports, Limits, Instances, Images, AMIs, and more. A red arrow points to the 'Instances' tab. In the main content area, a table lists several EC2 instances. One instance, 'instructor\_test2', is selected. A context menu is open over this instance, with 'Instance State' expanded. Under 'Instance State', another red arrow points to the 'Stop' option, which is highlighted. The table columns include Name, Instance ID, Instance Type, Availability Zone, Instance State, Status Checks, Alarm Status, and Public DNS. The 'Instance State' column shows the status of each instance (e.g., running, stopped). The 'Status Checks' column shows 2/2 checks passing for the running instance. The 'Alarm Status' and 'Public DNS' columns also provide information for each instance.

Go to AWS EC2 Dashboard, select “Instances” tab, then find your instance. Right-click and chose ‘Instance State’ -> ‘Stop’

# Next morning, you can “Start” your instance again

The screenshot shows the AWS EC2 Dashboard. On the left sidebar, the 'Instances' tab is selected, indicated by a red arrow. In the main content area, a table lists various instances. One instance, 'JasonWalker' (ID i-3246aae8), is highlighted with a red box and has a context menu open over it. The menu is titled 'Instance State' and includes options: Start (which is highlighted with a red arrow), Stop, Reboot, and Terminate. Below the table, the instance details are shown: Instance: i-3246aae8 (JasonWalker) and Private IP: 172.31.5.175.

Go to AWS EC2 Dashboard, select “Instances” tab, then find your instance. Right-click and chose ‘Instance State’ -> ‘Start’

**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 Dashboard. On the left, there's a sidebar with various navigation links: EC2 Dashboard, Events, Tags, Reports, Limits, INSTANCES (with 'Instances' selected), IMAGES, AMIs, Bundle Tasks, ELASTIC BLOCK STORE, Volumes, Snapshots, NETWORK & SECURITY, Security Groups, Elastic IPs, Placement Groups, Key Pairs, Network Interfaces, LOAD BALANCING, Load Balancers, and AUTO SCALING. The main area displays a list of instances. At the top of this list are three buttons: 'Launch Instance', 'Connect' (which has a red arrow pointing to it), and another button. Below these buttons is a search bar with the placeholder 'Filter by tags and attributes or search by keyword'. The instance list table has columns for Name, Instance ID, Instance Type, Availability Zone, Instance State, Status Checks, Alarm Status, and Public DNS. The first instance listed is 'instructor\_test2'. At the bottom of the instance list, it says 'Instance: i-068e6cdc (instructor\_test2) Public DNS: ec2-52-10-8-86.us-west-2.compute.amazonaws.com'. Below this, there's a 'Description' tab with tabs for 'Description', 'Status Checks', 'Monitoring', and 'Tags'. The 'Description' tab is active. It shows the Instance ID as 'i-068e6cdc', the Public DNS as 'ec2-52-10-8-86.us-west-2.compute.amazonaws.com', and the Instance state as 'running'. To the right of the Public DNS, there's a 'Public IP' field containing '52.10.8.86' with a red arrow pointing to it.

# **So, at this point:**

- Your Mac desktop 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

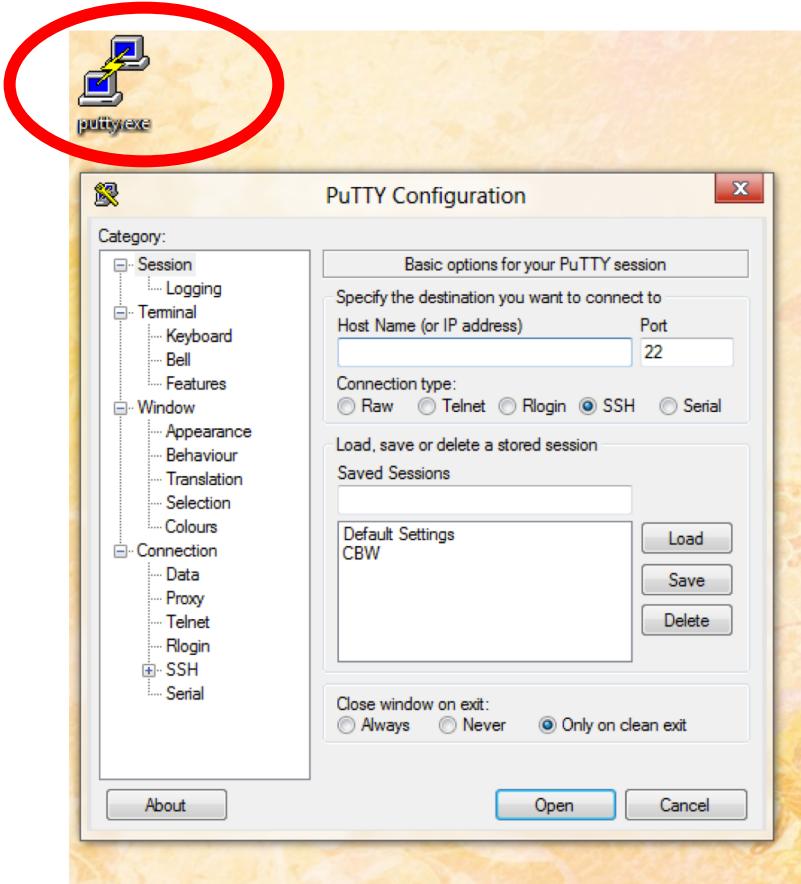
# Break

# Obtain the course SSH key file

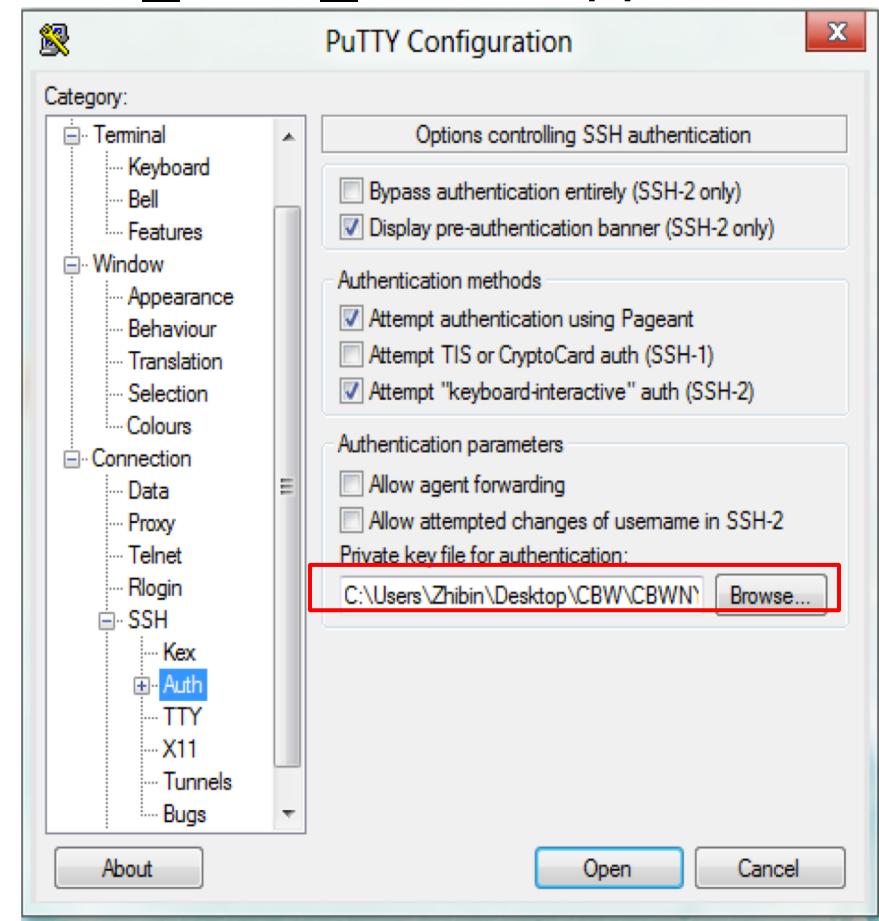
- NOTE for Mac users. You will need to use a “.pem” file
- **NOTE for Windows Users.** You will need to use a “.ppk” file instead.
  - This is created from the “.pem” file.
  - <https://aws.amazon.com/premiumsupport/knowledge-center/convert-pem-file-into-ppk/>
- The SSH key file will be used to securely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

# Logging into your instance (Windows)

Open PuTTY

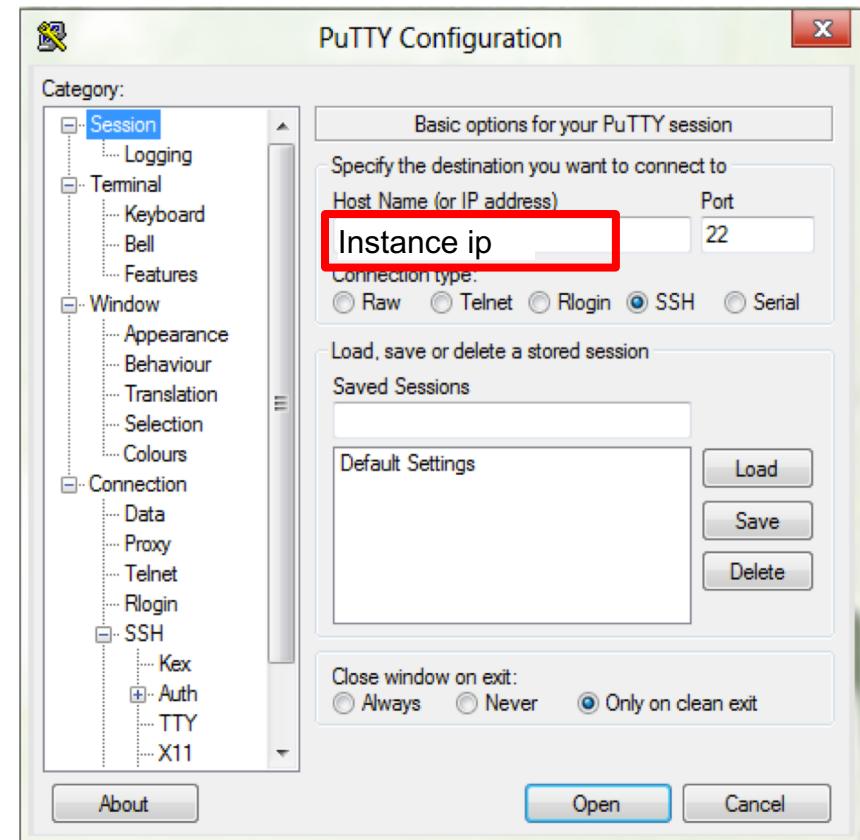
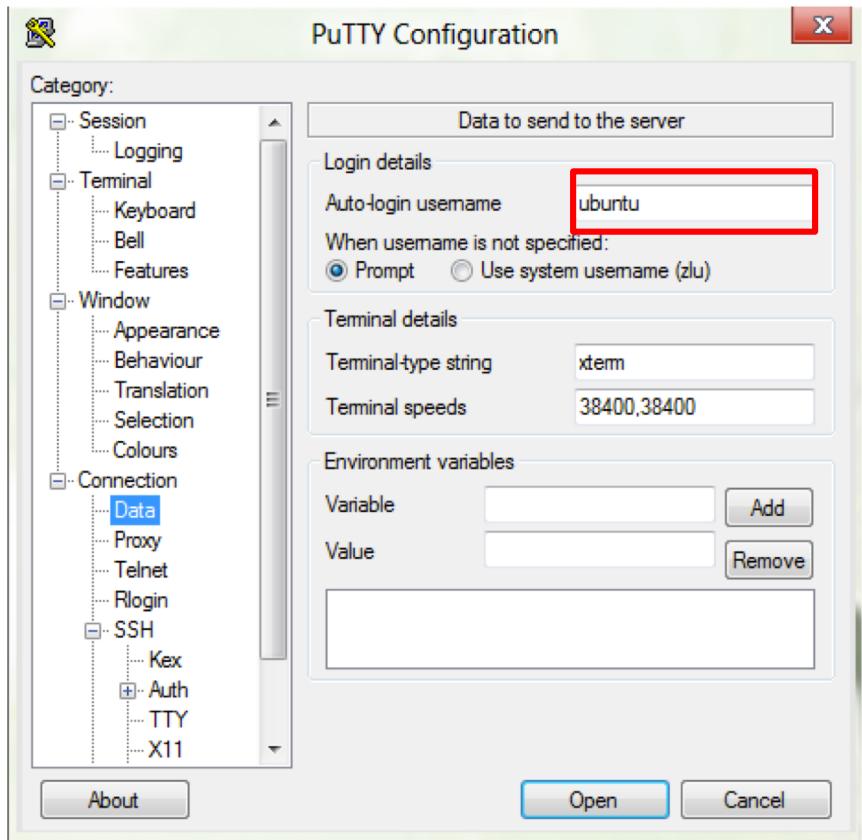


Browse to the  
cshl\_2018\_student.ppk file



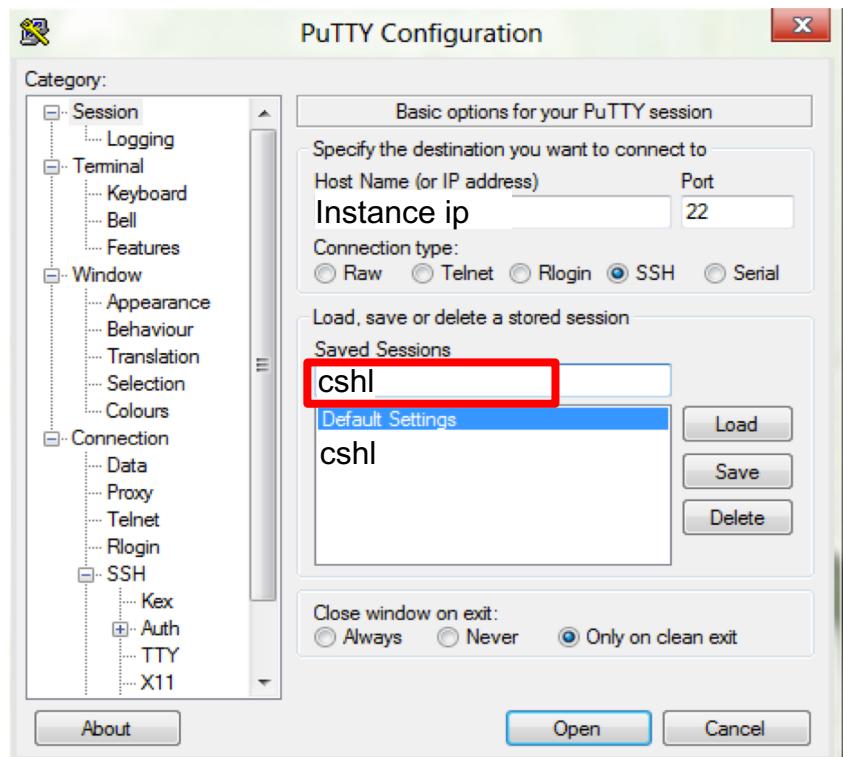
# Logging into your instance (Windows)

Enter the user name ‘ubuntu’      Enter the host name



# Logging into your instance (Windows)

Open PuTTY



# Break