



Canadian Bioinformatics Workshops

www.bioinformatics.ca

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Introduction to cloud computing

Malachi Griffith, Obi Griffith, Francis Oullette

Informatics for RNA-seq Analysis

June 16 - 17, 2016



Learning objectives of the course

- **Module 0: Introduction to cloud computing**
- Module 1: Introduction to RNA Sequencing
- Module 2: Alignment and Visualization
- Module 3: Expression and Differential Expression
- Module 4: Isoform Discovery and Alternative Expression

- Tutorials
 - Use the AWS EC2 console to set up an EC2 instance
 - Login to instance from command line

Learning objectives of module 0

- 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/\$)

DNA
Sequencing (bp/\$)

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



REVIEW

The case for cloud computing in genome informatics

Lincoln D Stein*

1,000,000

1,000,000,000

100,000

100,000,000

10,000

10,000,000

1,000

1,000,000

100

100,000

10

10,000

1

1,000

100

10

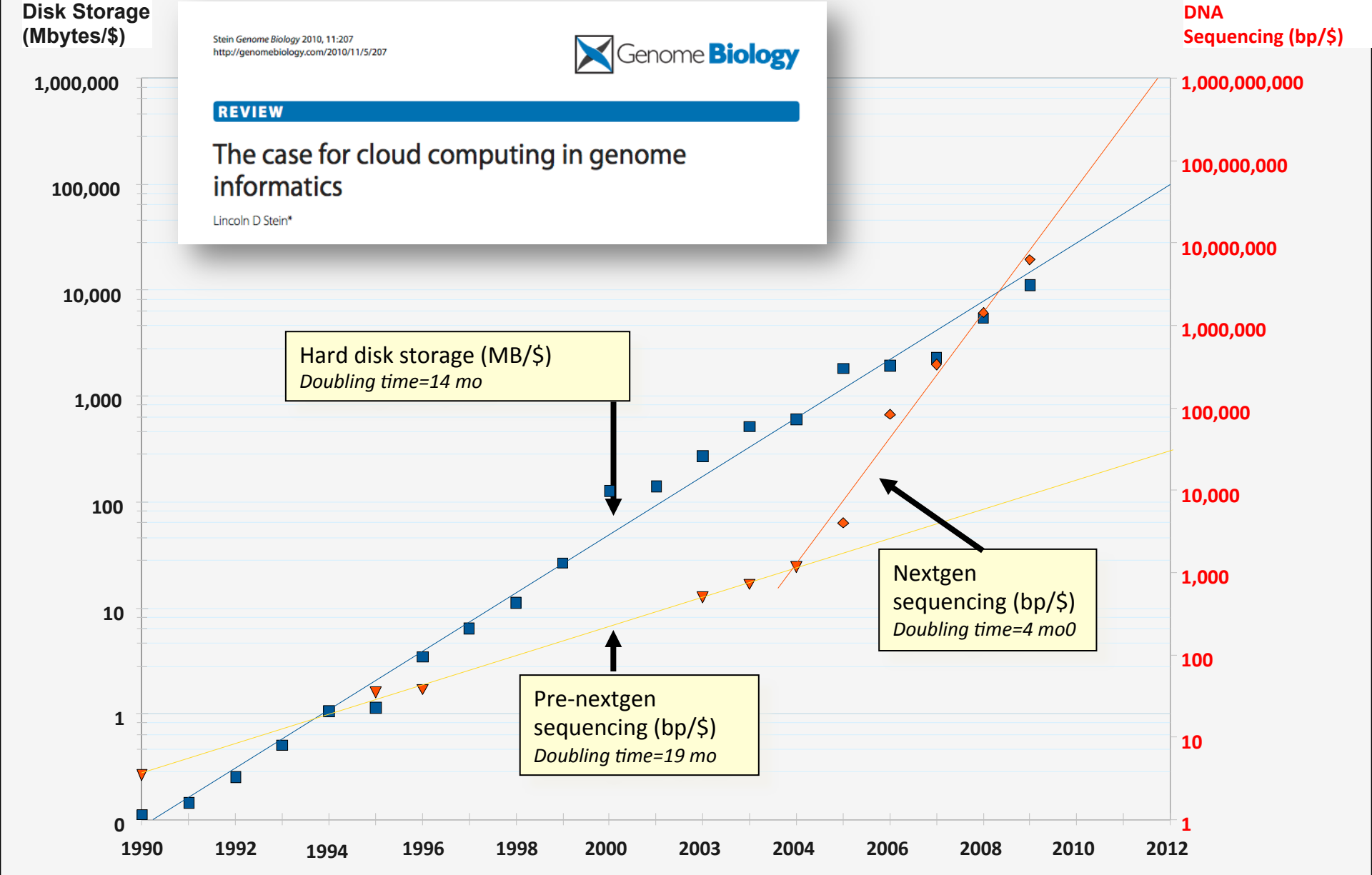
1

1990 1992 1994 1996 1998 2000 2003 2004 2006 2008 2010 2012

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

Nextgen
sequencing (bp/\$)
Doubling time=4 mo0

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



About DNA and computers

- We'll hit the \$1000 genome during 2015-?, then 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/>
- Others I have not tried:
 - Microsoft Azure (<https://azure.microsoft.com/en-us/>)
 - Rackspace cloud (<http://www.rackspace.com/cloud>)

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

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 an ftp server
- We brought up an Ubuntu (Linux) instance, and loaded a whole bunch of software for NGS analysis.
- We then cloned this, and made 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.

Amazon AWS documentation

https://github.com/griffithlab/rnaseq_tutorial/wiki/Intro-to-AWS-Cloud-Computing

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

Logging into Amazon AWS

Login to AWS console



i **Coming Soon: Changes to Multi-Factor Authentication (MFA)**
Entry of an MFA security code for IAM users will move from this sign-in page to a subsequent page

Account:

User Name:

Password:

I have an MFA Token [\(more info\)](#)



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

<https://364840684323.signin.aws.amazon.com/console>

Select "EC2" service

The screenshot shows the AWS Management Console interface. At the top, the navigation bar includes the AWS logo, 'Services', 'Edit', and user information 'cshl.student @ 3648-4068-4323' with a dropdown arrow. The region is set to 'Oregon' and 'Support' is also available. The main content area is titled 'Amazon Web Services' and is divided into several categories:

- Compute:** EC2 (Virtual Servers in the Cloud), EC2 Container Service (Run and Manage Docker Containers), Elastic Beanstalk (Run and Manage Web Apps), Lambda (Run Code in Response to Events).
- Storage & Content Delivery:** S3 (Scalable Storage in the Cloud), CloudFront (Global Content Delivery Network), Elastic File System (Fully Managed File System for EC2), Glacier (Archive Storage in the Cloud), Import/Export Snowball (Large Scale Data Transport), Storage Gateway (Integrates On-Premises IT Environments with Cloud Storage).
- Database:** RDS (Managed Relational Database Service), DynamoDB (Predictable and Scalable NoSQL Data Store), ElastiCache (In-Memory Cache), Redshift (Managed Petabyte-Scale Data Warehouse Service).
- Developer Tools:** CodeCommit (Store Code in Private Git Repositories), CodeDeploy (Automate Code Deployments), CodePipeline (Release Software using Continuous Delivery).
- Management Tools:** CloudWatch (Monitor Resources and Applications), CloudFormation (Create and Manage Resources with Templates), CloudTrail (Track User Activity and API Usage), Config (Track Resource Inventory and Changes), OpsWorks (Automate Operations with Chef), Service Catalog (Create and Use Standardized Products), Trusted Advisor (Optimize Performance and Security).
- Security & Identity:** Identity & Access Management (Manage User Access and Encryption Keys), Directory Service (Host and Manage Active Directory), Inspector (Analyze Application Security), WAF (Filter Malicious Web Traffic).
- Internet of Things:** AWS IoT (Connect Devices to the cloud).
- Mobile Services:** Mobile Hub (Build, Test, and Monitor Mobile apps), Cognito (User Identity and App Data Synchronization), Device Farm (Test Android, Fire OS, and iOS apps on real Cloud), Mobile Analytics (Collect, View and Export App Analytics), SNS (Push Notification Service).
- Application Services:** API Gateway (Build, Deploy and Manage APIs), AppStream (Low Latency Application Streaming), CloudSearch (Managed Search Service), Elastic Transcoder (Easy-to-use Scalable Media Transcoding), SES (Email Sending Service), SQS (Message Queue Service), SWF (Workflow Service for Coordinating Application Components).
- Enterprise Applications:** (Section header only).

On the right side, the 'Resource Groups' section is visible, with a red arrow pointing to the 'Oregon' region in the top right. Below it, there is a text box explaining that a resource group is a collection of resources that share one or more tags. Further down, there are links for 'Getting Started', 'AWS Console Mobile App', 'AWS Marketplace', and 'AWS re:Invent Announcements'. At the bottom of this section, it states 'Service Health' and 'All services operating normally.' with a green checkmark. The update time is 'Updated: Nov 13 2015 21:17:00 GMT-0500'.

Make sure you are in Oregon region

Launch a new Instance

The screenshot displays the AWS Management Console interface. At the top, the navigation bar shows 'AWS', 'Services', and 'Edit'. The user's account information 'cshl.student @ 3648-4068-4323' and the region 'Oregon' are visible. The left-hand navigation pane is expanded to 'EC2 Dashboard', with sub-items like 'Events', 'Tags', 'Reports', 'Limits', 'INSTANCES', 'IMAGES', 'ELASTIC BLOCK STORE', 'NETWORK & SECURITY', 'LOAD BALANCING', and 'AUTO SCALING'. The main content area is titled 'Resources' and lists EC2 resources in the US West (Oregon) region: 4 Running Instances, 7 Volumes, 3 Key Pairs, 0 Placement Groups, 0 Elastic IPs, 9 Snapshots, 0 Load Balancers, and 2 Security Groups. Below this is a 'Create Instance' section with a blue 'Launch Instance' button, which is pointed to by a red arrow. A note states that instances will launch in the US West (Oregon) region. The 'Service Health' section shows that the US West (Oregon) service is operating normally across all three availability zones (us-west-2a, us-west-2b, us-west-2c). The right-hand sidebar contains 'Account Attributes' (Supported Platforms, Default VPC), 'Additional Information' (Getting Started Guide, Documentation, etc.), and 'AWS Marketplace' (Tableau Server, SAP HANA One).

Choose an AMI – Find the CSHL SEQTEC 2015 AMI in the Community AMIs

Step 1: Choose an Amazon Machine Image (AMI) Cancel and Exit

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.

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

Quick Start

My AMIs

AWS Marketplace

Community AMIs

Operating system

- Amazon Linux
- Cent OS
- Debian
- Fedora
- Gentoo
- OpenSUSE
- Other Linux
- Red Hat
- SUSE Linux
- Ubuntu
- Windows

Search: cshl_seqtec_2015_v2

AMI ID	Root device type	Virtualization type	Architecture
cshl_seqtec_2015_v2 - ami-28130249	ebs	hvm	64-bit
cshl_seqtec_2015_v2_noworkspace - ami-e9100188	ebs	hvm	64-bit

Search for: cshl_seqtec_2015_v3 - ami-58031239 (US West - Oregon)

Choose "m4.2xlarge" instance type, then "Next: Configure Instance Details".

AWS Services Edit

cshl.student @ 3648-4068-4323 Oregon Support

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

Step 2: Choose an Instance Type

Amazon EC2 provides a wide selection of instance types optimized to fit different use cases. Instances are virtual servers that can run applications. They have varying combinations of CPU, memory, storage, and networking capacity, and give you the flexibility to choose the appropriate mix of resources for your applications. [Learn more](#) about instance types and how they can meet your computing needs.

Filter by: All instance types Current generation Show/Hide Columns

Currently selected: m4.2xlarge (26 ECUs, 8 vCPUs, 2.4 GHz, Intel Xeon E5-2676v3, 32 GiB memory, EBS only)

	Family	Type	vCPUs	Memory (GiB)	Instance Storage (GB)	EBS-Optimized Available	Network Performance
<input type="checkbox"/>	General purpose	t2.micro Free tier eligible	1	1	EBS only	-	Low to Moderate
<input type="checkbox"/>	General purpose	t2.small	1	2	EBS only	-	Low to Moderate
<input type="checkbox"/>	General purpose	t2.medium	2	4	EBS only	-	Low to Moderate
<input type="checkbox"/>	General purpose	t2.large	2	8	EBS only	-	Low to Moderate
<input type="checkbox"/>	General purpose	m4.large	2	8	EBS only	Yes	Moderate
<input type="checkbox"/>	General purpose	m4.xlarge	4	16	EBS only	Yes	High
<input checked="" type="checkbox"/>	General purpose	m4.2xlarge	8	32	EBS only	Yes	High
<input type="checkbox"/>	General purpose	m4.4xlarge	16	64	EBS only	Yes	High

Cancel Previous Review and Launch Next: Configure Instance Details

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

The screenshot shows the AWS Management Console interface for configuring an instance. The top navigation bar includes the AWS logo, 'AWS', 'Services', 'Edit', and user information 'cshl.student @ 3648-4068-4323' in 'Oregon' with a 'Support' link. The breadcrumb trail shows steps: 1. Choose AMI, 2. Choose Instance Type, 3. Configure Instance (highlighted), 4. Add Storage, 5. Tag Instance, 6. Configure Security Group, and 7. Review.

Step 3: Configure Instance Details

Configure the instance to suit your requirements. You can launch multiple instances from the same AMI, request Spot instances to take advantage of the lower pricing, assign an access management role to the instance, and more.

- Number of instances:** 1. [Launch into Auto Scaling Group](#)
- Purchasing option:** Request Spot instances
- Network:** vpc-ebcc188e (172.31.0.0/16) (default). [Create new VPC](#)
- Subnet:** No preference (default subnet in any Availability Zone). [Create new subnet](#)
- Auto-assign Public IP:** Use subnet setting (Enable)
- IAM role:** None. [Create new IAM role](#)
- Shutdown behavior:** Stop
- Enable termination protection:** Protect against accidental termination
- Monitoring:** Enable CloudWatch detailed monitoring. Additional charges apply.
- Tenancy:** Shared tenancy (multi-tenant hardware). Additional charges will apply for dedicated tenancy.

Advanced Details

Buttons at the bottom: Cancel, Previous, Review and Launch, Next: Add Storage (highlighted with a red box).

You should see "snap-xxxxxxx" (32GB) and "snap-xxxxxxx" (500GB) as the two storage volumes selected. Then, "Next: Tag Instance"

The screenshot shows the AWS Management Console interface for configuring an EC2 instance. The navigation bar at the top includes the AWS logo, 'Services', and 'Edit' dropdown. The user's account information 'cshl.student @ 3648-4068-4323' and region 'Oregon' are also visible. The progress bar indicates the current step is '4. Add Storage', with other steps being '1. Choose AMI', '2. Choose Instance Type', '3. Configure Instance', '5. Tag Instance', '6. Configure Security Group', and '7. Review'.

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.

Type	Device	Snapshot	Size (GiB)	Volume Type	IOPS	Delete on Termination	Encrypted
Root	/dev/sda1	snap-6f450833	32	General Purpose (SSD)	96 / 3000	<input checked="" type="checkbox"/>	Not Encrypted
EBS	/dev/sdb	snap-11e6954e	500	General Purpose (SSD)	1500 / 3000	<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.

Navigation buttons: [Cancel](#), [Previous](#), [Review and Launch](#), [Next: Tag Instance](#)

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

The screenshot shows the AWS Management Console interface during the 'Tag Instance' step. The top navigation bar includes the AWS logo, 'Services', 'Edit', and user information 'cshl.student @ 3648-4068-4323' in the 'Oregon' region. A progress bar at the top indicates seven steps: 1. Choose AMI, 2. Choose Instance Type, 3. Configure Instance, 4. Add Storage, 5. Tag Instance (highlighted), 6. Configure Security Group, and 7. Review.

The main heading is 'Step 5: Tag Instance', followed by a sub-heading: 'A tag consists of a case-sensitive key-value pair. For example, you could define a tag with key = Name and value = Webserver. [Learn more](#) about tagging your Amazon EC2 resources.'

The tag configuration area has two columns: 'Key' (127 characters maximum) and 'Value' (255 characters maximum). The 'Key' field contains 'Name' and the 'Value' field contains 'ObiGriffith'. A red arrow points to the 'Value' field. Below the fields is a 'Create Tag' button with the text '(Up to 10 tags maximum)'. At the bottom right, there are four buttons: 'Cancel', 'Previous', 'Review and Launch', and 'Next: Configure Security Group'. The 'Next: Configure Security Group' button is highlighted with a red box.

Important: Don't forget to name your instance

Select an Existing Security Group, choose "SSH_HTTP_8081_IN_ALL_OUT". Then hit "Review and Launch".

AWS Services Edit cshl.student @ 3648-4068-4323 Oregon Support

1. Choose AMI 2. Choose Instance Type 3. Configure Instance 4. Add Storage 5. Tag Instance 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
<input type="checkbox"/> sg-64d8be01	default	default VPC security group	Copy to new
<input checked="" type="checkbox"/> sg-5a53633f	SSH_HTTP_8081_IN_ALL_OUT	Allow web, ssh, and GMS class viewer incoming and all outgoing	Copy to new

Inbound rules for sg-5a53633f (Selected security groups: sg-5a53633f)

Type	Protocol	Port Range	Source
HTTP	TCP	80	0.0.0.0/0
SSH	TCP	22	0.0.0.0/0
Custom TCP Rule	TCP	8081	0.0.0.0/0

Cancel Previous **Review and Launch**

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

AWS Services Edit cshl.student @ 3648-4068-4323 Oregon Support

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

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: 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.

[Don't show me this again](#)


Warning: Improve your instances' security. Your security group, `SSH_HTTP_8081_IN_ALL_OUT`, 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](#)

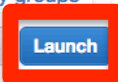
AMI Details [Edit AMI](#)

 **cshl_seqtec_2015_v2 - ami-28130249** 
Root Device Type: ebs Virtualization type: hvm

Instance Type [Edit instance type](#)

Instance Type	ECUs	vCPUs	Memory (GiB)	Instance Storage (GB)	EBS-Optimized Available	Network Performance
m3.2xlarge	26	8	30	2 x 80		High

Security Groups [Edit security groups](#)

[Cancel](#) [Previous](#) [Launch](#) 

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

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

I acknowledge that I have access to the selected private key file (CSHL.pem), and that without this file, I won't be able to log into my instance.

Cancel **Launch Instances**

AMI Details
cshl_seqtec_2015_v2 - ami-281302
Root Device Type: ebs Virtualization type: hvm

Instance Type

Instance Type	ECUs	vCPUs
m3.2xlarge	26	8

Security Groups

Cancel Previous **Launch**

View Instances to see your new instance spinning up!



AWS ▾

Services ▾

Edit ▾

cs1.student @ 3648-4068-4323 ▾

Oregon ▾

Support ▾

Launch Status



Your instances are now launching

The following instance launches have been initiated: [i-45e4089f](#) [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

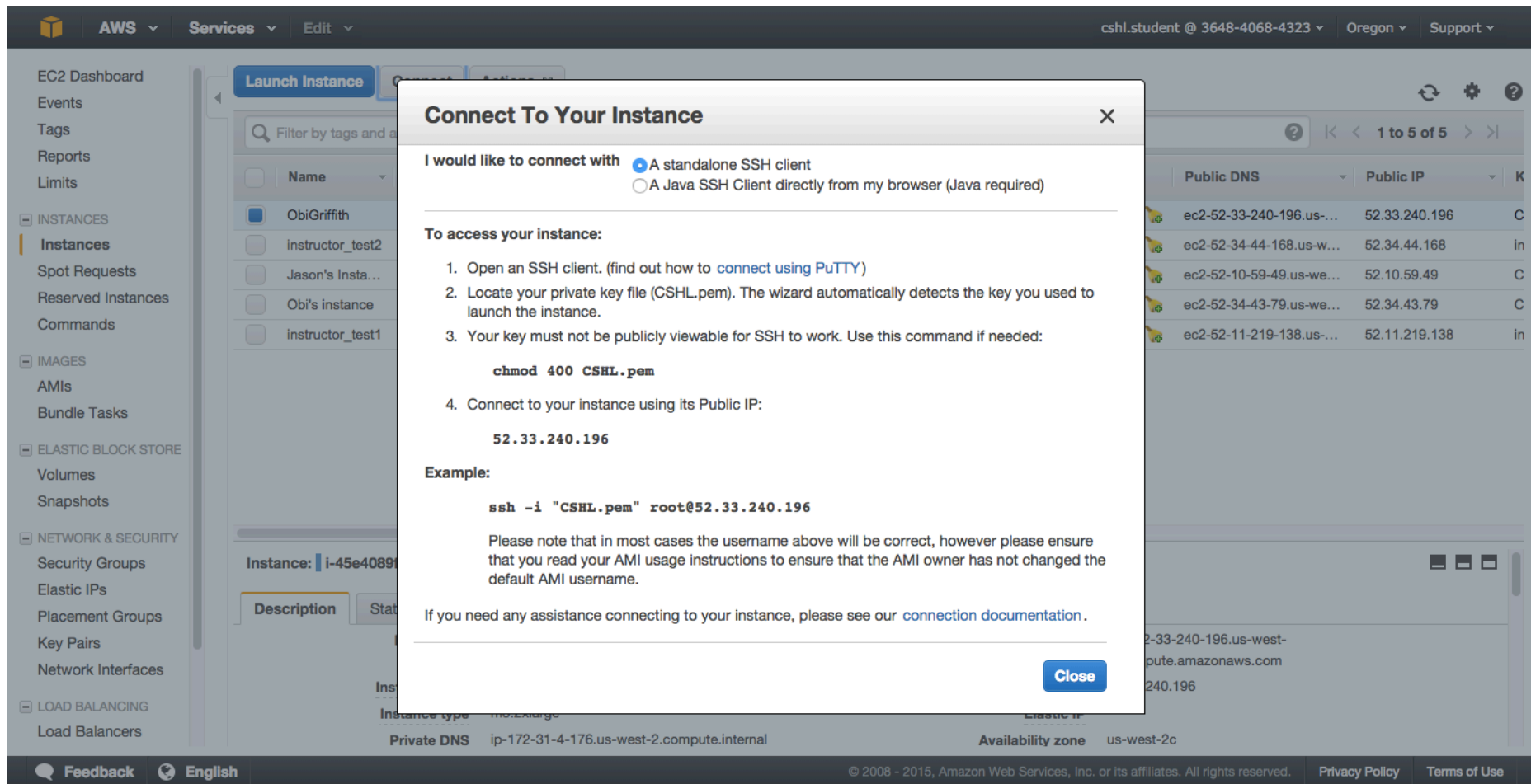
The screenshot shows the AWS Management Console interface for the EC2 service. The top navigation bar includes the AWS logo, 'Services', 'Edit', and user information 'cshl.student @ 3648-4068-4323' in the 'Oregon' region. The left sidebar lists navigation options like 'EC2 Dashboard', 'Instances', 'Spot Requests', etc. The main content area shows a table of EC2 instances. The 'Connect' button in the top action bar is highlighted with a red box. A red arrow points to the 'ObiGriffith' instance in the table. Below the table, the details for the selected instance 'i-45e4089f (ObiGriffith)' are displayed, including its Public DNS, Public IP, and other attributes.

Name	Instance ID	Instance Type	Availability Zone	Instance State	Status Checks	Alarm Status	Public DNS	Public IP	K
<input checked="" type="checkbox"/> ObiGriffith	i-45e4089f	m3.2xlarge	us-west-2c	running	Initializing	None	ec2-52-33-240-196.us-...	52.33.240.196	C
<input type="checkbox"/> instructor_test2	i-068e6cdc	m3.2xlarge	us-west-2c	running	2/2 checks ...	None	ec2-52-34-44-168.us-w...	52.34.44.168	in
<input type="checkbox"/> Jason's Insta...	i-00967ada	m3.2xlarge	us-west-2c	running	2/2 checks ...	None	ec2-52-10-59-49.us-we...	52.10.59.49	C
<input type="checkbox"/> Obi's instance	i-15836fcf	m3.2xlarge	us-west-2c	running	2/2 checks ...	None	ec2-52-34-43-79.us-we...	52.34.43.79	C
<input type="checkbox"/> instructor_test1	i-66463ea0	m3.2xlarge	us-west-2a	running	2/2 checks ...	None	ec2-52-11-219-138.us-...	52.11.219.138	in

Instance: **i-45e4089f (ObiGriffith)** Public DNS: **ec2-52-33-240-196.us-west-2.compute.amazonaws.com**

Description	Status Checks	Monitoring	Tags
Instance ID	i-45e4089f	Public DNS	ec2-52-33-240-196.us-west-2.compute.amazonaws.com
Instance state	running	Public IP	52.33.240.196
Instance type	m3.2xlarge	Elastic IP	-
Private DNS	ip-172-31-4-176.us-west-2.compute.internal	Availability zone	us-west-2c

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



The screenshot shows the AWS Management Console interface. A modal dialog titled "Connect To Your Instance" is open, providing instructions for connecting to an EC2 instance. The dialog includes a table of instance details and a list of steps for accessing the instance.

Connect To Your Instance

I would like to connect with A standalone SSH client
 A Java SSH Client directly from my browser (Java required)

To access your instance:

1. Open an SSH client. (find out how to [connect using PuTTY](#))
2. Locate your private key file (CSHL.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.pem
```
4. Connect to your instance using its Public IP:

```
52.33.240.196
```

Example:

```
ssh -i "CSHL.pem" root@52.33.240.196
```

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.

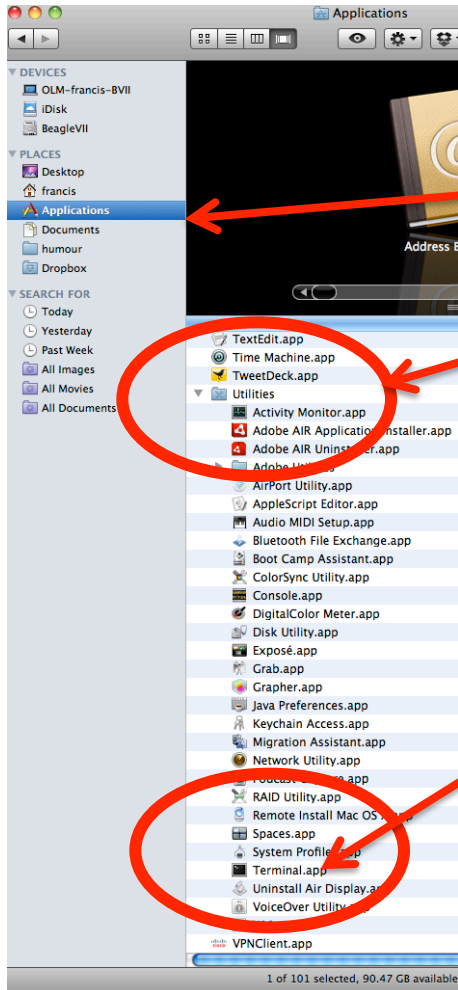
If you need any assistance connecting to your instance, please see our [connection documentation](#).

Close

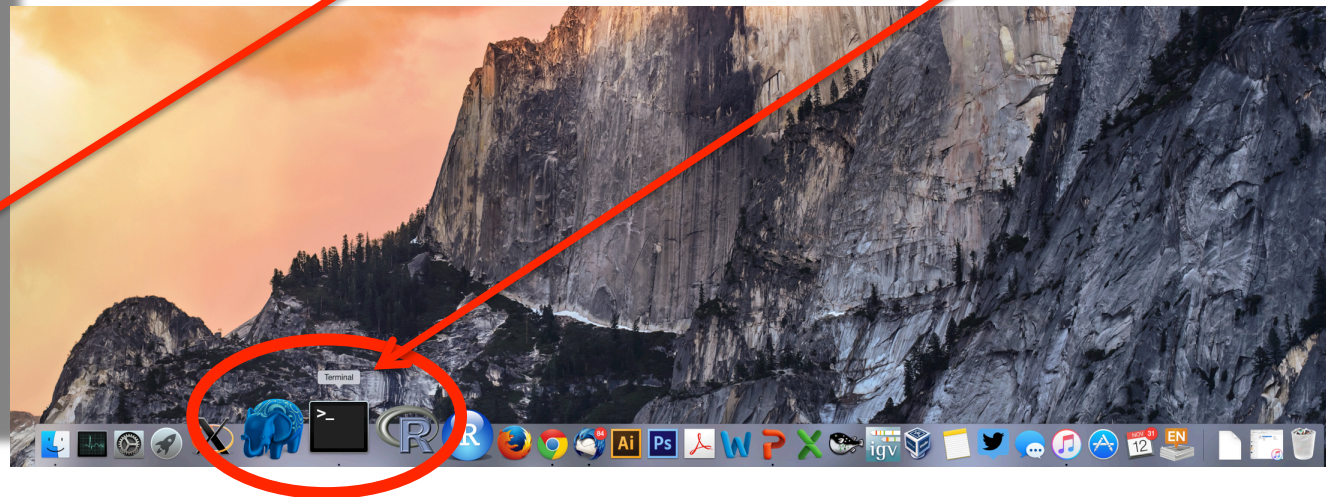
Public DNS	Public IP	K
ec2-52-33-240-196.us-... pute.amazonaws.com	52.33.240.196	C
ec2-52-34-44-168.us-w...	52.34.44.168	in
ec2-52-10-59-49.us-we...	52.10.59.49	C
ec2-52-34-43-79.us-we...	52.34.43.79	C
ec2-52-11-219-138.us-...	52.11.219.138	in

Opening a 'terminal session' on a Mac

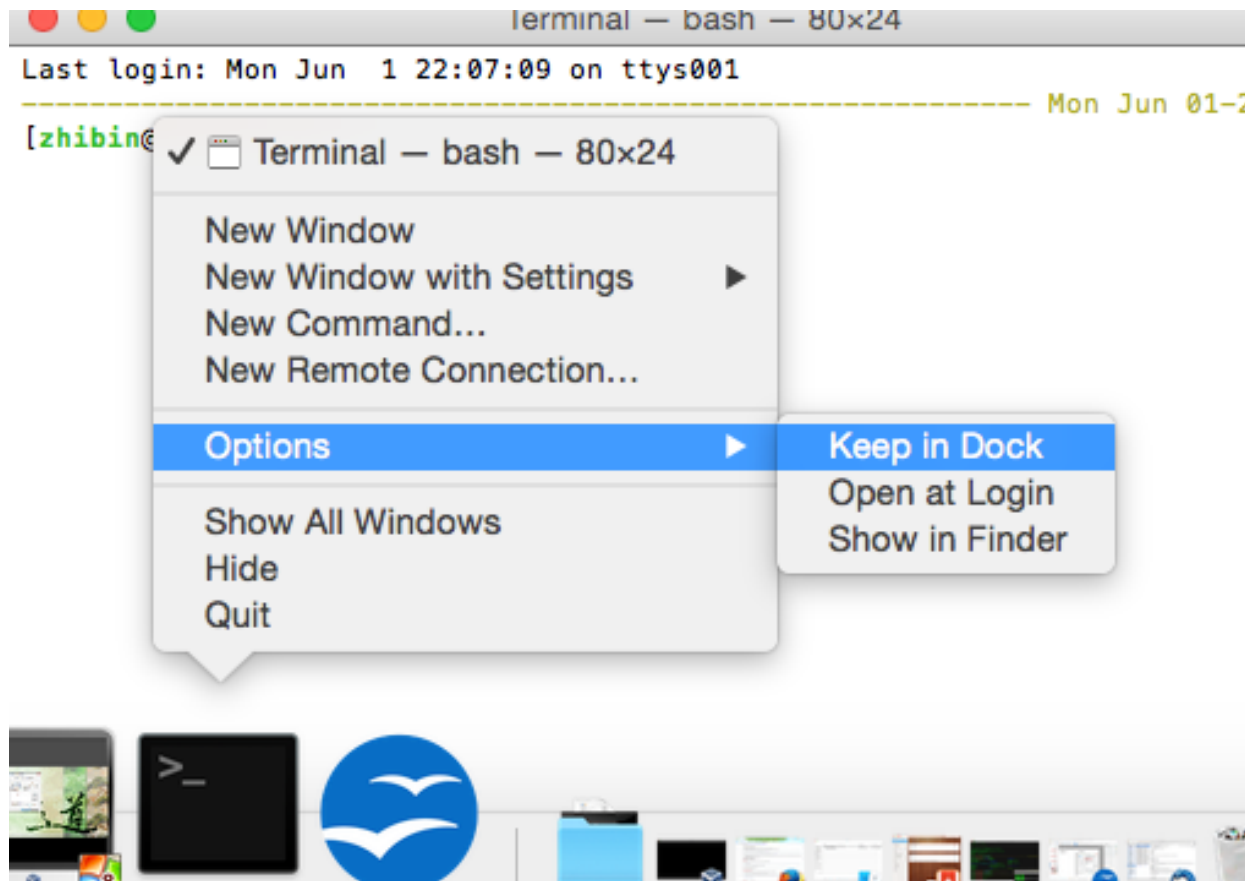
In a Finder window
'Applications' -> 'Utilities' -> 'Terminal'



Or on your dock



Add the terminal App to your dock



Creating a working directory on your Mac called 'cbw'

```
obis-air:~ ogriffit$ pwd
/Users/ogriffit
obis-air:~ ogriffit$ ls
Applications      Desktop           Dropbox           Movies            Public            gittemp          temp
Attachments       Documents        Google Drive     Music             bin              igv              ncbi
Box Sync          Downloads        Library          Pictures          git
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$ █
```

Obtain your AWS 'key' file from course wiki

- Resources
- Roster
- Forums
- Drop Box
- Chat Room
- Email Archive
- Meetings & Courses
- CSHL RSS
- Statistics
- Site Info
- Help

Presentations

20th November (Friday)

19th November (Thursday)

18th November (Wednesday)

17th November (Tuesday)

- [Informatics for RNA-seq: A web resource for analysis on the cloud](#)

16th November (Monday)

- [Obi, Malachi & Jason: Informatics for RNA-seq: A web resource for analysis on the cloud](#)

15th November (Sunday)

14th November (Saturday)

➤ [Malachi Griffith & Obi Griffith: Informatics for RNA-seq](#)

➤ [AWS Sign In Console](#)

- Username : cshl.student
- Password : seqtec

Connect to AWS via Terminal

- [Download CSHL.pem](#)
- `chmod 400 CSHL.pem`
- `ssh -i CSHL.pem ubuntu@YOUR_IP_ADDRESS`

➤ [Jason Walker: Unix Command-line Bootcamp](#)

Go to course wiki,
“Presentations”
page

On Mac:
Control+
Save Link As

Save key file to
your new 'cbw'
directory

Viewing the 'key' file once downloaded

```
obis-air:cschl ogriffit$ cd ~/cschl/
obis-air:cschl ogriffit$ ls -la
total 8
drwxr-xr-x  3 ogriffit  staff   102 Nov 13 22:21 .
drwxr-xr-x+ 58 ogriffit  staff  1972 Nov 13 22:18 ..
-rw-r-----@ 1 ogriffit  staff  1696 Nov 13 22:21 CSHL.pem
obis-air:cschl ogriffit$ cat CSHL.pem
-----BEGIN RSA PRIVATE KEY-----
MIIIEpgIBAAKCAQEAvJ5gwmTby9QZ2Idz+ugiEQQHw6Ps0ZAZFvr+mWdN4pKpccaVmDh7XjcEOLF
0kKJzaP9+jj0kSF0yNinitoB32DgrmVhgNhyheEqH5XMn28szxUj1EuoNXAogNuY7mWmo6MoWssSW
Rqy+rj19vMGQn5rsnMLjCM1smebPoqY0L8EPa1ccRbdGXG1dMTlCC1ho/Hk9bZweamGiZLaAWvmf
zOK/L0zXgY3K4cwaL48HV6oGuMh5lTDpnobxXghQ4oC5Mej+DpCRF8C+EG2uNDuyulzRjFqmfBV2
GKDWDwhdgGmKmx9IpMT9ubvNoQPy0vYLvM80eG3cMbz2IZpaNryihwIDAQABAoIBAQCZYT0TvF04
a3DdCEEC/rN9HMaS+bjFkm0kp9RTi15XJhTPvBmptjzibA6gWJfDaXgKIQGbzxJrEkxwCR2IB03v
0LV7jEcomZ2ggRMDPeJitFoUCuDnkZZtivppSk2az0zeaD+0/ZeqPx0L+Yr+7HSbpVLVoxEV/l5a
xDuCaWBMsy2cnGwKfEBLSPnB6fGZj8luGzv0aP/CETx/K78TIS56m4yrTIQIeEPfFt/PQr/EUqoL
7co5oy9K3sD1noPLDhk3vJa1VNrMjHkMZLkbZuaoHPzgsQHninm80Ca25WWTGsSZ8vQsBIUTlGI1
W7lzXH3wD1jJNd+03QK4bnKaZ+DZAoGBAPVpisa49JY/6K2f9B8naqtX/ljzVWtL3Q7r6t6uh21Y
oexmC8eJ2wQwd0qNjZWVxSMVksIwdM6xcsBIJRMmltWTVdmD0fkDv0fjd8CM4nctH76tvSvZz02e
qI9wSshHY1fh+09CoLZeefFSURxqWbkJfREjoZ4UGUWmi3k1rxC9AoGBAMTB1BB0WQ+5ojzQYu0L
Q4YrsIPg1/ni0WmJ+05vcTCJ2aeI88VhK5c2PoXPWwiJ9CdD2VFZDiCm2XuJA5iwJmnhuwGGHhEN
BFBqEF/ueJrW+r43pRcYRuRiXjiH4mQQlK4Zemecym5fAHvxZxq4fs2kwfMPySFaVufcP0VC7X6T
AoGBAMhro0xbrFQwaU0yh9oRhMneGPhn8WtvVjNjc/LcMfmZEtrPGnuhF965/hJCvEhXgiH+8lXo
4NwUixSBvtXnA/P0WX5Ea2ykIth2Kkx0Qlb14SEGHqH7RZ0saRiLqmcZ9gXFpkm6rimByrDMezVr
nU7CcwNWSB0ja0gluZoJv6k5AoGBAJJuFsmD5ZhkaS+lTtpnlZtXDIk5XsMkYQGQpS0clzqufQPI
UtPEm3Jv9lwTktDQSpqmTifShUcbpaPgtoJ+JjiKvGhH7QbxKK7II00kULG760SD+S0U972Rdj3Q
M1aRWHwxlH1KH0vDXFLhuAAU6poVBLR2PRPLbf4k1hmv05xtAoGBAJVQy1GF8uVNwk0CNzLIqmKY
uk9M24hfqn3N2GY3Zgqf43bD4kdYgL4rvsgp08QzotPf+19kVlCv0ciolSjEHLyUdlyPGzj4CTTH
1f1RoGHmYzVn9VuFTu4hJ17J+uwgXgIr9Sx/UTjwkmCjPf7CEyIuGxaThG/ZoR9stufZB5db
-----END RSA PRIVATE KEY-----obis-air:cschl ogriffit$
```

Changing file permissions of your 'key' file (Mac/Linux)

ls -l (long listing)

```
drwx-----+ 67 ogriffit staff 2278 22 May 21:25 ../  
-rw-r--r--@ 1 ogriffit staff 1696 22 May 21:31 CBW.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>

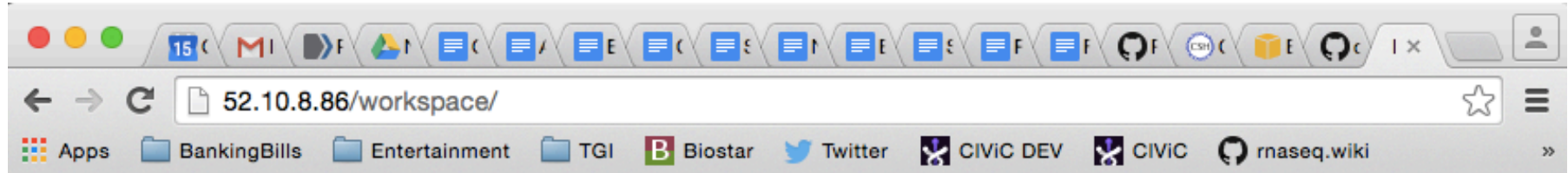
It is "r" for the the file owner **only**

Logging into your instance



Mac/Linux

```
cd cbw/  
chmod 400 CBW.pem  
ssh -i CBW.pem ubuntu@[YOUR INSTANCE IP ADDRESS]
```

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



Index of /workspace

Name	Last modified	Size	Description
 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://\[YOUR INSTANCE IP ADDRESS\]/](http://[YOUR INSTANCE IP ADDRESS]/)

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 Management Console interface for the EC2 Dashboard. The left-hand navigation menu is visible, with the 'Instances' tab selected. The main content area displays a table of EC2 instances. The instance 'instructor_test2' is highlighted, and its context menu is open, showing the 'Stop' option. A red box highlights the text at the bottom of the screenshot.

Name	Instance ID	Instance Type	Availability Zone	Instance State	Status Checks	Alarm Status	Public DNS
instructor_test2		m3.2xlarge	us-west-2c	running	2/2 checks ...	None	ec2-52-10-8-86.us-west-2.compute.amazonaws.com
JasonWalker		m3.2xlarge	us-west-2c	stopped		None	
pengpeng		m3.2xlarge	us-west-2c	stopped		None	
ALesiak		m3.2xlarge	us-west-2c	stopped		None	
djcoughlin		m3.2xlarge	us-west-2c	stopped		None	
jakesaunders		m3.2xlarge	us-west-2c	stopped		None	
YunjuSung		m3.2xlarge	us-west-2c	stopped		None	
Jonathan.Wan	i-6640acbc	m3.2xlarge	us-west-2c	stopped		None	
KateD	i-a241ad78	m3.2xlarge	us-west-2c	stopped		None	
JenTudor	i-0e42aed4	m3.2xlarge	us-west-2c	stopped		None	
YanZhang	i-0342aed9	m3.2xlarge	us-west-2c	stopped		None	
ArenMarshall	i-0242aed8	m3.2xlarge	us-west-2c	stopped		None	

Instance: i-068e6cdc (instructor_test2) Public DNS: ec2-52-10-8-86.us-west-2.compute.amazonaws.com

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 Management Console interface for the EC2 service. The left sidebar contains navigation options such as INSTANCES, SPOT REQUESTS, RESERVED INSTANCES, COMMANDS, IMAGES, AMIs, BUNDLE TASKS, ELASTIC BLOCK STORE, NETWORK & SECURITY, LOAD BALANCING, and AUTO SCALING. The main content area displays a table of EC2 instances. The instance 'JasonWalker' (ID: i-3246aae8) is in a 'stopped' state. A context menu is open over this instance, with the 'Instance State' option selected, and the 'Start' option highlighted. A red box at the bottom of the screenshot contains the following text:

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 IP address. Select your instance and “Connect” or look in Description tab. Then go back to instructions for “Logging into your instance”

The screenshot displays the AWS Management Console interface for EC2 instances. The top navigation bar shows 'AWS Services' and the user 'cshl.student @ 3648-4068-4323' in the 'Oregon' region. The left sidebar contains navigation options like 'EC2 Dashboard', 'Instances', 'Spot Requests', etc. The main content area shows a list of instances. The 'instructor_test2' instance is selected, and the 'Connect' button is highlighted with a red arrow. Below the list, the 'Description' tab is active, showing details for instance 'i-068e6cdc'. The 'Public IP' field is highlighted with a red arrow, showing the address '52.10.8.86'.

Name	Instance ID	Instance Type	Availability Zone	Instance State	Status Checks	Alarm Status	Public DNS
instructor_test2	i-068e6cdc	m3.2xlarge	us-west-2c	running	2/2 checks ...	None	ec2-52-10-8-86.us-wes...
JasonWalker	i-3246aae8	m3.2xlarge	us-west-2c	stopped		None	
pengpeng	i-6740acbd	m3.2xlarge	us-west-2c	stopped		None	
ALesiak	i-0d42aed7	m3.2xlarge	us-west-2c	stopped		None	
djcoughlin	i-3540acef	m3.2xlarge	us-west-2c	stopped		None	
jakesaunders	i-a747ab7d	m3.2xlarge	us-west-2c	stopped		None	
YunjuSung	i-6540acbf	m3.2xlarge	us-west-2c	stopped		None	
Jonathan.Wan	i-6640acbc	m3.2xlarge	us-west-2c	stopped		None	
KateD	i-a241ad78	m3.2xlarge	us-west-2c	stopped		None	
JenTudor	i-0e42aed4	m3.2xlarge	us-west-2c	stopped		None	
YanZhang	i-0342aed9	m3.2xlarge	us-west-2c	stopped		None	
ArenMarshall	i-0242aed8	m3.2xlarge	us-west-2c	stopped		None	

Instance: **i-068e6cdc (instructor_test2)** Public DNS: **ec2-52-10-8-86.us-west-2.compute.amazonaws.com**

Field	Value
Instance ID	i-068e6cdc
Instance state	running
Public DNS	ec2-52-10-8-86.us-west-2.compute.amazonaws.com
Public IP	52.10.8.86

So, at this point:

- Your Mac 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

We are on a Coffee Break & Networking Session

