

# Read Mapping

# 4 Main Stages

1

Biological  
Question

2

Design &  
Conduct  
Experiment

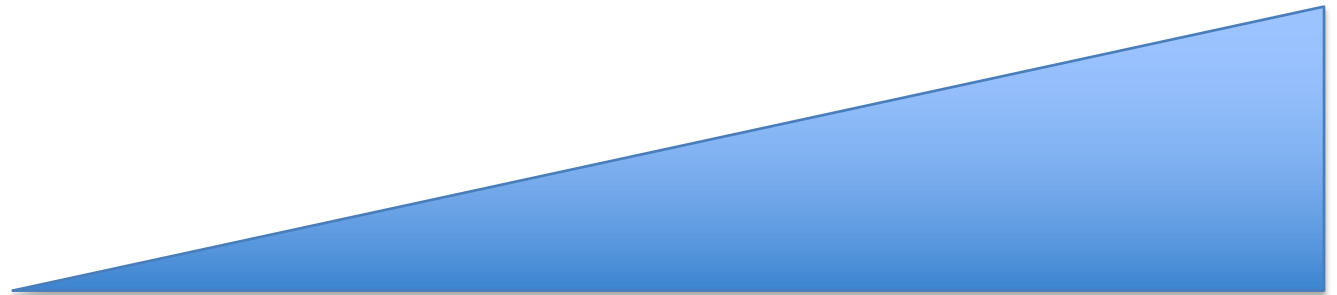
3

Prepare NGS  
Library &  
Sequence

4

Sequencing  
Analysis

Class time



# 4 Typical Stages of Variant Analysis

1

Read Quality  
Control



2

Map Reads



3

Identify Variants

4

Visualize Variants

# Why Map Reads?

- Fastq files are listed in an arbitrary order based on where they were located on the flow cell during sequencing. This is not informative in any way, and checking each read separately for specific information would not be possible.
- Imagine throwing 1,000s or 1,000,000s of copies of Hamlet into a paper shredder, and trying to see how many of the copies misprinted ‘to be not to be’ rather than ‘to be or not to be’. If the text was in order an impossible task simply becomes daunting.

# What do we map reads to?

- Reference genomes.
- Other reads.

# Not all Reference genomes are equal

## 1. Accuracy

1. Your organism
2. Public reference
3. Incomplete (contigs)
4. “similar” organisms

## 2. Annotations:

1. Without annotations: know where/what mutation is
2. With annotations: insight into effect of mutation

# Where to find reference genomes

1. Public databases such as NCBI.
  1. This should be your goal whenever possible.
2. Created yourself starting from:
  1. Publicly available reference
    1. The closer the reference is the easier it will be.
    2. May require multiple rounds of identifying variants, and incorporating them back into the reference sequence.
  2. Next-generation sequencing itself and assembled.
    1. We will optionally cover this towards the end of class.
    2. Exceptionally difficult (though if [Oxford Nanopore](#) error rates decrease this will hopefully become easier to even trivial).

# How does read mapping work

- Build an index to facilitate “speedy” read mapping.
  - Allows a read to be placed on the reference at a location (a “**seed**”) where it knows at least a piece of the read matches perfectly (or with only a few mismatches).
  - By jumping right to these spots in the reference, rather than trying to fully align the read to every place in the genome, it saves a ton of time.
  - Indexes can be reused for mapping any set of reads.
- Align reads using the index
  - Full reads are aligned around “seed” locations on a base by base basis.



# Mapping score vs. Alignment score

- **Mapping score** is the probability that a read is mapped to the correct location in the genome.

**Read 1**

**Read 2**

ATCGGGAGATCC

or

ATCGGGAGATCC

GCGTAGTCTGCC

|||||

|||||

|| ||| |||

...TAATCGGGAGATCCGC...TTATCGGGAGATCCGC... ..TAGCCTAGTGTGCCGC...

- **Alignment score** is how well a read maps to the given location.

ATTGCGATCGGATGAAGACG..AA

||||| ||| | XX || | XXX ||

ATTGCGATCGGATGTTGACTTTAA

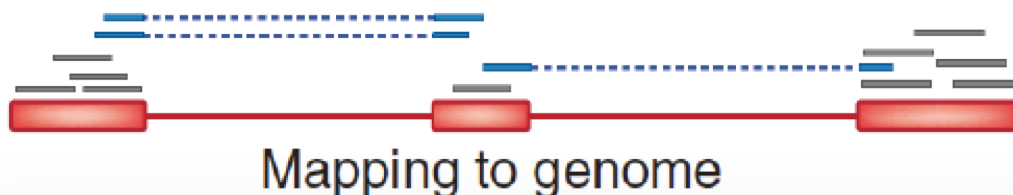
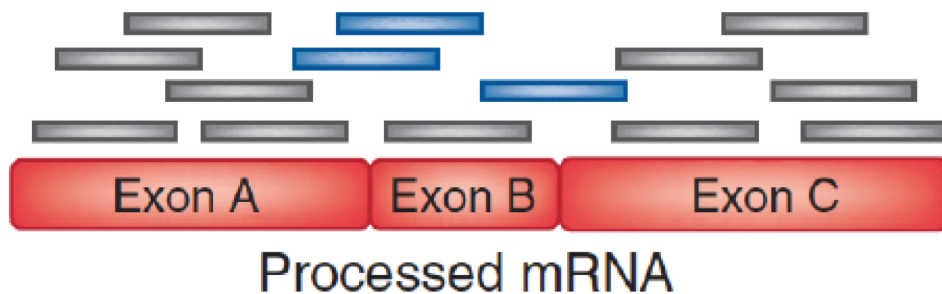
# **TYPES OF MAPPING**

# Paired End Mapping

- There is an expected insert size distribution based on the DNA fragment library.
- Mapping one read anchors the paired read to a specific location, even if the second read alone maps multiple places equally well.
- Only one read in a pair might be mappable. (Known as singletons/orphans).
- Both reads can map with an unexpected insert size or orientation (known as discordant pairs).

# Split Read Alignment

- Useful for predicting structural variants (or splice variants in RNA-seq, as pictured).
- Not many mappers do this directly, usually happens in a post-processing pipeline step.

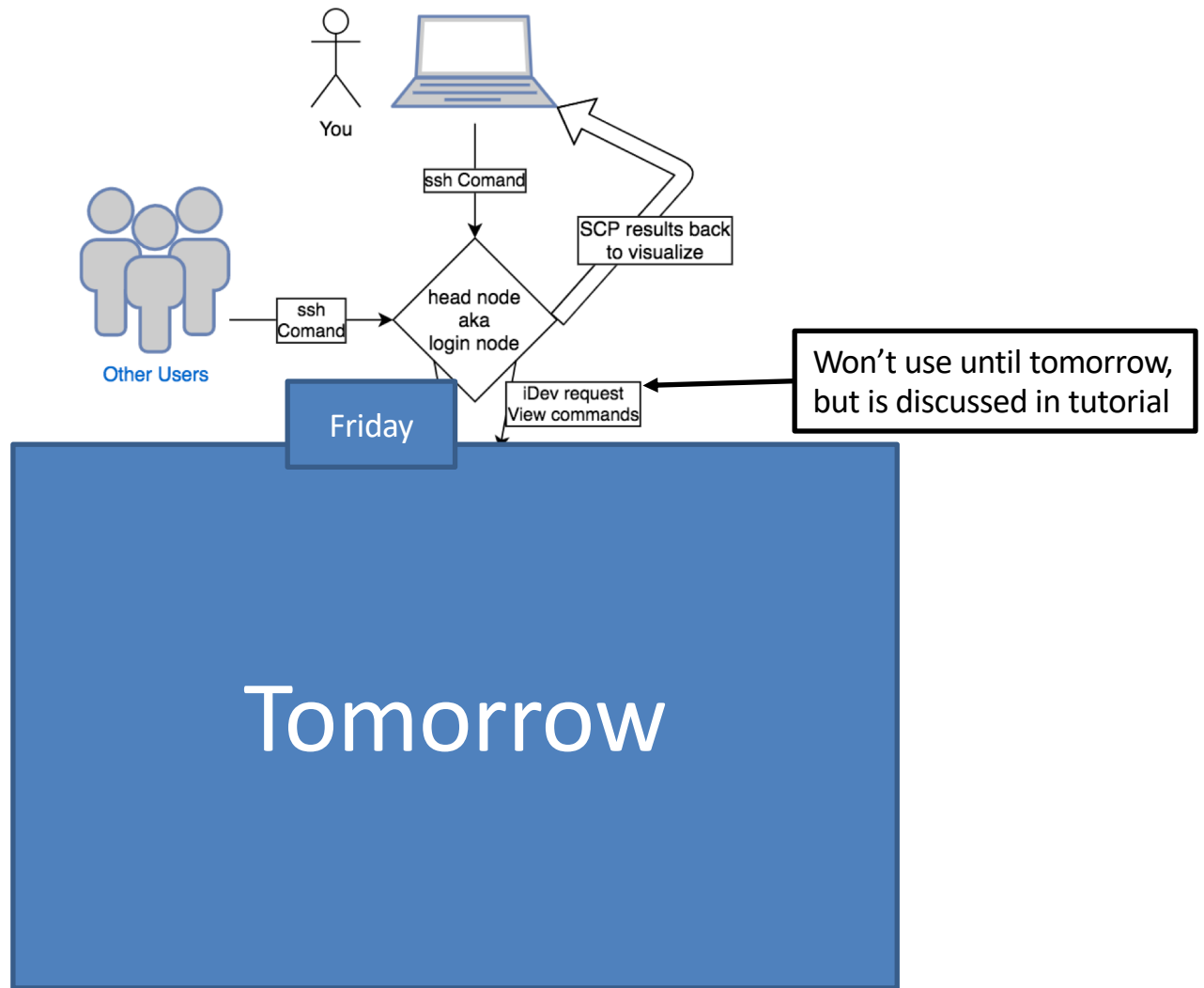


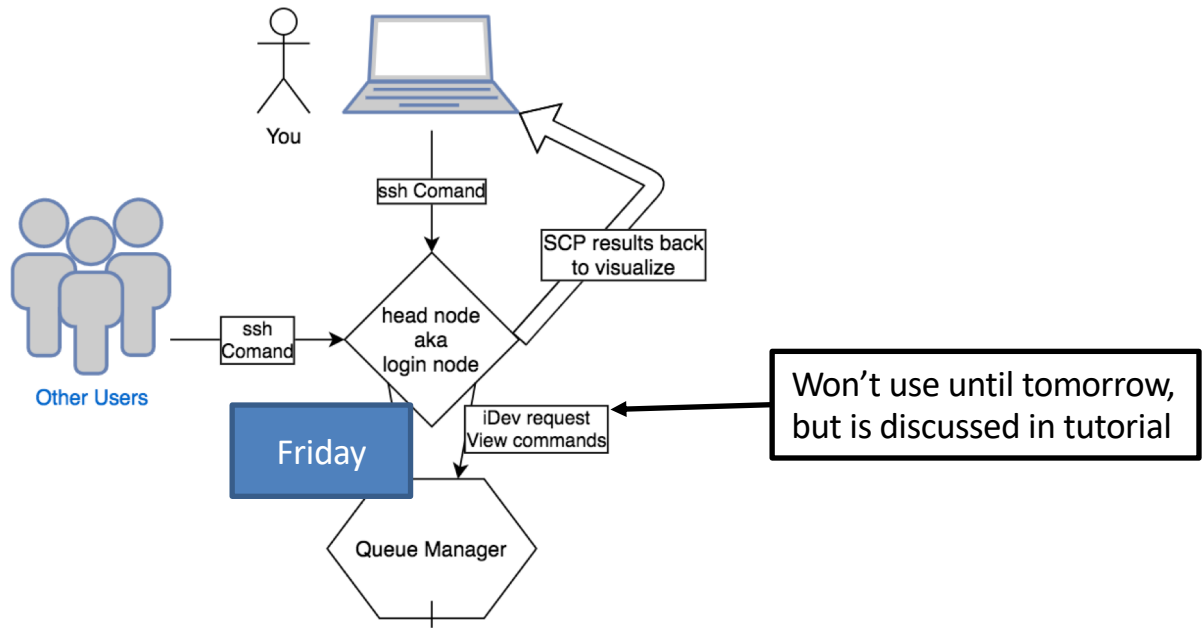
Trapnell, C. & Salzberg, S. L. How to map billions of short reads onto genomes. *Nature Biotech.* 27, 455–457 (2009).

**HOUSEKEEPING**

# Conda environments

- Broadly 2 ways to use them:
  1. 1 environment with all programs
  2. 1 program per environment
- For today, we will set up 3 different environments with the following programs:
  1. bowtie2
  2. samtools, and bcftools







# idev nodes & the reservation

- TACC has reserved a set of computer for us to use so we don't have to wait in the queue.
- Important that we use the compute nodes instead of the head/login node so we don't interfere with other users.

# Onto the tutorials!

- Quickly work through the day 1 catchup tutorial to make sure you have the minimum completion requirements.
- Complete the bowtie2 read mapping tutorial to learn how to actually map reads back to a reference file.
- Be sure to start an idev session when you see the warning to do so before indexing.