Computer Operating Systems

Computer fundamentals for bioinformatics

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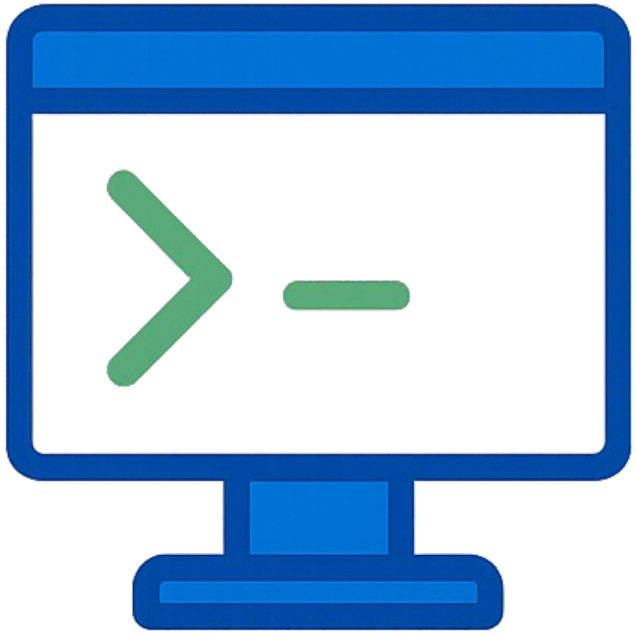

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Module Objectives

- Basic computer architecture
  - BIOS/UEFI

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  - What does *nix means for bioinformatics?

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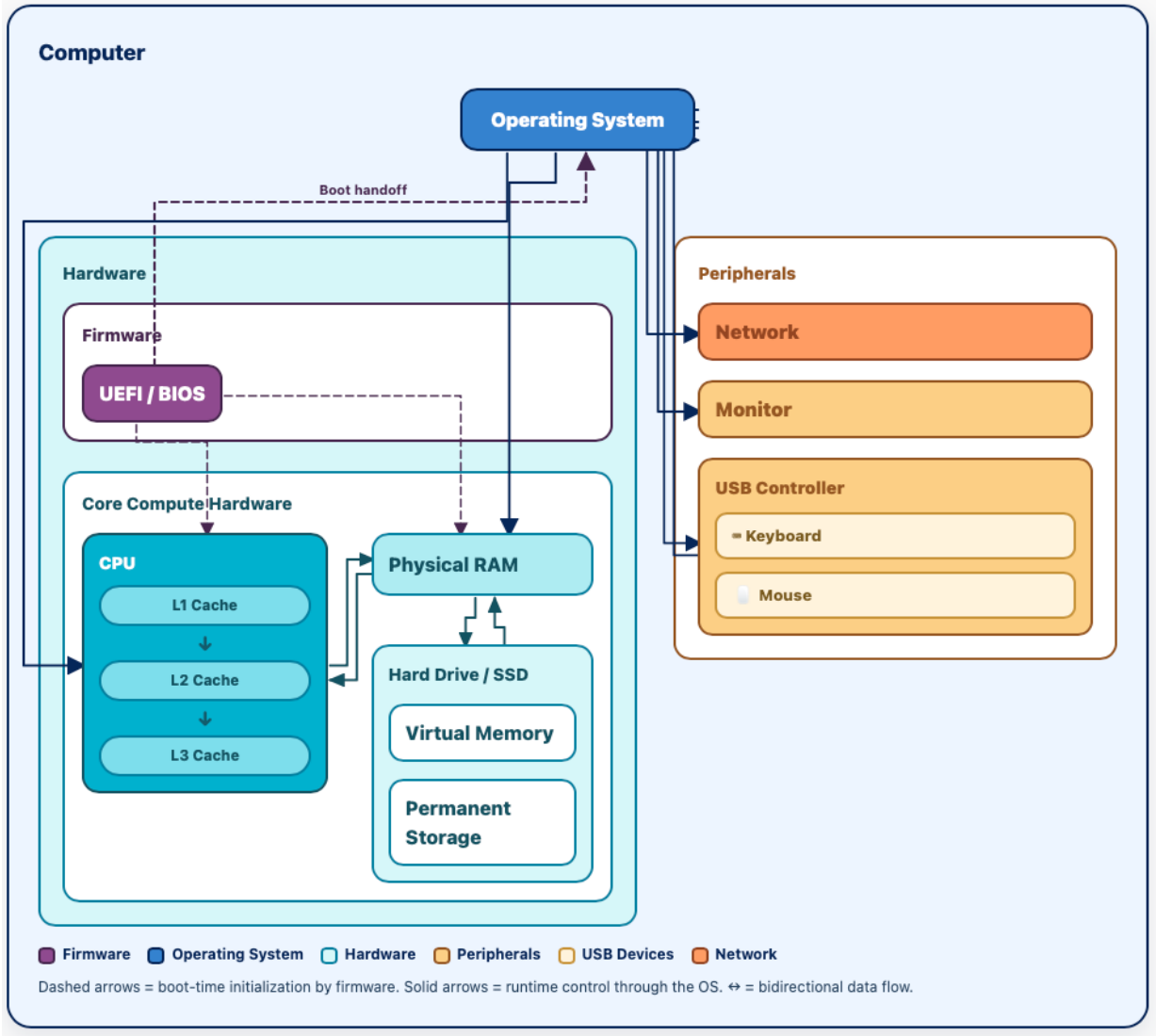
  - What does *nix means for bioinformatics?
- Install WSL on windows machines, access command prompt from MacOS

Computer architecture

- Basic computer architecture

Core Hardware Components

- **CPU (Processor)**
  - Executes instructions
  - Determines compute capacity
  - More cores = more parallel processing
- **RAM (Memory)**
  - Temporary working space for running programs
  - Fast, volatile storage
  - Limits how much data can be processed at once
- **Hard Drive (Storage)**
  - Long-term data storage
  - Slower than RAM
  - Used for files, datasets, logs, and outputs



Computer architecture

- Basic computer architecture

In Bioinformatics, We Primarily Monitor:

1. Memory (RAM usage)

Large datasets can exhaust memory

Insufficient RAM causes crashes or slowdowns

2. I/O (Disk Read/Write Speed)

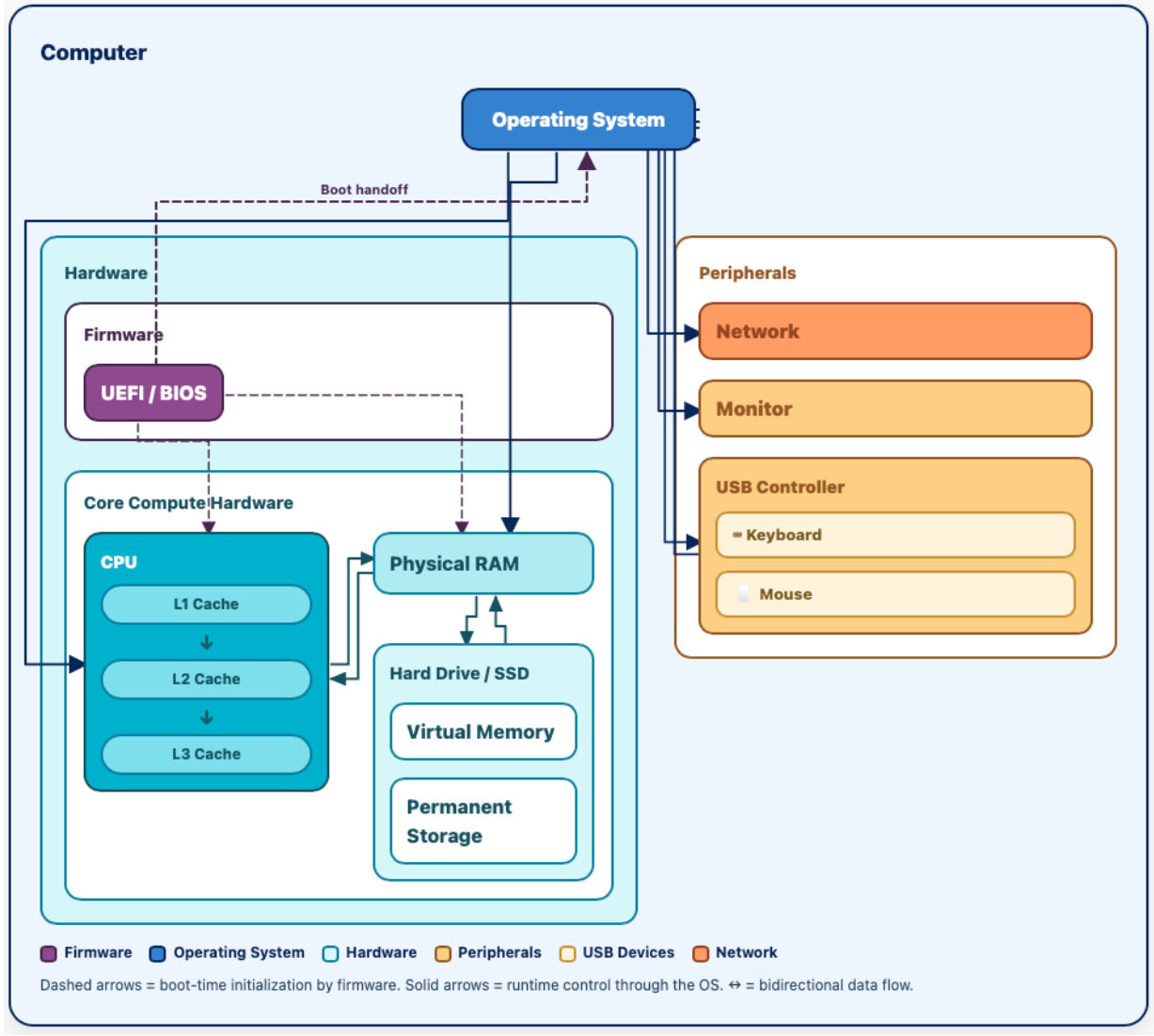
Moving large files can become a bottleneck

High disk usage slows pipelines

3. CPU Count (Core Availability)

Many tools support multithreading

More cores can reduce runtime



Operating Systems (OS)

- An **operating system** (OS) is the core software that manages all hardware and software resources on a computer
- Provides a **user interface**, allowing people to interact with applications, files, and the system itself
- Handles essential tasks
  - memory management
  - process scheduling
  - storage access
  - security controls
- Allows applications to run by managing how programs access hardware resources

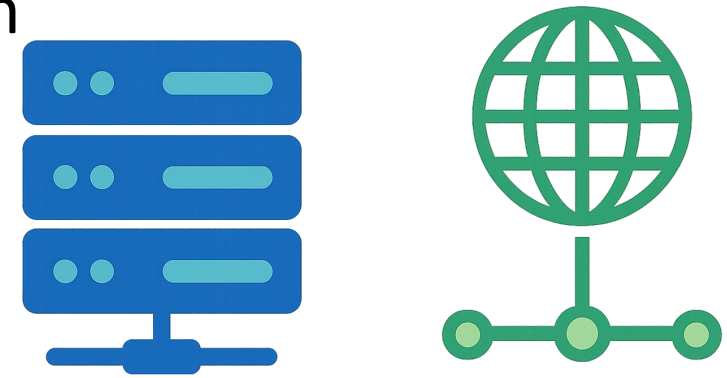
- Common OS examples
  - Windows
  - macOS
  - Linux
  - Android
  - iOS

Virtual Machines (VMs)

- A **virtual machine** (VM) emulates a full computer system, allowing multiple operating systems to run on a single physical machine
- Run two different operating systems on the same hardware for flexibility:
  - Compatibility needs
  - Using tools available only on a specific OS
  - Ease of use
- VMs provide strong isolation between multiple operating systems

Networks and Servers

- A **network** is a system that connects computers and devices, allowing them to **share** data, resources, and services through wired or wireless communication links
- A **server** is a computer system designed to provide resources or services—such as data, applications, or network functions—to other devices over a network
  - $$$$
  - Optimized for reliability and continuous operation
  - Handle requests from clients, managing tasks
    - Data storage
    - Application hosting
    - Authentication
    - Communication between systems



Command Line Interface

- Much of bioinformatics is done in a Linux (or unix) OS: ***nix**
- Unix and Linux are built around a command-line–focused design: system control, automation, and scripting
  - Windows is oriented toward a graphical user interface (GUI)
    - also provides command tools like PowerShell and Command Prompt
- Unix/Linux environments are widely used in servers, bioinformatics, and high-performance computing
    - command-line tools
    - **shell scripts**

Command Line Interface

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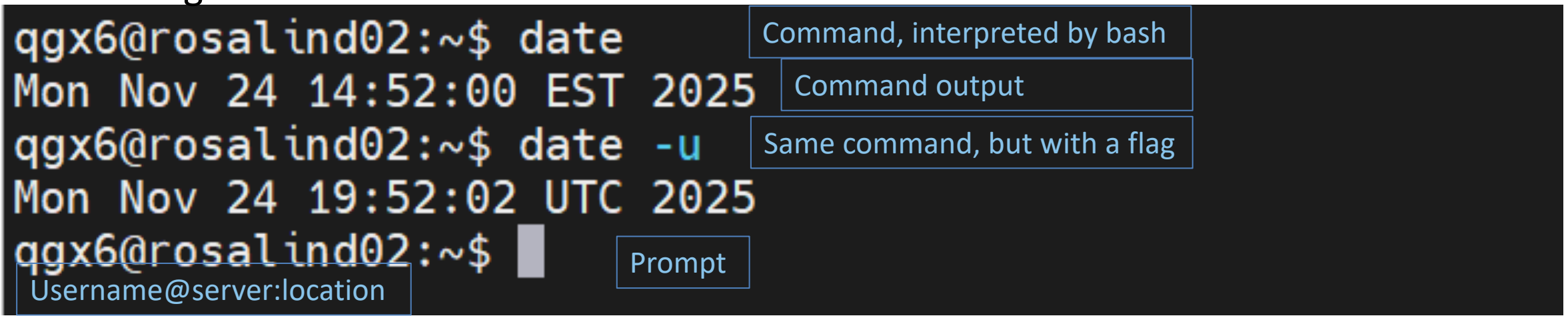
```
[root@localhost ~]# ping -q fa.wikipedia.org
PING text.pmtpa.wikimedia.org (208.80.152.2) 56(84) bytes of data.
^C
--- text.pmtpa.wikimedia.org ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 540.528/540.528/540.528/0.000 ms
[root@localhost ~]# pwd
/root
[root@localhost ~]# cd /var
[root@localhost var]# ls -la
total 72
drwxr-xr-x. 18 root root 4096 Jul 30 22:43 .
drwxr-xr-x. 23 root root 4096 Sep 14 20:42 ..
drwxr-xr-x.  2 root root 4096 May 14 00:15 account
drwxr-xr-x. 11 root root 4096 Jul 31 22:26 cache
drwxr-xr-x.  3 root root 4096 May 18 16:03 db
drwxr-xr-x.  3 root root 4096 May 18 16:03 empty
drwxr-xr-x.  2 root root 4096 May 18 16:03 games
drwxrwx--T.  2 root gdm  4096 Jun  2 18:39 gdm
drwxr-xr-x. 38 root root 4096 May 18 16:03 lib
drwxr-xr-x.  2 root root 4096 May 18 16:03 local
lrwxrwxrwx.  1 root root   11 May 14 00:12 lock -> ../run/lock
drwxr-xr-x. 14 root root 4096 Sep 14 20:42 log
lrwxrwxrwx.  1 root root   10 Jul 30 22:43 mail -> spool/mail
drwxr-xr-x.  2 root root 4096 May 18 16:03 nis
drwxr-xr-x.  2 root root 4096 May 18 16:03 opt
drwxr-xr-x.  2 root root 4096 May 18 16:03 preserve
drwxr-xr-x.  2 root root 4096 Jul  1 22:11 report
lrwxrwxrwx.  1 root root    6 May 14 00:12 run -> ../run
drwxr-xr-x. 14 root root 4096 May 18 16:03 spool
drwxrwxrwt.  4 root root 4096 Sep 12 23:50 tmp
drwxr-xr-x.  2 root root 4096 May 18 16:03 yp
[root@localhost var]# yum search wiki
Loaded plugins: langpacks, presto, refresh-packagekit, remove-with-leaves
rpmfusion-free-updates                                   | 2.7 kB     00:00
rpmfusion-free-updates/primary_db                        | 206 kB     00:04
rpmfusion-nonfree-updates                                | 2.7 kB     00:00
updates/metalink                                         | 5.9 kB     00:00
updates                                                  | 4.7 kB     00:00
updates/primary_db                  73% [=============        ]  62 kB/s | 2.6 MB     00:15 ETA
```

Command Line Interface Terminology

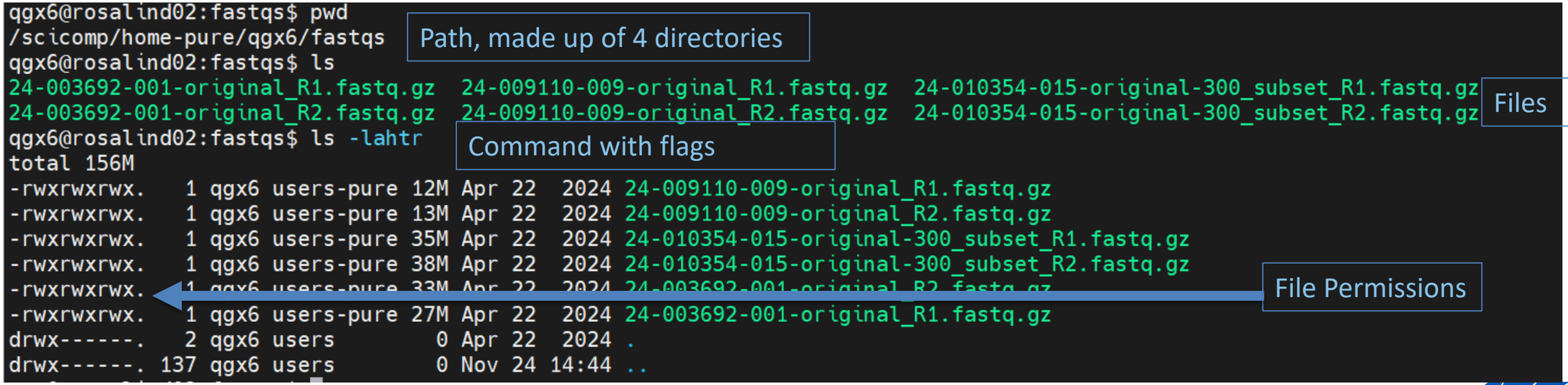
- **Shell** — The program that interprets command-line input and runs commands
  - bash (Linux)
  - zsh (Unix)
  - PowerShell (Windows)

  Very similar → *nix
- **Prompt** — The text displayed by the shell indicating it is ready to accept a command.
- **Command** — **A program** or instruction typed into the shell to perform an action, such as listing files or moving data
- **Flag (or option)** — A modifier added to a command (often starting with - or --) that changes how the command behaves.



Command Line Interface Terminology

- **Directory** — A location in the filesystem used to organize files; similar to a “folder” in graphical interfaces.
- **Path** — The exact location of a file or directory in the filesystem, written as a sequence of directory names.
- **Permissions** — Rules that control who can read, write, or execute a file or directory.



Linux and Filesystem

Linux treats most things like files: one consistent way to access resources

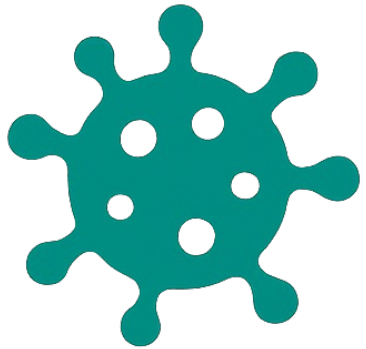
- Regular files (documents, programs)
- Directories
- Devices (/dev)
- System information (/proc)

- All files exist under one root directory

```
/
├── home/
├── etc/
├── var/
└── dev/
```

Bioinformatics and CLI

Much of Bioinformatics is file manipulation and stringing together inputs and outputs from command-line tools



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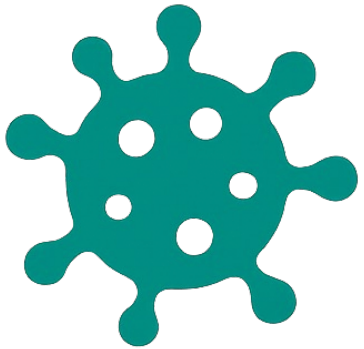

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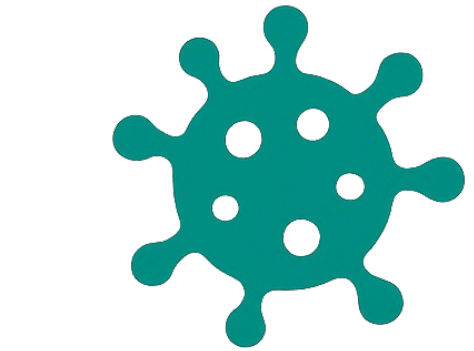
Many programs are designed for command-line execution, providing flexibility, scalability, and compatibility with high-performance and cloud-computing environments



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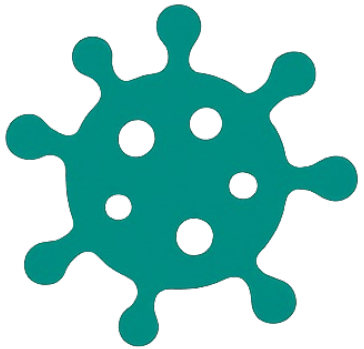
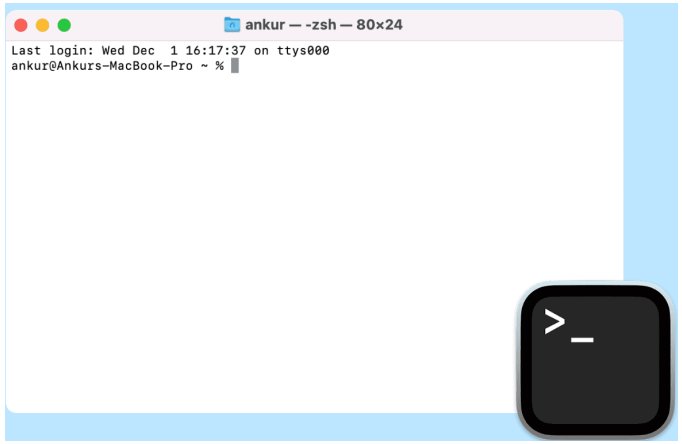
An adept informatician is incredibly comfortable working in the CLI



Practical: Command-line on your Computer

MacOS:

1. Press Command (⌘) + Spacebar to open Spotlight.
2. Type **Terminal**.
3. Press Return to open it.
4. A command prompt will appear on your screen



Windows computer:

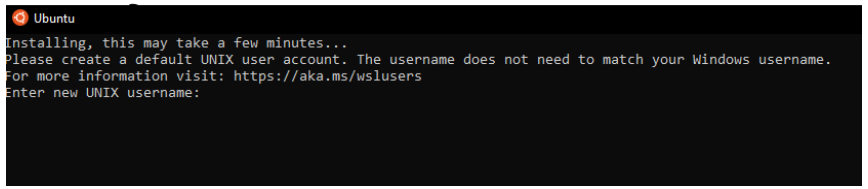
1. Run **Powershell** as Administrator
2. Run the following command in Powershell:

```
wsl --install
```

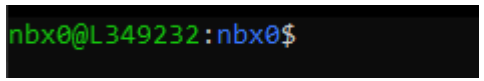
3. Restart your computer
4. Reopen Powershell and enter the following commands:

```
wsl --set-default-version 2
wsl --install -d Ubuntu-24.04
```

Following successful installation, an Ubuntu terminal should pop up



5. Enter a username that will be exclusive for WSL. Press Enter and then enter a password
6. A command prompt will appear on your screen



LinuxOS:

1. Open the Applications or Activities menu (top-left or bottom-left, depending on your system).
2. Search for Terminal, Console, or Xterm (names vary by distribution).
3. Click the icon to launch it.
4. A command prompt will appear on your screen