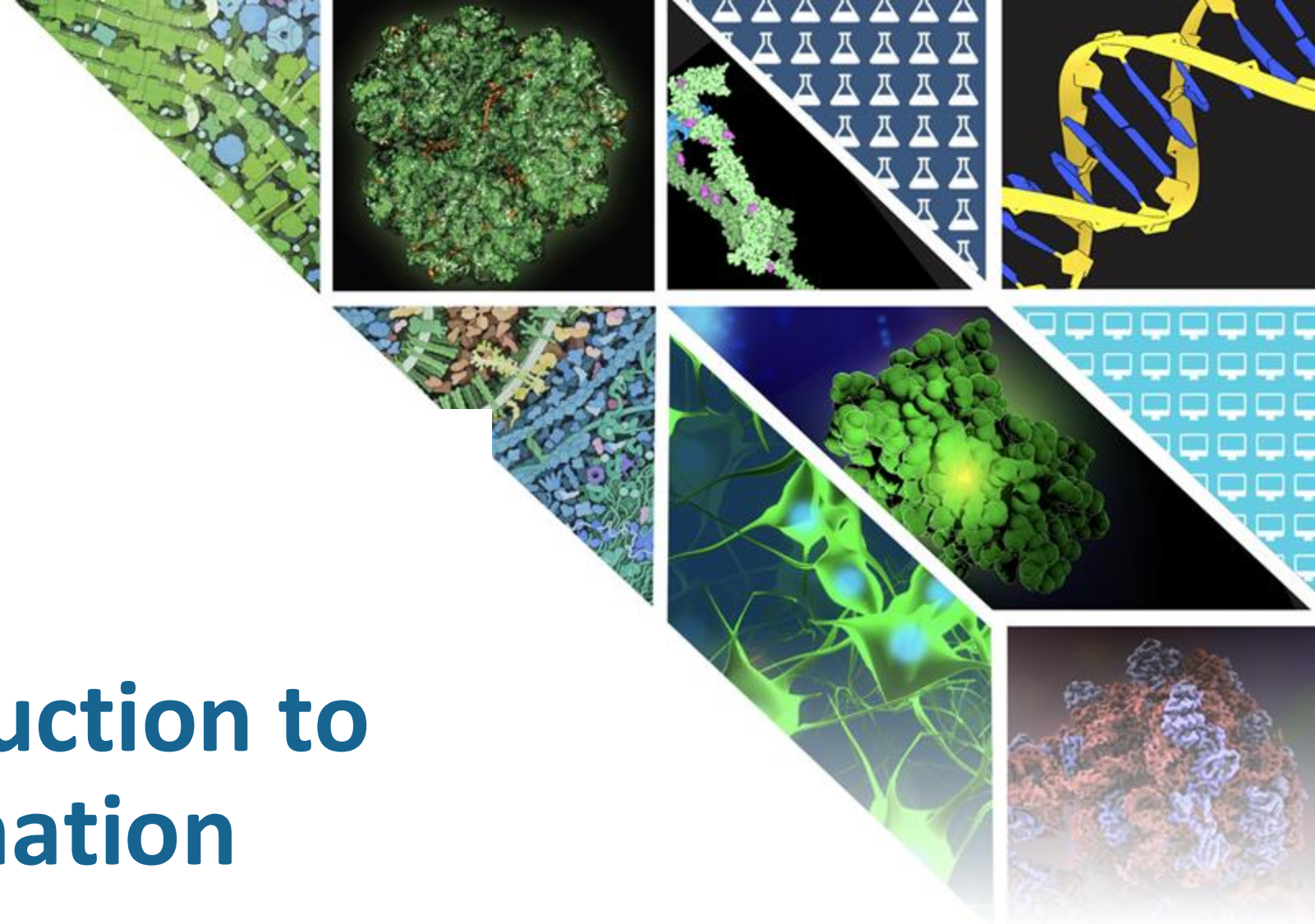


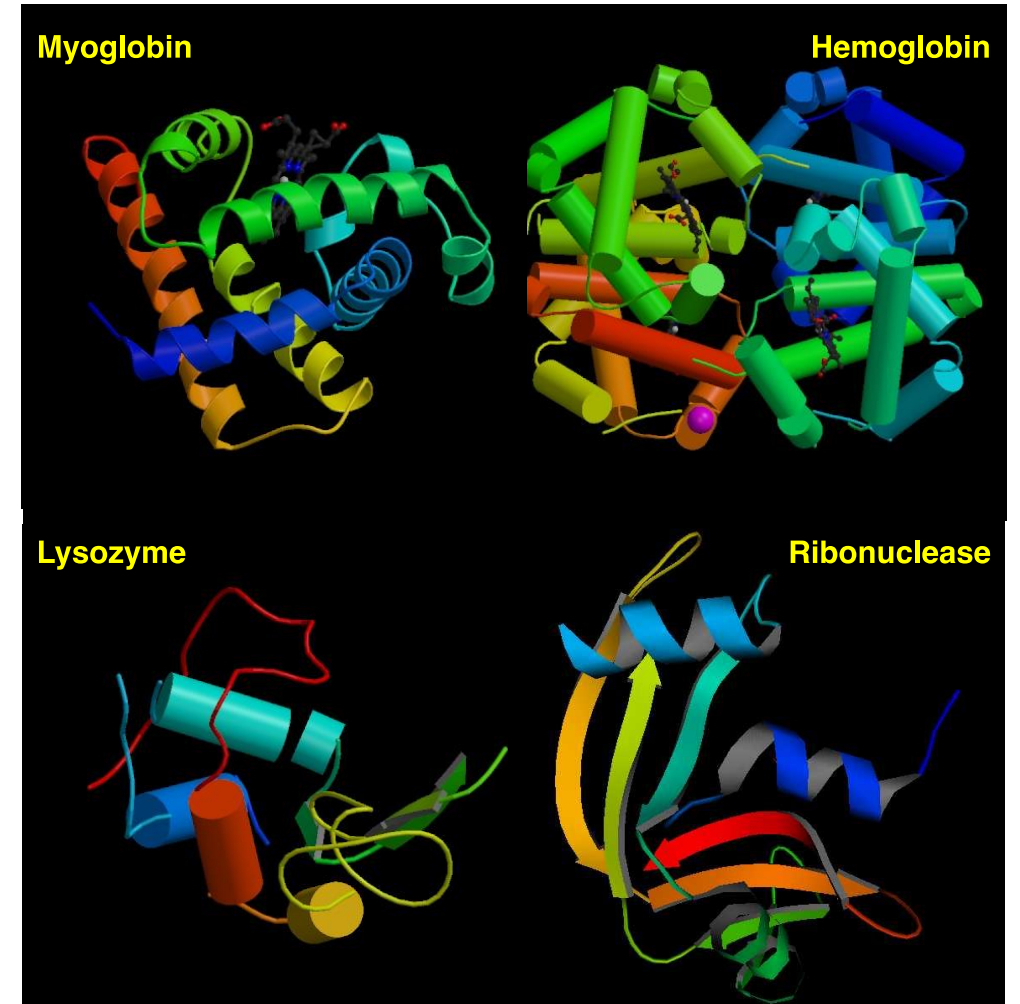
Tutorial: Introduction to Molecular Animation

Maria Voigt
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RCSB PDB, Rutgers University



Animating Protein Data Bank (PDB) Data

- A single global archive for structural biology data
- Started in 1971 with just 7 protein structures
- Now:
Over 237,000 structures freely available



Today's Pipeline

Story board preparation



**Visual Content
Preparation:**

ChimeraX



Make a video for a
presentation/publication/social
media



Repurpose parts of the work to
make a gif animation

Example animation that you can make based on the skills demonstrated in today's tutorial



Materials for Download for this Workshop

- go.rutgers.edu/byokkdet
- **Google Drive** folder with:
 - ChimeraX-sessions (folder): ChimeraX sessions for each stage of assets prep
 - 00-PDB-structures.csx
 - 01-models.csx
 - 02-views.csx
 - 03-labels.csx
 - 04-scene-recording.csx
- **commands-for-workshop.txt**
Text file containing commands we will learn today
- **Full-animation-tutorial.pdf**
Step-by-step tutorial how to create the assets and animate them as shown in the **example_video.mp4**
- Power Point slides from today

The Story

Objective:

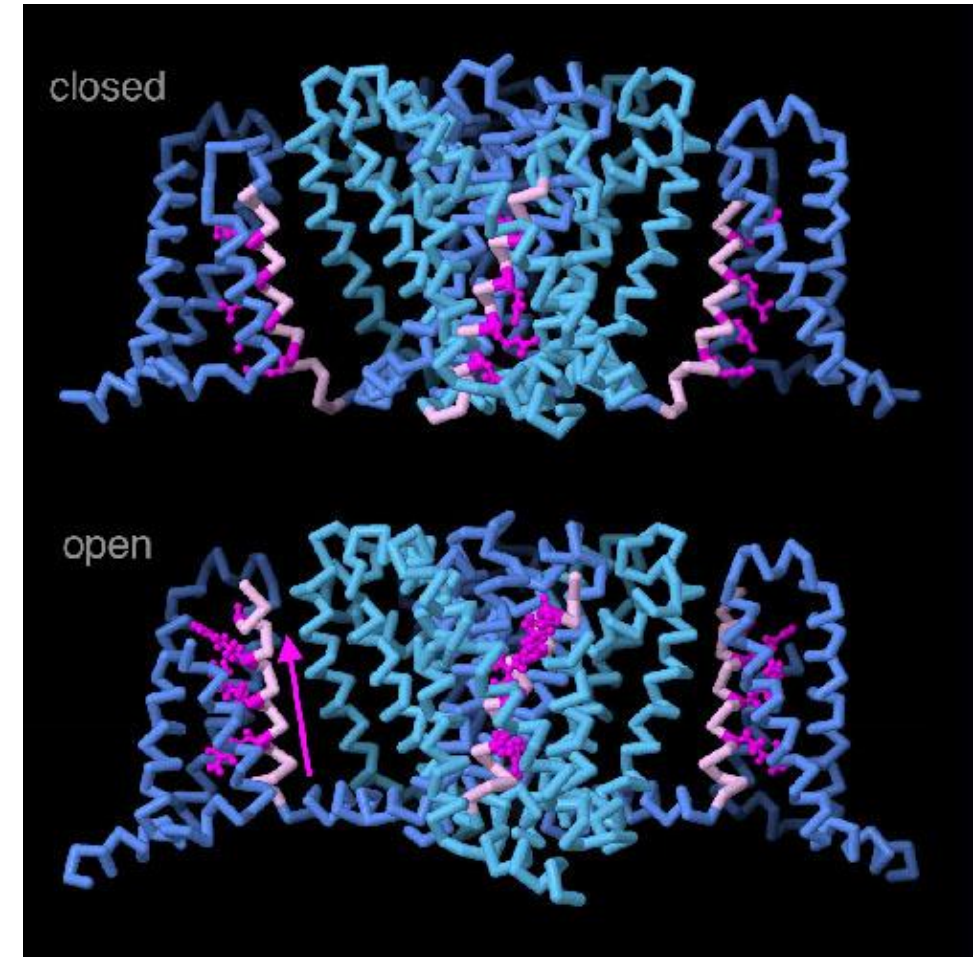
The viewer will understand the structure-function relationship in voltage-gated ion channels

The Data:

Different conformations of the **eucariotic** Na_v channel (PDB structures: 6j8j, 5x0m)*

The Story:

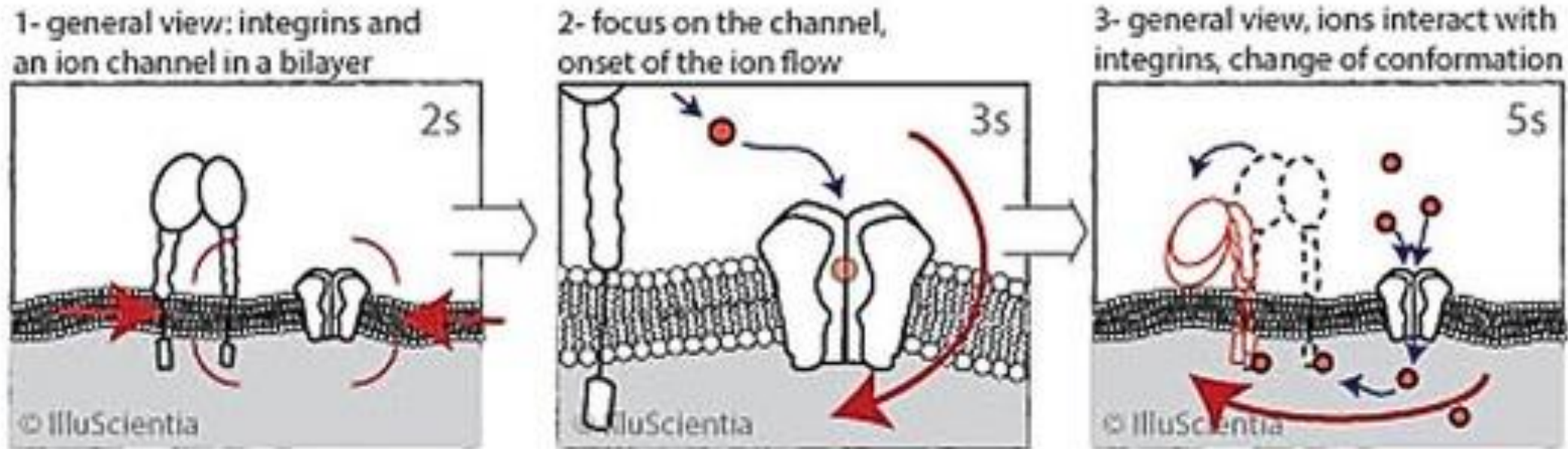
The voltage-gated sodium channels are found in neuronal membranes. In the center of the protein is the ion pore that is closed when the neuron is at rest. The pore is tethered to voltage-gated domains. These domains sense the increase of positive charges inside the cell. This triggers conformational changes that open the pore allowing sodium to enter the neuron.



*Image from PDB-101 Molecule of the Month:
Voltage-gated Sodium Channels*

The Story Board

- A storyboard is a graphic representation of how your video will unfold, shot by shot



Source: www.illuscientia.com/resources/storyboarding-animations/

Creating a simplified 'story board'

1. Write your story and divide it into shots (single continuous takes)

Narration/Audio	Visuals
Shot 1	
The voltage-gated sodium channels are found in neuronal membranes.	
Shot 2	
In the center of the protein is the ion pore that is closed when the neuron is at rest.	
Shot 3	
The pore is tethered to voltage-gated domains.	

Creating a simplified 'story board'

1. Decide what visual elements best illustrate the story.

Narration/Audio	Visuals
Shot 1	
The voltage-gated sodium channels (overall shape) are found in neuronal membranes (where is the membrane in relationship to the channel and what is the orientation of the channel inside the membrane).	Start with the closed state model. Begin with the cartoon view of the molecule in the membrane and spin 180 degrees. After the rotation is done, this will be the main (front) view. Indicate membrane and label 'neuronal membrane' as well as 'inside', 'outside'.

Creating a simplified 'story board'

1. Decide what types of assets are needed

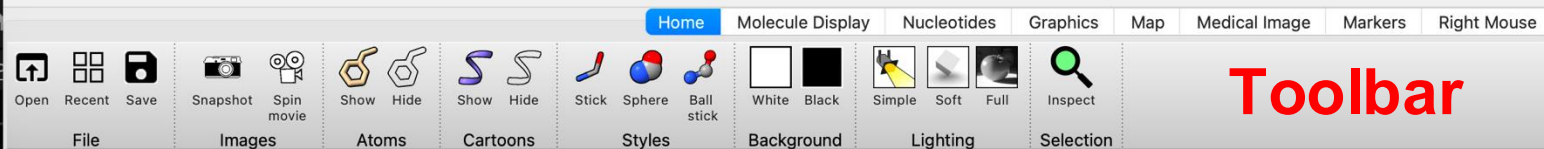
Narration/Audio	Visuals
Shot 1	
The voltage-gated sodium channels are found in neuronal membranes.	Start with the closed state model in cartoon representation. Begin with the view of the molecule in the membrane and spin 180 degrees. After the rotation is done, this will be the main (front) view. Indicate membrane with lines and label 'neuronal membrane' as well as 'inside', 'outside'.

Assets types: **models**, **views**, **arrows/lines**, **labels**

Creating a simplified 'story board'

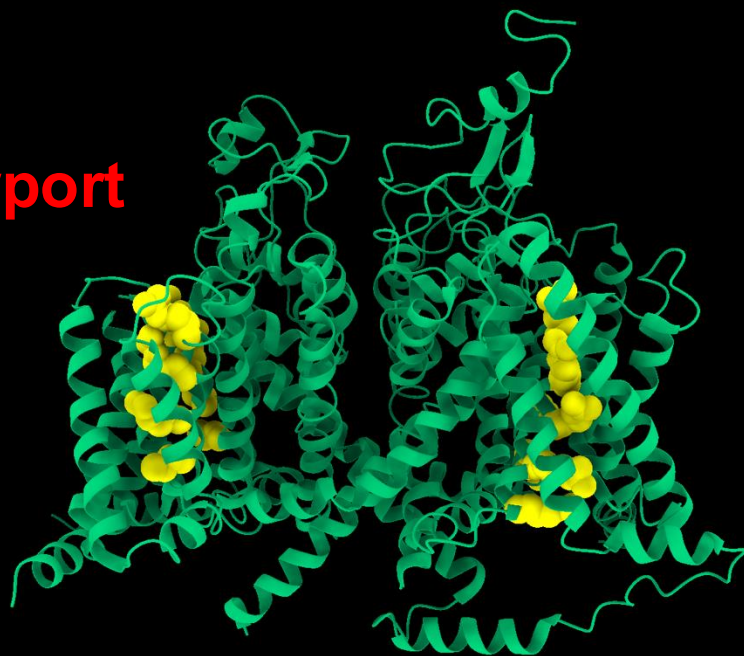
1. Decide what visual elements best illustrate the story.

Narration/Audio	Visuals	Assets to create
Shot 1		
The voltage-gated sodium channels are found in neuronal membranes .	Start with the closed state model in cartoon representation. Begin with the view of the molecule in the membrane and spin 180 degrees. After the rotation is done, this will be the main (front) view. Indicate membrane with lines and label 'neuronal membrane' as well as 'inside', 'outside'.	Models: Closed state in cartoon Views: front back Labels: inside outside neuronal membrane Lines: 4 membrane lines



Toolbar

Viewport



Log

Log

UCSF ChimeraX version: 1.9 (2024-12-11)
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[open](#) /Users/mariavoigt/Desktop/animation-webinar/Chimera-sessions/04-scene-recording.cxs format session
► Log from Sat Jun 21 12:22:12 2025
opened ChimeraX session

[hide](#) #!3 models

[hide](#) #!5 models

[select add](#) #3
7757 atoms, 7851 bonds, 5 pseudobonds, 1120 residues, 2 models selected

[show](#) #!3 models

[select subtract](#) #3
Nothing selected

[turn](#) y 180

[turn](#) x 80

[move](#) x20
Missing or invalid "axis" argument: Expected 3 floats or "x", or "y", or "z" or two atoms

[move](#) x 20

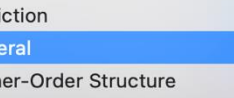
[view](#) front

Name	ID	Models
> 6j8j	1	☐
> 5x0m	2	☐
> Morph - 5x0m	3	☐
> closed-state	4	☐
> 2D arrows	5	☐
> 2D labels	6	☐

Coordinate sets Morph - 5x0m (51)

Model 1

Models Panel



The screenshot shows the Chimera application's menu bar. The 'General' menu is open, displaying a list of options. The 'Command Line Interface' option is highlighted in blue. Other visible options include 'Binding Analysis', 'Depiction', 'Higher-Order Structure', 'Medical Imaging', 'Sequence', 'Structure Analysis', 'Structure Editing', 'Structure Prediction', 'Utilities', 'Volume Data', and 'More Tools...'. The 'Molecule Display' menu is also partially visible to the right.

Menu Item	Status
Binding Analysis	Available
Depiction	Available
General	Selected (Open)
Higher-Order Structure	Available
Medical Imaging	Available
Sequence	Available
Structure Analysis	Available
Structure Editing	Available
Structure Prediction	Available
Utilities	Available
Volume Data	Available
More Tools...	Available
Command Line Interface	Selected
File History	Available
Log	Available
Meeting	Available
Model Panel	Available
Selection Inspector	Available
Send to Quest	Available
Shell	Available
Side View	Available
Toolbar	Available

- ✓ Command Line Interface
- ✓ Coordinate s... - 5x0m (51)
- ✓ Log
- ✓ Models
- ✓ Toolbar



me Molecule Display Nucleotides Graphics Map Medical Image Markers Right Mouse



Log

UCSF ChimeraX version: 1.9 (2024-12-11)
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open /Users/mariavoigt/Desktop/animation-webinar/Chimera-sessions/04-scene-recording.cxs format session

► Log from Sat Jun 21 12:22:12 2025
opened ChimeraX session

hide #!3 models

hide #!5 models

select add #3

7757 atoms, 7851 bonds, 5 pseudobonds, 1120 residues, 2 models selected

```
show #!3 models
```

select subtract #3

Nothing selected

turn y 180

turn x 80

move x20

Missing or invalid "axis" argument: Expected 3 floats or "x", or "y", or "z" or two atoms

```
move x 20
```

[view front](#)

Models

Name	ID			Skip
> 6j8j	1		☐	☐
> 5x0m	2		☐	☐
> Morph - 5x0m	3		☒	☐
> closed-state	4		☐	☐
> 2D arrows	5		☐	☐
> 2D labels	6		☐	☐

Close
Hide
Show
View
Info
Next
Previous

Animations in Chimera X

- Animations can currently only be created through the command line interface
- If you are interested in learning the UI interface for animation for UCSF Chimera, visit <https://pdb101.rcsb.org/learn/videos/visualizing-pdb-structures-with-ucsf-chimera>

Scene set up (or reset):

```
windowsize 1280 720;  
hide #5-6;  
show #5.1-4;  
show #6.1-3  
view back
```

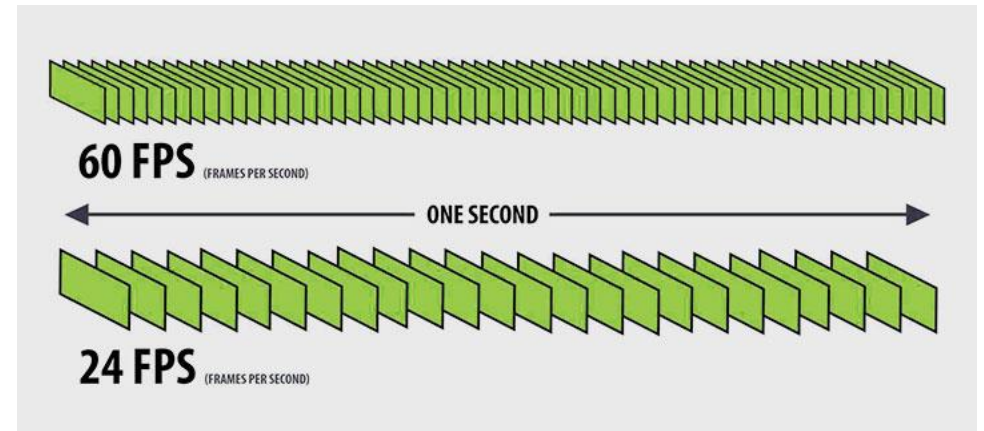
Movie commands:

```
movie record;  
fly 130 back front
```

```
wait 20;  
movie encode ~/Desktop/scene1.mp4
```

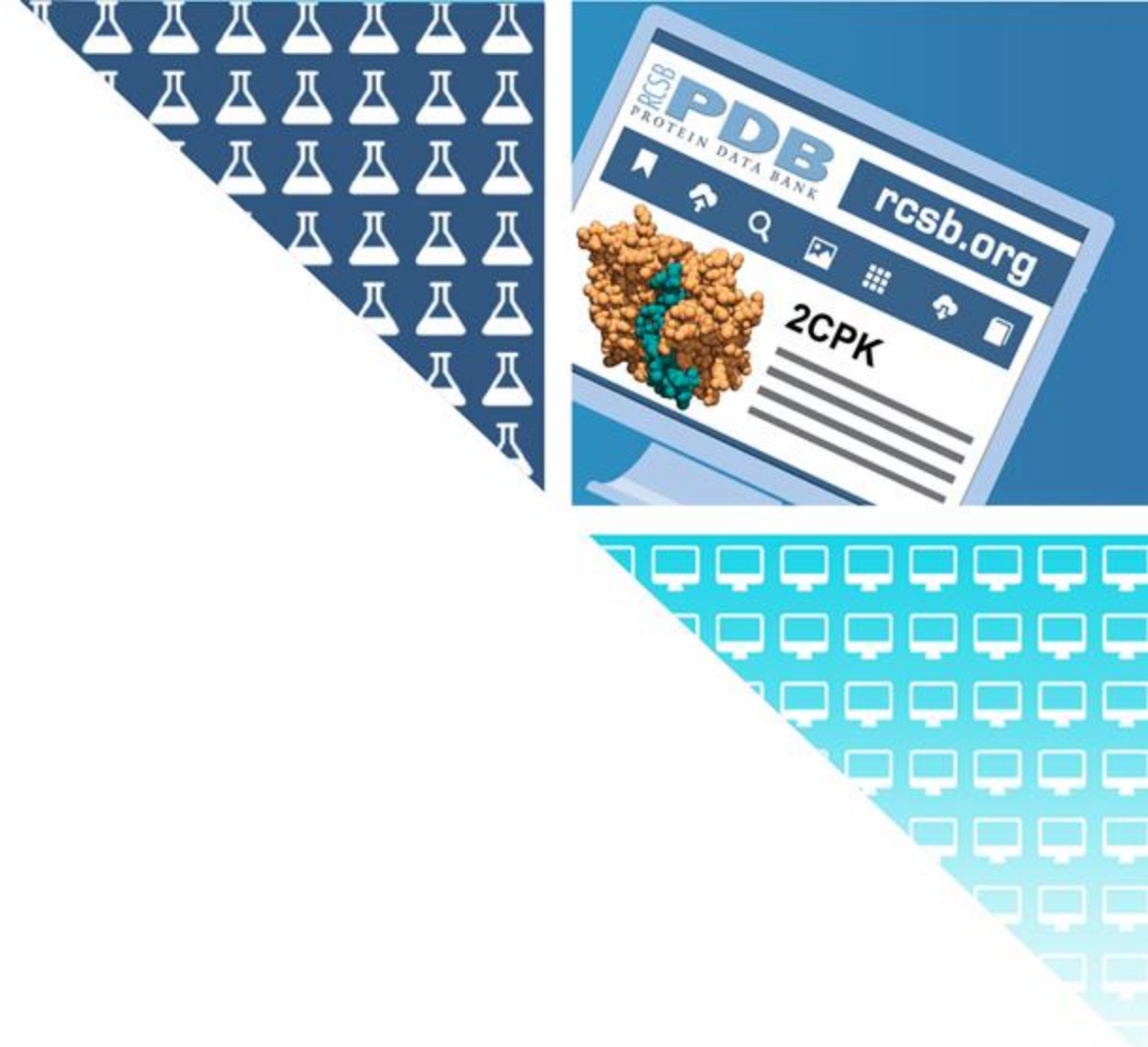
Frames per second

- Frames per second (FPS) is a measure of how many individual images, or frames, are displayed within a second
- Default ChimeraX FPS is 25
- In this command:
`morph #1,2 frames 50`
Model 1 will transition to the confirmation of model 2 over 50 frames, which means the animation will last 2 seconds



Source: www.videoproc.com/resource/frame-rate.htm

Creating the assets in ChimeraX



Creating the 3D models



Creating Morphs

Starting session: 00-PDB-structures.cxs

We have 2 PDB structures of the voltage-gated sodium channel: 6j8j 5x0m

We are morphing 5x0m [#2] into 6j8j [#1]

Before morphing, the structures should be aligned

match #2 to #1

To morph structures in ChimeraX, they need to have the same number of chains

morph #2, 1 frames 50

Playing the morphs

Use `coordset` or graphical slider. The command will be useful once we start recording the move

`coordset #3`

`coordset #3 1,` (play from first frame to the last)

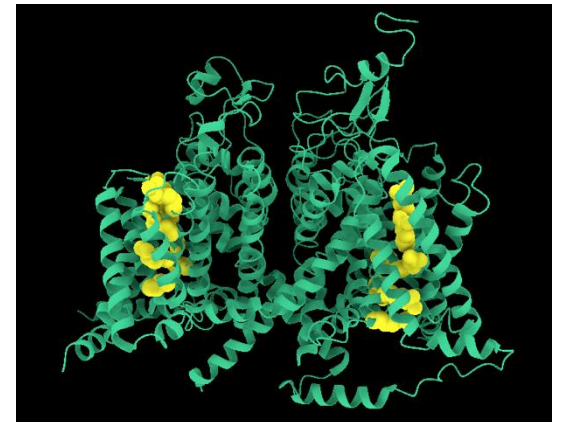
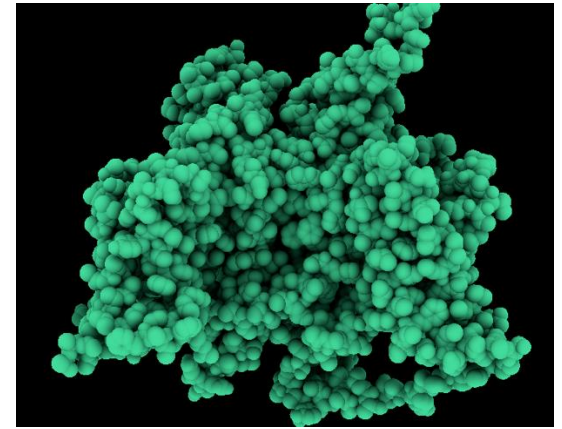
`coordset #3 10,22` (start at frame 3 and stop at frame 22)

`coordset #3 51,1` (play from the last frame to the first)

`coordset slider #3` (restore the graphical slider if you close it)

Finishing up Model Creation

- Create different models for different representations. It simplifies the movie recording process.
- Make the final decisions on colors and depictions and use the combine command to create copies of the model
`combine #3`
- To select the relevant residues, we used the select and select add commands
`select #3/A:619;`
`select add #3/A:616;`



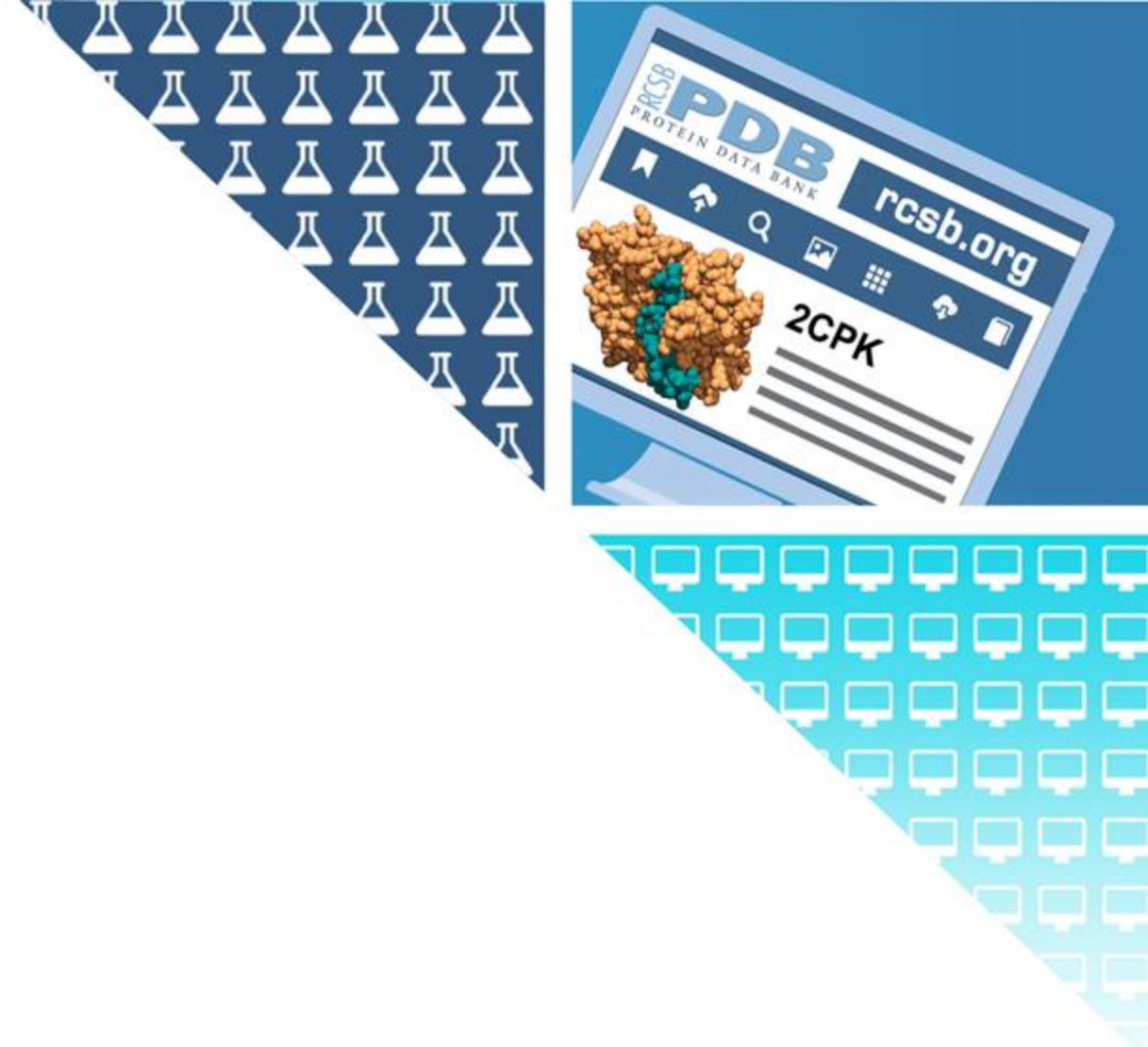
Sizing the animation



Sizing the Animation

- Power Point **widescreen** format slides use the **16x9** aspect ratio (the older format uses 4x3 size ratio). For the animation to fully cover your widescreen slide, you can size your viewport to
 - HD: 1280 x 720 pixels
 - Full HD: 1920 x 1080 pixels
- It's important to decide on the animation aspect ratio before you start creating any content that is relative to the window such as views, labels, arrows, etc.
- Use the command **window size** to size the viewport + width & height in pixels
 - **window size 1280 720**

Creating named views



Saving named views

- The named views allow for saving the position of the camera
view name front
(saves the current view in the viewport with the name *front*)
view front
(resets the view in the viewport to the view saved as front)
view list
(lists the saved views in the log)

Flying through the named views

- The `fly` command allows us to switch from one view to another and the transition is animated
`fly front back;`
(goes from the front to back view in 100 frames - default)

`fly 50 front top`

(goes from one view to another in 50 frames (2 seconds))

`fly 25 back front 100 top`

(goes from back to front in 1 second and then from front to top over 4 seconds)

- Fly can be used in animation with the `wait` command (waits until previous command is executed)
`wait 25` holds the last frame from previous command over number of frames specified

`fly 50 front back;`

`wait;`

`wait 50;`

`fly back top;`

Creating 2D labels and arrows

Starting session: [02-views.cxs](#)

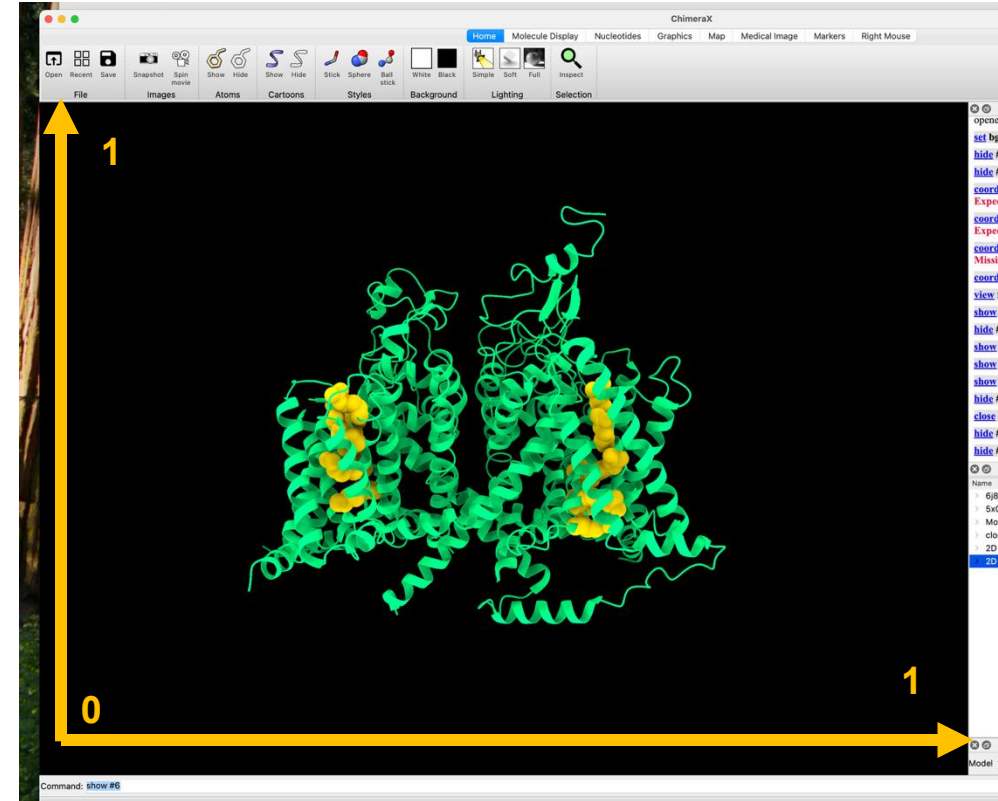


2D arrows and labels: indicating the neuronal membrane

- Be sure you work in proper size ratio before creating arrows and labels

2dlabels arrow start 0.5,0.5 end 0.5,0.7
color red weight 0.6 headStyle pointer

- Head styles:
blocky | **solid** | pointy | pointer
- Use the Right Mouse toolbar tab and choose the 'Move Label' button to position the lines in the viewport



ChimeraX viewport size is 1x1

Editing the attributes for labels

- Each label can be selected by its unique ID (e.g. #5.1) and attributes can be added or overwritten

2dlabels arrow #5.1 weight 1

- You can edit all labels at once
2dlabels arrow all weight 0.3

Creating and Editing Labels

Create a basic label:

2dlabels text 'neuronal membrane' **color** white **size** 25

1. Attributes **color, bgColor, margin, outline, size, xpos, ypos, font, bold, italic, visibility**
2. To edit an individual label, call it by ID and add/overwrite attributes
2dlabels #6.1 size 50
3. To edit **all labels** in the session, add/overwrite attributes
2dlabels all color #ccc
4. To position a label, go to the 'Right Mouse' tab in the toolbar. Choose 'Move label' and drag it wherever you want it with the right mouse button

Setting up the Shot

Narration/Audio	Visuals	Shot Scripts
Shot 1		
The voltage-gated sodium channels are found in neuronal membranes.	Start with the closed state model in cartoon representation (#4). Begin with the view (back) of the molecule in the membrane and spin 180 degrees. After the rotation is done, this will be the main (front) view. Indicate membrane with lines (#5.1-4) and label 'neuronal membrane'(#6.3) as well as 'inside' (#6.2) , 'outside' (#6.1) .	Models panel: show closed state (#4) Shot set up (or reset): <code>window size 1280 720;</code> <code>hide #5-6;</code> <code>show #5.1-4;</code> <code>show #6.1-3;</code> <code>view back</code>

Timing the animation

Narration/Audio	Visuals	Shot Scripts
Shot 1		
The voltage-gated sodium channels are found in neuronal membranes. ~6 seconds > ~150 frames	Start with the closed state model in cartoon representation (#4). Begin with the view (back) of the molecule in the membrane and spin 180 degrees. After the rotation is done, this will be the main (front) view. Indicate membrane with lines (#5.1-4) and label 'neuronal membrane'(#6.3) as well as 'inside' (#6.2) , 'outside' (#6.1) .	Models panel: show closed state (#4) Shot set up (or reset): <code>window size 1280 720;</code> <code>hide #5-6;</code> <code>show #5.1-4;</code> <code>show #6.1-3;</code> <code>view back</code> Record and save movie <code>movie record;</code> <code>fly 125 back front;</code> <code>wait;</code> <code>wait 25;</code> <code>movie encode</code> <code>~/Desktop/scene1.mp4</code>

Recording a movie

The **movie record** command starts recording frames according to subsequent commands.

```
movie record;
```

```
fly 50 back front
```

The command **movie status** lists frames recorded.

movie stop creates a pause in recording, but the frames are saved.

You can resume by using the movie **record command**

The recorded frames can be cleared by the **movie reset** command

Saving a movie

```
movie encode ~/Desktop/test.mp4
```

Encoding a movie means converting raw video footage into a digital format suitable for storage, transmission, and playback.

The command `movie formats` lists all available formats in the log

Streamlining the recording process

- Record shot by shot and ensure your transitions are seamless (always paste the commands for shot reset first, then record the movie)
- Shorter command sequences are easier to manage
- Smaller files are easier to manage
- If you create a video for a [Power Point Presentation](#), add scenes to individual slides. They will create an illusion of a movie as the scenes transition seamlessly. It will give you more control when you narrate live
- Use free resources such as [Adobe Express](#) to combine your scenes into one movie (you can also add narration and additional things)

Repurposing your work

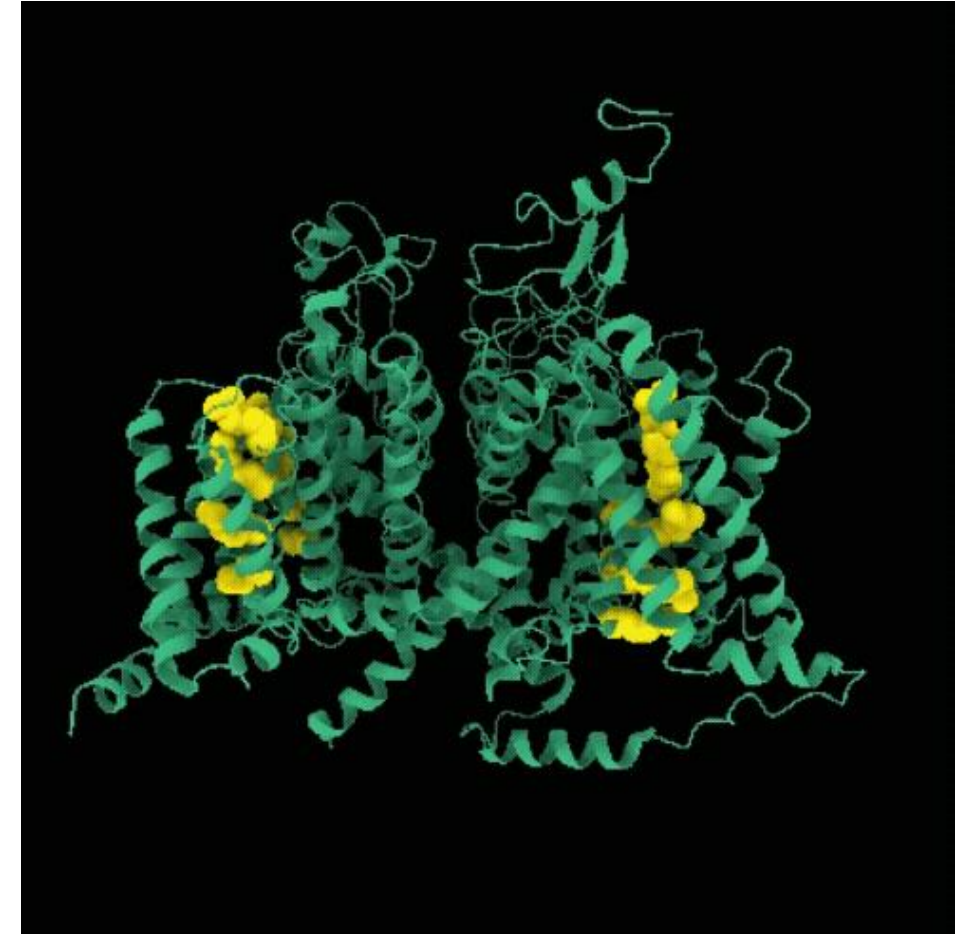
- The assets can be used independently to create other stories and materials.
- For example, you can create a gif oscillating in-between the open and closed states

```
window size 400 200;  
hide #5-6  
view front;  
movie record;  
wait 10;  
coordset #3 1,51
```

```
wait 10
```

```
coordset #3 51,1
```

```
movie encode ~/Desktop/morph.mp4
```



Go to any site that converts movies to gifs and upload your file (e.g. Adobe Express)

Summary

- Working with simplified story boards
- Creating assets in ChimeraX
 - 3D models
 - Views
 - Arrows
 - Lines
- Recording and encoding a movie
- Creating a gif animation
- Further steps: Explore the ChimeraX page 'Making Movies'



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National Institute of Allergy and Infectious Disease, and
National Cancer Institute (NIH R01GM157729), and the
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Management



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