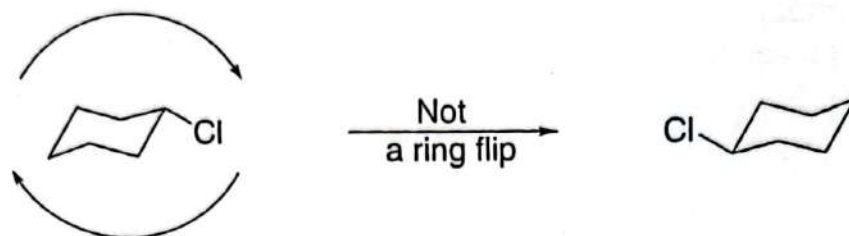
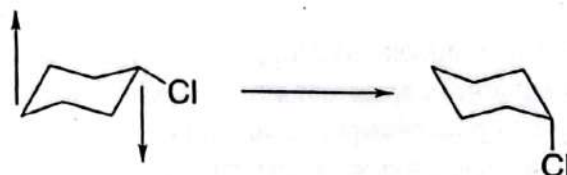


## 6.5 RING FLIPPING

Ring flipping is one of the most important aspects of understanding chair conformations, yet students commonly misunderstand this. Let's try to avoid the mistake by starting off with what ring flipping is not. It is *not* simply turning the ring over:



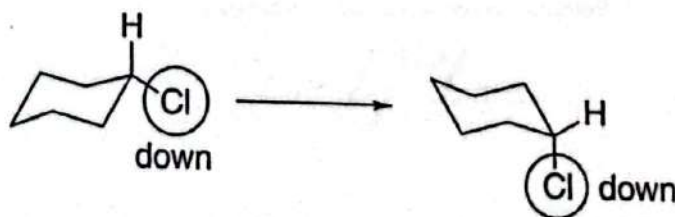
It makes sense why students think that this would be a flip—after all, this is the common meaning of the word “flipping.” But we are talking about something very different when we say that rings can flip. Here is what we really mean:



Notice that in the drawing on the left, the left side of the chair is pointing down. In the drawing on the right, the left side of the chair is pointing up. This is a different chair. Also notice that the chlorine went from being in an equatorial position to being in an axial position. This is a critical feature of ring flips. When performing a ring flip, all axial positions become equatorial, and all equatorial positions become axial.

Let's consider an analogy to help us get through this. Imagine that you are walking down a long hallway. Your hands are swaying back and forth as you walk, as most people do with their hands when they walk. One second, your left hand is in front of you and your right hand is behind you; the next second, it switches. Your hands switch back and forth with every step you take. The cyclohexane ring is doing something similar. It is moving around all of the time, flipping back and forth between two different chair conformations. So all of the substituents are constantly flipping back and forth between being axial and being equatorial.

There is one more important feature to recognize. Let's go back to the example above with the chlorine. We said that the chair flip moves the chlorine from an equatorial position into an axial position. But what about the up/down terminology? Let's see:



Notice that the chlorine is down all of the time. In other words, up/down is not something that changes during a ring flip, but axial/equatorial does change during a ring flip. This proves that there is no relationship between up/down and axial/equatorial. If a substituent is up, then it will stay up all of the time, throughout the ring flipping process.

So now we can understand that a common hexagon-style drawing represents a molecule that is flipping back and forth between two chair conformations. The hexagon drawing shows us which substituents are up and which are down. That never changes. But whether those groups are axial or equatorial will depend on which chair you are drawing. So far, we have learned how to draw only one of these chairs. Now we will learn how to draw the other.

The process for drawing the skeleton of the chair is very similar to how we did it before. The only difference is that we draw our lines in the other direction. When we drew our first chair, we followed these steps:



Now, to draw the other chair, we follow these steps:



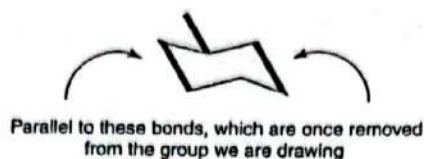
Compare the method for drawing the second chair to the method for drawing the first. The key is in step 2. If you compare step 2 for the first and second chair, everything else should flow from there. Use the following space to practice drawing the second chair:

Now, let's make sure you know how to draw the substituents. The rules are the same as before. All axial positions are drawn straight up and down, alternating:





and all equatorial positions are drawn parallel to the two bonds that are once removed:



### PROBLEM

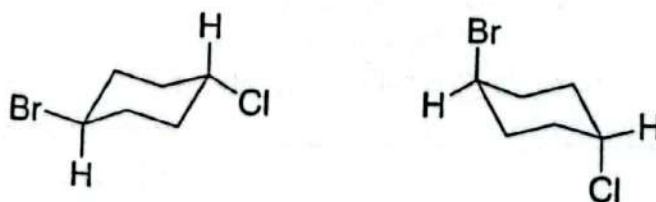
**6.22** In the space below, practice drawing the second chair, showing all 12 substituents.

Let's now go back and review, because it is important that you understand the following points. When we are given a hexagon-style drawing, the drawing shows us which positions are up and which positions are down. No matter which chair we draw, up will always be up, and down will always be down. There are two chair conformations for this compound, and the molecule is flipping back and forth between these two conformations. With each flip, axial positions become equatorial positions and vice versa. Let's see an example.

Consider the following compound:

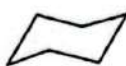


Notice that there are two groups on this ring. Cl is down (because it is on a dash), and Br is up (because it is on a wedge). There are two chair conformations that we can draw for this compound:

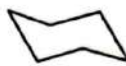


In both chair conformations, Cl is down and Br is up. The difference between these drawings is the axial/equatorial positions. In the conformation on the left, both groups are equatorial. In the conformation on the right, both groups are axial.

So any hexagon-style drawing will have two chair conformations. Now let's focus on making sure you can draw both conformations for any compound. We already saw in the last section how to draw the first one. We used a numbering system to determine where to put the groups, and we used the up/down terminology to figure exactly how to draw them (whether to draw them as equatorial or axial). To draw the second chair, we simply follow the same procedure. We begin by drawing the skeleton for the second chair (this is where you begin to see the difference between the chairs):



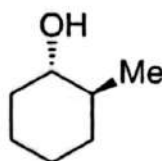
Skeleton for  
first chair



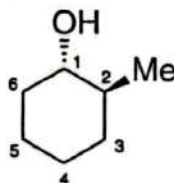
Skeleton for  
second chair

Once we have drawn the skeleton, we number the carbons going clockwise. Then we place the groups in the correct positions, making sure to draw them in the correct direction (up or down). So we can really use this method to draw both chairs at the same time. Let's do an example.

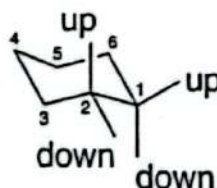
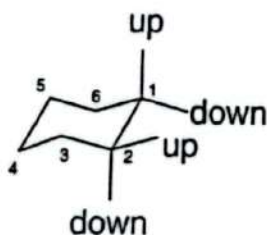
**EXERCISE 6.23** Draw both chair conformations for the following compound:



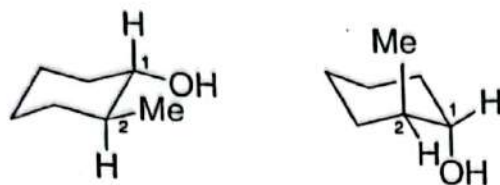
**Answer** Begin by numbering the hexagon at the first group and then going clockwise. This puts the OH at the position numbered 1 and the Me at the position numbered 2.



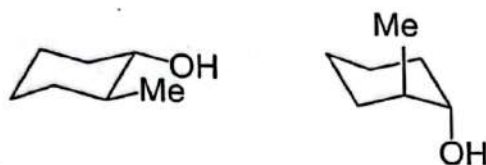
Next draw both chair skeletons and number them going clockwise. Then put in the up and down positions at the carbons numbered 1 and 2:



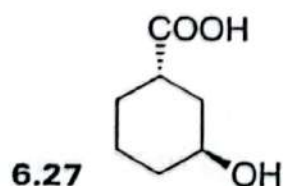
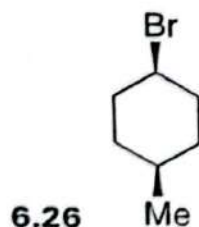
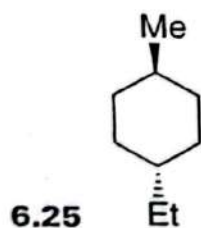
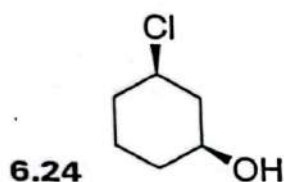
Finally, place the groups where they belong in both chairs. The OH should be at the number 1 position in the down position (because it was on a dash in the hexagon drawing), and the Me should be at the number 2 position in the up position (because it was on a wedge):

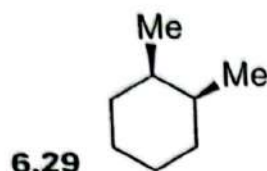
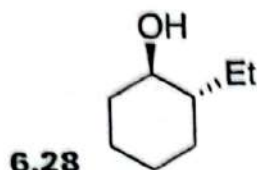


When we redraw these compounds without showing any numbers or hydrogen atoms, it is clear to see that we need to go through these steps methodically because the relationship between these two conformations is not so obvious:



**PROBLEMS** For each of the compounds below, draw both chair conformations.



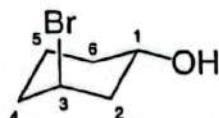


Sometimes, we might be given one chair conformation and be asked to draw the second chair conformation. Again, we use numbers to help us out. Let's see an example:

**EXERCISE 6.30** Below you will see one chair conformation of a substituted cyclohexane. Draw the other chair (i.e., do a ring flip):

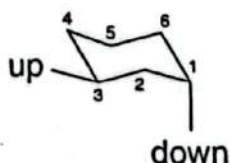


**Answer** Begin by numbering the first chair. Start on the right side of the chair, and put a 1 at the first group. Then go clockwise. This puts the Br at the position numbered 3.



Notice that the OH is down and the Br is up.

Next draw the skeleton for the second chair. Begin numbering on the right side again, making sure to go clockwise. Then draw the down position at the 1 position, and draw the up position at the 3 position:



Finally, place the groups where they belong:





**PROBLEMS** For each chair conformation shown below, do a chair flip and draw the other chair conformation.

