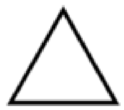
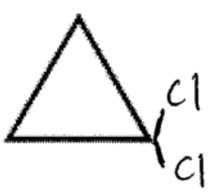
2.3 Cyclic Alkanes

We can bring an C chain around to its starting point and form a cyclic ring. We can form rings of different sizes. Let's look at each in detail.

Cyclopropane 

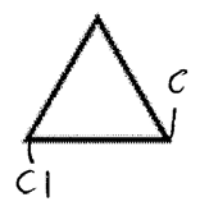
We mentioned the fact that in regular alkanes the bond angle for single C bonds is 109.5^o. What is the bond angle in a 3-membered cyclic ring? 60^o. That's 49.5^o different from the bond angle that C prefers and as you will note I have used springs to make my model; if we tried putting wooden pegs in, we'd bust them because the holes were set for 109.5^o. As a result cyclopropane decomposes very easily and is very unstable; in fact, it's not only unstable, it's explosive; and yet at one time it was used as a general inhalation anesthetic; can you imagine what would have happened to your patient if that cyclopropane had exploded? You know that old story about how all the king's soldiers and all the king's men couldn't put Humpty Dumpty together again.

In the previous we talked about cyclopropane we mentioned the fact that geometric isomers (cis- trans isomers) can occur in cyclopropane ring even though there is no double bond. This turns out to be true for rings in general. To review it lets draw all the isomers that have 2 C1 atoms substituted on a cyclopropane ring and we'll name them.



1,1-dichlorocyclopropane

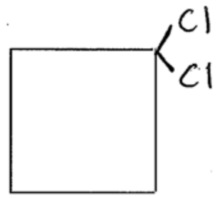
cis-1,2-dichlorocyclopropane



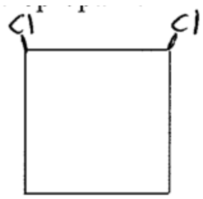
trans-1,2-dichlorocyclopropane

Note that the last two isomers have identical names except for the cis and trans out front.

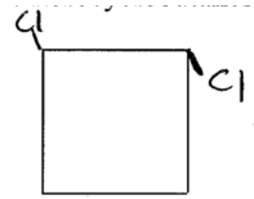
Cyclobutane-4-membered cyclic ring. It is to be expected that the bond angle would be 90^o while it would prefer to be 109.5^o. (The actual structure is a bit kinked and not exactly square, but we won't worry about this.) Cyclobutane is unstable and explosive although not quite as bad as cyclopropane. We can have geometric isomers in cyclobutane rings analogous to the isomers we had with cyclopropane; in fact we can have even more than we did for cyclopropane. Let's look at all the dichlorocyclobutanes:



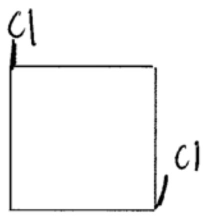
1,1 dichlorocyclobutane



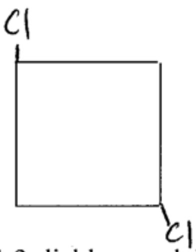
cis-1,2-dichlorocyclobutane



trans-1,2-dichlorocyclobutane



cis-1,3-dichlorocyclobutane

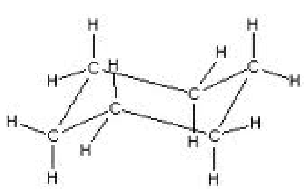


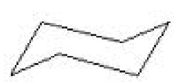
trans-1,3-dichlorocyclobutane

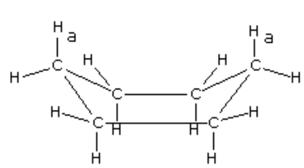
Cyclopentane is a 5-membered cyclic ring; bond angle is 108^o which is only 1^o off from what a normal C-C-C bond angle wants to be; cyclopentane is stable molecule, unlike cyclopropane and cyclobutane. The C atoms are essentially in one plane (one C atom is just a bit out of plane to improve the bond angle). Geometric isomers are possible with cyclopentane. Try drawing all the isomers of dimethyl cyclopentane. named below.

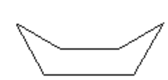
1,1 dimethyl cyclopentane | cis 1,2 dimethyl cyclopentane | trans 1,2 dimethyl cyclopentane | cis 1,3 dimethyl cyclopentane | trans 1,3 dimethyl cyclopentane

Cyclohexane is a 6-membered ring. In the previous ring structures I've drawn the molecules as being flat; that is, all the C atoms are in one plane of the paper. If this were true for cyclohexane, it would be in an hexagonal conformation with bond angles of 120^o which is considerably larger than the 109.5^o bond angle which it would prefer. In fact the bond angles in cyclohexane are 109.5^o. The molecule achieves this bond angle by getting a little kinky. Some organic chemist with an overwrought imagination called the two forms **chair conformation** and **boat conformation.**

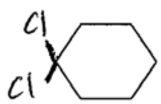



chair

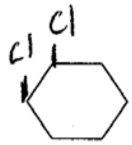



boat

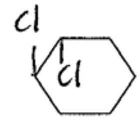
Note that we can still have cis and trans isomers in cyclohexane ring, although its a little harder to see. For writing isomers we will go ahead and draw the cyclohexane molecule as a flat hexagon. Let's go through and draw all the isomers of dichlorocyclohexane.



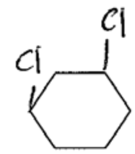
1,1-dichloro-
cyclohexane



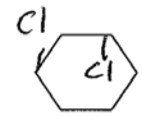
cis 1,2
dichloro-



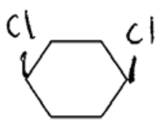
trans 1,2
dichloro-



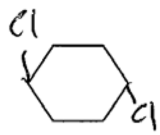
cis 1,3
dichloro-



trans 1,3
dichloro-



cis 1,4
dichloro-



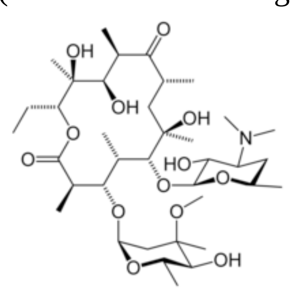
trans 1,4
dichloro-

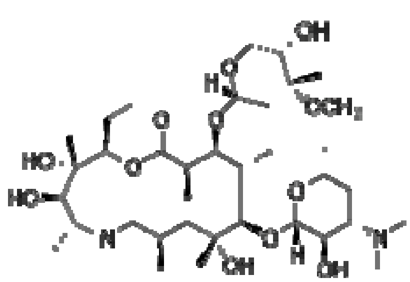
Note that even though even though the drawings may make most of Cl atoms look "outside" the ring and one of them "inside" the ring, this is just an artifact of the drawings.

Larger rings. As one increases the size of rings to 7 or more atoms in the ring, there is increased flexibility within the ring which allows the individual C atoms to achieve their desired bond angle (109.5 for single bonds) or something very close to it. For this reason most rings with 7 or more atoms are usually stable, at least as far as bond angle stability is involved. Thus cycloheptane and larger rings are stable (but not flat!) molecules.

Cyclooctane

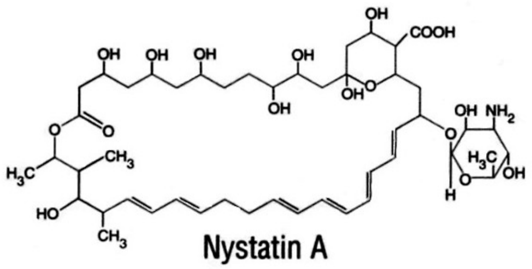
Some molecules with very large rings act as antimicrobial agents. The common antibiotic erythromycin has a 14-membered ring, as well as several 6-membered rings. The closely related antibiotic azithromycin has a 15-membered ring and two 6-membered rings (drawn flat in this diagram).



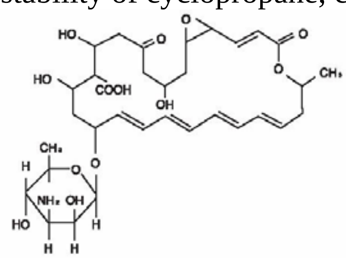


Erythromycin Azithromycin

Some antifungal molecules dissolve into the fungal cell membranes. The large ring is thought to create a “hole” in the fungal membrane allowing the contents of the fungal cell leak out, thus eviscerating the microbe. Examples of drugs which act by this mechanism are Nystatin which is used to treat epidermal fungal infections such as **thrush.**



Another antifungal, natamycin, is used for treating fungal infections as well as a mold inhibitor, especially for dairy products. (Notice the presence of the epoxide ring, 6-membered ring, as well as the large ring in natamycin.) Based on your knowledge of the stability of cyclopropane, comment on the stability of the epoxide ring.



Natamycin