

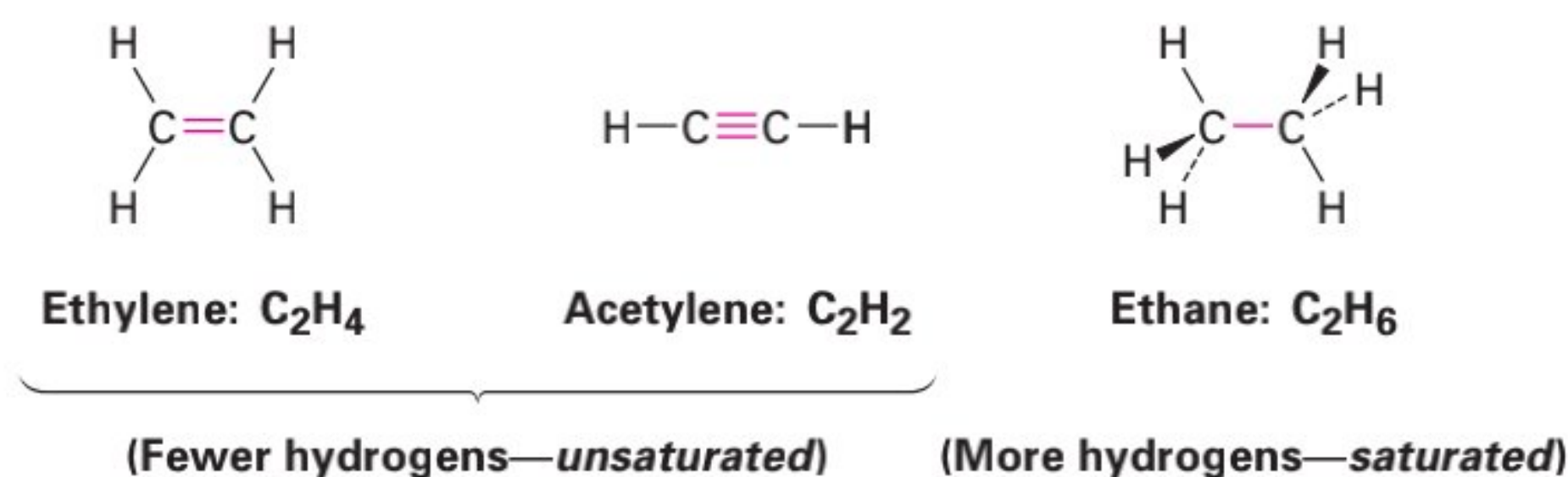
β -Carotene
(orange pigment and vitamin A precursor)

WHY THIS CHAPTER?

Carbon–carbon double bonds are present in most organic and biological molecules, so a good understanding of their behavior is needed. In this chapter, we'll look at some consequences of alkene stereoisomerism and then focus in detail on the broadest and most general class of alkene reactions, the electrophilic addition reaction. Carbon–carbon *triple* bonds, by contrast, occur less commonly than double bonds, so we'll not spend much time on their chemistry.

3.1 Naming Alkenes and Alkynes

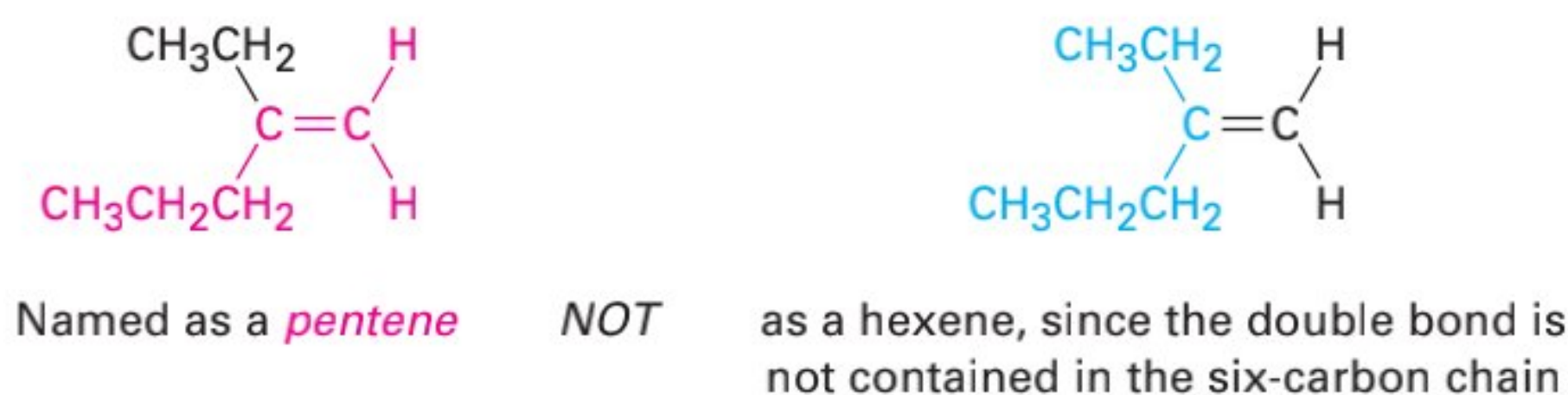
Because of their multiple bond, alkenes and alkynes have fewer hydrogens per carbon than related alkanes and are therefore referred to as **unsaturated**. Ethylene, for example, has the formula C_2H_4 , and acetylene has the formula C_2H_2 , whereas ethane has the formula C_2H_6 .



Alkenes are named using a series of rules similar to those for alkanes (Section 2.3), with the suffix *-ene* used in place of *-ane* to identify the family. There are three steps.

STEP 1 Name the parent hydrocarbon.

Find the longest carbon chain that contains the double bond, and name the compound using the suffix *-ene* in place of *-ane*.

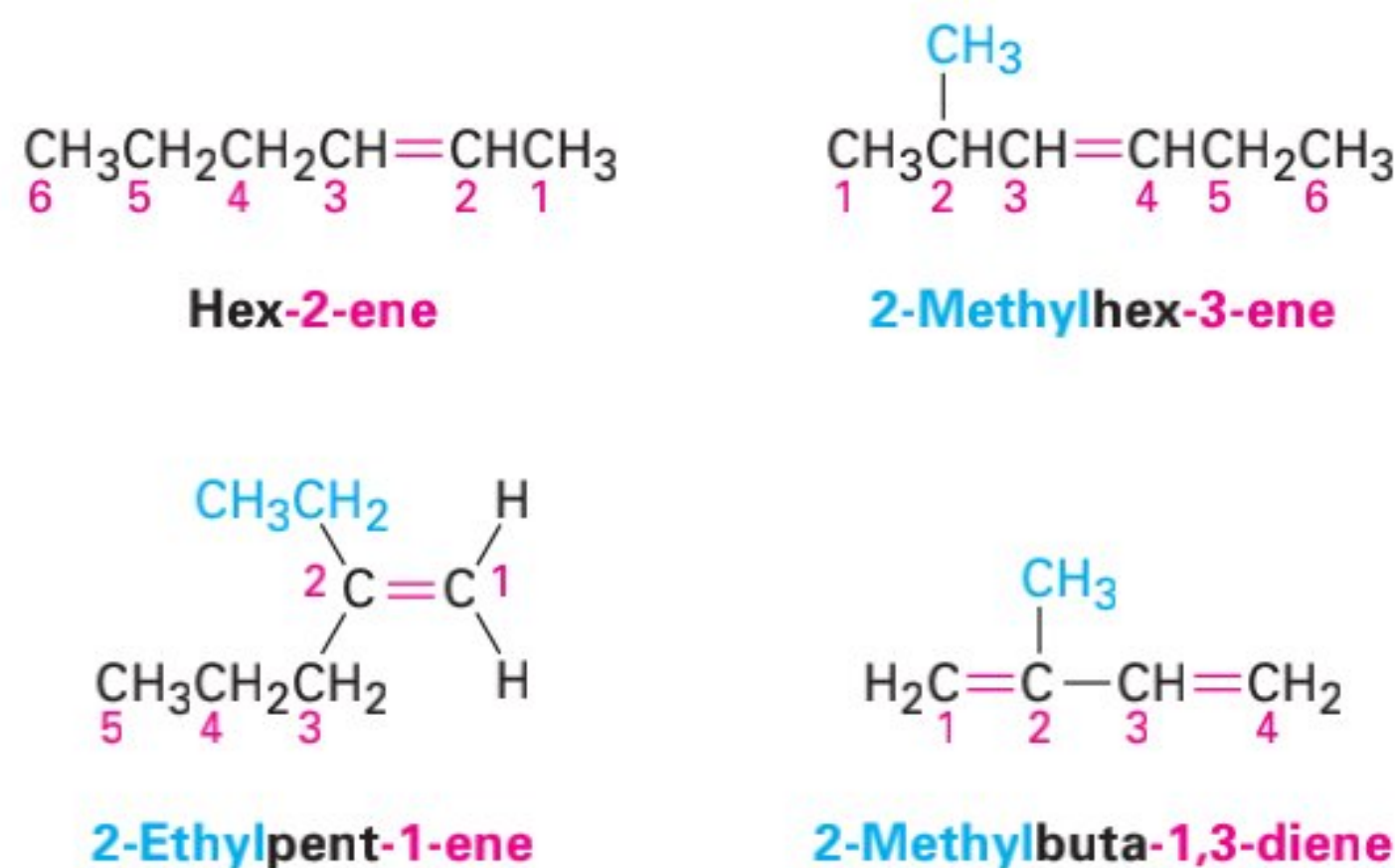


STEP 2 Number the carbon atoms in the chain.

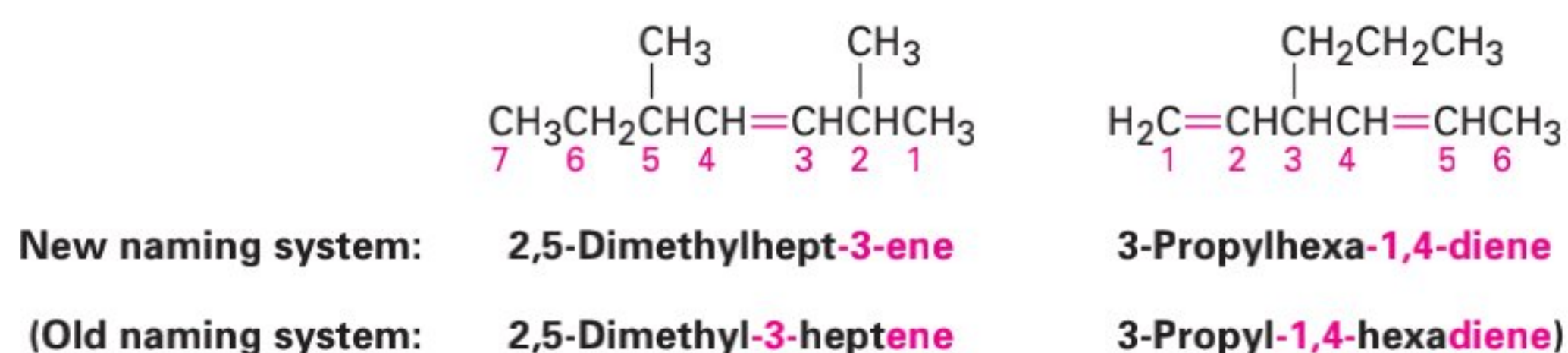
Begin numbering at the end nearer the double bond, or, if the double bond is equidistant from the two ends, begin at the end nearer the first branch point. This rule ensures that the double-bond carbons receive the lowest possible numbers.

**STEP 3** Write the full name.

Number the substituents on the main chain according to their position, and list them alphabetically. Indicate the position of the double bond by giving the number of the first alkene carbon and placing that number directly before the *-ene* suffix. If more than one double bond is present, give the position of each and use the appropriate multiplier suffix *-diene*, *-triene*, *-tetraene*, and so on.

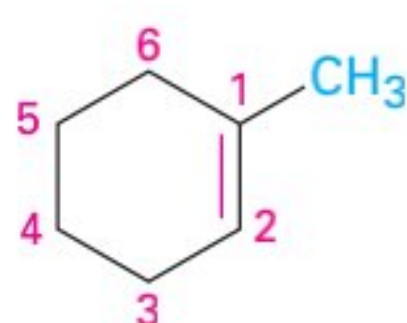


We should also note that IUPAC changed its naming rules in 1993. Prior to that time, the locant, or number locating the position of the double bond, was placed before the parent name rather than before the *-ene* suffix: 2-butene rather than but-2-ene, for instance. Changes always take time to be fully accepted, so the new rules have not yet been adopted universally and some texts have not yet been updated. We'll use the new naming system in this book, although you may encounter the old system elsewhere. Fortunately, the difference between old and new is minor and rarely causes problems.

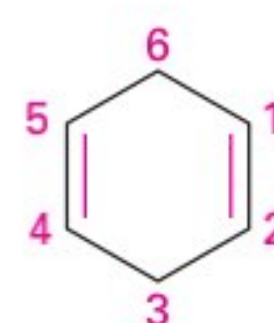
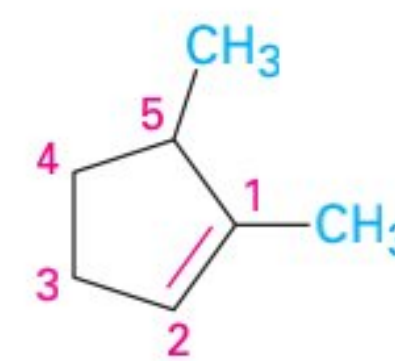


Cycloalkenes are named similarly, but because there is no chain end to begin from, we number the cycloalkene so that the double bond is between C1 and C2 and the first substituent has as low a number as possible. Note

that it's not necessary to specify the position of the double bond in the name because it's always between C1 and C2.



1-Methylcyclohexene

Cyclohexa-1,4-diene
(Old name: 1,4-Cyclohexadiene)

1,5-Dimethylcyclopentene

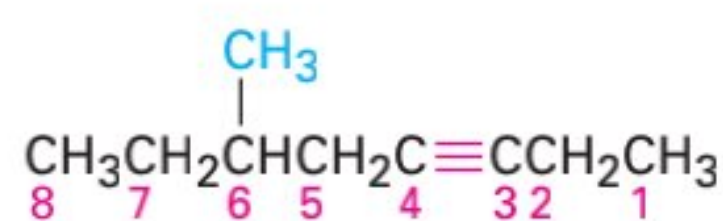
For historical reasons, there are a few alkenes whose names don't conform to the rules. For example, the alkene corresponding to ethane should be called *ethene*, but the name *ethylene* has been used for so long that it is accepted by IUPAC. Table 3.1 lists some other common names accepted by IUPAC.

Table 3.1

Common Names of Some Alkenes

Compound	Systematic name	Common name
$\text{H}_2\text{C}=\text{CH}_2$	Ethene	Ethylene
$\text{CH}_3\text{CH}=\text{CH}_2$	Propene	Propylene
$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3\text{C}=\text{CH}_2 \end{array}$	2-Methylpropene	Isobutylene
$\begin{array}{c} \text{CH}_3 \\ \\ \text{H}_2\text{C}=\text{C}-\text{CH}=\text{CH}_2 \end{array}$	2-Methylbuta-1,3-diene	Isoprene

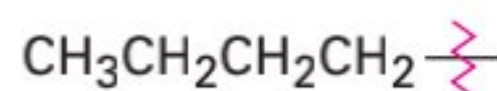
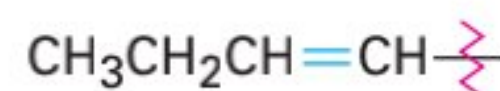
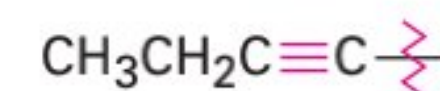
Alkynes are named in the same way as alkenes, with the suffix *-yne* used in place of *-ene*. Numbering the main chain begins at the end nearer the triple bond so that the triple bond receives as low a number as possible, and the locant is again placed immediately before the *-yne* suffix in the post-1993 naming system.



Begin numbering at the end nearer the triple bond.

6-Methyloct-3-yne
(Old name: 6-Methyl-3-optyne)

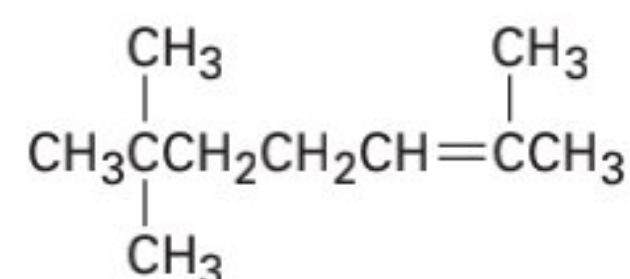
As with alkyl groups derived from alkanes, *alkenyl* and *alkynyl* groups are also possible.

Butyl
(an alkyl group)But-1-enyl
(a vinylic group)But-1-ynyl
(an alkynyl group)

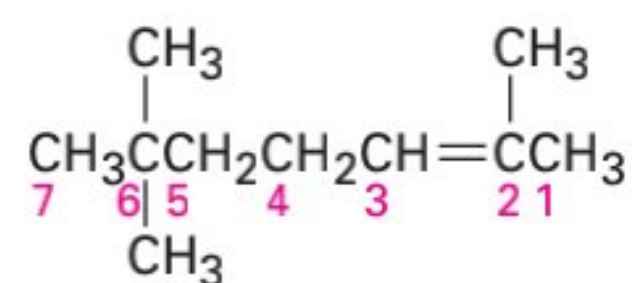
Worked Example 3.1

Naming an Alkene

What is the IUPAC name of the following alkene?

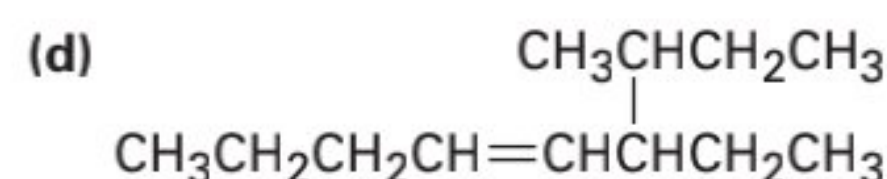
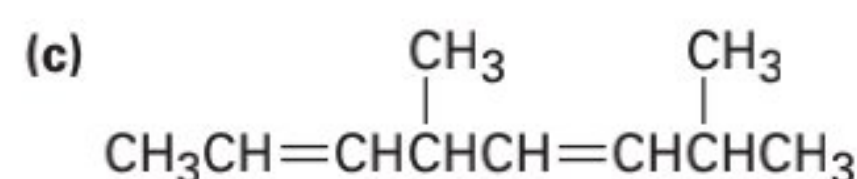
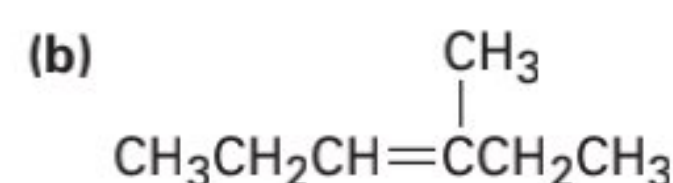
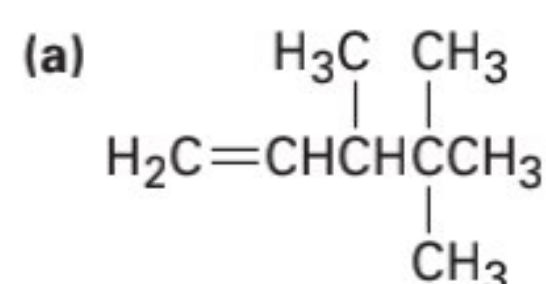


Strategy First, find the longest chain containing the double bond—in this case, a heptene. Next, number the chain beginning at the end nearer the double bond, and identify the substituents at each position. In this case, there are three methyl groups, one at C2 and two at C6.

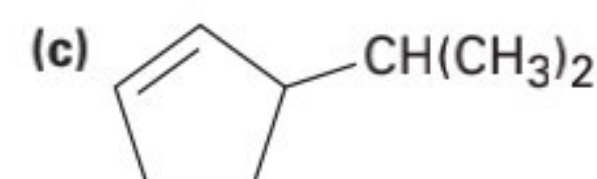
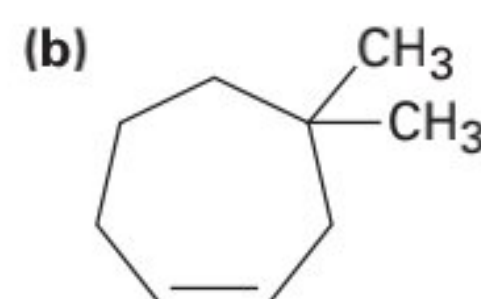
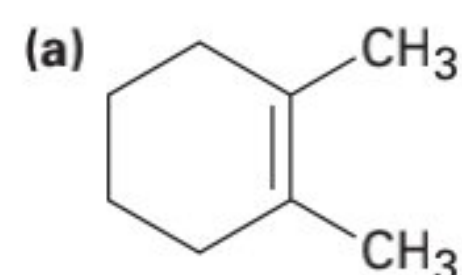


Solution Write the full name, listing the substituents alphabetically and giving the position of each. Identify the position of the double bond by placing the number of the first alkene carbon before the *-ene* suffix: 2,6,6-trimethylhept-2-ene.

Problem 3.1 Give IUPAC names for the following compounds:



Problem 3.2 Name the following cycloalkenes:



Problem 3.3 Draw structures corresponding to the following IUPAC names:

(a) 2-Methylhex-1-ene

(b) 4,4-Dimethylpent-2-yne

(c) 2-Methylhexa-1,5-diene

(d) 3-Ethyl-2,2-dimethylhept-3-ene

Problem 3.4 Name the following alkynes:

