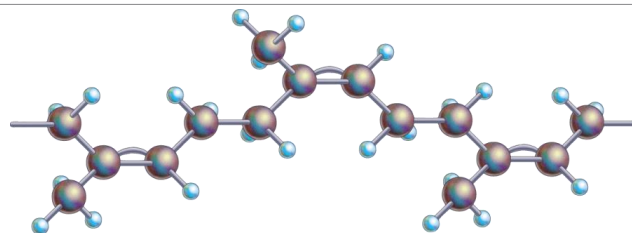




**DAYTONA**  
STATE COLLEGE

# How Polymers Work



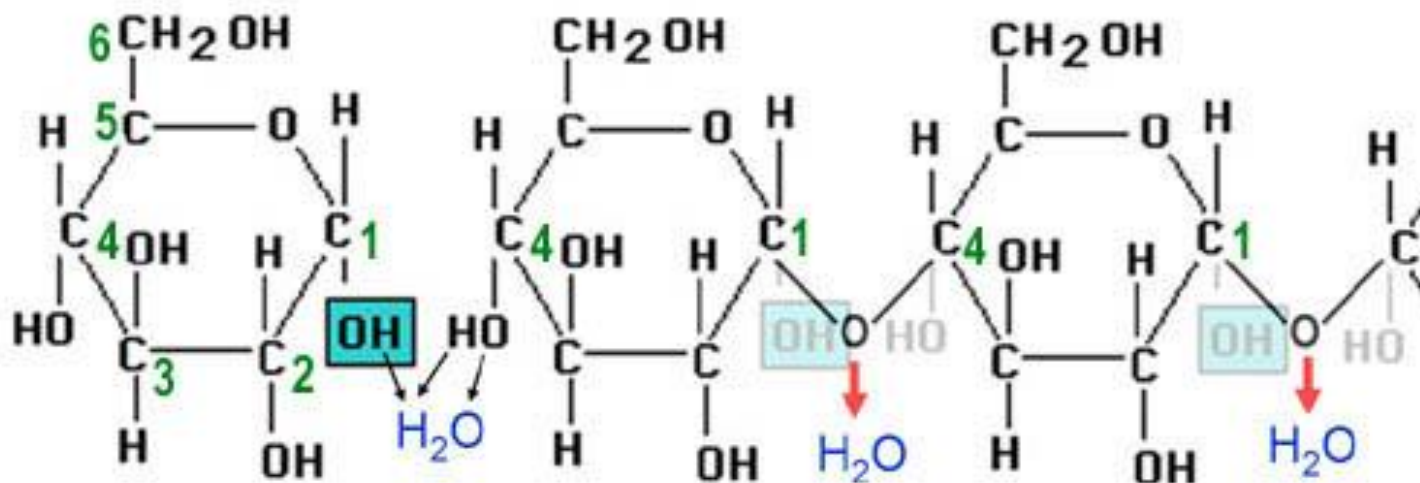
POLYMERS

# POLYMERS

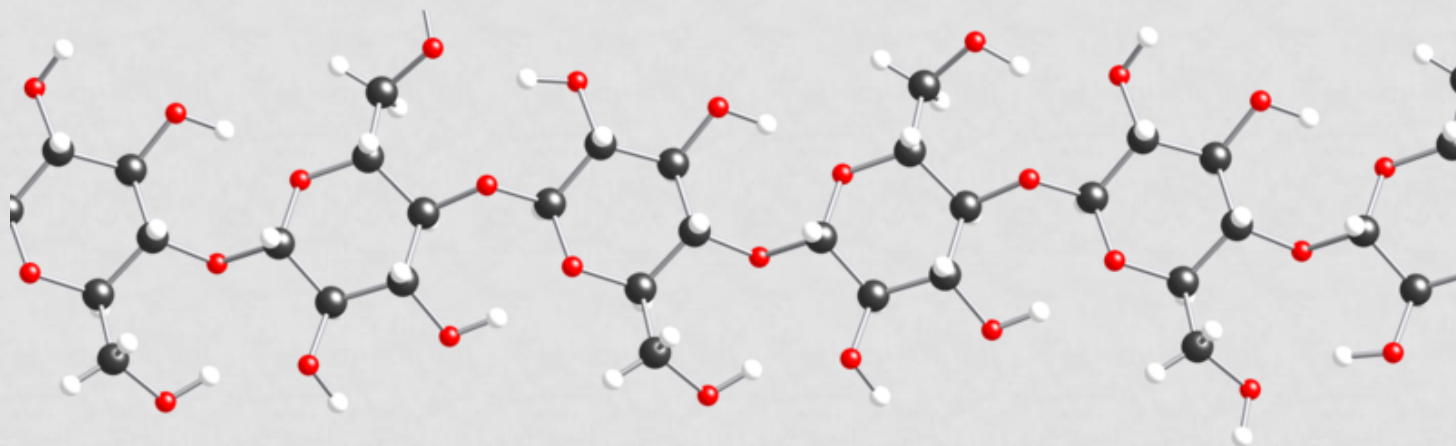
**Polymers** are

- large, long-chain molecules.
- found in nature, including cellulose in plants, starches in food, proteins, and DNA in the body.
- also synthetic such as polyethylene and polystyrene, Teflon, and nylon.
- have small repeating units called **monomers**.
- can be made from reaction of small alkenes.

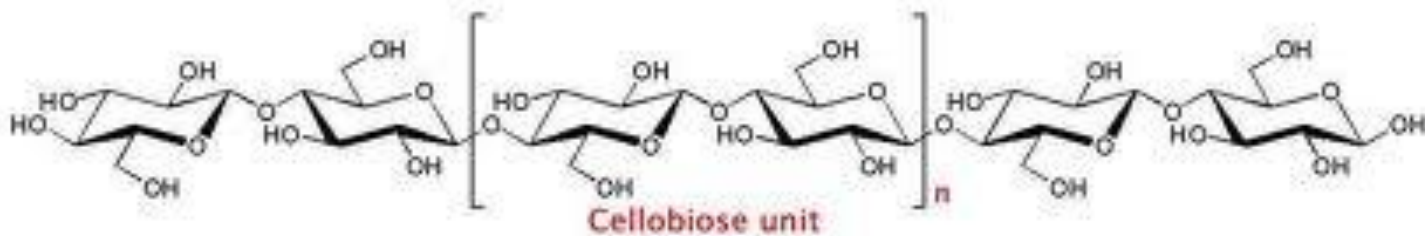
# STARCH



# CELLULOSE



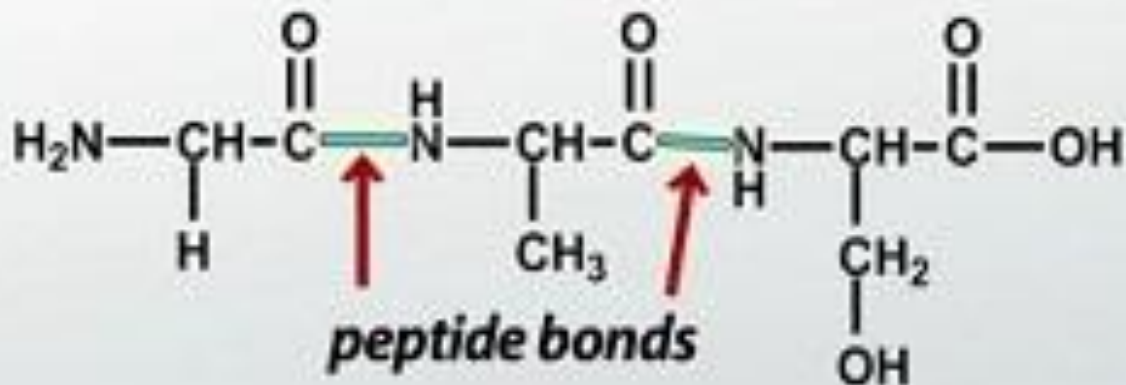
## Cellulose



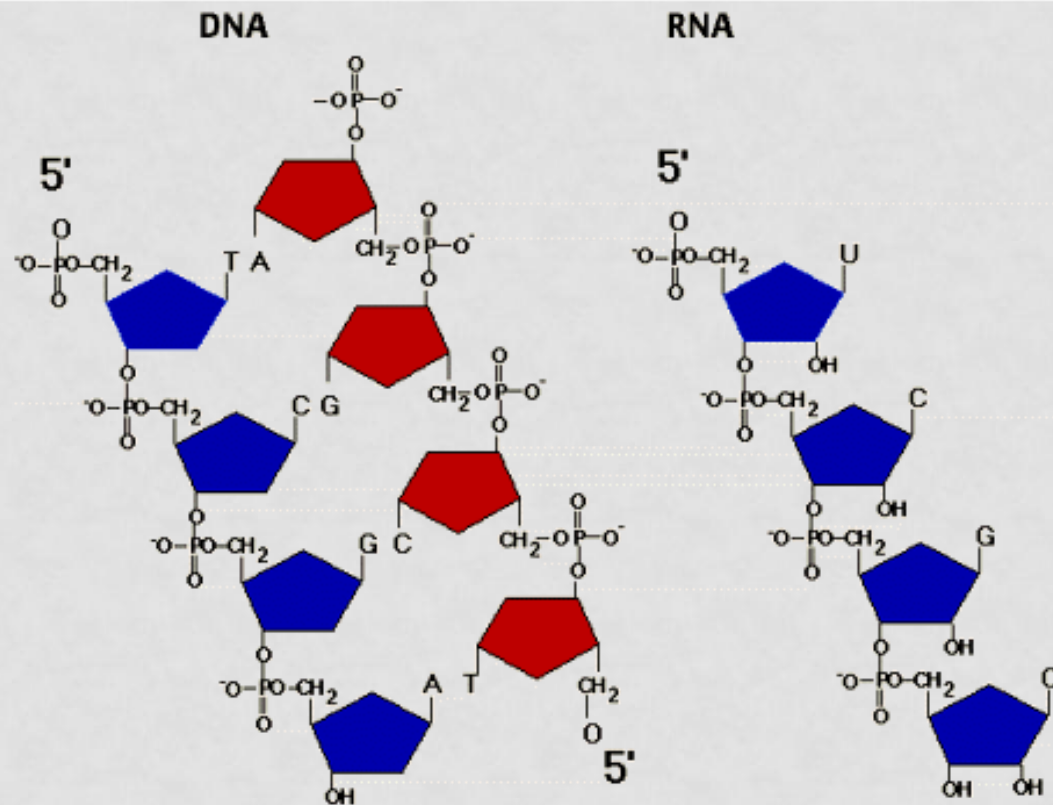
# PROTEINS

## NATURAL POLYMERS

### Proteins



# DNA & RNA



# COMMON SYNTHETIC POLYMERS



**Polyethylene**



**Vinyl chloride**



**Polypropylene**



**Polytetrafluoroethylene (Teflon)**



**Polydichloroethylene (Saran)**

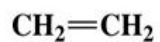


**Polystyrene**

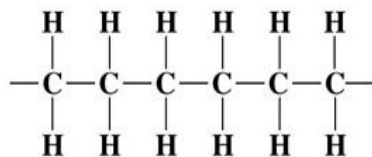
Timberlake, General, Organic, and Biological Chemistry. Copyright © Pearson Education Inc., publishing as Benjamin Cummings



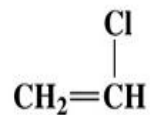
# COMMON SYNTHETIC POLYMERS



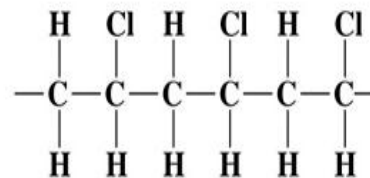
Ethene (ethylene)



Polyethylene



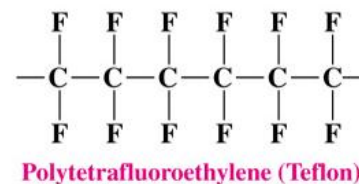
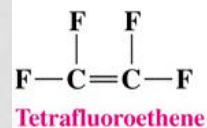
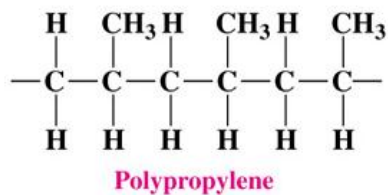
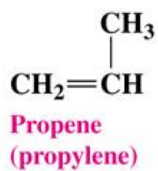
Chloroethene  
(vinyl chloride)



Polyvinyl chloride (PVC)

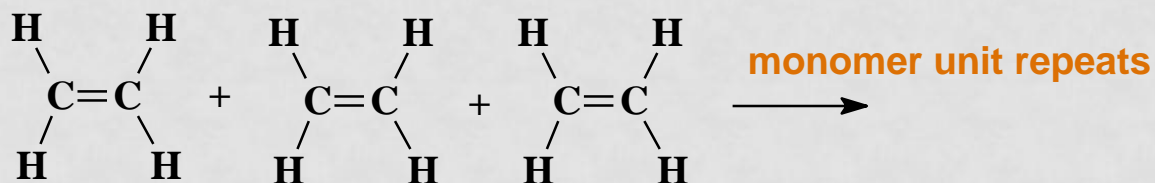


# COMMON SYNTHETIC POLYMERS

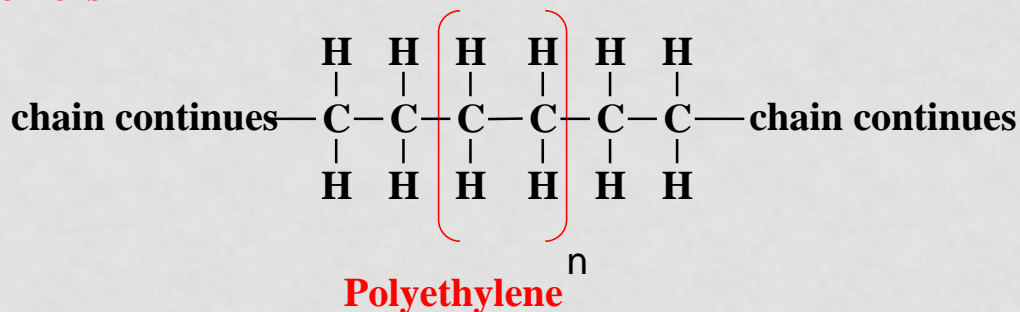


# POLYMERIZATION

In polymerization, small repeating units called **monomers** join to form a long chain polymer.



**Ethylene monomers**



# POLYMERS FROM ADDITION REACTIONS

Monomer	Polymer Section	Common Uses
$\text{CH}_2=\text{CH}_2$ Ethene (ethylene)	$\begin{array}{cccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\   &   &   &   &   &   \\ -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}- \\   &   &   &   &   &   \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$ Polyethylene	Plastic bottles, film, insulation materials
$\begin{array}{c} \text{Cl} \\   \\ \text{CH}_2=\text{CH} \end{array}$ Chloroethene (vinyl chloride)	$\begin{array}{cccccc} \text{H} & \text{Cl} & \text{H} & \text{Cl} & \text{H} & \text{Cl} \\   &   &   &   &   &   \\ -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}- \\   &   &   &   &   &   \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$ Polyvinyl chloride (PVC)	Plastic pipes and tubing, garden hoses, garbage bags
$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_2=\text{CH} \end{array}$ Propene (propylene)	$\begin{array}{cccccc} \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 \\   &   &   &   &   &   \\ -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}- \\   &   &   &   &   &   \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$ Polypropylene	Ski and hiking clothing, carpets, artificial joints

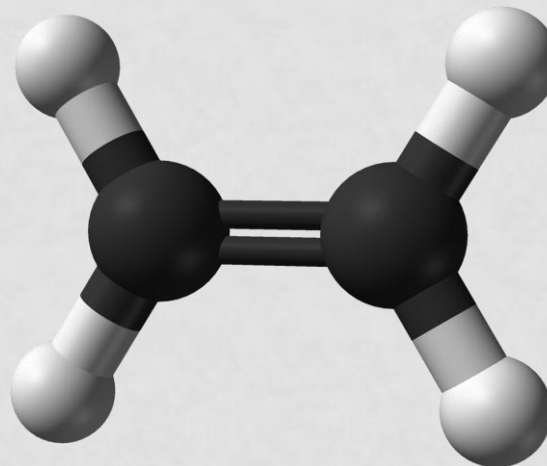
# MORE MONOMERS AND POLYMERS

Monomer	Polymer Section	Common Uses
$\begin{array}{c} \text{F} \quad \text{F} \\   \quad   \\ \text{F}-\text{C}=\text{C}-\text{F} \end{array}$ <p>Tetrafluoroethene</p>	$\begin{array}{cccccc} \text{F} & \text{F} & \text{F} & \text{F} & \text{F} & \text{F} \\   &   &   &   &   &   \\ -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}- \\   &   &   &   &   &   \\ \text{F} & \text{F} & \text{F} & \text{F} & \text{F} & \text{F} \end{array}$ <p>Polytetrafluoroethylene (Teflon)</p>	Nonstick coatings
$\begin{array}{c} \text{Cl} \\   \\ \text{CH}_2=\text{C}-\text{Cl} \end{array}$ <p>1,1-Dichloroethene</p>	$\begin{array}{cccccc} \text{H} & \text{Cl} & \text{H} & \text{Cl} & \text{H} & \text{Cl} \\   &   &   &   &   &   \\ -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}- \\   &   &   &   &   &   \\ \text{H} & \text{Cl} & \text{H} & \text{Cl} & \text{H} & \text{Cl} \end{array}$ <p>Polydichloroethylene (Saran)</p>	Plastic film and wrap
$\begin{array}{c} \text{C}_6\text{H}_5 \\   \\ \text{H}_2\text{C}=\text{CH} \end{array}$ <p>Phenylethene (styrene)</p>	$\begin{array}{ccccccc} \text{C}_6\text{H}_5 & & \text{C}_6\text{H}_5 & & \text{C}_6\text{H}_5 & & \text{C}_6\text{H}_5 \\   & &   & &   & &   \\ -\text{CH}_2- & \text{CH}- & \text{CH}_2- & \text{CH}- & \text{CH}_2- & \text{CH}- & \\ &   & &   & &   & \\ & \text{C}_6\text{H}_5 & & \text{C}_6\text{H}_5 & & \text{C}_6\text{H}_5 & \end{array}$ <p>Polystyrene</p>	Plastic coffee cups and cartons, insulation

# LEARNING CHECK

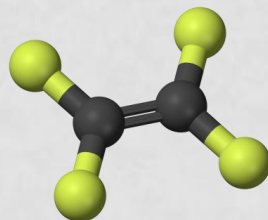
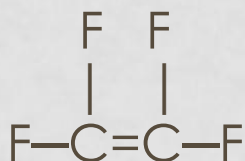
What is the starting monomer for polyethylene?

- Ethene (ethylene)
- $\text{CH}_2=\text{CH}_2$

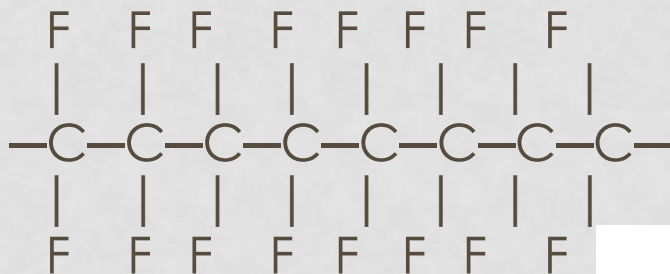


# LEARNING CHECK

Name the monomer used to make Teflon and write a portion of a Teflon polymer using four monomers.



tetrafluoroethene



portion of Teflon



Teflon,  $-(\text{CF}_2\text{CF}_2)-$

# RECYCLING PLASTICS

Recycling is simplified by using codes on plastic items.

- 1 PETE** Polyethyleneterephtalate
- 2 HDPE** High-density polyethylene
- 3 PVC or PV** Polyvinyl chloride
- 4 LDPE** Low-density polyethylene
- 5 PP** Polypropylene
- 6 PS** Polystyrene



Avoid products  
marked as:










Look for safe  
products:





# RECYCLING PLASTICS

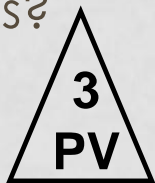
PLASTIC RECYCLING CHART						
						
PET	HDPE	PVC	LDPE	PP	PS	OTHER
POLYETHYLENE TEREPHTHALATE	HIGH DENSITY POLYETHYLENE	POLYVINYL CHLORIDE	LOW DENSITY POLYETHYLENE	POLYPROPYLENE	POLYSTYRENE	OTHER PC POLYCARBONATE
COSMETIC CONTAINERS FOOD JARS JELLY AND JAM CONTAINERS MOUTHWASH BOTTLES PEANUT BUTTER CONTAINERS PLASTIC BOTTLES PREPARED FOOD TRAYS SALAD DRESSING BOTTLES SINGLE USE WATER BOTTLES SOFT DRINK BOTTLES SPORT DRINK BOTTLES	AGRICULTURAL PIPE DETERGENT BOTTLES EXTRUDED PIPE GROCERY BAGS ICE CREAM TUBS MILK JUGS JUICE JUGS OIL VINEGAR BOTTLES PAIS PLAYGROUND EQUIPMENT SHAMPOO BOTTLES SHIPPING CONTAINERS	BLISTER PACKS BLOOD BAGS CABLE SHEATHING CARPET BACKING FLOOR TILES GARDEN HOSE MEAT WRAP MEDICAL TUBING OUTDOOR FURNITURE PLUMBING PIPE WINDOW FRAMES WIRE INSULATION	6-PACK RINGS BREAD BAGS DRY CLEANING BAGS GARBAGE BAGS HEAVY DUTY BAGS MOLDED LABORATORY EQUIPMENT PLASTIC FOOD WRAP RECYCLING BINS SQUEEZABLE BOTTLES TOYS	BOTTLE CAPS CEREAL LINERS COTTAGE CHEESE CONTAINERS HINGED LUNCH BOXES KETCHUP BOTTLES MARGARINE CONTAINERS MEDICINE BOTTLES MICROWAVE OVENWARE PACKING TAPE POTATO CHIP BAGS RUBBERMAID CONTAINERS STRAWS	CAFETERIA TRAYS CD AND VIDEO CASES DISPOSABLE HOT OR COLD DRINK CUPS & PAPER PLATES DRINKING GLASSES EGG CARTONS FAST FOOD CLAMSHELLS FOAM PACKING HINGED BAKERY CONTAINERS PACKING PEANUTS PLASTIC CUTLERY STYROFOAM TOYS YOGURT CONTAINERS	BABY BOTTLES CAR PARTS FIBERGLASS LARGE WATER BOTTLES NALGENE BOTTLES SIPPY CUPS TUPPERWARE WATER COOLER BOTTLES

Reorder: NHE-14285 www.ComplianceSigns.com

# LEARNING CHECK

What types of plastic are indicated by the following codes?

A.



B.



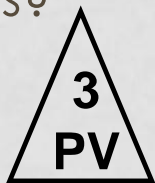
C.



# SOLUTION

What types of plastic are indicated by the following codes?

A.



Polyvinyl chloride

B.



Polypropylene

C.



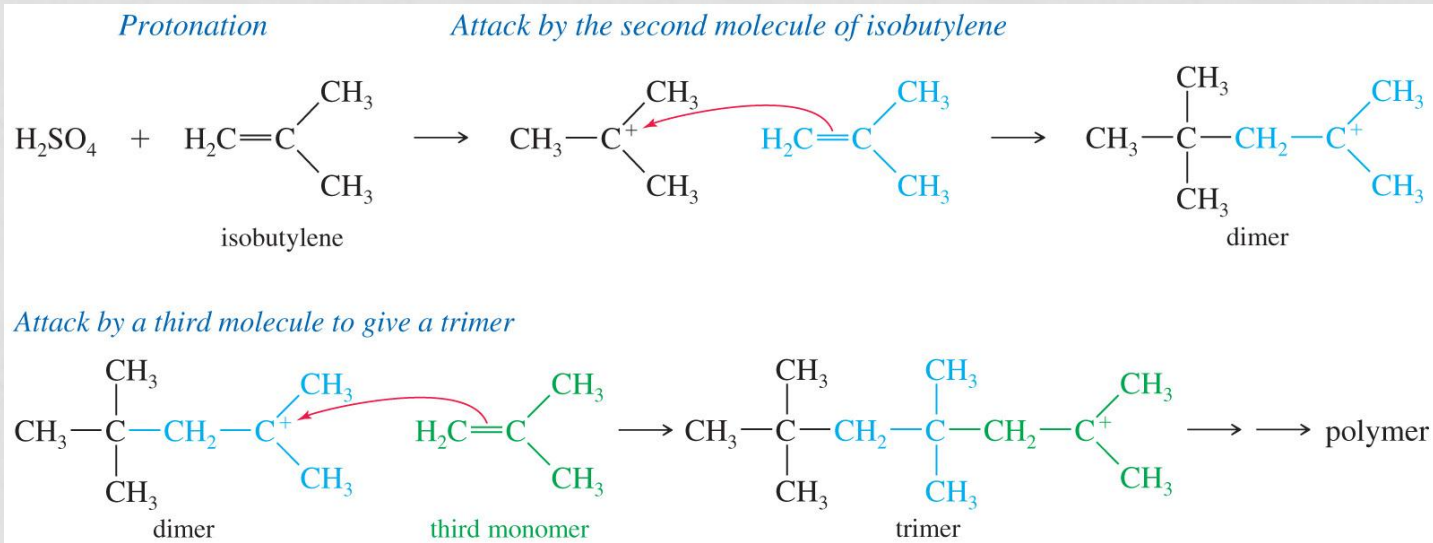
Polystyrene

.

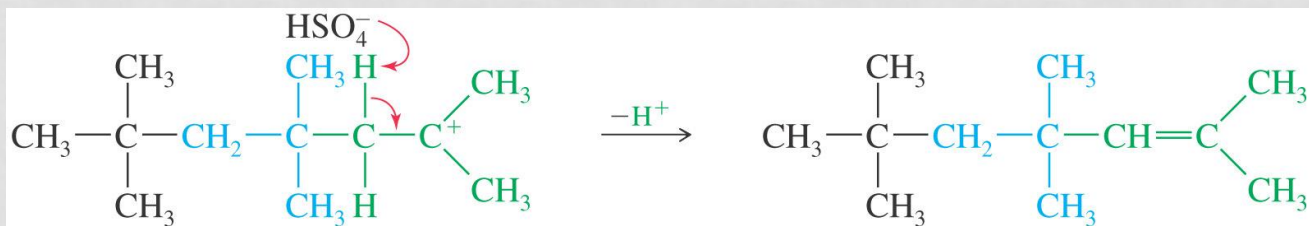
# POLYMERIZATION

- An alkene (monomer) can add to another molecule like itself to form a chain (polymer).
- Three methods:
  - Cationic, a carbocation intermediate
  - Free radical
  - Anionic, a carbanion intermediate (rare)

# CATIONIC POLYMERIZATION



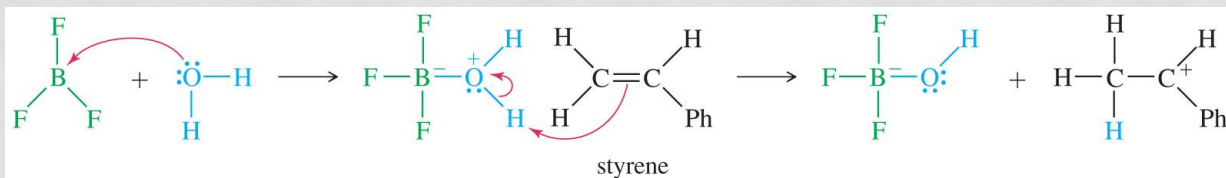
# TERMINATION STEP OF CATIONIC POLYMERIZATION



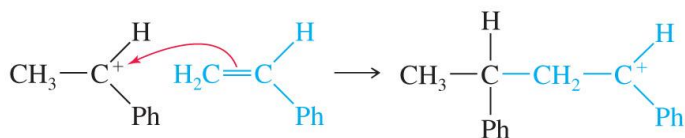
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- The chain growth ends when a proton is abstracted by the weak base of the acid used to initiate the reaction.
- The loss of a hydrogen forms an alkene and ends the chain growth so this is a termination step.

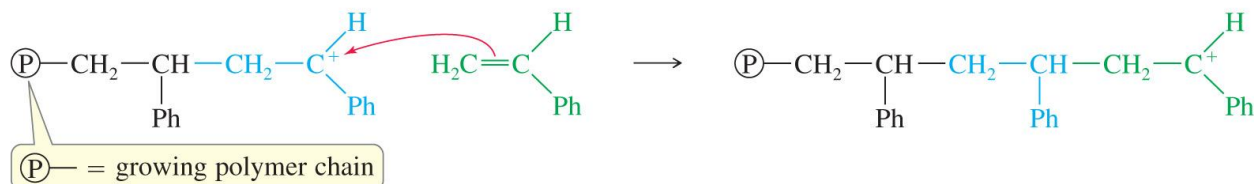
# CATIONIC POLYMERIZATION USING $\text{BF}_3$ AS CATALYST



*First chain-lengthening step*



*After many steps the polymerization continues*

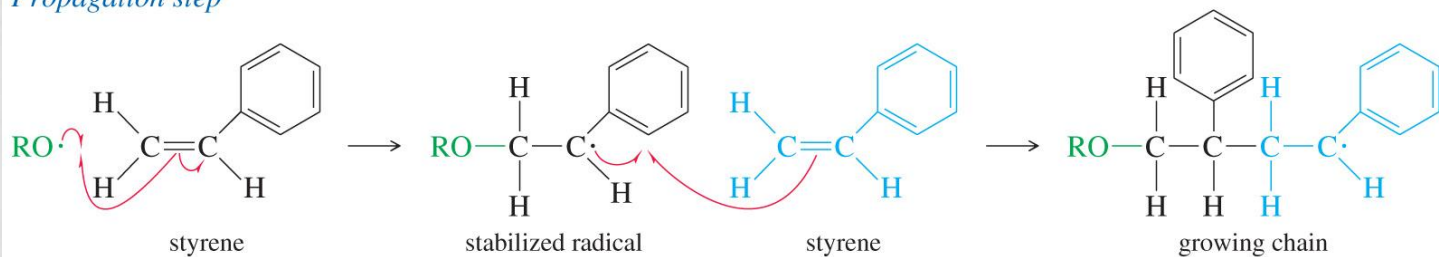




# RADICAL POLYMERIZATION

*Initiation step*     $\text{ROOR} \xrightarrow{\text{heat}} 2 \text{RO}\cdot$

*Propagation step*



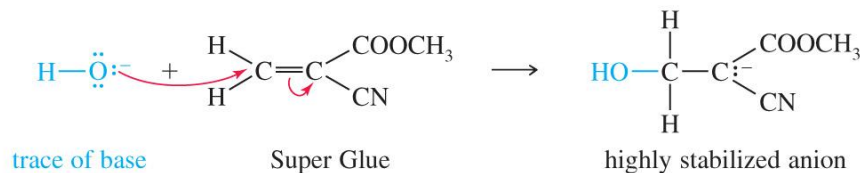
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- In the presence of an initiator such as peroxide, free-radical polymerization occurs.

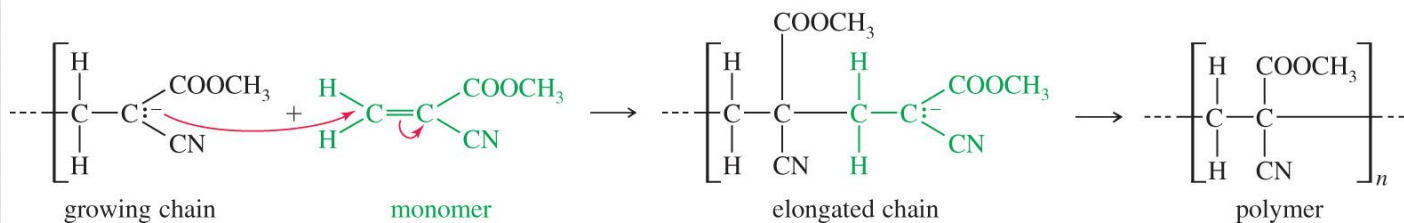
# ANIONIC POLYMERIZATION

- For an alkene to gain electrons, strong electron-withdrawing groups such as nitro, cyano, or carbonyl must be attached to the carbons in the double bond.

## Initiation step



## Chain lengthening step





# DAYTONA STATE COLLEGE

## Questions



*Compiled from various sources by*

*D. Leonard (Learning Specialist)*

*The Academic Support Center @ Daytona State College*

<http://www.daytonastate.edu/asc/ascsciencehandouts.html>