

STRUCTURAL ISOMERS HAVE THE SAME ATOMS BUT DIFFERENT BONDING  
STEREODISOMERS HAVE THE SAME ATOMS, SAME BONDING, BUT  
DIFFER IN THE SPATIAL ORIENTATION OF THE ATOMS  
THIS INCLUDES CIS/TRANS ISOMERS  
AND, CHIRAL MOLECULES

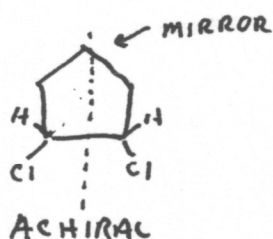
CHIRAL INDICATES HAVING LEFT AND RIGHT HANDED FORMS  
TWO MOLECULES ARE 'SUPERIMPOSABLE' IF THEY CAN BE PLACED  
ON TOP OF ONE ANOTHER AND ALL ATOMS COINCIDE (ACHIRAL)  
IF A PAIR OF MIRROR IMAGES ARE NOT SUPERIMPOSABLE, THEY ARE  
A CHIRAL PAIR CALLED "ENANTIOMERS". THIS IS THE ULTIMATE TEST OF CHIRALITY  
ANY COMPOUND THAT IS CHIRAL MUST HAVE AN ENANTIOMER  
ANY COMPOUND THAT IS ACHIRAL CANNOT HAVE AN ENANTIOMER

### ASYMMETRIC CARBONS

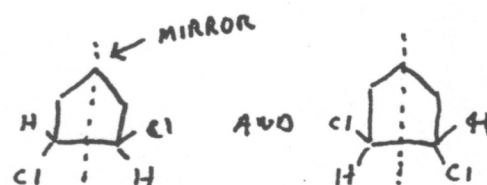
A CARBON BOUND TO 4 DIFFERENT GROUPS IS CHIRAL, CALLED  
ASYMMETRIC, DESIGNATED C\*

### MIRROR PLANES OF SYMMETRY

ANY MOLECULE THAT HAS AN INTERNAL MIRROR PLANE OF SYMMETRY  
CANNOT BE CHIRAL, EVEN IF IT HAS CHIRAL CARBONS



VS



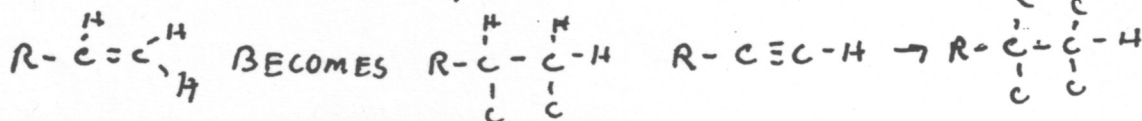
### R AND S

TO SYSTEMATICALLY NAME CHIRAL CARBONS WE USE THE LETTERS R AND S  
THE CAHN-INGOLD-PRELOG SYSTEM

- 1) ASSIGN A PRIORITY TO EACH GROUP BONDED TO THE CHIRAL ATOM  
ATOMS WITH HIGHER ATOMIC NUMBER RECEIVE HIGHER PRIORITY  
IF TWO ATOMS ARE ISOTOPES OF THE SAME ELEMENT, THE HIGHER  
MASS ISOTOPE HAS RANK

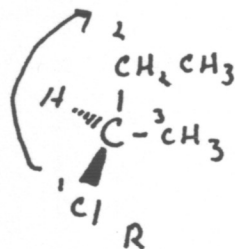
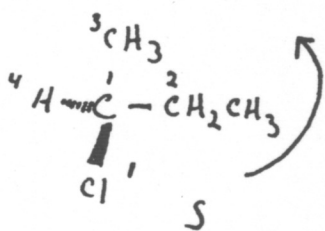
- 1b) I > S > O > N > <sup>13</sup>C > <sup>12</sup>C > <sup>2</sup>H > <sup>1</sup>H  
IN THE CASE OF TIES, USE THE NEXT ATOM ALONG THE CHAIN  
AS TIE BREAKERS

- 1c) DOUBLE AND TRIPLE BONDS, BREAK AND DUPLICATE



- 2) PUT LOWEST (4<sup>th</sup>) PRIORITY GROUP TO REAR  
 VIEW FROM C\* TOWARDS 4<sup>th</sup> GROUP  
 DRAW AN ARROW FROM GROUP 1 TO 2 TO 3  
 CLOCKWISE = R  
 COUNTERCLOCKWISE = S

AN EXAMPLE



NOTE THAT  
 CHANGING 2 GROUPS  
 CHANGES THE  
 CARBON FROM S TO R

## OPTICAL ACTIVITY

ENANTIOMERS HAVE IDENTICAL PHYSICAL PROPERTIES, SPECTRA,  
 EVERYTHING.

ITS LIKE A PAIR OF SHOES, EACH IS IDENTICAL UNTIL YOU  
 HAVE TO PUT THEM ON

WHEN ENANTIOMERS HAVE TO INTERACT WITH CHIRAL MOLECULES,  
 ENZYMES, OR CHIRAL ENVIRONMENTS, THEY ACT DIFFERENTLY

## PLANE-POLARIZED LIGHT

IS ELECTROMAGNETIC RADIATION WHICH OSCILLATES IN 1 PLANE ONLY  
 AS OPPOSED TO NORMAL LIGHT WHICH OSCILLATES IN ALL PLANES

A SPECIAL FILTER ALLOWS ONLY 1 PLANE TO PASS

CHIRAL COMPOUNDS "ROTATE THE PLANE OF POLARIZED LIGHT"

EACH ENANTIOMER ROTATES LIGHT IN THE OPPOSITE DIRECTION  
 BY EXACTLY THE SAME AMOUNT

MEASURED IN A POLARIMETER, CLOCKWISE = D (+) \* NO RELATION  
 COUNTERCLOCKWISE = L (-) TO R + S

$$\text{SPECIFIC ROTATION} = \frac{\text{MEASURED ROTATION}}{\text{CONC (g/ml)} \times \text{LENGTH (dm)}}$$

RACEMIC MIXTURE = 50% D, 50% L

HAS NO ROTATION

ALSO CALLED A RACEMATE, OR A D,L-PAIR

ANY REACTION THAT USES NO OPTICALLY ACTIVE REACTANTS OR MEDIA  
 PRODUCES CHIRAL COMPOUNDS AS RACEMATES

## OPTICAL PURITY

IF ONE ENANTIOMER IS IN EXCESS IN A MIXTURE, OPTICAL ACTIVITY WILL BE BETWEEN 0 AND THE MAXIMUM

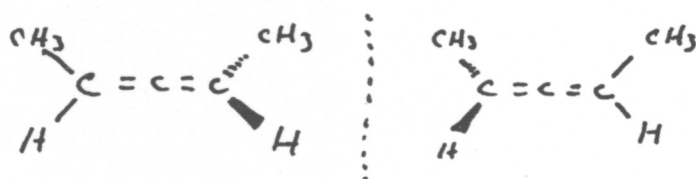
$$\text{OPTICAL PURITY} = \frac{\text{OBSERVED ROTATION}}{\text{ROTATION OF PURE ENANTIOMER}} \times 100$$

ALTERNATIVELY CALCULATED AS ENANTIOMERIC EXCESS

$$\text{O.P.} = \text{E.E.} = \frac{|d-l|}{d+l} \times 100 \quad \text{OR} \quad \frac{|\text{EXCESS OF 1 OVER THE OTHER}|}{\text{TOTAL MIXTURE}} \times 100$$

## CHIRAL COMPOUNDS WITHOUT CHIRAL CARBONS

### THE ALLENES



ENANTIOMERS OF 2,3-PENTADIENE

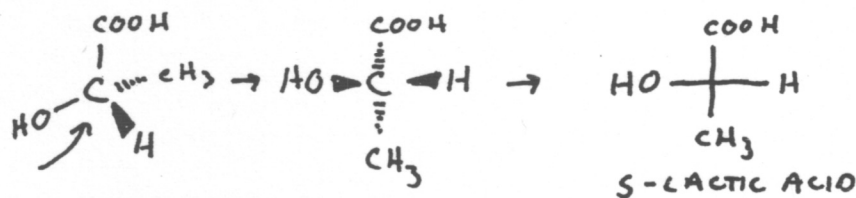
## FISCHER PROJECTIONS

A SIMPLER WAY TO COMPARE PERSPECTIVES

DRAW A CROSS, WITH  $\text{C}^*$  IN THE CENTER

HORIZONTAL LINES ARE WEDGES

VERTICAL LINES ARE DASHES



THE CARBON CHAIN IS USUALLY PLACED ALONG THE VERTICAL, WITH THE

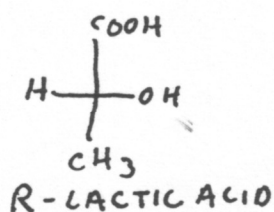
MOST OXIDIZED (OR MOST BONDS TO OXYGEN) CARBON ON TOP

A  $180^\circ$  ROTATION MAKES NO CHANGE IN THE MOLECULE

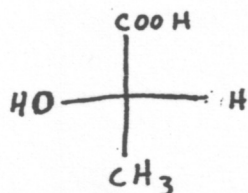
$90^\circ$  ROTATIONS ARE NOT ALLOWED

INTERCHANGING

REVERSING LEFT AND RIGHT SUBSTITUENTS GIVES MIRROR IMAGE OR ENANTIOMER



R-LACTIC ACID

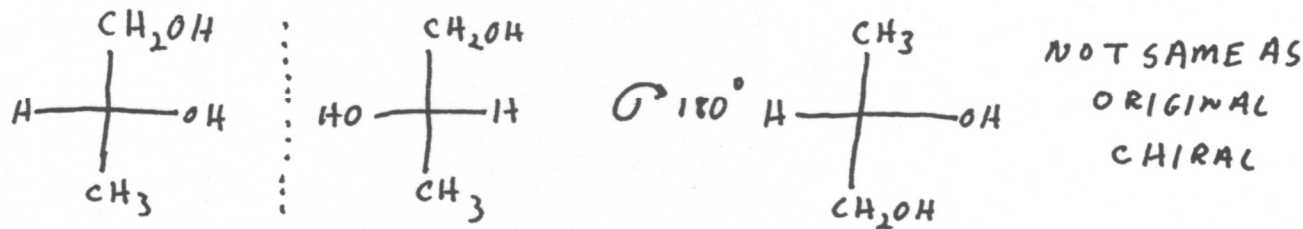
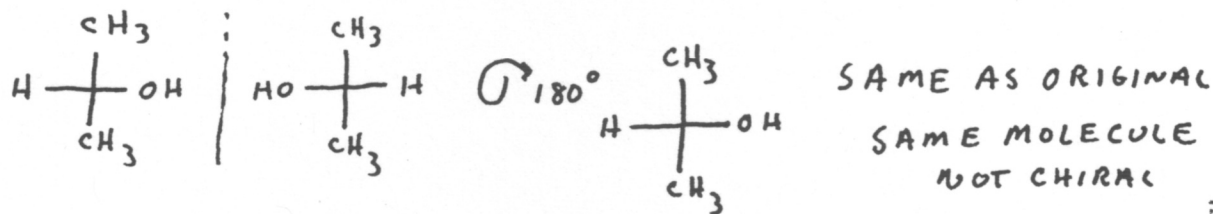


S-LACTIC ACID

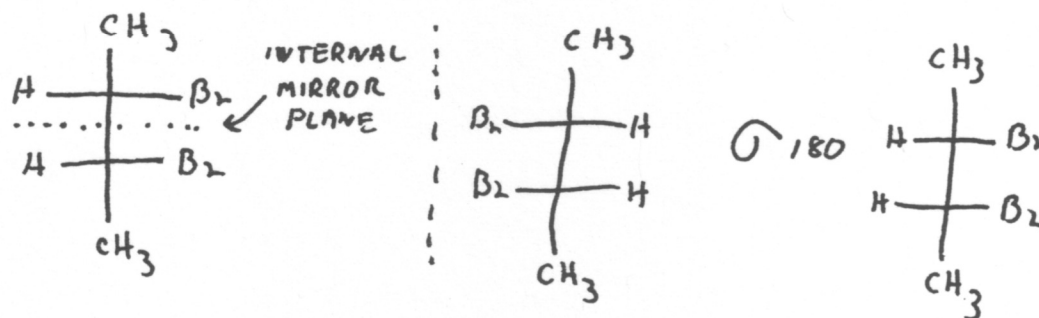
# MIRROR IMAGES FROM FISCHER PROJECTIONS

JUST REVERSE LEFT AND RIGHT

TEST FOR ENANTIOMERS BY A  $180^\circ$  ROTATION OF THE MIRROR IMAGE



INTERNAL MIRROR PLANES ARE CLEAR IN FISCHER PROJECTIONS



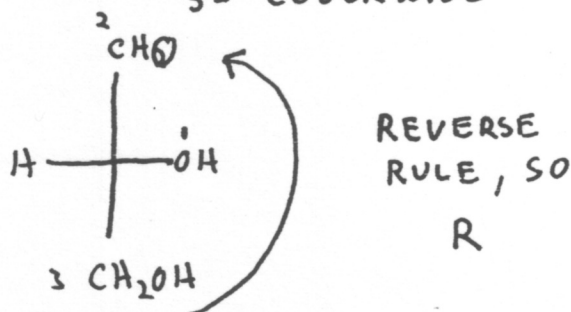
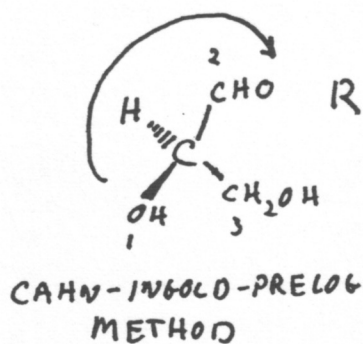
## ASSIGNING R AND S FROM FISCHER PROJECTIONS

ASSIGN PRIORITIES AS USUAL

DRAW THE ARROW CONNECTING GROUPS 1, 2, 3

SINCE THE H (LOWEST PRIORITY) GROUP IS ON THE VERTICAL, POINTING UP, WE ARE LOOKING AT THE MOLECULE IN REVERSE OF OUR NORMAL R AND S METHOD

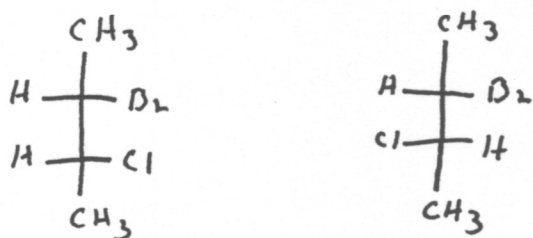
SO, WE REVERSE THE RULE: R = COUNTERCLOCKWISE  
S = CLOCKWISE



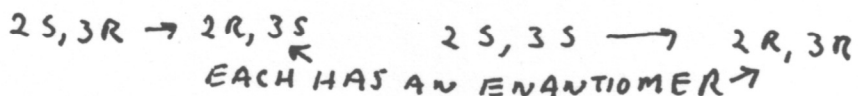
## DIASTEREOMERS

ARE STEREO ISOMERS THAT ARE NOT MIRROR IMAGES  
SUCH AS CIS/TRANS ISOMERS IN ALKENES AND RINGS

MOLECULES WITH TWO OR MORE CHIRAL CARBONS



DIASTEREOMERS

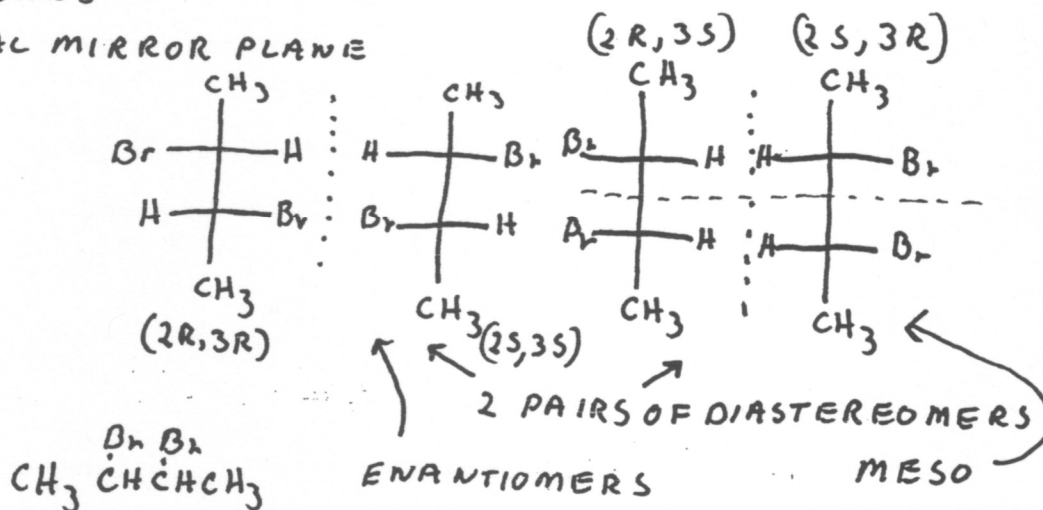
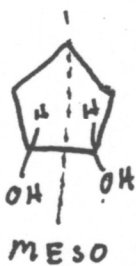


A COMPOUND WITH  $n$  CHIRAL CENTERS MAY HAVE AS MANY  
AS  $2^n$  STEREOISOMERS

IF ITS LESS THAN  $2^n$ , ITS DUE TO SYMMETRY, INTERNAL  
REFLECTION PLANES

COMPOUNDS WITH CHIRAL CARBONS BUT NO CHIRALITY ARE  
CALLED MESO COMPOUNDS

LOOK FOR AN INTERNAL MIRROR PLANE



## ABSOLUTE CONFIGURATION

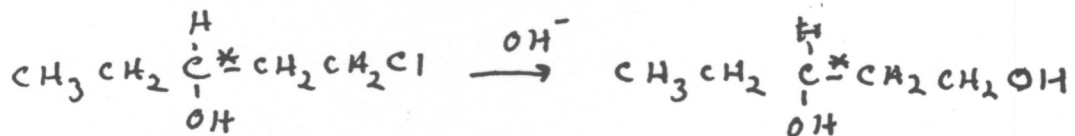
MEANS THE KNOWN RANOS CONFIGURATION AT EACH CHIRAL CARBON

## RELATIVE CONFIGURATION

MEANS THE EXPERIMENTALLY DETERMINED RELATIONSHIP BETWEEN  
THE CONFIGURATIONS OF TWO MOLECULES WHEN THE ABSOLUTE  
CONFIGURATION MAY NOT BE KNOWN

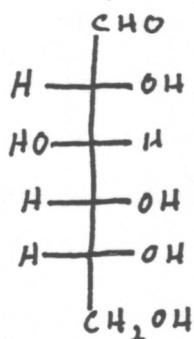


## AN EXAMPLE OF RELATIVE CONFIGURATION

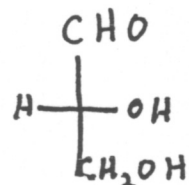


SINCE NO BONDS TO THE CHIRAL CARBON HAVE BEEN BROKEN, WE CAN SAY THAT THESE 2 HAVE THE SAME RELATIVE CONFIGURATION

THE 1902 NOBEL PRIZE IN CHEMISTRY WAS AWARDED TO EMIL FISCHER FOR DETERMINING THE RELATIVE CONFIGURATION OF GLUCOSE, WITH 4 CHIRAL CARBONS (AND 16 POSSIBLE STRUCTURES)



BY DEGRADATIVE CHEMISTRY THIS GLUCOSE CAN BE RELATED TO THE CONFIGURATION OF →



D-(+)-GLYCERALDEHYDE

## PHYSICAL PROPERTIES OF DIASTEREOMERS

IN A WORD, DIFFERENT!

CIS/TRANS DIASTEREOMERS HAVE DIFFERENT POLARITY, MP, BP, CHROMATOGRAPHIC BEHAVIOR, SPECTRA

WE USE THIS PROPERTY TO RESOLVE ENANTIOMERIC PAIRS

IF A RACEMIC MIX ENCOUNTERS A CHIRAL RESOLVING AGENT, IT WILL FORM 2 (SOMETIMES VERY TEMPORARY) DIASTEROMERS

RESOLVING AGENTS MAY BE CHEMICAL, CHROMATOGRAPHIC, OR MEDIA

## STEREOCHEMICAL REACTIONS

### 1) REACTIONS AT THE CHIRAL CARBON

INVERSION OF CONFIGURATION - WALDEN INVERSION

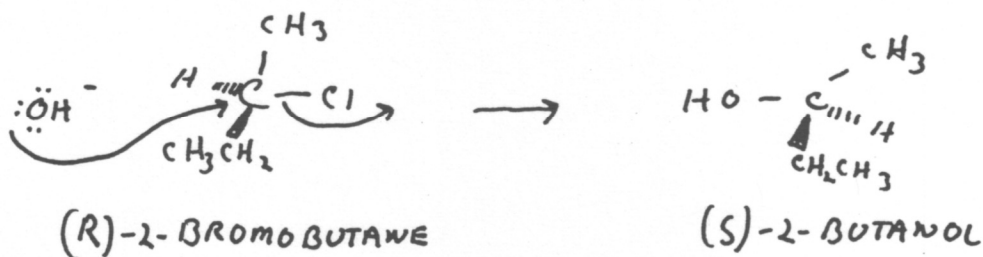
RACEMIZATION - USUALLY INVOLVES A PLANAR INTERMEDIATE

RETENTION - A NEW FUNCTIONAL GROUP REPLACES AN

OLD ONE WITH NO CHANGE IN CONFIGURATION

## INVERSION

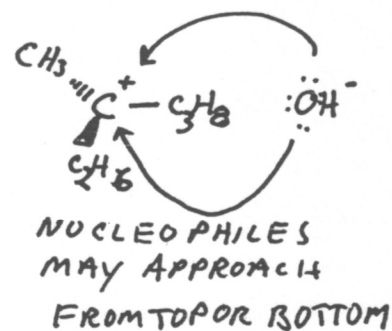
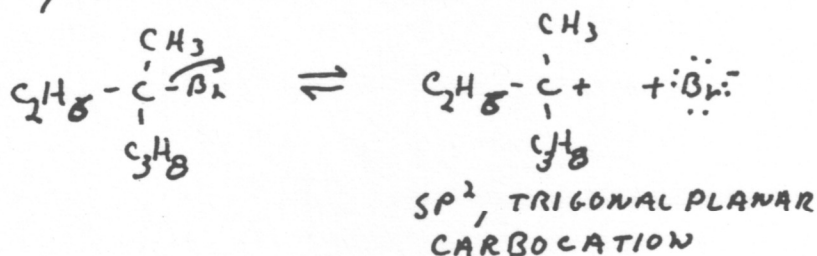
THE CONFIGURATION OF A CHIRAL CARBON IS INVERTED



THIS IS A  
NUCLEOPHILIC  
SUBSTITUTION

## RACEMIZATION

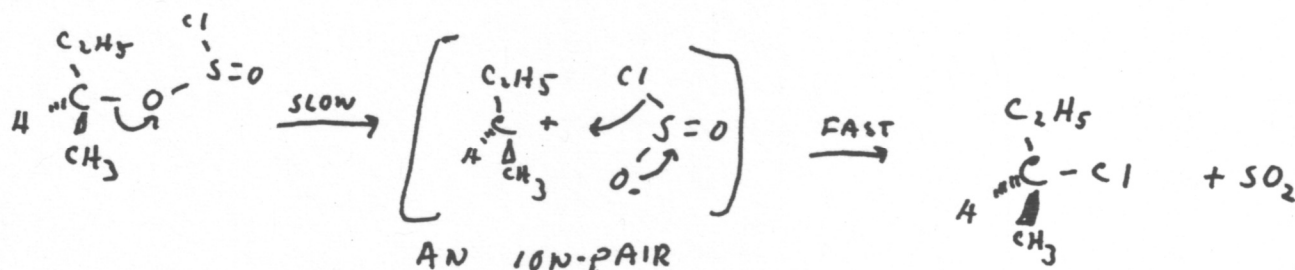
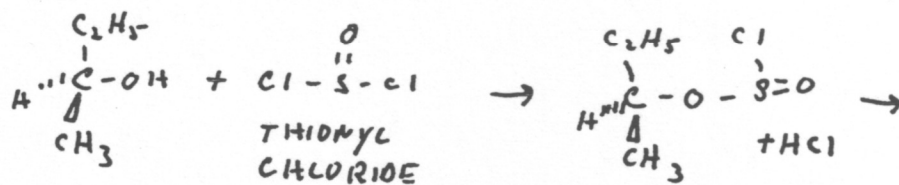
VERY OFTEN THE CONFIGURATION OF A CHIRAL CARBON IS RANDOMIZED  
A 50/50 R/S PRODUCT RESULTS  
PLANAR INTERMEDIATES LIKE CARBOCATIONS OR RADICALS ARE  
USUALLY INVOLVED



THE PRODUCT IS A RACEMIC MIXTURE

## RETENTION

LESS COMMON



THE NUCLEOPHILE DOES NOT COME FROM A RANDOM DIRECTION, IT  
COMES FROM WITHIN THE SOLVATED ION-PAIR

WE WILL ALSO SEE REACTIONS THAT PROCEED WITH PARTIAL INVERSION,  
RETENTION, AND RACEMIZATION

MANY REACTIONS CREATE NEW CHIRAL ATOMS, MOSTLY RACEMATES  
BUT OPTICALLY ACTIVE REAGENTS OR CATALYSTS CAN MAKE OPTICALLY  
ACTIVE PRODUCTS

### ASYMMETRIC INDUCTION

CHIRAL REAGENTS OR CATALYSTS CONVERT ACHIRAL REACTANTS  
TO CHIRAL PRODUCTS

THE BEST EXAMPLE IS ENZYMATIC REACTIONS

2-BUTANONE CAN BE ENZYMATICALLY REDUCED, ADDING  $H_2$  TO  
JUST ONE FACE OF THE TRIGONAL PLANAR CARBONYL

