Nuclear magnetic resonance spectroscopy

- The origin of the NMR signal
- Chemical equivalence
- The NMR experiment - an overview
- The basis for differences in chemical shift: shielding
- Spin-spin coupling
- $^{13}$C-NMR spectroscopy
- Determining unknown structures
- NMR of phosphorylated molecules

Phosphoryl transfer reactions

- Overview of phosphates and phosphoryl transfer reactions
- Phosphorylation reactions - kinase enzymes
- Hydrolysis of phosphates
- Phosphate diesters: DNA and RNA

Nucleophilic carbonyl addition reactions

- Nucleophilic additions to aldehydes and ketones: an overview
- Stereochemistry of the nucleophilic addition reaction
- Hemiacetals, hemiketals, and hydrates
- Acetals and ketal
- N-glycosidic bonds
- Imine (Schiff base) formation
- A look ahead: addition of carbon and hydride nucleophiles to carbonyls
Acyl substitution reactions

- Introduction to carboxylic acid derivatives and the nucleophilic acyl substitution Reaction
- Acyl phosphates as activated carboxylic acids
- Thioesters
- Esters

Nucleophilic acyl substitution reactions involving peptide bonds

- Activated amide groups
- A look ahead: acyl substitution reactions with a carbon or hydride nucleophile

Reactions with stabilized carbanion intermediates

- Tautomers
- Isomerization reactions
- Aldol reactions
- Claisen reactions
- Carboxylation and decarboxylation reactions
- Carbon nucleophiles in the lab
- Michael additions and beta-eliminations
- Variations on the Michael reaction
- Pyridoxal phosphate-dependent reactions
- Thiamine diphosphate-dependent reactions
- The transition state geometry of reactions involving pi bonds

Electrophilic reactions

- Overview of electrophilic reactions
- Electrophilic addition
- Electrophilic isomerization and substitution (addition/elimination)
- Conversion of shikimate to chorismate
- Electrophilic aromatic substitution
- Electrophilic aromatic substitution in the lab
- Carbocation rearrangements
- Cation-pi interactions
- The Diels-Alder reaction and other pericyclic reactions
- Oxidation and reduction reactions
• Oxidation and reduction of organic compounds - an overview
• The importance of redox reactions in metabolism
• Methanogenesis
• Hydrogenation/dehydrogenation reactions of carbonyls, imines, and alcohols
• Hydrogenation of alkenes and dehydrogenation of alkanes
• Additional examples of enzymatic hydride transfer reactions
• NAD(P)H, FADH$_2$ and metabolism - a second look
• Observing the progress of hydrogenation and dehydrogenation reactions by UV assay
• Hydrogenation/dehydrogenation reactions and renewable energy technology
• Oxygenase reactions- flavin-dependent monoxygenases
• Redox reactions involving thiols and disulfides
• Redox reactions in the organic synthesis laboratory
• Radical reactions
• The structure and reactivity of radical species
• Radical chain reactions
• Enzymatic reactions with free radical intermediates

Contributors