

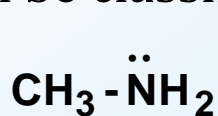
Amines

Nomenclature and Properties

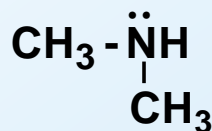
Dr. Sapna Gupta

Amines

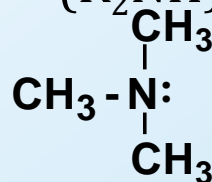
- Organic derivatives of ammonia, NH_3
- Nitrogen atom has a lone pair of electrons, making amines both basic and nucleophilic
- Amines can be classified as 1° (RNH_2), 2° (R_2NH), 3° (R_3N)



Methylamine
(a 1° amine)

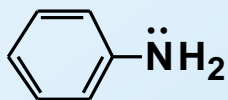


Dimethylamine
(a 2° amine)

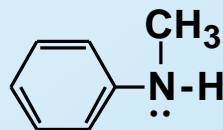


Trimethylamine
(a 3° amine)

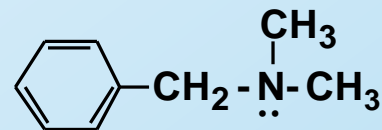
- Amines are further divided into aliphatic, aromatic, and heterocyclic amines:
 - Aliphatic amine: An amine where nitrogen is bonded only to alkyl groups.
 - Aromatic amine: An amine where nitrogen is bonded to one or more aryl groups.



Aniline
(a 1° aromatic amine)



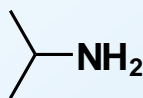
N-Methylaniline
(a 2° aromatic amine)



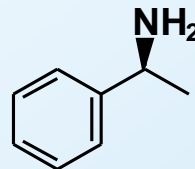
Benzyltrimethylamine
(a 3° aliphatic amine)

Nomenclature

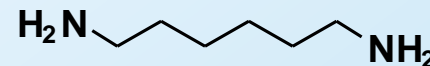
- Aliphatic amines: replace the suffix **-e** of the parent alkane by **-amine**.



2-Propanamine

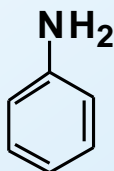


(S)-1-Phenylethanamine

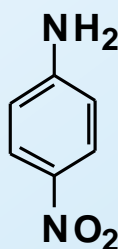


1,6-Hexanediamine

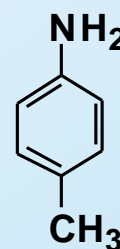
- The IUPAC system retains the name aniline.



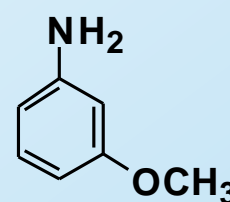
Aniline



4-Nitroaniline
(*p*-Nitroaniline)

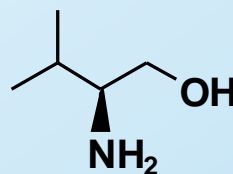


4-Methylaniline
(*p*-Toluidine)

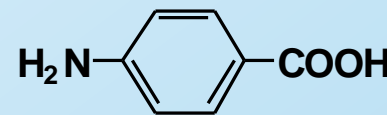


3-Methoxyaniline
(*m*-Anisidine)

- Among the various functional groups discussed in the text, -NH_2 is one of the lowest in order of precedence.

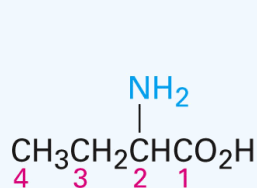


(S)-2-Amino-3-methyl-1-butanol

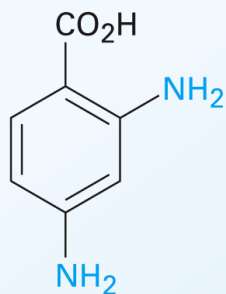


4-Aminobenzoic acid

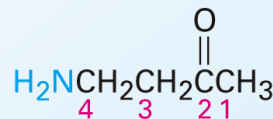
Nomenclature – contd.



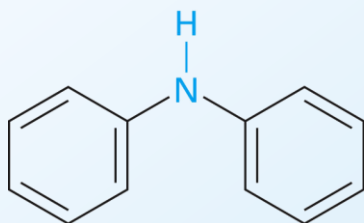
2-Aminobutanoic acid



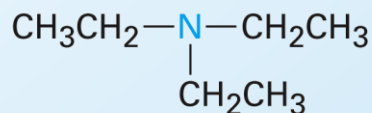
2,4-Diaminobenzoic acid



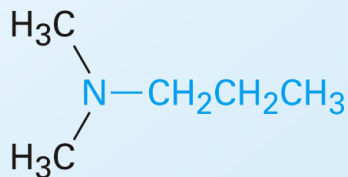
4-Amino-2-butanone



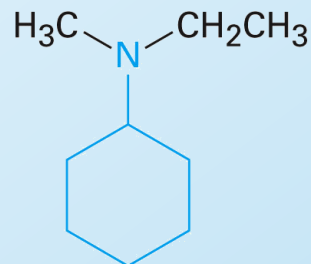
Diphenylamine



Triethylamine



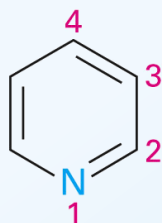
N,N-Dimethylpropylamine



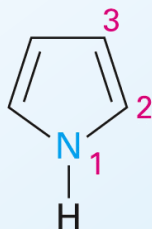
N-Ethyl-N-methylcyclohexylamine

Heterocyclic Amines

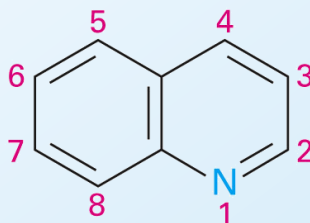
- Nitrogen is part of the ring.



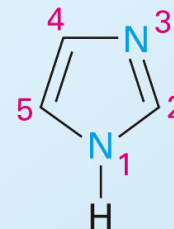
Pyridine



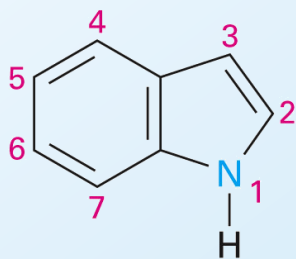
Pyrrole



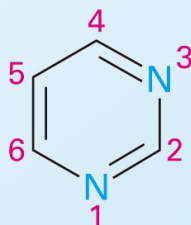
Quinoline



Imidazole



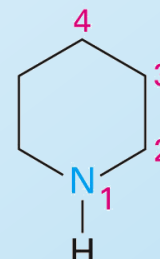
Indole



Pyrimidine



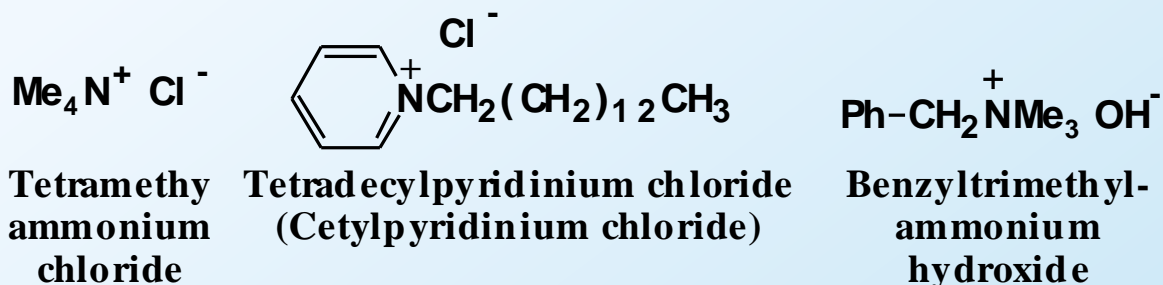
Pyrrolidine



Piperidine

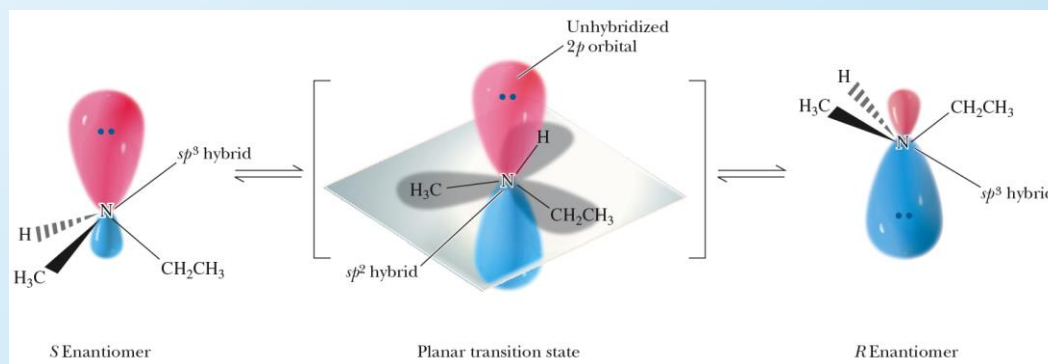
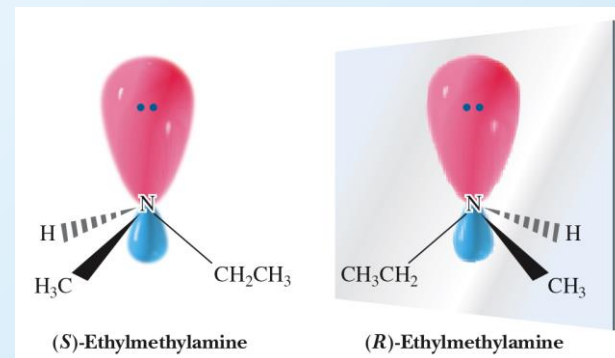
Nomenclature – Quarternary Salts

- When four groups are bonded to nitrogen, the compound is named as a salt of the corresponding amine. These are also called quarternary salts.



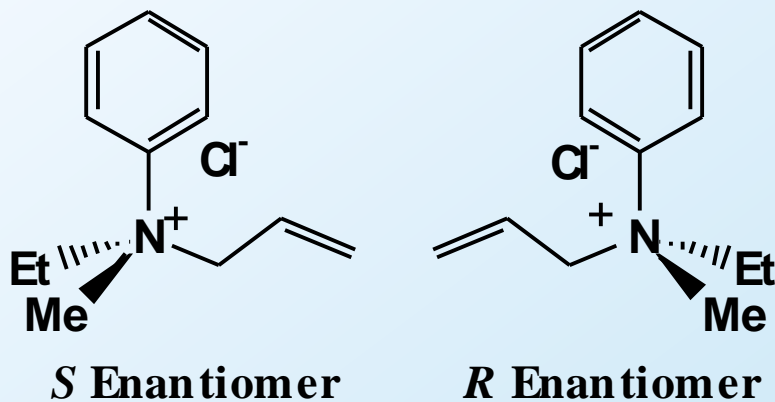
Chirality of Amines

- Consider the unshared pair of electrons on nitrogen as a fourth group, then the arrangement of groups around N is approximately tetrahedral.
- An amine with three different groups bonded to N is chiral and exists as a pair of enantiomers and, in principle, can be resolved.
- In practice, however, they cannot be resolved because they undergo pyramidal inversion, which converts one enantiomer to the other.



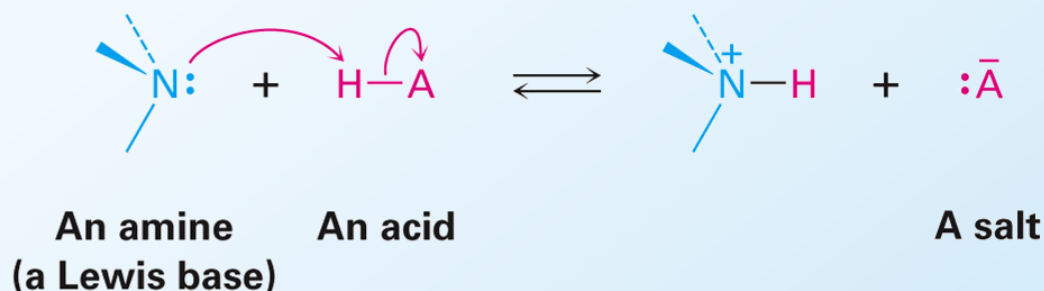
Chirality of Amines

- The pyramidal inversion is not possible in quarternary amines and the salts can be resolved.



Basicity of Amines

- The lone pair of electrons on nitrogen makes amines basic and nucleophilic
- They react with acids to form acid–base salts



- Amines are stronger bases than alcohols, ethers, or water
- Most simple alkylammonium ions have pKa's of 10 to 11
- In gas phase, the basicity of amines is $1 > 2 > 3$



- In aqueous phase the basicity of amines is $2 > 1 > 3$. This is because H of N is stabilized by hydrogen bonding.

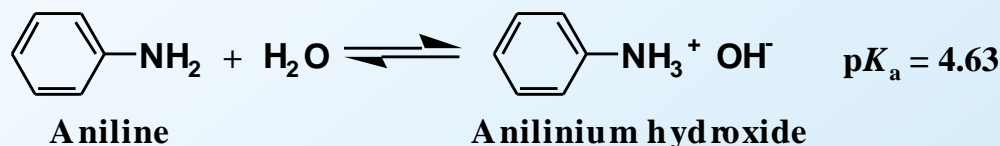
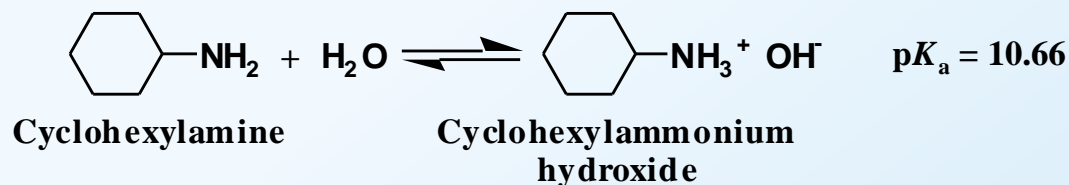


Basicity – pK_a of Aliphatic Amines

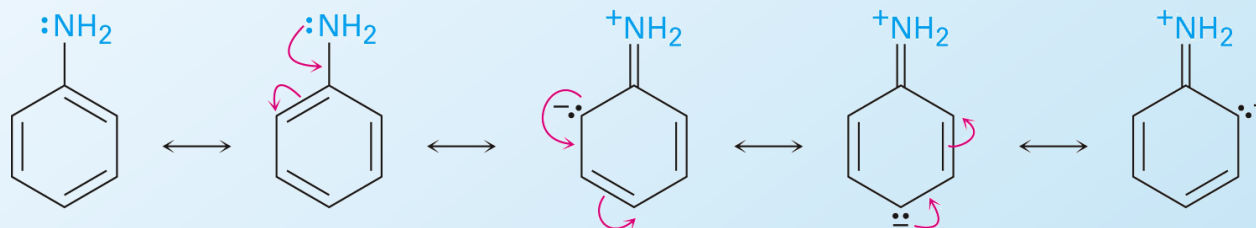
Amine	Structure	pK _a	pK _b
Ammonia	NH₃	9.26	4.74
Primary Amines			
methylamine	CH ₃ NH ₂	10.64	3.36
ethylamine	CH ₃ CH ₂ NH ₂	10.81	3.19
cyclohexylamine	C ₆ H ₁₁ NH ₂	10.66	3.34
Secondary Amines			
dimethylamine	(CH ₃) ₂ NH	10.73	3.27
diethylamine	(CH ₃ CH ₂) ₂ NH	10.98	3.02
Tertiary Amines			
trimethylamine	(CH ₃) ₃ N	9.81	4.19
triethylamine	(CH ₃ CH ₂) ₃ N	10.75	3.25

Basicity of Arylamines

- Aromatic amines are weaker than aliphatic amines.

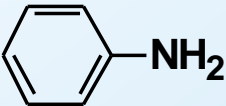

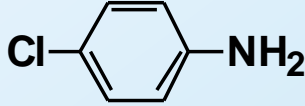
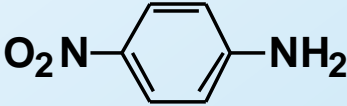
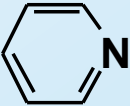
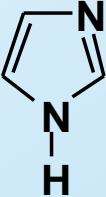


- The N lone-pair electrons in arylamines are delocalized by interaction with the aromatic ring pi electron system and are less able to accept H^+ than are alkylamines



- Substituted arylamines can be more basic or less basic than aniline
- Electron-donating substituents (such as $-\text{CH}_3$, $-\text{NH}_2$, $-\text{OCH}_3$) increase the basicity of the corresponding arylamine
- Electron-withdrawing substituents (such as $-\text{Cl}$, $-\text{NO}_2$, $-\text{CN}$) decrease arylamine basicity

Basicity – pK_a of Aromatic Amines

Amine	Structure	pK _a of Conjugate Acid
Aromatic Amines		
Aniline		4.63
4-Methylaniline		5.08
4-Chloroaniline		4.15
4-Nitroaniline		1.0
Heterocyclic Aromatic Amines		
Pyridine		5.25
Imidazole		6.95

Physical Properties of Amines

- Boiling point: relatively high due to hydrogen bonding. $1^\circ > 2^\circ > 3^\circ$ due to decreasing hydrogen bonding.

	CH_3CH_3	CH_3NH_2	CH_3OH
MW (g/mol)	30.1	31.1	32.0
bp ($^\circ\text{C}$)	-88.6	-6.3	65.0

- Solubility in water: as above
- Odor: foul smelling compounds
 - Fish smell: trimethyl and dimethyl amine
 - Cadaverine: 1,5-hexanediamine
 - Putrascene: 1,4-butanediamine

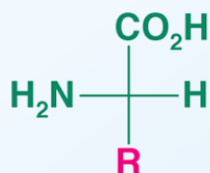
Physical Properties

Name	Structure	mp (°C)	bp (°C)	Water Solubility (25°C) (g 100 mL ⁻¹)	pK _a (aminium ion)
Primary Amines					
Methylamine	CH ₃ NH ₂	-94	-6	Very soluble	10.64
Ethylamine	CH ₃ CH ₂ NH ₂	-81	17	Very soluble	10.75
Propylamine	CH ₃ CH ₂ CH ₂ NH ₂	-83	49	Very soluble	10.67
Isopropylamine	(CH ₃) ₂ CHNH ₂	-101	33	Very soluble	10.73
Butylamine	CH ₃ (CH ₂) ₂ CH ₂ NH ₂	-51	78	Very soluble	10.61
Isobutylamine	(CH ₃) ₂ CHCH ₂ NH ₂	-86	68	Very soluble	10.49
sec-Butylamine	CH ₃ CH ₂ CH(CH ₃)NH ₂	-104	63	Very soluble	10.56
tert-Butylamine	(CH ₃) ₃ CNH ₂	-68	45	Very soluble	10.45
Cyclohexylamine	Cyclo-C ₆ H ₁₁ NH ₂	-18	134	Slightly soluble	10.64
Benzylamine	C ₆ H ₅ CH ₂ NH ₂	10	185	Slightly soluble	9.30
Aniline	C ₆ H ₅ NH ₂	-6	184	3.7	4.58
p-Toluidine	p-CH ₃ C ₆ H ₄ NH ₂	44	200	Slightly soluble	5.08
p-Anisidine	p-CH ₃ OC ₆ H ₄ NH ₂	57	244	Very slightly soluble	5.30
p-Chloroaniline	p-ClC ₆ H ₄ NH ₂	73	232	Insoluble	4.00
p-Nitroaniline	p-NO ₂ C ₆ H ₄ NH ₂	148	332	Insoluble	1.00
Secondary Amines					
Dimethylamine	(CH ₃) ₂ NH	-92	7	Very soluble	10.72
Diethylamine	(CH ₃ CH ₂) ₂ NH	-48	56	Very soluble	10.98
Dipropylamine	(CH ₃ CH ₂ CH ₂) ₂ NH	-40	110	Very soluble	10.98
N-Methylaniline	C ₆ H ₅ NHCH ₃	-57	196	Slightly soluble	4.70
Diphenylamine	(C ₆ H ₅) ₂ NH	53	302	Insoluble	0.80
Tertiary Amines					
Trimethylamine	(CH ₃) ₃ N	-117	2.9	Very soluble	9.70
Triethylamine	(CH ₃ CH ₂) ₃ N	-115	90	14	10.76
Tripropylamine	(CH ₃ CH ₂ CH ₂) ₃ N	-93	156	Slightly soluble	10.64
N,N-Dimethylaniline	C ₆ H ₅ N(CH ₃) ₂	3	194	Slightly soluble	5.06

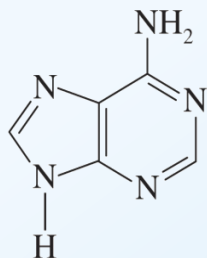
Amines in Nature

- Nitrogen containing natural products:

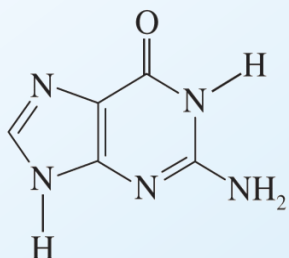
- Amino Acids (20)



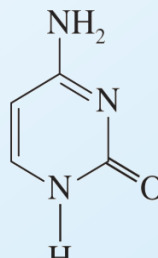
- Nuclear bases (5)



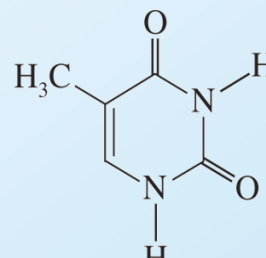
Adenine
(A)



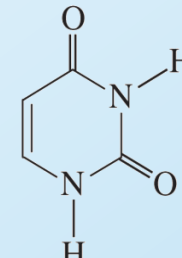
Guanine
(G)



Cytosine
(C)

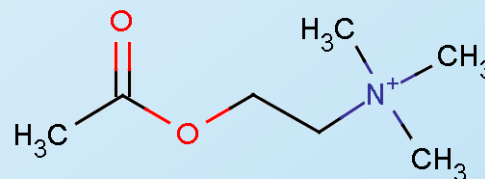


Thymine
(T)

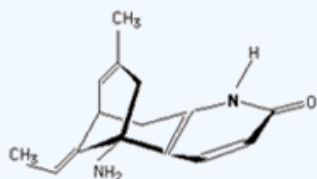


Uracil
(a pyrimidine)

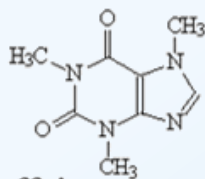
- Neurotransmitters (*next slide*)
- Are usually addictive and in some cases toxic.
- Body's common transmitter is acetylcholine.



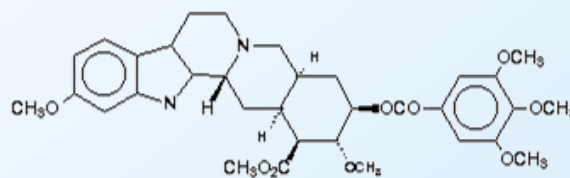
Alkaloids - examples



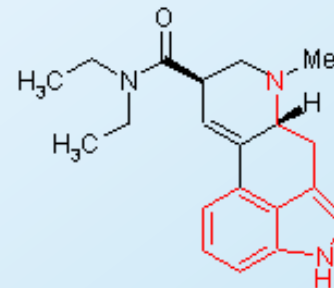
huperzine A
Chinese herbal medicine
nootropic



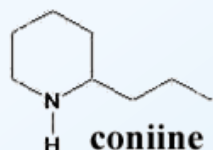
caffeine
Coffea arabica
study



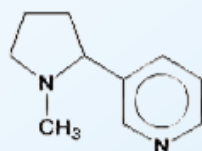
reserpine
Indian herbal medicine
antipsychotic



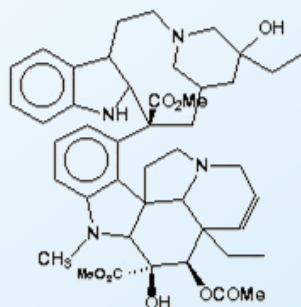
LSD



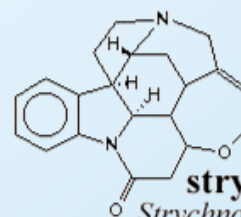
coniine
hemlock
ants, Socrates



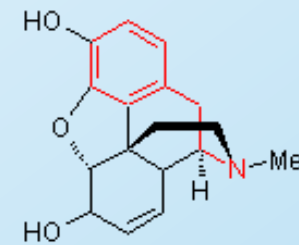
nicotine
tobacco
Black Leaf 40
insecticide



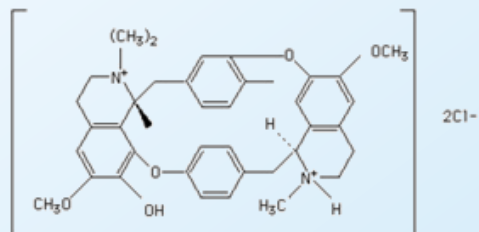
vinblastine
Madagascar periwinkle
antileukemic



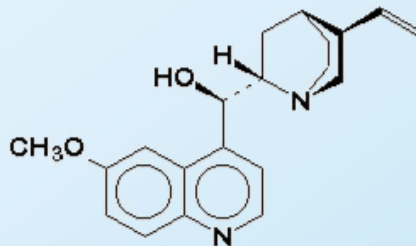
strychnine
Strychnos nux-vomica
rodenticide



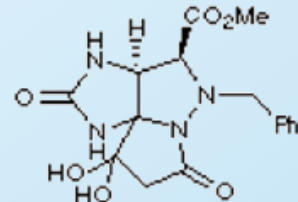
Morphine



D-tubocurarine
arrow poison, muscle relaxant for surgery



quinine
Cinchona tree, antimalarial

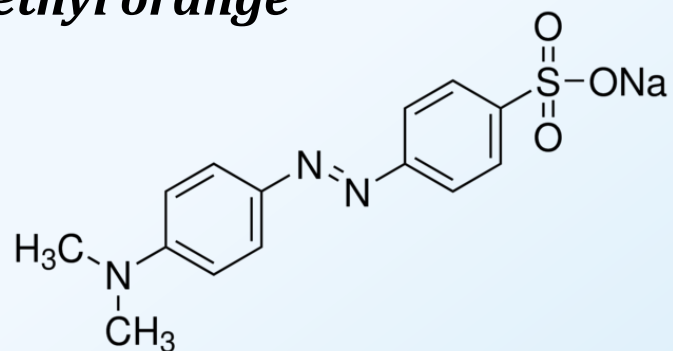


saxitoxin
deadly algal toxin
chemical warfare agent
CIA suicide pill

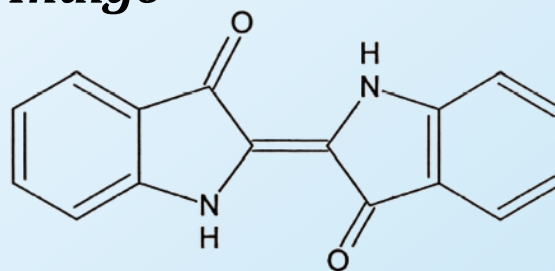
Amines - Dyes

Amines are important functional group in synthesis of dyes.

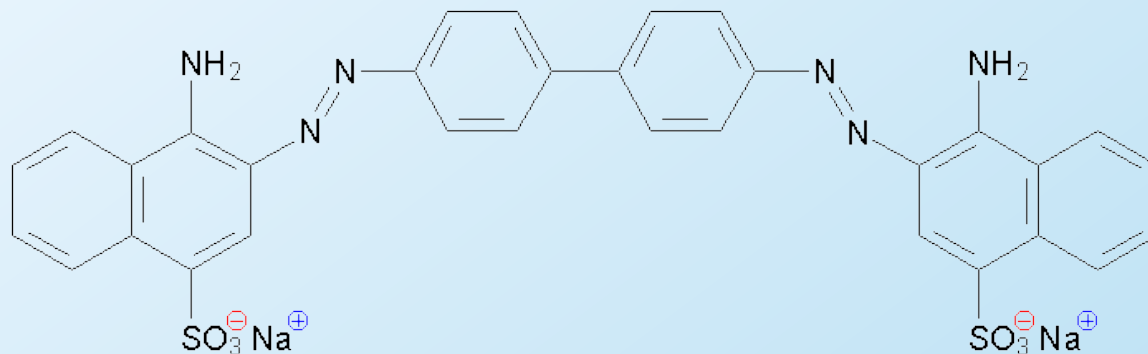
Methyl orange



Indigo



Congo Red



Key Words/Concepts

- Nomenclature
- Physical properties
- Basicity of amines