The Vegetable Alkaloids
Their Chemical Composition
and their
Physiological Effects.

by

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Outline

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- Occurrence
- Classification
- Reactions for alkaloids
- General Chemical properties.

Examples of ten common alkaloids.

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- Nicotine
- Morphine
- Strychnine
- Curarine
- Atropine
- Quinine
- Cocaine
- Thes Bromine
- Coffeine (Theine)

Part II.

Uses of Alkaloids

- In medicine
- In daily life - (Habitually)
- Physiological effects.

Examples of ten common alkaloids.

(Same as listed above)

Part I

Chemical Composition

Of the many organic compounds found in the vegitable world, there is a considerable number that are very complex in composition but very important because of their frequent occurence, common usage and great medical activity.

Some of these have been used for ages, either in medicine or habitually in daily life, but used because because of physiological effects and without a definite knowledge of their chemical composition and conduct.

Among the most important and most complex of these are the vegitable alkaloids, which are sometimes designated chemically as the Pyridine bases. They are found in a variety of plants, and are Nitrogenous organic compounds, also called bases as they are capable of neutralizing acids. They are divided into two classes — the <u>volatile</u> and <u>non-volatile</u>

The volatile are compounds of Carbon,

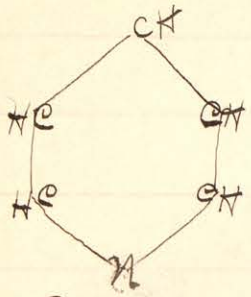
Hydrogen and Nitrogen.

(2) The non-volatile are compounds of Carbon, Hydrogen, Nitrogen and Oxygen.

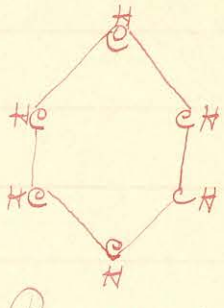
Both classes include bodies having decided basic qualities and having a strongly alkaline reaction.

The alkaloids are found in the barks or fruits of various plants and trees. The pure alkaloids may be obtained by extracting them from their natural sources. As nearly all of the alkaloids are insoluble in pure water and are readily soluble in ether, alcohol, and chloroform as well as the acids, the extraction is frequently made by making an infusion with acidulated water, and then dissolving the alkaloid of the precipitation by an alkali by means of one of the above named solvents.

The chemical structure of these bases is not well understood, but the Pyridine group has the general empirical formula — $C_n H_{2n-5} N$. To illustrate the structure of these bases, Pyridine and Quinoline may be taken for they show the comparison with the ring formulas of Benzene and Naphthalene —

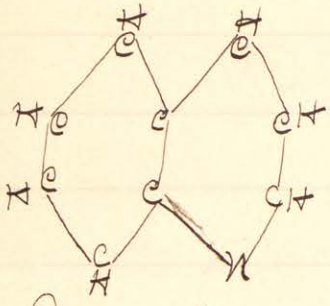


Pyridine

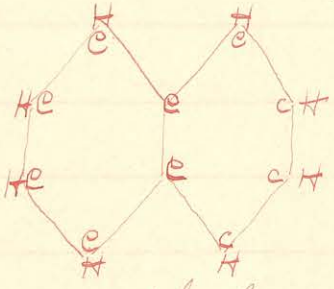


Benzene

The relation of Pyridine to Benzene is clearly shown, the difference being, that there is one Nitrogen atom in the ring.



Quinoline



Naphthalene

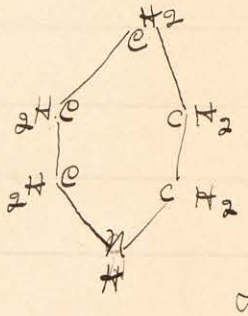
The above formulae show a similar relation between Naphthalene and Quinoline, the Nitrogen atom being in the second ring.

After this brief consideration of the alkaloids in general, we will now take up in more detail the Chemistry of ten common alkaloids.

I <u>Piperidine</u>:

One of the most common and most important of the Pyridine bases is Piperidine. This has the formula $C_5H_{11}N$, and its relation to Pyridine is plainly

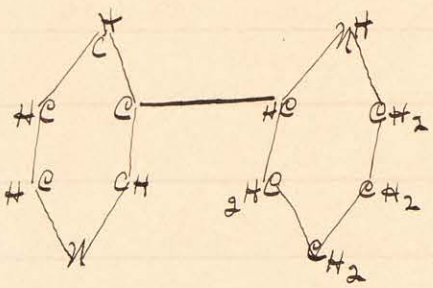
indicated as an addition product of that base.



Thus it is seen that it contains a hexagon ring made up of one amido and five methyline groups.

Piperidine is a colorless liquid of peculiar odor resembling pepper. It is found in pepper in connection with piperic acid in the form of the alkaloid piperine. This substance is the active principle in pepper.

II- Nicotine, $C_{10}H_{14}N_2$ or



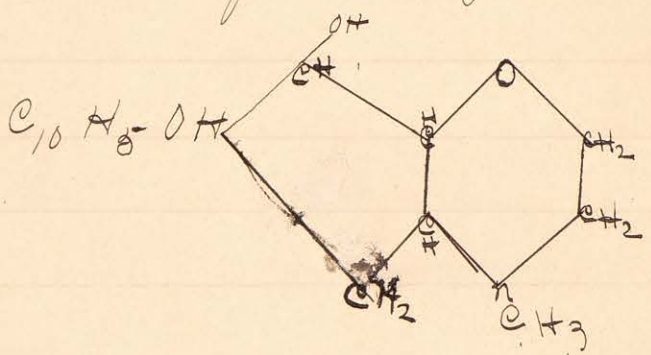
The formula for Nicotine shows the Pyridine ring plus the Piperidine ring.

Nicotine is a strong acid base. It is the poisonous constituent of various parts of the tobacco plant. It is oily, readily soluble in water alcohol and ether. It has a stupefying odor

and can be distilled unchanged in an atmosphere of hydrogen, but becomes brown in air. The odor resembles that of tobacco smoke, and it has a warm bitterish aromatic taste.

III Morphine -

The probable formula for Morphine is $C_{17}H_{19}NO_3$ or



This is one of the Opium alkaloids which comes from the exudation obtained from the unripe fruit (capsuls) of the Poppy (Papaver Somniferum). It is found in all parts of this plant but more particularly in the leaves stems and seeds just before maturity. In dried opium morphine is found in quantities of from 3% to 20%. Morphine is readily recognized under the microscope by its crystalline form, and by the color test with Frochde's reagent. Morphine crystalizes from water solutions. It is without odor, and has a bitter taste.

II- Strychnine - $C_{21} H_{22} N_2 O_2$ -

This is an alkaloid found in the Snake Button, (or fruit of the Strychnos nux-vomica). Its chemical constitution is as yet not definitely known. It is identified by the fooding purple test, the crystallization of the free alkaloid, and by the physiological tests of tetanic effect and bitterness. The bitterness is graphite in a solution diluted 600 000 to 700 000 parts. Strychnine may be separated from its source by treating the finely ground seeds of nux-vomica with a mixture of alcohol and chloroform.

I- Curarine - $C_{18} H_{35} N$ (?)

This alkaloid also, is found in a plant of the genius Strychnos. The exact chemical composition of Curarine is not known, but the above is the probable formula.

It occurs as a sulphate in Curara a resinous arrow poison used by the South American Indians. It is said to be obtained by boiling the plant with water. It gives a red color with concentrated sulphuric acid and with Nitric acid. It is soluble in water

alcohol and chloroform, but insoluble in ether. It is generally regarded as the most intensely poisonous substance known.

VI- Atropine - $C_{17}H_{23}NO_3$.

Atropine is one of the Mydriatic alkaloids found in the root and leaf of the Belladonna (Solanaceae). It is soluble in six hundred parts water at 15° C, and is also soluble in glycerine, alcohol, chloroform and ether. The aqueous solutions are not very stable. It has a decidedly alkaline reaction. When extracted in the pure form it is a colorless or amorphous white powder. It has no odor but has a disagreeable taste and is extremely poisonous!

VII- Quinine - $C_{20}H_{24}N_2O_2 + 3H_2O$

or

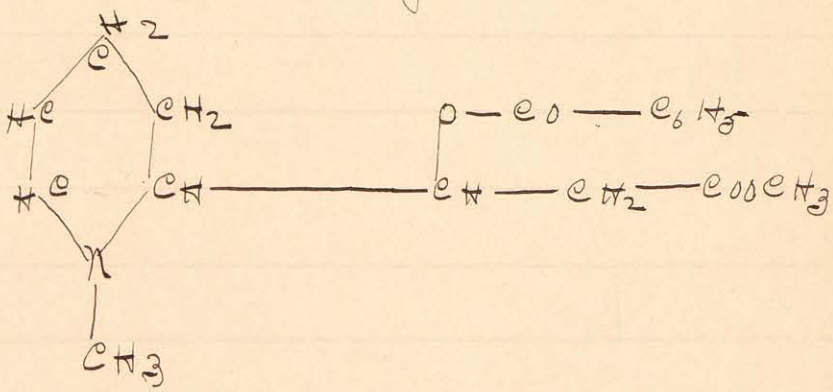
$(CH_3O)C_9H_5N - C_{10}H_{15}(OH)N$.

The structural formula for Quinine is as yet not clearly worked out. It is one of the alkaloids found in Cinchona bark. It is closely related chemically to Pyridine and Quinoline. It is easily recognized by the

blue fluorescence of its salts in dilute solutions. It crystallizes in prisms or silky needles, and has an extremely bitter taste.

VIII - Cocaine, - $C_{17}H_{21}NO_4$

or probably

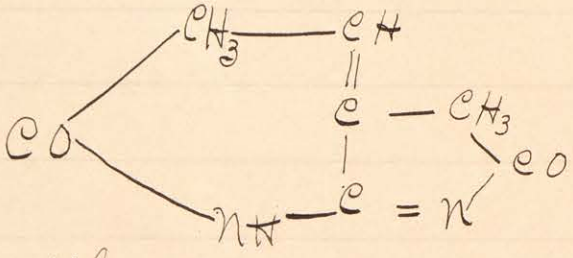


This is the crystallizable natural alkaloid of the fresh coca leaf (Erythroxylon Coca). Cocaine is easily saponified by an acid. In decomposition cocaine is liable to form simple Pyridine compounds showing a direct relation to the Pyridine series. The structural formula shows that it is an addition product of Pyridine.

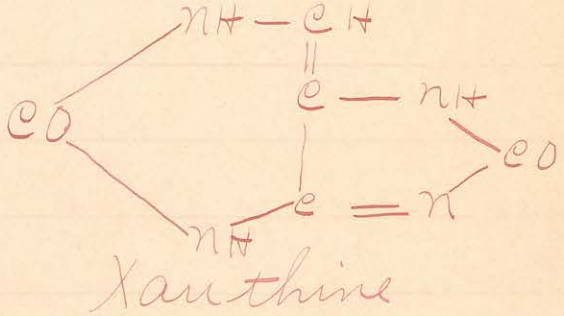
Cocaine crystallizes in white crystals. It has the property of deadening pain.

II - Theo Bromine - $C_7H_8N_4O_2$.

Chemically Theo Bromine is a dimethyl Xanthine. This is shown in the following formulae.



Theo Bromine.

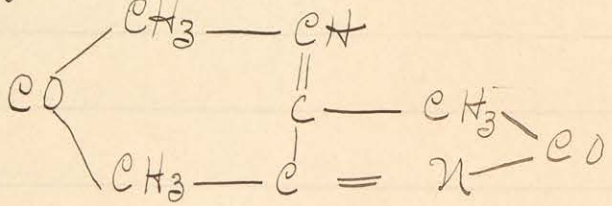


Xanthine

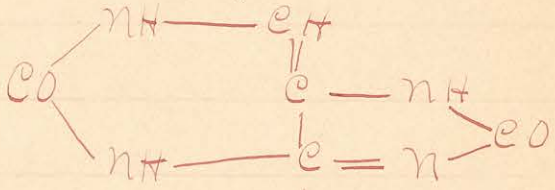
This alkaloid is found in the seed of the cocao plant or "chocolate nut" (Theobroma cocao). It is also found with coffine in the seed of the Sticulia Acuminata. Theo Bromine crystallizes in anhydrous white needles. It has a very bitter taste, is sparingly soluble in water and alcohol. It forms salts both as a base and an acid. When heated with CH_3I it yields coffine.

X- Theine or Caffeine, $C_8 H_{10} N_4 O_2$.

In regard to the chemical composition of this alkaloid it is a Tri-methyl Xanthine.



Caffeine



Xanthine.

"Theine" found in tea, and "Caffeine" found in coffee are chemically identical. They differ widely from Theo Bromine but are related to it as will be seen from the given formulae.

The so called Coffeine is found in the berry of the common coffee plant (Coffea Arabica) and the Theine in the common tea leaf (Camillia Thea).

It differs greatly from Theo Bromine in solubility. It is identified by the long silky needles in which it crystallizes. Its salts are readily decomposed by water. It may be prep and artificially from Theo Bromine or from Xanthine.

Tannic acid precipitates Caffeine from concentrated aqueous solutions. It is a very feeble base forming salts only by the action of concentrated acids. It is neutral

to test paper.

In an experiment for the extraction of coffeine, one hundred grams of finely ground coffee was used. With this four successive infusions with acidulated boiling water was made, using 250 cc of water with 2 cc of Sulphuric acid for each infusion. The solution was then filtered and evaporated with 40 gm of Magnesia and 100 gm of ground quartz. After evaporating, the dry powder was treated with 1000 cc. of ether in four separate portions. This was then filtered off and the ether allowed to evaporate from a crystalliging dish. The crystals of coffeine remained. On examining them under the microscope they were found to be long, silky needle-like crystals.

The pure coffeine has no odor, and a very bitter taste resembling quinine. After standing in the air for some hours the crystals become discolored having a yellowish color.

Note:- For the above experiments the directions given in Wagendorff's "Plant Analysis" and Prescott's "Organic Analysis", were followed.

As a quantitative or assay test the above method is not satisfactory, but though an imperfect test the results show that there is comparatively little of the alkaloid present in coffee and tea as it is used for a beverage. The masked effect of the small amount present illustrates the great activity of the alkaloids in general, for Caffeine is numbered with the milder ones.

The same method was used to extract Theine from tea, using the same proportions except that in making the infusions with water no acids was used. The crystals obtained from the tea were the same in appearance and taste.

Part II

Physiological Effects

Although very little is definitely known of the vegitable alkaloids as regards their chemical constitution, their physiological effects have been widely studied and are of the utmost importance to us because of their practical usage in daily life.

I- Piperidine -

With the exception of salt there is no food condiment, so habitually used as pepper, in which the alkaloid Piperidine is found in combination with Pipric acid forming Alpine. The stimulating influence of pepper upon the nervous system is due to this alkaloid. When taken in large doses it is very irritating to the digestive organs. The burning sensation produced by pepper is largely due to the oils present. The value of pepper as an antidote for fever is due to the presence

of the alkaloid. It has been used successfully as a medicine, both in connection with quinine and alone.

II- Nicotine.

Nicotine is obtained from the tobacco plant. It is present in all parts of the plant, when fresh as well as in the dried leaves. According to Kissling tobacco smoke owes its toxic action mainly to this alkaloid. Nicotine acts poisonously upon all animals. In man it acts primarily upon the spinal and sympathetic nervous system and not upon the brain. The habitual use of tobacco may cause chronic diseases of the digestive organs. It may permanently impair the nerves and frequently causes serious diseases of the eye. Nicotine stands next to Prussic acid in the rapidity and energy of its poisonous action. The minimum fatal dose is not known.

III- Morphine.

From the medicinal point of view, there is no more important drug

than morphine, an alkaloid belonging to the opium bases.

Its influence as a hypnotic is well known and when the saving of life depends upon the saving of strength by relief from pain, morphine has no superior. Morphine is mildly stimulating to the nervous system and circulation, and lowers the temperature. In small doses, it is used for stimulating the heart in cases of pulmonary obstruction. While small doses are stimulating large doses act as a narcotic.

The habitual use of morphine causes a degeneration of the brain and spinal marrow. The lungs and liver also become engorged. Aside from the effects on the body, morphine acts as a destroyer of mental and moral powers. Its use should be restricted to extreme cases, and then should be handled with extreme caution.

II - Strychnine -

Strychnine is a violent poison when taken in certain doses. The smallest fatal dose varies from ½ to 2 grains. The symptoms of poisoning indicate that death is

caused by asphyxia produced by the rigidity of the muscles of respiration.

In small doses, strychnine is used as a tonic. It stimulates the nerves and seems to promote the functions of the special senses. It does not affect the brain. In healthy persons it has no evil after-effects. Like other bitter tonics the continued use causes a derangement of the digestive organs.

V - Curarine.

This, as has been stated, is the poison used by the Indians of South America in the preparation of arrow poison. The crystals of Curarine have a very bitter taste. It is far less poisonous when taken into the stomach than when it comes in contact with the skin. It causes some ulceration. Taken hypodermically it primarily affects the nerves. Some physicians say that the effect is upon the ~~ster~~terminations of the nerves, others that it causes paralysis of the motor nerve trunks. It is employed as medicine in cases of nervous spasms.

V - Atropine.

For the relief of pain, Atropine stands next to opium. Though a poison, it is not often fatal. It causes the pupils of the eyes to dilate, and hence is employed for this purpose by Physicians when they desire to examine the iris or remove a cataract.

It has also been successfully used as an antidote for poisoning by Strychnine.

VI - Quinine.

Quinine is rarely poisonous, except in excessive doses. It is very valuable as a medicine when judiciously used, acting as a stimulant to the nervous and circulatory systems. When used habitually or with too great frequency, it may become injurious. It causes deafness, affects the nerves and digestive organs, and after a time, may impair the action of the heart. In cases of poisoning by quinine, the lungs and brain were found engorged with blood. It is considered physiologically antagonistic to Atropine.

VIII - Cocaine -

Cocaine, which is found so abundantly in the Coca leaf, is very different in effect upon the body from any of the alkaloids thus far considered. It stimulates the nerves when given in moderate doses, but large doses cause a depression. It enables one to remain sometime without food, at the same time greatly increasing the muscular strength and endurance, enabling one to endure unusual fatigue. It does not effect the mind except to relieve fatigue. The conclusion is that cocaine retards the waste of tissue to such an extent that the above effect is produced. It depends upon the amount taken as to whether it is wholsome or poisonous.

Cocaine is used a great deal as a local anasthetic. In connection with other things as well as when used alone it has the power to relieve pain when applied externally as a poultice. In cases of many kinds of local inflamation where the pain is intense it is very valuable.

X- Theo Bromine

The common usage of Chocolate and cocoa as a beverage makes the alkaloid contained in them a very important one. Although these beverages are taken principally for the food value of the fat, the alkaloid or active principle present exerts a mildly stimulating and soothing effect upon the system.

It is exhilirating, allays hunger, retards the waste of tissue, and while it excites the nervous and vascular systems to some extent it is not followed by a feeling of depression afterwards.

The pure Theo-Bromine is a poison to animals, causing paralysis of the spinal cord. It is poisonous in much smaller doses than coffeine. As a medicine it is probable that it may be substituted for coffeine in many cases as having a more desirable effect, but it is far more difficult to procure than coffeine.

X- Caffeine (Theine)

The alkoloids Coffeine in coffee and Theine in tea are identical not only in Chemical composition but also in physiological effect. Although tea and coffee may vary in their effect upon individuals, this is due to the other constituents, such as the oils and tannic acid, and the varying quantities used rather than any diffrence in the alkoloid contained in them.

Both tea and coffee retard the waste of tissues in the body. Coffee excites the nervous and vascular syptems, while tea has a soothing effect. In general, the effect of the beverages may be said to be the same except that tea is a milder stimulant.

Pure caffeine (or theine) is used in medicine as a stimulant, as an antidote for strychnine and opium poisoning, and is also considered an excellent tonic when taken in moderate doses.

Excessive doses of coffeine are very dangerous, as it produces muscular spasms, intestinal and throat irritation, and [illegible]

To sum up—

It is plain that the vegitable alkaloids are among the most active and most effective of the organic compounds. Their common usage in medicine and in daily life make it doubly important that we should consider their effects upon the body with far greater seriousness than is usually given to the drinking of tea and coffee or the use of pepper.

It is evident that even in small amounts, the alkaloids produce an effect upon the system which is abnormal, and which if continued may cause disease.

The habitual use of the various beverages and condiments containing alkaloids as well as the reckless manner in which many of them are administered as medicine seems alarming when their true effects are known.

That all of the alkaloids have great value as medicine and none as food is self evident. Under normal conditions the body does not require these things, and the use of them should be reserved for times when mild or active stimulants are

required.

Coffine is among the mildest of the alkaloids, and the poisonous effect of this substance when pure illustrates the more gradual but equally harmful effect that comes from excessive use of tea and coffee. Caution and judgement should be exercised in the use of all substances which contain the vegetible alkaloids.