

Dictionary of Alkaloids

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CHAPMAN AND HALL

Dictionary of Alkaloids

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LONDON NEW YORK
CHAPMAN AND HALL

First published in 1989 by Chapman and Hall Ltd
11 New Fetter Lane, London EC4P 4EE
29 West 35th Street, New York NY 10001

Phototypeset in the United States of America by
Mack Printing Company, Easton, Pennsylvania 18042
Printed in Great Britain at the University Press, Cambridge

ISBN 0 412 24910 3 (*two volume set*)

© 1989 Chapman and Hall Ltd

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British Library
Cataloguing in Publication Data

Southon, I.W.
Dictionary of alkaloids.
1. Alkaloids
I. Title II. Buckingham, J. (John)
547.7'2

ISBN 0-412-24910-3

Library of Congress
Cataloging-in-Publication Data

Dictionary of alkaloids/editorial board: G.A. Cordell . . . [et al.];
compiled and edited by I.W. Southon, J. Buckingham.

p. cm.

Bibliography: p.

Includes indexes.

ISBN 0-412-24910-3 (set)

1. Alkaloids—Dictionaries. I. Southon, I.W. (Ian W.)

II. Buckingham, J.

[DNLM: 1. Alkaloids—dictionaries. QD 421 D554]

RS431.A53D53 1989

615'.321—dc 19

DNLM/DLC

for Library of Congress

88-39785

CIP

Dictionary of Alkaloids

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Caution

Treat all organic compounds as if they have dangerous properties.

The information contained in this volume has been compiled from sources believed to be reliable. However, no warranty, guarantee, or representation is made by the Publisher as to the correctness or sufficiency of any information herein, and the Publisher assumes no responsibility in connection therewith.

The specific information in this publication on the hazardous and toxic properties of certain compounds is included to alert the reader to possible dangers associated with the use of those compounds. The absence of such information should not however be taken as an indication of safety in use or misuse.

Preface

Alkaloids have played an important part in the development of the chemical and biological sciences. They were originally defined as pharmacologically active, nitrogen heterocyclic bases of plant origin – a definition which was a natural consequence of the early experiences of alkaloid isolation, and which focussed on plants which had been used as sources of drugs for centuries, or were well known to be extremely toxic.

Since those early years of the nineteenth century the use of the term alkaloid has gradually been extended and broadened, and it now includes most naturally occurring, nitrogen-containing secondary metabolites of plant, microbial, or even animal origin. Further, although many alkaloids exhibit a pronounced physiological activity, and some are used clinically, this particular characteristic is now no longer a prerequisite. Of the several thousand alkaloids known to-day some have no well-defined activity, while others, and perhaps the majority, have never been examined for pharmacological activity, either because close structural relatives have not shown any particular activity, or because they have not been isolated in sufficient quantity to merit pharmacological evaluation.

Whatever view is taken of the strict definition of an alkaloid (and in this Dictionary we have used the widest definition) they constitute a vast class of compounds exhibiting a variety of structures unrivalled in any other group of natural products. From a purely organic chemical point of view alkaloids have an endless fascination because of this variety, and because they present a continuing challenge in terms of structure determination, synthesis, and biosynthesis, which shows no sign of abating, and has perhaps even intensified during the last few years.

Their significance in various branches of biology hardly needs emphasising. Various alkaloids continue to play key roles in pharmacology and medicinal chemistry and the cultivation of alkaloid bearing crops (opium poppy, coca leaf) is currently, for good or ill, playing an important part in the economies of several third-world countries. Other alkaloid-bearing plants are significant in many regions as sources of natural toxins in both human and animal poisoning. From a more academic standpoint, the documentation of alkaloid occurrence throughout the plant kingdom and the unravelling of the biosynthetic pathways leading to them is of great significance in plant systematics and taxonomy.

In setting out to compile this Dictionary we have had the simple aim of including accurate and critical data on every known alkaloid; certainly every one of which the structure is known, and as many as possible of reasonably well-characterised alkaloids of unknown structure (which are, of course, much more difficult to enumerate and classify than those of known structure). Whilst it is certain that there have been some inadvertent omissions, the view that we have been reasonably successful in this aim is borne out by the fact that the number of alkaloids contained in the Dictionary (9900 ± 100) considerably exceeds any previous informal estimate of the number of known alkaloids.

The compilation of a Dictionary such as this would not be possible without the existence of several extensive review series covering the alkaloids, although we would emphasize that virtually every piece of data cited in the Dictionary has been checked against the primary literature. In addition, we would like to acknowledge the invaluable support of our Editorial Board during the compilation period. George Smith was responsible for the compilation of the alkaloid entries for the Fifth Edition of the *Dictionary of Organic Compounds* (1982), and these provided a secure platform from which the current Dictionary could be produced by a process of updating and expansion. Edwin Saxton provided the introductory section describing the main alkaloid types, while Maurice Shamma saw every proof and provided all of the botanical family names given throughout the Dictionary.

We expect in due course to produce supplements to this Dictionary which will ensure that it continues to remain the current and definitive source of easily accessed factual data on all aspects of alkaloid chemistry and biology. Any errors or omissions remain our responsibility and we would appreciate their being pointed out to us so that they can be rectified.

I.W.S.
J.B.

Introduction

1. Using the Dictionary

The Dictionary is arranged alphabetically by entry name. Every entry is numbered to assist ready location. Many alkaloids are included as derivatives of main entry compounds; the extensive indexing of the Dictionary means that these can be readily located through the Name, Molecular Formula or Type of Compound indexes.

Indexes

There are five printed indexes which are located in the separate Index Volume. These are:

Name Index. This lists every name given throughout the Dictionary, whether it refers to an entry, stereo-isomer or derivative, and including also some names buried in the text of entries.

Molecular Formula Index. This lists all molecular formulae given in the Dictionary in Hill convention order. Molecular formulae are reported for all alkaloids but not normally for derivatives which are not themselves thought to be alkaloids. Cationic alkaloids are given a molecular formula which is that of the cation and the various salts are listed as derivatives, together with their molecular formulae.

CAS Registry Number Index. Lists all CAS (Chemical Abstracts Service) Registry numbers given throughout the Dictionary.

Type of Compound Index. This valuable index classifies all alkaloids included in the Dictionary under one or more of approximately 300 headings based principally on skeletal type, but also including some headings related to miscellaneous structural characteristics (e.g. alkaloid *N*-oxides) or to source (e.g. fungal alkaloids). A full list of the headings used in the Index is given at the beginning of the Index, and these headings follow broadly the same sequence as in the Descriptions of Main Alkaloid Types which follow this Introduction.

Species Index. This newly-developed index lists in alphabetical order all species names given throughout the Dictionary, with an accompanying list of all alkaloids given in the Dictionary as occurring in that species. Where the Dictionary cites only the generic

name (e.g. "Alkaloid from *Papaver* spp."), a generic entry will appear.

It is important to note that many common alkaloids are so widespread that, in the context of this Dictionary, only a general indication of their occurrence may be given (e.g. "Widespread in the Papaveraceae and Ranunculaceae"). Such a general statement of occurrence will generate *no* entries in the Species index, which must therefore be used with caution and is best suited to the tracking of the rarer alkaloids. It is hoped, demand permitting, that a considerable expansion of the source content of the database will enable the eventual publication of a much expanded species index as a companion volume to the Dictionary.

2. Chemical Names and Synonyms

The Dictionary contains a wide range of synonyms which may be (a) those found in the primary literature, (b) *Chemical Abstracts* names (these are omitted when they are excessively long), or (c) a small proportion of names added editorially to achieve as much consistency as possible with other closely-related substances.

Most entries are headed by a trivial alkaloid name, but in a few cases such as the simple carbazole alkaloids, the systematic name is preferred and the entry can be found from the trivial name using the Name Index.

Care has been taken to include as many alternative and obsolete trivial alkaloid names as possible. A few obsolete synonyms have been taken directly from *Chemical Abstracts* or from other secondary sources such as Raffauf [10] without checking.

Where an alkaloid has been isolated more than once and given different names by different authors, we have normally used as entry name that which predominates in the existing literature, sometimes because it is preferred by reviewers as being more descriptive of the structure. Thus, choice of a particular name in the Dictionary does not necessarily imply that it has historical precedence.

Unfortunately, the literature contains an appreciable number of author-generated semisystematic names which contain breaches of fundamental nomenclature rules (e.g. the non-alphabetical ordering of substituents), presenting the compilers

of a dictionary such as this with the dilemma of whether to report the authors' names exactly as they stand or to correct the most glaring discrepancies. In most cases we have taken the latter course.

Names corresponding to those used by CAS during the 8th and 9th Collective Index periods (1967–1971 and 1972–1976 respectively) are labelled with the suffixes 8CI, 9CI. Names first introduced since 1976 are referred to as 9CI since there have been no substantial changes of CA nomenclature since that date affecting organic compounds.

If a compound cannot be located immediately in the main body of the entries, **it is important to use the indexes.**

3. Literature Coverage

In compiling this Dictionary the primary literature has been surveyed to the early part of 1988, and extensive reference has been made to reviews available at that time.

4. Coverage

This Dictionary employs a wide definition of the term Alkaloid and includes substances of plant, microbial and animal origin. Structurally speaking, the majority of classes of substance which have at one time or another been considered as alkaloids are covered, thus:

1. There is extensive coverage of peptide alkaloids but for the plant amino acids, the user is referred to the *Amino-acid and Peptide Sourcebook* [1].
2. Most classes of nitrogen-containing secondary metabolites are covered, especially those based on heterocyclic ring systems. Some of these also occur in the companion *Dictionary of Antibiotics* [2], in which a full coverage of other nitrogenous antibiotics and related substances is provided.
3. Pterins are not covered.
4. A number of simple aliphatic amines are known to be widespread in plants, but their occurrence there does not seem of sufficient significance to warrant their inclusion, and is in any case not very well documented. The simple aromatic and heterocyclic amine alkaloids are, however, covered.
5. Degradation products of alkaloids, some of which have trivial names, are not included; neither are synthetic alkaloid-like compounds having trivial names (e.g. Coralyne).

5. Information on Pharmacology and other biological effects

The amount of information available concerning the biochemistry of individual alkaloids varies from zero in many cases, to extremely extensive in the case of some common alkaloids. For such common alkaloids, evidence for many different types of physiological effect can be found throughout the literature but much of it has no practical importance. As far as possible information in this Dictionary has been gathered from critical sources such as the Manske [3] and Pelletier [8] series.

6. Taxonomic Classification

The botanical names for higher plants given throughout the Dictionary are based on Willis [2]. Readers should be aware that the taxonomic placing of some species and, especially, genera is controversial and that other schemes exist. Where the primary literature refers to a generic name not listed by Willis, this is noted. In the case of fungal, microbial or animal species any familial information is derived from the primary literature and the generic names are unchecked.

There are many instances in the literature of incorrect identification of plant samples from which alkaloids have been isolated. The resolution of such misidentifications is not possible without reference to the original plant material, and is therefore outside the scope of the Dictionary.

7. Hazard Information

Many alkaloids are highly toxic. Information on their toxicity is highlighted by the use of the symbol \triangleright , which also appears in the indexes (except the Species Index). While every effort has been made to alert the user to potential hazards associated with particular alkaloids, **the absence of such information cannot be taken as a guarantee of safety in use or misuse.**

8. Further Information

For further information about the presentation of data in this and other dictionaries, see the introduction to the *Dictionary of Organic Compounds*, Fifth Edition and Supplements.

9. Principal abbreviations

[α]	specific rotation
abs config	absolute configuration
Ac	Acetyl
AcOH	Acetic acid
Ac ₂ O	Acetic anhydride
amorph	amorphous
anal	analytical applications, analysis or detection
aq.	aqueous
B	base
bibl	bibliography
biosynth	biosynthesis
Bp	boiling point
BAN	British Approved Name
c	concentration
ca.	(<i>circa</i>) about
cd	circular dichroism
chromatog	chromatography
cmr	¹³ C nuclear magnetic resonance
col	colour, coloration
conc	concentrated
config	configuration
constit	constituent
compd	compound
cryst struct	X-ray crystal structure determination
d	density
dec	decomposes, decomposition
degradn	degradation
deriv(s)	derivative(s)
descr	described
detn	detection
dil	dilute, dilution
dimorph	dimorphic
esr	electron spin resonance
Et	Ethyl
EtOAc	Ethyl acetate
fluor	fluoresces, fluorescence
glc	gas liquid chromatography
Glc	β -D-glucopyranosyl
haz	hazard
hydrol	hydrolyses, hydrolysed, hydrolysis
ir	infra-red spectrum
isol	isolation
isom	isomerises
LD	lethal dose: LD ₅₀ , a dose which is lethal to 50% of the animals tested
M	molecular weight (formula weight)
max	maximum
Me	Methyl
metab	metabolite

misc	miscible
mixt	mixture
mod	moderately
Mp	melting point
ms	mass spectrum
<i>n</i>	index of refraction (e.g. n_D^{20} for 20° and sodium light)
obt	obtained
occur	occurrence. References labelled thus may refer <i>either</i> to the detection of an alkaloid in a particular source without its full characterisation, <i>or</i> to a listing of sources in which the alkaloid occurs
ord	optical rotatory dispersion
pet. ether	Petroleum ether (light petroleum)
Ph	Phenyl (C ₆ H ₅)
pharmacol	pharmacology
pmr	proton (¹ H) nuclear magnetic resonance
props	properties
purifn	purification
Py	Pyridine
ref	reference
resoln	resolution
rev	review
r.t.	room temperature
sl	slightly
sol	soluble
soln	solution
solv	solvent
subl	sublimation, sublimes
synth	synthesis
tautom	tautomerism
tlc	thin layer chromatography
tox	toxicity
unsatd	unsaturated
USAN	United States Approved Name
uv	ultraviolet spectrum
v	very
vol	volume

References and Further Sources of Information on Alkaloids and Related Substances

1. *Amino-Acids and Peptides*, Davies, J.S., Chapman and Hall Chemistry Sourcebook Series, 1986.
2. *Dictionary of Antibiotics and Related Substances*, ed. B.W. Bycroft, Chapman and Hall, London, 1988.
3. *The Alkaloids*, Academic Press, Vols. 1–17, ed. R.H.F. Manske; Vols. 18–20, ed. R. Rodrigo; Vols. 21–29, ed. A. Brossi. (Referred to throughout the Dictionary as “*Alkaloids* (N.Y.)”).

Introduction

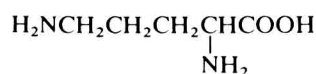
4. *The Alkaloids*, Specialist Periodical Reports, Royal Society of Chemistry, London; Vols. 1–5, ed. J.E. Saxton (1971–1975); Vols. 6–13, ed. M.F. Grundon (1976–1983). Referred to as “*Alkaloids (London)*”, following CAS practice.
5. *Natural Product Reports*, Royal Society of Chemistry, London. Vols. 1–5 (1984–1988).
6. *The Monoterpenoid Indole Alkaloids*, ed. J.E. Saxton. Wiley-Interscience, New York, 1983.
7. *Introduction to Alkaloids: A Biogenetic Approach*, G.A. Cordell, Wiley-Interscience, New York, 1981.
8. *Alkaloids: Chemical and Biological Perspectives*, ed. S.W. Pelletier, Wiley, Vols. 1–5.
9. *A Dictionary of the Flowering Plants and Ferns*, J.C. Willis, 8th Ed., Cambridge, 1988.
10. *A Handbook of Alkaloids and Alkaloid-Containing Plants*, R.A. Raffauf, Wiley, 1970.

Description of Main Alkaloid Types

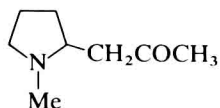
The purpose of this section is to provide orienting information to assist the user in obtaining maximum benefit from the remainder of the Dictionary. Sections give basic information about each main group of alkaloids together with (1) biosynthetic information, (2) the numbering scheme used in the Dictionary (together with Chemical Abstracts numbering where this is different) and (3) leading reviews for each alkaloid class. Alkaloids which are referred to in this section but not specifically illustrated here are given in boldface type and their structures can readily be seen by consulting the main body of the Dictionary.

The alkaloid groups are presented here in roughly the same order as they appear in the Type of Compound Index which begins on page 311 of Volume 2, and from which a complete listing of each type can be obtained. The ordering of groups is, as far as possible, systematic based on the major amino acid from which they are believed to be derived and within each class going from the simple to the more complex. However, particularly with the more complex alkaloids the ordering is to some extent arbitrary since many alkaloids are derived from more than one of the major precursors.

Alkaloids Derived from Ornithine



Ornithine



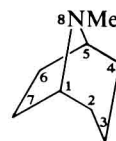
Hygrine

1. *Simple Alkaloids.* Several simple alkaloids derived possibly from ornithine are known. These include Hygrine and **Stachydrine**. Condensation of two ornithine units with acetoacetate gives **Cuscohygrine**. Other alkaloids containing a pyrrolidine ring include **Nicotine**, **Codonopsine***, **Ficine** (in which the pyrrolidine ring is attached to a flavone nucleus), **Macrostromine** (in which it is attached to a benzylisoquinoline skeleton), and **Brevicolline** (in which it is

* Inclusion in this sub-group does not necessarily imply that a derivation from ornithine has been rigorously established. Indeed codonopsine may well prove to have a different origin.

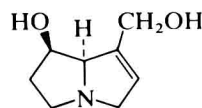
attached to a β -carboline unit). Clearly the biogenesis of these molecules requires other important precursors. Macrostromine is presumably derived from tyrosine, just as Brevicolline has been shown to be derived from tryptophan.

2. *The tropane alkaloids*, which are derived from ornithine and acetoacetate, include the well-known atropine and cocaine groups. Almost all of them are esters of mono-, di-, and tri-hydroxytropanes. They are characteristic constituents of the Solanaceae. **Atropine** and **Cocaine** are important representatives. Recent evidence suggests that for some alkaloids (Cocaine and its close relatives) malonylcoenzyme A is involved in the biosynthesis, rather than acetoacetylcoenzyme A.

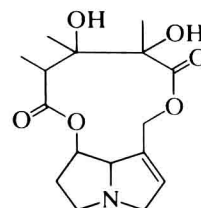


Tropane

3. *The pyrrolizidine alkaloids* occur in species of the *Senecio* genus, and elsewhere in the Compositae and Leguminosae. They have been shown to be responsible for the toxic effects, particularly liver damage, in livestock grazing on pastures infested by these species. Toxicity appears to be the result of oxidation *in vivo* to pyrrole derivatives. Examples of pyrrolizidine alkaloids, which now number upwards of 200 bases, are Retronecine, a diol from which many of the complex ester alkaloids are derived, and Monocrotaline, a particularly toxic diester alkaloid. The necic acid units in this latter and other diester alkaloids are themselves probably derived from an amino acid (e.g. isoleucine), rather than acetate or mevalonate.



Retronecine



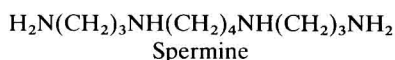
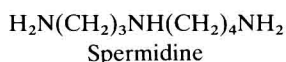
Monocrotaline

Description of Main Alkaloid Types

Many, and perhaps the majority, of pyrrolizidine alkaloids occur in the plant as *N*-oxides, the *N*-oxide function being lost during isolation.

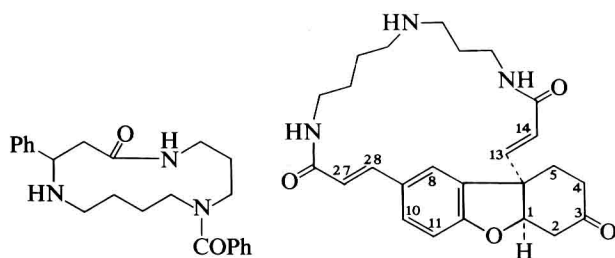
4. *Phenanthroindolizidine alkaloids*. A small group of phenanthroindolizidine alkaloids, exemplified by **Tylophorine**, are clearly derived from phenylalanine and/or tyrosine (*v. infra*), together with ornithine.

5. *Spermine, Spermidine, and Related Alkaloids*. A number of alkaloids are derived from spermine or spermidine, themselves derived from ornithine *via*



putrescine. Condensation of either spermidine or spermine with one or two cinnamic acid units, or with an unbranched carbon chain, gives the skeleton of these alkaloids. Aside from these aliphatic amines, therefore, phenylalanine or tyrosine, and long-chain fatty acids are involved. The biosynthesis clearly also involves phenol coupling processes in certain cases, e.g. **Codonocarpine**.

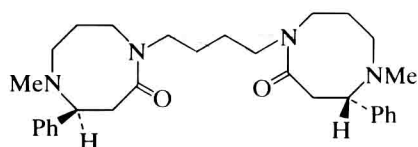
The spermidine alkaloids can be subdivided into four sub-groups: (a) simple diamides, e.g. **Maytenine**; (b) medium-ring compounds involving one cinnamic acid unit in the ring, e.g. Celabenzine; (c) medium-ring compounds involving two cinnamic acid units in the ring, e.g. **Codonocarpine**, Lunaridine; (d) medium ring compounds containing a C₁₀ to C₁₆ unbranched carbon chain in the ring, e.g. **Cannabisativine**.



Celabenzine

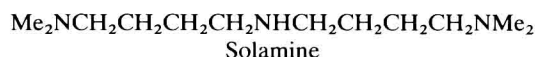
Lunaridine, 9Cl

The spermine-derived alkaloids may be divided into three sub-groups: (a) those in which the two terminal putrescine chains form an eight-membered ring with a cinnamic or a C₈ or C₁₀ unbranched carbon chain, e.g. Homaline; (b) **Pithecolobine**, in which the one large ring involves a C₁₂ chain; (c) two alkaloids in which two medium rings are formed with two cinnamic acid units.

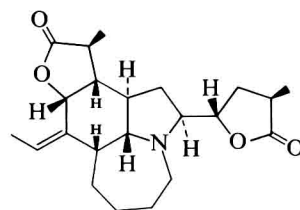


Homaline

A small group of amides of solamine may also be placed in this class.



6. *Miscellaneous alkaloids*. Two other small groups of alkaloids may be derived from ornithine, but this remains to be proved. The *Stemona* alkaloids, e.g. Tuberostemonine, contain a pyrrolidine ring, possibly originating from ornithine, but the structure reveals that its biosynthesis is complex. The *Elaeocarpus* alkaloids, e.g. **Elaeocarpine**, may also originate from ornithine, together with a polyketide unit. Alternatively, the whole skeleton may be polyacetate-derived. In the case of **Elaeocarpidine** tryptamine is also obviously implicated.



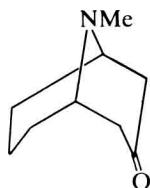
Tuberostemonine

Additional references

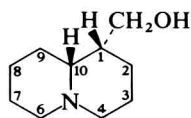
1. R.B. Herbert, The Synthesis of Indolizidine and Quinolizidine Alkaloids of *Tylophora*, *Cryptocarya*, *Ipomoea*, *Elaeocarpus*, and Related Species, in *Alkaloids: Chemical and Biological Perspectives*, Ed. S.W. Pelletier, Vol. 3, Wiley-Interscience, New York, 1985.
2. E. Gellert, Indolizidine Alkaloids, *J. Nat. Prod.*, 1982, **45**, 50.
3. E. Gellert, The Phenanthroindolizidine Alkaloids, in Pelletier, Vol. 5, 1987.
4. M. Hesse and H. Schmid, Macrocyclic Spermidine and Spermine Alkaloids, in *MTP Series 2*, Vol. 9, Alkaloids, Ed. K. Wiesner, Butterworths, London, 1976.

Alkaloids Derived from Lysine

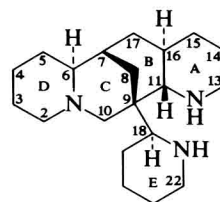
1. *Simple piperidines*. These may be derived from lysine, acetate, acetoacetate, etc., in analogous fashion to the simple pyrrolidine alkaloids. They include Pseudopelletierine, **Anabesine**, Lupinine.



Pseudopelletierine



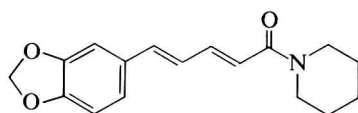
Lupinine



Ormosanine

All these structural types have their analogues among the pyrrolidine alkaloids, and while it is tempting to assume biosynthesis from lysine it may not in all cases be true; **Coniine**, for example, appears to be acetate-derived.

Relatively simple derivatives of piperidine include the alkaloids of black pepper (*Piper nigrum*), e.g. Piperine.

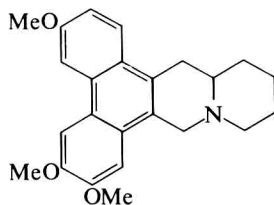


Piperine

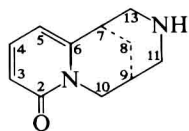
2. *Lobelia alkaloids*. These have no analogy among the pyrrolidine alkaloids. An example is **Lobelanine**.

3. *Miscellaneous*. An important example is **Slaframine**.

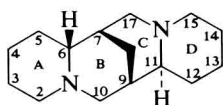
4. *More complex alkaloids*, which number in excess of 250, include Cryptopleurine, the tri- and tetra-cyclic alkaloids of *Cytisus* and other species of Leguminosae, e.g. Cytisine, the poisonous principle of the laburnum, and Sparteine, which occurs in



Cryptopleurine



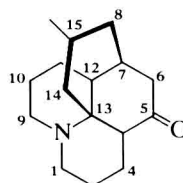
(+)-Cytisine



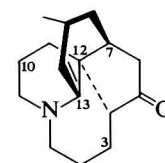
(-)-Sparteine

many species including the common broom (*Cytisus scoparius*). Penta- and hexa-cyclic bases are found in *Ormosia* species; of these, ormosanine is representative.

5. *The Lycopodium alkaloids*, e.g. Lycopodine, are constituents of the club mosses. Whereas the earliest proposal concerning their biosynthesis implicated two C₈ units derived from acetate, it has more recently been established that two lysine units are involved. Numerous skeletal variants are known, all of which can be related to the Lycopodine skeleton; examples are Fawcettidine and **Serratinine**.

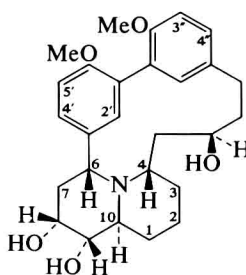


Lycopodine

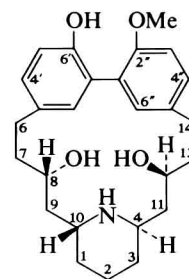


Fawcettidine, 9CI

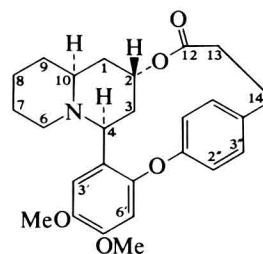
6. *The Lythraceae alkaloids* are characterised by several unusual structural features. Lythrancine contains a quinolizidine ring system attached to a diphenyl residue, one of the benzene rings in which is derived from cinnamic acid. Other alkaloids in this group contain a diphenyl ether grouping, e.g. Decaline, and others a piperidine ring instead of a



Lythrancine, 9CI



Lythranidine, 9CI



Decaline, 9CI

Description of Main Alkaloid Types

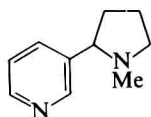
quinolizidine ring, e.g. Lythranidine. The biosynthesis of these alkaloids involves lysine as source of the quinolizidine or piperidine ring, and phenylalanine as precursor of one of the aromatic rings.

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Alkaloids Derived from Nicotinic Acid

This small group may be divided into five sub-groups. Nicotine and **Anabasine** are presumably derived from nicotinic acid and ornithine or lysine, respectively. However, the piperidine ring in **Anatabine**, from *Nicotiana glutinosa*, appears not to be derived from lysine or from a polyacetate precursor; instead, both rings are derived from nicotinic acid. **Arecoline**, from betel nuts, and **Ricinine**, from the castor oil plant, are clearly derivable from nicotinic acid; in the case of ricinine this has been established. **Dioscorine**, from *Dioscorea hispida*, provides a fascinating example of the unexpected in alkaloid biosynthesis. At first sight it seems plausible to postulate that it may be formed from lysine and a polyketide fragment. However, lysine is not a precursor, and it would appear that dioscorine is formed from nicotinic acid and, probably, a polyacetate unit.



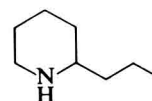
Nicotine

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Alkaloids of Polyketide Origin

Numerous alkaloids are derived from polyacetate precursors, together with one or more amino acids; these have been classified, in general, under the relevant amino acids. A few alkaloids, however, are almost entirely acetate-derived. These include Coniine, from hemlock; this, perhaps surprisingly, is



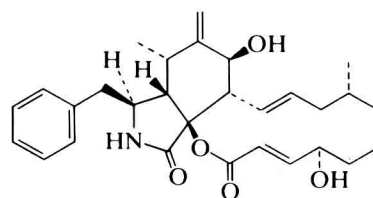
Coniine

not derived from lysine. Similarly, **Pinidine**, from *Pinus sabiniana*, is acetate-derived. Other piperidine derivatives with side-chains at position 2, which may be acetate-derived, although proof is at present lacking, include **Nigrifactine** from *Streptomyces* species, **Carpaine** and **Cassine**.

More complex examples include **Coccinellin**, the defensive agent of the common ladybird, *Coccinella septempunctata* L, **Porantherine**, from the shrub *Poranthera corymbosa*, and the alkaloids of the **Ancistrocladine** group.

Still more complex are the *Galbulimima* alkaloids, e.g. **Himbacine**, which may be formed from a nonaketide unit plus acetoacetate.

Finally, of great interest and potential importance are the cytochalasans, a group of microbial metabolites with antitumour activity. These metabolites are clearly derived predominantly from a polyketide precursor, together with phenylalanine (cytochalasin B, D, E) or tryptophan (**Chaetoglobosin A**, **Cytochalasin G**).



Cytochalasin B

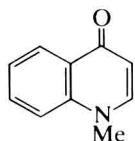
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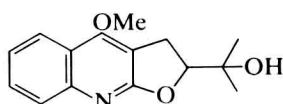
Alkaloids Derived from Anthranilic Acid

A number of diverse structural groups belong in this category, the major ones being the quinolone, furanoquinoline, pyranoquinoline, acridine and quinazoline groups.

1. *Simple quinolines and quinolones* include Echinopsine and the phenethylquinoline, **Cusparine**.

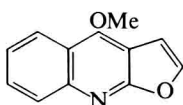


Echinopsine



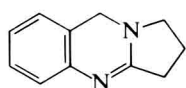
Platydesmine

In simple quinolone derivatives C-2 and C-3 are derived from acetate; introduction of a prenyl group at C-3 followed by cyclisation then gives a furanoquinoline, e.g. Platydesmine, or a pyranoquinoline alkaloid, e.g. **Flindersine**. Interestingly, Dictamine, from *Dictamnus albus*, appears to be formed by loss of acetone from an oxidation product of Platydesmine.

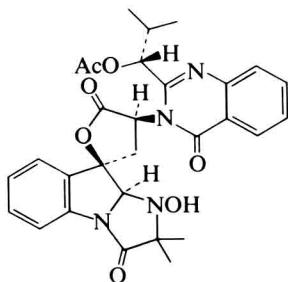


Dictamnine

2. *Quinazoline alkaloids* include Vasicine, from *Adhatoda vasica*, and **Rutaecarpine**, from *Evodia*



Vasicine

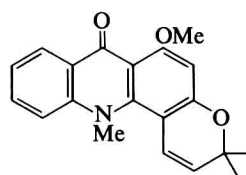


Tryptoquivaline

rutaecarpa; this latter base is clearly also derived from tryptophan. The tryptoquivalines, which are toxic metabolites from *Aspergillus clavatus*, are also derived from anthranilic acid and tryptophan precursors, together with (presumably) valine and methylalanine-derived units.

Macrorine, from *Macrorungia longistrobus*, is obviously derived from anthranilic acid and histidine.

3. *The acridine alkaloids*, which number about 50 bases, can be broadly divided into two main sub-groups. The simple acridones may be exemplified by **Melicopidine** and **Melicopicine**, and the prenyl-acridones in which a prenyl group introduced into the acridone nucleus is cyclised to give a pyran ring, by Acronycine.



Acronycine

4. *The benzodiazepine antibiotics* **Cyclophenin** and **Viridicatin**, from *Penicillium cyclopium* and *P. viridicatum*, are clearly derived from anthranilic acid and phenylalanine. Apparently no plant alkaloids with this skeleton are known to date. **Cryptolepine**, a violet base from *Cryptolepis triangularis*, is evidently formed from tryptophan and anthranilic acid, with loss of the tryptophan side-chain.

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Alkaloids Derived Wholly or In Part from Phenylalanine or Tyrosine

This extremely large and varied category consists of several widely different structural types, which range from simple β -phenylethylamine derivatives to the much more complex structures exemplified by the alkaloids of the Amaryllidaceae and the bisbenzyl-isoquinoline alkaloids. The isoquinoline derivatives themselves consist of a large number of structural types, which can be sub-divided into upwards of 20 sub-groups.

1. The simplest derivatives of phenylalanine or tyrosine are the β -phenylethylamines, which are