# TOXIGEN

**A MEKA application for computer-aided identification of toxic flowering-plant genera found in North America north of Mexico with printed illustrations for visual confirmation**

**Hunt Institute for Botanical Documentation**
**Carnegie Mellon University**

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**A MEKA application for computer-aided identification of toxic flowering-plant genera found in North America north of Mexico with printed illustrations for visual confirmation**

*Compiled and edited by*

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**This book and/or the applications TOXIGEN and ASTERGEN cannot replace the advice and assistance of qualified medical personnel.**

**In all cases of suspected poisoning by plants or plant parts, immediate medical attention should be sought.**



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**Contents**

Infusing lore with tragedy, the toxicity of some plants has been recognized, utilized and feared for millennia. History records the important roles that plant toxins played in ancient medicine, religion and politics. The Ebers Papyrus, an Egyptian record that dates from the sixteenth century BC, contains over 800 prescriptions and recipes, many with toxic plants included as the main ingredients. Socrates was forced to commit suicide in 399 BC by drinking a concoction containing poison hemlock. The ancient Romans were said to have employed plant poisons to eliminate political rivals, as did the Borgias many centuries later. This lurid history, together with modern misconceptions, such as the alleged toxicity of poinsettia (*Euphorbia pulcherrima*), tends to distort our perceptions of some plants and leads us to regard them indiscriminately as dangerous or deadly. In fact, most of our early medications were natural plant toxins administered in controlled doses, and approximately 38% of current medical prescriptions are for substances of natural origin. The hermetic aura that surrounds plants, and their ubiquitous presence, make them the subjects of numerous calls to poison-information centers.

From 1985 to 1990, the American Association of Poison Control Centers (AAPCC) recorded approximately 545,000 plant exposures, representing almost 7% of all cases to which the poison-information centers responded. Approximately 86% of all plant exposures occur in children under the age of six. Furthermore, plant exposures are consistently the fourth-leading cause of poisoning, surpassed only by exposure to analgesics, cleaning products and cosmetics. However, caution must be exercised in the interpretation of these statistics; over 98% of all reported plant exposures result in the manifestation of no apparent or only minor toxicity. In fact, the AAPCC database reports only ten fatalities secondary to plant exposures during the same period, the majority involving either poison hemlock (*Conium maculatum*) or water hemlock (*Cicuta maculata* or *Cicuta douglasii*). Increased public awareness of the toxicity of these plants can prevent the rare but tragic associated fatalities, and expanded, aggressive poison-prevention education can help to reduce the large number of pediatric plant exposures.

In the past, hospital emergency rooms, pediatricians, family physicians and poison-information centers have relied on local professionally trained plant taxonomists and "seasoned" amateurs to aid in the identification of plants or plant parts that were implicated in exposures. Over the years, numerous texts and manuals with varying degrees of accuracy and readability have been published on the subject of poisonous plants. No book is an adequate substitute for an expert within reach, but often the emergency-room physician or poison-information center must rely on these works as the only source of information. In light of this, we have developed two applications (keys) called TOXIGEN and ASTERGEN for identifying toxic flowering-plant genera in North America north of Mexico. These keys and the accompanying printed illustrations and documentation are available without charge to health professionals and poison-information centers.

We stress that these computerized keys and the printed illustrations are only aids and do not eliminate the desirability of consultation with a trained taxonomist. Rather, their role is to help identify potentially toxic plants when expert identification cannot be obtained. No book or computer program can fully replace the assistance of a qualified taxonomist.

TOXIGEN and ASTERGEN run under the MEKA (Multiple-Entry Key Algorithm) program developed by Drs. Thomas Duncan and Christopher Meacham of the University of California, Berkeley, which enables random access to the database underlying a key. This flexibility allows the user to move quickly around the database, via the key, without having to progress in a step-by-step manner through all the questions/statements. See the Appendix for documentation on the MEKA program.

The TOXIGEN and ASTERGEN keys consist of four files each. One file records sources of the data, the second contains brief designations of characteristics, the third contains names of the plant taxa (mostly genera), and the fourth contains a data matrix of characteristics by taxa.

## Introduction

Together, TOXIGEN, ASTERGEN and the printed illustrations account for 325 genera in 76 families. The main key is TOXIGEN, which provides leads to families and, usually, genera of native and introduced/ cultivated plants. ASTERGEN is a smaller, specialized key to be used only in connection with the taxonomically difficult aster family (Asteraceae). TOXIGEN will identify these plants at family level, but further keying to genus will require switching to ASTERGEN. The 325 genera exhibit varying degrees of toxicity, but all have been implicated significantly in actual plant poisonings or have been alleged to be toxic in the literature. This slate of genera is not exhaustive, but the ones covered account for the majority of those described as toxic in manuals, texts and other toxicological literature pertinent to North America north of Mexico. We have chosen not to provide for identification to the level of individual species, but rather have focused at the generic level. In most instances, medical management is genus-oriented.

We have attempted to illustrate representative toxic species for each genus. In some instances, because of great variability within the genus, we have illustrated more than one species. In a very few instances, illustrations of particular toxic species were unavailable or unsuitable. We therefore carefully and advisedly selected illustrations, for visual confirmation purposes, of macroscopically similar species; these illustrations have been marked with an asterisk.

We have illustrated toxic genera of the grass family (Poaceae) and the arum family (Araceae) but have not provided for identification beyond the family level in the key itself. The grasses are extremely complicated, with taxonomic distinction usually requiring microscopic examination of highly reduced and modified floral parts. The illustrations depict the macroscopic attributes necessary to make a tentative determination. Members of the arum family share the same active toxic agent and can be very difficult to identify owing to their vegetative similarity and the frequent absence of the flowers and fruits needed to distinguish them.

These keys and the illustrations cover only flowering plants. However, a few non-flowering vascular plants are occasionally implicated in poisonings. Several genera of ferns and fern allies have been involved in both human and animal poisonings, most commonly the bracken fern (*Pteridium aquilinum*), horsetails or scouring rushes (Equ*isetum arvense* and related species) and, to a lesser extent, the male fern (*Dryopteris filix-mas*) and the sensitive fern (*Onoclea sensibilis*). Some conifers (plants with needle or scale leaves) also have appeared in poisoning reports, notably members of the genus *Taxus*, which contain the compound taxine and are regarded almost universally as highly toxic. Other conifers reported to exhibit toxicity include *Pinus ponderosa*, *Pinus taeda*, *Cupressus macrocarpa* and *Juniperus virginiana*. The cycads, notably *Cycas revoluta*, are often found in greenhouses and contain toxic glycosides, but are rarely implicated in poisonings.

TOXIGEN and ASTERGEN each present a list of plant characteristics. The user is prompted to select those statements that correctly describe the specimen under consideration. See the Tutorial for more information on the identification process.

After a tentative identification is reached using the key, the user should consult the printed illustrations for visual confirmation or negation. The illustrations are arranged alphabetically by family and, within families, alphabetically by genus and species.

In the data matrixes we have attempted to encompass the full range of normal variation that occurs within the genera, but unusual extremes may not have been taken into consideration. We will be actively updating and augmenting the keys as we receive feedback from users, which we strongly encourage.



## Acknowledgments

We gratefully acknowledge generous and crucial financial support from the Vira I. Heinz Endowment, Pittsburgh, Pennsylvania. We thank Dr. Edward P. Krenzelok, Director, and the staff of the Pittsburgh Poison Center for their enthusiastic encouragement and many helpful suggestions. For much other technical and scientific assistance we thank Dr. Ann L. McGaffey, Saint Margaret Memorial Hospital, Pittsburgh; Charlotte A. Tancin, Sarah Y. Leroy, Sharon M. Tomasic, Autumn M. Farole and James J. White, Hunt Institute for Botanical Documentation, Carnegie Mellon University, Pittsburgh; Sue A. Thompson, Section of Botany, Carnegie Museum of Natural History, Pittsburgh; Drs. Christopher A. Meacham and Thomas Duncan, University of California, Berkeley; the Regents of the University of California; and the American Association of Poison Control Centers.

We also thank Stanford University Press for permission to reproduce the illustrations of *Conyza coulteri*, *Oxytenia acerosa*, and *Psathyrotes annua* (reprinted from Illustrated flora of the Pacific states, four volumes, 1923–1960, by Leroy Abrams and Roxana S. Ferris); West Virginia University for permission to reproduce those of *Armoricia rusticana*, *Lespedeza stipulacea*, and *Rubus laciniatus* (reprinted from Flora of West Virginia, 1952–1964, by P. D. Strausbaugh and Earl L. Core); and the Pennsylvania Department of Agriculture for permission to reproduce those of *Dieffenbachia maculata*, *Philodendron scandens*, *Hedera helix*, and *Lantana camara* (reprinted from Poisonous plants of Pennsylvania, 1986, by Robert J. Hill).

TOXIGEN and ASTERGEN are applications that run under the MEKA program, an interactive Multiple-Entry Key Algorithm for identifying unknown specimens or characterizing taxa. TOXIGEN is a key that facilitates the identification of toxic vascular plant genera, and it is supplemented by the key ASTERGEN for genera of the difficult family Asteraceae (aster family).

Although MEKA keys (such as TOXIGEN) can also be used to characterize a given taxon or set of taxa, this tutorial will focus on using TOXIGEN to identify an unknown plant specimen, which will be its most likely use in poison information centers and emergency rooms. Please refer to the Appendix for information on how to use MEKA keys to characterize taxa.

As for most applications, a "hands-on" tutorial is the best way for a first-time user to learn how to use TOXIGEN. The following step-by-step instructions explain how to load, run and close TOXIGEN. Also included are reproductions of some of the screen displays that you will encounter in using this tutorial. (Please note that your actual screens may differ in some details from the reproductions in this tutorial depending upon the version of the keys that you are using.) Commands can be issued in uppercase or lowercase letters — e.g., 'QU' or 'Qu' or 'qu' — and in any sequence. A list of the MEKA commands used in this tutorial follows. A full descriptive list of MEKA commands is included in the Appendix, and a summary of them can be obtained on screen at any time by typing '?' [enter] or 'MC' [enter] at the 'Enter Command' prompt.

**MEKA commands used in this tutorial:**

| | | |
|---|---|---|
| > | = | List the next 15 taxon names or characteristics |
| < | = | List the previous 15 taxon names or characteristics |
| VC <n> | = | **V**iew **c**haracteristics beginning with number <n> |
| AC | = | **A**dd active **c**haracteristics |
| KO | = | **K**ey **o**ut unknown |
| ST <n> | = | **S**elect **t**axa with <n> of mismatches |
| RS | = | **R**eset program |
| NK <keyname> | = | **N**ew **k**ey named <keyname> requested |
| QU | = | **Qu**it MEKA and return to the operating system |

## 1. Installing MEKA, TOXIGEN, AND ASTERGEN

All of the necessary files and the MEKA application itself are on the 5.25" DOS floppy disk provided. Copy the contents of the floppy disk to your hard disk into a directory called "ToxicPlants" (no space). If you do not have a hard disk, refer to the Appendix for instructions on how to use MEKA with a dual floppy system.

## 2. Loading TOXIGEN

To load TOXIGEN, simply type 'MEKA' and strike the enter key. (Throughout this tutorial, "[enter]" after a command, e.g., 'AC_10' [enter], will indicate that after inputting a command the enter key must be struck in order to register the command. Please note also that '_' indicates a space.) At the first prompt you will be asked for the name of the key that is desired. For this tutorial, type 'TOXIGEN' [enter].

```
                WELCOME TO MEKA (Version 1.3: 18 Jan 1989)
          Copyright (c) 1989 Regents of the University of California
               Limits for this copy:  1000 characters, 10000 taxa

================================================================================

     MEKA is distributed by Thomas Duncan and Christopher A. Meachan through
the University Herbarium, University of California, Berkeley, CA 94720.  The
program is available at a nominal charge to cover the cost of distribution.
Although the program MEKA is protected by copyright, permission is granted to
anyone to copy and distribute MEKA as long as this copyright message is not
removed, our names are not removed, and the copying and distribution are not
performed for profit.  If you have received this copy of MEKA from someone
else, please write to Duncan and Meachan to have your name added to the list
of users who will be notified of improved versions of MEKA.  We are pleased
to assist in the development of new MEKA keys for free public distribution.
     To use MEKA, enter a key name.  If the key files are not on the default
drive, include the drive letter and a colon before the key name.  If the key
files are on more than one drive, precede the key name with just a colon and
you will be prompted for the drive for each of the key files.  Type 'QU'
to quit; type 'MC' or '?' for a list of MEKA commands.

ENTER NAME OF KEY TO BE USED:    toxigen_
```

The key TOXIGEN is now activated. (ASTERGEN can be activated in the same way, by typing 'ASTERGEN' [enter] at this prompt. If you would like to try ASTERGEN after you complete the TOXIGEN tutorial, refer to 4C on p. xiii.)

```
ENTER NAME OF KEY TO BE USED:  toxigen

TOXIGENTOXIGENTOXIGETOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGEN

TOXIGENTOXIGENTOXIGETOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGEN

TOXIGENTOXIGENTOXIGETOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGEN

_________A MEKA APPLICATION FOR COMPUTER-ASSISTED IDENTIFICATION_________
___OF TOXIC FLOWERING PLANT GENERA FOUND IN NORTH AMERICA NORTH OF MEXICO___
_____________________VERSION 1.0_____________________
_______COPYRIGHT (c) 1993 HUNT INSTITUTE FOR BOTANICAL DOCUMENTATION_______

TOXIGENTOXIGENTOXIGETOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGEN

TOXIGENTOXIGENTOXIGETOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGEN

TOXIGENTOXIGENTOXIGETOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGENTOXIGEN

  254 taxa,   151 characters.   ASCII data format

ENTER COMMAND> _
```

### 3. Running TOXIGEN

Hypothetical Scenario:

A child who has ingested parts of an unknown plant arrives at a local emergency room. The parents bring a specimen along for identification. The following is a brief description of the specimen: The plant is herbaceous with gummy sap and a basal rosette of leaves that are lobed but not compound and have pinnate venation, and the inflorescence is of solitary, symmetrical flowers with the sepals and petals not fused.





**A. Compiling a list of characteristics for the unknown specimen**

At the 'Enter Command' prompt, type '>'. This enables you to view the first 15 possible characteristics. Note that characteristics are always viewed in screen sets of 15. For ease of reference, the complete list of all characteristics is provided separately in the TOXIGEN package. In contrast with usage in the MEKA documentation reproduced in the Appendix, we here employ the more precise term "characteristic" for what is there called a "character." Taxonomically, a character is a feature that is to be measured, counted or otherwise described, whereas a characteristic is one of the possible states of that feature, indicated by a specific descriptive term.. For example, the leaf margin (a character) may be toothed or entire (possible characteristics).

```
ENTER COMMAND> >

   1  Plant woody
   2  Plant herbaceous
   3  Plant aquatic, leaves floating or submerged
   4  Plant with no green parts
   5  Bulb present
   6  Stems or leaves exuding gummy sap when cut or broken
   7  Stems or leaves with thorns, spines, or prickles
   8  Tendrils present
   9  Plant grass-like
  10  Hairs present on stems, leaves, flowers and/or fruit
  11  Stinging hairs present on stems and/or leaves
  12  Basal rosette of leaves present
  13  Leaf arrangement opposite or verticillate
  14  Leaf arrangement alternate
  15  Leaf arrangement distichous

ENTER COMMAND> _
```

The '>' and '<' commands allow you to scroll forward and backward, respectively, through the characteristics list. If you now type '>', for example, you will view the next 15 characteristics, numbers 16 through 30.

To jump to a particular characteristic without repeatedly striking '>', type 'VC_' followed by the characteristic number desired. If you would like to view characteristic 60, for example, type 'VC_60' [enter]; characteristics 60 through 74 (a set of 15) will appear on the screen. Return to the first 15 characteristics by typing 'VC_ 1'.

To select those characteristics that are exhibited by the specimen in question, you will be working with the 'AC' command.

As you review the description of the specimen in the scenario above, you note that it is herbaceous, which corresponds to characteristic 2 on your screen. At the prompt, type 'AC_2' [but do not strike the enter key yet, since you want to add more characteristics at the moment]. The specimen has gummy sap, which corresponds to characteristic 6, and it has a basal rosette of leaves, which corresponds to characteristic 12. Always type one space between the numbers, e.g., 'AC_2_6_12'

```
ENTER COMMAND> >

    1  Plant woody
    2  Plant herbaceous
    3  Plant aquatic, leaves floating or submerged
    4  Plant with no green parts
    5  Bulb present
    6  Stems or leaves exuding gummy sap when cut or broken
    7  Stems or leaves with thorns, spines, or prickles
    8  Tendrils present
    9  Plant grass-like
   10  Hairs present on stems, leaves, flowers and/or fruit
   11  Stinging hairs present on stems and/or leaves
   12  Basal rosette of leaves present
   13  Leaf arrangement opposite or verticillate
   14  Leaf arrangement alternate
   15  Leaf arrangement distichous

ENTER COMMAND>  ac 2 6 12_
```

The next part of the description is "leaves are lobed." This does not correspond to any of the first 15 characteristics, so view the next 15 characteristics by typing '>'. On this second screen you will notice that "leaves are lobed" corresponds to characteristic 27, so type '27' to add that to your list. The "leaves not compound" description corresponds to characteristic 17, "leaves simple." And "pinnate venation" corresponds to characteristic 22. Characteristic numbers, you notice, do not have to be entered in numerical order.

After adding characteristics 17, 22, and 27, use the '>' command to move to subsequent screens to see further parts of the characteristics list.

Continue to match the specimen-description information to characteristic numbers, and add those using the 'AC' command. You should be adding 31, 42, 66 and 82 to your list, thereby accounting for all of the descriptive information provided so far. At the bottom of your screen your list should now show that the sample specimen that you wish to key out exhibits characteristics 2, 6, 12, 17, 22, 27, 31, 42, 66 and 82.

Throughout the process of selecting characteristics for keying, you can be as specific or as general as you wish, entering many or few, but of course the more specific you are — i.e., the more information that you have and the more characteristics that you select — the more likely it will be that the TOXIGEN search will produce an unequivocal result. The 'AC' command initiates the compilation of characteristics that are used in the identification process. As you scroll through the screens and add characteristics, a list at the bottom of the screen provides a running tab of those you have already selected.

When you finish adding the last characteristic, 82 in this example, strike the enter key. This terminates the adding of characteristics for the time being and prepares the way for MEKA/TOXIGEN to compile them. After you strike the enter key, you will be back at the 'Enter Command' prompt.

**B. Keying out the unknown specimen**

At the 'Enter Command' prompt, type 'KO' [enter] and MEKA will begin to key out the specimen, i.e., search TOXIGEN for that taxon or those taxa that exhibit the characteristics 2, 6, 17, 22, 27, 31, 42, 66 and 82 that you have indicated are present in your specimen.





```
CONTINUE COMMAND> ac 2 6 12 17 22 31 42 66 82 >

   76  Petals 6
   77  Petals 7
   78  Petals 8
   79  Petals 9
   80  Petals 10
   81  Petals more than 10
   82  Petals not fused together
   83  Petals fused together for part or all their length
   84  Petals overlapping each other laterally in the bud
   85  Petals twisted together in the bud
   86  Petals not overlapping each other laterally in the bud
   87  Corona present, or corolla with scales in the throat
   88  Fertile stamens 1
   89  Fertile stamens 2
   90  Fertile stamens 3

CONTINUE COMMAND> ac 2 6 12 17 22 27 31 42 66 82

ENTER COMMAND> ko_
```

Because they are being used to key out a specimen, these characteristics become "active." As the program searches the matrix, the characteristics will appear on the screen under the heading 'KEY CHARACTERS SEARCHED.' This provides you with a confirmation of those you have selected.

```
KEY CHARACTERS SEARCHED

   2+ Plant herbaceous
   6+ Stems or leaves exuding gummy sap when cut or broken
  12+ Basal rosette of leaves present
  17+ Leaf simple
  22+ Venation pinnate in leaf or leaflets
  27+ Leaf or leaflets lobed or divided
  31+ Inflorescence of solitary flower(s)
  42+ Flowers radially symmetric
  66+ Sepals not fused together
  82+ Petals not fused together
```

Under this heading, notice that plus signs — "+" follow the characteristic numbers, indicating that each is in the set currently selected.

**C. Viewing names of taxa that match all the characteristics chosen, or that match all but one or more of them**

Under the heading 'TAXON SUMMARY BASED ON CHARACTER SEARCH', notice that MEKA indicates that 2 taxa exactly match the 10 characteristics you have selected. Two genera missed by one characteristic, meaning that they do not match all of the characteristics selected. Thirteen genera missed by 2 characteristics, 15 genera missed by 3, and so on. The names of the genera are not indicated at this point.

```
TAXON SUMMARY BASED ON CHARACTER SEARCH

    2 TAXA MATCH CHARACTERS EXACTLY
    2 TAXA MISS BY  1
   13 TAXA MISS BY  2
   15 TAXA MISS BY  3
   38 TAXA MISS BY  4
   59 TAXA MISS BY  5
   76 TAXA MISS BY  6
```

Under the heading 'TAXA THAT EXACTLY MATCH', notice that 2 genera, *Argemone* and *Papaver* (both in the family Papaveraceae), matched all the characteristics selected, and that therefore, at this point, your specimen could belong to either genus. Equivocal results such as these occur when a particular single characteristic that differentiates one genus from another is unknown or at least so far not included in your selection of characteristics.

```
TAXA THAT EXACTLY MATCH

  160  Argemone Papaveraceae
  162  Papaver Papaveraceae

ENTER COMMAND> _
```





Although you will be primarily interested in those genera that are exact matches, there will be instances in which it is useful for you to investigate the partial mismatches — those taxa that "missed" by one or a few characteristics — as you may be unsure about one or more of the characteristics that you selected. In any case, the "near misses" may need to be considered. If you are interested in viewing the names of the taxa that missed, use the 'ST' command. Using the 'ST' command makes those names of taxa "active." To see the names of those taxa that missed by 1 characteristic, for example, type 'ST_1' [enter]. Notice that in our present example the genera *Ranunculus* and *Sanguinaria* appear as the taxa that missed by one characteristic.

```
ENTER COMMAND> st 1

TAXA WITH  1 MISMATCHED CHARACTER(S)

   56= Ranunculus Ranunculaceae
  163= Sanguinaria Papaveraceae

ENTER COMMAND> _
```

The command 'ST_0' will display those taxa that exactly match the characteristics selected. Note that if there are 10 or fewer exact matches, as is the case here, all of those names will be listed automatically. If more than 10 taxa match exactly, you will need to type 'ST_0' to view their names.

**D. Adding and deleting characteristics**

If you can add more characteristics to the list, you may be able to decrease the number of taxa that match exactly. For example, suppose that more detailed examination of our hypothetical specimen reveals that it has spiny leaves. "Stems or leaves with thorns, spines, or prickles" is characteristic 7. Type 'AC_7' [enter] at the prompt to add that characteristic to your list. Now key out again by typing 'KO' [enter]. In the present case, only the single genus *Argemone* now matches exactly.

```
ENTER COMMAND> ac 7

ENTER COMMAND> ko

KEY CHARACTERS SEARCHED

    7+ Stems or leaves with thorns, spines, or prickles

TAXON SUMMARY BASED ON CHARACTER SEARCH

    1 TAXA MATCH CHARACTERS EXACTLY
    1 TAXA MISS BY  1
    4 TAXA MISS BY  2
   12 TAXA MISS BY  3
   22 TAXA MISS BY  4
   42 TAXA MISS BY  5
   55 TAXA MISS BY  6

TAXA THAT EXACTLY MATCH

  160  Argemone Papaveraceae
```

Alternatively, you may want to delete some of characteristics previously selected, in order to broaden the search. To do that, use the 'DC' (delete active characters) command. Refer to the Appendix for more information about the use of the 'DC' command.

In actual practice, you will often find that in your first attempt to identify an unknown specimen, several taxa — rather than a single one — will key out as possibilities. This will usually happen because you have not selected enough characteristics to narrow the search among taxa within the same family. Related genera often share many characteristics in common, including toxic components. As you are able to select more characteristics, the number of taxa selected should decrease.

**4. What to do next**

**A. Beginning a new search in TOXIGEN**

If you would like to conduct a new search without exiting TOXIGEN, type 'RS' at the "Enter Command" prompt. This will re-set TOXIGEN and enable you to begin identification of another unknown specimen.

**B. Closing TOXIGEN and quitting MEKA**

To close TOXIGEN (or any other key) and quit MEKA, type 'QU' at the "Enter Command" prompt. This will return you to the operating system.

**C. Closing TOXIGEN and loading ASTERGEN**

To close TOXIGEN and load the supplemental key ASTERGEN (without quitting MEKA), type 'NK' at the "Enter Command" prompt. Proceed with ASTERGEN as for TOXIGEN. ASTERGEN, the supplemental key for identifying toxic genera in the Asteraceae (aster family), uses the same commands and works the same way as TOXIGEN does. Note that in TOXIGEN, members of the aster family will not key out at the generic level, but rather at family level—as simply Asteraceae. If you suspect initially that you have a member of the Asteraceae, or if TOXIGEN indicates that family as one of the taxa matched, you load ASTERGEN to pursue a generic identification

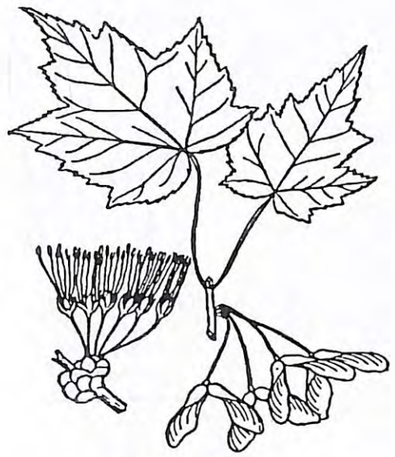




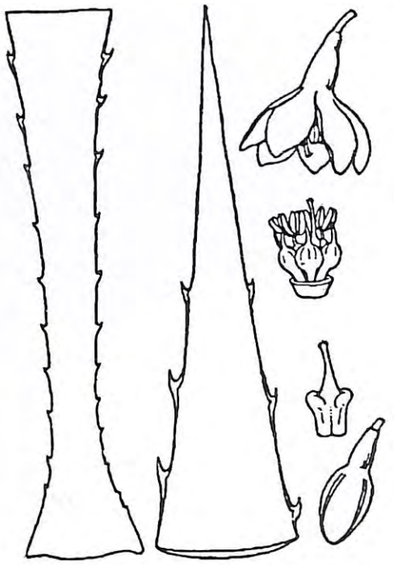
```
ENTER COMMAND> nk

ENTER NAME OF KEY TO BE USED:  astergen
```

Now that you have a basic understanding of how MEKA operates, you should be able to utilize TOXIGEN and ASTERGEN for identifying unknown taxa. Please refer to the Appendix if you have further questions about the MEKA environment and commands.

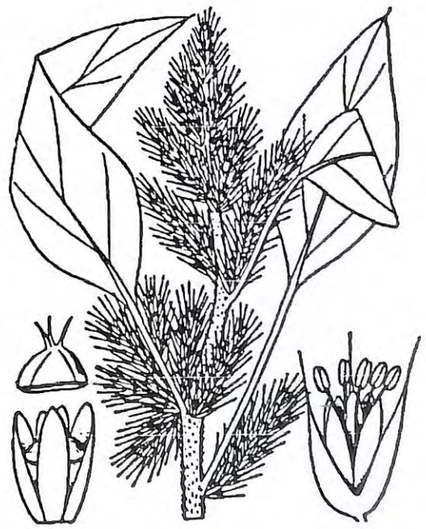


*Acer rubrum* Linnaeus
Aceraceae

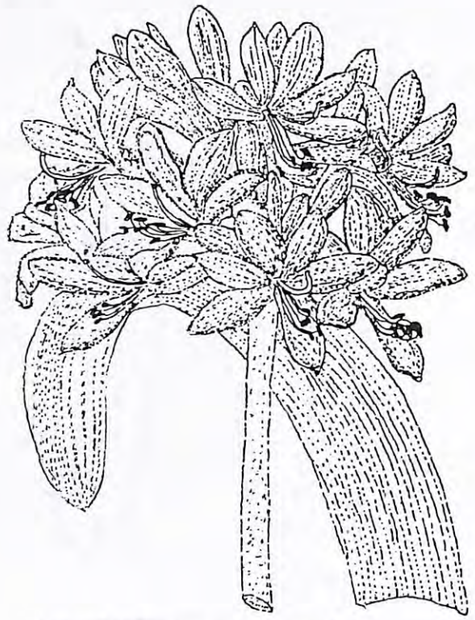


*Furcraea macrophylla* Baker
Agavaceae

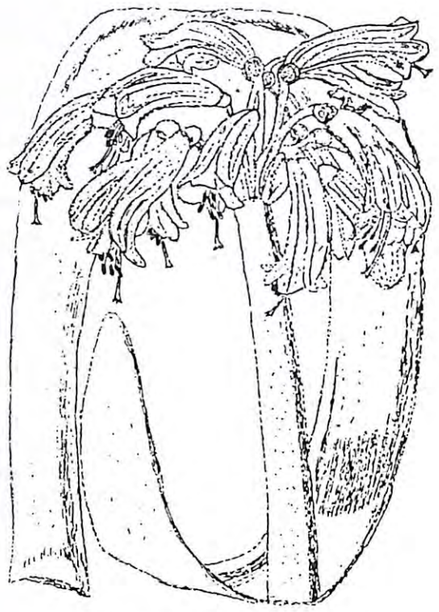
*Agave virginica* Linnaeus
Agavaceae



*Amaranthus retroflexus* Linnaeus
Amaranthaceae

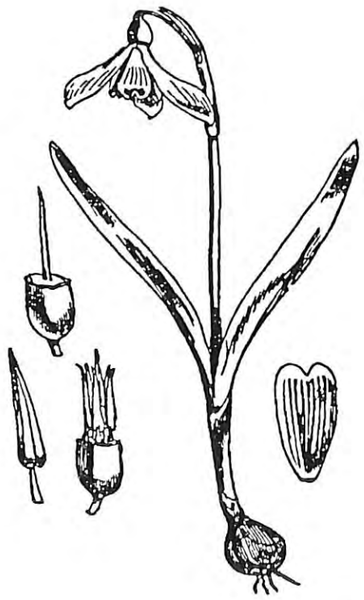


*Agapanthus africanus* (Linnaeus) Hoffmannsegg
Amaryllidaceae



*Clivia gardenii* Hooker
Amaryllidaceae

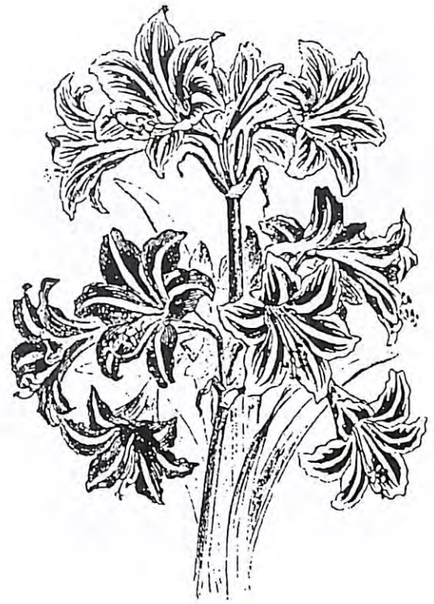
*Amaryllis belladonna* Linnaeus
Amaryllidaceae



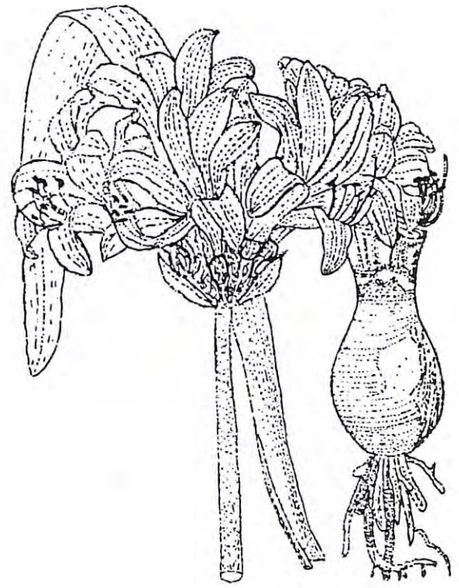
*Galanthus nivalis* Linneaus
Amaryllidaceae



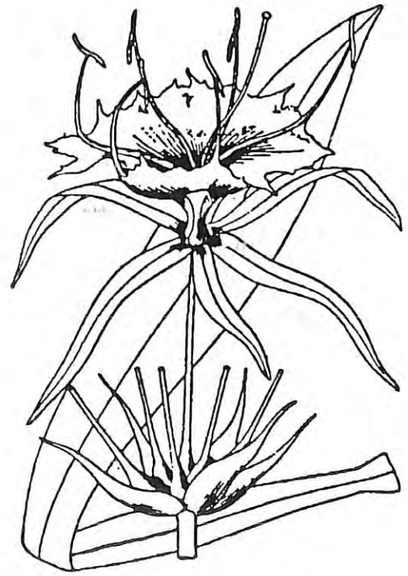




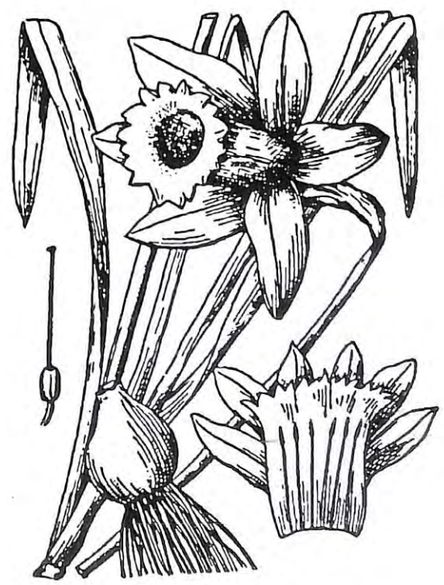
*Hippeastrum* species
Amaryllidaceae



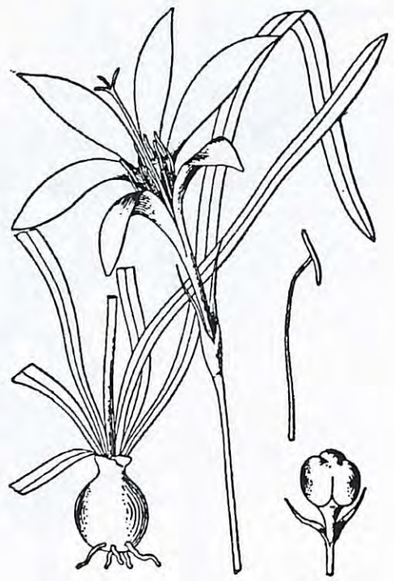
*Lycoris squamigera* Maximowicz
Amaryllidaceae



*Hymenocallis occidentalis* (LeConte) Kunth
[*Hymenocallis caroliniana* (Linnaeus) Herbert]
Amaryllidaceae

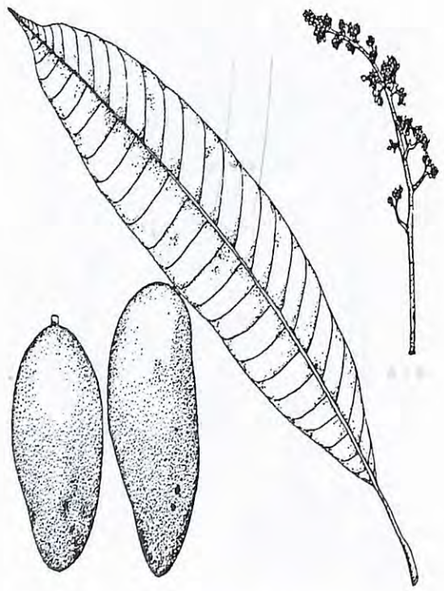


*Narcissus pseudonarcissus* Linnaeus
Amaryllidaceae



*Zephyranthes atamasco* (Linnaeus) Herbert
Amaryllidaceae

*Schinus terebinthifolius* Raddi
Anacardiaceae



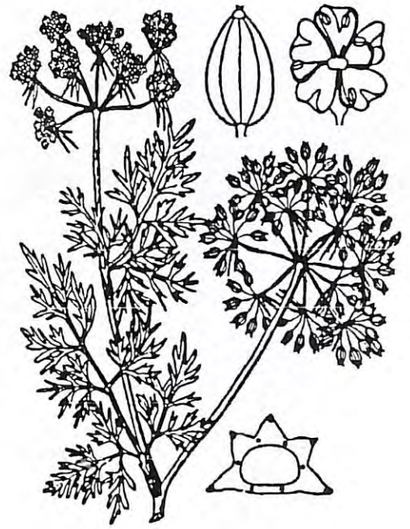
*Mangifera indica* Linnaeus
Anacardiaceae

*Toxicodendron diversilobum* (Torrey & A. Gray) Greene Anacardiaceae





*Toxicodendron radicans* (Linnaeus) Kuntze
Anacardiaceae



*Aethusa cynapium* Linnaeus
Apiaceae

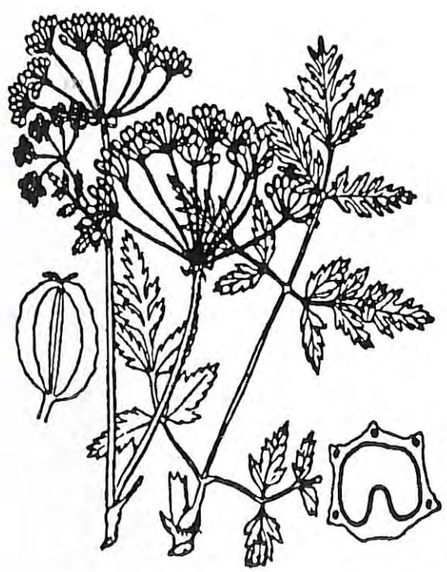
*Toxicodendron vernix* (Linnaeus) Kuntze
Anacardiaceae

*Ammi majus* Linnaeus
Apiaceae

*Apium graveolens* Linnaeus
Apiaceae

*Cicuta maculata* Linnaeus
Apiaceae

*Berula erecta* (Hudson) Coville
Apiaceae

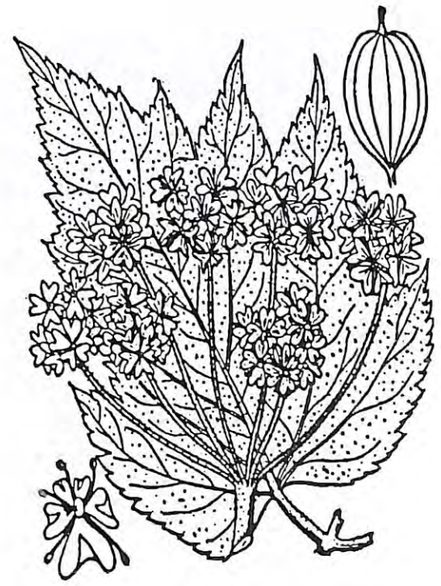


*Conium maculatum* Linnaeus
Apiaceae



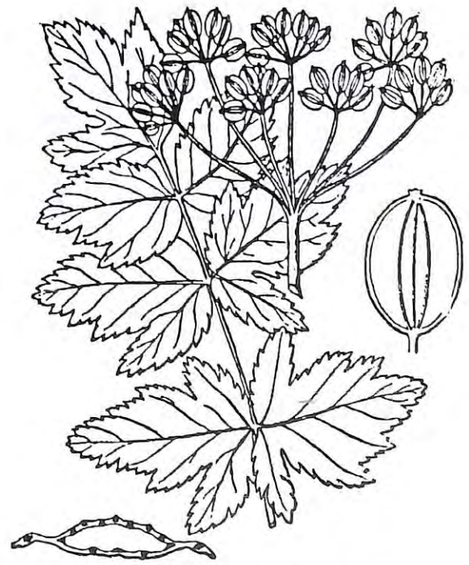


**Cymopterus acaulis* (Pursh) Rafinesque-Schmaltz
Apiaceae



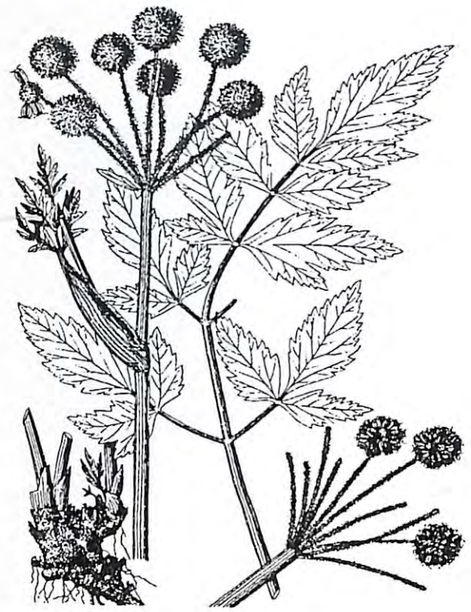
*Heracleum lanatum* Michaux
Apiaceae

*Daucus carota* Linnaeus
Apiaceae

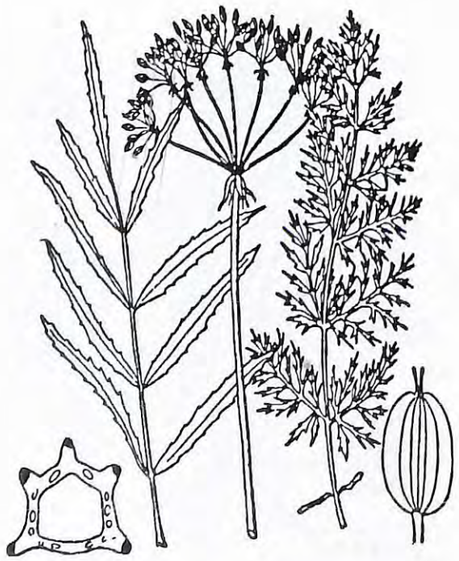


*Pastinaca sativa* Linnaeus
Apiaceae

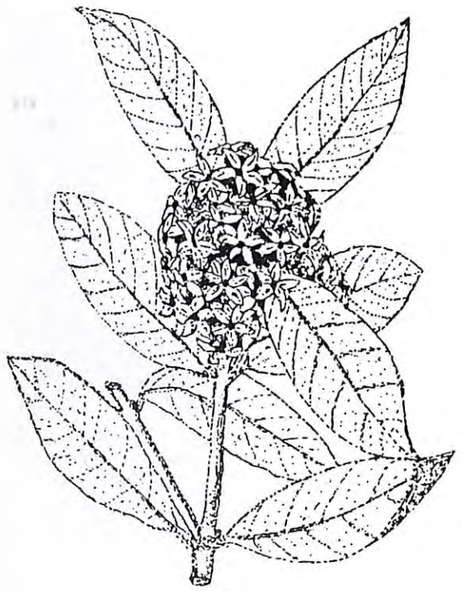
**Sanicula europaea* Linnaeus
Apiaceae



*Sphenosciadium capitellatum* A. Gray
Apiaceae



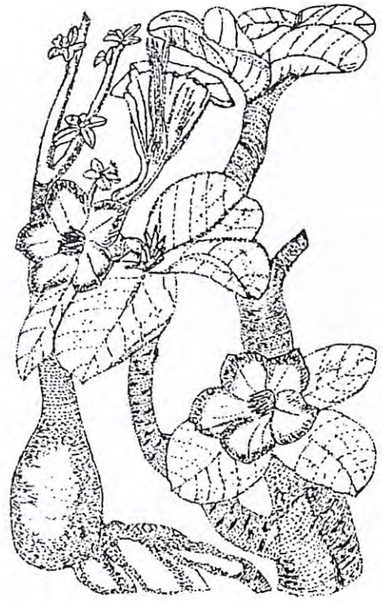
*Sium suave* Walter
Apiaceae



*Acokanthera oblongifolia* (Hochstetter) Codd
Apocynaceae



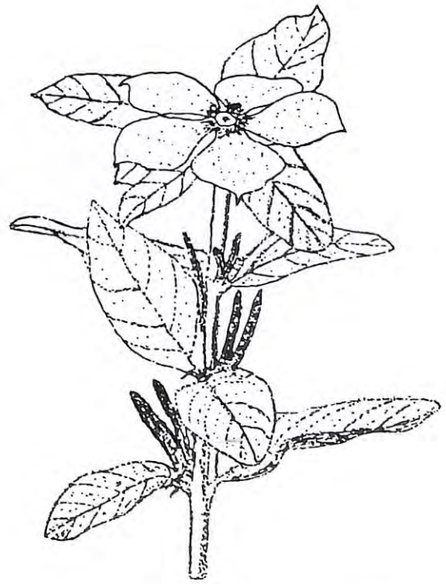




*Adenium obesum* (Forsskål) Roemer & Schultes
Apocynaceae

*Apocynum androsaemifolium* Linnaeus
Apocynaceae

*Allamanda neriifolia* Hooker
Apocynaceae



*Catharanthus roseus* (Linnaeus) G. Don
Apocynaceae

*Nerium oleander* Linnaeus
Apocynaceae

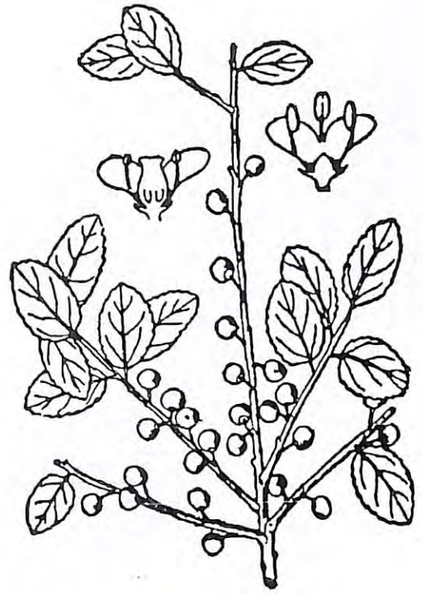
*Urechites lutea* (Linnaeus) Britton
Apocynaceae

*Thevetia peruviana* (Persoon) K. Schumann
Apocynaceae

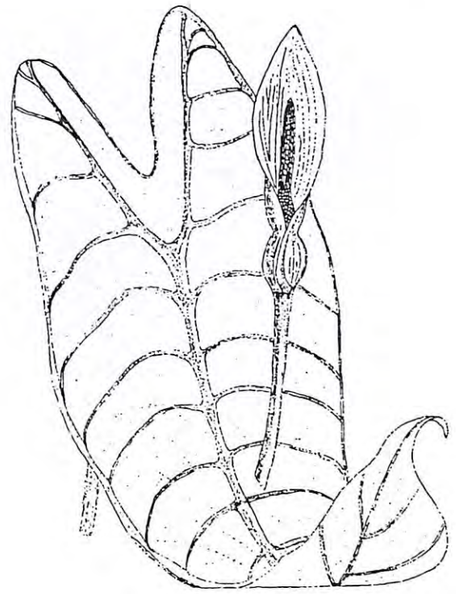
*Vinca minor* Linnaeus
Apocynaceae



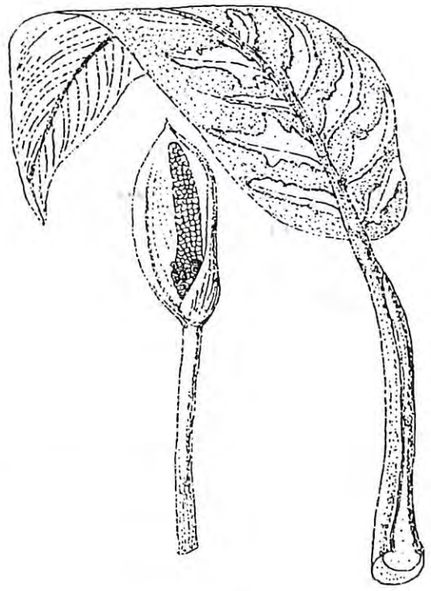




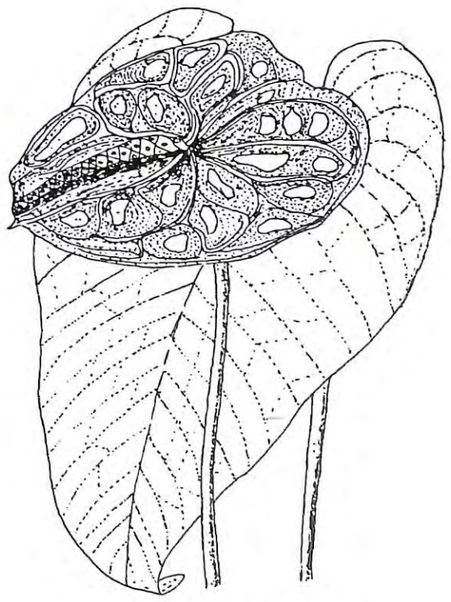
*Ilex vomitoria* Aiton
Aquifoliaceae



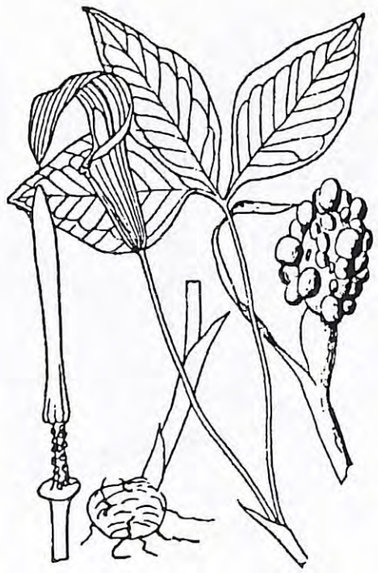
*Alocasia lowii* Hooker
Araceae



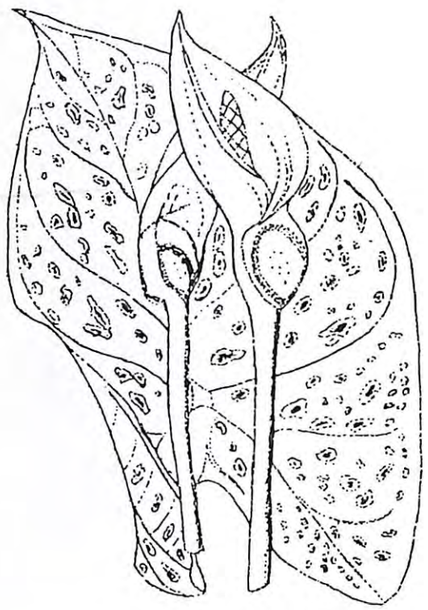
*Aglaonema commutatum* Schott var. *maculatum*
(Hooker f.) Nicholson
Araceae



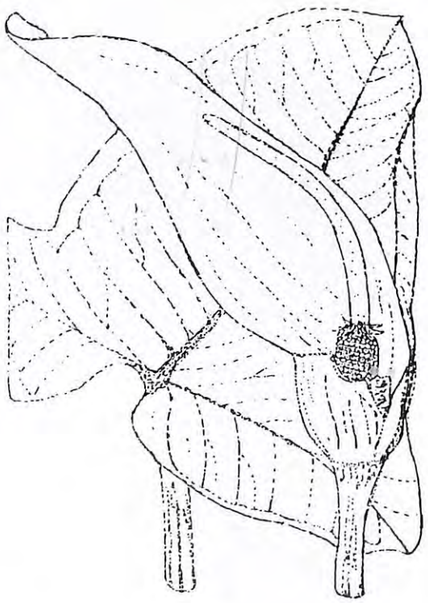
*Anthurium andraeanum* Linden
Araceae



*Arisaema triphyllum* (Linnaeus) Torrey
Araceae



*Caladium bicolor* (Aiton) Ventenat
Araceae

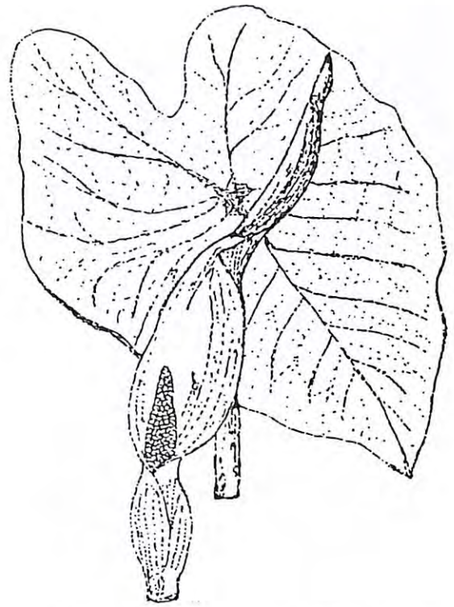


*Arum palaestinum* Boissier
Araceae

*Calla palustris* Linnaeus
Araceae

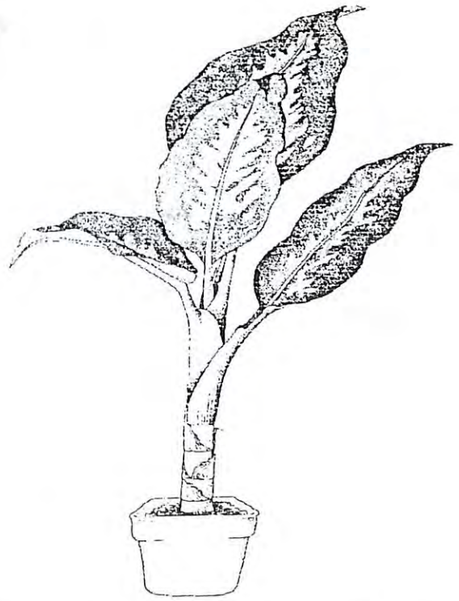






*Colocasia esculenta* (Linnaeus) Schott var.
*antiquorum* (Schott) Hubbard & Rehder
Araceae

*Dracunculus vulgaris* Schott
Araceae



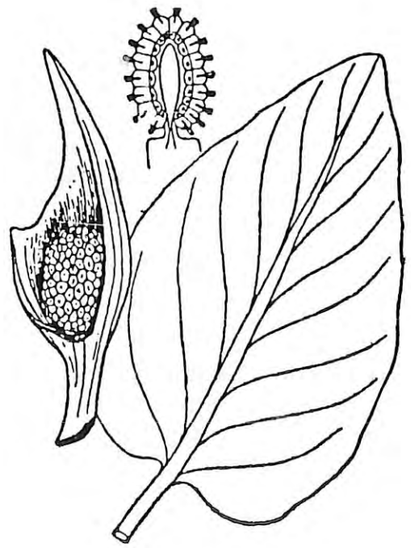
*Dieffenbachia maculata* (Loddiges) G. Don
Araceae

*Epipremnum aureum* (Linden & Andre) Bunting
Araceae

*Monstera deliciosa* Liebmann
Araceae

*Spathiphyllum* species
Araceae

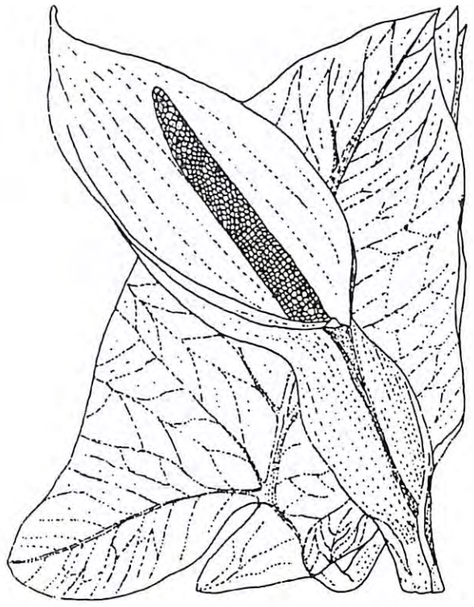
*Philodendron scandens* K. Koch & Sello
Araceae



*Symplocarpus foetidus* (Linnaeus) Nuttall
Araceae

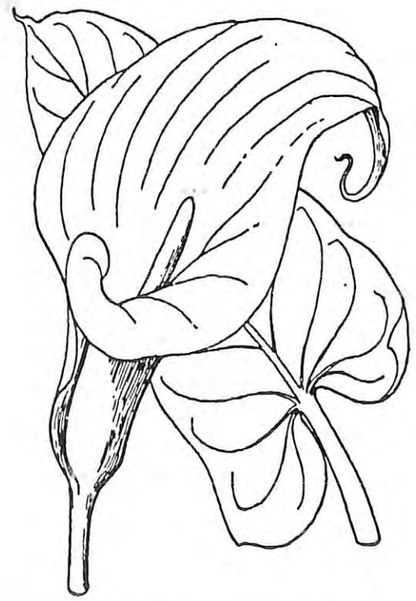




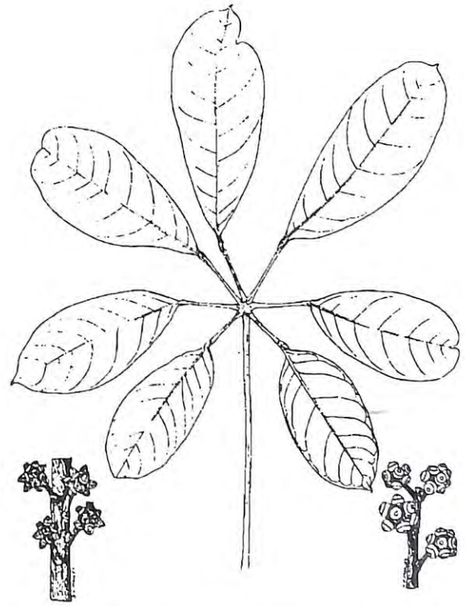


*Xanthosoma sagittifolium* (Linnaeus) Schott
Araceae

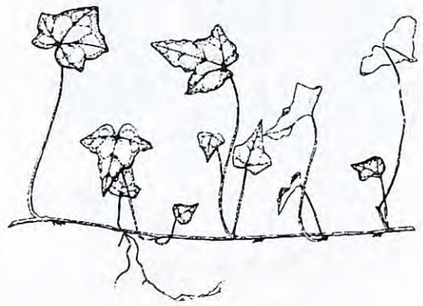
*Aralia spinosa* Linnaeus
Araliaceae



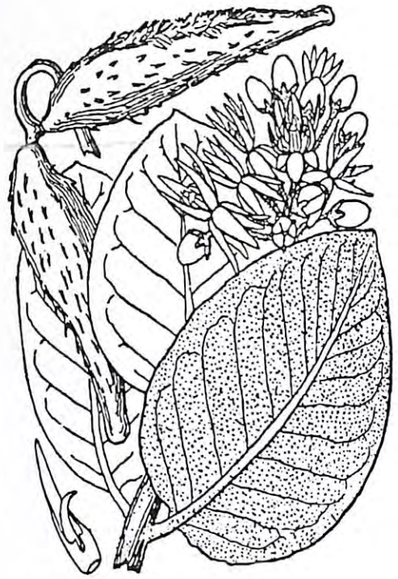
*Zantedeschia aethiopica* (Linnaeus) K. Sprengel
Araceae



*Brassaia actinophylla* Endlicher [*Schefflera actinophylla* (Endlicher) Harms]
Araliaceae

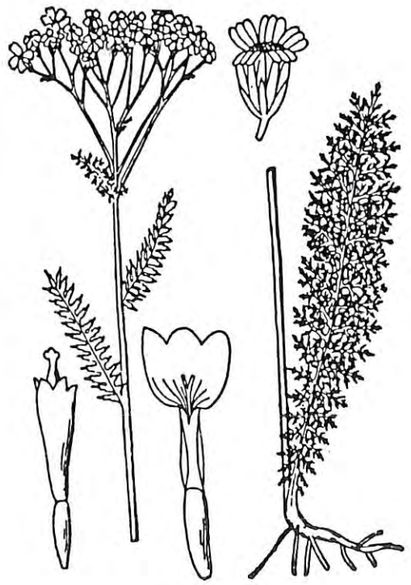


*Hedera helix* Linnaeus
Araliaceae



*Asclepias speciosa* Torrey
Asclepiadaceae

*Araujia sericifera* Brotero
Asclepiadaceae



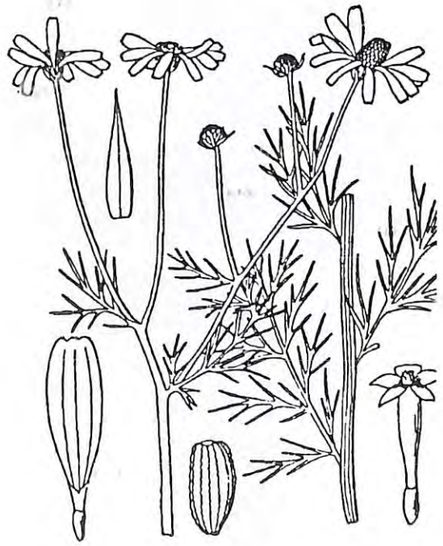
*Achillea millefolium* Linnaeus
Asteraceae





*Ambrosia artemisiifolia* Linnaeus
Asteraceae

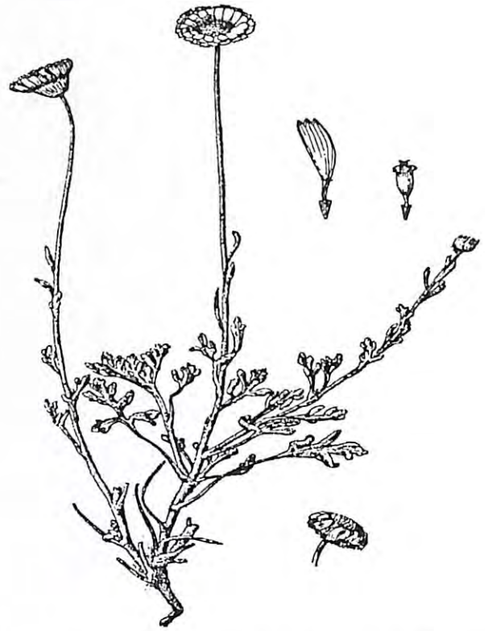
*Artemisia filifolia* Torrey
Asteraceae



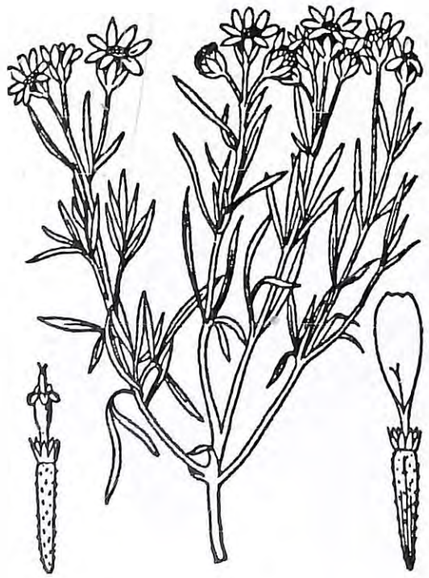
*Anthemis cotula* Linnaeus
Asteraceae

*Aster pilosus* Willdenow var. *pringlei*
(A. Gray) S. F. Blake
Asteraceae

*Baccharis halimifolia* Linnaeus
Asteraceae



*Baileya multiradiata* Harvey & A. Gray ex Torrey
Asteraceae



*Bahia oppositifolia* (Nuttall) de Candolle
Asteraceae

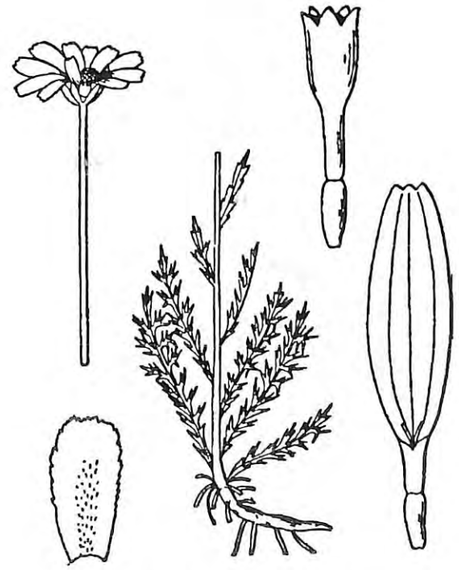
*Balsamorhiza sagittata* (Pursh) Nutall
Asteraceae



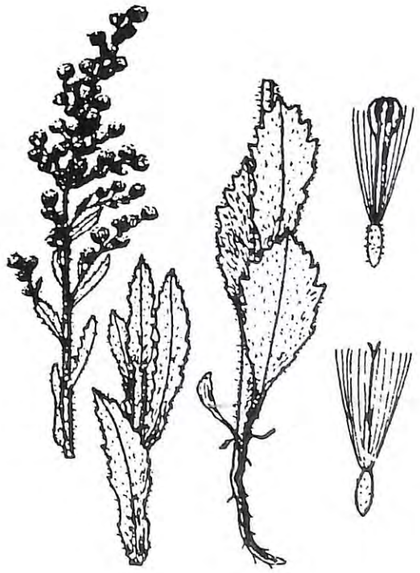


*Centaurea solstitialis* Linnaeus
Asteraceae

*Chrysothamnus nauseosus* (Pallas) Britton
Asteraceae



*Chamaemelum nobile* (Linnaeus) Allioni
Asteraceae



*Conyza coulteri* A. Gray
Asteraceae

*Eupatorium rugosum* Houttuyn
Asteraceae

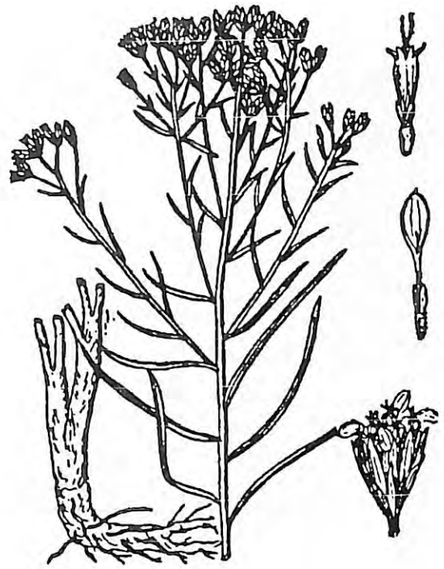
*Franseria discolor* Nuttall
Asteraceae

*Flourensia cernua* de Candolle
Asteraceae

*Grindelia squarrosa* (Pursh) Dunal
Asteraceae

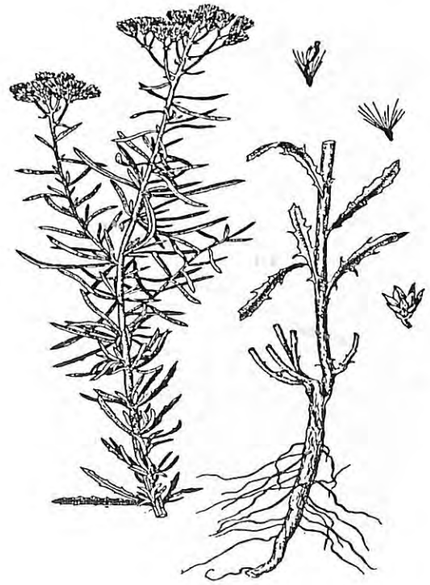






*Gutierrezia sarothrae* (Pursh) Britton & Rusby
Asteraceae

*Helenium autumnale* Linnaeus
Asteraceae

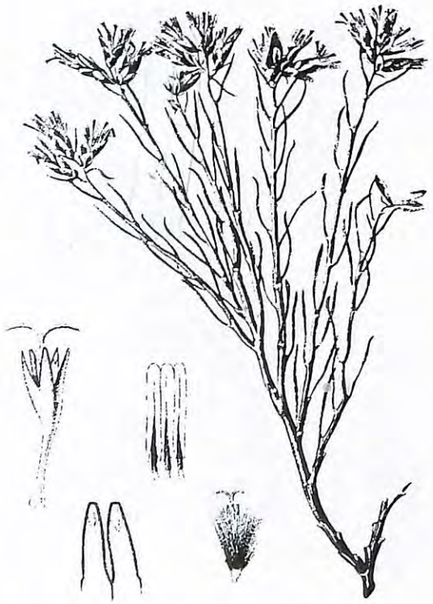


*Haplopappus heterophyllus* (A. Gray) S. F. Blake
Asteraceae

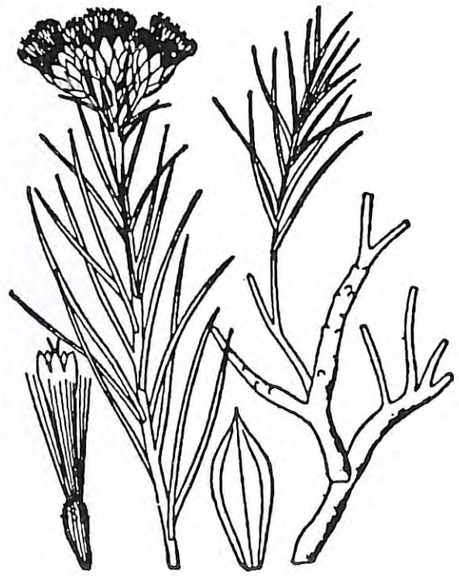
*Hymenoxys odorata* de Candolle
Asteraceae

*Lactuca serriola* Linnaeus
Asteraceae

*Matricaria chamomilla* Linnaeus
[*Matricaria recutita* Linnaeus]
Asteraceae



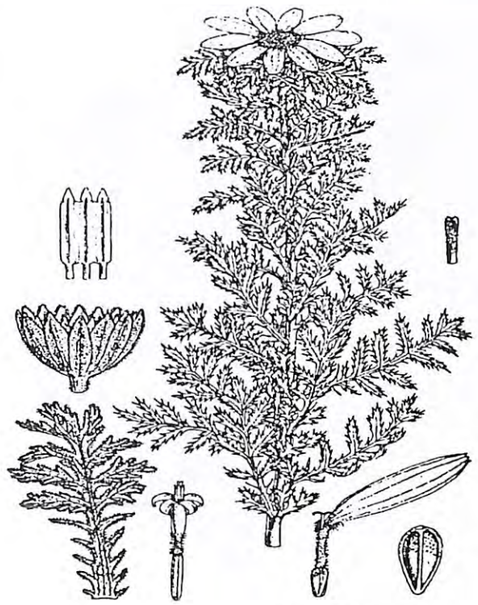
*Lepidospartum striatum* Coville
Asteraceae



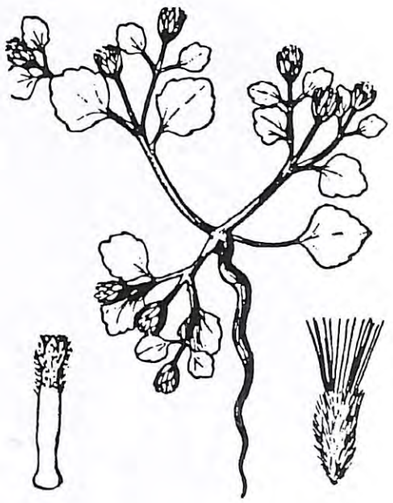
*Oonopsis englemanii* (A. Gray) Greene
[*Happlopappus englemanii* (A. Gray) Hall]
Asteraceae





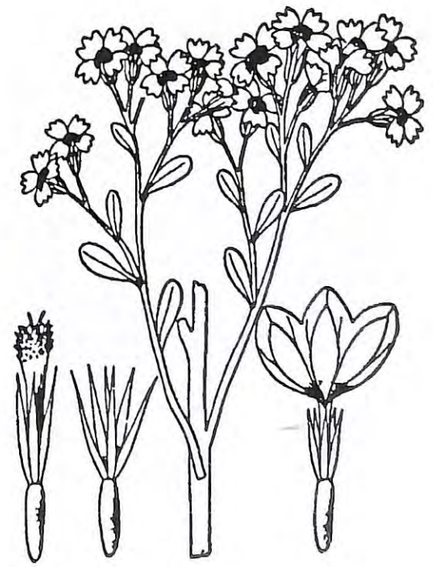


*Osteospermum tanacetifolium Macowan
Asteracceae

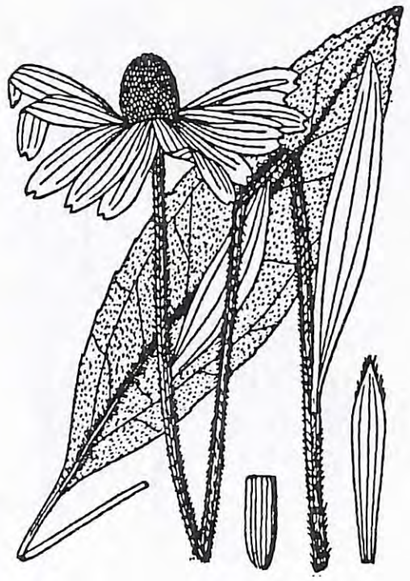


*Psathrrotes annua* (Nuttall) A. Gray
Asteraceae

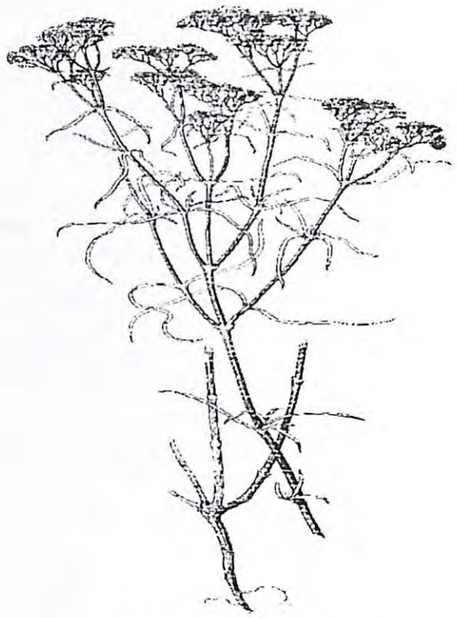
*Oxytenia acerosa* Nuttall [*Iva acerosa*
(Nuttall) R. C. Jackson]
Asteraceae



*Psilostrophe tagetinae* (Nuttall) Kuntze
Asteraceae

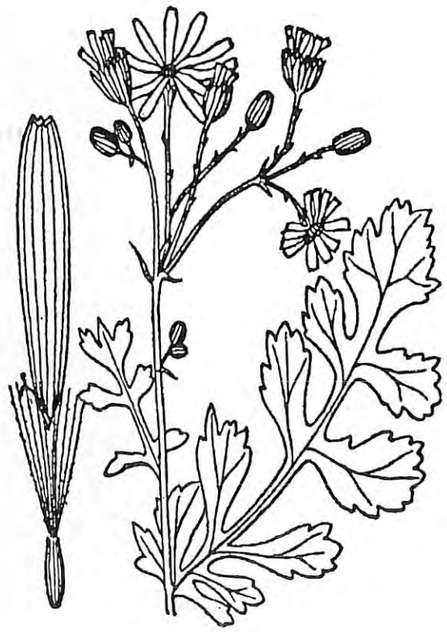


*Rudbeckia hirta* Linnaeus
Asteraceae



*Sartwellia flaveriae* A. Gray
Asteraceae

*Rudbeckia lacinata* Linnaeus
Asteraceae



*Senecio glabellus* Poiret
Asteraceae

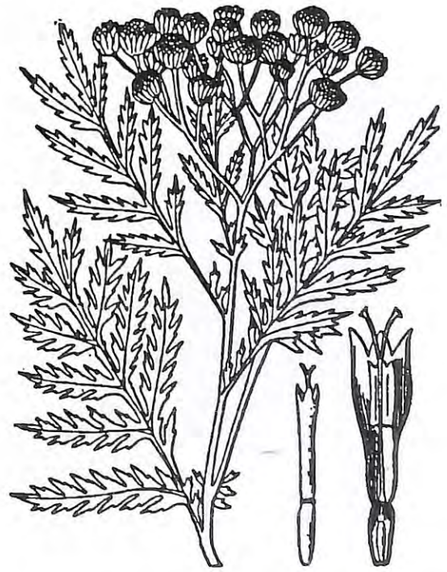




*Senecio vulgaris* Linnaeus
Asteraceae

*Solidago mollis* Bartling
Asteraceae

*Solidago hispida* Muhlenberg
Asteraceae



*Tanacetum vulgare* Linnaeus
Asteraceae

*Tetradymia canescens* de Candolle
Asteraceae

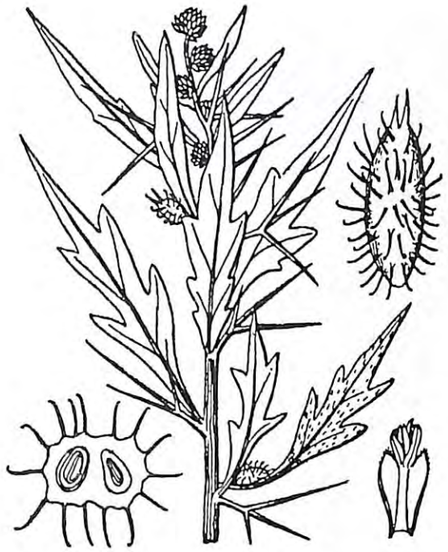
*Viguiera annua* (M. E. Jones) S. F. Blake
Asteraceae

*Verbesina encelioides* (Cavanilles)
Bentham & Hooker
Asteraceae

*Xanthium strumarium* Linnaeus
Asteraceae

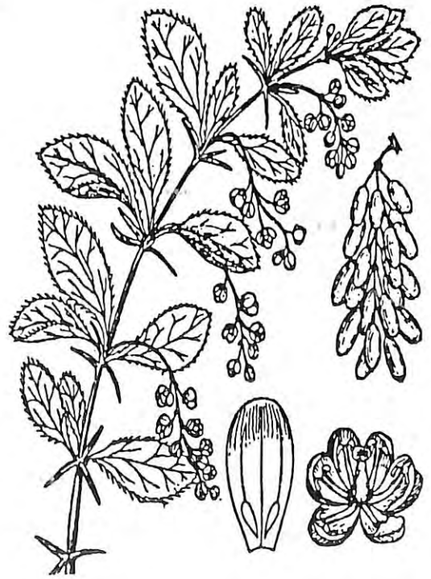




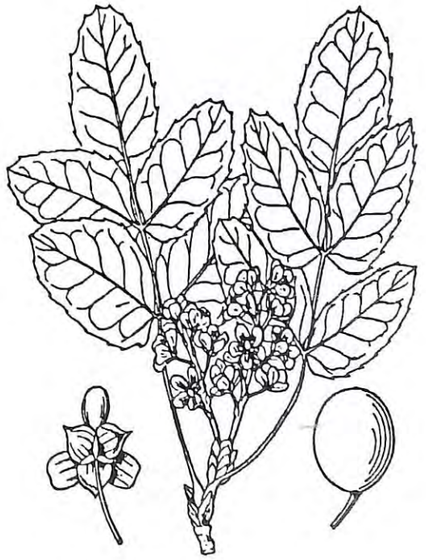


*Xanthium spinosum* Linnaeus
Asteraceae

*Caulophyllum thalictroides* (Linnaeus) Michaux
Berberidaceae



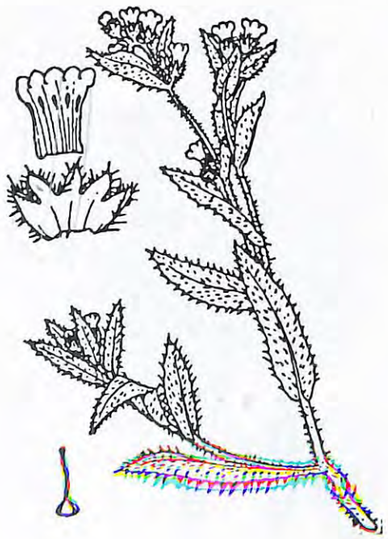
*Berberis vulgaris* Linnaeus
Berberidaceae



*Mahonia repens* (Lindley) G. Don
Berberidaceae

*Podophyllum peltatum* Linnaeus
Berberidaceae

*Cynoglossum officinale* Linnaeus
Boraginaceae

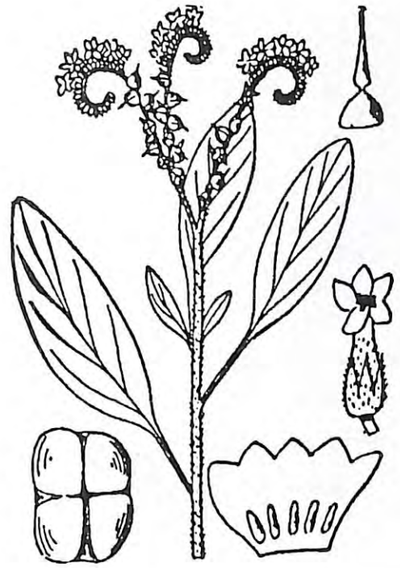


*Amsinckia lycopsoides* Lehmann
Boraginaceae

*Echium vulgare* Linnaeus
Boraginaceae







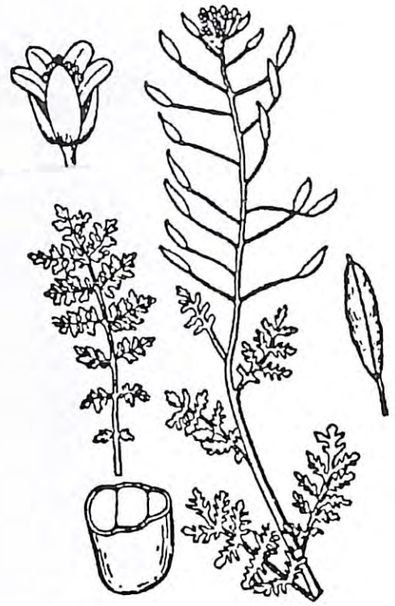
*Heliotropium europaeum* Linnaeus
Boraginaceae

*Armoracia rusticana* Ph. Gaertner,
B. Meyer & Scherbius
Brassicaceae

*Symphytum officinale* Linnaeus
Boraginaceae

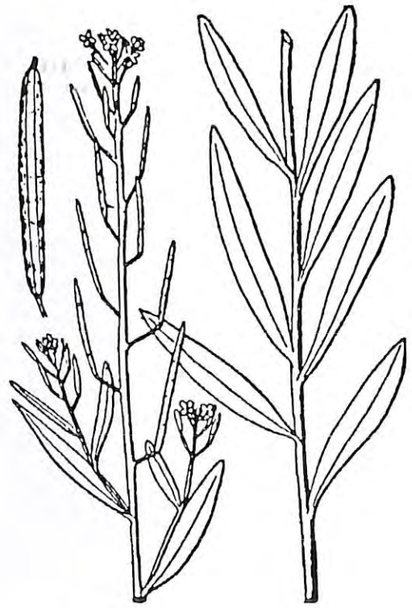
*Barbarea vulgaris* R. Brown
Brassicaceae

*Brassica juncea* (Linnaeus) Czernjaëw
Brassicaceae



*Descurainia pinnata* (Walter) Britton
Brassicaceae

*Cardaria draba* (Linnaeus) Desvaux
Brassicaceae



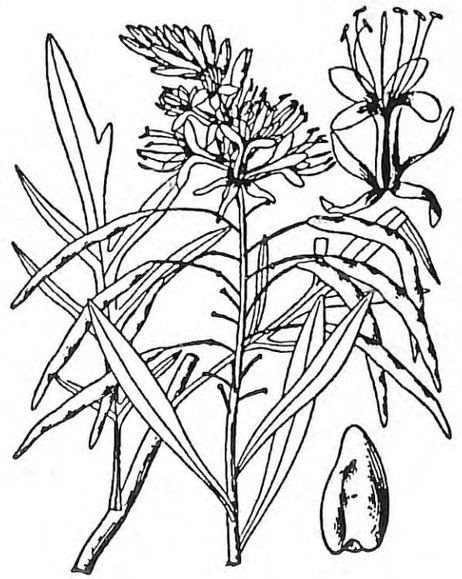
*Erysimum cheiranthoides* Linnaeus
Brassicaceae





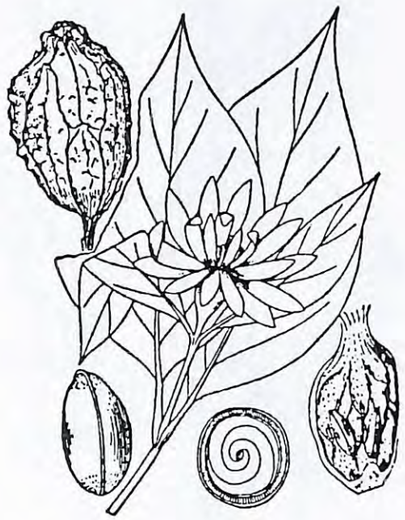
*Raphanus raphanistrum* Linnaeus
Brassicaceae

*Thlaspi arvense* Linnaeus
Brassicaceae



*Stanleya pinnata* (Pursh) Britton
Brassicaceae

*Buxus sempervirens* Linnaeus
Buxaceae



*Calycanthus floridus* Linnaeus
Calycanthaceae

*Cannabis sativa* Linnaeus
Cannabaceae

*Lobelia cardinalis* Linnaeus
Campanulaceae

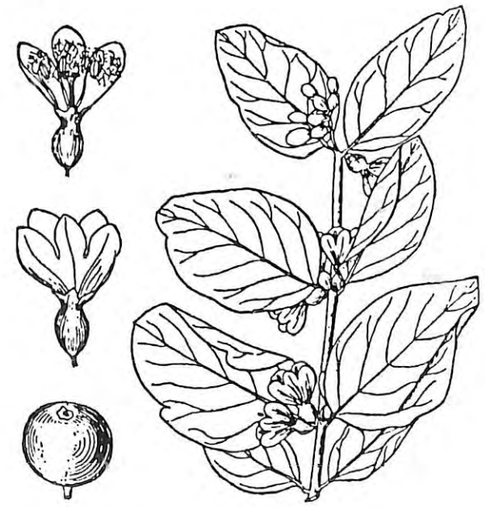
*Wislizenia californica* Greene
Capparaceae



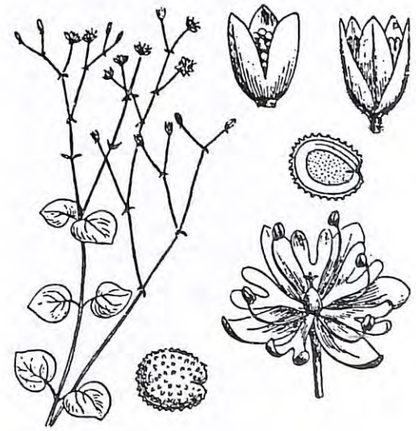


*Sambucus canadensis* Linnaeus
Caprifoliaceae

*Agrostemma githago* Linnaeus
Caryophyllaceae



*Symphoricarpos albus* (Linnaeus) S. F. Blake
Caprifoliaceae

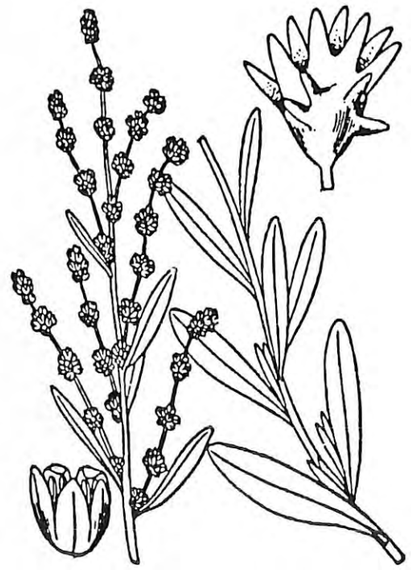


**Drymaria cordata* Willdenow ex
Roemer & Schultes
Caryophyllaceae

*Saponaria officinalis* Linnaeus
Caryophyllaceae

*Euonymus obovatus* Nuttall
Celastraceae

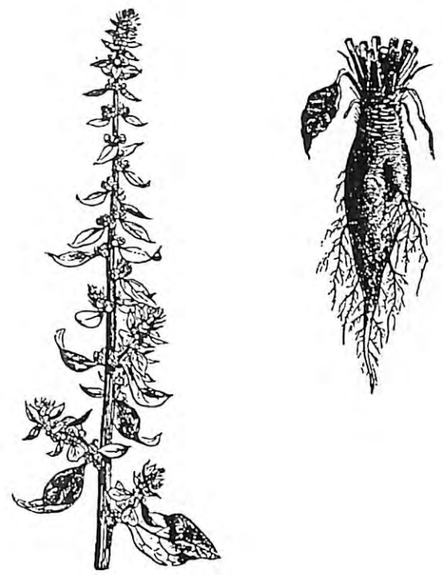
*Celastrus scandens* Linnaeus
Celastraceae



*Atriplex canescens* (Pursh) Nuttall
Chenopodiaceae





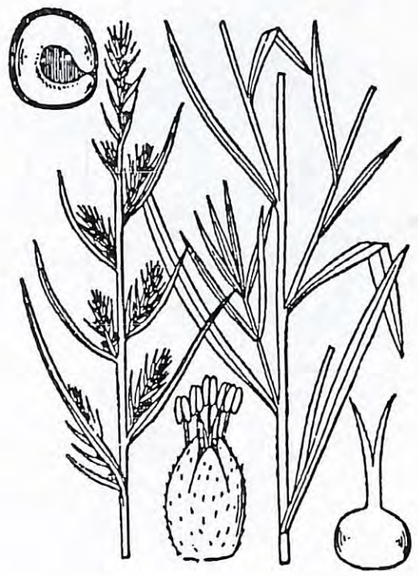


*Beta vulgaris* Linnaeus
Chenopodiaceae

*Grayia spinosa* (Hooker) Moquin-Tandon
Chenopodiaceae

*Chenopodium album* Linnaeus
Chenopodiaceae

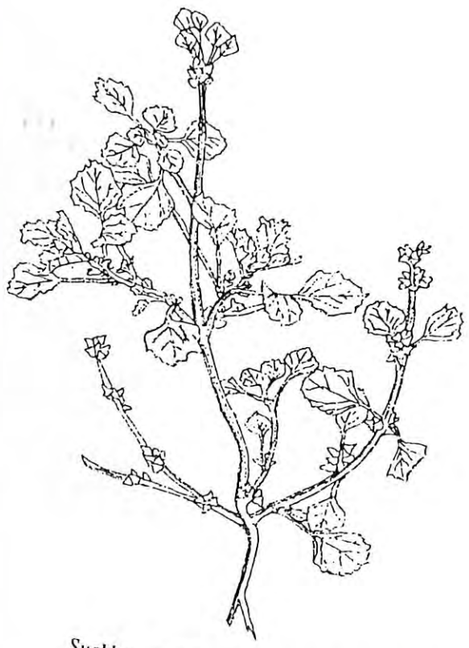
*Halogeton glomeratus* (Beiberstein) C. A. Meyer
Chenopodiaceae



*Kochia scoparia* (Linnaeus) Schrader
Chenopodiaceae

*Sarcobatus vermiculatus* (Hooker) Torrey
Chenopodiaceae

*Salsola tragus* Linnaeus
Chenopodiaceae



*Suckleya suckleyana* (Torrey) Rydberg
Chenopodiaceae





*Ipomoea batatas* (Linnaeus) Lamarck
Convovulaceae

*Cuscuta pentagona* Engelmann
Cuscutaceae

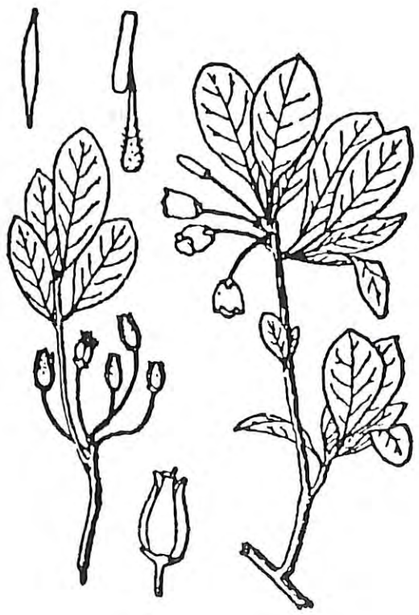
*Momordica charantia* Linnaeus
Cucurbitaceae

*Datisca cannabina* Linnaeus
Datiscaceae

*Kalmia angustifolia* Linnaeus
Ericaceae

*Leucothoe axillaris* (Lamarck) D. Don
Ericaceae

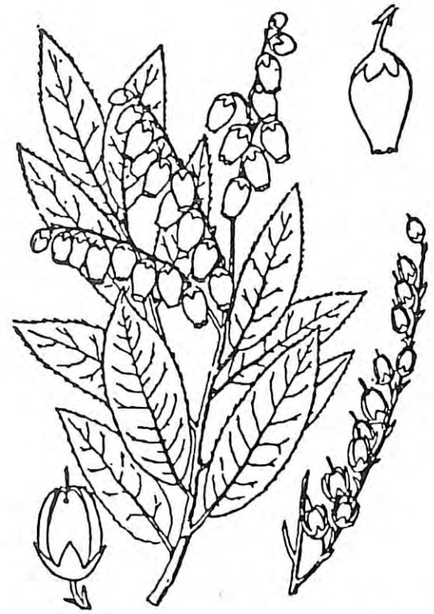
*Ledum palustre* Linnaeus var. *decumbens* Aiton
Ericaceae



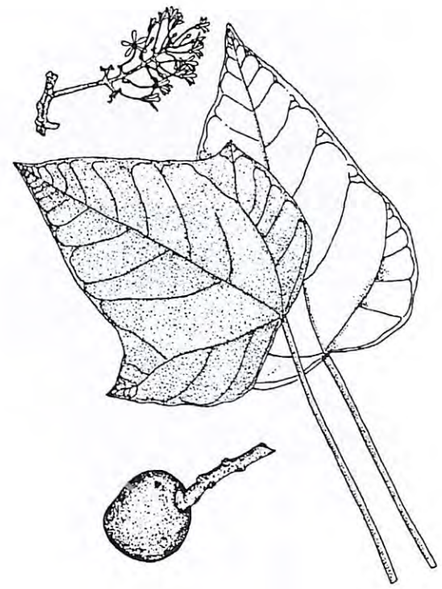
*Menziesia ferruginea* J. E. Smith
var. *glabella* (A. Gray) Peck
Ericaceae



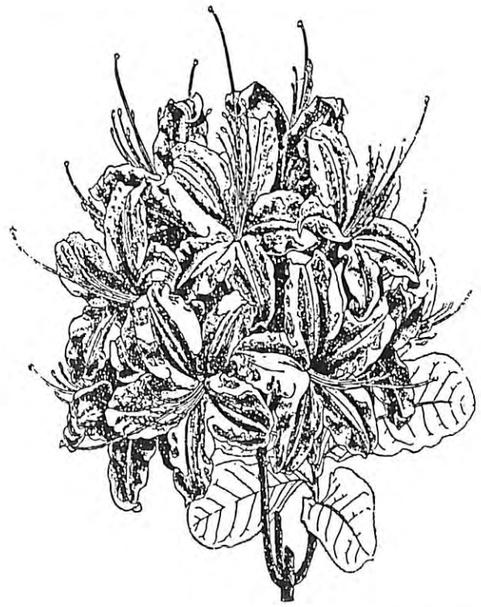




*Pieris floribunda* (Pursh) Bentham & Hooker
Ericaceae



*Aleurites moluccana* (Linnaeus) Willdenow
Euphorbiaceae



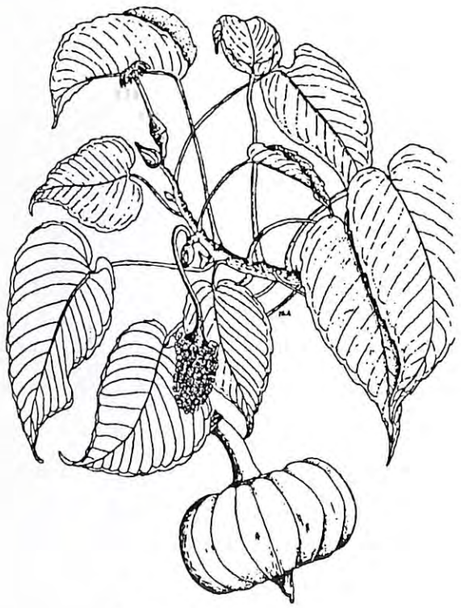
*Rhododendron occidentale* (Torrey & A. Gray)
A. Gray [*Azalea occidentale* Torrey & A. Gray]
Ericaceae

*Croton capitatus* Michaux
Euphorbiaceae

*Eremocarpus setigerus* (Hooker) Bentham
Euphorbiaceae

*Hippomane mancinella* Linnaeus
Euphorbiaceae

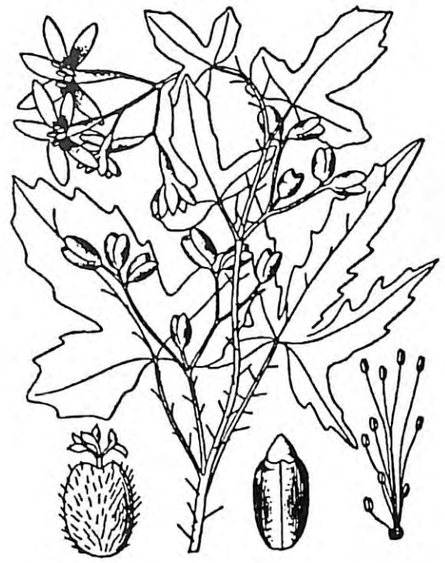
*Euphorbia maculata* Linnaeus
Euphorbiaceae



*Hura crepitans* Linnaeus
Euphorbiaceae



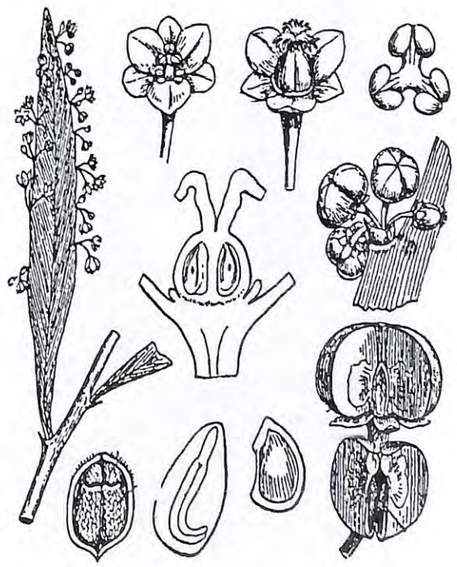




*Jatropha stimulosa* Michaux [*Cnidoscolus stimulosus* (Michaux) Englemann and A. Gray]
Euphorbiaceae

*Mercurialis annua* Linnaeus
Euphorbiaceae

*Manihot esculenta* Crantz
Euphorbiaceae

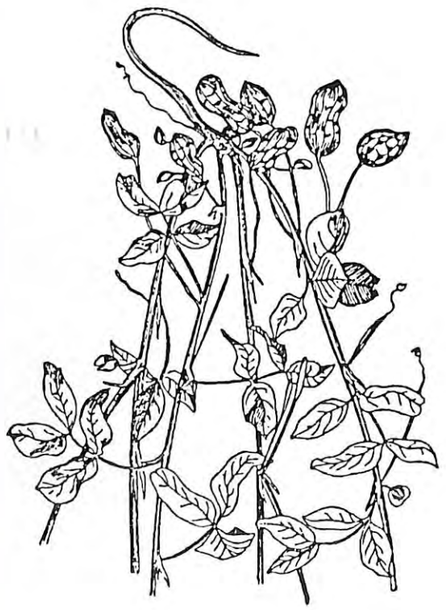


*Phyllanthus epiphyllanthus* Linnaeus
Euphorbiaceae

*Ricinus communis* Linnaeus
Euphorbiaceae

*Acacia angustissima* (P. S. Miller) Kuntze
Fabaceae

*Abrus precatorius* Linnaeus
Fabaceae

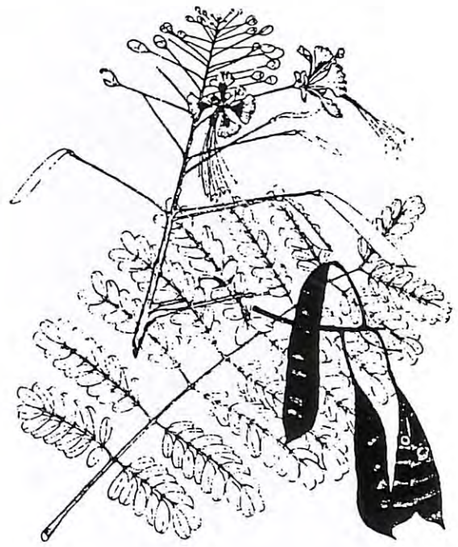


*Arachis hypogaea* Linnaeus
Fabaceae



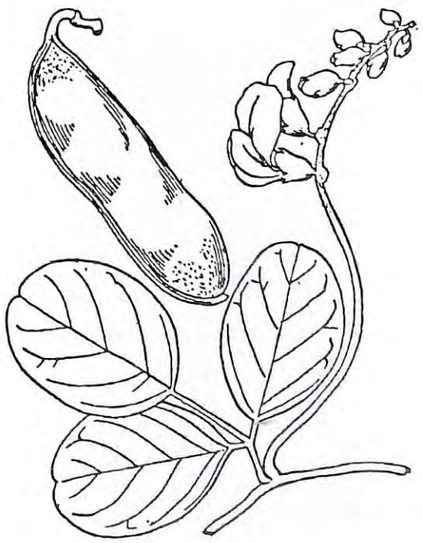


*Astragalus mollissimus* Torrey
Fabaceae



*Caesalpinia pulcherrima* (Linnaeus) Swartz
Fabaceae

*Baptisia lactea* (Rafinesque-Schmaltz) Thieret
Fabaceae



**Canavalia rosea* (Swartz) de Candolle
Fabaceae

*Cassia marilandica* Linnaeus
[*Senna marilandica* (Linnaeus) Link]
Fabaceae

*Crotalaria sagittalis* Linnaeus
Fabaceae

*Castanospermum australe*
A. Cunningham & C. Fraser
Fabaceae

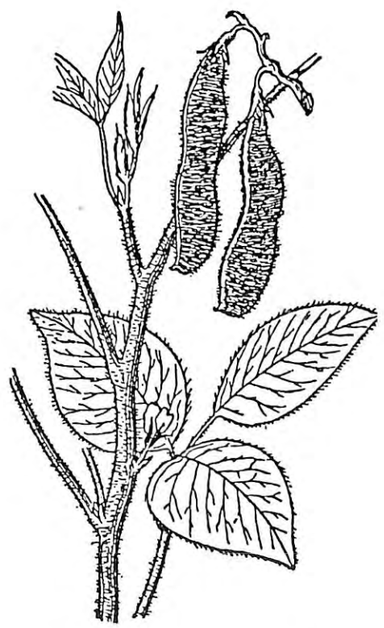
*Cytisus scoparius* (Linnaeus) Link
Fabaceae





*Erythrina crista-galli* Linnaeus
Fabaceae

*Gymnocladus dioicus* (Linnaeus) K. Koch
Fabaceae



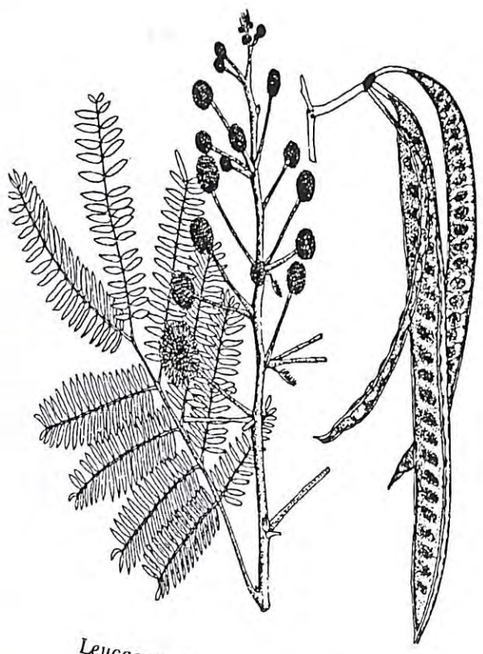
*Glycine max* (Linnaeus) Merrill
Fabaceae

*Indigofera miniata* Ortega [*Indigofera letosepala*
Nuttall in Torrey & A. Gray]
Fabaceae

**Laburnum alpinum* (P. S. Miller)
Berchtold & J. Presl
Fabaceae

*Lespedeza stipulacea* Maximowicz
Fabaceae

*Lathyrus latifolius* Linnaeus
Fabaceae



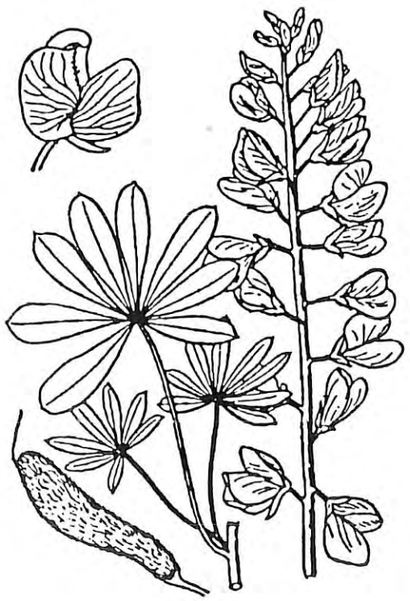
*Leucaena glauca* (Linnaeus) Bentham
Fabaceae





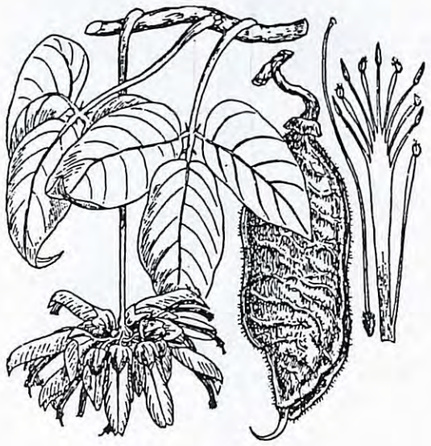
*Lotus corniculatus* Linnaeus
Fabaceae

*Medicago polymorpha* Linnaeus
Fabaceae



*Lupinus perennis* Linnaeus
Fabaceae

*Melilotus officinalis* (Linnaeus) Pallas
Fabaceae



*Mucuna sloanei* Fawcett & Rendle
Fabaceae

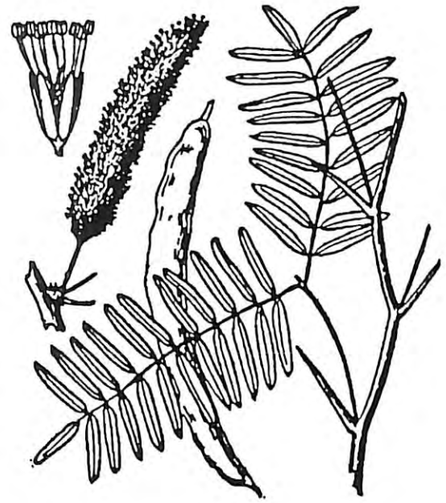
*Phaseolus vulgaris* Linnaeus
Fabaceae

*Oxytropis lambertii* Pursh
Fabaceae

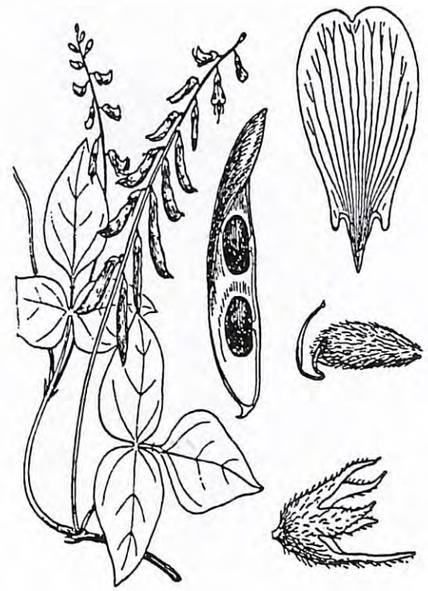
*Pisum sativum* Linnaeus
Fabaceae







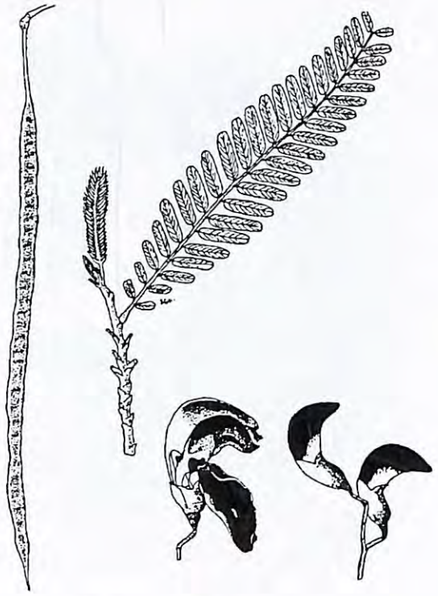
*Prosopis glandulosa* Torrey
Fabaceae



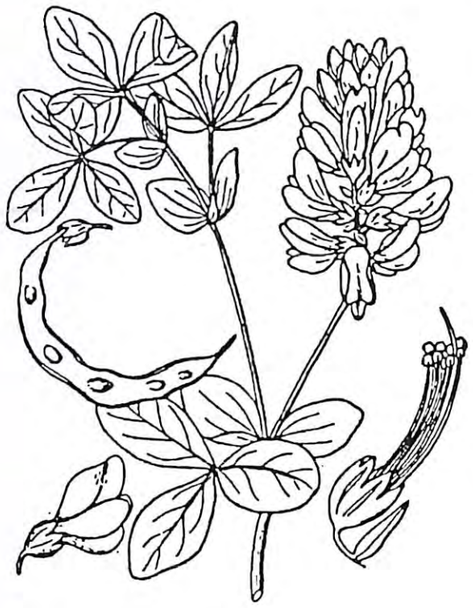
*Rhynchosia minima* de Candolle
Fabaceae

*Psoralea argophylla* Pursh
Fabaceae

*Robinia pseudoacacia* Linnaeus
Fabaceae

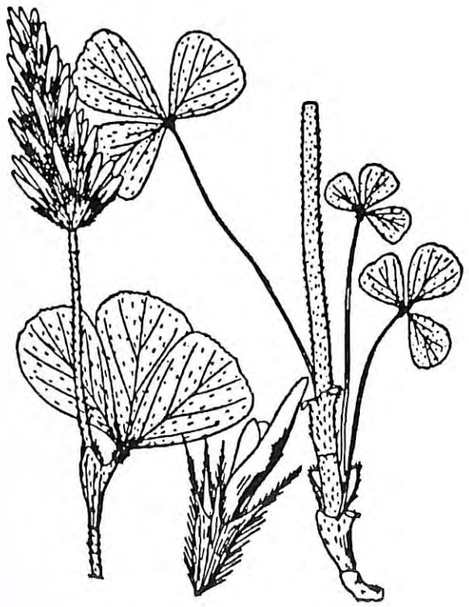


*Sesbania grandiflora* (Linnaeus) Poiret
Fabaceae



*Thermopsis rhombifolia* Nutall ex Richardson
Fabaceae

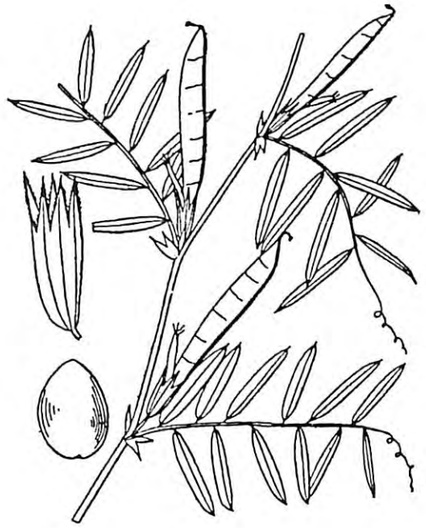
*Sophora sericea* Nuttall
Fabaceae



*Trifolium incarnatum* Linnaeus
Fabaceae



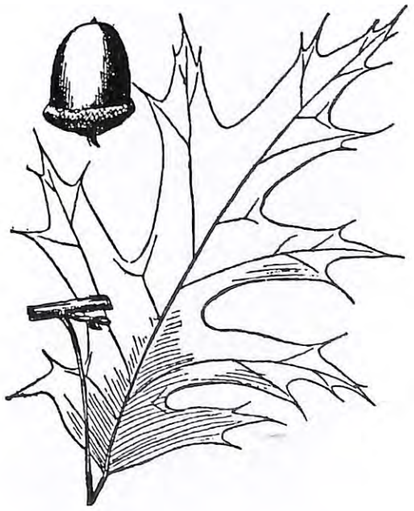




*Vicia angustifolia* Linnaeus
Fabaceae

*Fagus grandifolia* Ehrhart
Fagaceae

*Wisteria macrostachya* Nuttall
Fabaceae



*Quercus rubra* Linnaeus
Fagaceae

*Corydalis flavula* (Rafinesque-Schmaltz) de Candolle
Fumariaceae

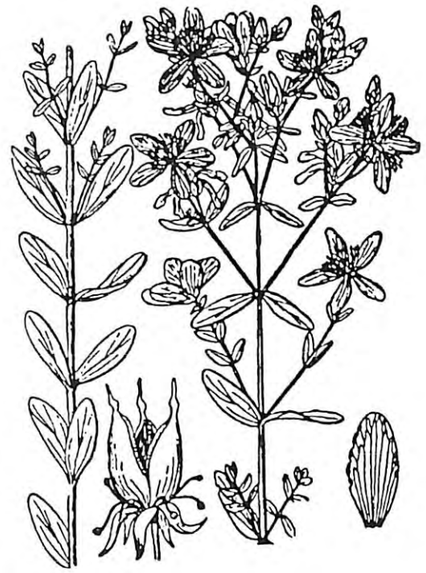
*Centaurium calycosum* Fernald
Gentianaceae

*Dicentra canadensis* (Goldie) Walpers
Fumariaceae

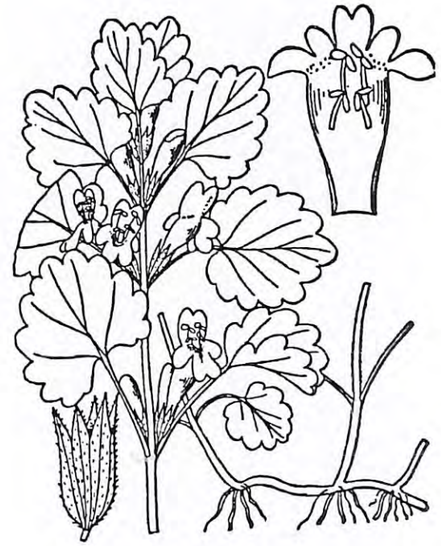
*Aesculus hippocastanum* Linnaeus
Hippocastanaceae



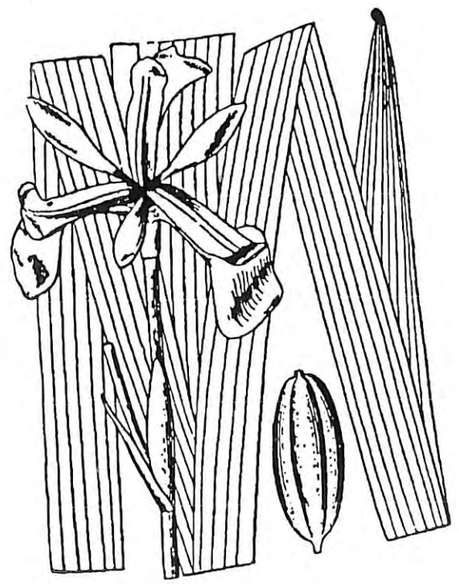




*Hypericum perforatum* Linnaeus
Hypericaceae



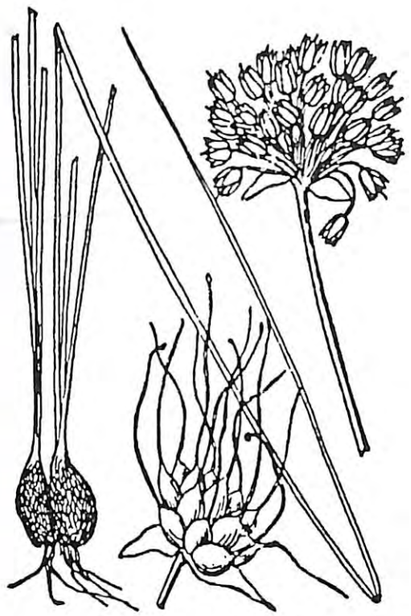
*Glechoma hederacea* Linnaeus
Lamiaceae



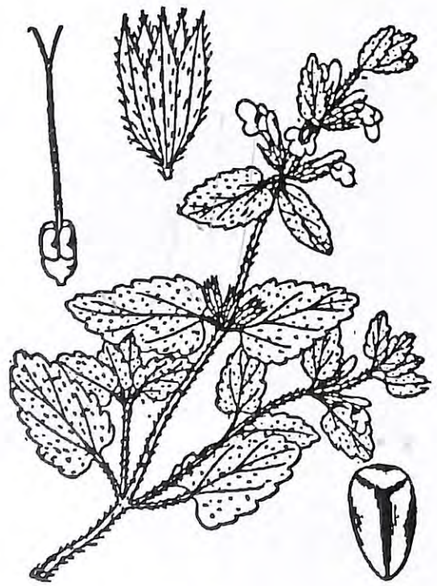
*Iris versicolor* Linnaeus
Iridaceae

*Lamium amplexicaule* Linnaeus
Lamiaceae

*Salvia reflexa* Hornemann
Lamiaceae



*Allium canadense* Linnaeus
Liliaceae



*Stachys arvensis* Linnaeus
Lamiaceae

*Aloe barbadensis* P. S. Miller
Liliaceae



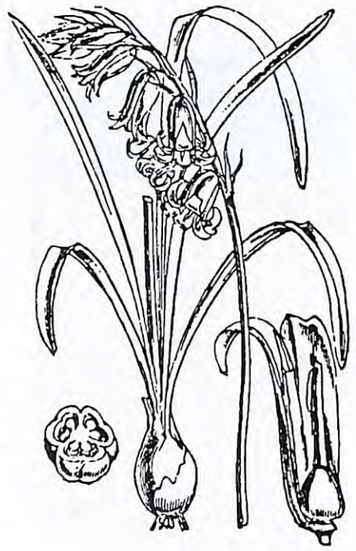


*Asparagus officinalis* Linnaeus
Liliaceae

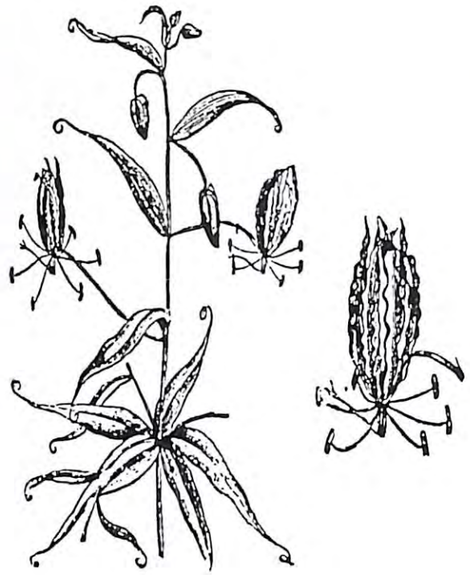
*Convallaria majalis* Linnaeus
Liliaceae

*Colchicum autumnale* Linnaeus
Liliaceae

**Dianella ensifolia* (Linnaeus) de Candolle
Liliaceae



*Endymion non-scriptus* (Linnaeus) Garcke
Liliaceae



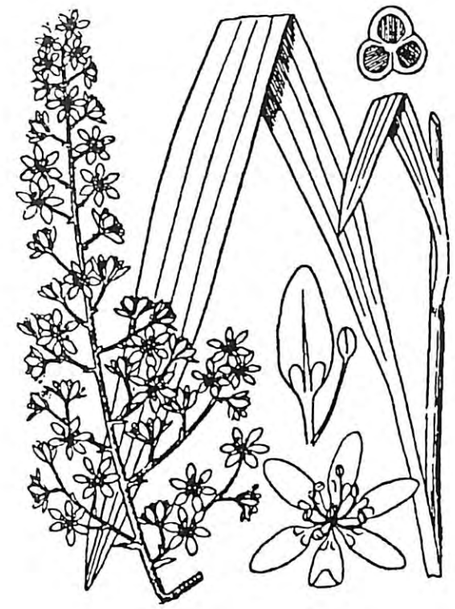
*Gloriosa superba* Linnaeus
Liliaceae

*Fritillaria meleagris* Linnaeus
Liliaceae

*Hyacinthus orientalis* Linnaeus
Liliaceae







*Melanthium virginicum* Linnaeus
Liliaceae

*Scilla autumnalis* Linnaeus
Liliaceae

*Ornithogalum umbellatum* Linnaeus
Liliaceae

*Tulipa sylvestris* Linnaeus
Liliaceae

*Urginea maritima* (Linnaeus) Baker
Liliaceae

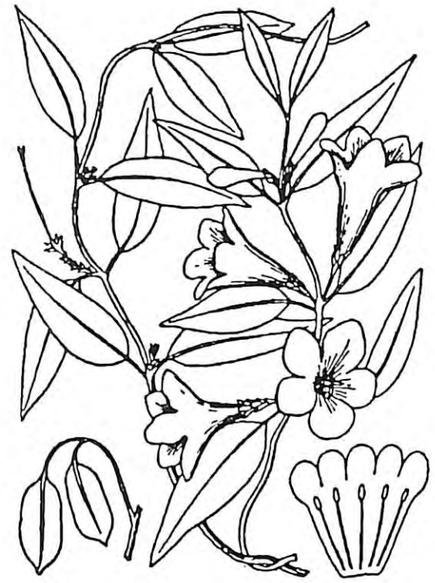
*Zigadenus venenosus* S. Watson
Liliaceae

*Veratrum viride* Aiton
Liliaceae

*Linum usitatissimum* Linnaeus
Linaceae



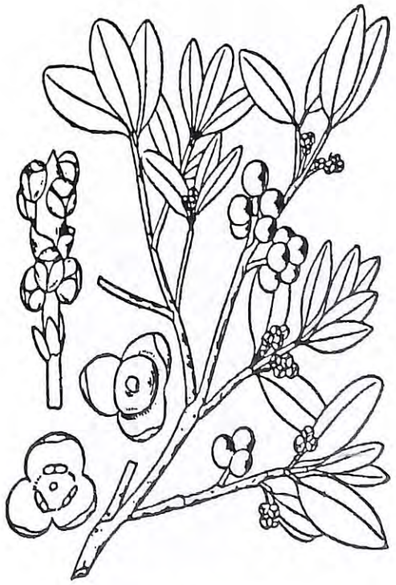




*Gelsemium sempervirens* (Linnaeus) Aiton
Loganiaceae

*Strychnos nux-vomica* Linnaeus
Loganiaceae

*Spigelia marilandica* Linnaeus
Loganiaceae

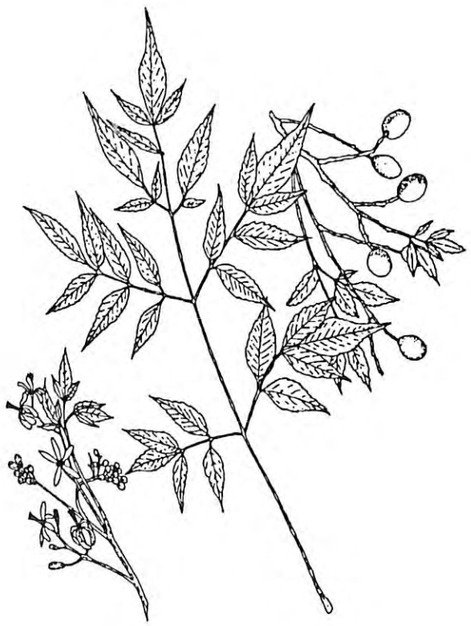


*Phoradendron serotinum*
(Rafinesque-Schmaltz) M. C. Johnston
Loranthaceae

*Gossypium arboreum* Linnaeus
Malvaceae

*Modiola caroliniana* (Linnaeus) G. Don
Malvaceae

*Malva alcea* Linnaeus
Malvaceae



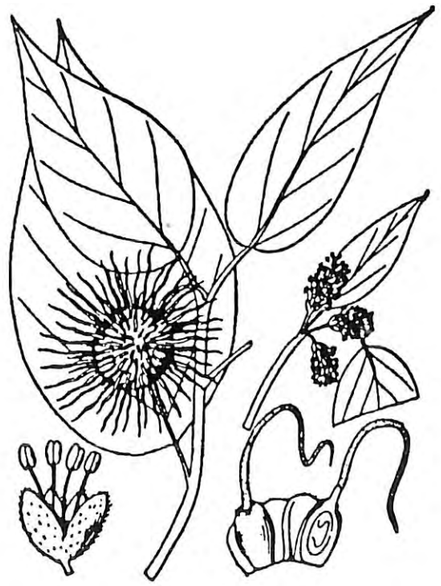
*Melia azedarach* Linnaeus
Meliaceae





*Menispermum canadense* Linnaeus
Menispermaceae

*Morus rubra* Linnaeus
Moraceae



*Maclura pomifera* (Rafinesque-Schmaltz)
C. K. Schneider
Moraceae

*Eucalyptus resinifera* J. E. Smith
Myrtaceae

*Mirabilis jalapa* Linnaeus
Nyctaginaceae

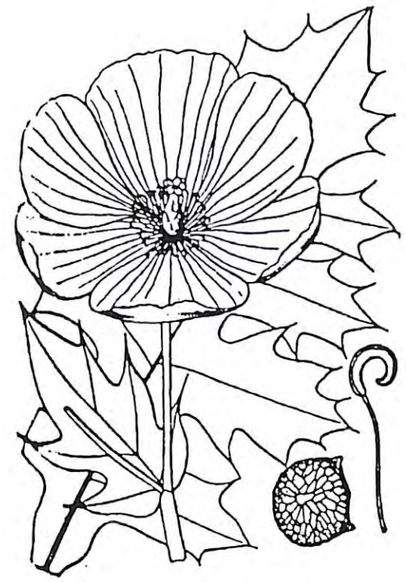
*Ligustrum vulgare* Linnaeus
Oleaceae

*Nymphaea odorata* Aiton
Nymphaeaceae

*Oxalis acetosella* Linnaeus
Oxalidaceae







*Argemone albiflora* Hornemann
Papaveraceae

*Papaver somniferum* Linnaeus
Papaveraceae

*Chelidonium majus* Linnaeus
Papaveraceae

*Papaver rhoeas* Linnaeus
Papaveraceae

*Sanguinaria canadensis* Linnaeus
Papaveraceae

*Rivina humilis* Linnaeus
Phytolaccaceae

*Phytolacca americana* Linnaeus
Phytolaccaceae

*Plumbago auriculata* Lamarck
Plumbaginaceae





*Avena sativa* Linnaeus
Poaceae

*Eragrostis cilianensis* (Allioni) Link
Poaceae

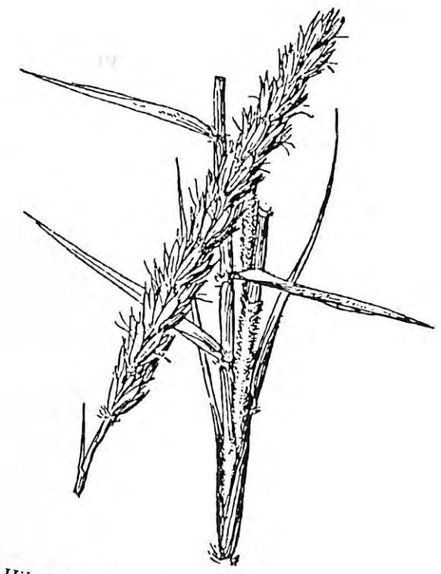
*Cynodon dactylon* (Linnaeus) Persoon
Poaceae

*Festuca elatior* Linnaeus
Poaceae

*Festuca rubra* Linnaeus
Poaceae

*Heteropogon contortus* (Linnaeus) Beavois ex Roemer & Schultes
Poaceae

*Glyceria striata* (Lamarck) A. Hitchcock
Poaceae



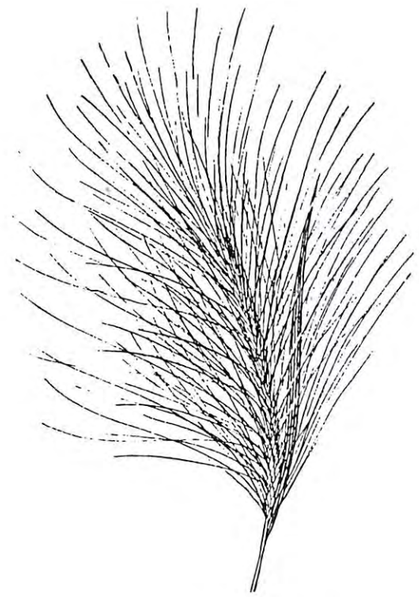
*Hilaria rigida* (Thunberg) Bentham ex Scribner
Poaceae





*Holcus lanatus* Linnaeus
Poaceae

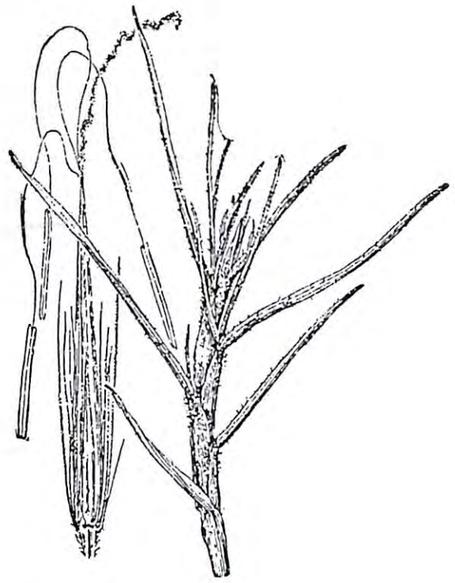
*Hordeum vulgare* Linnaeus
Poaceae



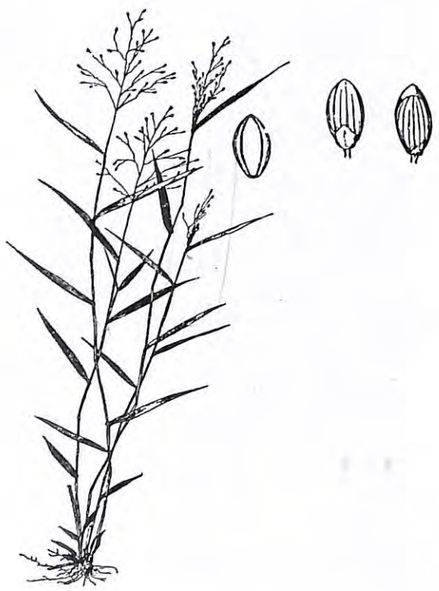
*Hordeum jubatum* Linnaeus
Poaceae

*Lolium temulentum* Linnaeus
Poaceae

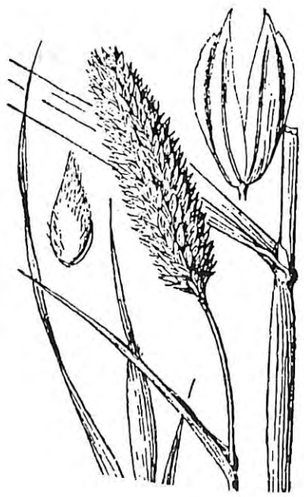
*Panicum capillare* Linnaeus
Poaceae



*Pennisetum clandestinum* Hochstetter ex Chiovenda
Poaceae



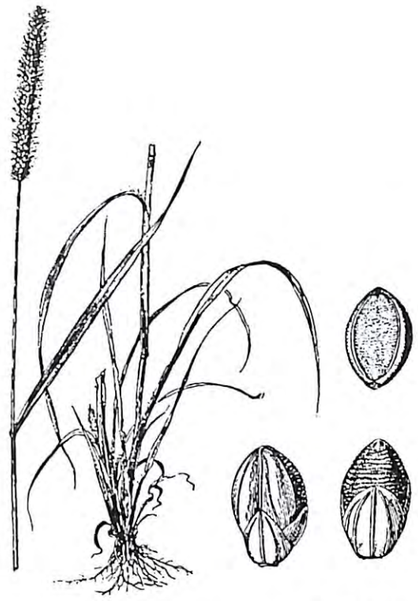
*Panicum dichotomum* Linnaeus
Poaceae



*Phalaris minor* Retzius
Poaceae

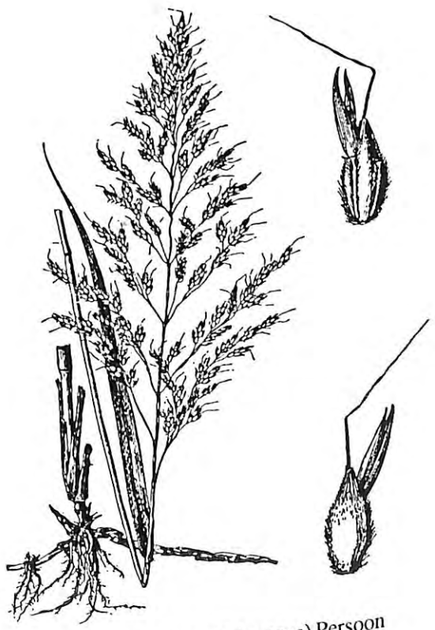






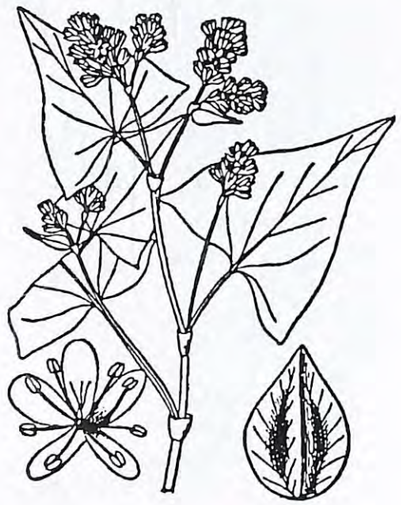
*Setaria lutescens* (Weigel) F. T. Hubbard
Poaceae

*Stipa robusta* Scribner
Poaceae

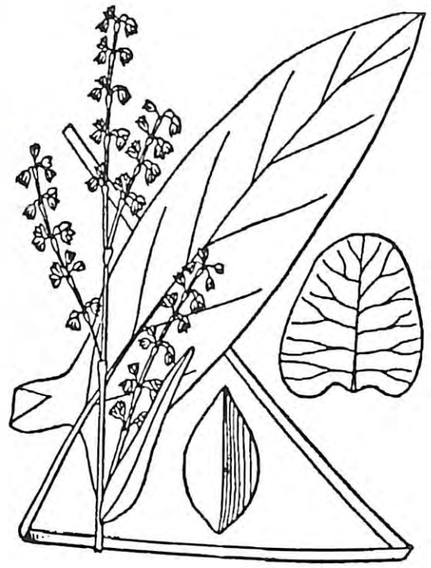


*Sorghum halpense* (Linnaeus) Persoon
Poaceae

*Zea mays* Linnaeus
Poaceae

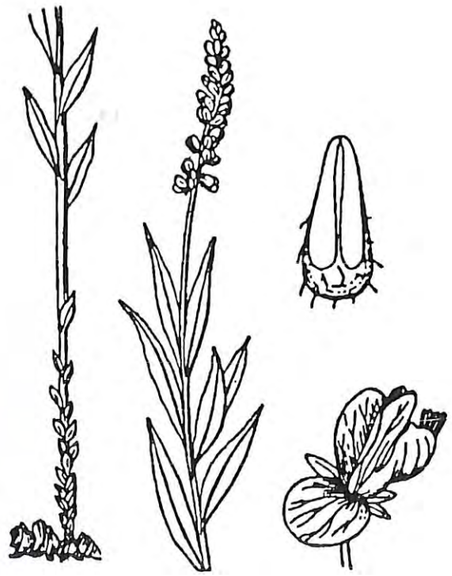


*Fagopyrum esculentum* Moench
Polygonaceae



*Rumex acetosa* Linnaeus
Polygonaceae

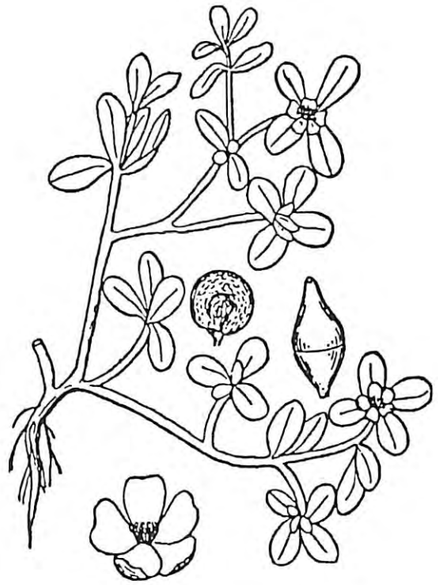
*Rheum officinale* Baillon
Polygonaceae



*Polygala senega* Linnaeus
Polygalaceae

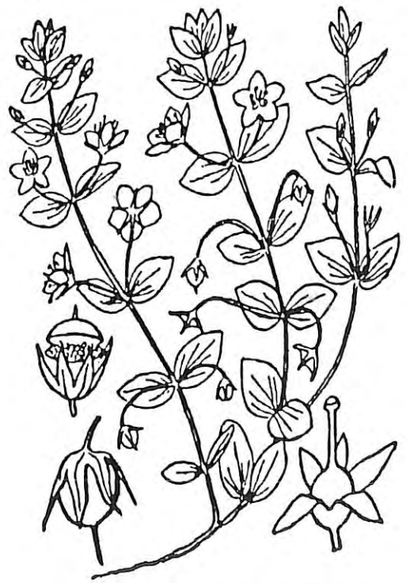




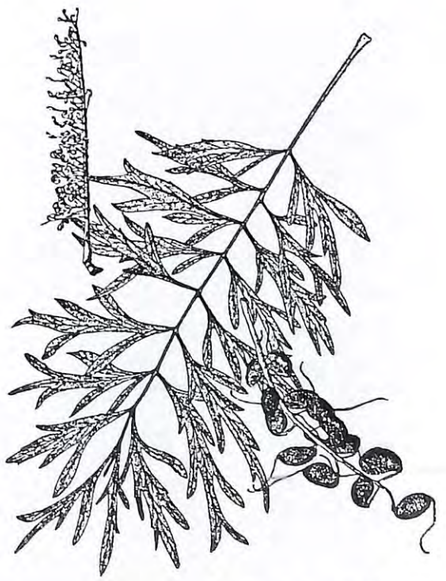


*Portulaca oleracea* Linnaeus
Portulacaceae

*Cyclamen hederifolium* Aiton
Primulaceae

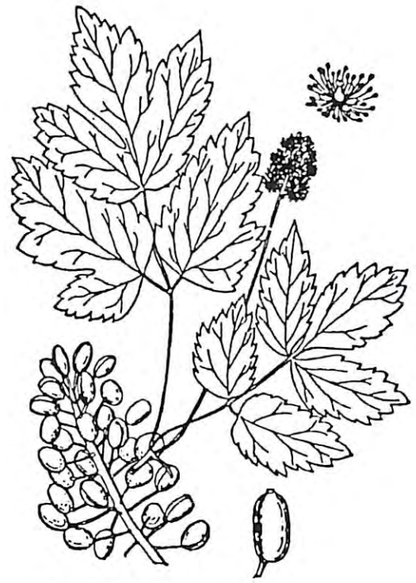


*Anagallis arvensis* Linnaeus
Primulaceae

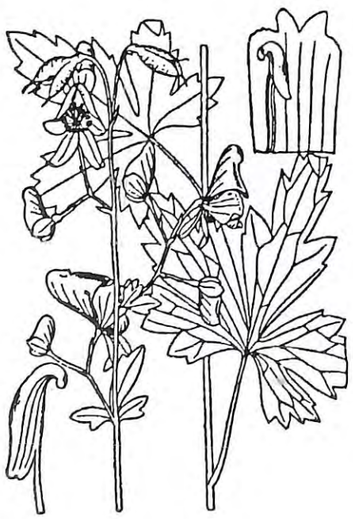


*Grevillea robusta* A. Cunningham ex R. Brown
Proteaceae

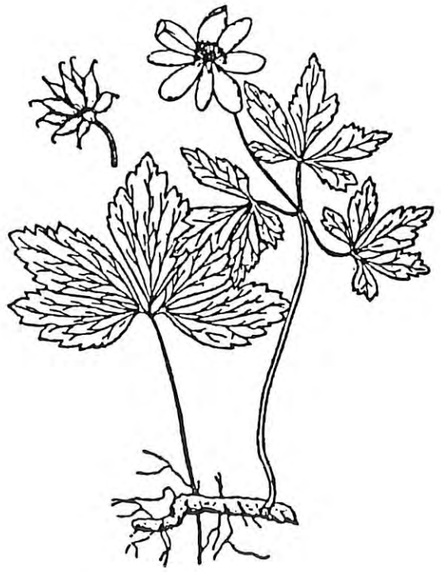
*Aconitum reclinatum* A. Gray
Ranunculaceae



*Actaea rubra* (Aiton) Willdenow
Ranunculaceae



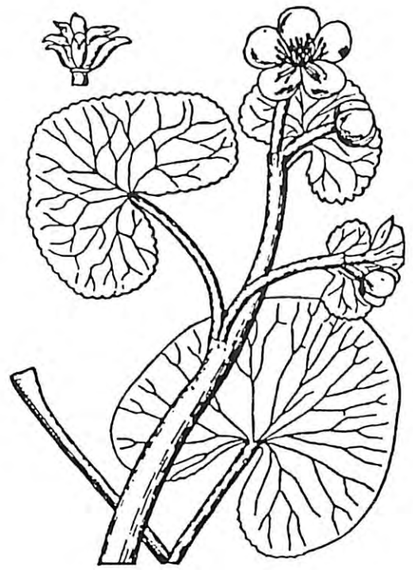
*Aconitum uncinatum* Linnaeus
Ranunculaceae



*Anemone lancifolia* Pursh
Ranunculaceae







*Caltha palustris* Linnaeus
Ranunculaceae

*Clematis virginiana* Linnaeus
Ranunculaceae

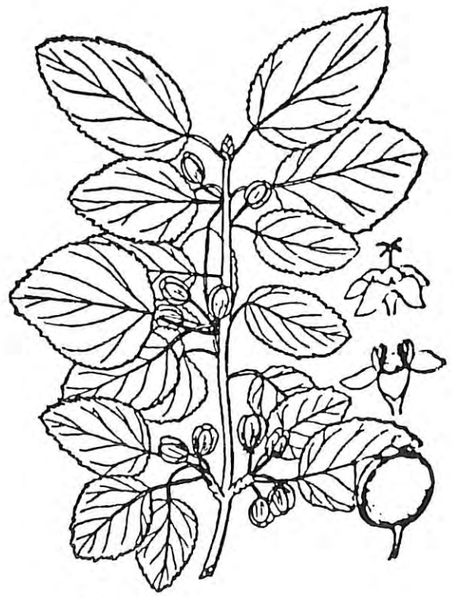
*Clematis ligusticifolia* Nuttall ex Torrey & A. Gray
Ranunculaceae

*Delphinium tricorne* Michaux
Ranunculaceae

*Helleborus viridis* Linnaeus
Ranunculaceae

*Ranunculus acris* Linnaeus
Ranunculaceae

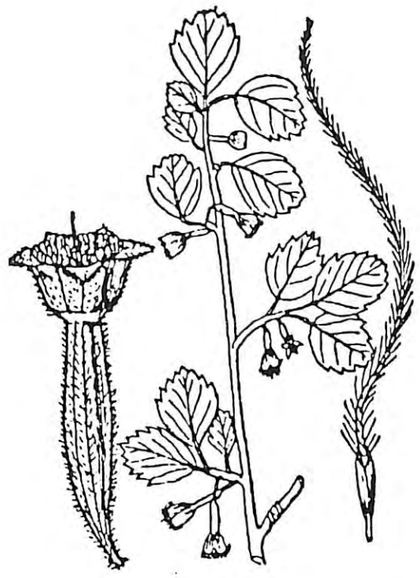
*Hydrastis canadensis* Linnaeus
Ranunculaceae



*Rhamnus cathartica* Linnaeus
Rhamnaceae







*Cercocarpus montanus* Rafinesque-Schmaltz
Rosaceae

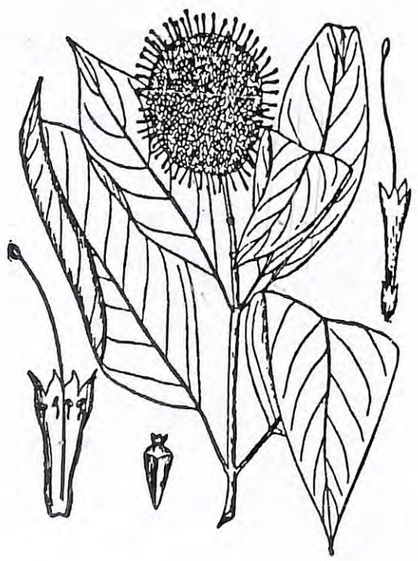
*Prunus americana* Marshall
Rosaceae

*Malus sylvestris* P. S. Miller
Rosaceae

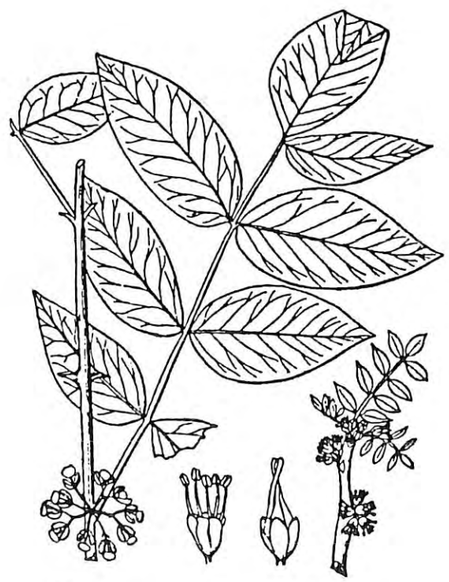
*Rhodotypos scandens* (Thunberg) Makino
Rosaceae

*Rubus laciniatus* (Weston) Willdenow
Rosaceae

*Citrus sinensis* (Linnaeus) Persoon
Rutaceae



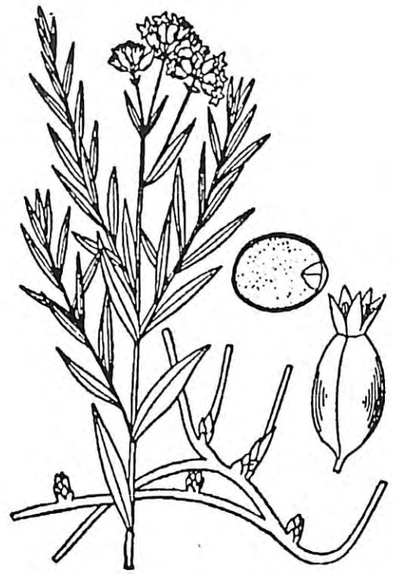
*Cephalanthus occidentalis* Linnaeus
Rubiaceae



*Zanthoxylum americanum* P. S. Miller
Rutaceae

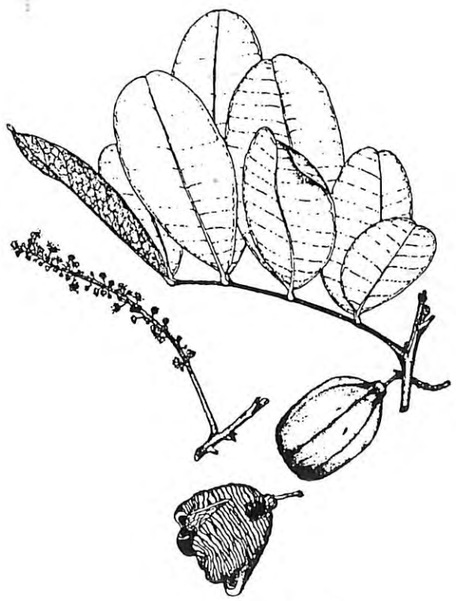






*Comandra umbellata* (Linnaeus) Nuttall
Santalaceae

*Hydrangea aborescens* Linnaeus
Saxifragaceae [Hydrangeaceae]



*Blighia sapida* Koenig
Sapindaceae

*Castilleja coccinea* (Linnaeus) Sprengel
Scrophulariaceae

*Digitalis purpurea* Linnaeus
Scrophulariaceae

*Brugmansia* × *candida* Persoon
Solanaceae

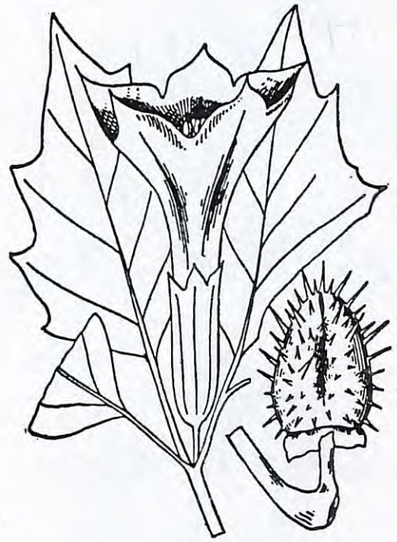
*Atropa bella-donna* Linnaeus
Solanaceae

**Brunfelsia americana* Linnaeus
Solanaceae

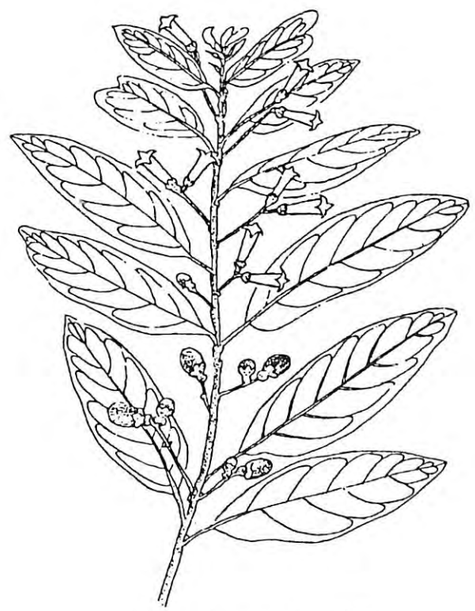




*Capsicum annuum* Linnaeus
Solanaceae



*Datura stramonium* Linnaeus
Solanaceae



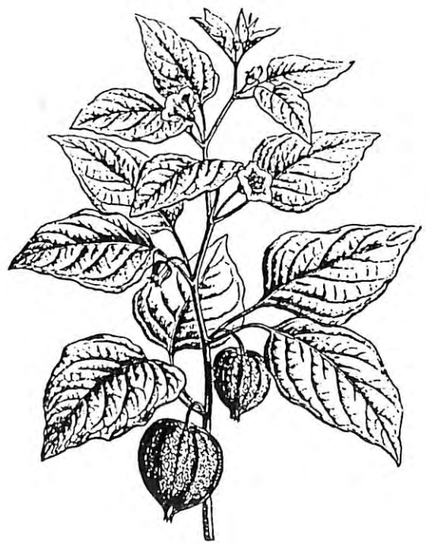
*Cestrum diurnum* Linnaeus
Solanaceae

*Hyoscyamus niger* Linnaeus
Solanaceae

*Lycium barbarum* Linnaeus
Solanaceae

*Nicotiana tabacum* Linnaeus
Solanaceae

*Lycopersicon lycopersicum* (Linnaeus)
Karst ex Farwell
Solanaceae



*Physalis alkekengi* Linnaeus
Solanaceae



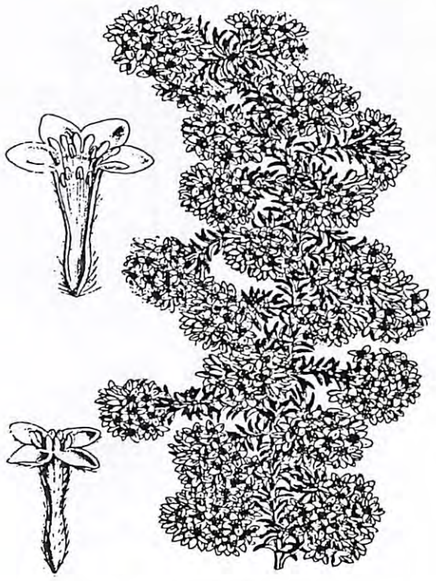


*Solandra grandiflora* Swartz
Solanaceae

*Daphne mezereum* Linnaeus
Thymelaeaceae

*Solanum dulcamara* Linnaeus
Solanaceae

*Dirca palustris* Linnaeus
Thymelaeaceae



*Gnidia polystachya* Bergius
Thymelaeaceae

*Urtica dioica* Linnaeus
Urticaceae

**Pimelea haematostachya* F. Mueller
Thymelaeaceae

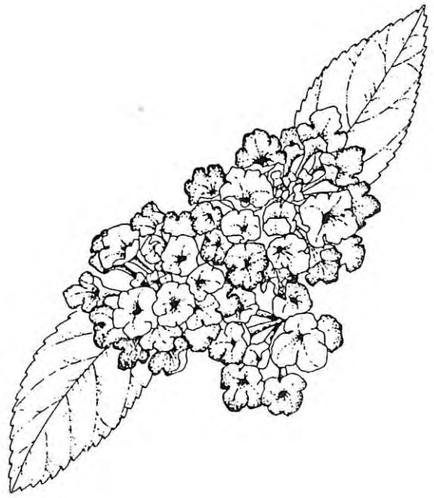
*Aloysia triphylla* (L'Heritier) Britton
Verbenaceae





*Duranta repens* Linnaeus
Verbenaceae

*Viola odorata* Linnaeus
Violaceae



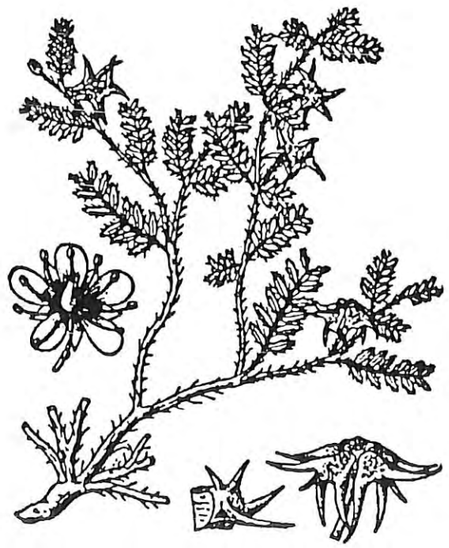
*Lantana camara* Linnaeus
Verbenaceae

*Viola tricolor* Linnaeus
Violaceae

*Parthenocissus quinquefolia* (Linnaeus) Planchon
Vitaceae

*Peganum harmala* Linnaeus
Zygophyllaceae

*Larrea tridentata* (de Candolle) Coville
Zygophyllaceae



*Tribulus terrestris* Linnaeus
Zygophyllaceae





*Abrus precatorius* Linnaeus Fabaceae. From William Fawcett and Alfred Barton Rendle. Flora of Jamaica. London, British Museum (Natural History), 1910–1936. Vol. 4.

*Acacia angustissima* (P. S. Miller) Kuntze Fabaceae. From Nathaniel Lord Britton and Addison Brown. An illustrated flora of the northern United States and Canada. New York, C. Scribner, 1896–1898. Vol. 2.

*Acer rubrum* Linnaeus Aceraceae. From Nathaniel Lord Britton and Addison Brown. An illustrated flora of the northern United States and Canada. New York, C. Scribner, 1896–1898. Vol. 2.

*Achillea millefolium* Linnaeus Asteraceae. From Nathaniel Lord Britton and Addison Brown. An illustrated flora of the northern United States and Canada. New York, C. Scribner, 1896–1898. Vol. 3.

*Acokanthera oblongifolia* (Hochstetter) Codd Apocynaceae. Redrawn by T. D. Jacobsen from Curtis's botanical magazine, London, 1878. Vol. 104, plate 6359.

*Aconitum reclinatum* A. Gray Ranunculaceae. From Nathaniel Lord Britton and Addison Brown. An illustrated flora of the northern United States and Canada. New York, C. Scribner, 1896–1898. Vol. 2.

*Aconitum uncinatum* Linnaeus Ranunculaceae. From Nathaniel Lord Britton and Addison Brown. An illustrated flora of the northern United States and Canada. New York, C. Scribner, 1896–1898. Vol. 2.

*Actaea rubra* (Aiton) Willdenow Ranunculaceae. From Nathaniel Lord Britton and Addison Brown. An illustrated flora of the northern United States and Canada. New York, C. Scribner, 1896–1898. Vol. 2.

*Adenium obesum* (Forsskål) Roemer & Schultes Apocynaceae. Redrawn by T. D. Jacobsen from Curtis's botanical magazine, London, 1863. Vol. 89, plate 5418.

*Aesculus hippocastanum* Linnaeus Hippocastanaceae. From Nathaniel Lord Britton and Addison Brown. An illustrated flora of the northern United States and Canada. New York, C. Scribner, 1896–1898. Vol. 1.

*Aethusa cynapium* Linnaeus Apiaceae. From Nathaniel Lord Britton and Addison Brown. An illustrated flora of the northern United States and Canada. New York, C. Scribner, 1896–1898. Vol. 2.

*Agapanthus africanus* (Linnaeus) Hoffmannsegg Amaryllidaceae. Redrawn by T. D. Jacobsen from Curtis's botanical magazine, London, 1800. Vol. 14, plate 500.

*Agave virginica* Linnaeus Agavaceae. From Nathaniel Lord Britton and Addison Brown. An illustrated flora of the northern United States and Canada. New York, C. Scribner, 1896–1898. Vol. 1.

*Aglaonema commutatum* Schott var. *maculatum* (Hooker f.) Nicholson Araceae. Redrawn by T. D. Jacobsen from Curtis's botanical magazine, London, 1865. Vol. 91, plate 5500.

*Agrostemma githago* Linnaeus Caryophyllaceae. From Nathaniel Lord Britton and Addison Brown. An illustrated flora of the northern United States and Canada. New York, C. Scribner, 1896–1898. Vol. 2.

*Aleurites moluccana* (Linnaeus) Willdenow Euphorbiaceae. From Elbert L. Little, Jr., Roy O. Woodbury and Frank H. Wadsworth. Trees of Puerto Rico and the Virgin Islands, second volume. Washington, D. C., Department of Agriculture, 1974. (Agricultural Handbook no. 449.)

*Allamanda neriifolia* Hooker Apocynaceae. From Revue Horticole, Paris, 1859.

*Allium canadense* Linnaeus Liliaceae. From Nathaniel Lord Britton and Addison Brown. An illustrated flora of the northern United States and Canada. New York, C. Scribner, 1896–1898. Vol. 1.

*Alocasia lowii* Hooker Araceae. Redrawn by T. D. Jacobsen from Curtis's botanical magazine, London, 1863. Vol. 89, plate 5376.

*Aloe barbadensis* P. S. Miller Liliaceae. From Nathaniel Lord Britton. Flora of Bermuda. New York, C. Scribner's Sons, 1918.

*Aloysia triphylla* (L'Heritier) Britton Verbenaceae. Redrawn by T. D. Jacobsen from Curtis's botanical magazine, London, 1797. Vol. 11, plate 367.

*Amaranthus retroflexus* Linnaeus Amaranthaceae. From Nathaniel Lord Britton and Addison Brown. An illustrated flora of the northern United States and Canada. New York, C. Scribner, 1896–1898. Vol. 2.

*Amaryllis belladonna* Linnaeus Amaryllidaceae. From George Nicholson. The illustrated dictionary of gardening. London, L. Upcott Gill, [1884–1889?]. Vol. 1.

*Ambrosia artemisiifolia* Linnaeus Asteraceae. From Nathaniel Lord Britton and Addison Brown. An illustrated flora of the northern United States and Canada. New York, C. Scribner, 1896–1898. Vol. 3.

*Ammi majus* Linnaeus Apiaceae. From Nathaniel Lord Britton and Addison Brown. An illustrated flora of the northern United States and Canada. New York, C. Scribner, 1896–1898. Vol. 2.

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Please note: This is an excerpt from the MEKA manual. Information in square brackets has been provided by us. If you are interested in the complete documentation and the two keys ANGIOFAM and TROPIFAM, please contact Dr. Thomas Duncan, University Herbarium, University of California, Berkeley, CA 94720 for ordering information.

# MEKA (VERSION 1.3)[1]
# MEKAEDIT (VERSION 1.3)

## A GENERAL PURPOSE MULTIPLE-ENTRY KEY ALGORITHM AND EDITOR

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MEKA is an interactive **M**ultiple-**E**ntry **K**ey **A**lgorithm that allows identification of an unknown specimen or the characterization of a group of taxa. The program MEKAEDIT allows users to make their own keys for access by MEKA. These programs are written in Turbo Pascal and run on microcomputers using PC-DOS operating systems that have at least 256k bytes of memory. We distribute the programs on an IBM PC-DOS formatted disk for running on IBM-compatible machines. Two keys to angiosperm families are included as examples of the application of these programs. The programs MEKA and MEKAEDIT can be copied and given to others as long as this distribution is not for profit. Because of copyright restrictions imposed by the Department of Botany of the British Museum (Natural History), we must maintain a roster of all recipients of ANGIOFAM. Please contact Duncan and Meacham at the above address for permission to copy ANGIOFAM. We would appreciate knowing about users who have received the program from another source, about other keys that have been developed, and about additional features that would be desirable. We will send users who are known to us information about updates to the programs and additional keys.

## DOCUMENTATION FOR MEKA

In order to attain flexibility, MEKA does not lead the user in a fixed, stepwise fashion through a series of questions to which the user must respond. Instead, the user can issue MEKA commands in any sequence. MEKA keeps track of the results of commands by maintaining lists of "active characters" and "active taxa." In order to understand how to use MEKA, it is necessary to understand how these lists influence MEKA commands and how MEKA commands alter the lists. It is true that this flexibility places a greater initial burden on the user who must know how to proceed without prompting from the program. After some experience with MEKA, we hope that the user will find that this approach enhances MEKA's utility.

Characters become active when they are used to key out a specimen. The user can add or delete characters from the list of active characters as desired. MEKA calculates the number of mismatched active characters for each taxon. For example, if we have indicated to MEKA that a given character state is present in a specimen and the data set shows that the character state is absent for a particular taxon, then that taxon is considered mismatched for that character. MEKA maintains a list of the number of mismatches for each taxon in the data set. The user causes taxa to become active by selecting sets of taxa on the basis of number of mismatched characters or by explicitly making them active without regard for [the] number of mismatches. MEKA allows the character states of active taxa to be listed in several ways. The lists of active characters and active taxa cause results of previous commands to influence the outcome of subsequent commands.

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STRUCTURE OF KEYS USED BY MEKA

A MEKA key consists of four disk files. One file contains text that describes the nature and source of the data, a second contains brief descriptions of the characters used in the key, a third contains the names of the taxa used in the key, and a fourth contains the data matrix arranged as characters by taxa. Additional details about the structure of these files are given below. The names of these files consist of the name of the key plus a three[-]letter extension that designates the type of file.

The character state of a single taxon can have one of four values in the data matrix file (.DAT). The value '+' indicates [the] presence of the character state in all members of the taxon, a '-' indicates the absence of that state from the taxon, a '*' indicates that the state is present in some but not all members of the taxon, and a '?' indicates that the condition of that state is not known for the taxon. Because of the nature of the original punched-card keys on which ANGIOFAM and TROPIFAM are based, these keys use only the states '*' and '-'.

CONTENTS OF THE STANDARD PC-DOS 5.25 INCH DISTRIBUTION DISKETTE

The PC-DOS distribution diskette is a double-sided, double-density (360k) 5.25 inch diskette that should be readable by PC-DOS systems that are version 2.0 or higher. These files are included:

| | |
|---|---|
| MEKA.COM | The executable MEKA program |
| MEKA.DOC | The documentation for MEKA |

COPYING MEKA TO YOUR SYSTEM

1. Dual floppy disk systems less than 360k bytes per diskette.

Use your operating system command to examine the directory of the master diskette. Use your operating system copy command to copy the files with [extension] .DAT to one diskette. Copy the remaining files to a diskette that contains the operating system so that you can boot your system using this second diskette.

2. Dual floppy disk systems with more than 360k bytes per diskette.

Use your operating system copy command to transfer all files from the master diskette to a single diskette that contains the operating system so that you can boot your system using this diskette.

3. Hard disk systems.

Use your operating system copy command to transfer all files to the user area or directory on the hard disk that you will use to run MEKA. If you are fortunate enough to have two hard disks, putting the '.DAT' file on a different disk will make disk access a bit faster.

RUNNING MEKA THE FIRST TIME

If you have a floppy disk system, place the diskette that contains the MEKA files and the operating system in drive A and log in [to] drive A. If two disks are required to hold all files, place the other diskette in drive B. If you have a hard disk, log in the user area or directory that contains MEKA and the data files. Type 'MEKA' to begin the program. If two diskettes are required to hold all the files, precede the name of the key to be used with a colon (':') so that MEKA prompts you for the drive that contains each of the four files for the key you wish to use, e.g. type ':ANGIOFAM' instead of 'ANGIOFAM'. At this point, MEKA is ready to access the key.

OVERVIEW OF THE USE OF MEKA

Most uses of MEKA fall into two main categories: (1) the identification of an unknown or (2) the characterization of a taxon or set of taxa. Before describing the specific commands, we outline each of these two tasks.





In the identification of an unknown specimen, the sequence of operations is: (1) develop a character list using the characters displayed by a specimen, (2) key out a specimen, (3) select taxa that match the characters chosen or lack one or more of these characters, (4) search data for other characters that separate candidate taxa, and (5) choose additional characters if needed.

In the characterization of a set of taxa, the sequence of operations is: (1) select a set of taxa for examination and (2) search data for characters uniformly present, absent, variable or unknown in this set of taxa.

COMMAND REFERENCE

This is a detailed description of the action of each MEKA command. An example of the usage of each command is given.

MC (MEKA Commands) or ? Example: 'MC' or '?'

MC or a question mark causes MEKA to display the following summary of MEKA command abbreviations to jog your memory:

AC, DC, LC, CC - Add, Delete, List, or Clear active characters
AT, DT, LT, CT - Add, Delete, List, or Clear active taxa
  AC, DC, AT, DT are each followed by a list of characters or taxon numbers; '-' following a character number indicates absence
KO - Key Out unknown
SS - Summarize Search
ST <n> - Select Taxa with <n> mismatches
CU, CP, CA, C? - Characters Uniform, Characters Present, Characters Absent, or Characters unknown in some active taxa
RS - ReSet program
MM <n> - [S]et Maximum Mismatches for search summary to <n>
LM - List Mismatched characters for active taxa
VT <n>, VC <n> - View Taxon or Character names beginning with number <n>
> - List the next 15 taxon names or character names
< - List the previous 15 taxon names or character names
NK <keyname> - New Key requested named <keyname>
OU <destination> - OUtput to be sent to <destination>
PA - PAuse after full screen; initially on
MC or ? - Meka Commands (this list)
QU - QUit program and return to the operating system

VC (View Characters) Example: 'VC 50'

VC causes MEKA to display the next fifteen character descriptions beginning at the current position in the character description list. If followed by an integer, as in 'VC 50', MEKA displays fifteen character descriptions beginning with number 50. After each display, the current position is incremented by fifteen so that the next time the command is issued, the next fifteen will be displayed. Active characters are indicated by a '+' or '-' after the character number. After VC is issued, the characters '>' and '<' cause MEKA to move forward and backward in the character description list and to display fifteen descriptions each time. The characters '>' and '<' display character descriptions until the next VT command is issued.

VT (View Taxa) Example: 'VT 50'

VT displays taxon names in the same fashion that VC displays character descriptions. Active taxa are indicated by a '=' after the taxon number. After a VT command is issued, '>' and '<' cause taxon names to be displayed until the next VC command is issued.

AC (Add Character) Example: 'AC 2 4/6 10- 13-/17-'

The AC command marks characters for use by the KO (Key Out) command, which will add the indicated characters to the list of active characters. The character numbers are entered on the same line as the AC command and are separated by blanks. To indicate a range of character numbers, use a slash to separate the first number in the range and the last number in the range. For example, '23/45' indicates all the characters from 23 to 45 inclusive. A minus sign ('-') following the character number is used to indicate that the character is absent. If a minus sign follows the character number, then the KO command will score a match for the character if a taxon has one of the states '-', '*', or '?'. If the taxon has the state '+', the KO will score a mismatch for that character. The character numbers do not need to be entered in numerical order.

DC (Delete Character) Example: 'DC 10 5 23/27'

The DC command marks characters for deletion from the list of active characters by the subsequent KO command. All mismatches that are scored for taxa based on the deleted character are removed when the KO command deletes the character. The character numbers do not need to be entered in numerical order.

KO (Key Out) Example: 'KO'

The KO command adds or deletes characters from the active character list according to any AC or DC commands that have been issued since the last KO command and updates the mismatch scores based on accessing the data matrix for each character. If the character state indicated in the AC command was '+', then every taxon with the state '-' has one mismatch added to its mismatch score. If the character state indicated in the AC command was '-', then every taxon with the state '+' has one mismatch added to its mismatch score. After performing this search of the data matrix, the KO command automatically invokes the SS (Summarize Search) function described below.

SS (Summarize Search) Example: 'SS'

The SS command summarizes the mismatch scores for all the taxa. It lists the number of taxa that exactly match, followed by the number of taxa that mismatch on one character, followed by the number of taxa that mismatch on two characters, and so on, up to the maximum number of mismatches (which may be changed by the MM command). If the number of taxa that match exactly is less than or equal to ten, then the taxa that match exactly are listed.

ST (Select Taxa) Example: 'ST 0'

The ST command is issued with one parameter, an integer between zero and the maximum number of mismatches, inclusive. ST lists all taxa with the number of mismatches specified by the integer and adds all of these taxa to the list of active taxa. The list of active taxa is not cleared by ST.

AT (Add Taxa) Example: 'AT 1 15 21/45'

AT adds taxa to the list of active taxa. The taxa are indicated by taxon number. Ranges of numbers are indicated by a slash.

DT (Delete Taxa) Example: 'DT 1 15 21/45'

DT deletes taxa from the list of active taxa. The taxa are indicated by taxon number. Ranges of numbers are indicated by a slash.

LC (List active Characters) Example: 'LC'

LC lists all active characters. The symbol '+' after the character number indicates that taxa with state '-' receive a mismatch for that character. The symbol '-' after the character number indicates that taxa with state '+' receive a mismatch for that character.





LT (List active Taxa) Example: 'LT'

LT lists all active taxa.

CC (Clear active Characters) Example: 'CC'

CC removes all characters from the list of active characters and resets the mismatch scores of all taxa to zero.

CT (Clear active Taxa) Example: 'CT'

CT removes all taxa from the list of active taxa.

RS (ReSet) Example: 'RS'

RS is equivalent to issuing CC followed by CT.

LM (List Mismatched characters) Example: 'LM'

LM lists, for each active taxon, the active characters that are mismatched. The symbol after the character number indicates the state of the character possessed by the taxon.

CU (Characters Uniform) Example: 'CU'

CU lists all characters for which all active taxa possess the same state. The symbol after the character number indicates the state that is possessed by all active taxa.

CA (Characters Absent) Example: 'CA'

CA lists, for each character that has the state '-' for some, but not all active taxa, the active taxa that have the state '-'.

CP (Characters Present) Example: 'CP'

CP lists, for each character that has the state '+' or '*' for some but not all active taxa, the active taxa that have either '+' or '*'. The symbol after the taxon number indicates the state of the character possessed by that taxon.

C? (Characters unknown) Example: 'C?'

C? lists, for each character that has the state '?' for some, but not all active taxa, the active taxa that have state '?'.

NK (New Key) Example: 'NK ANGIOFAM'

NK causes MEKA to access a new key. If all key files are on the default drive, simply giving the key name, as in 'NK ANGIOFAM', is sufficient. If all the files are on some other drive, indicating the drive in the standard fashion is sufficient, e.g. 'NK B:ANGIOFAM'. If the four key files are on different drives, then issuing the compound with just a colon in front of the key name will cause MEKA to prompt the user for the drive for each of the key files, e.g. 'NK:ANGIOFAM'.

OU (OUtput) Example 'OU LST:'

OU directs a copy of MEKA output to any valid filename or valid device name. The file or device name follows the command as in 'OU B:MEKAOUT'. To stop copying output, use the argument 'OFF' as in 'OU OFF'. The destination of the output can be changed as often as desired. 'LST:' is the default printer.

**Appendix**

PA (PAuse) Example: 'PA'

PA toggles pausing on and off. When pausing is on, MEKA stops writing output to the screen when the screen is full. Pausing is on by default when MEKA begins.

MM (Maximum Mismatches) Example 'MM 5'

MM sets the maximum number of mismatches that are summarized by the SS command. There is an upper limit that may vary depending on the copy of MEKA you have. If you try to set the maximum number of mismatches above this limit, you will be told what the limit is for your copy. Use 'MM 100' to discover the upper limit for your copy.

QU (Quit) Example 'QU'

QU causes MEKA to terminate execution.

FORMAT OF MEKA FILES

There are four MEKA files for each key. The key description file is a text file identified by the [extension] '.DES' that tells the user some basic information about the key such as the taxa, the source of date, the addresses of authors, etc. The other three files are Turbo Pascal random access files. In each of these three files, all records are the same length. There are no line feeds or carriage returns in these files.

The file identified by the [extension] 'CHR' is the character description file. Each record is 80 ASCII characters long. Each character description occupies just one record. The total number of bytes required for this file is eighty times the number of characters.

The file identified by the [extension] '.TAX' is the taxon name file. Each record is 40 ASCII characters long. Each taxon name occupies one record. The total number of bytes required for this file is forty times the number of taxa.

The file identified by the [extension] '.DAT' is the data matrix file. Each record is 40 ASCII characters long. Each ASCII character in the record corresponds [to] the character state of one taxon. The data is arranged by character in the same order as the character descriptions in the file '.CHR'. Within the data for one character, the character states for the taxa are arranged in the same order as the taxon names in the file '.TAX'. The data for one character occupies as many records as necessary. The first ASCII character on the first record for a particular character is the state of taxon number 1, the first ASCII character on the second record is the state of taxon number 41, etc. For example, the ANGIOFAM data set includes 411 taxa. This requires 11 records for each character. The eleventh record for each character contains the character state information for taxa 401 through 411. In this eleventh record, the twelfth through fortieth ASCII characters are blanks. The valid character states are the ASCII characters '+', '-', '*', and '?'. The state '+' (present) means that the character is found in all members of the taxon. The state '-' (absent) means that the character is found in no members of the taxon. The state '*' (variable) means that the character may be either present or absent in a member of the taxon. The state '?' (unknown) means that the condition of the character is not known for the taxon. The number of bytes required by this file can be calculated by determining the smallest multiple of forty greater than or equal to the number of taxa and multiplying this number by the number of characters.