

**FORENSIC ANALYSIS OF MARIJUANA AND THE
KURZMAN MYSTERY:
A CASE STUDY OF FLAWED LOGIC IN
DETERMINATION OF GUILT**

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Recent revelations concerning the number of innocent people our justice system has incarcerated and then found to be innocent by DNA analysis causes concern that our justice system may have an unacceptable error rate.¹ Why do we convict as many innocent people as we do? Aside from outright prosecutorial misconduct, failings of the defense bar to properly represent clients, flaws in eyewitness identifications, biased police lineups, and false confessions, we should also be naturally concerned with the inherent problems within crime laboratories.² The national media has exposed problems in crime laboratories all across the United States, from the crime laboratory of the Federal Bureau of Investigation, to local crime labs in Washington, Texas, Florida, and beyond.³ Determinations of innocence necessarily guide us to this question: If DNA has consistently lead to findings of innocence, then has the rest of forensic science found guilt when in fact innocence exists?

We need a model to ask and answer this question. We need a forensic technique, a protocol, that is easily understood and that has resulted in the conviction of hundreds of thousands of Americans. One such protocol is the forensic analysis of marijuana.⁴ We need to determine which protocol is being used to identify marijuana, and if this protocol is logical and valid. If there are flaws in the protocol, then we should determine how long these flaws have

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1. *E.g.*, D. Michael Risinger, *Innocents Convicted: An Empirically Justified Factual Wrongful Conviction Rate*, 97 J. CRIM. L. & CRIMINOLOGY 761, 763 (2007).

2. See Fredric Whitehurst, *Forensic Crime Labs: Scrutinizing Results, Audits & Accreditation—Part I*, CHAMPION, Apr. 2004, at 6, 6.

3. See *id.*

4. RYAN S. KING & MARC MAUER, *THE WAR ON MARIJUANA: THE TRANSFORMATION OF THE WAR ON DRUGS IN THE 1990S*, at 1-4 (2005).

existed, why we have not recognized them, and why our justice system could continue utilizing a flawed protocol without testing its validity. Utilizing this model, we can go beyond simple science and question the justice system's error rate. Can we discover methods to ensure valid forensic techniques, or at the very least, should we simply stop accepting the opinions of individuals in white laboratory coats and seriously review their work product?

I. CANNABIS, THE MODEL

The plant *Cannabis sativa*, also known as marijuana, presents unique issues in our justice system, especially regarding the identification of the substance by law enforcement officers as well as forensic crime laboratories.⁵ A review of the *Handbook of Forensic Drug Analysis* notes that “[t]he identification of marijuana or its chemical constituents has long been one of the most often performed analyses in the forensic drug laboratory. This includes analysis of the very common botanical samples, ranging from whole plants to finely chopped vegetation.”⁶ In 1972, John Thornton and George Nakamura presented an analytical protocol for the identification of marijuana, which requires microscopic analysis of botanical features as well as the Duquenois-Levine test, a chemical spot test,⁷ which is being used in most crime labs throughout the U.S. But what are we identifying with this protocol? In a 1969 paper, Nakamura noted that *Cannabis sativa* is classified as follows:

<i>Division:</i>	Spermatophyta (seed plants)
<i>Class:</i>	Angiospermae (flowering plants)
<i>Subclass:</i>	Dicotyledons (dicots); 31,874 species
<i>Order:</i>	Urticales (elms, mulberries, nettles, and hemp); 1,753 species
<i>Family:</i>	Cannabinaceae (hops and marijuana); 3 species
<i>Genus:</i>	<i>Cannabis</i>
<i>Species:</i>	<i>sativa</i> ⁸

Therefore, we are looking for a plant that (1) produces seeds, (2) has flowers, (3) is a dicotyledon, and (4) has some or all of the features of elms, mulberries, nettles, and hemp.⁹

5. See discussion *infra* Part I.

6. Charles Tindall et al., *Cannabis: Methods of Forensic Analysis*, in HANDBOOK OF FORENSIC DRUG ANALYSIS 43, 43 (Frederick P. Smith ed., 2005).

7. J.I. Thornton & G.R. Nakamura, *The Identification of Marijuana*, 12 J. FORENSIC. SCI. SOC. 461, 461 (1972); see also G.R. Nakamura, *Forensic Aspects of Cystolith Hairs of Cannabis and Other Plants*, *Drug Abuse Control*, 52 J. ASS'N OFFICIAL ANALYTICAL CHEMISTS 5, 5 (1969)

8. Nakamura, *supra* note 7, at 6.

9. See *id.*

We must start marijuana analysis with an understanding of the form in which the alleged marijuana presents itself to the analysts.¹⁰ Most submissions to forensic laboratories are in the form of crushed plant materials that no longer retain gross botanical features.¹¹ The crushed form of these submissions means law enforcement officers seize plant materials they recognize as marijuana despite the fact that it no longer retains identifying features.¹² This seizure, of course, depends upon the law enforcement officer's ability to determine that the sample is plant material.¹³ On the surface, believing that any individual could not determine that a plant is a plant seems ridiculous. We see plants every day and recognize them as trees, grass, ornamental flowers, and the ever present weeds in our gardens. On this level of understanding, we would most appropriately go to a dictionary to determine the definition of a plant not to a treatise on botany. *The American Heritage Dictionary* defines a plant as "[a]n organism of the vegetable kingdom, characteristically having cellulose cell walls, growing by synthesis of inorganic substances, and lacking the power of locomotion."¹⁴ So when a law enforcement officer seizes crushed plant material, we hope that the officer would refer to a standard, like the dictionary definition, when determining if a substance is plant material.

Can we determine from a field examination of crushed material if the seized material is composed of cells with cellulose cell walls? Well, not really. This determination requires at least a microscopic analysis as well as a chemical analysis.¹⁵ History books tell us about the excitement when newly invented microscopes detected the presence of the cellular structure of living matter. If we could not see those cells before microscopes came along, then how can the police officer on the street see those cells with the naked eye? The cellulose making up the walls of those cells requires a chemical analysis; therefore, how can a police officer determine the cell walls are composed of cellulose? And although the officer can determine if the material lacks locomotion (even parts of a dead animal or pieces of newspaper lack locomotion), the proper question is whether the seized material, when in its natural state, existed in an object that lacked locomotion? An officer cannot know that. The material is no longer in its natural state. Finally, can the law enforcement officer know whether the seized material grows by the synthesis of inorganic substances? The answer to this question, of course, is no. So how does the law enforcement officer know whether the seized material is a plant?

But suppose that by some method, the police officer can determine that the seized plant material is a plant. If Nakamura's classification of marijuana is correct, the next level of analysis determines if the seized material is a seed

10. See Tindall et al., *supra* note 6, at 45.

11. See Nakamura, *supra* note 7, at 5.

12. See Tindall et al., *supra* note 6, at 43-44.

13. See *id.*

14. THE AMERICAN HERITAGE DICTIONARY 948 (Margery S. Berube et al. eds., 2d College ed. 1982).

15. See Thornton & Nakamura, *supra* note 7, at 461.

plant (i.e., a spermatophyte).¹⁶ My own law enforcement experience in the investigation of marijuana cases has shown that marijuana samples are often accompanied by what appear to be seeds. But are these objects really seeds? How do we determine that? Do we plant the seeds to see if they grow? Do we open them up to see if there are two halves (two cotyledons) and the tiny beginnings of a plant?¹⁷ Even if we can determine whether these seeds are present, how do we know that they are seeds of *Cannabis sativa*? How do we differentiate these seeds from any other seeds?

Assume, however, that we have answered the plant material and seed questions. Next, we must ask if the seized seed plant has flowers (i.e., is an angiosperm).¹⁸ To answer, we must know what a flower is, the different parts of flowers, the kinds of flowers growing in a marijuana standard, and if the flowers seen in marijuana are like flowers in any other kind of plant. Just because marijuana flowers have particular features, one cannot assume that no other plants have flowers with the same features.¹⁹ Because the form of most marijuana samples seized is crushed plant material there may be difficulty in determining whether these crushed flowers are identical to marijuana flowers.²⁰

Now suppose that we can determine that we have plant material with seeds and flowers. Do we then know whether they are dicotyledons? Anyone who has ever planted a bean, a watermelon seed, or a peanut knows what a cotyledon is. Those first little fat leaves from the seed itself are the cotyledons,²¹ and plants that have two cotyledons are referred to as dicotyledons.²² We see these seed leaves and initially wonder what we have planted and why it looks so different from what we expected from our planting project. But soon those cotyledons give way to tiny little leaves and our plants grow up to look like we expected. At one time there were 31,874 known dicotyledons.²³ Because marijuana is one of these dicotyledons, the real question becomes: can the naked eye of a drug analyst or police officer determine that the crushed flower-producing seed is a dicotyledon?²⁴ Without careful scrutiny, this cannot be determined.²⁵ Though a trained botanist might

16. *Id.* at 495-96.

17. A cotyledon is "an embryonic leaf in seed-bearing plants, one or more of which are the first leaves to appear from a germinating seed." THE NEW OXFORD AMERICAN DICTIONARY 385 (Erin McKean ed., 2d ed. 2005).

18. See *supra* note 8 and accompanying text.

19. See generally Robert F. Thorne, *How Many Species of Seed Plants Are There?*, 51 TAXON 511 (2002) (discussing the numerous types of seed plants).

20. See Thornton & Nakamura, *supra* note 7, at 495.

21. See *supra* note 17 (defining cotyledon).

22. See THE NEW OXFORD AMERICAN DICTIONARY, *supra* note 17, at 470 (defining dicotyledon).

23. See Nakamura, *supra* note 7, at 6.

24. See Thornton & Nakamura, *supra* note 7, at 495 (discussing the difficulty of identifying crushed plants).

25. See Tindall et al., *supra* note 6, at 48 (discussing the difficulty of identifying marijuana).

be able to discern that a plant is a dicotyledon, “most seized drug analysts are not trained as botanists.”²⁶

Now suppose that we have plant material that has seeds and flowers and is a dicotyledon. Because there are many dicotyledons, we must discern proper marijuana plants from other dicots.²⁷ A further subdivision of dicotyledons, an order named urticales, contains 1,753 species of elms, mulberries, nettles, and hemp.²⁸ Therefore, can the law enforcement officer determine from examining crushed plant material in a baggy if the material originated from a plant in the order urticales?

Now put this paper down and take a break. Go into your back yard and look at the types of plants you see. Look at the myriad of different leaves, shapes, plants, and even weeds. You might be looking at 100 species of plants right now. Take some of those leaves into your office and let them dry for a week or two. Then crush them up. Can you now differentiate those leaves in their crushed form just by looking at them, and can you tell which plant you took them from?

Leaves are classified according to leaf orientation, organization, shape, margin, texture, gland position, petiole, types of venation, and elements of tooth architecture.²⁹ Looking at the form of leaf margin, we see classification concepts including entire, lobed, toothed, crenate, erose, revolute or enrolled, sinuses, spacing, and series.³⁰ Without even defining the meaning of any one of these, we can ask ourselves whether the plants being examined fit into the classification scheme. To do so, we need to know how the leaves appeared before they were crushed up and prepared for distribution. Yet this information may be unavailable, so how can we say we are looking at marijuana?

If we have found that the material is a seed-bearing, flower-producing dicotyledon, and has the characteristics of those plants in the order urticales, then we may further ask about the description of the flowers. We know from our experience of simply looking into our gardens that all flowers were not created equally. Day lilies certainly look different than roses. Thus, we can assume that the flowers of marijuana are different from other plants' flowers. Professor Herman E. Hayward's treatise, *The Structure of Economic Plants*, provides a seemingly exhaustive description of the inflorescences of marijuana: “[a]lthough hemp is disecious, it is not uncommon for an individual plant to bear both staminate and caepellate flowers.”³¹ So, have we seen evidence of either staminate or carpellate flowers in the crushed material that the law enforcement officer has presented as marijuana?

26. *Id.* at 48.

27. See Nakamura, *supra* note 7, at 6 (noting the variety of dicotyledons).

28. See, e.g., *id.*

29. Leo J. Hickey, *A Revised Classification of the Architecture of Dicotyledonous Leaves*, in 1 ANATOMY OF THE DICOTYLEDONS 25, 28-30 (C.R. Metcalfe & L. Chalk eds., 2d ed. 1979).

30. *Id.* at 28-29.

31. HERMAN E. HAYWARD, *THE STRUCTURE OF ECONOMIC PLANTS* 217 (1938).

Additionally, “[t]he staminate flowers develop in small, drooping, branched panicles, which arise in the axils of foliage leaves . . . [t]he flowers of the panicle may occur singly on slender pedicels or in groups, and usually the terminal branches bear three flowers”³² Do we see drooping branched panicles, located in the axils of foliage leaves, and if we do not, then can we say with any certainty that we are either looking at or have identified this material as marijuana? And do the flowers of the panicle occur singly on slender pedicels or do they occur in groups?

And further, “[t]he individual flowers are apetalous with a deeply parted calyx having five greenish-yellow or red lobes that are widespread at maturity.”³³ Have we seen the apetalous flowers with a deeply parted calyx that have five lobes, either greenish-yellow or red, that are widespread at maturity?

And further, “[t]he oval sepals are acuminate, the outer surface and margins being covered with multicellular glands and slender, pointed unicellular hairs with crystals of calcium oxalate deposited in their swollen bases. The inner epidermis is practically devoid of hairs and stomata which are present in the outer epidermis.”³⁴ Has the law enforcement officer who identified the green leafy material as marijuana (or even the forensic lab examiner) been able to determine if the oval sepals are acuminate with the outer surface and margins covered with multicellular glands in addition to slender pointed unicellular hairs with crystals of calcium oxalate deposited in the swollen bases? Has anyone in the identification process even determined the presence of calcium oxalate?

So far, in order to determine if we have marijuana, we need to know if we have plant material, if that material is from seed-bearing and flower-bearing dicotyledonous plants of the order urticales, and if the botanical features of marijuana described by Hayward are identified. An alternative method involves determining if marijuana has unique characteristics that set it apart from the universe of plants on earth.³⁵ Obviously *Cannabis sativa* is unique as a species, or we would not have called it a plant species. In the 1970s, the issue of whether the genus *Cannabis* was composed of a number of different species came to the attention of the legal community when debating whether legal statutes properly proscribed the possession and distribution of all species of *Cannabis* or simply *Cannabis sativa*. The arguments were rendered moot by legislators and will not be discussed here. We will merely ask whether one can identify *Cannabis sativa* to the exclusion of all other plants by (1) utilizing the protocol suggested by Nakamura and Thornton and recommended by others,³⁶

32. *Id.* at 218.

33. *Id.*

34. *Id.* at 219.

35. *See id.* at 214-15 (describing the various species of the genus *Cannabis*).

36. The Scientific Working Group for the Analysis of Seized Drugs (SWGDRUG) notes the use of both macroscopic and microscopic examinations of cannabis only as methods of analysis in its February 2006 report. SCIENTIFIC WORKING GROUP FOR THE ANALYSIS OF SEIZED DRUGS (SWGDRUG),

or (2) simply looking at the material and comparing it to one's memory of marijuana seen at the police academy some number of years ago during training, as seems to be the trend in the justice system at this time.

II. THE PROTOCOL

Nakamura's 1969 paper presented a protocol for analysis of seized alleged marijuana samples as follows:

A leaf specimen (100 mg sample) was macerated in 25 ml petroleum ether, filtered into a beaker, evaporated to dryness without heating, and tested by the Duq. L test as described by Butler.

For morphological examination, leaf specimens were studied under stereoscopic binoculars, 10 to 50X, and a simple compound microscope, 50-100X; 50-100: the subject was illuminated with narrowly directed reflected light of "Flexilight" unit (Iota-Cam Corp., 28 Teal Rd., Wakefield, Mass.) which is capable of producing 3,000-11,000 candle powers.

Photomacrography was conducted through a 16 mm Zeiss Luminar lens mounted on a 35 mm Leica by aid of Visoflex reflex and bellows attachments. Kodak Panatomic film was used. Unless otherwise indicated, all prints were enlarged to a final 60X magnification for all specimens to provide a size comparison.³⁷

The analysis is that simple. Nakamura further notes that "[s]ince most marijuana examined in forensic laboratories is crushed and no longer retains gross botanical characteristics, the presence of cystolith hairs on leaf fragments has been used as the principal criterion for morphological identification."³⁸ What are these cystolith hairs described here? A cross section of a marijuana leaf will reveal the presence of bear-claw-shaped hairs on the top surface of the leaf as well as clothing hairs on the bottom of the leaf.³⁹ The bear claws should also have large areas containing amorphous (noncrystalline) calcium carbonate in their base.⁴⁰ Some of the clothing hairs will also have cystoliths that are smaller than the cystoliths in the bear claws. Though not exactly like the image

RECOMMENDATIONS 14 (2d ed. 2006), available at http://www.swgdrug.org/OLD/SWGDRUG%20Recommendations_080907.pdf

The United Nations' 1987 pamphlet *Recommended Methods for Testing Cannabis, Manual for Use by National Narcotics Laboratories* recommends the examination of macroscopic and microscopic features of suspected marijuana as well as the use of the Duquenois-Levine test. DIVISION OF NARCOTIC DRUGS, UNITED NATIONS, RECOMMENDED METHODS FOR TESTING CANNABIS: MANUAL FOR USE BY NATIONAL NARCOTICS LABORATORIES 19-23, 26 (1987), available at http://www.unodc.org/pdf/publications/report_cannabistest_1987-02-01_1.pdf.

37. Nakamura, *supra* note 7, at 6 (footnote omitted).

38. *Id.* at 5.

39. DRUG ANALYSIS BY CHROMATOGRAPHY AND MICROSCOPY 126 (Egon Stahl et al. eds., 1973); see *infra* fig. 1.

40. DRUG ANALYSIS BY CHROMATOGRAPHY AND MICROSCOPY, *supra* note 39.

in Figure 1, Figure 2 shows a bear claw on the upper surface of the leaf and longer hairs on the bottom surface of the leaf.⁴¹

Figure 1: A photomicrograph of a cross section of a marijuana leaf.⁴²

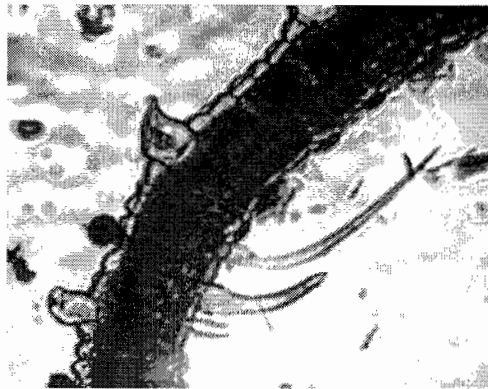
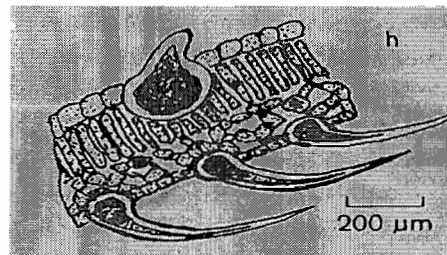


Figure 2: A cross section of a marijuana leaf.⁴³



The aim of the forensic analyst is to observe these features through observations, through microscopic analysis of a suspected marijuana leaf, or through simply microscopically observing the top and bottom of the leaf.⁴⁴ Nakamura notes the importance of microscopic examination:

Only after a studied examination, under high magnification, can the cystolith hairs of marihuana be tentatively identified. Microscopic identification of marihuana, therefore, depends not only upon the presence of cystolith hairs but on its association with the longer clothing, or nonglandular hairs, on the other side of the leaf, and if present, the fruits and their hulls, the glandular

41. *Id.*

42. This photomicrograph was taken by the author.

43. See DRUG ANALYSIS BY CHROMATOGRAPHY AND MICROSCOPY, *supra* note 39.

44. See Nakamura, *supra* note 7, at 15.

hairs, and the flowering tops as set forth in U.S. Treasury Department Manual. The Duq. L test should be used in final confirmation.⁴⁵

Nakamura's dependence upon not only the cystolithic hairs, but also, if present, the fruits, hulls, glandular hairs, and flowering tops is troubling to the analyst who is left with a choice of a protocol without clear parameters. Who will define a protocol in which the minimum characteristics that need to be detected are clearly described? Do we need to see the fruits, hulls, glandular hairs, and flowering tops, or can we simply stop with the cystolithic hairs?

III. ANALYSIS OF THE PROTOCOL

Critical review of Nakamura's paper leads one to question his numerical data. The number of dicotyledons, 31,874, is a particularly intriguing figure. Nakamura cites the authors Solereder, Metcalfe, Chalk, and Hayward when discussing this figure.⁴⁶ A review of Solereder's book immediately reveals that it was written in 1908.⁴⁷ If Solereder's information is the basis for the number of dicotyledons noted by Nakamura, then one must wonder if botanists have discovered any new dicotyledons in the past one hundred years. Solereder's book was not the principal source of the number of dicotyledons but rather of discussions concerning the antagonistic relation between the size of cystoliths and the size of the hairs in which they are found.⁴⁸ This is useful information when examining bear claws and clothing hairs, which vary in length, but it does not help determine the origin of the number 31,874.

Hayward's book also does not provide a clue as to where Nakamura came up with his figure, but it does give us a very in-depth description of the complete marijuana plant.⁴⁹ Hayward wrote the book in 1938⁵⁰ during the Great Depression, which begs the question as to how many resources he actually had at his disposal during that time to thoroughly investigate *Cannabis sativa*.

Both editions of Metcalfe and Chalk's *Anatomy of Dicotyledons* provide a list of plant families in which certain diagnostic features occur.⁵¹ The book lists, in particular, the families of plants that contain simple (unbranched) short

45. *Id.* at 16 (footnote omitted).

46. *See id.* (listing references upon which his paper relies).

47. HANS SOLEREDER, SYSTEMATIC ANATOMY OF THE DICOTYLEDONS: A HANDBOOK FOR LABORATORIES OF PURE AND APPLIED BOTANY (D.H. Scott ed., L.A. Boodle trans., 1908).

48. *See id.* at 11-12. The bear claws are shorter than the clothing hairs and have larger cystolithic deposits in them. *Id.* at 11.

49. *See generally* HAYWARD, *supra* note 31, at 214-45 (describing the general morphology of *cannabis sativa*).

50. *See id.*

51. *See* R.C. METCALFE & L. CHALK, ANATOMY OF DICOTYLEDONS: LEAVES, STEM, AND WOOD IN RELATION TO TAXONOMY 1326-59 (1st ed. 1950); *List of Families in which Certain Diagnostic Features Occur*, in 1 ANATOMY OF THE DICOTYLEDONS, *supra* note 29, at 190-221.

hairs, as well as those which contain simple long hairs.⁵² We can reasonably infer that Metcalfe and Chalk were the original source from which Nakamura derived his number of dicotyledons. Nakamura probably cross referenced those plant families that had both types of hairs, determined the number of species in each family, and added up those numbers. But Metcalfe and Chalk published their first edition in 1950,⁵³ so one must question the thoroughness of information given that it is over fifty years old. Possibly more dicotyledons have been discovered and classified since then.

So how many dicotyledons are known today? Is it still 31,874, or have scientists discovered more species? Robert F. Thorne reports that there are 199,350 known species of dicotyledons.⁵⁴ Thorne also notes the disagreement within the scientific community concerning the size of this number but cites other researchers as proffering numbers of flowering plants between 200,000 and 400,000.⁵⁵ Obviously, botanists have been rather busy in the past fifty years, and many more flowering plants have been discovered and classified. What does this mean for identifying marijuana based on its botanical features and for the reaction of a plant to the Duquenois-Levine test? Nakamura responds with the following:

Representative species that bear cystolith hairs or hairs accompanied by independent calcified growth in the leaf, most of which are similar in structure to those of *Cannabis*, are listed below. (No attempt was made to prepare a comprehensive listing because of the sheer magnitude of the task of examining 31,874 dicotyledons)⁵⁶

Nakamura microscopically examined 600 of the 31,874 dicotyledons and found that he could not differentiate eighty-two of those using his microscope.⁵⁷ He then subjected those eighty-two to the Duquenois-Levine test and found that only one of them gave a positive for marijuana—the marijuana itself.⁵⁸ But Nakamura admitted that the “sheer magnitude” of examining all known dicotyledons prohibited him from examining them all.⁵⁹ We are then left without really knowing how many plants other than the 600 microscopically examined would have given false positive results for the presence of marijuana. Nakamura’s paper is as unclear about this as the 1972 paper by Nakamura and Thornton.⁶⁰

52. See METCALFE & CHALK, *supra* note 51, at 1326-29 (listing types of hair); *List of Families in which Certain Diagnostic Features Occur*, *supra* note 51, at 190-93.

53. METCALFE & CHALK, *supra* note 51.

54. Thorne, *supra* note 19, at 511.

55. *Id.*

56. Nakamura, *supra* note 7, at 15.

57. *See id.* at 5.

58. *See id.* at 5, 15.

59. *Id.* at 15.

60. *See id.* at 5, 15; Thornton & Nakamura, *supra* note 7, at 15.

The number of possible alternative plants that may have cystolithic hairs of the same description as marijuana has expanded significantly.⁶¹ If we were to apply the same analytical scheme to the 199,350 plants proposed by Thorne,⁶² what would be the result? I have found nothing in the forensic or scientific literature that discusses this issue. Papers that exist assume that the only plant that will give a positive test for marijuana using the Nakamura/Thornton protocol is marijuana.⁶³ When we identify marijuana we declare that the features seen and the data collected is unique to marijuana to the exclusion of all other plants.⁶⁴ Can we say that today? Can law enforcement officers without any training, experience, or education in botany—not to mention the taxonomic features of plants—say that what they are seeing in the seized evidence is marijuana to the exclusion of all other plants? Can forensic lab examiners, after having detected the presence of bear claws and clothing hairs on leaf surfaces, and then subjecting the material to the Duquenois-Levine test, say that those tests uniquely identify marijuana to the exclusion of all other plants? According to Thorne there are 199,349 other plants that share characteristics with marijuana.⁶⁵ Have we tested all of them?

Let's consider what that testing would entail. First, we need to acquire the plant specimens themselves, which is not a simple task. This requires travelling to an arboretum, or a number of them, and asking for specimens of plants whose leaves have hairs similar to those found on marijuana leaves. We need to know the names of those specimens so that they are easy to locate. Then we have to microscopically analyze each of those plants that have been determined to have long and short single-celled nonglandular hairs.⁶⁶ Although Nakamura microscopically tested 600 of 31,874 dicotyledons based on the classification of Metcalfe and Chalk,⁶⁷ that does not mean that we would necessarily test 600, 6,000, or 60,000. We cannot infer that simply because we have expanded our database by a factor roughly of six that we will then have to microscopically analyze six times 600 species, or 3,600 species. We just will not know the number of plants that we must analyze until we find which new species have those hairs.

The analysis also entails the use of the Duquenois-Levine test, which gives rise to another level of complexity.⁶⁸ At approximately the same time that Nakamura and Thornton were publishing their study of marijuana analysis, Fochtman and Winek of the Toxicology Department of the Allegheny County (Pa.) Coroner's Office published a note concerning marijuana testing and the

61. See Thorne, *supra* note 19, at 511.

62. *Id.*

63. See Thornton & Nakamura, *supra* note 7, at 461-65.

64. See Nakamura, *supra* note 7.

65. Cf. Thorne, *supra* note 19, at 511 (noting the number of dicotyledons).

66. See Nakamura, *supra* note 7, at 6.

67. *Id.* at 5.

68. See *infra* text accompanying notes 83-87.

Duquenois-Levine test.⁶⁹ Although the Duquenois-Levine test had been used routinely over the past several decades, Fochtman and Winek recommend that identification be made after the use of microscopic and chemical analysis because of the importance of positive identification of marijuana.⁷⁰ They recommend the use of a thin layer chromatography or gas chromatography for the positive identification of the cannabinoids in marijuana and specifically advised that “[t]he microscopic and Duquenois-Levine chemical test should be used as a screening method only.”⁷¹

C.G. Pitt, working under a grant from the Law Enforcement Association Agency and the State of North Carolina, also agrees with Fochtman and Winek regarding the need for chromatographic testing:

In conclusion, it is believed that if the criteria for a positive Duquenois test are rigorously adhered to, and botanical evidence is also available, then the Duquenois color test is a reliable screen for cannabinoids. However if botanical evidence is not available, the ubiquitousness of phenols in nature and their diversity of structure makes it mandatory to supplement the colorimetric test with chromatographic evidence. This conclusion is substantiated by [Fochtman’s recent report] that certain commercial brands of coffee give a positive Duquenois-Levine color test.⁷²

Thornton and Nakamura seem to disagree with these conclusions regarding chromatographic testing.⁷³ They note that “although a rigorous identification of the marijuana plant may be effected through an examination of its botanical characteristics, it is generally considered advisable to perform a chemical test in most instances, and necessary to perform it in others.”⁷⁴ While they go on to note that “the Duquenois test, the most widely used chemical test, is a somewhat enigmatic reaction whose mechanism is poorly understood,” one is led to believe that the protocol can be used to rigorously identify marijuana.⁷⁵ They did not, however, address the issue of possible false positives.⁷⁶

The theme of identity continues through the paper of Hughes and Warner, Drug Enforcement Administration chemists with the Mid-Atlantic Regional Laboratory in Washington, DC.⁷⁷ Despite testing a limited number of materials

69. Fredrick W. Fochtman & Charles L. Winek, *A Note on the Duquenois-Levine Test for Marijuana*, 4 CLINICAL TOXICOLOGY 287, 287-89 (1971).

70. *Id.* at 288-89.

71. *Id.* at 289.

72. C.G. Pitt et al., *The Specificity of the Duquenois Color Test for Marijuana and Hashish*, 17 J. FORENSIC SCI. 693, 699 (1972) (footnotes omitted).

73. *See generally* Thornton & Nakamura, *supra* note 7 (discussing the benefits of chemical analysis on cannabis samples).

74. *Id.* at 461.

75. *Id.* at 462.

76. *See id.* at 461-62 (failing to discuss the problem of false positive outcomes with the Duquenois-Levine test).

77. R.B. Hughes & V.J. Warner, *A Study of False Positives in the Chemical Identification of Marihuana*, 23 J. FORENSIC SCI. 304 (1978).

and presenting no data concerning the number of possible chemicals one might find in the plant kingdom, Hughes and Warner, with a flair for the ipse dixit, note that “if glandular, clothing, and unicellular cystolithic hairs are present then either a modified Duquenois-Levine test or TLC when sprayed with Fast Blue B salt are positive evidence that cannabis is present in the sample.”⁷⁸ They do not say that cannabis is conclusively present, just that the test results are positive evidence that cannabis is present.⁷⁹ This is akin to saying that because my car has four tires there is positive evidence that my car was involved in the bank robbery where a car with four tires was used as a get-away vehicle.

The myth involving the infallibility of the Duquenois-Levine test is passed on in such papers as that written by Coutts and Jones. They cite Pitt as stating that “[f]ew, if any, other plant products react identically in the Duquenois-Levine test.”⁸⁰ Without reading the Pitt paper, we would be left with the impression that we had the solution to this identification issue. We would not know of the pitifully small number of samples Pitt actually tested, nor would we have any idea of the significance of the number of chemicals found in plants.⁸¹

IV. THE KURZMAN MYSTERY

This critique of marijuana testing follows Marc G. Kurzman and Dwight S. Fullerton’s paper, *Winning Strategies for Defense of Marijuana Cases: Chemical and Botanical Issues*.⁸² For any scientist, the title of this paper alone is a strong warning that the contents are biased, are meant as winning strategies, and may be suspect. But this long and detailed treatise lays out the fundamental flaws in the classical forensic marijuana analytical scheme so clearly that even lay readers can understand.⁸³ This paper is not a trick to be played on unprepared prosecutors and triers of fact but instead is actually a thorough study of the problem.⁸⁴ Because Kurzman wrote his paper in 1975, it would seem that the use of the hairs on marijuana leaves and the purple alchemy of the Duquenois-Levine test would have long since been successfully challenged and would no longer be useful as evidence in courts of law.⁸⁵ At the very least, one would hope that the original experimental design proposed by Nakamura would be revisited, and that a proper analysis would be conducted of

78. *Id.* at 309. Hughes and Warner limited their study to those substances reported to give a positive response for marijuana under various tests, such as the Duquenois-Levine test. *Id.* at 304

79. *See id.*

80. R.T. Coutts & G.R. Jones, *A Comparative Analysis of Cannabis*, 24 J. FORENSIC SCI. 291, 291 (1978) (citing Pitt et al., *supra* note 72, at 693-700).

81. *See* Pitt et al., *supra* note 72, at 694-99.

82. M.G. Kurzman & D.S. Fullerton, *Winning Strategies for Defense of Marijuana Cases: Chemical and Botanical Issue*, 1 NAT’L J. CRIM. DEF. 487, 522-31 (1975).

83. *See generally id.* (giving a comprehensive look at the successful acquittals of marijuana possession cases, the methods which identify cannabis, the inconsistencies in the law, and forensic analyses).

84. *See id.* at 489.

85. *See id.* at 518, 522.

the over 250,000⁸⁶ flowering plants known at this time. But this has not happened. In fact, many jurisdictions still only conduct microscopic analysis and chemical tests.⁸⁷ In some jurisdictions, identification is even carried out by law enforcement officers with no more than visual analysis, and suspected marijuana is never even sent to a crime lab.⁸⁸ The issue that we are left with in this mystery is stated so well by Tobin and Thompson:

[T]he next step for assessment of forensic significance involves estimation of probabilities for determination of probative value. As noted earlier, there are two crucial questions: (1) how likely are the observed results if the samples had a common source; and (2) how likely are the observed results if the samples did *not* have a common source?⁸⁹

A review of the scientific literature concerning the identification of marijuana by utilizing microscopic analysis of cystolithic hairs on alleged marijuana leaves, as well as the chemical test known as the Duquenois-Levine test, reveals that the validity of the results is unknown if we do not know whether the samples did or did not have a common source.⁹⁰ There has not been enough basic research nor was the protocol properly validated as time went on.⁹¹ The Kurzman mystery here is simple: why is this protocol still being utilized to decide whether human beings should be confined to cages and at times, to death chambers?

V. SUMMARY

In 1969 and 1972, George Nakamura and John Thornton published scientific papers that were based on good logic, employed a disciplined approach to a very real problem, and offered a good protocol for the analysis of marijuana.⁹² That protocol depended upon the knowledge available to them at the time.⁹³ Neither Nakamura nor Thornton was a botanist; however, their logic was correct. They were attempting to identify crushed up plant material as marijuana to the exclusion of all other dicotyledon plants.⁹⁴ Dr. Nakamura's review of the scientific literature revealed the presence of 31,874

86. See Thorne, *supra* note 19, at 511.

87. See Paul Giannelli, *Expert Testimony and the Confrontation Clause*, 22 CAP. U. L. REV. 45, 57-58 (1993).

88. M.D. Blanchard & G.J. Chin, *The Enemy in the War on Drugs: A Critique of the Developing Rule Permitting Visual Identification of Indescript White Powder in Narcotics Prosecutions*, 47 AM. U.L. REV. 557, 588-89 (1998).

89. William A. Tobin & William C. Thompson, *Evaluating and Challenging Forensic Identification Evidence*, CHAMPION, July 2006, at 12, 17.

90. See *id.*

91. See *id.*

92. See Nakamura, *supra* note 7.

93. See *id.*

94. See Thornton & Nakamura, *supra* note 7, at 461.

dicotyledons.⁹⁵ After determining that there were 600 dicotyledons that had trichomes on the surfaces of the leaves, he microscopically observed those 600 plants but could not microscopically differentiate eighty-two of them.⁹⁶ He then applied a chemical test which resulted in only one plant, *Cannabis sativa*, of the 31,874 considered, passing through the sieve of his protocol.⁹⁷

In 1975, Marc Kurzman and coauthors published a critical review of the Nakamura/Thornton papers that has essentially been ignored by the legal and scientific community.⁹⁸ This gave courts the answer to a vexing problem, but courts did not question the validity of the Nakamura/Thornton protocol. Though a number of other authors have noted issues with the original protocol, forensic crime laboratories across the United States continue to use the original Nakamura/Thornton protocol to identify marijuana.⁹⁹ Questions about validity were not dealt with in such a manner that the protocol was serviced.¹⁰⁰ Servicing would have required newly discovered plant species to undergo the Nakamura/Thornton protocol to determine if they passed the gauntlet of microscopic and chemical analyses resulting in false positives.¹⁰¹ But this never happened.

Considering the marijuana identification problem as a model leaves us with another question: Has anyone ever established an effective mechanism within the justice system to determine if scientific protocols used to determine the truth are actually valid? Unless we know if we are getting the right answers from scientific laboratories, how will we know if we are convicting the innocent based on flawed scientific evidence? When our answer to this question is that defendants in courts of law are allowed to review the evidence against them to stop flawed scientific evidence from being admitted in court, then the naiveté of the court system is exposed. Judges and lawyers without scientific credentials have obviously failed to detect serious flaws in crime laboratories as long as crime labs have existed.¹⁰²

The model presented by forensic marijuana analysis in our attempt to understand how innocent citizens can be convicted of crime is clear.¹⁰³ We are

95. See Nakamura, *supra* note 7, at 6.

96. See *id.* at 5.

97. See *id.*

98. See Kurzman & Fullerton, *supra* note 82.

99. See generally *id.* (discussing methods and inconsistencies in the identification and law of marijuana).

100. See *id.*

101. See *id.* at 488-92 (discussing proper procedures for testing protocols).

102. See *id.* at 488.

103. Ryan King and Marc Mauer report the recent marijuana statistics in their treatise:

Of the 450,000 increase in drug arrests during the period 1990-2002, 82% of the growth was for marijuana, and 79% for marijuana possession alone;

Marijuana arrests now constitute nearly half (45%) of the 1.5 million drug arrests annually;

Few marijuana arrests are for serious offending: of the 734,000 marijuana arrest in 2000, only 41,000 (6%) resulted in felony conviction

KING & MAUER, *supra* note 4.

arresting vast numbers of citizens for the possession of a substance that we cannot identify by utilizing the forensic protocol that is presently in use in most crime labs in the United States.¹⁰⁴ We have no idea what the error rate of marijuana analysis is despite professed concerns of our justice system for fairness and a need to determine the probative value of evidence put before it. Do we really care about innocence?

104. See generally Kurzman & Fullerton, *supra* note 82 (discussing methods and inconsistencies in the identification and law of marijuana).