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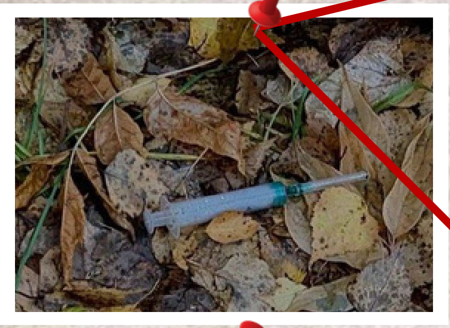

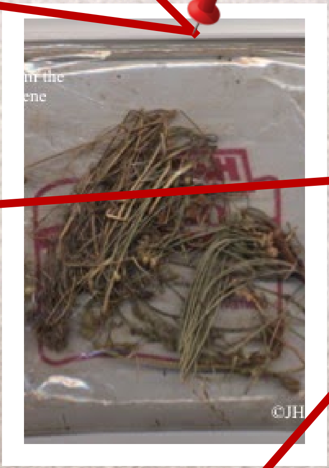

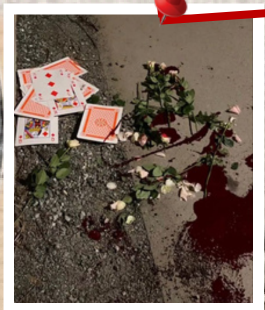

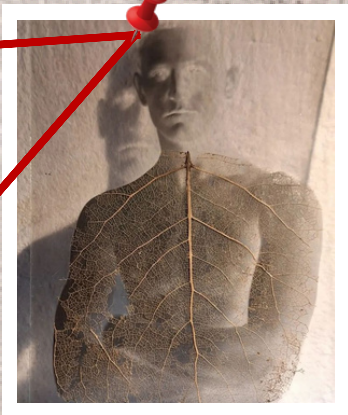

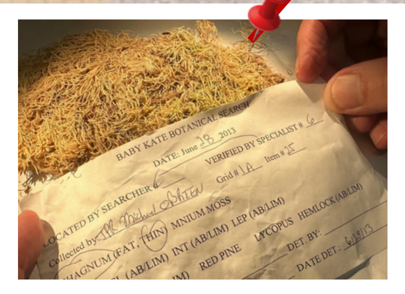

FORENSIC BOTANY

Verdict : FLORA

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1. The Science of Forensic Botany

The Role of Plants in Criminal Investigation

-Gargi

A crime scene is never really empty. Footprints get wiped away. Fingerprints get gloved over. But the plants stick around, and they don't forget anything. That's more or less the whole idea behind forensic botany: using plants and fungi to help crack criminal cases. Sounds a little far-fetched at first, but think about how plants actually work. They're rooted in one spot, they're everywhere, and they pick up traces of whatever brushes past them. Someone can swear up and down they were never near a scene, and then a seed turns up stuck to their sock, or pollen shows up on a jacket sleeve they haven't washed, or there's sawdust from a workshop floor caught in a shoe tread. None of it looks like much on its own. Small stuff, easy to miss. But get it under a microscope, or run it through a sequencer, and suddenly it's talking. It won't convict anyone by itself, usually. What it does is close gaps, tie a person or an object to a place, and help investigators build out a timeline of what happened.

History of Forensic Science

This didn't start as a real scientific field until the late 1800s. Before that, nobody was looking at the weeds around a body and thinking "evidence." **Hans Gross**, an Austrian criminologist, was one of the first to write it down, in his 1893 textbook *Handbuch für Untersuchungsrichter als System der Kriminalistik*. Edmond Locard, working in France not too long after, actually put it into practice, cracking real cases with mud, a handful of leaves, and a magnifying glass. Nothing fancy. It sat mostly on the margins for decades after that. Then, almost by accident, one of the most notorious crimes of the century dragged it into the spotlight. When investigators pulled a homemade ladder from the scene of the **1932 Lindbergh kidnapping**, they brought in Arthur Koehler, a wood expert, to look it over. Koehler traced one part of that ladder, painstakingly, ring by ring, back to a specific floorboard sitting in the suspect's own attic. Tedious work. Borderline obsessive, honestly. But it worked, and it proved something courts hadn't fully accepted before: a scrap of wood could hold as much weight as a fingerprint.

Pollen of *Avena fatua* (Source: Royal Botanical Gardens, Kew, Rob Kesseler).

Subdisciplines of Forensic Botany

Nobody really practices "forensic botany" as one single skill. It splits off into smaller, oddly specific specialties, and each one leans on a totally different kind of evidence.

Take **palynology**, which is just the study of pollen and spores. These grains are tiny, produced by the millions, and coated in a shell that can survive almost anything nature throws at it. Different areas, different seasons, different pollen mixes. That variation is basically a fingerprint, and experts can use it to figure out where somebody's been, or narrow down a crime scene to a specific region.

Cross section of wooden block containing different tree species (Source: Royal Botanical Garden, Kew).

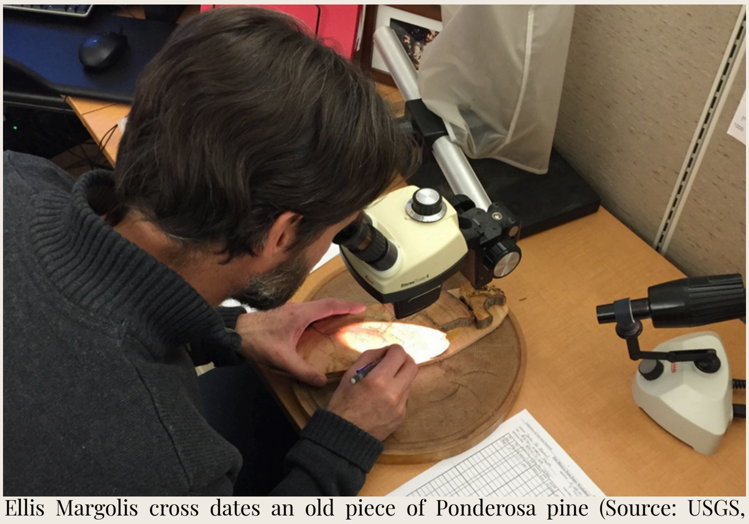
Then there's **dendrochronology**, the tree-ring people. Every ring is basically a little diary entry from the year it grew. Read enough of them, along with the wood's cell structure, and you can date an object or trace a stolen piece of timber back to wherever it was cut.

Limnology goes a different direction entirely: it's about water. Specifically, the tiny silica-shelled algae called diatoms, which are tough enough to survive inside a body long after death. If they've made it into someone's bone marrow or lungs, that's about as solid an indicator of drowning as forensic science has.

Mycology is the fungi angle. Fungal spores can tie a suspect to wherever they've been standing, and fungi eat away at dead tissue at a fairly steady, predictable rate, so their growth can work almost like a clock for figuring out how long a body's been there.

Methodology

For a long time, this whole field ran on eyeballs and a decent microscope. Look at the leaf veins. Look at the seed shape. Look at the wood cells. Cheap, doesn't ruin the sample, and you can go back and check it again later if you need to. The problem shows up when the material's degraded, or half-digested, or just shredded into pieces too small to recognize by sight. At that point, looking harder doesn't help. So labs turn to DNA barcoding instead. Sequence a specific chunk of the plant's genome, run it against a reference database, and you can often nail down the species even from a scrap that's barely there anymore. Honestly, the two methods work better together than either does alone: the old-school visual check is fast and gets you a first answer, and the DNA work backs it up (or overrides it) when the sample's too far gone for the naked eye.



Ellis Margolis cross dates an old piece of Ponderosa pine (Source: USGS, Collin Haffey).

Forensic Botany in the Court

What this all boils down to, for a judge or a jury, is a way of pinning down what actually happened. Suspects, victims, objects, all of it can get tied back to a specific place. It's not just murder cases either: this stuff shows up when someone's tracing where a shipment of food came from, or trying to prove timber was cut illegally, or chasing down the origin of drugs. Two examples say a lot. Koehler, working the Lindbergh case, picked out four different types of wood in that ladder: North Carolina pine, ponderosa pine, Douglas fir, and birch. He then traced one rail straight back to a floorboard in the suspect's attic. Locard did something similar decades earlier, in 1908: mud on a suspect's shoes matched up with hawthorn leaves, birch buds, and moss from the scene. He pulled off a second case too, spotting hop plant cells on a knife that tied a guy to some plantation vandalism.

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2. Dendrochronology

Chronicles of Time and Climate

-Divisha Singh

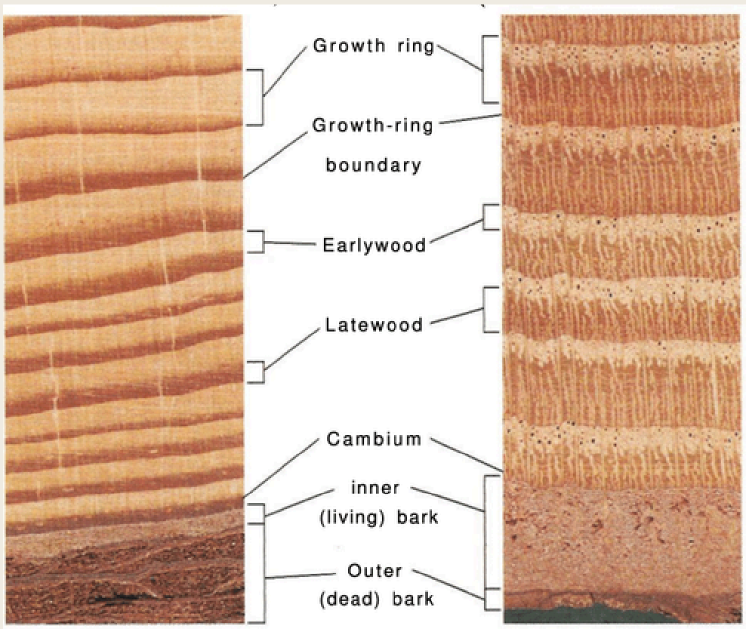
Trees are sanctuaries. Whoever knows how to speak to them, whoever knows how to listen to them, can learn the truth." — Hermann Hesse, Bäume (Trees)

Dendrochronology derives from the Ancient Greek **dendron**, meaning "tree", **khronos**, meaning "time", and -**logia**, meaning "the study of". Trees not only act as natural time capsules for environmental phenomena but also help shed light on events such as volcanic eruptions, droughts, floods, and forest fires, as well as past climatic conditions. The growth pattern of the tree rings helps researchers study the various environmental conditions that influence the growth of trees. By analyzing tree-ring width variations, researchers can detect fluctuations in climate, extreme weather events, and ecological shifts, among other things.

It was first used to date ancient Native American pueblos in the southwestern United States. Leonardo da Vinci (1452–1519) was the first person to mention that tree rings form annually, and their thickness is determined by the conditions under which they grew. During the latter half of the nineteenth century, the scientific study of tree rings and the application of dendrochronology experienced a boom, with many researchers studying the interlinkages between the formation of tree rings and the conditions that affect them. **Andrew Ellicott Douglass** (1867-1962), who pioneered the study of tree rings in relation to sunspots and climatic changes, is famously regarded as the **Father of Dendrochronology**.

Formation of the tree rings: Trees in the temperate region show distinct ring growth, with light-coloured, wide rings formed during early spring (called earlywood) and dark-coloured, dense rings formed during late summer and autumn (called latewood). One light and one dark layer together form one annual ring. In tropical regions, seasonal variations are often less pronounced. Consequently, many tropical tree species either lack clearly defined annual rings or produce irregular growth rings, making dendrochronological analysis more challenging.

At locations where tree growth is limited by water availability, trees produce wider rings during wet and cool years than during hot and dry years. Drought or a severe winter often results in narrower rings.

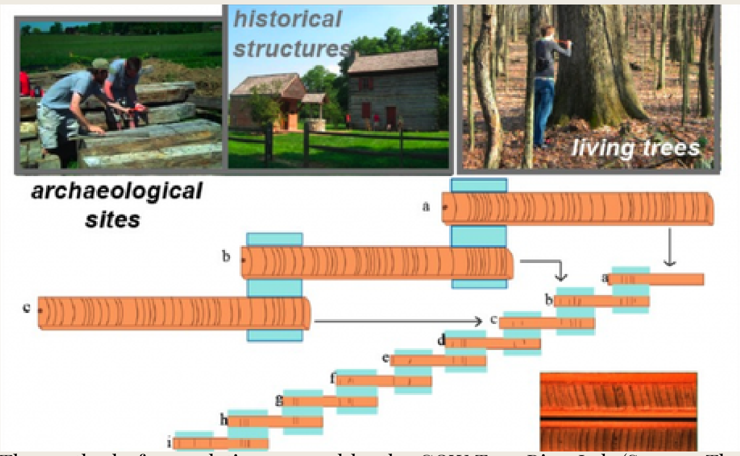


llustration of tree stem and annual/growth rings (Source: Hoadley [2000]).

The fundamental principle of dendrochronology is crossdating. This process involves matching patterns of wide and narrow rings across multiple trees to create a master chronology. Trees belonging to the same species in a particular area have shown similar ring patterns due to common environmental conditions. Scientists can thus re-imagine the chronologies of trees and environmental events far beyond what the lifespan of any single tree can hope to produce by overlapping the ring patterns from living trees with those from older, dead trees or preserved wood. Crossdating can also help in the identification of missing or false rings, thereby improving the accuracy of age determination and climatic reconstructions.

Applications of dendrochronology-

- **Estimation of age**- The tree rings play a crucial role in the estimation of the age of trees. A 7104 -year tree ring chronology has been developed for bristlecone pine, Pinus aristata, in the White Mountains of east -central California, U.S.A. The chronology was extended backward in time by crossdating tree rings with older, dead tree fragments. However, this method is not foolproof yet due to various environmental factors like missing rings caused by severe stress or drought, false rings triggered by unseasonal weather pauses, inner ring compression near the center, and the lack of distinct rings in many tropical species. In such cases, radiocarbon dating has proven to be useful. **Old Tjikko**, a Norway Spruce in Sweden, was believed to be only a few hundred years old according to the dendrochronology of the stem. However, carbon dating of the roots proved that the tree was a part of a clonal system where the roots were as old as around 9500 years.



The method of crossdating as used by the COW Tree Ring Lab (Source: The College of Wooster Tree Ring Lab).

- **Dendroarchaeology**- Dendrochronologists typically reconstruct their chronological records from long-lived trees either naturally buried or preserved in ancient structures. But wooden coffins can provide data in places where other records are missing. Recent studies from the wood of the pine coffin of a Chinese Han dynasty soldier found buried in western China revealed that from 270 B.C.E. to 77 C.E. average humidity levels were 18% to 34% higher than today's, which may have allowed the Han to expand westward into what was once and is again a desert today. Such studies help archaeologists reconstruct ancient environments, trade routes, settlement patterns and historical human activities.

- **Dendroclimatology**- It is the science of determining past climates from trees. Studies of annual precipitation (rainfall) on the northeastern Tibetan Plateau over the last 3,500 years using juniper tree rings reveal that the region has gradually become wetter over the last three and a half millennia, with recent decades being the wettest in the record, and show that regional precipitation is more closely related to Northern Hemisphere temperature than to Asian monsoon intensity. This case demonstrates how dendrochronology complements historical records and provides independent evidence of major global climatic disturbances. Similar studies reveal how the climate of Earth has shifted over the centuries. Scientists believe that these studies can shed light on global temperature trends and improve predictions of future climate change.


A Fir plank from a coffin found in eastern China (Source: Science, Yesi Zhao).

CASE STUDY - THE YEAR WITHOUT SUMMER - 1816

The eruption of Mount Tambora(1815), located on the island of Sumbawa in present-day Indonesia, released large amounts of ash and volcanic dust into the stratosphere. Temperatures fell by 0.4–0.7 °C (0.7–1 °F) worldwide as the airborne material blocked sunlight in the stratosphere. Bengal experienced abnormal cold and snow in the winter monsoon. Countries such as the United Kingdom, France, and Ireland experienced significant hardship, with food riots and famine becoming common.

This phenomenon can be traced back with the help of dendrochronology. Researchers noted that the majority of trees in the Northern Hemisphere during this period showed extremely thin rings reflecting a year of severely reduced growth. By comparing tree-ring records from different regions, scientists confirmed that the cooling was not a local event but a widespread climatic anomaly. These synchronized patterns allowed researchers to reconstruct the timing, duration, and severity of the volcanic winter caused by the Mount Tambora eruption.

Art history: Dendrochronology plays a crucial role in the dating of art panels and helps reveal crucial information about their source. When performed on the wooden panels of **a portrait of Mary, Queen of Scots** in the National Portrait Gallery, London, it was revealed to be an original creation by an unknown artist in the later half of the sixteenth century as opposed to the earlier belief that it was an eighteenth-century copy.


A portrait of Mary, Queen of Scots (Source: National Portrait Gallery).

Conclusion-

Dendrochronology acts as a natural archive of Earth, allowing scientists to accurately date trees, reconstruct past climates, date archaeological artefacts, authenticate historical artworks and study major natural events such as volcanic eruptions and prolonged droughts. As the impacts of climate change become ever more evident, tree-ring records provide an insightful glimpse of the past and equip us with the knowledge to better predict and prepare for the environmental challenges of the future.

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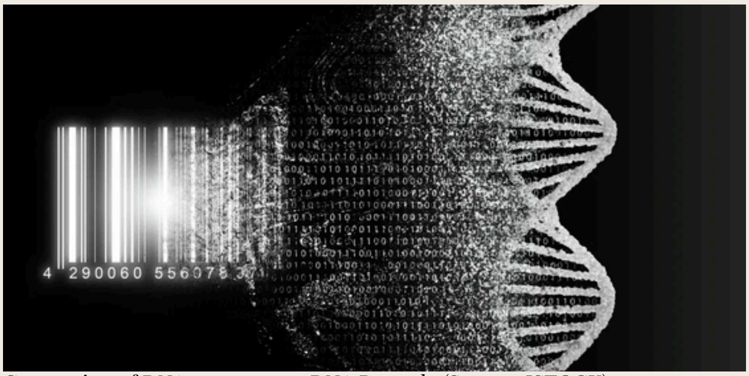
3. DNA Barcoding

The Genetic Trail

-Nisha Kumari

DNA barcoding is a method of species identification that uses a short DNA sequence from a specific gene or genes. The premise of DNA barcoding is that, by comparison with a reference library of such DNA sections (also called "sequences"), an individual sequence can be used to uniquely identify an organism to species, just as a supermarket scanner does.



Conversion of DNA structure to DNA Barcode (Source: ISTOCK)

2003 Proposal: Paul Hebert and his team at the University of Guelph, Canada published "Biological identifications through DNA barcodes," suggesting the mitochondrial cytochrome c oxidase subunit I (COI) gene as a 648 base-pair standard tag for animals. Later on, because COI does not work well for all groups(as in plants, mitochondrial genes exhibit low mutation rates), researchers expanded standard markers to include rbcL and matK for plants, and the Internal Transcribed Spacer (ITS) region for fungi.

The Supermarket Metaphor: Hebert was inspired by the Universal Product Code (UPC) stripe system used in grocery stores to scan and identify products quickly.
A chloroplast has three membrane systems, namely the outer membrane, inner membrane, and the thylakoid system where photosynthesis occurs. The stroma (matrix) contains multiple copies of chloroplast DNA (cpDNA), enzymes, ions, and metabolites. Chloroplast DNA is double-stranded, circular, and typically 120,000–170,000 base pairs, larger and more variable in size than mitochondrial DNA, making cpDNA genomics important evidence in forensic identification of plant species. Inverted repeats (IRs) are repetitive sequences in cpDNA that occur more than once and are relatively conserved within species but vary in position and sequence between species. Because of this variability, IRs are useful for inter- and intraspecific identification and for resolving phylogenetic relationships among plants. Chloroplast microsatellites (chloroplast SSRs) are tandem nucleotide repeats across the chloroplast genome. Widely found in nuclear and organellar genomes, SSRs are highly polymorphic, multi-allelic markers. Because of their variability and reliability, chloroplast SSRs are useful molecular markers and can serve as DNA barcodes for plant species identification.

MARKERS FOR PLANTS: Plants can be identified using different DNA regions called barcode markers. Researchers have suggested a few useful ones, such as ITS, trnH-psbA, matK, rpoC1, rpoB, and trnL-trnF. Sometimes one marker is not enough, so scientists combine two or three markers to get more accurate identification.

SEQUENCE OF ACTIONS

1. Building the Barcode Library: A comprehensive DNA barcode reference library (used for the taxonomic identification, also called annotation, of sequences obtained from barcoding) is established by carefully selecting one or more individuals from each species to act as reference samples. Samples come from live specimens in the wild or from preserved tissues in museums and herbaria. Voucher specimens provide a permanent link between DNA barcodes and identified species. Taxonomists are tasked with creating and validating DNA barcodes for these species.

2. DNA Extraction and Sequencing: Extract DNA from tissue, amplify target regions by PCR, and sequence the amplified fragments to generate the barcode.

3. Comparison with Barcode Library: Compare the unknown barcode to the reference library using algorithms such as BLAST or Kimura-2-Parameter distance to find the closest match and identify the specimen.

4. Sequence Alignment: Use alignment algorithms to measure genetic distance. Identification accuracy depends on similarity between the unknown sequence and the reference barcode; closer matches give more precise identifications.


The images of cross sections of the mature logs of three species (Source: Assessment of the applicability of wood anatomy and DNA barcoding to detect the timber adulterations in Sri Lanka, scientific reports).

CpDNA: NATURE'S PLANT ID CARD

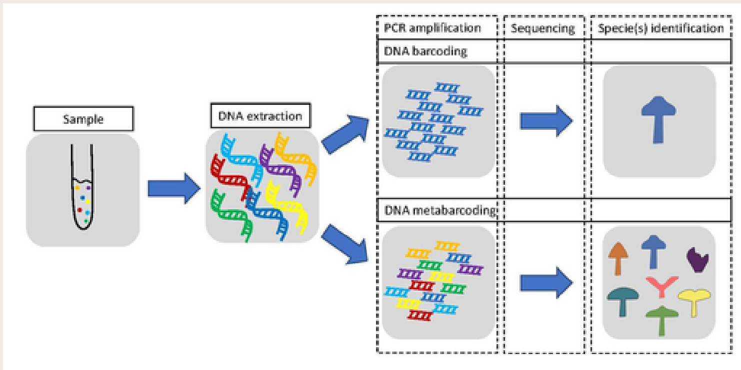
DNA barcoding is a vital tool in forensic investigations, linking biological specimens to crimes. In forensic botany, analyzing plant evidence from crime scenes used to track a body's movement, trace a suspect's path, or identify illicit pharmaceutical plants—can critically advance cases. Because human activity, illegal trade, and smuggling threaten rare species, accurate identification via plant DNA barcoding is essential for conservation and preventing extinction. The technique also supports authentication and traceability of food, especially processed products and supplements; the US FDA promotes DNA-based methods for assessing herbal product quality. Overall, plant DNA barcoding enhances forensic science by improving the accuracy and efficiency of investigations. Crime scenes contain varied evidence—human blood, hair, sperm, plus plant and animal material—so analysis of both human and non-human DNA is increasingly important. Previously, human identification dominated evidence, but non-human DNA analysis now plays a prominent role.

DNA BARCODING ON TRIAL

Coding and non-coding regions of plastomes and their multiple combinations have helped in identifying *Santalum* species, *Paphiopedilum* species, *Aloe* species, woody plants, and medicinal herbaceous plants.

CASE STUDY - GENOME CLUES TO CURB ILLEGAL TIMBER TRADE

In order to monitor and regulate the illegal timber trade across the globe, chloroplast DNA (cpDNA) has also played a significant role in identifying the smuggled wood varieties. Jiao et al. (2018) conducted research on *Santalum album* and its adulterants in order to establish species-level identification of the five selected species of *Santalum* using the cpDNA barcoding technique. *Santalum* L. is widely recognized for its fragrant heartwood oil, which is extracted and diffused into scent perfumes and incense sticks. Generally referred to as 'Sandalwood', it has high market value due to the increasing demand for its products, and the detrimental consequences of escalating sandalwood product demand include the excessive and illicit logging of wild *Santalum* populations, which imperils their ecological distribution in numerous areas. CpDNA proved to be effective in curbing this. Wood identification is usually done by looking at wood anatomy, but this often cannot tell closely related species apart because their wood looks very similar. To help with this, the researchers used DNA barcoding as an additional method. They tested four chloroplast DNA markers—matK, psbA-trnH, trnK, and trnL—both individually and in combinations to tell apart five Santalum (sandalwood) species.



Differences in the standard methods for DNA barcoding and metabarcoding (Source: Wikipedia Commons).

According to Yu et al. (2017), a DNA barcode method for wood should give correct results more than 70% of the time. In this study, the success rates (ability to get usable DNA barcodes) were: trnK 95.9%, matK 91.8%, etc. These high rates show these markers work well for wood forensics. The researchers checked differences within and between species using Neighbor-Joining (NJ) trees and TaxonDNA analysis. They found that combining psbA-trnH + trnK gave the best species discrimination and had a 100% recovery rate. Using these chloroplast markers, they were also able to identify six wood samples that had no voucher specimens, correctly assigning them to species. Thus, this evidence bypasses falsified export papers and visual mimicry, providing legally defensible proof to prosecute illicit logging operations.

Ultimately, although DNA barcoding has achieved notable progress in plant identification, the task of creating a universal DNA barcode for all plant species still remains a challenge. Recent technical breakthroughs such as **Next-Generation Sequencing (NGS)** and **super-barcoding** offer new opportunities for more precise and efficient species identification. These methods improve largescale plant barcoding and can be used in forensic botany to link suspects to crime scenes, detect illegal plants, and help conserve endangered species.

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4. Forensic Palynology

The Forensic value of Pollen and Spores

-Naorem Khushi Yaiphabi

'Spring,' is the season we all adore, as we are surrounded by different flowers in a variety of shapes, colours, and sizes. While most of us enjoy the spectacle, it also causes some of us to suffer, as we sneeze, cough, and fall victims to allergy. It can even send some of us to prison—a versatile substance indeed and the reason for these eventful things is the silent traces left behind by nature, which is none other than the **'Pollen Grains'**.

Forensic palynology is the study of pollen grains and spores as evidence used in legal investigations. Pollen is the male gametophyte of plants which are microscopic and highly versatile in nature, usually around 10–100 micrometers wide, and nearly indestructible due to the presence of a substance called **sporopollenin**. This substance makes it highly resistant to acid, base, and even temperature, making it a perfect tool for forensic investigation as well as fossil evidence. Each plant species produces pollen with a unique shape, size, and surface pattern. As plants are tied to specific locations, seasons and habitats, they are confined to a narrow region. Therefore, the pollen around us becomes a **'Pollen fingerprint'** of where one might have been.

One might destroy evidence or hide it, such as cleaning blood, throwing away weapons, or manipulating evidence. It is hard to remove pollen that might have latched onto clothes or other objects. Once it's there, it tells a story and becomes a silent witness left behind by nature. While they are silent witnesses to events around them and are **'nature's glitters'** as called by the scientists, it is a wonder as to how they are applied in forensic investigations.

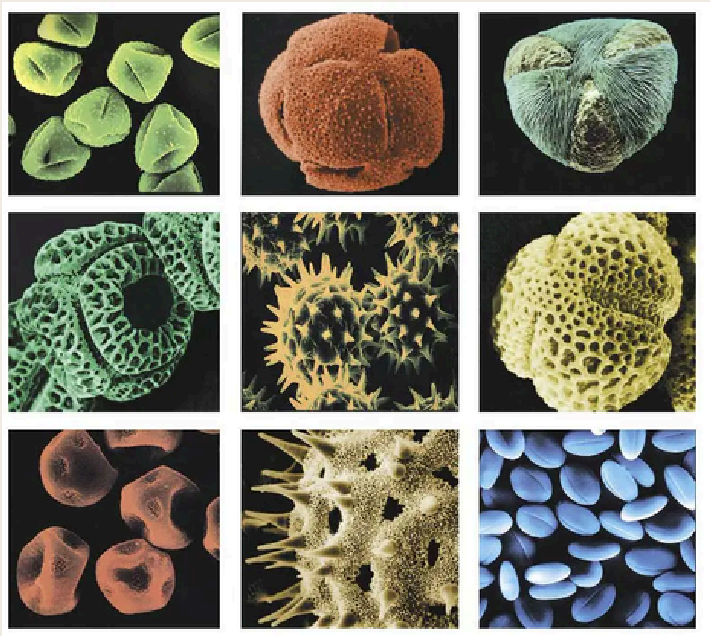
Forensic palynology can be applied to investigation due to its ubiquitous nature. While plants may not be able to travel long distances as they are non-motile, their pollen does. Wind, insects, and water carry pollen for miles which creates a recognizable pattern.

It occurs in 3 steps:

Sample collection : The investigators collect pollen samples from the suspects, victims, vehicles, crime scenes, clothes and the possible surroundings via tape lift, air filter, etc. The collected sample is then sent off to the laboratory for further analysis.

Identification : In the laboratories, the collected samples are then treated with suitable chemicals so that the rest of the substances are dissolved except for exine which is the outer layer of pollen grain made of sporopollenin. Under a microscope, palynologists then identify pollen grains by morphology. Modern labs also use DNA barcoding to confirm plant species.

Interpretation and Analysis : Pollen cannot be found singular or alone; they occur in assemblage. Palynologists analyze the "assemblage" — which is a mix of 20–50 species in one sample. This mix of pollen species is unique to a place and time as the pollen found in a forest during summer will differ from the ones found in wetland in winter. As pollen assemblage is specific to time and location, it is used by experts to analyze by comparing crime scenes and suspect's pollen to interpret whether the locations are consistent or different.



False-colored scanning electron micrographs of pollen showing diverse surface ornamentation (Source: Biochemistry and Molecular Biology of Plants).

REAL CASE STUDIES

CASE 1: THE UK KIDNAPPING, 2009

It is one of the most publicized palynology cases that happened in England, where a 20-year-old woman was abducted and held captive in a shed for around 24 days. The case was a difficult one, as there were no eyewitnesses or a clear location where the victim was held captive. With further investigation, the police arrested a suspect whose footwear—boots and trousers—was covered in mud, from which a sample was collected and sent to forensic laboratories. Forensic palynologist **Patricia Wiltshire** analyzed the mud and found results that led to further investigation. She found a rare combination of pollen assemblage species: *Rhododendron ponticum, Impatiens glandulifera* (Himalayan balsam), and *Phragmites australis* (common reed). This specific plant community only occurred in three locations in southern parts of England. Police pinpointed the location and searched them and found the shed with the victim inside. In court, the pollen evidence was used to directly link the suspect's boots to the crime scene. He was convicted of kidnapping and false imprisonment.

Vaughn Bryant, the first forensic palynologist in the US at Texas A&M University (Source: The power of pollen: how CBP is at the forefront of using pollen as a new forensic tool, Yolanda Choates).

CASE 2: THE MINNESOTA BOG MURDER, 1959

It is one of the earliest US cases to use pollen in forensic investigations. A murder took place in 1959 where a woman's body was found in a peat bog in Minnesota, USA. Police investigation led to a suspect who denied ever being near the bog. Investigators examined the car. The mud from the trunk and tires was collected and sent to the forensic lab for further analysis. Palynologists analyzed it and found pollen from *Sphagnum* moss and other bog-specific plants that only grew in that exact bog. The suspect had claimed he never drove near that particular area. However, the pollen analysis contradicted him. Combined with other evidence, it helped secure a murder conviction. This case set the precedent that soil and pollen on vehicles could be traced back to source locations.

Other famous cases include the **'Manuka Honey Fraud, New Zealand'**, where fake honey was sold in place of Manuka honey, known for its anti-bacterial properties. Analysis of pollen helped crack the fraud, and thus, pollen testing is done for honey products.

Conclusion

These are the following features that make pollen a great witness:

• Ubiquitous: It is everywhere.

•Durable: The pollen exine can survive for thousands of years in soil and peat.

•Specificity: An assemblage can narrow a location and a specific season.

•Silent: Suspects can lie, but pollen doesn't. It's used in murder, kidnapping, terrorism, illegal logging, border crossing cases, and even art forgery.

While it has been helping in solving cases, be it kidnapping or environmental-related problems, the downside of it is that this study of 'Palynology' requires experts. There are fewer than 50 practising forensic palynologists worldwide. Analysis takes time and training. Weather and contamination, might lead to complicated results but with DNA barcoding and automated pollen scanners, the forensic palynology field is growing; thus, in the coming tomorrow, pollen evidence will be applicable in court hearings and legal investigations. In a world of fingerprints and DNA, pollen reminds us that nature is the silent witness to all events. Tiny, invisible, and persistent, it records where we have been. Thus, pollen tells a story that is small in size but leaves the biggest impact.

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5. Forensic Mycology

Clues from the Kingdom Fungi

-Adyasha Mishra

Introduction

Forget fingerprints, DNA swabs, and blood spatter for a moment, some of the most compelling evidence in a criminal case can come from mould. Forensic mycology, an emerging subdiscipline, applies fungal biology, ecology, and taxonomy to criminal and civil investigations. Once confined to identifying poisonous or psychotropic mushrooms, it now helps estimate postmortem interval (PMI) and time of deposition, link suspects and victims to locations through trace evidence, locate clandestine graves, investigate mycotoxin poisoning, and assess mould-related health and property claims. Fungi are everywhere - soil, air, damp surfaces, drains, carpets, cellars; and because each habitat hosts a distinctive fungal community, their presence on an object, garment, or body carries real evidentiary value. Forensic mycologists' central contribution lies in establishing associative links between evidence and a crime, such as connecting a suspect to a scene through matching spore profiles.

1.**Fungi as Trace Evidence**

The evidentiary use of fungi rests on Locard's Exchange Principle: any contact between a person, place, or object results in a mutual transfer of material including fungal spores. Fungi suit this role well: they're produced in enormous quantities, microscopically small and adhesive enough to cling to surfaces, and often environment-specific enough to act as a biological "signature" for a location.

Greenish yellow patches of the fungus *Penicillium griseofulvum* developed directly on the skin of a torso of a human cadaver (Source: Forensic mycology: current perspectives - Scientific Figure on ResearchGate).

Comparing fungal and pollen evidence from a suspect's belongings with crime-scene samples can corroborate or refute an alibi. In one vivid case, an elderly couple selling firewood bundles were badly injured in a burglary; of twenty-nine fungal spore types found at the scene, twentyeight also turned up on the suspects' boots and getaway vehicle while none at their alibi site. One critical species grows only on conifers not native to the UK and had previously been recorded solely at Kew Gardens. Both suspects pleaded guilty. Trace evidence isn't limited to spores; lichen fragments and mouldy material can also feature in an investigation. Even unidentified spores hold evidentiary value if matching types appear across exhibits, while formal identification reveals the substrates or host plants involved. Because fungal evidence can hide in hair, wounds, or mud smears, pathologists must stay alert to it during examination.

2. **Estimating Time Since Death (Postmortem Interval)**

Fungal colonisation of a corpse follows a somewhat predictable pattern under given conditions, useful for estimating PMI. The technique traces to Van de Voorde and Van Dijck (1982), who cultured fungi from a deceased woman's eyelid and groin and used the growth observed to estimate death at roughly 18 days earlier which later corroborated independently. Hawksworth and Wiltshire emphasise measuring the growth rates of colonies recovered from a body and comparing them with growth on artificial media under scene-mimicking conditions, rather than relying on species identification alone, but what matters is how the fungus responds to a controlled temperature range, so the work can be done in a basic microbiology lab. This has worked in UK cases, including one where fungal growth on dismembered foetal remains indicated the body had been stored in a confined, refrigerated space for months before being abandoned. Other groups have approached PMI through direct culture of fungi from remains and burial soil, with mixed results like one study found soil fungi growing through skin and clothing by the second week after burial, data later combined with entomological findings to build PMI-estimation criteria.

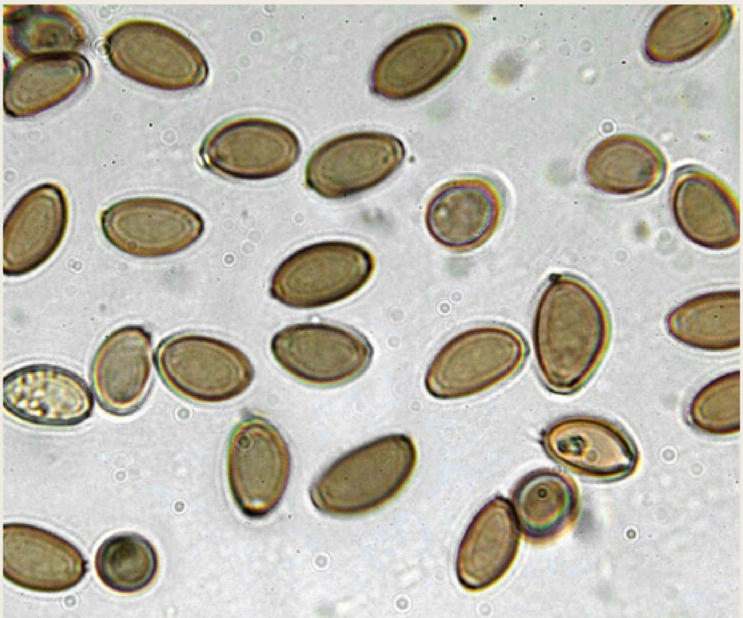
3.Molecular Characterisation of Soil, Locating Clandestine Graves, and Determining Time and Place of Deposition

DNA-based methods could one day characterise soil samples recovered from cadavers and link them to specific locations, but hurdles remain as reproducibility is hard to achieve, no standardised extraction protocol exists, and sequencing remains especially unreliable for fungal communities specifically. A newer, still-developing application uses "grave-associated" fungi to locate buried or hidden remains: species in the genus Hebeloma, nicknamed "corpse-finders," tend to fruit preferentially in soil enriched by decomposing organic material. In one case, fungi beneath a decomposed cadaver differed markedly from control soil, showing how such shifts can help locate burial sites; sounds promising, but still emerging rather than established. Fungi and lichens can also reveal how long a body has been at a location, or whether it's been moved, since many species are seasonal or environmentally sensitive and act as a rough biological clock. In one case, a twig beneath a plastic-wrapped body part bore the lichen Xanthoria parietina, which discolours predictably when deprived of light and moisture, its condition let investigators estimate the covering had been in place for roughly five days, matching the body's actual movement timeline.

4.Psychotropic, Hallucinogenic Fungi and Toxic Substances

Mushroom poisoning remains a globally significant cause of accidental and occasionally, intentional, leading to death. Only a minority of known species have been formally identified, and just a small fraction are toxic; misidentification of edible lookalikes is a persistent hazard among foragers, and symptoms can sometimes mimic unrelated conditions like stroke. Precise identification by specialists is essential as even well-known fungi can spring surprises: molecular analysis of dried "porcini" purchased in a London shop revealed a mixture of three Boletus species new to science, fortunately non-poisonous. The most forensically significant toxins responsible for most fatal poisonings are Amatoxins, found chiefly in Amanita species like the "death cap". Heat-stable and lethal at just 0.1 mg/kg, they inhibit RNA synthesis and cause fatal liver failure. Hallucinogenic "magic" mushrooms, mainly Psilocybe and Panaeolus species, produce psilocybin and psilocin, with effects comparable to LSD; possession is criminalised in many jurisdictions.

Casework draws on three tiers: microscopy when spore and gill features remain intact, DNAbased methods when morphology fails, and chromatography to detect specific toxins. Screening often stops once a substance is found whereas meaningless common toxins go undetected unless investigators request gut-content examination, since symptoms may not appear for days, by which time material has passed into the lower bowel.



Spores of *Psilocybe semilanceata* (Source: Mushroom Observor, Wikipedia Commons).

5.Mould Growth in Buildings and Civil (Insurance) Applications

Beyond criminal casework, forensic mycology has civil applications, as in case of, mould-related property damage and health claims, though establishing causation remains challenging. Where illness or death has occurred in a mouldy building, the implicated fungi should be investigated rather than dismissed, with attention to allergen sensitivity and possible fungal growth within the lung.

Colonies of *Stachybotrys chartarum* (Source: Forensic mycology: current perspectives - Scientific Figure on ResearchGate).

Airborne spore sampling alone is problematic, since concentrations fluctuate by time and season, and culture-based sampling can grow spores not actually present on site, hence, in-situ taping of visible colonies is preferred. The same colony-growth-rate comparison used in PMI estimation can estimate a minimum age for building mould colonisation, useful in adjudicating water-damage insurance fraud claims.

6. Limitations and Future Directions

Several limitations recur: no standardised methodology, leading to inconsistent lab results and reduced courtroom confidence; degraded samples that complicate identification; PMI estimates highly sensitive to storage, climate, and biotic factors, and dependent on sparse growth-rate data; regions lacking culture facilities entirely; legitimate scientific debate over certain estimates; immature molecular soil methods; and toxicology analysis often curtailed once one plausible substance is detected, potentially missing co-ingested toxins. Even with these gaps, forensic mycology is genuinely useful and applicable more broadly than commonly recognised. Practitioners typically come from mycology or biology backgrounds rather than formal forensic training, and the field remains underused outside a handful of countries, chiefly the UK and US; countries without established capacity could outsource the work to university laboratories instead. The consistent recommendation is continued investment in documenting fungal growth rates, standardising collection and identification protocols (including routine gut-content sampling in suspected poisonings), maturing molecular methods, and raising awareness of fungi's evidential value and positioning the discipline to complement, or sometimes substitute for, methods like forensic entomology in PMI estimation, while expanding its underrecognised role in civil work.

CASE STUDY: FUNGAL EVIDENCE AND FORENSIC MYCOLOGY — WEST YORKSHIRE, JANUARY 1996

In January 1996, a young woman was found dead in a flat in West Yorkshire. The case became a landmark in forensic mycology, later cited by mycologists **David Hawksworth** and **Patricia Wiltshire** as one of the clearest demonstrations of mould growth determining time since death which was considered to be a courtroom-grade evidence, not just investigative background, that contributed to a murder conviction and life sentence. The pathologist noted mummification and skin slippage, consistent with a body dead well past the window where standard methods (body temperature, rigor and livor mortis) remain reliable exactly where mycological evidence proved decisive. Investigators observed bluish-green and grey mould colonies on the body. Police took swabs, measuring the bluish-green colonies while excluding the grey ones, whose margins were too diffuse to delineate. The moulds belonged to the genera *Penicillium* and *Mucor*, though not identified to exact species. Rather than rely on a generic growth-rate figure from the literature, a mycologist grew the actual isolates recovered from the scene removing strain-to-strain variability as a source of error, on two artificial media over 28 days, at two temperatures matching real conditions: roughly 4°C (the cold flat) and 21–24°C (room temperature). Since mould growth slows dramatically in cold, lowhumidity conditions like an unheated British flat in January, this produced a growth-rate curve specific to the case, calibrating colony diameter against elapsed days for the actual organisms at the actual temperature the body had been exposed to, against which the colony sizes on the body were then compared. The controlled, repeatable design gave the resulting estimate real defensibility, rather than an educated guess. The mycological evidence contributed directly to securing the conviction and life sentence which was one of the earliest solid demonstrations that fungal evidence, when recognised and preserved, can stand up in a murder prosecution rather than remain a background observation.

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6. Did you Leaf that?

Interesting facts every reader should know

-Kirti Tripathi

The world's largest known organism is a fungus. The honey fungus *Armillaria ostoyae* in Oregon occupies roughly 9.6 km^2, making it one of the largest known organisms on Earth.

The largest flower in the world has no leaves, stems, or roots. *Rafflesia arnoldii* is essentially a giant parasitic flower. Most of the organism lives hidden inside the tissues of its host vine (Tetrastigma), emerging only to flower.

90 % of the foods people eat come from just 30 plants, yet there are over 80,000 edible plants in the world.

The theory of plate tectonics was supported by fossils of the genus *Glossopteris*. It was a "seed fern," a type of plant which no longer exists, that lived across South America, Africa, Antarctica, and Australia when they were all a single land mass.

Some plants have completely lost the genes needed for photosynthesis, they have drastically reduced chloroplast genomes, retaining only a small set of genes needed for chloroplast maintenance rather than photosynthesis.

Strawberry is the only food that bears its seeds on the outside. Each dot on a strawberry is a separate tiny fruit containing a single seed inside.

Bladderworts capture prey in less than a millisecond, making them the fastest-moving carnivorous plants in the world.

Diatoms build glass-like cell walls. Their microscopic particles called frustules are so intricate that engineers study them for applications in optics and nanotechnology.

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