Differential diagnosis of common tremor syndromes

R Bhidayasiri

Tremor is one of the most common involuntary movement disorders seen in clinical practice. In addition to the detailed history, the differential diagnosis is mainly clinical based on the distinction at rest, postural and intention, activation condition, frequency, and topographical distribution. The causes of tremor are heterogeneous and it can present alone (for example, essential tremor) or as a part of a neurological syndrome (for example, multiple sclerosis). Essential tremor and the tremor of Parkinson’s disease are the most common tremors encountered in clinical practice. This article focuses on a practical approach to these different forms of tremor and how to distinguish them clinically. Evidence supporting various strategies used in the differentiation is then presented, followed by a review of formal guidelines or recommendations when they exist.

ESSENTIAL TREMOR: THE MOST COMMON FORM OF ACTION TREMOR

Action tremor refers to any tremor that is produced by voluntary contraction of muscles, including postural, isometric, and kinetic tremor. The last includes intention tremor. As there are no validated serological, radiological, and pathological markers in ET, the diagnosis is primarily based on clinical findings (box 1). Therefore, the examination should be comprehensive. Firstly, observe the patient sitting at rest to note whether there is evidence of a resting tremor of the head, hands, or legs. Then, ask the patient to stretch out the arms and hands completely and look for a postural tremor, followed by checking finger-nose-finger movements looking for a kinetic tremor. Typically, essential tremor is an action tremor, either postural or kinetic in character, mainly affecting the hands. It is usually bilateral with a frequency of 4 Hz to 12 Hz and largely symmetrical. The upper limbs are affected in about 95% of patients, followed by head (34%).

Abbreviations: EMG, electromyography; EEG, electroencephalography; EPC, epilepsia partialis continua; PD, Parkinson’s disease; ET, essential tremor; PET, positron emission tomography; DAT, dopamine transporter; DBS, deep brain stimulation; VIM, ventral intermedius nucleus
lower limbs (20%), voice (12%), face and trunk (5%). With the passage of time, the frequency of the tremor decreases and the amplitude may increase. The prevalence ranges from 0.4% to 6.7% in persons over 40 years old so it is the most common type of tremor. Many studies have shown that ET is much more prevalent than tremor of PD (up to 20 times difference). However, some experts suspected that the condition might be overdiagnosed. Although the condition is both clinically and genetically heterogeneous, half of the cases are considered familial with an autosomal dominant pattern of inheritance. 

Tremor that occurs while voluntarily maintaining a position against gravity.

Tremor that occurs during any voluntary movement. It may include visually or non-visually guided movements. Tremor during target directed movement is called intention tremor.

Tremor that occurs as a result of muscle contraction against a rigid stationary object.

Tremor that occurs in a body part that is not voluntarily activated and is completed supported against gravity.

Tremor of moderate amplitude is present in at least one arm.

Tremor of moderate amplitude is present in at least one arm during at least four tasks, such as pouring water, using a spoon to drink water drinking water, finger-to-nose manoeuvre, and drawing a spiral.

Tremor must interfere with at least one activity of daily living.

Medications, hypothyroidism, alcohol, and other neurological conditions are not the cause of tremor.

Tremor of moderate amplitude is present in at least one arm during at least four tasks, or head tremor is present.

Medications, hyperthyroidism, alcohol, and other neurological conditions are not the cause of tremor.

### Classification of tremor

<table>
<thead>
<tr>
<th>Type of tremor</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>Rest tremor</td>
<td>Tremor that occurs in a body part that is not voluntarily activated and is completed supported against gravity.</td>
</tr>
<tr>
<td>Action tremor</td>
<td>Any tremor that is produced by voluntary contraction of muscle, including postural, isometric, and kinetic tremor. The last includes intention tremor.</td>
</tr>
<tr>
<td>Postural tremor</td>
<td>Tremor that is present while voluntarily maintaining a position against gravity.</td>
</tr>
<tr>
<td>Kinetic tremor</td>
<td>Tremor that occurs during any voluntary movement. It may include visually or non-visually guided movements. Tremor during target directed movement is called intention tremor.</td>
</tr>
<tr>
<td>Isometric tremor</td>
<td>Tremor that occurs as a result of muscle contraction against a rigid stationary object.</td>
</tr>
<tr>
<td>Task specific tremor</td>
<td>Kinetic tremor that may appear or become exacerbated during specific activities.</td>
</tr>
</tbody>
</table>
Unfortunately, pharmacological treatment of ET remains unsatisfactory. Probably, ET is not as benign as it is often referred as benign essential or familial tremor. About 15%–25% of patients with ET retire prematurely and 60% of patients choose not to apply for a job or promotion because of the uncontrollable shaking of their hands. The two most often used drugs are non-selective β blockers (for example, propranolol) and primidone. Because these drugs can result in multiple side effects, especially during the titration phase, they are not recommended for mild cases that do not cause dysfunction or social embarrassment. Tremor of different body parts and various tremor subtypes may also have different pharmacological responsiveness. In general, the start of specific pharmacological treatments is typically based on patient age, coexistent conditions, prior exposure to drug therapy, concurrent drug therapies, contraindications, physician and patient bias, as well as benefits and potential adverse effects of certain agents. Drug dose is initially low, gradually titrated upward as tolerated, and adjusted as appropriate to identify the most efficacious dose with a minimum of adverse effects (regulation of dose). If the drug is of no benefit at a dose that causes adverse effects, dose levels are gradually tapered down and treatment is eventually stopped. If a drug is reported to be beneficial, it may be continued at the regulated doses and the next drug may be added to the drug regimen. If the response to a drug is adequate and the dose well tolerated, the physician may keep the patient at the same dose or decide to increase the dose level (and continue to monitor tolerance). Propranolol, a non-selective antagonist, is more effective than selective β₁ activity, with the dose of at least 120 mg/day resulting in a significant reduction in the severity of tremor. In a dose response study of propranolol, 240–320 mg/day was found to be the optimal dose range. Furthermore, long acting propranolol (propranolol LA) has been shown to be equally effective as conventional propranolol and has better compliance. Propranolol is generally well tolerated. However, relative contraindications, including asthma, heart failure, arterioventricular block, and diabetes mellitus, have limited its use in some patients. The mechanism of propranolol in ET is not exactly known although central and peripheral mechanisms have been proposed. In general, 50%–70% of patients obtain symptomatic relief from propranolol, but dramatic improvement occurs in a much smaller percentage. Similarly, primidone, an anticonvulsant in doses of up to 750 mg/day, has been shown to be effective than placebo, but dramatic improvement occurs in a much smaller percentage. Phenobarbital is one of primidone’s active metabolites but it has little, if any, consistent effect on tremor.

### Table 2 Features differentiating tremor of PD from ET

<table>
<thead>
<tr>
<th>Features</th>
<th>Parkinson’s tremor</th>
<th>Essential tremor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tremor</td>
<td>At rest, increases with walking.</td>
<td>Posture holding or action</td>
</tr>
<tr>
<td>Frequency</td>
<td>3–6 Hz</td>
<td>5–12 Hz</td>
</tr>
<tr>
<td>Distribution</td>
<td>Asymmetrical</td>
<td>Symmetrical (mostly)</td>
</tr>
<tr>
<td>Body parts</td>
<td>Hands and legs</td>
<td>Hands, head, voice</td>
</tr>
<tr>
<td>Writing</td>
<td>Micrographia</td>
<td>Tremulous</td>
</tr>
<tr>
<td>Course</td>
<td>Progressive</td>
<td>Stable or slowly progressive</td>
</tr>
<tr>
<td>Family history</td>
<td>Less common (1%)</td>
<td>Often (30%–30%)</td>
</tr>
<tr>
<td>Other neurological signs</td>
<td>Bradykinesia, rigidity, loss of postural reflexes</td>
<td>None</td>
</tr>
<tr>
<td>Substances that improve tremor</td>
<td>Levodopa, anticholinergics</td>
<td>Alcohol, propranolol, primidone</td>
</tr>
<tr>
<td>Surgical treatment</td>
<td>Patients usually have other parkinsonian features, requiring subthalamic nucleus or internal globus pallidus deep brain stimulation (DBS)</td>
<td>Thalamic VIM DBS or thalamotomy</td>
</tr>
</tbody>
</table>

Figure 1 Comparison of handwriting in patients with PD (top) and ET (bottom). Note that the handwriting in PD is small and illegible in contrast with ET, which is large and tremulous.
any, antitremor effect on its own. Common reported side effects include nausea, vertigo, drowsiness, and unsteadiness. Koller et al. showed in a placebo controlled study that primidone (50–1000 mg/day) significantly reduced the amplitude of hand tremor in both untreated and propranolol treated patients. There was no correlation between therapeutic response and serum concentrations. Neither drug was conclusively shown to be superior to the other but more patients had a preference for primidone than for propranolol in one study.

In addition to the first line treatments, many other drugs have been used as monotherapy or adjunctive treatment. Topiramate has been shown to be effective as well as gabapentin and alprazolam. Theophylline, flunarizine, olanzapine have been used with variable success. Intramuscular injections of botulinum toxin type A into intrinsic hand muscles can be considered in medically resistant cases. Lastly, DBS in the ventral intermediate nucleus (VIM) of the thalamus in ET (Activa Tremor Control Therapy) is effective, with over 90% of patients having a satisfactory result. Because this rate of improvement cannot generally be achieved with current pharmacological therapy and several long term studies have also shown the long term efficacy, the Food and Drug Administration (FDA) has approved this device for medically intractable cases. 

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### Parkinsonian Tremor: The Most Common Form of Resting Tremor

The tremor in PD typically occurs at rest and becomes less prominent with voluntary movement. It typically occurs initially in the distal upper extremity, and over time, moves proximally and then to the other upper extremity, again in a distal to proximal pattern. Seventy percent of patients with PD present with tremor and it usually has a better prognosis, compared with PD patients with early postural instability and akinesia. Action or postural tremor does occur in PD, either alone or in combination, making the diagnosis difficult in some cases, especially in the early stage. In fact, pure rest tremor is infrequent in PD; more common is the combination of rest and postural kinetic tremors. Isolated postural and kinetic tremor rarely occurs in PD. As a result of the variability of the clinical expression of tremors in PD, the definition is based on the general diagnosis of PD rather than on specific features of tremors. Only the rest tremor component is by itself, a positive diagnostic criterion for PD but other tremors are often seen. When the diagnosis is unclear, levodopa trial may be considered to record the remarkable improvement in patients with PD. In contrast with akinesia and rigidity, the response of parkinsonian tremor to dopaminergic treatment can be so variable and it is the overall improvement that counts and supports the diagnosis. A variety of agents have been used for tremor in PD, including levodopa, dopamine agonists, anticholinergics, budipine, and as second line treatments, clozapine, propranolol, and clonazepam. However, double blind, randomised trials specifically assessing their efficacy in tremor in early PD are few with different methodologies and the results are variable. Anticholinergics, such as trihexyphenidyl, have been shown to be effective but rarely used now because of its side effects, especially in the elderly population. Therefore, anticholinergics are not generally recommended to patients with cognitive decline or elderly patients over 65 years of age. Both dopaminergic and anticholinergics are probably equally effective in parkinsonian tremor, but dopaminergic substances additionally improve other parkinsonian signs. Dopamine agonists, such as pramipexole and ropinirole, are probably the most effective antitremor drugs among all dopaminergic treatments and should be considered in all newly diagnosed tremor predominant PD patients who have no cognitive impairment. Improvement of tremor has also been reported with other dopamine agonists, including pergolide and bromocriptine. Dopamine agonists are also useful in advanced PD patients with tremor that is refractory to levodopa and anticholinergics. As for akinesia and rigidity, after longer disease duration the additional use of levodopa may become necessary for adequate control of resting tremor in many patients.

Some patients have a predominant postural tremor in addition to their rest tremor. This form is uncommon and has been considered to be a combination of an ET with PD although the relation between postural tremor that is phenomenologically similar to ET and PD has not been well defined. Further studies are needed to define the relation between ET and other tremors, including PD and other task specific tremors.

### What Is the Physiological Tremor?

Physiological tremor is seen in all normal people when muscles are activated. The tremor is typically postural and is thought to arise from the resonant oscillation of a limb as a result of mechanical factors affecting it. The frequency of physiological tremor has 8–12 Hz, and a rhythm in the electroencephalogram has a similar frequency (7–13 Hz), a common central hypothesis was raised. Physiological tremor can be barely visible to the naked eye and does not interfere with activities of daily living. The frequency of physiological tremor is <6 Hz before age 9 years, increasing to 12 Hz by the mid-teens year, and decreasing slightly above 60 years. The frequency usually decreases when large inertia loads are applied to the limb, as shown with accelerometry and electromyography. The amplitude is typically so low as to be virtually undetectable under normal circumstances. Increased physiological tremor is defined by the easy visibility of high frequency, postural tremor with no evidence of an underlying neurological disease. Furthermore, the cause is usually reversible. Certain conditions can exacerbate physiological tremor, for example stress and anxiety before public performance. Indeed, some professional performers have learned to avoid this response by taking a β blocker before the event. Fatigue because of lack of sleep and consuming a large amount of caffeine can be precipitating factors although one study did not find physiological tremor to be significantly increased by caffeine. Relaxation sessions have been shown

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**Box 2 Commonly used drugs that may cause tremor**

- β₂ adrenergic agonists
- Valproic acid
- Lamotrigine
- Lithium
- Tricyclic antidepressants
- Antihistamines
- Thyroxine
- Amiodarone
- Nifedipine
- Neuroleptics
- Theophylline
- Nicotine
- Monoamine oxidase inhibitors
- Cyclosporin A
to decrease tremor significantly. In general, no drugs are usually warranted. However, a small dose of propranolol can be useful in some people, for example ophthalmic surgeons, when fine coordinative movements are required. Other conditions that can augment physiological tremor include thyrotoxicosis, pheochromocytoma, hypoglycaemia, withdrawal from opioids or sedatives.

Tremor is a common side effect of many drugs (box 2 lists commonly used drugs that can cause tremor). Various drugs and toxins can cause all types of tremor known clinically although increased physiological tremor is most commonly seen. Tremor is the dose limiting side effect of the β2 adrenergic agonists, salbutamol and terbutaline, used to treat obstructive airway diseases. Tremor is usually seen within a month of starting valproic acid treatment and is more evident when a dose is >750 mg/day although it can also occur when the dose is within therapeutic range. It is the most common tremorogenic drug among anticonvulsants, affecting up to 25% of patients. Intention tremor may occur in patients on lithium. The occurrence rate increases with increasing serum lithium levels and manifests almost 100% in patients with lithium toxicity. Tardive tremor, a rare disorder, represents a separate entity in which, by definition, is caused by exposure to a dopamine receptor blocking agent (DRBA) within six months of the onset of symptoms and persisting for at least one month after stopping the offending drug. It is usually static in nature but can occur at rest and on intentional movements, such as eating and writing. Tremor can also occur as a toxic reaction to marijuana, and 3,4-methylenedioxymethamphetamine or ecstasy.

CEREBELLAR TREMOR

Classic cerebellar tremor is often termed as intention tremor. The tremor is typically of low frequency below 5 Hz. It is characteristically kinetic in nature and has an added volitional component and particularly affects the head and the upper half of the body. Postural tremor may be present, but rest tremor is usually absent. When kinetic tremor occurs or worsens as the target is reached, it is referred to as terminal tremor. In rare occasions, cerebellar tremor also has a rest component in which case it would be described as Holmes’ tremor. In cerebellar tremor, the oscillations are of variable amplitude and are perpendicular to the direction of movement. It is usually best elicited during the finger-nose-finger or heel-shin-heel tests. Furthermore, cerebellar tremor is often associated with dysmetria, dyssynergia, and hypotonia. If this is another tremor that is probably a result of abnormality of the cerebellum or its afferent/efferent pathways and is a slow frequency oscillation depending on postural innervation. Its rhythmicity is, at times, the only sign distinguishing it from ataxia of the trunk. Multiple sclerosis is a common cause of cerebellar tremor. Other causes include Friedreich’s ataxia, spinocerebellar degeneration, and cerebellar infarction. Although no clear correlations between cerebellar lesions and tremor have been established, lesions in the superior cerebellar peduncle and dentate nucleus are the most common reported sites resulting in intention tremor. Unfortunately, there is no established pharmacological treatment for cerebellar tremor. The results of medical treatment are often less than satisfactory. However, as multiple neurotransmitters as well as feedback pathways including brain stem, thalamus and cortical neurons, seem to be involved, several drugs have been tried, but with variable success, including odanaceton (5-HT3 antagonist), ondansetron, physostigmine, carbamazepine, and clonazepam. In refractory cases, chronic DBS of the VIM (or less commonly nucleus ventralis oralis posterior and zona incerta) may provide an alternative. Although few studies used highly standardised quantitative outcome measures, and follow up periods were generally one year or less, the data suggested that chronic DBS of the VIM produced improved tremor control in multiple sclerosis. However, complete cessation of tremor is generally not achieved. There were some reported cases in which tremor control decreased over time, and frequent reprogramming became necessary.

PSYCHOGENIC TREMOR

The criteria suggestive of psychogenic tremor are sudden onset but rarely a remitting course (box 3). The onset is mostly associated with a stressful life event. According to a modified Fahn’s criteria for psychogenic dystonia, the diagnosis of psychogenic tremor is accepted with the followings: 1) the major causes of symptomatic tremors (such as medications, thyroid dysfunction, and hormonal or metabolic dysfunction) have been excluded, 2) essential and parkinsonian tremors are excluded on the basis of clinical criteria, 3) no evidence for any other neurological disorders is present, and 4) the patients had a period without tremor of at least two weeks during the observation period. The tremor of psychogenic in origin is usually a combination of resting and postural or intention tremors and most often involves both arms, followed by the head and then the legs. The tremor may be continuous or intermittent with fluctuating frequency and amplitude, but lacks the physiological pattern. As mentioned, the onset is usually abrupt (73%) with maximal disability (46%) at the onset that had static course in 46% and fluctuating course in 17%. Although certain criteria are provided for the diagnosis of psychogenic tremor, the diagnosis can be obvious in patients with generalised shaking. In these instances, the shaking usually stops during the examination as they are exhausting for patients. Differential diagnosis in this setting is limited, but includes orthostatic tremor, essential stance tremors, or the rare stance tremor of PD.

The examination, especially the two clinical signs, are very useful in this situation; the entrainment of tremor frequency
and the coactivation sign.\textsuperscript{66} Entrainment entails requiring the patient to maintain a tapping rhythm in an uninvolved body part (finger or foot) at a different frequency than the suspicious tremor. A psychogenic tremor automatically changes to the frequency that is being enforced on the uninvolved hand or foot, because it is difficult to maintain two different volitional movement frequencies simultaneously in two different body parts. During passive movement of the involved limb, an increased tone can be palpated by the examiner. When the increased tone disappears, the tremor also disappears (coactivation sign). Cogwheeling in the setting of PD and ET differs from the present coactivation sign as the first is present over the whole range of movement of a particular joint. In contrast, coactivation in psychogenic tremor resembles voluntary coactivation with overlying rhythmic trembling. In addition, coactivation can produce bizarre positioning of the hands when they are outstretched. The absence of finger tremor is also suggestive of psychogenic in origin. While physiological and pathological tremors show a decrease of tremor amplitude when postural with and without loading is compared, psychogenic tremor tends to show an increase of their tremor amplitudes during loading.

Commonly, patients with psychogenic tremor often undergo a large number of diagnosis and therapeutic procedures before the final diagnosis is established. A review of medical history in these patients usually shows multiple functional somatic or psychosomatic illnesses. Once the diagnosis is made, most patients continue to have a fluctuating or constant course, followed by improving and progressive periods suggesting the prognosis is far from benign. The therapeutic success is also variable, but the treatment approach should include various combinations of psychotherapy as well as drugs, such as mild anxiolytics and antidepressants. While pharmacological treatment in organic tremor may reduce amplitude, but does not change the tremor frequency, the effect of treatment in psychogenic tremor usually varies from total suppression of tremor, especially when associated with the suggestion of a “cure” to no benefit.\textsuperscript{67} Interestingly, most of successfully treated patients were young.\textsuperscript{68}

OTHER TYPES OF TREMOR

In addition to the tremors described above, there are other forms of tremor that are less common and some of them have only been reported in a few case studies. Of these, dystonic tremor is worth mentioning as many patients with dystonia have tremor and it is sometimes difficult to distinguish dystonic tremors from static tremors associated with dystonia, which occur unspecifically in regions unaffected by dystonia. Dystonic tremor is mainly a postural and kinetic tremor in an extremity or body part affected by dystonia and is not usually seen during complete rest.\textsuperscript{1} It is now considered as a distinct entity from ET, as it is irregular, has a broad range of frequencies (mainly less than 7 Hz), and remains localised. A typical example is tremulous spasmatic torticollis. The tremor tends to be localised, asymmetric, and irregular in amplitude and periodicity. Many patients with dystonic tremor use their own tricks (geste antagoniste or sensory tricks) to reduce the tremor amplitude. These together with the absence of attempts at suppressing the tremor by voluntary muscle contractions are a fairly reliable diagnostic sign. Head tremor is common in patients with cervical dystonia and treatment with botulinum toxin often results in significant improvement of tremor as well as dystonia.

Orthostatic tremor is a rare disorder of middle aged or elderly people that is characterised by unsteadiness on standing, secondary to 16 Hz tremor in the lower extremities. Characteristically, the tremors remit on walking, but disappear when sitting or lying down.\textsuperscript{1} Patients prefer to stand on a wide base but walk normally and only a fine ripple of muscle activity is visible. Confirmation of the diagnosis can be obtained by EMG showing a 16 Hz pattern in the leg muscles with the patient standing. In terms of treatment, the drug most commonly used is clonazepam, followed by levodopa and then drugs used for ET. Overall, the treatment response seems to be unsatisfactory, but some success has been reported with gabapentin (300–2400 mg/day) in a small placebo controlled, double blind, crossover trial.\textsuperscript{67}

Holmes’ tremor is a term, proposed by the Ad Hoc Scientific Committee on Movement Disorders, to refer to previously used midbrain tremor, rubral tremor, thalamic tremor, myorhythmia, and Benedikt’s syndrome.\textsuperscript{1} It is a symptomatic tremor of predominantly proximal limbs of low frequency (<4.5 Hz) during postural in nature, worsening during movement and goal directed tasks. Like cerebellar tremor, Holmes’ tremor is almost always attributable to lesions, reported in upper brain stem, thalamus, or cerebellum, interrupting pathways in the midbrain tegmentum (rubro-olivocerebellar loop, rubrospinal fibres, nigrostriatal fibres), and the serotonergic brain stem telencephalic fibres.\textsuperscript{69} Palatal tremor, previously termed palatal myoclonus, can be either symptomatic attributable to brain stem and/or cerebellar lesions or essential without any identified brain lesions. In symptomatic palatal tremor, inferior olivary pseudohypertrophy is seen and considered as a hallmark for the condition.\textsuperscript{70} 71 Sleep does not abolish the symptoms. In essential cases, patients usually have characteristic ear clicks (rhythmic movements of the tensor veli palatini muscle), which do not present in a symptomatic variety. Botulinum toxin injection into each tensor veli palatini has been reported to be of some benefits.\textsuperscript{72} Tremors, mostly postural and kinetic, can also develop in patients with some forms of peripheral neuropathy, particularly demyelinating neuropathies (especially dysgammaaglobulinaemic neuropathies). The term “cortical tremor” is a misnomer as it is not a tremor but a specific form of rhythmic myoclonus.\textsuperscript{68} Distinguishing rhythmic myoclonus from tremor (particularly Holmes’ tremor) can be difficult because the driving muscle contractions can be so brisk resulting in longer pauses between individual jerks.

Tremor is a common problem seen in clinical practice. Among all types of tremor, essential tremor is the most common cause. In most cases of tremor, there is no diagnostic laboratory test to confirm or exclude a particular type of tremor and the diagnosis heavily relies on physician’s own observation and thorough clinical examination as well as clinical history. In persons younger than 40 years of age, the possibility of Wilson’s disease should be excluded, as it is a treatable and reversible condition if recognised promptly. Differentiation between essential tremor and tremor of PD is particularly important as the management and prognosis in these two conditions are vastly different. Almost all drugs used to treat tremor should be titrated slowly as side effects and tolerability are the main issues of compliance. The treatment should be evidence based. We recommend that the first line treatments, if available, should be firstly attempted, followed by second line treatments that are supported by prospective clinical trials before finally choosing drugs from anecdotal evidence.

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