

# ARCTIC HYSTERIA IN SALEM?

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**Abstract:** The outbreak of "witchcraft" in Salem was the most widespread of several similar occurrences in late 17th-century New England. Although many people later became involved in accusations and counter-accusations, the original 8 to 10 afflicted girls were affected by a behaviour-altering phenomenon which their contemporaries did not recognize as having natural causes. It was more than a month later that witchcraft was diagnosed. In this paper I am suggesting that the original cause of the behavioural abnormalities may have been the condition now called *pibloktoq* or Arctic hysteria. The cause of this behavioural anomaly is not completely understood but there is a substantial argument that it is influenced by low or fluctuating levels of calcium cations (hypo-calcemia) which also reciprocally affect the phosphate balance. The running, yelling, convulsive behaviours manifested are very similar in the two conditions although they may easily have been regarded as unnatural in 1692, since the phenomenon of *pibloktoq* was not diagnosed until the late 19th century. Data concerning diet, light levels and activity patterns of 17th-century lifestyles are drawn from recorded information and indicate that calcium levels may indeed have been low in young women of that time period. If skeletal material were available for examination it is possible that metabolic deficiencies could be ascertained, but at present such material cannot be located.

**Résumé:** La manifestation de la «sorcellerie» à Salem était la plus répandue de cas semblables en Nouvelle Angleterre vers la fin du 17e siècle. Même si beaucoup de gens étaient impliqués dans l'affaire plus tard, les 8 à 10 filles atteintes au début étaient affectées par un phénomène modifiant leur comportement que leurs contemporains ne pouvaient pas traiter en tant qu'ayant des causes naturelles. La sorcellerie a été diagnostiquée un mois plus tard. L'auteur propose que le comportement anormal des filles était peut-être causé par une condition que l'on appelle *pibloktoq*, ou hystérie arctique. La cause de cette condition n'est pas encore bien connue, mais il semble qu'elle est influencée par un niveau bas ou fluctuant de cations de calcium (*hypo-calcémie*) qui, de façon réciproque, affecte aussi l'équilibre de phosphate. L'excitation, les cris et les convulsions manifestés sont presque

identiques dans les deux cas; par contre, ce genre de comportement a dû sembler anormal en 1692, car le phénomène de *pibloktoq* n'a été découvert que vers la fin du 19<sup>e</sup> siècle. L'information sur la nourriture, les niveaux de lumière et les activités habituelles du 17<sup>e</sup> siècle est tirée de documentation indiquant que le niveau de calcium aurait bien pu être bas chez les jeunes femmes de cette période. Si des restes squelettiques étaient disponibles pour examination, l'on pourrait vérifier l'étendue des déficiences métaboliques. A présent, ces restes ne peuvent pas être localisés.

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## Introduction

Many theories have been presented in an attempt to explain what caused the outbreaks of witchcraft accusations in 17th-century North America. Probably because of the numbers of people involved and the consequences of accusation, the most famous cases were those occurring at Salem, Massachusetts in 1691-92. A number of causal explanations have been suggested to account for the spate of accusations. Past authors have investigated the phenomenon by referring to case histories, court records and psychological reasoning (e.g., Caulfield 1943, Mather 1862 and Hansen 1968 in Mappen 1980) to suggest factors of political and psychological stress which might have been sufficient to cause the afflicted behaviours. Hansen (1969) argues that the psychological consequences of living in unsettled times along with a harsh Puritan lifestyle may have led to clinical hysteria. Mappen (1980) presents a whole range of possibilities from the social stress of internal political arguments, through actual demonic possession to outright lying. A more concrete physical cause is suggested by Caporael (1976) who used maps of town fields to make an argument that the rye crop in one area was poisoned by ergot fungus and thus affected a particular group of people whose fields were close together. Each of these interpretations has its adherents and its critics. This paper adds to the list of suggestions the argument that a physiological condition of hypocalcemia similar to one of the suggested etiologies for Arctic hysteria (*Pibloktoq*) could have been an underlying factor in the outbreak of bizarre behaviours manifested by the 10 originally afflicted young women.<sup>1</sup>

Three lines of evidence are being utilized to support this proposal. The first part of the paper focusses on a comparison of the symptoms displayed in cases both of Arctic hysteria and of the 10 young women who originally exhibited the bizarre behaviours which convinced their compatriots that they were possessed. Although a clear understanding of the factors underlying Arctic hysteria has not been attained, several studies seem to indicate that a state of hypocalcemia is closely connected with its manifestations

(Foulks 1972; Katz and Foulkes 1970; Gusso 1960; Wallace and Akerman 1960). There are a number of different subsets of Arctic Hysteria but this paper will focus on the "winter madness" or *Pibloktoq* as it was named by Josephine Peary in 1893. That the Puritans of 17th-century New England were not familiar with this set of symptoms is demonstrated by the fact that almost two months elapsed before witchcraft was diagnosed, in a society that was obsessed with fear of witches and the devil (Miller 1954). The incidence of hypocalcemia may be controlled by a wide variety of factors which fluctuate periodically in populations under particular dietary stress. The state of calcium balance in humans is affected by the dietary intake of calcium, the intake of nutrients which are antagonistic to calcium absorption, levels of vitamin D, which is required for calcium metabolism, the constancy of circadian rhythms which maintain metabolic balance and levels of acidity in the blood which can be affected by hyperventilation brought on by sudden shock. The gender of the afflicted is also relevant because of the alterations in nutrient metabolism due to menstrual cycling, as well as to the more restricted and heavily clothed lives that women in many cultures lead. Therefore, the first section of the paper examines the general dietary conditions and activity patterns that can result in pathologically low calcium levels. The argument continues with a brief examination of neurological connections between hypocalcemia and uncontrolled agitated behaviour. Calcium level fluctuations effect nerve responses with great rapidity. This factor would have made it possible for those who felt they were afflicted by witchcraft to have "fallen into fits" almost immediately at the sudden appearance of the women accused of tormenting them. An explanation of this volatility is important because the immediacy of their seizures at the sight of the accused witches has long convinced many people that the girls were lying and simulating their afflictions.

Part 2 of the paper presents evidence concerning the conditions existing in Salem during the late 1600s. The dietary situation and activity patterns of colonial Massachusetts residents in general and adolescent girls in particular are examined to ascertain if they were at risk of being hypocalcemic. Ambient light levels are also important in maintaining the correct absorption level of calcium ions as well as the regularity of circadian rhythms in the body. Therefore architecture, type of windows, light sources and time spent outside are relevant details of investigation.

In Part 3, the data are derived from an examination of the particular living conditions of the 10 originally afflicted young women. I have focussed on these individuals in particular because it is possible that those who showed symptoms subsequently may have picked up the behaviours of affliction for a number of social, political or psychiatric reasons, and contributed to the "snowball" effect of accusation and counter-accusation (Hansen

1969; Boyer and Nissenbaum 1972). In addition to these young women, I will mention a few other cases with similar symptoms of affliction. The fits which were the central symptom of the outbreak occurred in less than half the witchcraft torments recorded in New England (Demos 1982) and this may have been one feature which made the diagnosis a difficult one.

One very clear method of testing the hypothesis that 17th-century New Englanders and particularly those in Salem may have suffered from low calcium levels would be analysis of skeletal remains. If it had been possible to track down the grave sites of any of the originally afflicted women it might have been possible to analyse some of the skeletal remains for indications of mineral deficiencies. The internal structure of bone responds to dietary stress by remodelling in an effort to minimize the effects of such stresses (Huss-Ashmore et al. 1982). The effects of stress remodelling can be observed by taking small plugs of bone from the femur and examining them in cross section at a microscopic level. This technique has the advantage that deficiencies in calcium level can be determined by analysis of very small bone fragments (Richman et al. 1979). Another possible study technique uses a sample of rib bone over 5.5 grams. Ashing of these bone samples permits the levels of calcium and phosphorus remaining in the bone to be ascertained and permits comparison with the levels found in the remains of other individuals (Katzenberg 1984). This technique also reveals whether calcium from the soil is contaminating the sample. Either of these techniques of ascertaining levels of calcium in the skeletal remains of those afflicted by seizures might provide evidence for the explanation which has been suggested here.

However, because of the 1695 decision by the judges that they were mistaken in condemning so many to death as witches, their accusers tended to keep a very low profile after their brief period of notoriety. Investigations in the Essex County Institute did not reveal where any of them were buried. Most of the young women married, changed their names and moved away to other communities. In addition, bone preservation in Massachusetts soil is very poor (Spence P.C.) and permission to excavate graveyards of that time period is difficult to obtain (Armelagos P.C.). Therefore even bone samples of the general population from the relevant time would not be available, unless perhaps skeletal material was being moved for some other purpose and samples could be taken. Also, since bone is a living substance, responding to its environment, later changes in life circumstances such as an improved diet for adult women might mask evidence of calcium levels at an earlier life stage.

Other sources of information which could be investigated to support the hypothesis of low calcium levels in 17th-century New England populations would include medical reports referring to rickets, osteomalacia and diffi-

culties in healing bone fractures. Contemporary portraits could also assist in assessing the possible presence of diseases such as rickets which would indicate calcium stress in the population. This type of evidence might be more available than direct skeletal material but is limited by the level of extrapolation and inference required to sift past 17th-century diagnostic abilities as well as variable levels of artistic skill and convention in representation. The major value of suggesting these alternative lines of evidence lies in the potential they hold for providing data in other cases of altered behaviour states attributed to possession where testing is more feasible than in the case of the Salem afflicted. Episodes of hysteric behaviour states have occurred in a large number of populations under dietary stress, such as the Djerid of Tunisia, the Nguni Bantu, the Digo women of Kenya and poor Ethiopian women (Kehoe and Giletti 1981). However, on the other hand I would like to stress that I am not attempting to explain the phenomenon of witchcraft affliction in general, but rather suggesting a component that may have been acting in particular cases. The hypothesis that I am proposing is that the behaviour of these young women was affected by the occurrence of hypocalcemia in a syndrome that has become known as "Arctic hysteria" or *pibloktoq*. I realize that, unless some very exceptional circumstances ensue, the true cause of these strange behaviours will probably never be known. Nevertheless, in an ensemble of political, social, religious and psychological arguments it seems reasonable to suggest that there may be room for physical and physiological bases for manifestations of altered behaviour states. This is particularly the case now that we are more aware of the consequences of alterations in trace element composition on human behaviour (Rubin et al. 1985).

### Part I—Symptoms of the Disorders

A comparison of the following lists of symptoms for the two conditions of witchcraft affliction and Arctic hysteria reveals their extensive similarity. These effects are then compared with the consequences of deficiencies in calcium metabolism. These consequences mainly centre on uncontrolled firing of the nervous system and muscle spasming which can lead to convulsions. The fits which affected the young women of Salem manifested themselves periodically in two noticeable stages. The following list of symptoms is compiled from several sources, but principally Mappen (1980) and Demos (1982).

#### *Initial Onset*

- Victim anxiously preoccupied;
- fainting, hysterical crying, disordered speech;

### *Acute Stage*

- Frenzied motor activity, including rolling on the ground, running aimlessly and trying to fly, tearing at clothes;
- occasional breaking out in animal imitations, “bark like a dog, purr like so many cats, bleat like a calf”;
- contortions of body, extreme rigidity alternating with complete limberness, extreme convulsions, very strong, requiring several people to hold them;
- pricking, pinching, burning, sensation of choking or strangulation, gasping for breath;
- hallucinations;
- loss of hearing, speech, memory, appetite;
- all of these alternating with frolicsome intervals of cavorting, babbling, insults and gestures of assault directed towards bystanders, friends and family.

Intervals of hours or days would occur in which the victims showed little memory of their behaviour, but rather manifested an attitude of lassitude and melancholy. The muscular effects of the fits referred to in this condition are described as “beyond the power of any epileptic fits or natural disease to effect” (Rev. John Hale of Beverly quoted by Hansen 1969:1). Cotton Mather who had a medical degree and examined several witchcraft victims at close hand affirmed that these fits were stronger than those found in epilepsy (Caulfield 1943).

Arctic hysteria is a very general term and seems to be related to a number of conditions such as kayak phobia, hermiting behaviour and *qivitoq* (ghost person). It was referred to by the name *pibloktoq* by Mrs. Josephine Peary in 1893, although, as early as 1856, Kane’s expedition recognized an “anomalous spasmodic disorder allied to tetanus” (Wallace 1960). Kane also referred to a strange epilepto-tetanoidal disease which affected both humans and animals. Sled dogs were described as running wildly, snapping, howling as if in fear, diving into the ocean and undergoing convulsive seizures. This evidence that *pibloktoq* is not confined to humans is paralleled by a number of accusations that animals were afflicted by witchcraft in Salem as well.

*Pibloktoq* is also divided into several stages which in severe cases may occur as periodic episodes.

### *Initial Stage*

- Individual is withdrawn and quiet;
- does not respond to questions and avoids the light;

### *Attack Stage*

- Victims scream, sing incoherently, mimic animal sounds;

- are violent, overturn furniture, destroy food and clothes;
- carpopedal seizures;
- tear off clothes, run outside, shout at pursuers, throw things;
- seem unaware of own safety;
- spasms of the throat, face and other muscles;
- very strong, requiring several people to hold them down.

In general the people are oblivious to their surroundings, strongly agitated, feverish, talk quickly, and seek things that are hard to get.

#### *Terminal Stage*

- Individual is exhausted, flushed, convulsions, drops into sleep or recovers.

#### *Recovery*

- seems complete, no memory for incident.

This marked resemblance in the symptomology of the two conditions appears to have first been noted by Dall in 1870 (Foulks 1972) who described Arctic hysteria among Athabascan Indians in Alaska as follows:

The patient fell in a sort of convulsion, struggled violently, appearing unconscious, tearing the clothing and breaking everything within reach. There were no symptoms of any disease and the fits were epidemic, seizing one after another at short intervals. The cases resembled the descriptions of those who in ancient times were supposed to be bewitched, and also some of those appearances which have accompanied cases of semi-religious mania in Europe in modern times. (Foulks 1972:11)

Arctic hysteria was just in the process of being recognized as a cohesive set of symptoms in the 1870s when Dall made his observations. This is one reason why I feel that the set of symptoms in the first list was not recognized as a natural phenomenon in the 17th century. As Dall realized, the major characteristics of these two conditions are very similar. These include screaming, disordered talking, animal mimicry, convulsive fits in which several adults are required to hold one individual, carpopedal seizures, episodes of rigidity, followed by extreme limberness, and violent disruptive behaviour, as well as the episodic nature of the affliction.

In addition to the list of symptoms common to both afflictions, there are a number of other similarities between the two conditions. Probably the most notable is that both conditions occur with much higher frequency in women and in girls around the age of menarche than in men. Foulks (1972) estimates that the sex ratio of affliction in Arctic hysteria is about 10 women to 4 men. This is supported by observations of Haggard (1941 in Wallace and Akerman 1960) who studied the phenomenon in Greenland and Peary (1981) who was one of the first to report it. In the case of witchcraft afflic-

tion, by far the largest number of individuals afflicted were adolescent girls, although some boys and married women also reported torments at a later stage of the outbreak. The second point is that although many violent acts are attempted by those in the throes of a seizure, only property damage actually occurs (Gussow 1960). Individuals who attempt to throw themselves in the ocean, or the fire, or to kill other people, are thwarted and do not succeed in causing severe physical damage to themselves or others. Thirdly, the afflictions only occur during a short period of the year, from late October until about the end of February, in other words, during the most severe and darkest part of the winter. Another similarity is the fact that both Arctic hysteria and the hysterias claimed to be spirit possession have been attributed to a variety of causes in addition to hypocalcemia. Aberle (1952) and others (e.g., Parker 1962) have suggested a psychopathological problem in a number of populations which produces an affective disorder involving hysteria and involuntary behaviours. These scholars relate the incidence of such disorders to social conditions such as female role disadvantages, cultural factors such as rearing practices and individual problems such as wife abuse. The argument is that the condition of hysteria occurs because individuals have not learned techniques of delaying satisfaction, and respond to frustration and anxiety by hysteria. This approach to cultural hysterias draws its data from a very wide range of cultures, but its very breadth reduces the degree of similarity shown between the various conditions. Parker (1962) in fact draws a clear distinction between the situation among the Polar Eskimo and Ojibwa, arguing that the relevant cultural aspects are antithetical so that the types of "wild" behaviours shown in both cultures (Windigo and Arctic hysteria) must have differing psycho-cultural causes. Chronic middle ear infection has been suggested as a cause of uncontrolled behaviours, but the regular patterning of symptom onset seen in *Pibloktoq* argues for a more regular physiological cause. Also, the frequency of onset and apparent post-seizure normality of the victims seems to argue against a chronic condition such as middle ear infection. Foulks (1972), on the other hand, who studied the phenomenon of Arctic hysteria in Alaska in 1968, feels that it may have a consortium of causes including birth trauma, chronic middle ear disease and central nervous system pathology. However, he concludes that a combination of low levels of calcium ions and vitamin D, coupled with the stresses caused by alterations of the circadian and circannual rhythms due to the long arctic night, is the probable cause. He tested the serum calcium levels of those who had seizures, but usually after a delay of 24 hours (Kehoe and Giletti 1981) which may have allowed the level to readjust somewhat. Even so he found the serum calcium levels to be at the low end of the normal range for the 10 individuals he tested (Foulks 1972).



However, the Inuit diet in 1968 was probably much more vitamin and mineral enriched because of the consumption of processed food than that found in earlier times. This may correlate with the lessening frequency of *pibloktoq*. Foulks only discovered 10 cases during the winter of 1968, whereas Admiral Peary in the 1890s sometimes saw 5 cases a day, and considered it to run in epidemics. An analysis of the Eskimo diet of 1855 by Harrison et al. (1964) indicates that calcium levels at that time would have been 54 percent of the required nutritional intake, or about 5.4 mg percent, which is very low. Normal calcium levels are about 10 mg percent. Hypocalcemia is diagnosed at 9 mg percent, is acute at a serum calcium level of 6 mg percent, and a level of 4 mg percent is lethal (Guyton 1977). Thus a state of low dietary calcium and lack of sunlight was certainly present in the individuals Peary noted as exhibiting this behavioural disturbance.

### Hypocalcemic Physiology

The main source of calcium necessary for growth and physiologic function is diet, although once calcium is ingested many factors affect whether it is usable by the body. In addition to varying levels of calcium content in ingested foods, the degree of usability is affected by other food eaten at the same time, which can affect its uptake. Cereal grains contain phytate, and many other plants have oxalates, both of which combine with calcium to form non-absorbable compounds (Katz and Foulks 1970). A diet highly dependent upon fish provides elevated phosphate levels which are inversely correlated with the rate of calcium uptake because phosphorus and calcium ions combine to form an insoluble precipitate (Guyton 1977). Also high phosphorus intake causes calcium to be removed from blood plasma and excreted in the feces (Draper 1985). Animal fat as a source of vitamin D may help to buffer problems in maintaining calcium level. Meat protein, on the other hand, has a very complex effect. At very high or low levels it increases the urinary output of calcium which increases the loss of the ion (Linkswiler 1981). This was long considered to be balanced by an increase in intestinal absorption caused by protein, but the increase in absorption is more than offset by increased loss in the urine (Yuen et al. 1984). Thus, the optimal conditions for a sufficient intake of usable calcium include a diet containing milk and cheese and leafy vegetables which are the major calcium sources, sunlight, animal fat and fresh vegetables to produce vitamin D, and a healthy parathyroid gland.

Low levels of serum calcium can result from a combination of factors in addition to the levels of calcium provided in diet. Vitamin C provides a calcifiable matrix, vitamin A organizes the continuous reshaping of bone and vitamin D controls the process of calcification by affecting the transforma-

tion of calcium ions to a form which can be absorbed by the digestive tract and therefore must be present in adequate amounts (Huss-Ashmore et al. 1982). The actual amount of available calcium is related to dietary intake, absorption and excretion through urine and kidneys, such that under normal circumstances about 25 percent of the daily input is retained (Schroeder et al. 1985). Less than 1 percent of the total body calcium is in solution in body fluids and a few millimoles of calcium lost or gained from the extracellular fluid (E.C.F.) pool of calcium may be critical to survival (Schroeder et al. 1985).

Hypocalcemia affects neuromuscular function to produce muscle cramps, tetony, convulsions and other symptoms. "Along with other cations (especially  $K^+$  and  $Mg^{2+}$ ) calcium exerts an important effect on cell membrane potential and permeability manifested prominently in neuromuscular function. It plays a central role in muscle contraction" (Schroeder et al. 1985:596). Sodium, potassium, calcium and magnesium are essential for adequate electrophysiological function: "Deficiencies or excesses of these elements can result in severe neuropsychological abnormalities" (Sandstead 1986:37). Due to the close interrelationship between cations, hypocalcemia may be due to loss of available potassium. It may shift to the internal cell fluid, which can cause periodic paralysis, weakness, tetony and cardiac arrhythmias. If phosphate concentrations in the E.C.F. rises, then corresponding calcium concentrations will fall. The levels of calcium are mainly regulated by the parathyroid hormone which acts to release calcium and phosphate from the bone in the presence of vitamin D. Calcitonin, which is a peptide hormone secreted by the parafollicular cells of the thyroid gland, reduces E.C.F. levels of calcium by reducing the release of calcium from bone. If the calcium levels become low, serum  $Mg^{2+}$  is commonly low and this hypomagnesia reduces tissue responsiveness to parathyroid hormone (Schroeder et al. 1985), thus interfering with calcium release from bone. Under circumstances of normal calcium levels these variations are buffered by internal mechanisms, but tetony can occur without a measured fall in total serum calcium if a sudden rise in pH level occurs, thus suddenly increasing the degree to which calcium is bound to proteins.

One very common cause of a rise in pH level is hyperventilation. In situations of hyperventilation, frequently caused by anxiety (Schroeder et al. 1985), respiratory alkalosis often results and renal compensation by the excretion of  $HCO_3^-$  is too slow to be effective. The arterial blood pH is elevated and the pressure of carbon dioxide ( $PCO_2$ ) is low. The extent to which protein is bound to calcium is very dependent on pH levels. At a high pH, a state of alkalosis is present which results in more calcium being bound to protein, and not free as ions. In fact, hypocalcemia can occur in alkalotic patients whose total plasma calcium is normal (Smith 1980), indicat-

ing that alkalosis can have a very intense effect. This may also occur if bicarbonate levels are increased too rapidly. Thus, hyperventilation due to an acute state of anxiety, which results in respiratory alkalosis can affect calcium ion levels sufficiently to cause partial paralysis, tetony and convulsions through the influence of unstable calcium levels on the functioning of the neuromuscular system. Katz and Foulks (1970) recognized that episodes of Arctic hysteria might be precipitated by hyperventilation. Other physiological effects of low calcium include an increase in the critical membrane potential of the nerves allowing unimpeded passage of nervous impulses. This can cause severe epileptoid convulsions and uncontrolled vocalizations and also adversely affect memory.

Many internal metabolic processes are under the influence of circadian rhythms and cycle in accordance with the body's requirements even when an individual is kept in darkness. Calcium rhythms indoors or in dark conditions, however, become free running and can get out of synchronicity with the potassium and sodium levels required to maintain nervous stability. This disruption to stability is also influenced by the loss of circadian periodicity in adrenal hormones and in urine calcium content. Urine and feces are major regulators of calcium levels. The urinary excretion of calcium can become free running although potassium excretion is maintained on a 24-hr. cycle. To summarize, causes of low plasma levels of ionized calcium include:

1. dietary effects, direct and indirect;
2. vitamin D deficiency;
3. parathyroid hormone deficiency;
4. alkalosis, which increases the protein binding of calcium (and can be due to hyperventilation);
5. a breakdown of circadian periodicity, which can allow excretion cycles of various cations to become misaligned, with deleterious effects on internal chemical balance.

Thus in a situation of low sunlight, little milk or fresh vegetables, a grain diet supplemented with fish, cold weather and sudden stress, which may cause hyperventilation due to anxiety, a hypocalcemic crisis could readily be precipitated.

## **Part II – Situation in Salem**

Turning to the situation at Salem Village in the winter of 1691-92, we see that such conditions may easily have prevailed in certain circumstances. The young women who were first to be affected ranged in age from about 10 to 20 years old. Most of them were bound servants while Betty Parris and Ann Putnam were living in their parental homes. It does not seem to be

recorded exactly when in December/January 1691-92 that Betty Parris began to exhibit the strange behaviours of crawling into holes and under furniture, making peculiar noises and twisting her body about. She was one of a group of 10 young women who spent some evenings that winter talking with Titubita a slave from the West Indies who belonged to Reverend Parris, Betty's father. Quite possibly Titubita believed herself to be a witch or at least to have some occult powers. She apparently told the girls stories of voodoo, magic and witchcraft and may have taught them some techniques of divination. Shortly after Betty manifested these strange behaviours the other nine young women began to show the same symptoms of convulsion, twisting and making strange noises. Reverend Parris, whose house was the initial focus of the activity, started to write an account of it a few weeks after it began. He also preached sermons about the evils of witchcraft and the horrors of being possessed by the devil. Puritan religion specifically taught that humans were all creatures of sin and would go to Hell when they died unless they had been singled out by God as one of his elect (Miller 1954). Abigail and Betty, who lived in the Parris household, as well as the others who heard him preach every Sunday, were well aware that listening to Titubita's stories of witchcraft and magic was a very dangerous activity which might result in damnation and eternal hellfire for their souls. If they did practise any divination it would have been with great trepidation, and if Titubita's West Indian background had enabled her to perform some magical revelations the young women would have been in very high states of anxiety. Parris (in Boyer and Nissenbaum 1974, and Brown 1984) refers to the vision of a coffin which the group appears to have conjured up as part of a divination, and this seems to have precipitated the initial attacks.

Since divination was the Devil's work, the threat of death, which a vision of a coffin represented, would under these circumstances have been terrifying. The shock of such a threatening vision could have caused the hyperventilation necessary to trigger a hypocalcemic episode, especially if serum calcium levels were already low. Even though only one person was initially affected, the anxiety levels in the others would undoubtedly be raised by her condition and could explain the "domino effect" whereby they all succumbed to similar influences. Once the victims had begun this type of behaviour, other factors could have intervened to promote its continuation because of the ensuing social benefits (Hansen 1969). If serum calcium levels remained low during the winter, the afflicted would undoubtedly discover that hyperventilation could quickly bring on an attack. Thus the intense fits that occurred when they were faced with the women they accused of bewitching them could have either been involuntary, brought on by anxious hyperventilation, or intentionally caused by the same means, but would still reflect an underlying physiological malfunction. These attacks were

amazing in their violence, and those who saw them repeatedly stated that the convulsions were much more severe than they had seen in illness or epilepsy. The attacks were also quite frequent, and initially the young women did not have any explanations for why they behaved in this way. They did not accuse anyone of witchcraft until they had been repeatedly questioned over a period of weeks by a panel of ministers, who eventually asked them "Who afflicts you?" (Brown 1984:9). The episode of feeding a dog with a cake made of rye meal and the girl's urine as a way of ascertaining who was responsible for their afflictions marked the beginning of their ability to respond to the question. To many it seemed evident that, if an act of witchcraft like this enabled the girls to speak, then witchcraft must be at the foundation of their afflictions. The minister rebuked Mrs. Sibley (who was responsible for the cake) for "using the Devil's methods to find out the Devil" (Upham, in Mappen 1980:48). However, the minister and doctors now firmly believed that witches were involved and repeated their questioning to elicit names of people to accuse. It was at this point early in March, nearly two months after the initial problems began, that the young women began accusing their fellow villagers of bewitching them by afflicting them with "fits." Their accusations first resulted in three older women, including Titubita, being charged as witches. As their afflictions continued others claimed that they too had been bewitched and began to exhibit the symptoms of convulsion. The accused witches named others as guilty of witchcraft, and the snowball of increasing numbers of afflicted and accused continued until October of that year. By the time Governor Phips forbade more executions 20 people had been killed and two had died in prison. It seems clear that accusations were being laid on a personal and political basis by the end of this period. Whether any of those who subsequently claimed to be afflicted by witchcraft were affected by a combination of low calcium levels and hysterical anxiety, or whether their activities were the result of malice and opportunity or a desire to save themselves from accusation is totally unclear. That is why this discussion is confined to the first set of people who exhibited these symptoms. Since actual serum calcium levels for these afflicted young women cannot be ascertained, I will examine various factors that influence them. Calcium is a very important aspect of human physiology, which fluctuates according to a number of factors outlined above. Of these I have chosen diet including calcium and vitamin D levels, light levels, activity patterns, sex and age as relevant features to examine. Calcium interrelationships with other elements such as sodium, potassium and magnesium is also important, but has only briefly been covered. Conditions of marginal calcium intake, low light levels, restricted activity and reduced vitamin D in young women would combine in a synergistic fashion to depress the body's ability to utilize what calcium was available. This indi-

rect approach to the study of population calcium levels is made necessary by the lack of direct skeletal evidence.

## Diet

The food preferences of 17th-century colonists combined with the difficulties of producing certain crops meant that in the yearly dietary cycle the winter was a period of low calcium intake, especially for the less wealthy. Many families of moderate to low income ate a fairly standard diet of maize and rye bread, pease porridge and salt meat when it was available. Although wheat was grown, it was a cash crop and seldom eaten except on special occasions: "wheat, which was a money crop was too valuable to eat" (Rutman 1968:45). Gardens were begun in the Salem area about 1634, but they were not common. The most frequently grown vegetables were leeks, turnips, onions, cabbages and parsnip. Garden products were made into "green sauce" in the summer and some root vegetables were stored in the autumn. However, McMahon notes that "the winter vegetable supply in Seventeenth Century households consisted almost entirely of dried pease" (1985:39). Indian vegetables such as beans and pumpkins were field crops sown with the corn. "With stewed pumpkins and bean or pea porridge, Indian meal or samp was the staple article of diet" (Bidwell and Falconer 1941:10). Thus the green leafy vegetables which provide calcium were lacking from the winter diet of stored and dried foods.

Meat was not rare in 17th-century New England, but poorer people did not have large supplies. The meat that was available for winter consumption was salted after the fall slaughtering of a swine or a beef. Animals were smaller in the New England colonies than in Europe or in modern times, and swine dressed at about 200 pounds (Russell 1976). Meat seems to have been consumed on a yearly cycle; fairly large amounts were eaten at slaughtering time and then the remainder was salted and eaten until the supply ran out. Since preservation was a problem the meat was not kept for more than a few months. Salt meat was considered a dietary staple, but the supply was usually consumed rapidly and was exhausted by early spring. The high levels of salt used may have interfered with the calcium, sodium, potassium equilibrium which is required to maintain stability of the nervous system. In times of high rate of consumption the levels of protein and phosphate in the meat may have been sufficient to increase urinary excretion of calcium. For those families with low supplies of meat the lack of protein would materially affect the transportation and utilization of vitamin A and calcium (Huss-Ashmore et al. 1982).

Fish and game were available to the settlers but in the early years "a prejudice against a fish and game diet prevented the colonists making use of the wild food until actually starved into it" (Bidwell and Falconer 1941:6). Fish in particular has high phosphate levels which are inversely correlated with calcium uptake as mentioned earlier. By the 1690s the low cost and ready availability of dried fish encouraged its use in poorer households but some types, particularly shad and salmon, were not considered socially acceptable. Salmon is one of the few fish with an appreciable calcium content (Harrison et al. 1964).

Most families attempted to keep a milk cow which provided a limited quantity of dairy products during the summer. In spite of Spanos and Gottleib's (1976) assumption that cows were plentiful in Salem, they were small, and one gallon at a milking was considered average and two gallons was quite an exceptional yield (Rutman 1968). Butter and cheese were made, but homesteads with only one or two milk cows consumed it as it was produced (McMahon 1985). After September or October the native grasses did not provide enough nutrients to keep the cows producing milk. English grasses such as clover were imported and planted, but experiments of this nature were still remarked upon as late as 1685 (Bidwell and Falconer 1941). Most of the livestock did not have winter shelter or feed, although the milk cows were sometimes fed a little hay. Thus, due to low levels of nutrition in the cattle, milk products were not readily available in winter. To replace milk as a beverage, colonists turned to fermented drinks such as beer and cider. Beer was the preferred drink until the early 1700s, but the effort of growing barley was much greater than the work required to produce apples, and orchards became very common. Large quantities of cider were made and served to replace milk in winter, even for very young children (Earle 1899).

Table 1 lists foods which are high in calcium and those high in phosphorus which has an antagonistic effect on calcium absorption. The calcium-rich foods are among those which might have been present in Salem in summer months, but were unavailable in winter, whereas the phosphorus-rich ones were much more likely candidates for winter consumption in 17th-century New England. Peas, rye, corn and pumpkin were staple foods while the fish and meat listed are all very high in phosphorus content. Thus, the winter diet, heavy in grains which inhibit the absorption of calcium ions, and lacking in fresh vegetables, greens and milk products, would probably not have provided satisfactory levels of calcium. The reliance on salt meat for those who had meat would not have improved the condition (Fremes and Sabry 1976). Fish, which was used to supplement meat in the New Eng-

land colonies, was a negative factor in maintaining an adequate calcium balance.

**Table 1**  
**List of Common Foods in Terms of Calcium/Phosphorus Content**

High Calcium			High Phosphorus		
Food	Ca (mg)	P (mg)	Food	Ca (mg)	P (mg)
Milk (whole)	288	227	Flounder	23	344
Cheddar Cheese	158	100	Tuna	13	374
Beans (green, 1 cup)	81	50	Lamb Chops (1 lb.)	24	429
Lettuce (1 cup)	19	14	Ham (3 oz.)	9	201
Spinach (1 cup)	242	53	Pork Chops (1 lb.)	28	624
			Beef Liver	9	405
			Beef Steak (1 lb.)	24	490
			Rye Bread (1 sl.)	19	37
			Corn (1 cob)	2	69
			Popcorn	1	19
			Peas (1 cup)	30	138
			Winter Squash	57	98
			Pumpkin Pie (1 sl.)	58	79
			Potatoes (1 cup)	50	103

*Source:* Figures taken from Avioli (1981).

### Light Levels

Problems arising from low dietary levels of calcium were undoubtedly compounded by low levels of light. The value of sunshine and cod liver oil in maintaining health was not discovered until the 19th century (Huss-Ashmore et al. 1982). Sunlight changes precursor molecules in the skin to vitamin D which is a necessary component for the utilization of calcium ions. The effect of lack of sunlight on an otherwise healthy population is clearly demonstrated in a study by Neer and Wurtman (Wurtman 1975). Healthy pension-age males living in Boston remained indoors during daylight hours under fluorescent lighting from the beginning of winter to the end of March. By mid-February, after seven weeks, all of the subjects were only absorbing 40 percent of the calcium that they normally would. One group of subjects were then exposed to artificial natural spectrum light, giving the equivalent of a 15 minute noontime summer exposure. Four weeks later the subjects who were not exposed to natural spectrum lighting were down to a 30 percent calcium absorption rate. The subjects who were exposed to the equivalent of sunlight had increased their calcium absorption rate to nearly 50 per-



cent of available calcium. This study indicates that both the quantity and the spectrum frequency of light is important in affecting vitamin D synthesis and calcium utilization.

The light sources in 17th-century homes in Massachusetts were far less efficient than the levels of indoor illumination experienced even by the confined subjects in the Boston study. "Diamond-pane casement windows were common after 1640 replacing oil paper, but they admitted little sunlight and, indeed, were normally covered with fabric in the winter to preserve warmth" (Rutman 1968:31). Wooden shutters were also commonly used to cover window openings in winter to retain warmth. Most of the interior light came from candlewood or pitchpine, with real candles being very expensive at four pence apiece (Earle 1898), and rarely used in less wealthy homes. Another architectural factor was the building style in which upper stories of houses overhung lower ones in order to hold the beams for the upper floors securely in place. This overhang reduced the amount of direct light coming into ground floor windows where kitchens were located. Windows were neither large nor numerous in kitchens, as can be ascertained from remaining houses of the period in Danvers and Salem.

### Activity Patterns

These low light levels indoors would have affected girls and women more than boys and men due to their activity patterns. The tasks performed by girls, whether they were daughters or bound servants, would have kept them working industriously indoors. Much of the time was spent pounding corn in a mortar, hatchelling flax, spinning, weaving and performing other household tasks. This indoor location would have affected vitamin D levels, due to restricted exposure to sunlight. Low vitamin D levels suppress the absorption and utilization of calcium which would exacerbate the effect of a low calcium diet. In the absence of a daily sunlight/dark cycle the circadian rhythmicity of calcium levels is altered to such an extent that synchronicity with sodium and potassium levels is lost. Calcium becomes an insoluble compound under these conditions and is excreted in urine and feces. Thus levels of this element could become severely unbalanced in relation to other minerals. Boys spent more time outside doing male chores such as caring for cattle, building fences and cutting wood. The time spent outdoors would increase their exposure to sunlight, and the difference would be particularly noticeable in the winter.

It is not unreasonable to assume that the young women of Salem village were kept busy since the amount of labour required to keep a family fed and clothed "with only hoe, scythe, sickle and spinning wheel for tools required . . . continuous labour for the whole family through all the daylight

hours'' (Russell 1976:99). Children were expected to become producing members of the household at a very early age and were often accomplished knitters by the age of four (Earle 1898).

It was not uncommon for a family to bind their children to a neighbour or relatives as indentured servants. In fact most of the afflicted girls who were bound servants had relatives in Salem village or nearby communities. The need for labour was so great that in some cases children were kidnapped in England and sent to the colonies as indentured servants. Adults also paid for their passage to the New World by binding themselves to work for a specific time period. Children were frequently bound for a period of 14 years for a total payment of their keep, two suits of clothes, a cow and a horse (Demos 1972). It was considered permissible to beat servants with a stick or whip, although, if it was for more than 10 lashes a time, the court executed the punishment (Earle 1899). Men, women and children were subject to beatings, and it was not until 1705 that the whipping of naked white servants was forbidden in Virginia (Eggleston 1972). Masters used thumbscrews, sweatings and a scant diet of Indian meal to keep servants in line. There is only one record of a child being killed by this treatment, but they were often ill-fed and ill-clothed as well, as some of their written complaints and petitions attest (Eggleston 1972). The pattern of daily activity centred around work, and for girls much of that was indoors.

Dietary patterns for children are not easy to assess but among adults there was some distinction between the diets of men and women, and this may have been the case for male and female children and servants as well. In addition males do not undergo the cyclical hormonal changes of menses, which may also affect the course of a nutritional disorder. Bound servants ate after the family and, according to their complaints, frequently were hungry. John Proctor, the owner of Mary Warren, one of the afflicted girls, said he kept her close to her wheel (for spinning) and promised to beat her sorely if she left it (Hansen 1969). Another afflicted girl, Elizabeth Hubbard, was a bound servant in the house of her uncle, Dr. Griggs. Doctor Griggs was the person who pronounced that the girls were suffering from witchcraft. Little is known about Elizabeth's condition, except that one can postulate that the doctor had ample opportunity to study this strange phenomenon.

### **Part III – History of Affliction**

These commonly found conditions of diet, light level and work load for servants and children were certainly present in Salem village at the time period in question. The dietary situation in the Parris household may have been particularly severe for Betty Parris and her cousin, Abigail Williams, since Samuel Parris was the village minister, and thus did not farm. He had been

promised payment of money, food and firewood for his ministerial services, but had so fallen out with much of the congregation that he did not receive any pay for some months (Boyer and Nissenbaum 1972). Several times during October 1691 he had no firewood and had to demand some from those who would provide it. In addition, ministers' households were frequently frugal in the matter of food with bread and milk often providing breakfast, and sometimes supper as well (Earle 1898:148). This may have been adequate in summer, but in winter there would be little or no milk, and cider was usually substituted, with probable nutritional consequences.

There was also some level of hardship in Thomas Putnam's household where Ann Putnam, Mercy Lewis and Mary Walcott lived. Although Thomas Putnam had a wealthy father, his patrimony was severely reduced by his father's second marriage. Land which had been ample for three families was now shared among eleven (Boyer and Nissenbaum 1972, 1974). The family was considered to belong to the better class of villagers, but they were hard pressed to keep up their position. One of the results of accusations made by Ann Putnam and her mother was the hanging of Rebecca Nurse, whose family they felt had wronged them financially.

The other five individuals under consideration were all servants in various village households. The dietary conditions, activity patterns and light levels discussed above were undoubtedly integral parts of their everyday lives. It is notable that both Mary Warren and Sarah Churchill had reservations about accusing members of the families they worked for as witches, but did so because otherwise they ran the risk of being accused themselves. To me this indicates that they did not consider themselves to be badly treated by community standards, even though they may have succumbed to nutritional stress. It is also noticeable that these accusations did not occur until April and May, by which point social factors may have begun to manifest themselves, blurring the physiological causes of affliction.

### Similar Afflictions

A point of comparison between this and other presumed cases concerns the fact that 1691 was an exceptionally snowy winter (Boyer and Nissenbaum 1974) which means that outdoor activity was probably curtailed even more than usual. Other episodes of witchcraft recorded in the 17th century also refer to the presence of extremely cold and snowy conditions. Several cases had occurred around Boston in the previous 40 years. Of these I would like to single out two for special mention because they have features which resemble those in the Salem cases very closely.

The first is the case of Elizabeth Knapp, also a bound servant, living in the home of Reverend Samuel Willard who kept an account of the course of

her malady from October 30, 1671 to January 15, 1672. The choking sensation in her throat was followed by "fits in which she was violent in bodily motions, leapings, straining and strange agitations, scarce to be held in bound by the strength of three or four; violent also in roarings and screamings" (from Willard's account in Hansen 1969). She also displayed symptoms including loss of speech, speaking in voices other than her own, barking like a dog and bleating like a calf. She was not physically debilitated by these fits but rather had her natural strength when her fits were not on her. Reverend Willard concluded that she was not affected by witchcraft, but rather that she was demon possessed. Legally speaking the difference was quite significant because, although Elizabeth attempted to accuse various people of bewitching her, no one was actually charged, and the incident remained an isolated one.

The next incident I would like to mention is the 1688 affliction of the Goodwin children. It started with the older girl – about age 13 – and eventually affected four of the six children. Their bodies were contorted into strange distended shapes, their eyes bulged and their mouths snapped open and shut. They shrieked uncontrollably and affected the postures of animals, crawling about the room, barking like dogs, bellowing like frightened cows, and tearing at their clothes (Demos 1982). They also exhibited frenetic energy "climb(ing) over high fences beyond their imagination of them that looked after them. . . . Fly(ing) like geese . . . having but just their toes now and then upon the ground and their arms waved like the wings of a bird" (Boyer and Nissenbaum 1974). They saw visions, indulged in foolish ridiculous speeches, fits, convulsive paroxysms and hysterical muscle spasms. When all this was finished they fell into a deep quiet sleep. The behaviour was most severe in Martha, the 13 year old, who was taken into Cotton Mather's home for several months before she finally recovered.

There are several features of these two accounts which tie them together and relate them to the Salem incidents. Both occurred in late fall, beginning in October and lasting into the winter. Indeed, in Elizabeth's Knapp's case it was noted that the snow was so deep that the ministers who were to pray with her sometimes could not get through. The treatment that was initially prescribed for all of these cases was prayer and fasting in order to exculpate any sins. If nutritional problems were at the root of this behaviour, fasting would contribute to the disorder. As in many Salem cases, these individuals attempted potentially destructive behaviour. Elizabeth attempted to throw herself in the fire, while others such as Mary Warren had tried to drown themselves in the well, and the Goodwin children scaled walls and fences.

This aspect corresponds very closely with one of the marked features of Arctic hysteria, which is the performance of remarkable feats of strength and endurance. These included episodes such as wading naked in the winter

ocean, rolling naked in the snow for up to 30 minutes at a time, running wildly across the sea ice and climbing incredible cliffs (Gussow 1960). In many cases the victims had to be rescued or restrained or they would have died from cold and exposure. On some occasions fits of violence occurred towards sled dogs, or children were attacked with knives, but no injuries were actually inflicted. These behaviours show a very marked similarity of intent, even though they differed in the means of attempted self-destruction. (Gussow [1960] commented that he interpreted the behaviour as the result of oblivion to dangerous environmental factors, rather than as deliberate danger seeking.) The aspect of visions, or hallucinations, is another marked concordance, as is the presence of animal calls and imitations. These are particularly noted, in cases of Arctic hysteria, by observers such as Peary who saw that victims crawled around barking like dogs, mimicking many animal noises (Peary in Gussow 1960).

After the Salem episode came the case of Mercy Short, a 17-year-old bound servant, who was afflicted from November 22, 1692 until March 16, 1693. Her behaviours are very similar to those already quoted, with the addition of a prolonged anorexia. She spent periods from seven to 15 days without eating, which might easily have increased the severity of her affliction. Boyer and Nissenbaum (1972) mention that she had at least one severe nose bleed during a seizure, and nosebleeds are a common symptom of calcium deficiency among the Inuit (Wallace 1960). She saw and heard spectres, went into rigid spasms and was strangely distorted in her joints. She also had periods of affliction that were not painful, where she frolicked about, becoming as "extravagant as a wild cat . . . (and) her speech excessively witty" (Boyer and Nissenbaum 1974:25). This type of behaviour compares closely with that recorded for Martha Goodwin whose frolics "lasted all day . . . she was in a state verging on ecstasy" (Mather in Boyer and Nissenbaum 1974:19). These types of frenzied, constantly talking, moving behaviour, are similar to those experienced by people in the throes of "spirit possession" as noted by Kehoe and Giletti (1981) in their discussion of the possible influence which nutritional deficiencies might have on possession states. They emphasize calcium deficiency and its synergistic relation to magnesium as cause for disordered behaviour, as well as the low dietary protein levels of women who live in societies where there are food restrictions, and who frequently eat after men. Women's dress may also have an effect, since there are many cultures in which women must be completely covered with clothes, which reduces their ability to synthesize vitamin D through the effect of ultraviolet light on the skin.

Thus evidence from a number of sources suggests that calcium deficiencies are certainly capable of causing the types of behaviour seen in the "witchcraft" afflictions experienced in Salem and other New England

towns. The question then arises as to why only certain individuals were affected. This is a difficult question to answer nearly 300 years later. It would be necessary to know what the particular activity patterns of those young women were, and whether they varied from those common to the rest of the population. Another important factor would be the particular diets and food preferences of those households, and how they might differ from the rest of the community. Moreover, the efficiency with which calcium is metabolized differs among individuals and would be impossible to determine for those long dead. If skeletal material becomes available for individuals from this region in the relevant time period some general indications of dietary stresses may be recovered from chemical analysis of bone and this would provide potential positive or negative evidence bearing on the question of dietary deficiencies in this population. However, as noted earlier, the levels of calcium low enough to produce behavioural effects may be quite transitory, and may also occur due to acute alkalosis in patients whose plasma calcium is normal.

## Conclusions

In this paper I have attempted to indicate that the symptoms displayed by those young women who claimed that they were afflicted by witchcraft are very similar to the symptoms of a clinical condition which was not recognized in the 17th century. This syndrome, known as *pibloktoq* or Arctic hysteria, is not yet well understood, but appears to derive at least in part from periodic episodes of severe hypocalcemia. Among the causes of low serum calcium levels are low levels of dietary calcium, low levels of vitamin D which is required to metabolize calcium, compounded by low levels of exposure to sunlight, the effects of other elements and poor parathyroid activity. The dietary situation and light exposure of New England colonists can be discovered from contemporary texts and appear to match the conditions which might lead to problems in maintaining calcium levels. Why these young women in particular were singled out to succumb to convulsions may have been related to their ages, sex, activity levels, reasons for high anxiety and personal metabolic idiosyncrasy. They were not the only individuals so afflicted in the surrounding community. In addition to the cases mentioned previously other people and some animals had suffered from fits during the decades surrounding the outbreak. Elizabeth Howell who had just given birth at the beginning of a hard winter had claimed she was bewitched in 1658, but was not believed. Mappen (1980) comments that some people had actually died from their fits, after being disoriented, distorted, scratched and bitten, running out of their chambers and across the fields. As the evidence indicating the presence of witchcraft mounted in the Salem community,

more and more people were afflicted with fits until a total of 34 people claimed to have suffered from them (Spanos and Gottlieb 1976). As mentioned previously, hyperventilation, which is a frequent symptom of anxiety, can trigger a hypocalcemic episode by changing the pH level of the blood sufficiently that the calcium ions are bound to protein and not available for metabolic functions. Rising levels of anxiety in the village may easily have shifted some individuals with subclinical problems over the brink into seizures. Others may have had better diets or been constitutionally less vulnerable and were not afflicted.

This evidence seems to indicate that the explanation of calcium deficiency in cases of "witchcraft affliction" is a possible one, in a situation in which we have at least some background information about the participants. I am sure that this is not the total cause of the problems seen in 1692, especially since the accusations were not directed randomly, but rather began with the poorer and more vulnerable members of the village. Gradually, as the accused were hounded into confessions, they in turn suggested further names. The afflicted named both men and women of increasing social position and respectability, including a former minister of the church and several influential townspeople. At one point the Reverend Samuel Willard was accused, but the justices of the court refused to consider this seriously and reprimanded the accuser (Brown 1984). Thus, as Mappen (1980) and others agree, the later testimony of accusation and affliction is open to severe doubt concerning the genuineness of the accusations. However, I feel that there is enough evidence to suggest that the initial problems had some more deep-seated cause than malicious imposturing. The topic is a complex one, but nutritional and metabolic factors may well have played a role in causing behavioural manifestations which are still not clearly understood after a lapse of almost three centuries.

### Note

1. The 10 young women I am referring to include Betty Parris, 9; Abigail Williams, 12; Elizabeth Booth, 16; Sarah Churchill, 20; Elizabeth Hubbard, 18; Mercy Lewis, 19; Ann Putnam, 12; Susannah Sheldon, 18; Mary Walcott, 16; and Mary Warren, 19 (Richardson 1983).

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