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Lunar biological effects and the magnetosphere

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ABSTRACT

The debate about how far the Moon causes biological effects has continued for two millennia. Pliny the Elder argued for lunar power "penetrating all things", including plants, fish, animals and humans. He also linked the Moon with tides, confirmed mathematically by Newton. A review of modern studies of biological effects, especially from plants and animals, confirms the pervasive nature of this lunar force. However calculations from physics and other arguments refute the supposed mechanisms of gravity and light. Recent space exploration allows a new approach with evidence of electromagnetic fields associated with the Earth's magnetotail at full moon during the night, and similar, but more limited, effects from the Moon's wake on the magnetosphere at new moon during the day. The disturbance of the magnetotail is perhaps shown by measurements of electric fields of up to 16 V/m compared with the usual <1 V/m, suggesting the possibility of weak biological effects on some sensitive organisms. Similar intensities found in sferics, geomagnetic storms, aurora disturbance, sensations of a 'presence' and pre-seismic electromagnetic radiation are known to affect animals and 10–20% of the human population. There is now evidence for mechanisms such as calcium flux, melatonin disruption, magnetite and cryptochromes. Both environmental and receptor variations explain confounding factors and inconsistencies in the evidence. Electromagnetic effects might also account for some evolutionary changes. Further research on lunar biological effects, such as acute myocardial infarction, could help the development of strategies to reduce adverse effects for people sensitive to geomagnetic disturbance.

1. Evidence for lunar biological effects

Early evidence for lunar biological effects was recorded by Pliny the Elder (1st century AD) [1]. He argued, following Lucilius, that the Moon nourished oysters, sea-urchins and mussels and for lunar power "penetrating all things" and influencing shell-fish growth, creatures without blood, human blood, leaves and vegetables. Pliny followed Mucianus in attributing behavioural changes to lunar influence, such as the emotions of exultation and depression in monkeys. Many modern studies and gardeners' practices continue to support these observations of lunar effects on shell-fish and plants, while some studies support animal and human behavioural effects. Further validation for Pliny's acceptance of lunar biological effects seemed to come from his linking of tides with the Moon's attractive power, following Pytheas. The Moon's influence on tides was confirmed through calculation by Newton in 1687. This led to claims [2] linking the Moon's gravity to lunar biological effects [3], but such theories soon fell out of fashion [4]. (See Table 5).

Many modern studies provide (a) positive evidence of biological effects, but some give (b) ambiguous evidence, and a few show (c) a lack of evidence.

(a) Positive evidence. Many modern studies continue to provide strong evidence of lunar influence on shell-fish and plants. By the 1970s this was well established for plants, such as water up-take by bean seeds [5]. Tree diameter variation reflected the lunar cycle [6], as did root growth [7]. Reproduction could follow a lunar rhythm [8], along with changes in glucocorticoids, a 'stress' hormone, and foraging by mice [9]. The marine mollusc orientated itself by geomagnetic fields but correlated with lunar phase [10]. Since ancient times evidence for human effects has been strongest for epileptic seizures, with increases of over 1.5 times [11], whereas for canine and feline epilepsy, only the onset could be correlated with lunar phases [12]. The number of sudden unexpected deaths in epilepsy was highest in full moon at 70% [13,14]. A significant clustering of seizures around the full moon period was observed in Greece [15]. Of patients with violent and acute behavioural disturbance, double the number presented during the full moon compared with other lunar phases [16]. Greater numbers of patients with non-

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affective psychotic disorders and, to a lesser extent, depression were linked with full moon days [17]. An increase in admissions related to gastrointestinal haemorrhage occurred during full moon [18]. Requests for new appointments at a thyroid clinic had a peak 5 days after full moon, and for follow-up appointments 3 days afterwards [19]. Human spontaneous abortion may be related to lunar periodicities [20]. The mean day of spontaneous full-term deliveries in multiparae and plurigravidae cases was the first or second day after full moon [21]. Birth defects were linked with lunar periodicity [22]. It was claimed that general practice consultation rates showed a small but significant correlation with the full moon [23]. The occurrence of attacks of atrial fibrillation have been correlated with lunar periods [24]. The occurrence of gout attacks and bronchial asthma in children has been correlated with full and new moon, and a reciprocal relationship for paroxysmal tachyarrhythmia [25]. Personality test scores were related to lunar phases [26].

(b) Ambiguous evidence. Emergency visits for dogs and cats occurred on fuller moon days in Colorado [27], and there were more animal bites during a full moon in Bradford [28], but not in Melbourne [29] or all Australia [30]. The incidence of intracranial aneurysm rupture in Lebanon peaked during new moon [31], whereas in Germany the impact of the lunar cycle on aneurysmal subarachnoid haemorrhage was regarded as a myth [32]. The highest frequency of renal colic in Iran was in the middle of the lunar month [33], whereas another study relating renal colic admissions to increased lunar gravitational forces found no correlation [34]. Distress calls by women were more strongly linked to the lunar month than those by men, but the data should be separated by sex or the effect can be lost. One study showed almost no correlation between acute myocardial infarction (AMI) and lunar phases based on the synodic month of 29.53 days [35], whereas another reported an increase in AMI during weaker gravitation periods, based on the sidereal month of 27.32 days [36].

(c) Lack of evidence. Some concepts are disputed, such as the belief, held by more than 40% of medical staff, that lunar phases could influence emergency frequency [37], although some 43% of people believed in lunar effects, especially mental health professionals [38]. Psychiatrists in 1999 proposed that prior to the advent of modern lighting sleep deprivation around the time of full moon "would have been sufficient to induce mania/hypomania in susceptible bipolar patients and seizures in patients with seizure disorders" [39]. Psychiatrists in 2005 suggested that belief in lunar effects remains strong because of "a lack of understanding of physics, psychological biases (e.g., selective recall or selective perception), sensationalism, and the entertainment value of a belief in lunar influence" [40]. Another psychological approach arose from the increased nocturnal predation by lions in the darker weeks after full moon, suggesting that the full moon indicates impending danger, "perhaps helping to explain why the full moon has been the subject of so many myths and misconceptions" [41]. Some studies make strong claims: "There is no solid evidence that human biology is in any way regulated by the lunar cycle" [42]. Such claims usually avoid biological effects on marine organisms and plants.

2. Lunar gravity insufficient as a mechanism

Pliny foreshadowed some modern assumptions by deducing the Moon's power from the example of tides. Evidence from both physics and biology, however, suggests that this is unlikely to be the prime factor in biological effects. Calculations show that the gravitational pull is very small for relatively small objects like individual people. Because of the potential movement of water, the gravitational pull producing tides is misleading; it has much greater effect on oceans than on humans. Although, of the Earth, Sun and Moon, the Earth's gravitational pull on a 80 kg person at the Earth's surface is by far the greatest of the three, followed by the Sun and then the Moon (785.0 N; 0.47 N; and 0.0027 N respectively), there is no effect, since all are in 'free fall' and move only under gravity. For tides it is different. A very large area of water is needed for observable tidal effects and this depends on the shape of the bed and coastlines; some oceans have areas of no change in tidal height. The oceans can have tides with a rise or fall of tens of metres, whereas the Great Lakes have 6 cm tides observable, and no tides can be observed in small lakes, swimming pools or water within the human body. The tidal stretch on a human body is the equivalent of holding a pea of mass 1.5 g at 0.5 m above a person's head, where such a tensile stress would produce a change in a person's height about 1 million times smaller than the size of an atom [43]. The maximum combined lunar and solar variation in gravity is 0.3 mGal [44], the same as for moving 1 m vertically on the Earth's surface. These factors make significant biological effects unlikely from lunar gravity alone.

Most biological effects reported at full moon are not also reported at new moon, although both phases have similar gravitational forces, with the Moon in alignment with the Earth and Sun. If the additional gravitational force when the Moon is aligned every 14 days at full moon and new moon is the key factor, then the Moon's twice-daily diurnal gravitational force, seen in the two high tides each day, would also be factor, and there is no suggestion that this is the case. Humans do not report the lunar biological effects under increased or reduced gravity, as in areas of the Earth with high levels of gravity and in rapid acceleration or deceleration produced by movement.

3. Lunar light insufficient as a mechanism

Since gravitational pull from the Moon is unlikely as a mechanism, the light from a full moon at night has been suggested as explaining the biological effects. This hypothesis, however, has five objections, two relating to the nature and intensity of the light and three based on outcomes.

The intensity of light reflected from the Moon, at 7% of the Sun's light [45], seems too small to trigger significant biological changes, unless the light is of a different quality, but there is no evidence for this. Although the reproductive success of fishes has been related to lunar periodicity [46], deep sea fish, which experience little or no light, still displayed lunar periodicity in reproduction, suggesting that light is not the cause [47]. Even coral reproduction might lack sufficiently strong underwater hyperspectral irradiance to act as a trigger for its lunar cycle [48]. This last argument, from insufficient intensity of light for deep water fish, raises questions about artificial lunar light which can apparently shift the circadian clock of fruit flies and increase nocturnal activity independently of the clock, and may instead suggest that on its own lunar light has no more effect than daylight [49,50]. Eels have been found to be both photophobic and to react to full moon without reliance on light [51]. Human evidence also supports lunar biological reactions independent of light, since a blind man had circadian rhythm based on 24.9 h, the period of a lunar day [52].

Three further arguments relating to outcomes from photo-exposure suggest lunar light is not the sole mechanism. Many people in industrialised locations now experience more light every night than at full moon, but do not present the associated symptoms; nor are these symptoms reported by people who are used to dark nights when they enter an area with artificial light. A full moon on a clear night gives 0.27–1.0 lux which some plant species do not interpret "as 'weak sunlight,' but as 'absolute darkness'"