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Noncoding DNA and the teem theory of inheritance, emotions and innate behaviour

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Summary The evolutionary function of noncoding 'junk' DNA remains one of the most challenging mysteries of genetics. Here a new model of DNA is proposed to explain this function. The hypothesis asserts the DNA molecule contains not one, but two separate modes of inheritance. In addition to exons that code for proteins and physical traits, it is argued noncoding repetitive elements code for the inheritance of emotions and innate behaviour in metazoans. That is to say, noncoding DNA functions as the medium of a second, hitherto unknown evolutionary process that genetically archives adaptive information, configured as emotions and acquired during the life of an organism, into an inheritable form. This second evolutionary process, here called 'Teemosis', is a ***selectionist*** process, but paradoxically, because it does not affect physical traits, it has no maladaptive Lamarckian consequences. The medical implications of the hypothesis are discussed.

Introduction

In the late 1960s, it was discovered that eukaryotic DNA contained sequences that do not code for proteins [1]. Because this noncoding DNA (ncDNA) appeared to have no significant evolutionary function, it was considered an evolutionary anomaly and dismissed as 'junk DNA' [2] 'selfish DNA' [3] and 'ignorant DNA' [4]. However, in the last decade, numerous studies have shown that ncDNA is highly conserved in a wide range of metazoans, from puffer fish to humans [5–7]. These findings are at odds with theories of neutral evolution [8,9] that predict that if ncDNA is non-functional, sequence similarity in ncDNA will be gradually erased. Also at odds with the 'junk' paradigm is the finding, (from 85 sequenced species) that 'the amount of noncoding DNA per genome is a more valid measure of the complexity of an organism than the number of protein-coding genes'' [10]. Indeed, 98.5% of the human genome is noncoding [11], more than any other animal. Although these findings suggest ncDNA serves an evolutionary function, so far, no consensus has emerged as to what that function may be.

The 'divided DNA' hypothesis

In the absence of a viable explanation of ncDNA's function, here it is proposed that ncDNA is the ge-

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netic medium of a second system of inheritance residing within the DNA molecule. In addition to the well known Mendelian system of inheritance, which uses protein-coding exons to code for physical traits, it is argued that natural selection gradually evolved a second, related, but independent system of genetic inheritance, specifically to moderate the inheritance of adaptive information acquired from the environment during the life of the organism. While the 'Mendelian Inheritance System' (MIS) exclusively moderates the inheritance of physical traits, it is suggested the second, nonMendelian system (here called 'Teemosis') exclusively moderates the inheritance of non-physical, environmentally acquired quantums of adaptive information configured as emotion, which is the basis of all emotions, innate behaviour and instincts. That is to say, while coding genes moderate physical evolution, ncDNA moderates emotional and behavioural evolution.

To understand the selective pressures that created this dual inheritance system, it is necessary to re-examine the evolution of emotions and innate behaviour — two subjects that have themselves long been problematical for biology. Although the co-discovery of natural selection (NS) by Charles Darwin and Alfred Wallace explained the evolution of physical forms, Darwin himself did not believe NS adequately explained the formation of complex new instincts. Like Lamarck, he believed an 'instructionist' evolutionary process must also exist, to facilitate what he called ''acquired adaptation'' — how adaptive environmental information becomes innate and inheritable.

Although the selectionist theories of Lamarck and Darwin (*acquired characteristics* and *pangenesis*, respectively), are now known to be incorrect, no viable alternative theory has been put forward to explain how complex environment-specific innate behaviours and instincts are first encrypted into DNA. To this day, no consensus exists on how instincts such as habitat construction, complex mating rituals and displays, landscape preference, the ability to identify predators and prey without prior knowledge, new sexual preferences, interspecies interactions and other environment-specific behaviours are first encoded into an organism's genes and inherited. How was the migratory green turtle's genes first encoded with the specific location of Ascension Island, 2240 km. from their breeding grounds in Brazil? How were the genes of turkeys first seeded with the shape and flight characteristics of predatory hawks so that all new born turkey chicks, fresh from their shells will run for cover when they see a hawk, but will not do so in response to pigeons, gulls, ducks or herons [12].

These examples of the environment 'instructing' the genome are problematical for Darwinian theory because NS is not an *instructionist* process. It is a *selectionist* process. The only way that NS can function adaptively is if it prohibits the inheritance of acquired physical traits in accordance with the 'central dogma'. of biology. As formalised by Crick [13] the central dogma asserts that genetic information does not flow from the environment to the genome, but in the opposite direction only — from DNA to RNA to proteins to phenotype. Apart from the enzymic reverse transcriptase activity of retroviruses [14], Mendelian inheritance of physical traits prevents the hereditary transmission of environmentally acquired characters under normal conditions. This ensures environmentally induced modifications in somatic cells do not affect (or 'instruct') germ cells, which prevents the inheritance of deleterious phenotypes such as disease, injuries and the effects of ageing [15—17].

Paradoxically however, while morphological evolution must prevent the inheritance of acquired traits that would deleteriously contaminate the germ-line, behavioural evolution requires the acquisition and inheritance of environmental information to create complex, environment-specific adaptive behaviours and emotions. It was these conflicting evolutionary imperatives, it is argued, that generated selective pressure for a new, divided DNA molecule — a molecule containing two separate modes of inheritance: protein-coding exons to modulate the evolution of physical traits in compliance with the central dogma; and various non-protein-coding elements to modulate the inheritance of emotional and behavioural traits.

Eventually, it is suggested, a new DNA emerged as a result of these selective pressures. Called 'eukaryotic DNA', this nucleated molecule evolved between 2.1 and 1.6 bya from progenitor prokaryotic DNA [18,19]. Unlike prokaryotic DNA, which contains almost no introns, eukaryotic DNA contains copious introns and other noncoding elements essential to the teemosis process. Because only organisms built from eukaryotic DNA can acquire teemosis, this predicts that only eukaryotic metazoans demonstrate complex innate behaviour and emotions, a prediction supported by the well-documented behavioural distinction between prokaryotes (bacteria, etc.) and eukaryotic animals.

It is suggested ncDNA demonstrates three principal properties that make it suitable as a medium of inheritance:

- Because ncDNA does not code for physical traits, it circumvents the deleterious consequences of Lamarckian inheritance.

- ncDNA mutates in response to environmental stress. These stress-induced *directed mutations* provide the means by which the environment *instructs* the genome.
- Stress-induced directed mutations are linguistically encrypted as alleles of ncDNA. That is to say, ncDNA is a genetic language that 'codes' for emotional information, using a different set of nucleotides and codons than the 64 exon codons.

How teemic inheritance works

It is suggested the 'Teemosis Inheritance System' (TIS) is initiated in animals by a nonlethal 'environmental stressor', (typically, a predatory assault, natural disaster, misadventure, mating encounter or other stressful life event), which precipitates an emotional trauma in an individual. Although negative emotions are more common due to predation and misadventure, the emotional trauma may involve either positive or negative emotions — the main requisite being the intensity of the emotional response. When transduced by the individual's sensory organs and conveyed via neural networks to the central nervous system (CNS) the emotional trauma must be powerful enough to disrupt CNS homeostasis and stimulate the hypothalamic—pituitary—adrenal axis.

Where the individual survives the physical consequences of the environmental stressor, (physical injury, shock, etc.) the intense emotions precipitate an abnormal production of catecholamine and corticosteroid stress hormones that can initiate mutational activity in noncoding nucleotides of DNA. This mutational activity may include the duplication, deletion, rearrangement and transposition of mono-, di-, tetra-, penta-, and hexanucleotide sequences (in addition to some trinucleotide codons), into linguistic arrays that correspond to (or *code* for) the stressor emotions. Teemic encryption continues until the salience of the stressor emotions subsides and homeostasis is re-established.

It is posited that each stressor event alters ncDNA differently. For example, aesthetic emotions — delight, satisfaction, balance, proportion, etc. generated by a Palaeolithic hominid gazing at a distant vista may be encrypted as a specific teemic sequence of noncoding nucleotides. A possum ravaged by a dingo however, will encode a completely different nucleotide sequence, coding for the emotions of apprehension, startle, dingo, teeth, terror, etc. By this means, each teemic mutational encryption creates a unique genetic record of the powerful emotions that precipitated the teemic mutation.

This trauma encoded mutational sequence is here called a 'teem'. Once encoded, the teem is inherited by offspring, and when expressed in limbic system cells, may be retrieved and experienced as an 'emotional memory' of a single specific event or circumstance, albeit, with no associated semantic or declarative memory, and no physical consequences (injury, etc.) of the event. Only the emotions of the stressor event are inherited. The term, 'teem' is in fact, derived from 'Trauma Encoded Emotional Memory'. To the extent that teems convey experiential information (in the form of emotions) from one generation to the next without recourse to learning or cultural protocols, teemosis is a functional instructionist process. Significantly though, teems do not contain information about physical traits so have no deleterious Lamarckian consequences.

Emotional perception

A crucial component of the teemosis evolutionary process is what the author has termed 'emotional perception' — the capacity of the CNS and sensory receptors to translate (or more accurately, 'transduce') objects and situations in the organism's perceptual field into emotional representations. That is to say, teemosis requires sensory information to be continually transduced, not into comprehendible images, discernable sounds, etc. but into genome compatible emotional code. Only precepts that can be transduced into emotional representations can be inherited via the teemosis process. This generates selective pressure to transduce everything a teemic organism sees, hears, smells, tastes, etc. into emotional code. When a squirrel looks at a nut, as well 'seeing' the nut, it also transduces the nut into an emotional representation. 'Perception', according to this model is actually the fusion of emotional and cerebral precepts. Emotional perception allows the squirrel to distinguish a ripe nut from an inedible nut by the emotions they each transduce, just as humans use emotions to differentiate faces, cars, paintings, etc.

Emotional perception is a crucial component of the teemosis process. It allows a turkey that survives a traumatic predatory attack by a hawk to encode a *hawk teem* that includes the emotions of terror and the transduced emotional precept of the hawk's wing shape and flight characteristics.

When inherited by progeny, the shape of a hawk's wing and its flight characteristics are transduced by the new born turkey chick. This triggers the ancestral hawk teem, recalling its emotions of terror, which inevitably initiates an escape response.

This hypothesis argues that all instincts and innate behaviour in animals (with the exception of reflex actions, kineses and tropisms) are encoded, genetically archived and inherited as quantums of emotion. When a teem is triggered, it releases emotions, some of which predispose the organism to specific behaviours. For example, sexual emotions predispose an organism towards mating behaviour, aggressive emotions predispose towards agonistic behaviour, and maternal emotions predispose maternal behaviour.

Over time, each species acquires its own unique 'library' of teems that define its species-specific emotional and behavioural repertoire. In humans, the teemic library manifests as *human nature*. The 'teemic library hypothesis' redefines 'species' as a population sharing the same teemic library. The hypothesis additionally argues that speciation and sexual selection occur when an individual encodes a new 'sexual preference teem'.

Testing the hypothesis

The hypothesis; that emotions caused by traumatic events can be genetically stored in ncDNA as a linguistic sequence of nucleotides generates a number of predictions and logical arguments that can be used to test the hypothesis.

Noncoding DNA is mobile within the genome

Teem theory predicts that unlike coding genes, ncDNA must be genomically mobile — able to be moved, duplicated, deleted and rearranged to form new linguistic arrays — teems, similar to the way that human language arranges letters and words into sentences.

Is there any evidence that this happens? Despite the view throughout much of the 20th century that all DNA nucleotides function from a single stable, immobile position on a chromosome, McClintock discovered noncoding 'jumping genes' in the genomes of maize over 50 years ago [20]. Now called 'transposable elements', (TEs) these noncoding mobile elements demonstrate the ability to replicate and relocate within genes and even chromosomes.

Teem theory does not assert that TEs are exclusive to teemosis. Rather it is more likely that TEs first emerged in preteemic phyla as a means of responding to environmental stress and rapid change, (as in the case of maize) and was simply adopted by teemic species via NS.

If TEs were non-functional 'junk', they would tend to accumulate randomly along the genome, whereas each class of TE occupies a distinct area within heterochromatin [21,22]. SINE elements, for example, preferentially accumulate in R-banding regions whereas LINE elements occur preferentially in sex chromosomes and G-banding regions [23].

ncDNA is modified by environmental stress

Protein-coding genes demonstrate resistance to all but the most pernicious environmental stressors. With the exception of ionising and ultraviolet radiation and a number of powerful chemical mutagens, replication appears impervious to environment stress. In stark contrast, teem theory predicts that noncoding TEs in teemic species mutate in response to environmentally induced stress emotions.

Although seemingly counter-intuitive (given the stability of coding genes), this prediction is supported by a wealth of sequencing data that reveals stress-induced mutability is a fundamental characteristic of TEs (including SINEs, LINEs and Alu elements) in eukaryotic animals [24—32]. Significantly, this stress-induced mutability is highly conserved in a number of phylogenetically disparate metazoans, which has been interpreted by Schmid [33] as indicating a little understood evolutionary function related to the genome's response to stress.

Teemic mutations of ncDNA are inheritable to offspring

Teem theory argues that emotion directed mutations of ncDNA (teems) are inheritable to offspring as emotions, which predicts that stress-induced mutations of TEs must be heritable. This may occur in two ways; either the teemic directed mutation occurs directly in germline ncDNA, or it occurs in somatic cells and is transferred to the germline in vivo. While this molecular dynamic remains little understood, some research on Drosophila indicates that stress induced somatic induction in TEs in females has effects on subsequent generations, transferred, it is presumed, through the cytoplasm of the eggs [34]. This maternally inherited effect has been reported in a number of Class II TEs; including mariner elements [35] hobo transposons [36—38] and Tam (1 and 2) elements, [39] which

has been interpreted as examples of non-Mendelian inheritance [34]. In their review of the impact of stress on TEs, Capy et al. [34] suggest ''a relationship may exist between the somatic activity of an element in a given generation and its germ-line activity in the following generation''.

Teem theory does not assert that traumatic stress will always precipitate TE mutations either in somatic or germline cells. Clearly, emotional response and stress are highly variable between individuals — events that cause traumatic stress and mutations in ncDNA in one individual will not necessarily precipitate the same molecular response in another individual. This is illustrated by several studies with Drosophila that demonstrate mobilisation of TEs in some individuals following heat shock [40,41], while other studies found no effect [42,43].

ncDNA contains encrypted emotional information

The hypothesis that ncDNA contains a second genetic code is clearly at variance with the notion of 'junk DNA' and the prevailing view that only one genetic language exists — that based on the four-letter exon alphabet that codes for proteins and amino acid assembly. However, the suggestion that a second genetic language exists is not without evidential support.

Although geneticists have been occupied since the 1950s with decoding the exon language of the MIS, by the 1980s, statistical analysis had began to discern structural differences between coding and noncoding sequences that were indicative of a linguistic distinction [44—46]. The suggestion that ncDNA may contain a hidden natural language was first postulated by Mantegna et al. from computer based statistical analysis of base pair sequences [48]. Applying Zipf's law [47], (normally used to analysis human language by ranking word frequencies), Mantegna [48] argued that ''noncoding regions are more similar to natural languages than the coding regions... supporting the possibility that noncoding regions of DNA may carry biological information''.

Although these conclusions have been challenged [49—51], a subsequent study, by Stanley [52] reported a fractal correlation between widely separated noncoding base pairs. Significantly, these long-range correlations do not occur in coding sequences [53]. When combined with the finding that the noncoding sequences appear more complex in more highly evolved species than in less evolved ones [54] it supports the conjecture that ncDNA displays a little understood linguistic function.

ncDNA scales with complexity

If ncDNA is a language that codes for emotions and innate behaviour, it predicts that noncoding elements in the genomes of higher teemic species such as primates, (that display highly variable emotions and innate behaviour) will be more numerous and complex than in lower teemic species such as insects. Sequencing evidence does indeed confirm that ncDNA scales with complexity. While coding genes demonstrate a remarkable homology between species and even taxa, their noncoding mobile element content is markedly variable. For example, vertebrate introns are longer and more complex than invertebrate introns [55,56], and mammalian introns are the longest and most complex of all [57]. Similarly, the pufferfish genome contains less than 3% mobile element repeats [58], the fruit fly ~3% [59], and the worm ~10% [60]. However, in the more developmentally complex mammals, such as the mouse and humans, the mobile elements content is significantly higher, in excess of 37% in the mouse [61] and over 45% of the human genome, which includes Alu elements that are unique to primates. Indeed, one of the most unexpected findings of the Human Genome Consortium was that the human diploid genome was comprised of 98.5% ncDNA, the highest of any species yet sequenced [62]. While, these findings have been considered problematical, they are consistent with teem theory and the view, based on observed emotional and behavioural complexity, that humans are the most 'teemic' of all species.

Medical implications of teem theory

The new model of DNA appears to have implications for human medicine. While space precludes a detailed discussion here, for that, see Vendramini, in press [63,64], two implications of teem theory are discussed here.

How traumatic emotions can cause disease

Teem theory asserts that traumatic life experiences — the death of a spouse, accidents, war, love and other highly emotional circumstances can precipitate a teemic mutation in human ncDNA. While most teemic mutations occur in introns, where

they do not interfere with protein manufacture, a teemic mutation may occasionally be transposed into or near a protein-coding exon that regulates a fundamental cellular process such as cell growth, apoptosis, or tumour suppression. If the teemic mutation is not repaired by enzymes, it may disrupt protein synthesis resulting in disease or death.

The hypothesis — that intense emotions can precipitate *directed* mutations in exons, resulting in disease appears supported by studies that show transpositions of noncoding microsatellites, Alu elements, SINEs, LINEs and other noncoding elements into exons cause as many as 36 neurodegenerative diseases and account for a significant fraction of human genetic disease [65—68]. While these mutations are thought to be random, teem theory argues they are non-random and are precipitated and directed by powerful emotions.

While the connections between emotions and disease have long been acknowledged but little understood, teem theory describes a feasible genetic mechanism by which powerful emotions can contribute to disease. It throws light on problematical medical research that links cathartic life events with cancer, such as the study by Kune [69] of 715 cases of colorectal cancer. Kune found that major illness or death of a family member, major family problems and major work problems were significantly more common during the five years preceding diagnosis compared to controls [69]. see also [70—72].

Emotional perception and psychopathology

The second implication of teem theory is extrapolated from the 'emotional perception' (EP) hypothesis. Human EP modules distributed throughout the CNS are subject to psychopathologies precipitated by extrinsic and intrinsic factors. Because EP contributes to cerebral precepts, any pathology in EP will distort or disrupt 'normal perception', resulting in affective-perceptual psychopathologies such as Anorexia nervosa, Capgras Syndrome, Asperger Syndrome, Anxiety disorders, Obsessive-compulsive disorder, Agoraphobia, Organic Delusional Syndrome, Dyslexia, Body Dysmorphic Disorder, etc. Finding new medical interventions for these problematical conditions will require a detailed understanding of the intricate emotional perception modules of the limbic and amygdaloid complex vis-à-vis teemosis, and an appreciation that 'normal perception' is comprised of two separate perceptual streams — emotional and cerebral.

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