

Hobson-McNamara Dialogues on "Conscious States" Spring-Summer 2020

Chapter 1

PM: You define consciousness as “a graded global integration of multiple cognitive functions yielding a unified representation of the world, our bodies and ourselves.”

AH: Yes. I adopt this simple definition for strategic reasons. The first is that my work does not attempt to solve the consciousness problem, but it does attempt to define the brain basis of conscious state change. Having done so, my scientific conviction is that the consciousness problem will be easier to solve. That is my second goal.

PM: It seems to me there are 3 key terms in your definition: 1. “Graded,” which points to the key advance I think your theory brings to the table—namely brain state changes and transitions; 2. “Global Integration,” which is consistent with other theories of consciousness like the global workspace model; and the third key term is 3. “Unified Representation,” pointing to the central, most intriguing feature of consciousness—namely the sense we each have of unity.

Our field of awareness is a unity, a gestalt. When we perceive or cognize anything, we experience it as a whole or unity, a “thing”. If we can solve that mystery we can solve the question of consciousness. In terms of our sense of ourselves we also experience a unity - the moment-by-moment awareness of myself seems unified - yet I am always conscious of conflicting desires, goals, aims and so on.

AH: Your analysis places my work in the context of more general, more extensive, and more ambitious theories, but my goals are at once more ambitious and more modest: To place dream theory at the heart and foundation of consciousness science.

PM: I do think your work and reflections on consciousness are more complete (precisely because it brings in dreams) than any other extant theory of consciousness out there so I think it worthwhile placing the work in that context while of course keeping in mind the focus on dreams...

You call attention to the fact that most consciousness science focuses on waking and ignores or pays only lip service to dreaming. Tell me more about what you hope to gain from this strategy.

AH: I want to learn more about consciousness by studying dreaming. My latest idea is that the brainmind creates a model of the world in REM dreaming that it then tests out during waking life. When it goes back to sleep It then returns to REM dreaming to update its model according to its experience of the world.

PM: Seeing dreaming as modeling the world and then updating the model each night is consistent with predictive processing accounts of the brain/mind. You have worked with Karl Friston on developing that perspective of REM dreaming in some detail. I know we will discuss that perspective in more detail later. But first lets return for a second to the attempt to

place your work in the contemporary scientific and philosophical scene. There is a disconnect which needs to be corrected.

For example, many people see you as the enemy of psychology. What do you say to them?

AH: Only that any psychologist who ignores physiology is in peril. Sigmund Freud is a stunning example of this mistake as is detailed in the history of our field in Chapter 2. As far as definitions are concerned, my choice of modesty and simplicity is in the service of modelling both the brain and its mind.

PM: The AIM model is easy to understand because it is so clearly visualized but many people will not grasp what you mean by declaring that AIM (Activation, Integration, Modulation) is a state space model.

AH: All of us experience consciousness as a continuously changing variable and unified mental process. AIM acknowledges both variability and unity and begins to place quantifiable bounds upon these fundamental properties. Using experimental data to guide adjustment of the 3 parameters of the model (e.g., increasing activation, decreasing integration and adjusting modulatory transmitters etc), we can account for the formal consciousness properties associated with each brain state (waking REM NREM), as well as intermediate hybrid states (such as lucid dreaming). My work, with Ursula Voss, shows how this AIM model pays off in explaining lucid dreaming as a hybrid state involving both REM and waking brain mechanisms.

PM: You rightly point out that dreaming and waking are 2 quite different states of consciousness. Why is it important to remember that there are many radically different states of consciousness? Is there any unity to all of these differing states of consciousness? For example, within each such state there may not be self-awareness but there is a subjective feel or “what it is like to be...” right? And there is that sense of unity or a unified perceptual field within each state right?

AH: Yes to both questions. I focus on the differences between states rather than the similarities. For example, the lack of self-reflective awareness, pointed out by Allan Rechtschaffen as a cardinal feature of dreaming consciousness, is one formal feature that I think may be explained by AIM. It can be understood as the failure of memory and orientation in REM dreaming related to aminergic demodulation.

In other words, it is not so much that we *want* to be disoriented as that we *are* disoriented for good physiological reasons. The brainmind must somehow profit from this loss. I suggest that it helps to reorganize memory, a major task of cognition.

PM: In the effort to try to understand how mind or consciousness is related to brain, you advocate what I think is a reasonable scientific strategy: correlate formal features of subjective reports of conscious episodes to psychological variables known to be reliably associated with those features and then correlate those psychological variables with brain activity/inactivity patterns.

That broad strategy seems consistent with the strategies advocated by neurophenomenology. Perhaps the neurophenomenologists and dream scientists should start to talk to each other. You mention your theory of proto-consciousness in this first chapter. The idea is that there is a genetically wired preverbal way of knowing that occurs for all mammals (including us) and

that we experience this innate proto-consciousness as a kind of virtual reality model of the “world”. Since, at least initially, during intrauterine life, it does not depend on sensory input from the outside world, the reality it depicts/constructs/presents, or models must be unusual but shaped by natural selection in some way. Can you say more about this?

AH: The basic idea derives from Helmholtz’s 1850 theory that the brainmind builds its consciousness function upon a sensorimotor template. It is obvious that our bodies are the locus of both our sensorium and motor programs and that these must be harnessed to cognition by the brain. In his *Physiological Optics*, Helmholtz devoted ten pages to discussing dreaming as imagined sensorimotor activation.

PM: Most people have never even heard of Helmholtz. Sigmund Freud does not cite him in his otherwise exhaustive review of the literature in Chapter One of the *Interpretation of Dreams*

AH: I only discovered him myself in the 1980’s when Jack Nelson, Bob McCarley and I had recognized the feed forward nature of information about REM sleep eye movements. Helmholtz’ prescient insight about dreaming is now linked to AIM and modern dream theory via its association with the Free energy theory (FET) of Karl Friston.

The important work of Charles Hong shows that activation waves (called PGO because they are easily recordable in the cat pons (P) the lateral geniculate body (G) and the occipital cortex (O)) are widespread in the human brain during REM sleep. Our REM sleep dreams are always animated, visual and emotional. These are facts of life deserving to be known every bit as much as the sexual instinct. I regard proto-consciousness as a fact, not a theory.

Chapter 2: Conscious states

PM: In Table 2 you mention Hermann Helmholtz and the pact against vitalism but say nothing about his substantive importance as a forerunner of some distinctive features of your theory.

AH: There are a couple of Helmholtzian ideas needing emphasis: the first is feed forward information generation and internal information processing.

In REM sleep information about the eye movements is sent ahead from the brainstem to the cortex. This data could be used in constructing dreams or at least constructing dream vision. A second idea derives from the first; dreaming is first and foremost a sensorimotor construct. This is evident in the somatic nature of dream experience. We inhabit our dream bodies and move through dream space.

PM: Would you agree, however, that sensorimotor aspects of dreaming are not the whole story? For example, when amputees dream, they dream themselves intact--even if the handicap was congenital. Deaf-mute individuals report dreams involving them talking and hearing normally. Patients with varying degrees of paraplegia report themselves flying, running, walking etc normally in their dreams--all for many years post trauma. If dreaming is "first and foremost" Helmholtzian unconscious inferencing in service to sensorimotor operations, then it is difficult to account for such dreams of the sensorially limited.

AH: My point is precisely that since there is nothing wrong with the central, motor pattern generating brain mechanisms of amputees, their model of the world is intact and their dreams are vividly sensorimotor. They imagine that they can walk and do so with great pleasure in their dreams. Subjects with acquired blindness see their long-lost loved ones in the dreams. These facts provide the strongest empirical validation of Helmholtz' theory.

PM: Could you explain free energy theory a bit more?

AH: Helmholtzian free energy theory (FET), is the most important and most difficult concept for us to grasp. I understand FET as protecting the mind from surprise as it models the world.

PM: On this view, FET is a mental safety device. But it also ties dream theory to the second law of thermodynamics. Why should we want such a tie?

AH: A key function of sleep and especially REM, is to assure brain temperature control. We may need to dream in order to stay warm as well as to review our memories.

PM: There does appear to be a lot of evidence linking sleep and thermal regulation but in REM we return to a poikothermic state right? Temperature control reflexes are absent during REM, right?

AH: This important fact shows that REM is an expensive, potentially perilous state. The trade off between risk and survival must be positive. Do we dream in order to stay warm? No, but we assure warmth at the same time that we update our memory model of the world. Welcome to sleep and dream science wonderland.

PM: Returning to your history of scientific approaches to dreaming, would you say that "Psychologists should interpret dream content as motivationally meaningful." is the essence of your criticism of Freud who famously said, "a cigar is sometimes just a cigar".

AH: I have no problem with the psychological interpretation of dream content. As a reformed Freudian, I do it all the time as I tried to make clear in my book "Six Dreams Freud Never Had". I want Freud and his psychologist followers to reopen their minds to brain science. Brain science fits so perfectly with cognitive behavioral therapy that, if I were young, I would embrace that approach and let psychoanalysis die a natural death. It was the mistakenly divisive movement of a self-styled genius nut who provided employment for other neurological illiterates. I almost became one myself!

Chapter 3: Philosophy

AH: My philosophical views have changed radically since writing this book a decade ago. I now see dual aspect monism (a la Spinoza) as the way out of the philosophical morass of Cartesian dualism. Here's the way I proceed:

By considering brain and mind as two aspects of a unified process dual aspect monism or DAM puts mind and brain on an equal footing while leaving a person free to believe in something more than the modest goals of tidying up sleep and dream science. The

philosopher who first suggested this theory was Benedict Spinoza, a 17th century thinker who was cast out of his native synagogue in Amsterdam for the antireligious implications of dual aspect monism.

PM: Although popular among neuroscientists interested in consciousness and some academic philosophers, dual aspect monism (especially the version advocated by Spinoza) has, in my view, already been, at least potentially, effectively called into question. Here are the concerns with DAM as I understand them: There can be no equal ontological or epistemic weight given to the 2 aspects of the one underlying reality. DAM theorists say both mind and matter are physical - yet that does not explain anything. It does not explain the roles or properties of each aspect. Mind has an epistemic function and status while matter has none. Mind can cause things to happen while matter cannot. Mind can know things while matter cannot etc... Those basic differences in capacities and properties are precisely what needs to be explained. Yet all that DAM claims is that both are physical. That explains nothing. Therefore, DAM advances us no further than Cartesian dualism.

AH: This discussion needs to be slowed down and unpacked. As I understand it, you are arguing for some sort of Cartesian dualism. I welcome this debate but want to express my reservations about 1 Refuting anything on philosophical grounds alone. This seems medieval, Thomistic, worse than Freudian splitting. I think of Freud as Cartesian. 2. Models are theories which account for findings; they are tentative ways of explaining observations until something better comes along. They cannot be refuted on rationalistic grounds alone.

PM: But isn't DAM a philosophical position--not a scientific model? It is a claim about the ultimate nature of reality, right? As such it cannot be refuted solely empirically. Therefore, logic and rational argument needs to be brought in. All I am saying is that DAM is philosophically problematic for the reasons I gave. I therefore do not understand why you unreservedly adopt it as the background assumption for your work.

My position is fundamentally pluralist and realist. William James' pluralistic metaphysics and Charles Sanders Peirce's realism in the line of old-fashioned Aristotelian realism seems best suited to the scientific outlook in my opinion.

AH: I have no objection to your saying that you prefer the realist philosophical position because of reservations about DAM. You may be interested in the arguments laid out for DAM in the recent Entropy article I wrote with Friston. The philosophical issues, however, take second place to empirical observations. It is easy to waste a lot of time if we do not stay close to the empirical facts concerning dreaming. Take Dan Dennett's long adherence to Norman Malcolm's skeptical claims about dreams occurring only during awakening. While dream science had long disposed of that mistake, fruitless discussions around Dennett and Malcolm's erroneous ideas continued for decades thereafter. What we learn from this episode is that philosophical positions, in the absence of data, tend to become mere uninformed opinion slinging. Get thee to the sleep lab! Keep a journal. Collect data!

PM: But there is really excellent work being done by philosophers on dreaming and consciousness. It seems to me that philosophers conversant with science such as Jennifer Windt, Thomas Metzinger and Antti Revonsuo (all of whom you mention in this chapter) have presented theories of the dreaming mind/brain as a simulation-prediction machine...just as you and Friston have done.

Chapter 4

PM: You were very harsh in your criticism of Sigmund Freud when you first enunciated your activation-synthesis dream theory in 1975 but you seem to have softened toward him since then. He put the idea of the unconscious on the map with respect to dreams and you have come back to this idea with your proto-consciousness concept.

AH: I was angry at Freud because I had believed in him as a college student but became skeptical in medical school and totally disillusioned in psychiatric training. I came to see Freud as dishonest and immoral and set my dream theory up as the brain-based integration of neurology and psychiatry that he had split asunder.

PM: Freud thought that dream science and psychiatry had no need for the work you summarize in this chapter. After an initial attempt at a neurological model of Mind in his Project for a Scientific Psychology, he dismissed brain research as unnecessary and unwanted, whereas you were convinced that no dream science could become scientific without it.

AH: I grew up in the dark ages of brain science but began to see the light after 1950. In retrospect, a great deal had been learned between 1900 and 1950 by brain scientists interested in sleep and dreams but very little or nothing by the Freudian psychoanalysts because Freud insisted that his theory was exclusively psychological. Bob McCarley and I challenged this assertion in our 1977 lead article in the American Journal of Psychiatry, an article which elicited more letters, most of them negative, than any other article in the journal's history.

PM: OK, so you touched a nerve, but what had the Freudians overlooked?

AH: The brain scientists in the first half of the 20th century demonstrated the importance of the brain stem in determining the nature of forebrain activity. Thus, sleep began to be seen as an active process driven largely by brainstem mechanisms. This fact is vigorously denied, even today, by those psychoanalysts who recognize its threat to Freud's outmoded dream theory and the unveiling of psychoanalysis as pseudoscience.

PM: While the brain scientists were uncovering the secrets of sleep the psychoanalysts were blaming the parents of schizophrenic and autistic kids for the psychosis and autism their kids were enduring! They accused these poor parents of being cold, frigid, loveless and distant people!

AH: Such ad hominem accusations are still ongoing in psychodynamic psychotherapy. Parents are blamed for their childrens' problems.

PM: Despite the pseudoscience of much of psychoanalysis were there any strengths or value in Freud's "findings" concerning dreams? For example, his fundamental claim that dreams often reflected sexual conflict seems to be supported by male v female dream content differences.

AH: What else is new? The war between the genders rages. There are more males in male dreams than female dreams. In those dreams there are high levels of physical aggression between males, while in female dreams there are high levels of verbal aggression directed

against other female characters. These male v female content differences are consistent with the evolutionary sexual strategies of the two sexes. Males compete with other males for access to females while females gossip/verbally denigrate other females as part of their sexual strategy.

PM: Yes, exactly! It seems to me that those dream content data support a view of dreams as reflecting, to some extent, sexual conflict. In addition, attachment theorists have begun to study dreams in the last decade. They have shown, pretty conclusively, that people tend to dream of their primary and desired attachment figures. The brain/mind is not merely a prediction machine, as Friston would have it, but it is a *desiring* machine. The simulations it produces are DESIRED states of affairs--not merely predicted states of affairs. These dream content trends are broadly consistent with Freudian theory right?

AH My predictions include my desires. I think it is a grave mistake to overlook this point. No one suggests that the predictions of my brainmind are unmotivated. This is a distortion designed to protect closet dualism. Enough already!

PM: My understanding of Friston's work is that predictions cannot include desires as desires are virtually always in conflict with reality. Surprizal or the Bayesian error signal used to update models is necessarily based on more or less accurate sensory sampling of the world *as it really is* --not as I would like it to be. If it were the latter, we would have psychosis. There are limits to what Friston can do for dream science.

AH: I agree. Friston would say that he is modelling sentience, not sentiment. I want more than that but math/physics doesn't care about me. My brain creates a model of the world according to its wishes (in this sense Freud was right) and revises that model in the light of its experience of that world. Call this process psychodynamic if you will but recognize its origin in a specific form of organic brain state activation, In addition, male female differences strike me as both weak and difficult to attribute to Freudianism. They are instead reflective of fundamental reproductive strategies of the 2 sexes. Dreams transparently reflect fundamental biology. They do not disguise it. Freud's dream theory was disguise censorship. I believe it was wrong and want to be clear on this point. He did not predict that men and women would dream very differently, and I am not impressed that the differences outweigh the similarities eg the formal features of bizarreness etc.

PM: It seems to me that some of the dream content differences that have been empirically established over the last few decades are reliable and stable. Therefore, they must be considered to be a part of the list of "formal dream features" right alongside dream bizarreness and the others. In fact, they should be considered even more important given that they speak directly--at least potentially, in the case of male-female differences to evolutionarily developed reproductive strategies. Or take Revonsuo's findings that many dream are simulations of threats...or take the fact that many dreams are simulations of our social interactions...These are all content items that are predicted by evolutionary biology. They are just as biologically based as bizarreness or other formal dream features.

AH: I fear that you are blurring the distinction between dream form and dream content. I often dream of love objects (CONTENT) but I see them clearly even when they don't look like the people they are supposed to be (FORM). My REM sleeping brain is making the best of a bad job when it predicts standins for my procreational impulses. I am not actively

disguising their identity. I am just betting badly because I have important housekeeping tasks to attend to.

PM: We can agree that the disguise - censorship theory of Freud is not supported empirically. What I am saying with respect to stable content differences in dreams is that, like the formal features of dreams, they can be considered non-arbitrary features of REM dreaming. They are just as characteristic of REM dreaming as the formal features. They need to be considered when formulating functional theories of dreaming. Ultimately, we need to invoke evolutionary biology in order to understand REM dreaming.

AH: I agree. The modern dream culture strikes me as wrong-headed in that it persistently ignores biology while trumpeting a lightweight psychology. It is not an exaggeration to say that dream discussion has achieved something like a cult status which I find both obnoxious and misguided. The differences between male and female dreams are correctly attributed to real gender contrasts. But men and women both dream for life preserving biological reasons which tend to be lost sight of when focussing exclusively on dream content and ignoring dream form. On formal dimensions men and women are so similar as to thrill the feminists.

PM: It does seem to be a mistake to neglect dream form while studying dream content. Conversely, we cannot focus solely upon dream form. Both dream form and dream content are required to understand dreams and are both produced by the brain. But here again I hold that reliable, stable, universal dream content indices should be considered formal features of dreams. The male female content differences are consistent with Darwinian evolutionary theory. Natural selection shapes both dreams and dream content. From this point of view dream content studies not only do not ignore biology; they appeal to it to explain their findings. There are some scientists who study dream content who do not rely on "lightweight psychology" to interpret their results. Instead they rely on standard evolutionary biology to do so.

AH: Bravo, right on but mind the dualistic gap!

PM: One criticism that psychologists level at brain scientists who study REM sleep is that they very rarely if ever study the evolutionary biology literature and therefore operate in ignorance of the relevance to dream science of fields like life history theory or genetic and sexual conflict theory.

AH: That can't be me although I can see why this misconception might arise. I demanded reform and many self-satisfied practitioners wanted me to get lost. I aimed to become the pre 1895 Project Freud who yearned for a psychology that was secure and free from doubt, one that married mind and brain rather than splitting them apart.

Chapter 5

PM: In this chapter you discuss some of the history of the work in neuroscience studies of REM dreaming including such figures as Giuseppe Moruzzi (1910-1986) and Frederic Bremer (1892-1982). Among many other contributions these scientists firmly established a role for the brainstem in sleep.

But you also discuss in this chapter the work of Mark Solms, the South African neuropsychologist who used the disconnection syndromes framework and lesion correlation approach to map out brain regions involved in loss of various aspects of dreaming.

Solms showed that lesions to the white matter connecting the frontal lobes with limbic sites as well as the white matter connecting parietal operculum with structures deep to the temporal lobes, led to the loss of various aspects of dreaming. He interpreted these results to support Freudian wish fulfillment theory. On his model, to put it somewhat crudely... a dream wish is activated during sleep and mediated by limbic frontal desire circuits. This wish is then hallucinated (mediated by posterior parietal sites) as fulfilled by the dream.

Many dream scientists have pointed out that most dreams are far from wish fulfillments so these efforts to resuscitate Freud seem to me to be somewhat strained. But what is your assessment of Solm's findings? How might they relate to your AIM model of dreaming?

AH: I am deeply skeptical about Solms' work because he seems to want to save Freud from the scientific ashbin to which I have consigned him. I accept and applaud Solms' contributions of the role of the forebrain to dream construction but categorically reject his idea that the brainstem has nothing to do with dream construction. According to me and most of our scientific peers, this as erroneous as Freud's now outmoded assertion that brain science has nothing to contribute to dream theory.

Chapter 6: A= Activation

PM: In this chapter you begin to discuss the role of the activation parameter in creating brain state changes related to dreaming. Physiological and brain arousal levels vary systematically across sleep-wake states and within a single overnight sleep episode. These state changes were first quantitatively captured by the breakthrough studies of Hans Berger (1873-1941) whose work on recording scalp potentials during sleep led to development of the EEG (electroencephalograph).

We observe five basic types of brain waves associated with REM, NREM and wake states. Gamma, beta and alpha waves appear to be associated with waking states while theta and delta waves are associated with sleep states--though gamma and alpha waves can reappear in REM.

What are the implications of these now well-established facts for consciousness? Would you say that these brain wave recordings demonstrate that brain and consciousness are periodically activated (A) and inactivated via electrical power (i.e. fluctuations in neural firing)?

AH: Yes. Electrical activation of the brain is essential to waking and dreaming consciousness while deactivation (or diminished activation) causes the impoverishment of cognition in NREM sleep.

PM: You also discuss the landmark description of REM sleep in 1953 by Aserinsky and Kleitman and soon thereafter the tight correlation of vivid dreaming with REM by Dement and associates.

AH: The REM/dreaming discovery has led to the paradigm shift that changed thinking about cognition dramatically. Dreaming is now seen to be a cardinal state of mind rather than an evanescent will of the wisp associated with waking up. The biological foundation of dreaming in brain activity is exactly what Freud hoped for in 1895. But we had to wait 60 years for this liaison between brain and mind to be established. We have spent another 60 years in working out how this unity may be achieved.

PM: What are the landmarks of brainmind unity?

AH: Activation synthesis dream theory, first enunciated in 1975, held that the brainmind was turned on in sleep (activation) and then made up stories (dreams) that synthesized recent and past experience.

I was eager to distance my theory from the disguise-censorship hypothesis of Freud. According to activation-synthesis, dreams revealed meaning rather than concealing it.

PM: OK, but that does not explain your emphasis on randomness in the generation of activation signals used to create the dream stories.

AH: I had two goals: one was that the signals were somatic, that is to say, sensorimotor; the other was that the signals were aleatory, meaning that they occurred by chance.

PM: So the body becomes the mind by virtue of forceful chance. Dream meaning is added after the fact and, while bizarre, is transparent.

AH: No wonder, I had trouble getting my message across. It was as unwelcome as it was difficult to understand. I wanted to explain both the sense and nonsense of dreams without resort to the Freudian idea of defensive obscuration of meaning.

PM: People discredited you by assuming you were just another pro-Freudian denier of obvious truth.

AH: By this means our psychoanalytic critics were able to ignore the physiology underlying the reciprocal interaction model elaborated by Bob McCarley and me in 1975. In 1977, we challenged the Freudian assertion that his disguise censorship dream theory was free of neurobiology. As Karl Pribram and others had already made clear, "the ghost of Freud's 1895 Project for a Scientific Psychology haunts his subsequent work". We argued that the ghost was as neurobiologically ill-informed as it was imaginary.

Chapter 7: Input-output gating

PM: "I" in the AIM model refers to input-output gating during REM. On the one hand sensory input from the outside world into the brainmind is dramatically reduced while on the other hand the dreamer is essentially paralyzed (except for eye movements). These facts led many to observe that nothing is coming in and nothing is going out during REM. We are forced by Mother Nature to "look inward" during REM it seems!

Although this a a BIG question, I'd like to get your thoughts on this remarkable fact. WHY has Mother nature set up this nightly system of forced inwardness with nothing in and nothing out?

AH: The answer is simple: the brainmind creates a model of the world that it uses to interpret its sensations and make predictions about external reality based upon its model. This theory was formulated by me and Karl Friston about five years ago. The beauty of this theory is its compatibility with clinical work using dream content to explore the psychological implications of dreams.

PM: Isn't the brain/mind generating models of the world; of expected sensory feedback during waking consciousness too? What is the advantage of gating input?

AH: It allows the brain/mind to complete processing of existing input and then update its modeling without interference from current input.

PM: Let me press you a bit now on the "output" REM situation. With regard to REM atonia or paralysis, the most common functional explanation for this strange phenomenon is that the paralysis prevents us from acting out our dreams. Why else would Mother Nature allow us to become so vulnerable to predation every night during a REM episode except to preserve us from injury if we acted out our dreams?

AH: Survival depends upon sensorimotor reflexes but consciousness itself benefits from accuracy of interpretation. Consciousness is our most important Darwinian adaptation and should not be lost sight of as we consider more elemental aspects of physiology.

PM: Support for this view comes from experiments with cats, you mention Jouvet's work in this chapter) whose brainstem neurons responsible for REM-related paralysis are experimentally destroyed. When that procedure is performed the cats appear to act out their dreams. In addition, REM Behavior Disorder is associated with destruction of cells responsible for REM paralysis and when loss of REM atonia occurs, patients exhibit very clear dream enactment behaviors.

But if the REM atonia functioned to prevent dream enactment it becomes difficult to understand why we don't have atonia associated with NREM sleep. After all we have very complex, vivid dreams during NREM sleep as well.

AH: I think of REM as supersleep, about four times more efficient than NREM, but only quantitatively, not qualitatively different from NREM sleep. For example, Rechtschaffen's sleep deprivation studies showed that it was nearly impossible to deprive an animal of REM sleep.

PM: So if NREM is NOT qualitatively different from REM why isn't there a related NREM atonia? Or are you assimilating NREM to REM? If so what about delta waves, sleep spindles and all the other distinctive characteristics of NREM?

AH: Again the dis-similarities between REM and NREM are overdrawn. REM sleep is both superbeneficial and superdangerous for the sleeper. I think of NREM as a test-drop for REM: is it safe for me to relax my guard on external threat and attend to my internal needs? This REM-centric view ignores, for the time being, the probably unique functional features of NREM sleep.

PM: Now let me press you a bit more on the "input" REM situation. There is substantial sensory gating or active suppression during REM but is it really so complete that nothing at all gets in? Thalamo-cortical gating of incoming sensory information is not complete during REM. During REM, evoked responses of thalamic neurons are only slightly attenuated compared with waking. Cortical neurons are still responsive to incoming auditory stimuli during REM sleep.

AH: Again the answer is quantitative not qualitative. Thresholds to arousal go up but can be surmounted by sufficiently strong stimuli. It is obviously important to be able to wake up if the security of your life is threatened.

PM: Evidence gathered from event-related potentials (ERP) studies demonstrates that auditory discrimination, recognition of an intrinsically meaningful stimulus (e.g., the dreamer's own name), and categorization of stimuli are intact during REM.

AH: I am very sensitive to environmental stimuli when I sleep. I monitor the environment constantly.

PM: In addition, convergent evidence from behavioral and neuroimaging studies suggest that the neuronal patterns prevailing in thalamocortical systems, a burst-silence mode during SWS versus a sustained single-spike activity during waking and REM, are strongly modulated not just by subcortical sites in the brainstem, the hypothalamus, and the basal forebrain, but in addition by widespread cortical networks, for example, the default mode network, but including secondary sensory areas that process semantic and abstract attributes of sensory stimuli.

AH: You are a better clinical neurophysiologist than I am. The important point is that the basic science supports and explains the findings very well. We have something like a science here and we are not blind to its psychological meaning,

PM: Although it is now clear that auditory information is processed during REM it is also clear that the ways in which the dreaming brain processes this information is different from the ways in which the waking brain processes the information.

AH: The brainmind is busy with its internal housekeeping necessities. When NREM sleep says this is safe, we go offline to fix our central processor and bring it up to date with today's experience. But that seclusion of the brainmind is only relative.

PM: Auditory information is not the only external sensory information that maintains access to the sleeping brain during REM. Chemical, smell, somato-sensory, and kinesthetic senses all continue to be processed during REM at least to some extent. Indeed, the only modality that is dramatically attenuated during REM is the visual modality but even here visual information is not completely abolished during REM. Ambient light energy is processed despite closed eyes for example.

AH: I think you underestimate the difficulty of getting sensory stimuli into the brain during REM. The efforts of dream experimentalists, going all the way back to Maury, to influence or label dream content by sensory stimulation, have been unsuccessful. That's why dream research was for so long unscientific. It was tied to the stimulus/response paradigm that led Freud into his follies. Remember what I said about letting the system alone, to reveal its secrets to us. Spontaneity is a special feature of brainmind function which planned experiments often miss.

PM: In this chapter you also touch briefly on the idea that 40HZ EEG power range is associated with binding and consciousness first proposed by Wolf Singer and then by several other prominent neuroscientists in the 90s. I seem to recall that 40HZ in gamma range may also occur during REM?

AH: Exactly! The 40 HZ EEG power that is correlated with waking consciousness is also seen in REM. This finding supports the idea that waking and dreaming consciousness are continuous and mutually interactive.

PM: Some scientists argue that 40HZ gamma indexes some binding activity across diverse functional brain regions? How does consciousness emerge from binding?

AH: “Binding” is a great word for the integration of information. Consciousness consists of the unified subjective experience of myriad phenomena. How this integration is accomplished by the brainmind is the deep, hard problem of cognitive neuroscience. Optimists suppose that this problem may be solved in twenty years. I would estimate many more and regret that I will not see how it all turns out. Much younger people than I can enjoy the trip even if they too do not reach its destination.

Chapter 8: M=Modulation

PM: “M” refers to modulation of the neurohormones/transmitters that turn on and off REM sleep. Your famous reciprocal – interaction theory of REM formulated with Robert McCarley treated the Pons as the cyclic oscillator...when it stimulates release of norepinephrine and serotonin the brain is activated and waking consciousness results. When the oscillator withholds those transmitters and pushes acetylcholine instead, REM is the result. In short REM is associated with reduced aminergic and enhanced cholinergic drive emanating from the pontine oscillator.

AH: Your summary of the reciprocal interaction model is excellent but I am surprised to hear you say that this model is famous. It is in textbooks but seems to be of little practical use these days. I had hoped it would prove more actively enduring. Instead of the deeper chemical analysis that I expected, many experimenters are returning to the psychedelic paradigms of the 1960’s. I consider such clinical adventures as regressive and permissive of speculation.

PM: Do you know of recent work showing that REM neurobiology is regulated to some extent by 5HT_{2A} receptor signalling? Those are the same receptors selectively activated by the psychedelics.

AH: Yes, but I am very sceptical of conclusions based on human experimentation. It is difficult to know how to interpret the findings. Having said that, I admit that there are many paradoxes in the serotonin story which invite an open mind. As you may know, Jouvet defended the 5 HT mediation of NREM sleep to the grave and he may be right about that hypothesis. I feel much more secure about the NE story. LC/norepinehrine activates waking, not REM sleep. Jouvet was dead wrong about that one.

PM: An open mind should be the watchword as we explore the chemistry of mental life.

AH: Factor “M” in the AIM model is about the neurochemistry of consciousness. There are many ways in which we attempt to alter our brainmind chemistry recreationally. Alcohol, cocaine, marijuana, LSD, name your poison. The quest for dreamlike ecstasy goes on and on

- *and we won't stop it with our words.* But it can be achieved safely via shifting attention toward dreaming. In other words, factor M can be psychologically influenced.

PM: Yes indeed. For centuries people have been using their own cognitions to alter their physiologies. Think of the placebo effect, fantasy, daydreaming, meditation, hypnosis, dream incubation techniques and fasting and ascetical regimens to mention only a few... There are whole mental technologies, so to speak, designed to influence M!

AH: This surprising conclusion is compatible with the assumption of dual aspect monism that both the brain and the mind are physical. They cause one another. That's good news for idealists and puritans like me. Of course, most people accept the mind over matter axiom. We are all dual aspect monists whether we like it or not.

Chapter 9: AIM

PM: The AIM or Activation, Input-output gating and Modulation model of sleep – wake states postulates that waking is characterized by high A, open gates (I) and high M or aminergic modulation. NREM sleep conversely is characterized by low values of all three parameters while REM has two low values (M and I), and one high. Activation is higher in REM than in waking states, while aminergic modulation goes to zero and input is largely reduced or blocked.

The thing I like best about AIM is its ease of visualization. I can see the three dimensional state space model very clearly. The idea of a state space in which I navigate as I wake, sleep and dream appeals to me intellectually.

AIM is a very elegant model of sleep-wake states. It creates a state space that is partially occupied by these three states but there are many more logical combinations of the 3 parameters.

For example, what would high A, intermediate M and low I yield? Lucid dreams?

AH: Yes, it might. We know that lucid dreaming is a hybrid state with both waking and dreaming components. High A for sure and low external I, but High internal I. Lucid dreaming is one of the best tests of the model but it also reveals two shortcomings: one is the conflict between external and internal I forces; the other is that AIM describes the whole brain instead of differentiating its component parts. In lucid dreaming there is both frontal lobe and occipital lobe activation whereas they are normally antagonistic structures. When I want to concentrate in waking, I shut my eyes in order to turn off my occipital visual processor; my frontal lobes are then free to select behavioural options.

PM: Another example: Isolated sleep paralysis appears to represent a hybrid of REM and waking. The individual is conscious and awake but he is paralyzed and cannot move because the muscle atonia associated with REM is persisting into the wake state. In addition, the individual hallucinates an intruder possibly because many REM dreams are about potential threats and so on.

AH: You have understood the statistical approach perfectly. Our thoughts and our behaviour are always mixed compromises between competing brainmind systems.

PM: I find the NREM parasomnias particularly interesting from the AIM point of view. Sleepwalking/talking and other NREM parasomnias represent a hybrid between NREM and waking. In these cases the individual remains in N2 or N3 sleep but can nevertheless engage in complex behavioral actions without awareness. Here the brain can coordinate complex behaviors without awareness because the waking state (presumably mediated by an activated dorsolateral prefrontal cortex) has intruded upon a brain not fully dis-engaged from slow wave activity. But it is a puzzle that you have no awareness or at least deep amnesia for these states.

AH: As an adolescent I sleep walked down the stairs and out into our garden to urinate. My bladder was full but my brain could not read and respond to its signals because it was deeply asleep.

PM: What about the hybrid of REM and NREM? Most sleep scientists believe that the REM/NREM hybrid just yields unconsciousness. But it is possible that some parasomnias may involve the REM/NREM hybrid. Although nightmares typically arise out of REM, trauma-related nightmares can occur outside of REM.

AH: The distinction between REM and NREM is overdrawn, as I have already pointed out. The two states have many common, overlapping features. For example Peretz Lavie, Rita Felfand and I found that frequent eye movements make NREM a misnomer. The differences between states are quantitative not qualitative. The differences must be measured and compared statistically. AIM lends itself to such quantitative, statistical analysis. My dream is that the model will be advanced by further mathematical study. Bob McCarley's death marks the end of one era of mathematical modeling of sleep.

PM: The phenomenon of sleep terrors suggests that the individual experiencing the NREM parasomnia is also experiencing an intense nightmare as the individual typically screams in terror. Theoretically, from the point of view of AIM I see no reason why some REM features like intense amygdala activity cannot temporarily occur with slow wave activity in many other parts of the brain. Such a state would produce a hellish nightmare.

AH: You are way ahead of me, but on the right track. Night terrors of all kinds may result from the activation in sleep of normally quiescent brain regions! I think that sleep disorders medicine can now move beyond the pathophysiological foundations that I first proposed in the 1980's. The obstacles now as then are due to perseverative adherence to the outmoded medical model. Brain scanning and Karl Friston to the rescue.

Chapter 10: Development

PM: One of the ways to understand sleep is to look at its development across the lifespan. You have pointed out that the fetus spends most of its time in a kind of proto-REM state. You claim that that fact suggests that proto-consciousness antedates our birth.

AH: Yes. The primordial brainmind is already mature enough to produce REM-like self-activation in utero at fetal age 6 months. We are thus "born" before we are born! This important scientific fact strongly supports the theory that the brain is preprogrammed to

generate something like conscious states. In its boldest form, the self-activated brain creates consciousness itself. And it does this automatically, driven by its own built-in programs.

PM: REM sleep even in the fetus appears to promote brain development by facilitating release of a kinase critical for neuronal plasticity, so called extracellular signal-regulated kinase or ERK. Kinase phosphorylation in the primary visual area of the cortex, area V1, requires REM sleep, because it will not occur in sleep-deprived animals.

AH: Thanks for that empirical update. I must admit that I have not kept up with the basic science literature but am sure that the more we look, the more we will find evidence supporting the central role of REM in human development. The crowning achievement will be a science of consciousness itself. The AI community is already alert to the importance of REM in modelling what it calls “intelligence”. For now, I am content to call it sentience but it is far more than that. Neither AI nor computational neuroscience models creativity yet.

PM: You point out in this chapter that in addition to its contributions to brain development REM appears to be crucial for other functional capacities that come online during development...But I want to ask you to comment on evolutionary aspects of REM development. Its abundance in juvenile organisms suggests a special role for REM in development.

AH: Childhood is long in humans because the construction of a brainmind that can think for itself is a major undertaking. Other animals have much shorter maturation schedules because thoughtless creatures have much less to achieve.

PM: Should not we sleep scientists use evolutionary theories, such as life history theory or parent-offspring conflict theory or attachment theory to understand REM’s developmental role?

AH: Absolutely. The integration of dream science and Darwinian evolutionary theory is part of my personal agenda. Humans are the king of the beasts because we have evolved brainminds capable of abstract data analysis. Monkeys don’t do crossword puzzles.

PM: Back to the womb for a minute. With regard to fetal sleep, David Haig (1993) has called attention to the fact that the placenta is genetically part of the fetus and not of the mother, and thus there is potential for a divergence of genetic interests between the fetus and the mother.

AH: This is news to me. Please tell me more about these fascinating genetic and epigenetic details.

PM: Abnormal triploid fetuses with a double set of the father’s genes and a single set of the mother’s have a very large placenta, while abnormal fetuses with a double set of the mother’s genes and one of the father’s have very small placentas and show a retardation of growth. Modeling of genetic strategies of parents and their offspring suggests that with respect to the maternal-fetal interaction, the fetus is selected to extract as much resources from the mother as possible, while the mother is selected to moderate attempts to extract her resources. Proto-REM is used by the fetus in this tug of war between mother and fetus.

AH: I am glad that I didn’t pose this problem for my own mom. Having such a rambunctious son as me was bad enough. But my second wife’s twins competed with each other for

epigenetic nourishment. That was almost certainly not a placental issue but they fought for pride of place in the uterus.

PM: Every new parent knows that you will not get a good night's sleep for a long while due to baby awakenings. Your baby keeps you awake all night with frequent night-wakings and loud "vocalizations" or crying episodes. There is a huge industry composed of supposed experts on infant sleep that advise new parents on how to get their baby to sleep all though the night so that parental sleep patterns can return to normal.

AH: Infancy could be said to be REMfancy.

PM: Why would Mother nature produce such a seemingly maladaptive pattern of sleep in the neonate? It apparently does no-one any good if neither the baby nor the parents get any sleep and are chronically sleep deprived.

AH: The payoff must be high. Is one Shakespeare worth 1000 insomniacs? You be the judge of this one. I am sure that such poetic skills as our consciousness confers is a product of sleep.

PM: Evolutionary biology to the rescue once again! Haig (2014) and Blurton Jones and da Costa's (1987) argued that infant night-wakings function to prolong interbirth intervals via nursing-induced suppression of ovulation. That is if the mother nurses the infant she cannot get pregnant (nursing induces suppression of ovulation). If the mother does not have another baby while the current baby is struggling to survive the first couple of years of life then that baby will get more resources from the mother and thus its chances for survival will increase. Thus, night-wakings, those nightly horror shows for every new parent's existence, may be an adaptive strategy that infant's use to monopolize maternal resources and prevent births of competitive siblings!

AH: Maybe. I prefer to keep an open mind and to favor the longterm investment policy. Even a mediocre brainmind requires prolonged, elaborate preparation. I applaud parents who suffer from this absurdly ambitious project. We are all in this together and need to be proud of our achievements and humble about our shortcomings.

PM: REM percentages decline with age but the proportion of total sleep spent in REM remains about the same. Same with N2 stage light sleep and N1 transitional sleep ; these proportions remain about the same or slightly increase as people age. But N3 slow wave sleep undergoes a steady decline with age until it almost completely disappears in old age.

AH: I try to fit these dramatic changes in sleep onto the equally dramatic changes in cognition over a lifetime. One of the central pillars of sleep medicine is the recognition of such dynamics as normal and useful. At age 87, I still REM/Dream, read and write every day despite the precipitous decline of my memory functions.

PM: But you claim that dreaming does not change much with age. That would seem to square with the fact that slow wave sleep changes but REM percentage is relatively constant with age.

AH: I have recently embarked on a journalistic self-study of my own dreams. They remain vivid, unpredictably bizarre and fraught with meaning. I know I still REM because I have

sleep lab data as a check on the sleep apnea that followed my medullary brain stem stroke twenty years ago. Recording and analysing my dreams is a very pleasurable and enlightening antidote to my regrettably fragmented slumber.

Chapter 11: Evolution

PM: In this chapter you argue that REM is a phylogenetically recent adaptation. While I am inclined to believe that certain elements of REM are evolutionarily recent, there is abundant evidence, isn't there, that REM as defined by its brain activity patterns itself is a very ancient system?

AH: The jury is still out on this one. I have argued against Jouvet's idea that REM was archisleep while NREM was neo-sleep. The scientific evidence on this point is quite clear. REM is correlated with brain development such that it achieves its zenith in mammals.

PM: However, key elements of REM have now been identified in reptiles. Shein-Idelson and colleagues (2016) identified in the Australian dragon lizard, *Pogona vitticeps*, electrophysiologic signs of REM and NREM sleep states that are similar to those seen in mammals and birds. What was most interesting in this report was that the lizard's REM and NREM sleep phases alternated one another just as they do in mammals. A phase characterized by low frequency/high amplitude sharp waves (homologous to mammalian slow-wave sleep) alternated with a phase characterized by awake-like brain activity and rapid eye movements (homologous to mammalian REM). In *Pogona*, SWS and REM alternate regularly throughout the night with a short period (~80 s), generating up to 350 SWS-REMS cycles (compared with four to five 90-min cycles in humans).

AH: My theory needs revision as follows: REM like brain activation in sleep may be essential to the development of any brain that controls sensorimotor integration. That includes lizards. I suspect however that dreaming comes to be a REM product only in a highly developed brain. We, and only we, suppose ourselves to exist, fear our death, write poetry and advance scientific theories.

PM: REM's distribution across the animal kingdom is far from straightforward. For example, some aquatic mammals dispense with REM altogether while others use it, facultatively, only when they sleep on firm ground.

AH: Following Rechtschaffen, I have suggested that REM and NREM sleep are interchangeable. According to this theory REM is supersleep, about four times as efficient as NREM in managing thermal and informational management.

PM: REMs also occur in the monotremes who are thought to be ancestral to mammals.

AH: Again, these beasts, like lizards sense the world and move through it but I don't expect them to read this book. In fact, I will be pleasantly surprised if my fellow humans do so.

PM: As you mentioned SWS can be expressed in one hemisphere in some birds and some aquatic mammals but this raises the question of whether that is the case also for REM. To my knowledge REM can only be expressed bihemispherically. It may be that one hemisphere or brain region cannot support REM? When REM occurs in marine mammals it is always

bihemispheric. The bilateral nature of REM may be considered one of its costs and the brain structure of certain marine mammals, apparently, cannot bear these costs?

AH: Stay tuned. Sleep science is still young and immature. Giulio Tononi has shown that cortical subregions may manifest NREM. Why not REM? Do fleeting thoughts arise from the whole brain or just a part of it? All we know, for certain, is that thoughts and dreams do not arise out of thin air. We are therefore sentient materialists who try diligently to be non-reductionistic. Mind and brain are two parts of a unified system. Both are physical. Both are mutually causal. This is what I mean when I say “I need to make up my mind” or “Let me sleep on it”.

PM: Let me ask you about ancestral *human* sleep. There is an ongoing debate about the normal human sleep pattern with some scholars claiming that humans sleep for a few hours during the night and then take a long nap in the late afternoon. This is called the “bimodal sleep pattern.” Other scientists claim that that bimodal pattern occurs during the dark period which is split up into two bouts of sleep with a period of wakefulness during the night. Yet other scholars claim that humans sleep in one long bout during the dark period; i.e. that there is no bimodal sleep pattern at all. Historians and anthropologists have presented extensive evidence that a bimodal pattern was common in pre-industrial societies. What would be the adaptive value of the bimodal pattern? If we awake at night and share dreams around the campfire that would mean that the bimodal pattern evolved to promote dream-sharing!

AH: My sleep is now distinctly bimodal and sometimes even trimodal. I think of this as meaning that my elderly brain decides which pattern it prefers by rules which are still obscure. When I am lucky enough to awaken with dream recall, I hurry to my computer campfire and share the delightful stories with you and other friends. Is my dream recall increased because of my sleep fragmentation? Perhaps. That awakening conditions correlate with dream recall is a canonical fact of human life.

Chapter 12: Deprivation

PM: In this chapter you rightly point out that it is nearly impossible to deprive an animal or person of REM sleep for more than couple of days. Once deprived of REM people tend to slip into daytime microsleeps to make up for lost REM.

AH: The powerful drive to sleep is testimony to its survival function.

PM: What then do you make of the fact that some sleep anti-depressants suppress one of more elements of REM for years without apparent ill effects? There have also been documented cases of lesion-induced loss of REM without apparent ill effect on cognition.

AH: The amine reuptake blockers are an exogenous substitute for the endogenous chemical benefits of REM. At last, we have a class of pharmaceuticals that is genuinely physiological. The beneficial effects of the SSRI's also support the extension of AIM to medicine. This is truly biological psychiatry.

PM: What do you make of the fact that recovery sleep can sometimes be local? In addition to the exponential decline of delta power across a single night of sleep there can also occur local

transient increases in various regions of the brain in delta power in relation to amount of use of that area of the brain.

AH: Sleep can be regional as well as global. Our mistaken emphasis on globality is related to its social consolidation and to norms derived from young students who try to adapt to schedules. As soon as the social structure breaks down and the brain ages dissociation becomes the rule.

PM: The regular more global changes in delta wave activity that occur each night appear to be more strongly related to use or engagement of particular regions of the frontal lobes and its interconnected regions than it is to other areas of the brain. If delta waves index recovery of function in frontal lobes how are we to understand down-regulation of frontal lobes in REM? No recovery of frontal lobe function can occur in REM if frontal lobes are down regulated in REM right?

AH: Frontal lobe activation in REM has been shown by Mark Solms to be localized to regions involved in cognitive operations that are enhanced in dreaming. It seems possible that REM dreaming is a specific enhancer of the brainmind's need to integrate disparate bits of information, no matter how incongruous they appear in dream reports.

It will be difficult to program computers to dream in the way that we do. Intuition and insight are two very valuable functions that will prove difficult to emulate in a hardware based machine. Machine learning is not yet insightful nor does it appear to be aware of its "self".

PM: In this chapter you raise the very interesting issue of sexual activation in REM. Men get erections and the clitoris gets engorged in women during REM. You suggest that this is Nature's way of preparing us for reproductive functions. But as you also point out overt sexual dreams are rare. The erections occur even in infants and across the mammalian taxa. The only known exception is the armadillo. Its erections occur during NREM.

If your suggestion is correct that REM-related sexual activation is to prime sexual function then why not do so throughout NREM as well?

AH: A hard-on is essential to penetration and fecundation. But that's not why we love sex. Our libidinal pleasure is entirely cerebral. REM best simulates the cortical activation necessary for enjoyment. It also happens to potentiate the procreative machinery by the mechanisms so beautifully detailed by the Schmidts (Father and son, sic)

PM: Doesn't the sexual activation associated with REM presuppose a background evolutionary ecology of co-sleeping? That is, we sleep scientists should assume a co-sleeping context whenever we do sleep science. Sleep is a social phenomena—or at least it always was up to the modern era. We will never understand sleep unless we see it as social...that is at least two persons in the same bed co-regulating each other's rhythms, cycles and dreams right?

AH: Sharing a bed, sleeping with a sexual partner entails the mutual synchronization of brain and body rhythms which enhance intimacy and procreation. I am reminded of the aphorism "Neurons that fire together wire together". The brain and its mind are indeed bedfellows for life.

Chapter 13: Field studies

PM: In this chapter you point to the difficulties and limitations of studying human sleep in the sleep Lab. Most people do not sleep normally in a scary, foreign environment with electrodes attached to the heads.

AH: My naturalistic interest in science inspires more attention to home studies. Since we are embarking on a new humanistic mission, I furthermore value the uncommon view that sleep and dreams are the province of every person alive. If we want to understand and care for ourselves and each other, why should we not look where the light is, our own bedrooms.

PM: You raise the issue of using portable, miniaturized devices to measure sleep variables in an ecologically natural environment like the home. What do you think of all the new sleep apps, smartphone measuring devices and things like sleep ring Oura?

AH: Capitalistic industry has manufactured gadgets galore. But the constructive use of wristband data requires a conceptual framework. That's where we come in. We need to spread the faith and convert the heathen (like us before sleep and dream science). On a more optimistic note, the evolution of internet communication, especially the in depth podcasts may be a useful mechanism. Why not create a podcast on Dreams?

PM: You are an avid dream diarist and a consistent practitioner of the art of self-observation. You are in the great tradition of scientific humanism. Using first person perspectives to throw new light on perennial medical and scientific issues. In dream science we can all cultivate the art of self-observation by simply keeping a dream diary.

What are the benefits, personal and scientific, to keeping a dream diary?

AH: I am retired now but so is everyone else who is hunkering down from coronavirus. I am also motorically handicapped but that doesn't stop me from thinking, reading and writing. In fact the less I can rely on my legs the more I learn to focus on my mind. I was never a fan of psychotherapy because I distrusted authoritarian psychology and was a diehard cheapskate. Now I can psychoanalyse myself for nothing . Those are a few of the benefits of self-observation. For those who retreat from the noisy world via meditation, attention to the messages of dreams should be a natural aspect of awareness tuning.

Chapter 14: Reciprocal interaction

PM: In this chapter you give us some of the history and science leading up to your work with Robert McCarley on the REM-ON and OFF cells in the brainstem that led to the reciprocal interaction model of REM generation. In sum, REM expression is regulated by antagonistic cellular groups with aminergic cell groups inhibiting expression of REM and cholinergic groups promoting expression of REM. When cholinergic REM-on cells are activated, aminergic REM-off cell groups are inhibited, and vice versa.

Is it fair to say that these data suggest that REM and NREM operate in an antagonistic fashion? While it is obvious that you cannot have REM and NREM or REM and wake at the same time REM rebound effects suggest that REM need accumulates during NREM and reverses some process that occurs during NREM. Thus, it seems reasonable to suppose that the physiologic processes of the two sleep states in some ways conflict with one another.

AH: I would use the word “complementary” rather than “conflictual” to describe the REM/NREM alternation. The brain needs both for overlapping and distinctly different reasons. My position on this question is, as usual, BOTH/AND rather than EITHER/OR. To some extent NREM and REM are interchangeable but both states are also independently valuable. Unfortunately we do not yet appreciate the unique value of NREM. My brain’s hunger for that state tells me that deep appetites are nourished when I am unconscious. I wish I could be more specific but I can’t.

PM: In 1975 you and McCarley presented a mathematical model of these apparently antagonistic REM-on and REM-off interactions using the classical Lotka-Volterra equations that describe conflict between predator and prey populations in field and ecological biology. Levels of activation in the two (REM-on and REM-off) neuronal groups represent population levels of the prey and predators. As inhibitory aminergic neurotransmitter levels decline, the activation levels of cholinergic REM-on cells recover and so forth. The equations describing reciprocal interactions between the two cell groups accurately predicted the cyclical alterations in firing rates observed in the two populations of neurons responsible for REM-on/REM-off dynamics in the cat pontine brain stem.

AH: The mathematical model of reciprocal interaction has languished for want of technical expertise. Most mathematicians, even those familiar with the Voterra/Lotka equations, are pursuing applications of their own devising. The physiological model, on the other hand, has thrived and been amplified by workers like Edward Pace-Schott who devoted a lengthy monograph on this subject to Cambridge University Press.

PM: Reciprocal interaction of these REM on and Off cells orchestrate dramatic changes in consciousness that we call dreaming and waking. When they are off we wake; when they are on we dream.

AH: Who would have guessed that our brainminds are subject to such simple, elegant self-control mechanisms. I certainly didn’t. I was lucky enough to have natural truth handed to me on a platter. My only claim to fame is active scepticism, a scientific attitude which I acquired in spite of myself. I was deeply antiauthoritarian and am even sceptical of my own theories. I hope they will not be overthrown and will be grateful if they are not entirely forgotten.

Chapter 15: Activation-Synthesis

PM: Was Activation-synthesis a development of the reciprocal interaction model of REM generation? The brainstem activates the forebrain, but does so neutrally or randomly.

AH: No. It was the other way around. I conceived of the activation-synthesis idea when the physiology began to be clearly supportive of autcreation. I began to talk about this new way

of thinking in about 1972. By 1975, I spoke of it at length to a very sceptical group of Freudians in the David Hume amphitheatre in Edinburgh. I remember feeling thrilled to have shocked them with an alternative to disguise censorship on which their whole empire of thought depended.

PM: No wonder you invited the public debates which made your ideas so well known.

AH: Bob McCarley was equally excited but far less provocative. He knew that a mathematical model would compliment the psychophysiology and found Volterra/Lotka in a history book. The key insight was regarding the interacting neurones of the brainstem as formally identical to the prey/predator populations of lynx and rabbits in the wilds of Canada. Bob then curve fitted the neuronal firing data to the Volterra/Lotka equation predictions and that put us on the pages of SCIENCE magazine in 1975. The rest is history, 45 glorious years of it and. of course, it is not over yet. Now that Freud is out of the way we still do battle with Cartesian dualism and 2000 years of superstition.

PM: Would you now say that activation of forebrain circuits is not random in REM? All of the neuroimaging studies of REM show high activation levels in amygdalar and paralimbic regions and low dorsal prefrontal activation. That pattern of activation is surely not random right?

AH: I used the word “random” to characterize the aleatory nature of brainstem sensorimotor signals. They are not psychodynamically meaningful but rather serve the Helmholtzian sensorimotor integration that Freud’s dream theory overlooked. Once these random signals reach the forebrain, the active search for psychodynamic integration can occur. I suspect that even that is a random process by which the system tries out all manner of signal processing which renders the dream both hypermeaningful and nonsensical. Again, I urge an open minded acceptance of the mutual benefits of chance and determination. This is a very hard sell.

PM: The synthesis portion of activation-synthesis refers to the meaning we ascribe to dreams?

AH: My dreams are both wild and significant. Their meaning is intrinsic, not added by interpretation. Interpretation may involve the ascription of other meanings. That’s why dreaming is central to psychotherapy. In this respect, Freud was absolutely right. Bob Stickgold quips that the Viennese father of psychoanalysis was 100% wrong and 100% right.

PM: You refer to the work of dream scientists like Antrobus, Domhoff and Schredl who generally hold that dream content is continuous with waking preoccupations of the dreamer. What is your evaluation of dream continuity theory?

AH: I think continuity theory is valid but find it potentially trivializing because it focuses on similarities and ignores differences. How could waking and dreaming be entirely dissimilar? I want to know exactly how dreaming benefits waking and vice versa. I will not learn this from an emphasis on similarities. A vivid example is that I “see” in both states but in dreaming there is no external stimulus so I must create the image using only the information that is in my brain. It may be true that the same rule applies in waking but in that state my created image must employ an exact sensory map of the external world in order to be adaptive. In

dreaming, other priorities prevail: I update my model of the world so that it will be more useful to me tomorrow. I don't care if that model appears nutty in the light of day.

Chapter 16: Attention

PM: Why is the study of attention important for study of dreams or REM? I can see its relation to consciousness but what about dreams?

AH: We cannot pay attention to our dreams. They seem to be motivated unconsciously as if they were not supposed to be attended to (or even remembered.) Thus your question may be ill-posed. It is precisely this failure of attention and memory which differentiates waking and dreaming consciousness. The mechanism may be aminergic demodulation, in keeping with the Gary Aston-Jones/Steve Foote hypothesis that attention depends upon locus coeruleus norepinephrine. AIM ascribes REM to aminergic demodulation. QED!

PM: You mention the idea proposed by Buzsaki and Llinas that attention is mediated by electrical signals arising in the thalamus that then propagate up to the cortex which is then scanned by these electrical signals presumably assessing contents in some way, thus allowing the thalamus to play its gating and routing function role.

AH: Thalamocortical interaction is essential to waking consciousness. Its occurrence in REM sleep is altered by the diminution in aminergic neuromodulation. We perceive vividly but neither attend nor remember most dream sensations.

PM: You also mention the interesting theory of Adrian Morrison concerning PGO waves. He seems them as a kind of startle reflex circuit which grabs the attentional system and orients it to some salient stimulus present in the dream. Does this theory capture what we know about PGO wave function in REM?

AH: Adrian Morrison showed that the network mediating the startle reflex became spontaneously active in REM. This could be the neural basis of our frequent experience of surprise in dreams. Rather than alerting us to internal stimuli, I suggest that Morrison's PGO startle network PGO waves may be dream stimuli per se. In other words, one part of the brain becomes a signal source for other parts of the brain. Dreaming is an active state amenable to sensorimotor integration as Helmholtz suggested in 1850. For decades, it was supposed that PGO waves might exist only in cats but they have recently been detected by Charles Hong in humans as well. This rounds out the picture of activation synthesis/reciprocal interaction dream theory

Chapter 17: Memory

PM: In this chapter you reference the now large literature on sleep-dependent memory processing. Carlyle Smith was an early investigator here who made some fundamental discoveries but Robert Stickgold and Jan Born have done a lot work on these issues as well.

While the data are now pretty clear that both REM and NREM sleep processes are crucial for consolidation of differing types of memories I want to ask you about recent data suggesting that dream content itself is important for memory consolidation.

Nielsen's work on the dream lag effect is instructive. Erin Wamsley has shown that improved performance on learning novel materials is significantly associated with the extent of dream incorporation—the greater the number of elements of the learned materials incorporated into dreams, the stronger the acquisition of those novel materials in subsequent daytime performance tests. Are dreams themselves required for memory consolidation?

AH:

I am sceptical of any function of “dreams themselves” because I do not believe in the dualistic assumptions underlying the question. There is no such thing as a disembodied dream. Every dream is the subjective experience of a brain process. The question might be rephrased as “does dream content predict memory consolidation?” I don't know the answer but would assume it could be yes. Translating my intuition into measurable parameters I would expect that dream bizarreness predicts performance on post-sleep memory tests. I would go a step further and predict that dreaming of taking the memory test in question correlates with test performance. That is the result which led to your question.

PM: You discuss the interesting phenomenon of dream amnesia. Why is memory paradoxically enhanced during dreams but diminished when we awaken? Why dream amnesia?

AH: It is not important to learning to have dream recall. What is important is to have REM sleep, and to change the state of the brainmind so that waking experience can be incorporated into the unconscious world model that we use to create cognitively adaptive consciousness. Subjects with no dream recall function quite well. Dreaming may be a fascinating process for us to study and experience but its function may be quite independent of our interests.

According to me and Karl Friston, dreaming serves to reorganise memory in the service of better prediction by the brain mind model of the world that guides us when we are awake. That's why dreaming is so redolent with memory: remote associations (long term memories) are dragged out and integrated with recent inputs (day residues). You don't need to be aware of this process so long as it occurs. That's why dream forgetting is usual. Why remember that you just fixed your memory? Just fix and forget it. Its an amazingly efficient process.

PM: You mention daydreaming as an integral component of memory and consciousness. What do you think of the old idea that there are 90 minute cycles of spontaneous daydreams during the day that are continuations of the 90 minute REM cycle at night?

AH: I have always been sympathetic to Dan Kripke's ultradian rhythm hypothesis but I share his disappointment in the weakness of the evidence and the lack of current interest in with wake state rhythms. It would be interesting to see if dorsal raphe serotonin neurons speed up and slow down during waking. Now that we have scanning technology it is also possible to observe human brain rhythmicity during the day time. Such a study could be undertaken as part of the investigation of so called default mode structures in the human cortex. My advice, for now, is to have an espresso when your attention needs a boost.

Chapter 18: Neuropsychology

PM: Many brain disorders involve changes or alterations in self-awareness and consciousness. Sophie Schwartz and associates have called attention to neuropsychological syndromes that mimic dream phenomenology. Things like Frégoli syndrome, whereby an unknown person's face is erroneously recognised as a familiar person, or like Capgras syndrome and the frontal lobe-related confabulation disorders, the visual agnosias and visual size perception disorders "micropsia" and ("macropsia")...the point here is that many brain disorders mimic dream experiences.

AH: The integration of neurology and psychiatry within the context of sleep and dream research is well under way and Sophie Schwartz is a pioneer of this new neuropsychology. Edward Pace Schott is another investigator with enough background in neurophysiology to make even deeper probes into the brain-becoming-mind. The field needs a clinical champion, someone like the late Norman Geschwind or his Northwestern neurologist disciple, Marcel Mesulam. Oliver Sacks and Atul Gawande are two physician New Yorker authors who made stories about cognitive disability more widely known and appreciated. We are living in an age of intellectual revolution and hope that more and more people will recognize the extraordinary power of their brainminds.

Chapter 19: Lucid dreaming

PM: Lucid dreaming appears to fit in nicely with AIM's theory concerning consciousness as a state dependent phenomenon. Lucid dreaming appears to be a hybrid state where awareness remains (due to partial activation of frontal lobes) despite REM.

AH: Lucid dreaming is the best example of the explanatory power of AIM. Many people, including me, never imagined that their waking dreams were engendered by specifiable alterations of their brains. But the fact that lucidity can be incubated also proves that mental set can alter brain physiology. In other words, dreams are not only meaningful but their quality can be influenced by thought. I always suspected that this might be so but now I regard what might have seemed to be mysticism as scientific principle. My dreams are still mostly non-lucid but occasionally the lights do come on in command central and my ability to switch on the lights guarantees that my will is sometimes free enough to assure a good show and mediate responsible behaviour.

PM: You point out that one of the many interesting things about lucid dreaming is that it implies at least two egos or selves within each of us. There is the dreaming ego and then there is the aware ego.

AH: We are of two minds. They cause and are caused by each other. Sometimes the two me's are in conflict but often they work together, "reciprocally" as the AIM model suggests. One me is a careless adventurer and a liberal. The other me is more careful, even conservative. I live in peace with myself when I recognize the importance of both me's.

PM: How should we understand non-self characters in lucid dreams? Lucid dreamers interact with these non-self characters as if they are real. Because the dreamer is aware that he or she is dreaming we cannot say that he or she accepts the independent status of the non-self characters due to the loss of reflective analytical thinking that supposedly characterizes

ordinary non-lucid dreams. The reality-checking functions of the prefrontal cortex are available to the dreamer in a lucid dream. His judgment that a dream character is a kind of real being, therefore, cannot be due to lack of insight.

AH: The social world is composed of self and others. Dreams underline this social reality. I am always me while the other may be someone in particular or no one I have ever known. This indicates that I may reduce surprise by programming what all these characters do on my terms. One of my frequent dream characters is my adolescent travelling companion, Chris Gates. After fifty years, he came alive again in my dream last night and helped me clean up a mess in one of my imaginary dream houses. Chris and I have helped each other with the imagination and order that shape our lives.

Chapter 20: Sleep disorders

PM: You touch on several sleep disorders and their relations to consciousness. I want to ask you some consciousness-related questions raised by a number of sleep disorders.

Take for example the recent report on creativity in narcoleptics. Lacaux et al (2019) reported that a large cohort of subjects with narcolepsy obtained higher scores than controls on the Test of Creative Profile in the three creative profiles (Innovative, Imaginative and Researcher) and on the Creative Achievement Questionnaire. They also performed better than controls on an objective test of creative performance. Most symptoms of narcolepsy except cataplexy predicted creativity. Given that narcoleptics experience a ton of REM these results seem to support a role of REM in creativity.

AH: Narcolepsy is a sleep disorder characterized by REM potentiation. In terms of AIM, that means that narcoleptics are hypercholinergic and hypoaminergic. Hence their treatment with direct or indirect aminergic stimuli.

It is no surprise to learn that narcoleptics are strong dreamers and that they are more creative than controls. They live closer to the dream world which is autcreative by definition. Whether or not you accept the physiological model, it is self evident that strong dreamers are, by definition, highly autcreative. I hope this helps them feel better about themselves and aids their adaptation to a socially problematic life. A natural explanation is better than a diagnostic pigeon hole any day (or any night!).

PM: What about really weird sleep disorders like “exploding head syndrome”? It is characterized by a sense of a flashbulb sound or explosion going off inside your head. Typically it occurs in the transition from waking into N1 sleep and the explosion sound wakes you up. It seems to have no lasting negative effects-yet it is strange.

AH: Many sleep onset phenomena are explosive. The feeling of falling is ascribed to the natural vertigo of vestibular disinhibition. Synesthetics see rainbows if not hear thunder and see lightning. As for exploding head syndrome, which is unknown to me, the best I can do is recount the volcanic eruption of thought that I now experience when I lie in bed unsuccessfully hunting the sleep snark. I don't hear bombs going off but I do shake with pain and fright in the never land between sleep and waking. I want to scream “stop” and am reminded of the 1930's band leader, Laurence Welk, who asked that “someone please turn off the bubble machine”. My brain is a bubble machine and a bomb waiting to explode, an epileptic seizure waiting to convulse. The brainmind is a springloaded device and it is

remarkable that things go as smoothly as they usually do.

PM: You mention REM Behavior Disorder (RBD). (RBD) is characterized by loss of the atonia normally associated with rapid eye movement or REM sleep. Patients therefore often act out dreams normally associated with REM sleep.

Let me ask you about this case which poses some fundamental problems about consciousness and our moral sense.

On April 10, 1878, Simon Fraser, a happily married 27-year-old man, sensed a wild animal in his room and discovered that the animal was about to harm his young son. Fraser managed to grab the legs of the animal and swung it round until he bashed its head repeatedly against the wall, killing it, and, he was sure, protecting his family from its attack.

Fraser woke up and realized that he had been dreaming. To his horror, he discovered that he had just bashed the head of his young son against the wall repeatedly, thereby killing him. Fraser was acquitted of murder because the jury believed he had no intention of murdering his son; in his mind, he was attempting to *save* his son.

But consider now the following hypothetical case, in which everything that occurred on the night on April 10, 1878, occurred as already explicated above: Fraser had his dream, enacted the dream due to RBD, and ended up killing his son.

But now let's change one detail. Instead of having Fraser dream of protecting his son from a wild animal, Fraser actually dreams about harming his son by picking him up and bashing his head against the wall until he was dead.

In this scenario, Fraser's dream intent *matches* his overt behavior. Fraser then could be found guilty of murder, according to the legal doctrine invoked in his case, in which "the act is not culpable unless the mind is guilty." This is called the *mens rea* doctrine. In this version of his dream, he *intended* to kill his son and in his overt behavior he did exactly that. The dream enactment behavior then matches his overt behavior during the crime.

Yet, Fraser was still *asleep* or in REM sleep. Do you think Fraser is guilty of murder in this case? If not then do we need to throw out or at least modify the doctrine of *mens rea*?

AH: Fraser was innocent because he was in the throes of an attack of REM sleep without atonia. I didn't kill my son but might have when I fell asleep and hallucinated a menacing stranger at my door recently. Fortunately, reform of jurisprudence is well under way in the light of modern sleep science. In 1878 Simon Fraser and his handlers knew nothing of REM nor did Sigmund Freud in 1895. They were both innocent of their crimes against humanity.

Chapter 21: Psychosis

PM: In this chapter you cover some of the deep links between dreaming and psychosis. If psychosis is seeing and believing things that are not real then dreaming is a psychotic experience.

But from the point of view of the Friston-Hobson theory of dreaming as a modelling of expected experience aren't we always "dreaming"? Yet we are not psychotic.

AH: Good question. The answer is that the mechanism which is unleashed in sleep such as to

create dream psychosis is both sixfold inhibited and strongly countered by sensory input in waking. These sensory inputs are actively blocked in sleep.

Thus there is a strong margin of safety protecting most of us from wake state psychosis. That said, it is also true that we are always dreaming in the background of conscious awareness. Fantasy and day-dreaming prove that point.

The idea that is paramount to grasp is that these phenomena are all probabilistic, statistical and quantitative. I don't like that math/physics truth any more than you do but I try to come to terms with it.

PM: Anti-hallucinogenic second generation anti-psychotics work via 5HT_{2A} receptor signalling system. In addition, LSD-induced effects are blocked by the serotonin 2A receptor (5-HT_{2AR}) antagonist ketanserin, indicating that effects of LSD are attributable to 5-HT_{2AR} stimulation. Finally, REM sleep appears to be strongly regulated by these same receptor signaling systems. Perhaps the virtual reality modeling system that is the mindbrain works via these same 5HT_{2A} receptor signaling systems?

AH: The serotonin pharmacology story shows, conclusively, that 5 HT is a potent neuromodulator of state control. We have known that since the early days of LSD/psychedelic ingestion in the 1960s and Hoffman's accidental LSD psychosis. The visual system is affected so that endogenous stimuli are "seen" as coming from the outside world. That the brainmind works via these receptors is now beyond doubt.

PM: In bipolar disorder you get a dramatically curious association of REM sleep indices with changes in mood and consciousness. During depressive episodes there is fragmentation of REM, reduced REM latency, increased REM density, and a greater percentage of awakenings; conversely in manic episodes you again get reduced REM latency, greater REM density and greater awakenings. The only difference is there is greater percentage of stage I sleep in mania. Nevertheless dreams change dramatically in depression vs mania. Why?

AH: The depression story is loved by AIM and vice versa. Everything physiological fits perfectly as Bob McCarley has eloquently demonstrated. With respect to dream content, it is important to note that awakening characteristics determine recall and arousal threshold determines dream report length so that interpretation of dream content differences must be cautious. That manics, who sleep lightly, have hot, long dreams while depressives, who may not sleep at all, have short cold ones is not surprising. Beyond that target, cautious AIM is not prepared to shoot.

Chapter 22: Epilepsy and migraine

PM: You say that normal dreaming is our experience of the brain's paroxysmal neuronal discharge akin to that of epileptic seizure. Are you saying that the PGO waves are like seizures? Please clarify.

AH: Yes. PGO waves are distinctly epileptiform (seizure-like) as Zeev Eleazar and I pointed out in Progress in Neurobiology paper on this subject. PGO waves are huge electrical spikes which until recently were seen only in laboratory animals but now have been recorded in humans. As with my idea that REM dreaming is a normal psychosis, so I see REM sleep as a

normal seizure.

Critics will object that nothing normal can be considered pathological and I understand this definitional objection but insist that the distinction between the normal and the abnormal is more quantitative than qualitative. On this view normal REM protects us from abnormal epilepsy. Evidence that my theory may be correct stems from the fact that REM deprivation lowers seizure threshold. In REM sleep we may protect ourselves from fits and simultaneously treat our own tendency toward depression by unleashing a modified seizure. REM is normal ECT.

PM: You mention the interesting case of the fugue states associated with temporal lobe epilepsy. These are dreamy states where the individual seems to operate on automatic pilot but can perform very complex behaviour for days at a time. Are TLE fugues associated with temporal lobe seizures activity?

AH: The temporal lobe is one target of REM PGO activity. The pontine brain stem thus normally stimulates the thalamocortical system and causes it to hallucinate. "I am lost in an unknown city looking for I know not what place or person". This statement could come from a TLE sufferer or a normal dreamer. Dreaming is a very fugue like state which is often unnoticed and always time limited. TLE fugues go on until the seizure activity spontaneously subsides is terminated or is medically treated.

PM: Migraine aura are associated with seizure like activity as well? What are dreams like in migraines? I am thinking of people like Friedrich Nietzsche and Simone Weill-2 brilliant thinkers who suffered terribly from migraines and described vivid dreams.

AH: I am not a migraine sufferer or scientist so I cant answer your question about Nietzsche. The artist who first got me interested in dynamic psychology was Fyodor Dostoyevski whose epilepsy Freud ascribed to his repressed hatred of his father. I've come a long way since Wesleyan and would now suspect that "Dostovevski and the Parricide" was a pipe dream, perhaps triggered by the cocaine Freud used as an antidepressant, and in any case it was wrong. The Brothers Karamazov is nonetheless a beguiling fantasy, perhaps driven by an epileptic focus in Dostoyevski's brain.

PM: Migraine attacks at night occur most frequently during transitions from REM. Not surprisingly dreams in migrainers are typically disturbing nightmares.

AH: My own sleep onset was, for five years afflicted by the ocular pain caused by cluster headaches. These severely unpleasant cephalagias were not accompanied by dreams. The absence of pain in the many dreams that I have had has always fascinated me. Nightmares, yes, severe panic attacks but no pain, even in mutilating, bloody dream scenarios. My teeth crumble and fall out but always painlessly. I always wondered if the explanation was simply neurological: Pain neurones are not activated in REM. I offer this story to show how my mind works.

Chapter 23: Altered states of consciousness

PM: The AIM model seems able to capture various altered states of consciousness including drug effects. Where would you place effects of LSD for example; high A, High M and high I? Unlike with dreams you are still getting input during an LSD trip right?

AH: LSD interferes with visual perception by making the internal predictive system more than usually excitable. But it does not shut down the external visual inputs whose perception it distorts. That's why it is so popular an hallucinogen. Two people can describe the effects to each other when both are "high". And they can indulge in mystical speculations about their experience. The problem is that street drugs are, by definition, unregulated hence subject to contamination and uncertain dosage. In LSD psychosis, A is high but both M and I are altered in the direction of REM.

PM: As mentioned before REM and LSD and other psychedelics may share a common 5HT2A signalling system. If so that system need intense investigation it seems to me. Yes?

AH: Cellular level studies are needed to compliment clinical pharmacology. Such studies have fallen victim to animal rights activism and it may be a long time before we know clear answers to these questions. Meanwhile we know enough to be sure that the brainmind is a unified natural system and that dreaming can be accessed and serotonin levels manipulated without the use of drugs. I tell my children that but of course they don't listen to me.

PM: You mention Tononi's information integration theory of consciousness (IIT) and relate it to AIM. How, in your view is Tononi's axiomatic theory of consciousness related to the theory you and Friston have worked on?

AH: Tononi's IIT attempts to explain consciousness itself whereas Friston and I apply FET to sentience, how the brain mind regulates its sensorium. This is a consciousness component but only one of many.

PM: For Tononi's IIT ,an experience is conscious if it satisfies several conditions: it is actual and occurrent, is structured (composed of differing phenomenal elements), is specific and distinctive (it can be uniquely differentiated from other experiences), is unified (is experienced as one integrated whole), and is definite. Surely dreams satisfy these criteria? How does the Friston-Hobson theory of consciousness improve upon IIT?

AH: IIT is to be applauded because it axiomatizes subjective experience. Most theories of consciousness do not deal with the phenomenology in such a principled way. However, I am sceptical of Tononi's phi theory because I can easily imagine a computer which processes more information faster than any real brain but is neither sentient nor conscious. Furthermore, IIT and most AI models of cognition pay only lip service to dreaming. I regard dreaming as prima facie evidence that Kant was right in positing *a priori* knowledge. I keep reminding Karl Friston of this important point.

Chapter 24: Virtual reality

PM: You see waking consciousness and dreams as versions of brain that specializes in creating virtual realities. But why do we take as real events that occur to us in dreams—even when those events clearly violate the laws of physics?

AH: The false belief that we are awake when we dream is a testimony to the tight relationship between our internal model of the outside world and external reality. Friston and I propose that the brainmind evolved to predict and analyse perceptual records of our

environment. To accomplish this remarkable feat an internal model was put in place by genetic instruction and later adapted by experience to encompass the wide variety of human experience. No wonder we are fooled by our hallucinatory experience in dreaming.

PM: You say in this chapter that a potential function of dreaming is to facilitate the predictive capacity of waking consciousness. I published a paper a long time ago in *Dreaming* arguing that dreams were essentially counterfactual simulations of real world events. Just as we learn from counterfactual thinking in waking life (“If I had taken the umbrella I would not now be wet. In future I will grab the umbrella”) so we learn from counterfactual processing in dreams. I showed that many dreams were literal counterfactual simulations to an initial triggering event in the dream.

AH: Counterfactuality is a brand of factuality. It may rain (in which case an umbrella would be useful) or it may not rain (in which case an umbrella is not needed). Better be safe than sorry. The example of uncertain weather prediction is reminiscent of the discovery of the butterfly effect and the strange attractor. Edward Lorenz discovered chaos because the US Navy hired him to help plan bombing raids on Japan more than two days in advance (the limits of accurate weather forecasting). He discovered that any complex system, like weather, was unpredictable for more than two days. The moral is: Take an umbrella even if the sun is shining. As you may know from my autobiography, Edward Lorenz was a Christmas Eve visitor to our house in West Hartford. We called him “young Edward” to distinguish him from his father, the inventor “old Edward”.

PM: In this chapter you return briefly to protoconsciousness theory where protoconsciousness is the consciousness we come equipped with and precedes adult waking consciousness. You equate REM with protoconsciousness though protoconsciousness precedes dreaming. If REM is not a fully developed form of consciousness how can it help to create predictive models of the world?

AH: My Protoconsciousness theory is designed to accommodate the accurate predictions of the effect of movement on perception. It is a sensorimotor model first and foremost. As far as dreaming is concerned, any model is better than no model. Models are only hypotheses, after all. In the case of dreaming, the brainmind guesses at what might happen. Of course these predictions are rarely born out but we are made ready for the most dire and desirable possible events that may befall us. Dreaming is thus not only scientifically explained but it is seen to be the essence of science itself: hypothesis testing. If you don't like my model, propose a better one but please don't say you have no hypotheses or prefer literary theories like psychoanalysis. That's a pseudo scientific cop-out!.

Chapter 25: Subjectivity

PM: You argue, against reductionistic neuroscience, that subjectivity is the very essence of consciousness. Please explain what you mean by subjectivity and how dreams fit into that picture.

AH: The most attractive aspect of the Hobson/Friston hypothesis is its recognition of the physicality of mind. For us,, the mind is real and it is causal. Mind will be shown to be a brain function (there are no minds without brains) but brains are under the causal influence of

minds. Without a mind the brain is powerless or condemned to what Gerald Edelman called secondary consciousness. By that he meant consciousness without self-consciousness. Awareness of the world and the body but not of the self. The self is a creation that comes to command its brain. Free will is the result.

PM: Subjectivity to me feels like something...It feels private, and there is an inwardness that is not available to others. Most of the time, this inwardness feels like “optimal flow” creativity, imagination, actuality or suchness, centeredness, ecstasis or moving out of the private realm and into others, and the public realm. I experience it most fully when I dream, daydream, imagine, reflect and love. If that is what you mean by subjectivity why does it have a constant unity across all of these varied states of consciousness?

AH: The unity of conscious experience is one of Tononi’s axioms. At this point in time we can only hand wave about the mechanism of unity. However it is certainly not irrelevant that the billions of neurones that create the conscious mind are massively interconnected and that they talk with each other at lightening speeds. Karl Friston calls this “message passing” and tries to incorporate this idea in his math/physics picture of sentience. This may fall short of what you want but it is certainly a step in the right direction.

PM: In this chapter you also allude to your work with Friston and the development of your dual aspect monism (DAM) philosophical position. We have discussed DAM and what I feel are its shortcomings. Reading further into your work with Friston, it seems you guys what to derive a basic metaphysic from asking what a basic “thing” is. You use the term “Markov blanket” to describe the boundary that separates processes occurring inside the boundary from those occurring outside and then ascribe differing information processing functions to each. Thus you arrive at DAM. It is a brilliant formulation.

AH: Thanks for the compliment. DAM a philosophy that works for us but we would rather call ourselves scientists than philosophers

PM: But I still feel I must stick to Charles Sanders Peirce metaphysics. Had you and Friston read Peirce you might have opted for a triadic metaphysic not a dual aspect monism. There is the inside and outside but there is also the membrane or boundary separating the two thus yielding a three part metaphysic.

AH: Peirce died in 1914 when quantum mechanics was being formulated. We base our dream theory on the probalistic statistics of quantum physics as we suppose Peirce might also have done. The membrane is the blanket separating what we take to be inside and outside. Feel free to extol Peirce. Friston and I hope to move beyond philosophy just as Peirce wanted to do in his mathematical endeavors.

It sounds as if we are on the same page in seeking to model consciousness. Friston and Hobson are the proud, natural descendants of Charles Sanders Peirce. However we distance ourselves from any pragmatism or pluralism which is invoked to save religious belief. I remind you that both Peirce and James were believers who had simply decided to continue to be so despite the lack of any evidence for their faith. The last word on this subject may not be so much “Peirce” as “Peace”.

PM: Neither Peirce nor James would say that they were believers "despite the lack of any evidence". They pointed to all kinds of evidence and presented rational arguments for their

positions on so-called spiritual reality. But lets return to the the crucial idea of “Free energy” as I am still not clear on it. Can you explain its relevance to consciousness and dreaming?

AH: Free energy is negative entropy. Free energy is the work that needs to be done to live rather than to die, to be sentient rather than unaware. Friston and I suppose that dreaming does that work by preparing the brain to predict life’s challenges. Consciousness is created as part of that predictive process. An idea, like ours, can be held in mind and examined.

We admit that we cannot yet model consciousness itself. For now, we focus on the representation of the sensorium, on the perceptual and attentional mechanisms that are the portals on conscious experience. Once we have established a firm foothold in this domain, we will try to fold in other aspects of cognition such as emotion, memory and narration. But don’t hold your breath. Its been a century since Peirce had a go at this and it may take at least that long to flesh out the theory. Meanwhile, we are happy to find ourselves in such good company.

PM: Your recommendations at the end of the book for a program of research are things that any sane person should be able to endorse it seems to me:

- develop DAM
- work on a formal analysis of subjectivity
- continue work on neurobiology of sleep-wake states
- attempt a mapping of formal subjective states to physiologic states/variables
- integrate data across domains

Any last words?

AH: See above blessing.

PM: This has been extraordinarily fun for me discussing these ideas with you. Its always a pleasure to not have to argue with someone about the importance of dreams. If only the rest of the world would see that our old nemesis Freud was onto something when he said that “dreams are the royal road to ...” He should have said: "the royal world to consciousness!"

AH: The problem is the grandiosity of the Royal Road metaphor. We follow a much more humble path and imagine no plaque commemorating our modest meanderings.

PM: Amen!