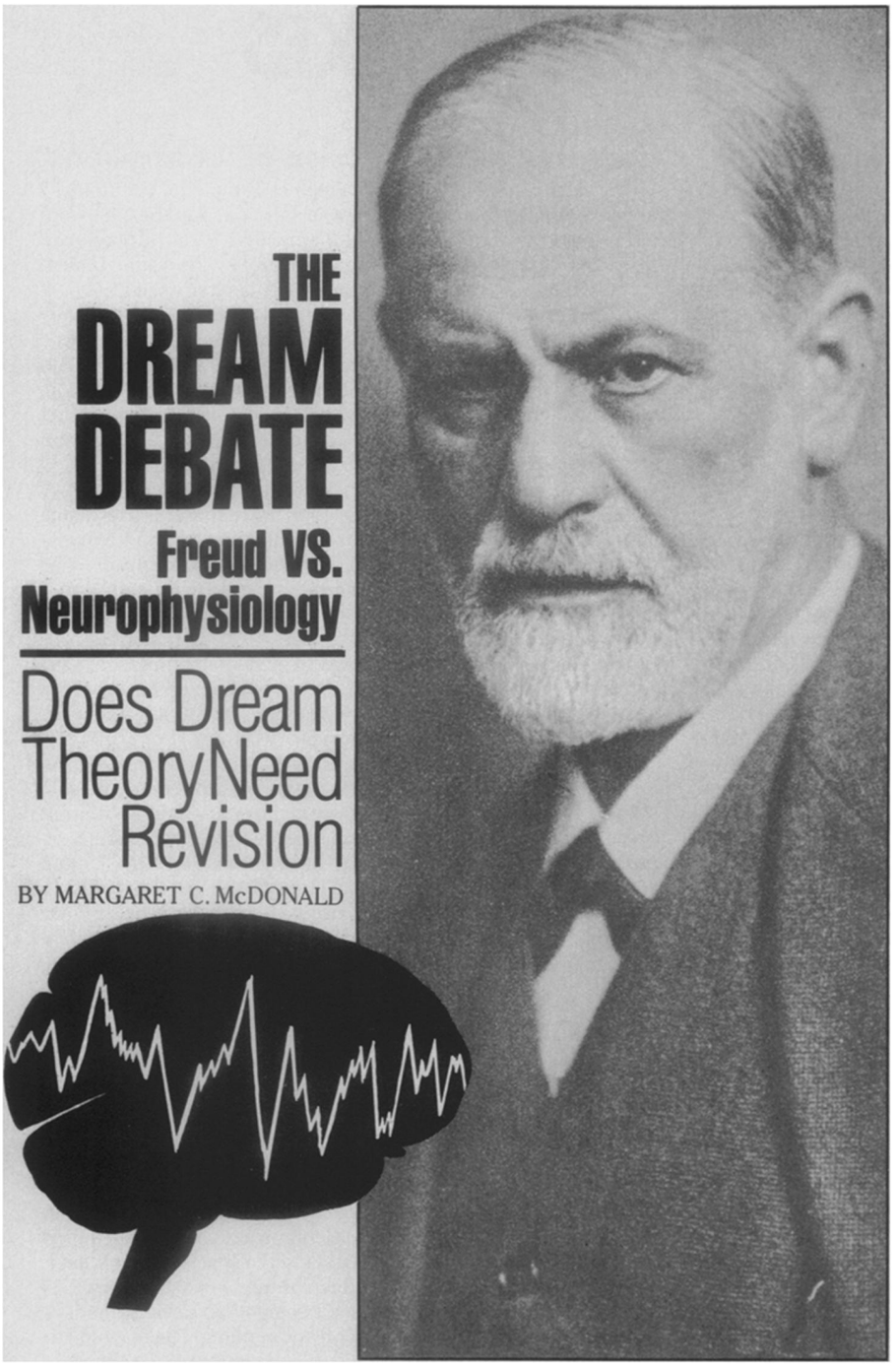


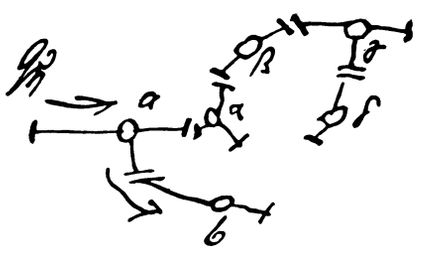

What is the stuff that dreams are made of? According to Sigmund Freud, one of the first scientists to seriously consider the question, the fantasies and sensations of the dream world are the yellow bricks that make up "the royal road to the unconscious." In his 1900 volume *The Interpretation of Dreams,* Freud theorized that dreams are the conscious expression, albeit in symbolic or disguised form, of unconscious fantasies that are repressed during the waking state. His psychological theory went without serious challenge until 1977, when two Harvard University sleep researchers, J. Allan Hobson and Robert W. McCarley, challenged the Freudian legend with their purely *physiological* explanation: Dreams, they suggest, are little more than the result of the internal and motivationally neutral activation of generator neurons in the pons area of the brain stem during the desynchronized sleep state (D sleep). They further hypothesize that what makes dreams "dreamy"—full of scene shifts, brilliant colors, bizarre characters and sensations of flying and falling—is not an attempt by the "psychic censor" to disguise repressed wishes stirred from the unconscious by the day's events prior to passing them into consciousness but merely an attempt by the forebrain, barraged with random stimulation from the giant neurons of the pontine reticular formation (PTG neurons), to make sense of disparate data. "With the new theory," says McCarley, "dreams are demystified and deneuroticized." The obvious question is, why try to analyze dreams?

Unlike Freud's dream theory, which reigned for three-quarters of a century, Hobson and McCarley's activation-synthesis hypothesis, as it is called, remained unchallenged only until other dream theorists and sleep researchers could garner their forces to submit articles of rebuttal to the AMERICAN JOURNAL OF PSYCHIATRY (Vol. 134, Nos. 11 & 12), the forum in which the work was first published. Opposed researchers included Emory University sleep researcher Gerald W. Vogel and Yale University's Anthony L. Labruzza. The debate escalated and took on more formal tones last month in New Orleans at the meeting of the American Psychiatric Association, at which Hobson and McCarley took the affirmative and Vogel, along with Yale's Morton Reiser, took the negative side of the question "Does Dream Theory Need Revision?" The activation-synthesis hypothesis was challenged on three levels—historical, physiological and conceptual.

First the historical: In reviewing the Freudian model, McCarley noted that Freud spent most of his early career as a neurobiologist. In fact, he was formulating his theory on the interpretation of dreams at the same time he was hard at work on his *Project for a Scientific Psychology,* in which he attempted to develop a physiology of the mind. According to McCarley, the two show amazing overlap and similarity. In fact, he feels that the *Project* contains "the embryos of most of Freud's major theoretical concepts" and that "the entire psychic model and almost the entire theoretical structure of *The Interpretation of Dreams*...is directly derived from the neurophysiological model of the *Project.*" This is significant, say Hobson and McCarley, because Freud's neurobiological theories were only as sophisticated as 1890s physiology would allow. For example, Freud saw neurons as passive reservoirs of energy from sources outside the brain, mainly from instincts. It is now known that neurons are information transmitters with their own metabolic energy sources. So, if Freud's dream theory is based on his understanding of physiology, does it not demand revision in light of new physiological understanding?

Not necessarily, says the negative team. While it is true, notes Reiser, that Freud worked on the *Project* simultaneously with his work on *The Interpretation of Dreams,* he was unable to reconcile his psychology with what was known physiologically and abandoned the *Project,* which went unpublished during his lifetime but was resurrected and published posthumously. In fact, in *The In-*

*McDonald, a Washington-based science writer, specializes in behavioral research.*



Hobson, McCarley

*This sketch illustrates Freud's concept of the flow of neural energy. (Neurons are labeled a and b.) And dreams of flying, to which Freud often attributed sexual interpretations, Hobson and McCarley explain as an attempt to synthesize vestibular information during D sleep.*

The Bettmann Archive

*terpretation of Dreams* Freud seemed to consciously decide to remain aloof from the physiological realm: "I shall entirely disregard the fact that the mental apparatus with which we are here concerned is also known to us in the form of an anatomical preparation, and I shall carefully avoid the temptation to determine psychical locality in any anatomical fashion. I shall remain upon psychological ground."

But what about the physiological ground on which McCarley and Hobson so comfortably tread? What if dreams are no more than a preprogramed physiological event? The major tenet of the activation-synthesis hypothesis is that "during dreaming the activated brain generates its own information by a pontine brain stem neuronal mechanism .... We hypothesize that this internally generated sensorimotor information, which is partially random and partially specific, is then compared with stored sensorimotor data in the synthesis of dream content."

Dreaming occurs predominantly during a state known as D sleep, which is characterized by EEG desynchronization (forebrain stimulation), electromyogram (EMG) suppression and rapid eye movements (REM's). D sleep periodically recurs in 20- to 25-minute periods roughly every 90 minutes during sleep. When the brain is in the D state, external input is excluded and motor output, except for the oculomotor pathway, is blocked. According to McCarley and Hobson, the FTG neurons are the likely generators of D sleep. They cite the following reasons: FTG cell activity increases several minutes before a REM period and peaks during REM; some of the giant cells are connected to the neurons responsible for eye movement and, therefore, might initiate the REM's of sleep; other FTG cells reach into the reticular formation just above the pons, which might be responsible for the characteristic REM brain waves; and the giant cells could cause some of the motor inhibition of D sleep through their action on cells in the reticular formation just below the pons.

*Shown below is a comparison of two models of the dream process.*

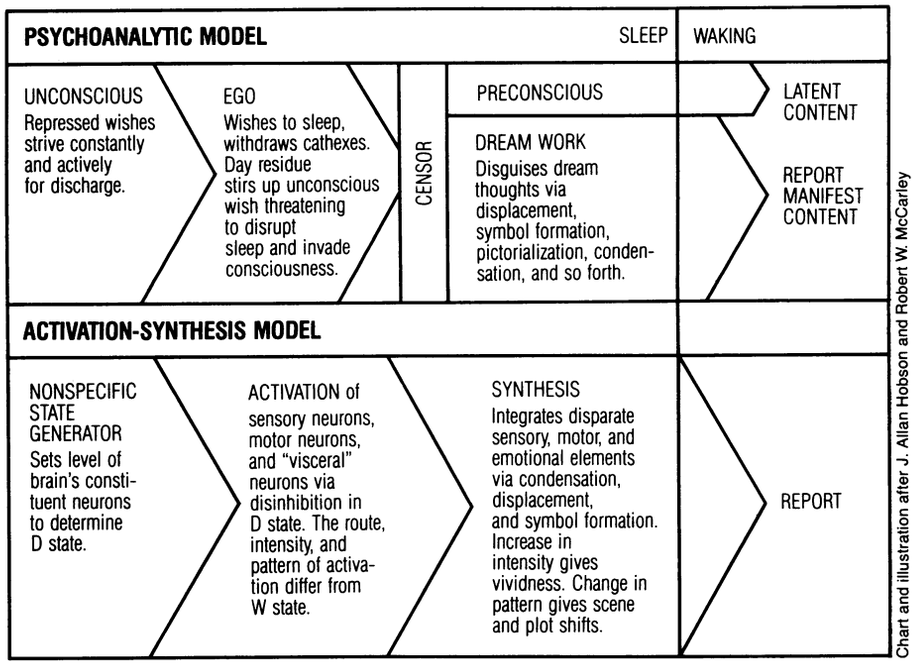
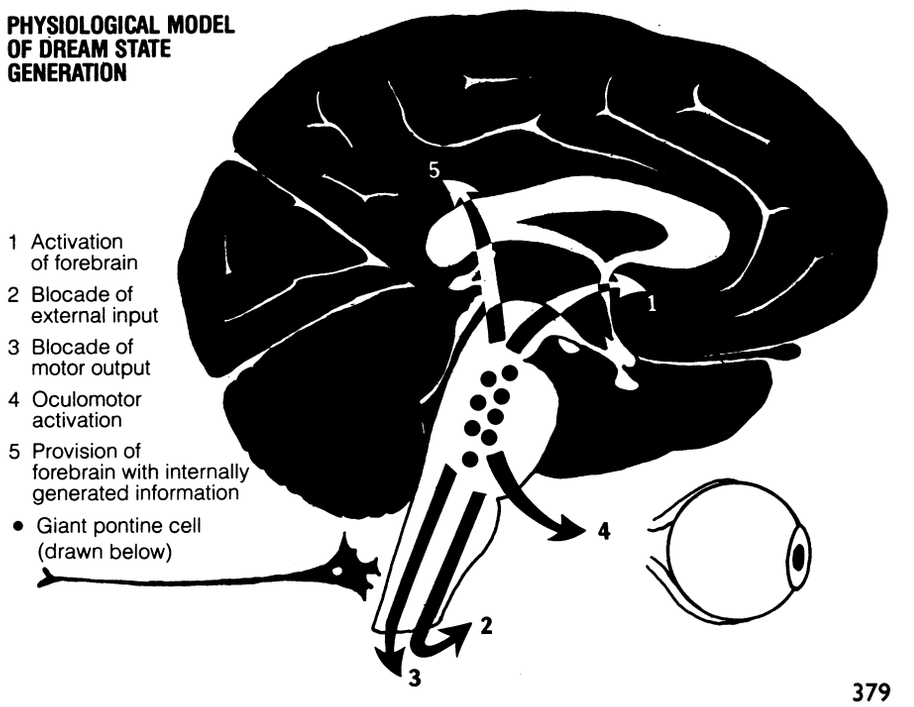



Chart and illustration after J. Allan Hobson and Robert W. McCarley

**PHYSIOLOGICAL MODEL OF DREAM STATE GENERATION**



The working model that Hobson and McCarley use to explain the biological rhythm of D sleep periodicity and its isomorphic counterpart, the mind state of dreaming sleep, involves reciprocal interactions between two neuron groups: the excitatory FTG cell whose activity peaks during D sleep and the inhibitory biogenic amine-containing cells of the locus coeruleus and raphe, whose activity is at its nadir during D sleep. The alternate waxing and waning activity of these two groups produces the periodic occurrence of D sleep.

Central to the activation-synthesis hypothesis is the activation of cells in other parts of the brain by FTG cell activity. For example, while the giant cells, during D sleep, "wake up the brain" in a sense, they turn off the motor command. Thus, cats whose motor control centers have been deactivated with lesions will show all D sleep characteristics except motor blocking. Such cats move their feet as if running, play, arch their backs and seem to "act out their dreams," leading researchers to believe that in normal cats movement patterns are generated in D sleep — they are simply not expressed. So, explain the Harvard pair, "in the classic chase dream, the dreamer who has trouble fleeing from a pursuer is as much accurately reading the activated state of his motor pattern generator and the paralyzed state of his spinal neurons as he is 'wishing' to be caught."

It is also likely that FTG cells activate the brain's visual centers and that information about REM eye movement is sent on to other centers, which generate visual images to account for the movements. This could explain the sudden scene shifts that occur in dreams, or such shifts could be triggered by short bursts of giant cell activation, explain Hobson and McCarley. The psychoanalytic interpretation that the dreamer is attempting to evade troubling material, they feel, is less likely.

Stimulation of the vestibular system, which is responsible for balance and our sense of position in space, is also characteristic of D sleep. "Flying dreams may thus be a logical, direct, and unsymbolic way of synthesizing information generated endogenously by the vestibular system in D sleep," say McCarley and Hobson. In fact, they feel that much of the bizarreness and symbolism of dreaming can be explained by two facts: Brain systems rarely active at the same time during waking are simultaneously stimulated during D sleep and dreams are activated by internal, not external, mechanisms.

So, while Hobson and McCarley do not go so far as to deny meaning to dreams, they feel that their theory suggests three fundamental changes: "1) a more direct route to their acquisition than anamnesis [recollections] via free association, since dream origins are in basic physiological processes and not in disguised wishes; 2) a less complex approach to their interpretation than conversion from manifest to latent content, since unusual aspects of dreams are not seen as disguises but as results of the way brain and mind function during sleep; and 3) a broader view of their use in therapy than that provided by the transference frame of reference, since dreams are not to be interpreted as the product of disguised unconscious (transference) wishes."

Vogel's rebuttal of Hobson and McCarley's thesis was swift, fierce, and struck at the heart of the activation-synthesis hypothesis. Vogel says that no evidence exists to prove that "the orderliness of mental sequences is determined by the pattern of hindbrain stimulation of the forebrain." And while he does not deny that evidence from animal studies indicates that the brain stem contains structures whose activities are necessary and sufficient "for the brain stem components of the D state," he feels that these facts "do not rule out the possibility that in the intact animal forebrain structures interact with the brain stem D state structures in such a way that the forebrain is crucial for D sleep." In support of this view, Vogel cites studies showing that lesions of the basal forebrains of cats eliminated D sleep for several weeks. In other studies, D sleep in diencephalic cats averaged two episodes in 24 hours, compared with 31 longer periods of D sleep per 24 hours in controls. "In the intact animal," notes Vogel, "the forebrain exerted an inhibitory influence on the D state phasic discharge pattern of the hindbrain. Therefore, ... the forebrain is not simply a passively responding slave of the hindbrain."

More interesting, perhaps, is that while pontine stimulation can indeed initiate the D state, so can stimulation of other brain structures, including the cortex, vagal nerve and visual system — all of which lie outside the brain stem. Equally fascinating are reports from several laboratories noted by Vogel that dreams indistinguishable from D state dreams occur in the absence of the D state, for example sleep onset dreams, which have not been found to be significantly different from D state dreams in bizarreness of content, length, hedonic tone or dreamlike quality. Vogel sees two implications in this finding: "First, the unique physiology of the D state does not explain the instigation or formal characteristics of the non-D state dreams. Second, the similarity of D state and non-D state dreams makes it unlikely that unique D state neurophysiology determines the characteristics of D state dreams. Rather the similarity of dreams in different states suggests that some properties common to all the dream states determine dream characteristics."

One final physiological note on research methodology: Vogel cited evidence from two sources that the original finding of selective firing of FTG cells during D sleep was a procedural artifact caused by rigid head restraints on the cats. He notes, "Using more flexible electrodes, Seigel, McGinty, and Breedlove ... found that in cats without head restraints the discharge rates of FTG cell during waking head movements were as high as during D sleep." Nor, adds Vogel, are lesion techniques so sophisticated as to rule out destruction of neighboring neurons or blood supply that could "dirty" the data.

Finally there is the conceptual argument. Labruzza and Reiser fault the Harvard team on what they see as sloppy application of the theory of isomorphism, or similarity of form. Reiser and Labruzza feel that different levels of explanation — in this case the physiological versus the psychological — need different frames of reference with their own, not necessarily translatable, languages. Labruzza explains: "It is not valid to move freely between independent logical systems of description and application. One cannot add apples and oranges without appealing to a superordinate concept such as fruit. Likewise, wishes cannot trigger cells, and cells firing in the pons cannot determine the meaning and motive of dreams.

"... Thus mind and brain (or body) need to be treated as two distinct orders, each having its own peculiar language, conceptualizations, and levels of abstraction; to treat them otherwise invites confusion and conceptual unclarity. There is, as yet, no superordinate framework or well-defined isomorphism that unites these realms of mind and body.... It was McCarley and Hobson's assumption of mind-body isomorphism 'in a less exact sense' that got them into theoretical difficulty."

Reiser carried the argument further, speaking in terms of the neutral monism theory — that there is a neutral other substance that comprises both mind and matter. Taking a specific emotion as an example, Reiser said, "Anger can be described as a neuron firing or as a feeling of wanting to hurt someone or something. These are two independent, equally valid descriptions of the same state. But we can't translate the psychological into the physiological and vice versa. And while the physiological model can tell us what the cell does, it cannot tell us the quality or direction of the anger. To say that because the firing of the FTG cell is neutral that the dream has no meaning is a non sequitur. We need a Rosetta stone — a conceptual intermediate template that is isomorphic for both the physical and psychological, and we simply don't have it. But you don't need the physiological data to give credence to the psychological theory any more than you could have found neurons in the pontine stem from dream interpretation."

Labruzza summed up the arguments: "As it now stands, the activation-synthesis hypothesis of the dream process is an impressive theoretical statement about the neurobiology of the dream state; however, its extrapolation to psychoanalytic dream theory is mere speculation, albeit fascinating speculation...." □