EXT. MISSION VIEJO POOL
MISSION VIEJO, CA

GREG LOUGANIS DIVING

Coach Ron O'Brien (V/O):
I think Greg Louganis, without question, is the greatest diver that's ever lived.
He creates the illusion, when doing the very hardest of dives, that it's very easy; that there's nothing to it.

C/U GREG LOUGANIS

George Page (V/O):
Many agree with Coach Ron O'Brien that Greg Louganis is one of the greatest divers that ever graced that sport. Somehow, he can make the complex, the dangerous, look effortless and simple.

MISSION VIEJO POOL CONT'D

George Page (V/O):
The most grueling of his dives is the reverse one-and-a-half with three-and-a-half twists. It may test muscles; it will surely test the brain. Few divers ever attempt the reverse one-and-a-half. Even fewer can reasonably expect to achieve a score of ten, diving perfection. In reaching for such a goal, Greg is a model for us all. He demonstrates how all of us navigate through this world of ours; how we internally adapt and how, with our senses, we survive. Action, reaction; input, output; everyday, as we undertake relatively simple tasks, our brains achieve neurobiological triumphs as great as Greg's.

GREG ENTERING WATER

GREG WALKING UP TO LADDER

George Page (V/O):
Greg Louganis shows us how our brains receive information and respond to it, with

GREG LOUGANIS' FACE

POOL

GREG LOUGANIS' FACE

GREG LOUGANIS ON DIVING BOARD

GREG LOUGANIS' FACE

GREG DIVES

GREG ENTERS WATER

elegance.

From his eyes to the back of his head, and along the two higher pathways of vision
there passes a continuous parade of Olympian activities.
So it is with all of us.
Thanks in part to incessant practice, he has forged highways of neurons between the input of vision, and the output of movement.
Motor cortex, cerebellum, basal ganglia--these areas of Greg's brain can operate almost reflexively as he reaches for the perfect 10.
What is aerial poetry for us may be but a mere reflex for him. Certainly, Greg Louganis has a superbly coordinated athletic body, but the feats he performs can only be achieved through his superbly designed brain.
While he creates miracles in air, for all of us to see, to respond, to take even one small step is just as great a miracle.

MODULE 12: HUNTINGTON'S DISEASE

NANCY WEXLER SITTING ON GROUND AT A RESEARCH SITE (HEREDITARY DISEASE FOUNDATION TAPE: 41:20- to 41:44)

George Page (V/O):
Clinical psychologist, Dr. Nancy Wexler, has been studying Huntington's Disease since 1979. She, and her colleagues, have traveled to Venezuela, China, Peru, and New Guinea. But it is her Venezuela research that has resulted in genetic breakthroughs into this dreaded disease.

INT. DR. WEXLER'S OFFICE HEREDITARY CHART AND PICS (ORIGINAL TAPE)

George Page (V/O):
The clues she sought were found within a family of over 15,000 Venezuelans, related not just by blood, but by the threat of a major brain disorder. Huntington's Disease can affect movement, cognition, judgment and emotionality-all important factors for human interaction and adaptation.

HEREDITARY DISEASE FOUNDATION STOCK FOOTAGE (ORIGINAL TAPE)

In the general population, Huntington's Disease affects one out of 10,000 people, but in this family, one out of four will die from it.

Dr. Wexler (O/C):
We needed a very large family to study.

INT. DR. WEXLER'S APARTMENT NEW YORK, NY (ORIGINAL TAPE)

We needed one that was very close together, and we needed one that shared the same kinds of living circumstances, climate,

DR. NANCY WEXLER
HEREDITARY DISEASE FOUNDATION
(ORIGINAL TAPE)

Dr. Wexler (O/C):
diet, bugs, social... customs. Venezuela was the absolutely ideal place for this. We found tiny villages around Lake Maracaibo,

HEREDITARY DISEASE FOUNDATION
Maracaibo, Venezuela (ORIGINAL TAPE)

Dr. Wexler (V/O):
a staggeringly huge family with Huntington's Disease. It's the largest concentration of Huntington's anyplace in the world.

George Page (V/O):
For 17 years, multi-disciplined detectives have been amassing genetic data from this enormous family, trying to pinpoint why its members, of all people, are so much more at risk.

INT. HUT LAB SET UP (ORIGINAL TAPE)

Dr. Wexler (V/O):
We don't know when it starts. It could start at birth. It could start before birth. It may start at puberty, it may start at middle age,

ALLISON ANIMATION
HEAD/BRAIN
(ORIGINAL TAPE)

Dr. Wexler (V/O):
but somehow, for some reason cells right in the middle of the brain begin to die.

(Add music)

George Page (V/O):
In a normal brain, the two small ventricle canals carry spinal fluid and are shaped like a butterfly. In a Huntington's Disease patient, these ventricles are enlarged to the size of a walnut, because the surrounding brain tissue has died.

HEREDITARY DISEASE FOUNDATION
Maracaibo, Venezuela (ORIGINAL TAPE)

CHILDREN PLAYING (ORIGINAL TAPE)

HEREDITARY DISEASE FOUNDATION
Maracaibo, Venezuela (ORIGINAL TAPE)

CU PATIENT (ORIGINAL TAPE)

MOTHER/CHILD (ORIGINAL TAPE)

CHILDREN (ORIGINAL TAPE)

Dr. Wexler (V/O):
It's been called one of the most diabolical diseases known to mankind,

because it affects every aspect of human functioning.

Dr. Wexler (V/O):
It affects the brain, which really controls everything that we are, and each child of a parent with Huntington's Disease

has a 50-50 risk of inheriting it.

George Page (V/O):
In the early years of investigation, there was no way of telling who was carrying the lethal gene until symptoms of the disease appeared. This usually occurs when afflicted individuals are in their thirties or forties, and often after they have had children of their own. Thus, the disease is spread unknowingly, and each child of that parent is under Damacles' sword, not knowing whether they will become the next victim- or if their brothers and sisters will become victims-or their aunts and uncles, or their cousins.

DR. WEXLER/VENEZUELAN WOMAN (ORIGINAL TAPE)	Dr. Wexler (O/C): She's been telling me that she comes from a family in which her mother died of Huntington's Disease when she was 24. She's now 39.
DR. WEXLER (ORIGINAL TAPE)	Dr. Wexler (O/C): She is very much aware exactly of what this disease does...
CU VENEZUELAN WOMAN	She says that she's often afraid of the illness, that her mother died very severely affected and she's scared that this will be her own future.
CU DR. WEXLER (ORIGINAL TAPE)	Dr. Wexler (O/C): My connection to Huntington's Disease is a very personal one because my mother died of Huntington's Disease as did all of her brothers. In my family we were told women couldn't get Huntington's Disease.
HEREDITARY DISEASE FOUNDATION STOCK FOOTAGE (ORIGINAL TAPE)	Dr. Wexler (V/O): After she had my sister and myself, she and my father discovered that this is a disease which strikes men and women equally and that my sister and I both have a 50% risk of developing the disorder.
NEED MORE VENEZUELAN FOOTAGE?	George Page (V/O): There is still no cure for Huntington's Disease, however, after 17 years of careful study, the gene responsible for the dsease has been identified. Through DNA testing, it is now possible to determine

George Page (V/O):
whether someone will get the disease during their lifetime. This means, however, that new medical, ethical, and moral issues arise: Should people be tested so they know in advance they will ultimately develop the disease? Dr. Wexler has struggled with this question.

DR. WEXLER (FROM TAPE #5: 51:30-52:57)

Dr. Wexler (O/C):
When the Huntington's gene was found, or even the marker was found and you could do testing, we said, "Look this information is just as toxic as chemotherapy, so it really has to be done in a protocol. And the same way that you would give very careful informed consent for chemotherapy, you have to do the same kind of thing for genetic prediction. You can't just gaze into your crystal ball and say, "You're going to die. You're going to live. You're going to die. You're going to live." You have to have counseling before hand. You have to have follow-up. You have to have a lot of protections in place because it's very rugged stuff, even though it's information. And I'm very worried that a

Dr. Wexler (O/C):
lot of this information is going to get to the pushed or get very matter-of-fact, in your doctor's office. You have 15 minutes with your doctor. I think I'm going to test your cholesterol. I'm going to test your thyroid. And hey, why don't we just do a Huntington's test? Aren't you at risk? Wait a minute. You know. You didn't ask me. You didn't ask me do I want this. So we need

DR. WEXLER (TAPE 5)

Dr. Wexler (O/C):
to have a lot more education, and we need to make every choice permissible because there aren't any moral right or wrongs. Not: to take this test is morally good or (to take)
to not take this test is morally cowardly. Both options are of equal validity, and it's up to each individual and a family as to what makes the best sense.

DR. WEXLER AND VENEZUELANS IN BLDG. 33:29-34:40 (TAPE #5)

Dr. Wexler (V/O):
(Tape #5, 54:29-55:15)
And there's been a tremendous amount of poignancy in being able to cross-over those geographic and cultural boundaries, and be taken into their hearts and theirs certainly taken into mine. So it's very

Dr. Wexler (V/O):
devastating to have all your brothers and sisters, you know, dying, and you can't stop it. And there's an enormous amount of trust, and I think that's very special. That doesn't happen. I think all of us feel that when we go to Venezuela, that it really puts things into perspective in a way that just otherwise doesn't happen. Everything that you thought was important, was so petty, you know, and what really matters is sort of life and death, and how you treat your neighbor and your relative.

Brain II - 2nd Edition

SLEEP AND CIRCADIAN RHYTHMS: MODULE 13

WILDLIFE STOCK FOOTAGE
Survival Anglia
GEESE MIGRATING

SALMON SWIMMING UPSTREAM

BUTTERFLIES

BIRDS IN FRONT OF MOON

NYC STREET SCENE

TIME LAPSE STOCK FOOTAGE
Energy Productions
BALTIMORE WATERFRONT
MOONRISE

M\S GEOFF HOYLE (mime) IN BED

C\U GEOFF'S HAND
C\U GEOFF'S FOOT

George Page (V\O):
Every creature on earth lives out its life in a series of biological waves. Knowingly or not, we are all prisoners of the years, the seasons, the tides, the cycles of the moon, the axis of the sun, light and dark...Among us all, the rhythms of the earth are closely linked to the rhythms of the brain. We humans may seem different; we are often unaware that we too have inherited those cycles. We have learned to time ourselves by clocks of our own making and to forget the beat of the earth.

Within our very brains are submerged global tides, lunar moods from which no window, however airtight, can insulate us.

George Page (V\O):
One of the best times to visualize our internal rhythms is during the various stages of sleep. At intervals of about 90 minutes we pass through periods of REM or Rapid Eye Movement Sleep, our bodies are asleep but our brains are very active.
These periods, brief at the beginning, become longer as the night advances. During these

C\U GEOFF'S EYE

M\S GEOFF IN BED

JESSE SALB'S EEG TOPOGRAPHIC MAP SEQUENCE-Dream Sleep

TIME LAPSE TOKYO CITYSCAPE
Tokyo, Japan

INT. CAVE
France
M\S MICHEL SIFFRE IN CAVE

times, the eyes dart behind the lids while the brain is infused by waves of vivid dreams. And so the night advances, pulsed by 90 minute cycles: vivid dreams, deep sleep, vivid dreams, deep sleep.

George Page (V\O):
In inventor Jesse Salb's computer images of our brain's electrical activity, nearly five hours of sleep have been compressed into 20 seconds, and the 90 minute flashes of recurring dream sleep appear like waves on a beach.

George Page (V\O):
But what precisely do these rhythms of sleep mean to us when we are awake? Do our brains run, for instance, exactly on a 24 hour schedule?

In the summer of 1972, a French cave explorer, Michel Siffre, lived deep in a Texas cave for 7 months in order to observe the rhythms of his brain in a world where there was no day, no night, no summer, no fall. What he found was not exactly what he expected.

Michel Siffre (V\O):
When you are beyond time,

VIDIFONT 3
Michel Siffre

INT. CAVE
Texas

L/S MICHEL SIFFRE IN TENT

C\U MICHEL SIFFRE

RIDING STATIONARY BIKE
TAKING BLOOD PRESSURE

PERFORMANCE SKILLS

COMPUTER

Michel Siffre (O\C):
I was beyond time, without any time cues...no television, no radio, nothin. You know no watch-you live following your mind, you know, it's all your brain, your functions...Then you have, it's black--you have not the alternance of sleep eh...day and night.

Michel Siffre (V\O):
The cave where I was, in Texas, it's a semi-tropical cave, you know, no sound, nothing...darkness completely.

Michel Siffre (O\C):
At a certain moment, you decide you are awake. It's curious because you are not sure, but well, in moving your eyes, you know, you decide. Then you're awake, you open the light, and your day begins when you light on the light.

George Page (V\O):
Every day for all those seven lonely months, Michel Siffre took painstaking measurements of all his vital functions sleeping and waking: blood pressure, brain waves, body temperature, performance skills, heart rate.
With the aid of a camera, a computer and telephone link-up, his behavior and

COMMUNICATING ON TELEPHONE

SUPPORT TEAM

COMPUTER

COOKING

EATING

READING

INT. CAVE
READING

L/S Michel Siffre

data were monitored and processed by a surface support team. And what did Siffre confirm? That we humans do indeed possess internal alarm clocks that ring even when there is no day, no night, no season.
The body has its own cues for its various functions. It knows to eat when there is no lunchbreak, to wake when there's no sun, and to sleep when there is no sunset.

George Page (V\O):
Siffre confirmed the curious finding that the body's day is not identical to the 24-hour day.

Soon after he descended into the cave, his so-called day lasted 25 hours; yet he never could tell that it was different from the 24-hour days he used to spend on the surface. Michel Siffre's life beyond time demonstrates that a very old part of our brains is left unrestrained, operates on a 25-hour schedule, causing our bodies to advance about one hour a day against the clocks of our own invention. Our 25 hour clock represents the length of the endogenous sleep-wake rhythm for three quarters of the adult population.

Module 14:SLEEP: BRAIN FUNCTIONS

VICKI PREPARING FOR SLEEP
SLEEP #1
2:35-2:43
7:00-7:30
8:08-8:20
(50 SEC)

George Page (V/O):
Each night at our accustomed time, we begin to engage in little rituals that set the stage for sleep. We go to bed, and consciousness gives way to gentle slumber.
From the outside, the body seems still except for some shallow and even breathing. A twisting, a muffled groan, twitching in the muscles, or fluttering of the eyes, may occasionally break the stillness.
But for 7 or 8 hours, we seem to have departed into a silent world of internal communion.
In the morning, we emerge like amnesics, having few if any memories of the preceding hours. It is surprising how easily we accept this suspension from active life. But why do we sleep anyway?

DR. MARTIN REITE
UNIVERSITY OF COLORADO
HEALTH SCIENCES CENTER
TAPE 2 (TIME CODE BACKWARD) 16:48-15:38

Dr. Reite (O/C):
Sleep is one of the last big mysteries. We spend about a third of our lives doing it, and in fact we don't really know why we sleep. What we do know for sure is that

Dr. Reite (O/C): if we don't sleep for a long enough period of time, we'll die. Animals that are not allowed to sleep for a prolonged period of time will universally die. They'll die of multiorgan failure. It's a very peculiar type of death. They begin to eat more, and yet they lose weight; therefore, their energy metabolism is messed up. Their ability to control their body temperature is significantly impaired. Eventually they die. What purpose sleep serves; therefore, is keeping us alive. How does it do this? We don't really understand. There's a lot of theories about how sleep might work. There are restoration theories, that somehow it restores the body. Some type of metabolic product or some type of function that is run down, sleep in some way restores. We don't know exactly what that is. We don't know how that works. There are a variety of theories as to why we sleep that are apart from that, but I think the bottom line is: we sleep to stay alive.

TAPE 3 (TIME CODE BACKWARD)
HOW MUCH SLEEP DO YOU NEED? 6:18-5:13

Dr. Reite (O/C):
An interesting question is: How much sleep do you need? There's no test that we can use that tells you how much sleep you need. There's no laboratory test. There's no blood test. The test of how much sleep you need is: do you feel rested, relaxed and alert during the day? And if you do you're getting enough sleep. Now what does this mean? This means that individuals are their best judge of whether they are getting enough sleep, and the amount of sleep, if you look across a population, that people need varies quite a bit. It's a bell-shaped curve in essence, and most people are in the middle at somewhere around seven and a half to eight hours. It takes about that much sleep in order to feel rested, relaxed and stay awake all day. Now on each end of the bell curve, there are people out there. Some people are what we call "long sleepers," and they require as much as

Dr. Reite (O/C):
maybe ten hours of sleep to feel rested and awake during the day. And then there's the other side, the "short sleepers" that really get along on four or five hours a night seemingly most of their life without any seemingly adverse effects.

VICKI SIMULATING SLEEP
SLEEP #1: 11:31-11:51

(20 SEC)

George Page (V/O):
The sleep experienced during the first third of the night, is believed to be restorative, replenishing the resources expended during wakeful activities. It is during the last third of the night, that a majority of our dream sleep occurs.

CSU SLEEP LAB
ELECTRODES APPLIED
TO VICKI,
CONTROL ROOM WITH EEG,
CLOSED CIRCUIT TV
TAPE 5
3:55-3:45
(20 SEC)

George Page (V/O):
Before the 1960's, the study of sleep was largely anecdotal. Then, investigators armed with tools like the electroencephalograph, recorded brain waves and other physiological measures. This clarified the nature of both normal and abnormal sleep. As knowledge of

George Page (V/O):
sleep has progressed,
a number of
sleep laboratories,
like this one at
Colorado State University
were developed.

COLORADO STATE UNIVERSITY
SLEEP LAB/PUTTING ON ELECTRODES
TAPE 4:(TIME CODE REVERSED)
4:05-4:00
1:30-1:15
1:00-53

TAPE 5: 18:48-34
17:53-48

George Page (V/O):
Both normal and
abnormal sleep are
defined by brain wave
and other physiological
signals. These are
recorded
through electrodes

George Page (V/O):
and sensors attached
to the subject.
Brain wave activity,
eye movements, respiration,
and body movements are
registered.
These signals from
the brain and body help
to define normal
sleep stages and to
diagnose sleep disorders.

VICKI BEING MONITORED
IN SLEEP LAB
TAPE 5: 17:40-17:28

George Page (V/O):
As wakefulness gives
way to sleep, we
go through
stages of
increasingly deep
sleep.
Changes in
the brain's
electrical activity
signal these
stages.

VICKI EYES CLOSED WITH STAGE 1 EEG PATTERN SUPERIMPOSED
TAPE 5: 16:10-15:25

George Page (V/O):
Stage One is the lightest stage of sleep. It can be thought of as a transition from drowsines: to deeper stages of sleep. The electrical activity of the brain is irregular or desynchronized, similar to when we are

George Page (V/O):
awake, but with a strong component of activity in the range of two to seven brain waves per second. It is easy to awaken a person during this stage, but if left undisturbed, the person will enter into deeper stages. Muscle tone decreases, the heart rate slows, and breathing becomes deeper and more regular.

VICKI EYES CLOSED WITH STAGE 2 EEG PATTERN SUPERIMPOSED
TAPE 5: 14:15-13:55
9:00-8:40 (CONTINUED)

George Page (V/O):
During Stage 2, brief bursts of electrical activity, that look like spindles of yarn, appear against the background of desynchronized activity. These are called sleep spindles. The appearance of wave patterns called K-

George Page (V/O):
complexes is also an indicator that the sleeper is in Stage 2. People who have difficulty maintaining sleep often have trouble moving through this stage. Recovering alcoholics and barbiturate abusers often have poorly defined Stage 2 sleep.

VICKI EYES CLOSED WITH STAGE 3 EEG PATTERN SUPERIMPOSED

TAPE 5: 8:40-8:05

HIGHLIGHT SPINDLES AND K-COMPLEX
TAPE 5: 7:00-6:40

George Page (V/O):
At the beginning of Stage 3, slow, large amplitude waves or delta waves, begin to be interspersed with the sleep spindles and K-complexes. Stage 3 occurs when at least 20 percent, but not more than 50 percent, of the record consists of delta waves. When delta waves account for more than 50 percent, the sleeper has entered Stage Four.

VICKI EYES CLOSED WITH STAGE 4 EEG PATTERN SUPERIMPOSED

George Page (V/O):
Stage Four is called deep sleep, and Stages Three and Four combined are called slow-wave sleep. In Stage Four, muscles are very relaxed, and it is difficult to awaken

George Page (V/O):
the sleeper. If awakened, the person comes into awareness slowly. It is normal to spend about 15 percent of the total night in Stage Four. If we do not get this amount, we will make it up on subsequent nights. Slow-wave sleep appears to be restorative. Interestingly, sleep walking, sleep talking, and night terrors all begin during slow-wave sleep and not during dream sleep, as one might expect.

VICKI EYES CLOSED/EEG; ON-SCREEN TRANSITION BACK TO STAGE 1 THROUGH STAGES 3 AND 2

George Page (V/O):
After an hour or so of uninterrupted sleep, one will begin to drift back from Stage Four into Stage Three and Stage Two.

VICKI EYES CLOSED/REM OVERLAY

George Page (V/O):
As the EEG pattern shifts back into what seems like Stage One, a new phenomenon occurs. The eyes begin to move as if following a scene. The onset of rapid eye movements, or REM's, signals the beginning of a new phase consisting of vivid

PICTURES FLASHED ON VICKI'S FOREHEAD

George Page (V/O):
dreaming. This is called REM or dream sleep. Fleeting, dream-like experiences can occur during non-REM sleep, but it is during REM that dreams seem real and are more readily remembered. Each night, adults spend about 25 percent of the night in REM sleep. Young infants will spend as much as 50% of their total sleep in REM.

SLEEP PATTERN GRAPH

For the most part, sleep is a series of repeating cycles, more like a rollercoaster ride than a steady unbroken journey. Stages of non-REM sleep, are followed by REM sleep, then back through the non-REM stages again.

This cycle is repeated about every 90 minutes.

George Page (V/O):
If the course of sleep stages through the night are traced on a graph, the cyclic pattern emerges.

As the night progresses, the duration of non-REM sleep decreases, and the length of REM periods increase.

George Page (V/O):
Fully half of the night's REM occurs during the last third of sleep, and the longest REM cycles may last from 30 to 50 minutes.

TAPE 5: 8:55-8:40
SLEEP LAB

George Page (V/O):
Still it appears that successive REM episodes must be separated by at least 30 minutes of non-REM sleep. Most people experience normal patterns of sleep. However, sleep disorders can constitute a real torture for some.

DR. MARTIN REITE
UNIVERSITY OF COLORADO

Dr. Reite (O/C):
There are a variety of disorders we now know that interrupt or prevent or interfere with sleep. We generally categorize sleep disorders in three broad categories. First of all, we may have somebody come in and say, "Doctor, I can't sleep." Now this categorizes the broad insomnia group, disorders of initiating or maintaining sleep. Now there's a flip side to that, there will be patients that come in and say, "I sleep too much. I

Dr. Reite (O/C):
fall asleep all day
long,"
and these are the
excessive daytime sleep
problems. And this
is a separate group
of problems from the
insomnias. And
there's a third
category of sleep
disorders, a major
category, strange
things that happen
during the night.
And these things are
usually complained about
by either the bed
partner or
by the parent in the
case of children
because these are the
parasomnias, the events
around sleep, and
they happen while a
person is asleep, but
they don't remember it
because they are asleep
when they happen.

VICKI IN HOUSE: SIMULATES
WAKING, GETTING OUT OF BED,
STRETCHING, APPEARING ALERT
AND RESTED

SLEEP #1: 8:00-8:15
13:45-13:57

George Page (V/O):
Researchers continue
to probe the mysteries
of normal sleep and
sleep disorders in an
attempt to understand
the brain's role in
these phenomena and
why it is that all
creatures must sleep.
Nevertheless, most of
us are
fortunate enough to
succumb to sleep
casually, go through
the normal sleep
stages, and wake up
feeling refreshed
and ready to take on
normal daily challenges.

Brain II - 2nd Edition

REM SLEEP AND DREAMING: MODULE 15

EXT. RICHARD HUTTON'S HOUSE
Chappaqua, NY

FRONT DOOR OPENS

INT. LIVING ROOM

INT. HOUSE

INT. BEDROOM
MEG PRASKAC SLEEPING

MEG PRASKAC SLEEPING

B\W PRINT-"Femme Endormie, Sanguin"
Toulouse Lautrec
Museum Boymans, Netherlands

COLOR-"Nightmare"
Fuseli
Goethe Museum, Germany

George Page (V\O):
Imagine you are studying life on earth, the biology of its populations. You have found that the earth is a dangerous place. Biologically and socially, the law of the jungle applies, and animals obey it nearly all the time, and yet there is one extraordinary exception. All animals close their eyes to sleep. And nearly all mammals enter a stage within sleep where they become vulnerable. Their brains remain active, but the messages to the muscles are damped, the reception of information from the senses nearly cut off. To give up all defenses in such a world seems like a supreme sacrifice.
So there must be a trade-off. The risks must be exceeded by the benefits. And so, with no preconceptions, you begin to examine that strange, altered state of consciousness, dreaming.

Dr. Hobson (V\O):
The strangeness of dreams has attracted the interest of people one might call "interpreter-prophets"...What's new today is that the physiological basis of the brain as a symbol generator has suddenly become concrete.

INT. DR. HOBSON'S OFFICE
Harvard Medical School
Boston, MA
DR. HOBSON
VIDIFONT 1
Dr. J. Allan Hobson
Harvard Medical School

Dr. Hobson (O\C):
Sleep and dreams are more than reactions to physical stress or psychological stress, they are inherent brain processes which must include the notion that the brain is doing something for its own benefit.

INT. DR. HOBSON'S SLEEP LAB
Harvard Medical School

George Page (V\O):
For the brain's own benefit. This means that Freudian interpretations of dreams aren't necessarily wrong, but incomplete. Dreaming must also exist for physical reasons.

CU DR. HOBSON

EEG'S BEING RECORDED

KERRY HERMAN FITTED WITH ELECTRODES ON SCALP

Nurse (V\O):
There's an intercom right next to your bed, and just talk into it, and I'll be able to hear you. Actually, you don't have to get up and move, I can hear you no matter where you are lying.

CU KERRY HERMAN

Dr. Hobson (V\O):
The difference between waking and dreaming is that the images are mainly in response to the outside world during the wake state. Whereas in dreaming, they seem to arise within the brain itself.

M\S NURSE\KERRY HERMAN

Nurse (O\C):
Okay, you want to just lie back and I'll hook you in?

George Page (V\O):
But nobody had discovered that sleeping and dreaming were states of consciousness until 1952, when researchers decided to stay up all night and watch.

CU KERRY HERMAN SLEEPING

DR. HOBSON'S SLEEP LAB CONTINUED
CU KERRY HERMAN

George Page (V\O):
They discovered an astonishing rhythm. Every 90 minutes or so a sleeper enters a period of rapid eye movement, or REM, sleep. The REM state is associated with the most vivid, most bizarre, best-remembered dreams.

EEG'S BEING RECORDED

VIDEO MONITOR
VIDEO MONITOR SHOWING
KERRY HERMAN SLEEPING

Today, the link between REM sleep and dreaming has taken scientists back, to where they think they can first see REM, the womb.

INT. RUSH PRESBYTERIAN ST.
LUKE'S MEDICAL CENTER
Chicago, ILL
VIDEO MONITOR-FETUS IN WOMB

Dr. Birnholz (V\O):
With fetuses you sort of have to take advantage with what you can see when you can see it, 'cause they move a lot.

MS DR. BIRNHOLZ\MONITOR

Dr. Birnholz (O\C):
I've got my bearings: the head is this big oval, right down here, and in fact you see all these little squiggly markings?

CU PATIENT MARY

Mary (O\C):
Uh huh.

MONITOR

Dr. Birnholz (V\O):
Inside, like cauliflower? Brain markings...the more squiggly the better.

INT. RUSH PRESBYTERIAN ST. LUKE'S MEDICAL CENTER

DR. BIRNHOLZ\PATIENT\MONITOR

MONITOR

MS DR. BIRNHOLZ\MONITOR
MS PATIENT\DR. BIRNHOLZ

DR. BIRNHOLZ PERFORMING ULTRASOUND EXAM

CU MARY

DR. BIRNHOLZ POINTS OUT FEATURES ON MONITOR

INT. RUSH PRESBYTERIAN ST. LUKE'S MEDICAL CENTER

George Page (V\O):
Dr. Jason Birnholz helped design the newest generation of ultrasound machines. They allow him to examine the fetus in extraordinary detail. For brain research, the technology can help determine when a fetus first develops the movements essential for life: breathing, sucking, hand coordination, eye movement.

Dr. Birnholz (V\O):
So far, the little lady looks very good.

Mary (O\C):
It's great to see them looking out at you. There's the mouth and the nose...

Dr. Birnholz (O\C):
Hmmm, looks like your nose.

Mary (O\C):
Yeah.

Dr. Birnholz (O\C):
Like Mum's nose.

Dr. Birnholz (O\C):
Hmmm...That bright white circle, that's the bright white circle of the eye itself. Actually, it's the lens of the eye, and what we look for is to see if there are rapid eye movements,

MACHINE GOING OVER MARY'S STOMACH

MONITOR SHOWING FETUS' EYES MOVING

CU MONITOR SHOWING FETAL EYE MOVEMENTS

CU MARY IN BED

REM ON MONITOR

ALLISON ANIMATION
Crystal Brain

Dr. Birnholz (V\O):
and they'll occur in little flurries.

Dr. Birnholz (O\C):
In fact, you notice every once in a while that there are these very short but very jerky fast movements that occur.

George Page (V\O):
Evidence that a fetus has rapid eye movement does not necessarily mean that its REM performs the same functions as REM sleep in adults. But the similarities between the two types of rapid eye movements are startling.

George Page (V\O):
Even if REM in fetuses and adults is similar, differences must exist. Our dreams emerge from life experiences so we can't know what--or even if--the unborn child dreams. But the fact that there is a physical side of the dream state does allow us to wonder how awareness and the brain coexist.

George Page (V\O):
The idea that states of awareness might be directly related to the physical properties of the brain changed the way scientists looked at those states.
During the past few decades, we have learned

Head Model

that sleep and dreams are related to chemical changes in the brain, that they operate rhythmically, that they involve specific areas of anatomy. The switch that turns on dreams, for instance, is now known to be located at the base of the brain, just above the spinal cord. Allan Hobson and his colleague Robert McCarley took information like this and devised a theory as to how dreams work. Here, from the pons, giant neurons send signals to parts of the brain involved in vision and movement. These areas respond as if we were actually seeing or moving. The dreaming brain has to account for these responses so the frontal cortex acts as a storyteller, trying to make sense of them. Meanwhile, the switch in the pons keeps the body from reacting to the brain's commands.

INT. DR. HOBSON'S SLEEP LAB
Harvard Medical School
Boston, MA

MS DR. HOBSON\3 MONITORS

Dr. Hobson (O\C):
Cells that are part of the same switch, when turned on, actually fool the brain into thinking that information is coming in from the outside world, whereas in fact it's being generated within the brain itself. And those centers are the centers that control the eye movements.

EEG'S MAPPED OUT
CU KERRY HERMAN

MONITOR KERRY SLEEPING

EEG'S

VIDEO MONITORS

CU KERRY HERMAN

INT. DR. HOBSON'S OFFICE
Harvard Medical School
Boston, MA
CU DR. HOBSON

B\W PRINT "Nightmare"
Farcy

B\W PRINT "A Promenade in the Sky"
Grandville
New York Metropolitan Museum

Dr. Hobson (V\O):
You really need to make a distinction between the function of dreaming as a psychological phenomenon and the function of REM sleep as a physiological phenomenon. I think ultimately they'll be seen as the same, or at least strongly parallel. But it's really impossible for us now to know whether dreams have some psychological function that is in some way different from the physiological functions that we're describing. I think not. Dreaming, after all, is a primarily sensory experience. And it's at this level,

Dr. Hobson (O\C):
I think that today we could begin at least to make some tentative correlations between brain activity and dream activity.

Dr. Hobson (V\O):
Now the fact that dreams have both bizarre features and striking coherence is really a credit, to the wonder of the brain\mind, and its capability to make sense out of an essentially nonsensical situation.

INT. DR. HOBSON'S OFFICE
CU DR. HOBSON

Dr. Hobson (O\C):
And so, what we're seeing, I think, during dreaming sleep, is the creative activity of the brain. And that really means, I think, to us that all people have an innate creative capability.

B\W PRINT "Nightmare"
Fuseli
Goethe Museum, Germany

B\W PRINT "Nightmare"
Farcy

George Page (V\O):
The link between dreams, awareness, creativity and the brain. All part of the enormous uncharted territory that brain science still has to map. And yet the questions themselves are rich and fascinating.

B\W PORTRAIT OF AUGUST KEKULE
Library of Medicine

Vienna, Austria. 1865. The chemist, August Kekule, was faced with a scientific problem--determining the structure of the compound benzene. Kekule knew that benzene contained six carbon atoms, but how were they arranged? For years he worked on the problem.

ALLISON ANIMATION
Snakes forming circle

George Page (V\O):
But one night, he dreamed of snakes, six of them. They writhed and twirled through his fantasy. Then each snake bit the tail of the snake ahead of him--and they formed a circle.

CARBON CHAIN

When Kekule awoke, he had the answer. The carbons, like the snakes, were joined, one to another. Benzene was shaped like a ring.

Module 16: The Locus of Learning and Memory

INT. DR. NEAL COHEN'S OFFICE
Beckman Institute
University of Illinois

Dr. Cohen (O/C):
I think one of the great challenges in memory research and in brain science more generally is to understand which regions of the brain are involved in or participate in the storage of memory. This is not a new issue. There's a long history of research on this topic. Perhaps the most famous episode in this history comes from the studies of Karl Lashley. He tried to determine which brain regions were involved by removing different portions of the brain hoping to find out just where in the brain memory was stored or where in the brain the lasting traces of experience which he called the "engram" were located.

PHOTOGRAPH OF KARL LASHLEY

RAT IN MAZE

George Page (V\O):
Karl Lashley's experiments in the 1920's were performed on laboratory rats. First, the rats were trained to remember the route through a tricky maze into a courtyard where a

bowl of food awaited them. Then, Lashley surgically removed a section of their brains, and retested them through the maze.

DR. COHEN IN OFFICE

Dr. Cohen (O/C):
He found that performance on the maze deteriorated as a function of how much brain damage was produced. If he removed a large portion of the cortex, then the animal is likely to have forgotten how to get through the maze. If he removed smaller portions of cortex; however, the animal was likely to be affected not at all. The animal did just fine, and it didn't matter which portion of cortex he removed, the animal's performance seemed unharmed. This led Lashley to conclude that there was no localization of memory storage in the brain, that there was no critical spot that when damaged produced loss of memory. Indeed, it led Lashley to wonder how it was even possible for the brain to support

RAT IN MAZE

learning and memory. This is the challenge that has been taken up by current researchers ever since.

PHOTOGRAPH OF DR. WILDER PENFIELD

George Page (V/O):
Another pioneer investigator in the science of memory was Dr. Wilder

CBC FOOTAGE 1961
"Explorations"

Penfield. As a practicing neurosurgeon, Dr. Penfield developed several new surgical procedures. He was also fascinated with the way the brain stored memories. Some of his operations called for him to stimulate the brain's surface; and sometimes, he seemed to elicit memories. His findings, at odds with Lashley's, indicated to him that memories were stored in one spot in the temporal lobe. He shared his hypothesis with one of his patients in 1949.

PHOTOGRAPH OF DR. WILDER PENFIELD
AND PATIENTS
Montreal Neurological Institute, CAN

CBC STOCK FOOTAGE 1961
"Explorations"
CU DORIS FOX

Doris Fox (O/C):
How are you Dr.?

CU DR. PENFIELD

Dr. Penfield (O/C):
Because eleven years ago, you were

VIDIFONT 7 Dr. Wilder Penfield and Doris Fox	Dr. Penfield (O/C): here and you had, as a little girl, around seven, an illness that left it's mark and so you began to have attacks which began, I remember your telling me,
CU DORIS FOX	Dr. Penfield (V/O): with a feeling of fear.
	Doris Fox (O/C): That's right.
CU DR. PENFIELD	Dr. Penfield (O/C): You remember, we studied you with the x-rays,
CU DORIS FOX	Dr. Penfield (V/O): with electrograms, saw the pattern of your attack, and there was only one place it
CU DORIS FOX	Dr. Penfield (V/O): could be and that's right here in your right temporal region. And so, we opened it up there,
CU DR. PENFIELD	Dr. Penfield (O/C): didn't we?
	Doris Fox (V/O): Yes.
	Dr. Penfield (O/C): under local anesthesia, you remember the pain?
CU DORIS FOX	Doris Fox (O/C): There was no pain.

CU DR. PENFIELD

Dr. Penfield (O/C):
Well, that's good. It's nice of you to say so, anyway.

Doris Fox (V/O):
Well, there wasn't.

DR. COHEN

Dr. Cohen (O/C):
Penfield, like many current neurosurgeons, did not remove any portion of the cortex without first electrically stimulating the portion of the brain where he was going to operate. The idea is that the electrical stimulation temporarily disrupts the normal workings of that portion of the brain permitting him to get an idea in advance of the surgery of what sort of disruption he is likely to confront.

CBC FOOTAGE 1961
"Explorations"

Dr. Penfield (O/C):
This is the brain. Now when we stimulate it at three, you had a tingling in your thumb.

CU DORIS FOX

Dr. Penfield (V/O):
You've probably forgotten now.

Doris Fox (O/C):
Not very clear.

OPERATION

Dr. Penfield (V/O):
Then, underneath this, we stimulated, and to my astonishment, you said, "I hear music." Then I repeated it without warning you,

CU DR. PENFIELD

Dr. Penfield (O/C):
a little while later and you said, "I hear that music again." Tell us what

CU DORIS FOX

Dr. Penfield (V/O):
you heard.

Doris Fox (O/C):
Well, I heard what sounded like an orchestra playing and I asked the nurse where it was

CU DR. PENFIELD

Doris Fox (V/O):
coming from and she asked me the name of it.

CU DORIS FOX

Doris Fox (O/C):
But I...I said, "I know the song, but I can't think of the

CU DR. PENFIELD

Doris Fox (V/O):
name of it."

Dr. Penfield (O/C):
Will you hum it now? Do you remember it?

Doris Fox (V/O):
Yes.

Dr. Penfield (O/C):
Go ahead.

CU DORIS FOX

Doris Fox (O/C):
La da da da da ...

CU DR. PENFIELD

Dr. Penfield (O/C):
Yes, and then when you got to that point,

CU DORIS FOX

Dr. Penfield (V/O):
the nurse...

DR. COHEN IN OFFICE

Dr. Cohen (O/C):
Penfield obtained these results only from the temporal lobes and so he concluded that memory was stored in the temporal lobe. But the problem with this is that he never actually verified that the incidents reported by the patients ever actually occurred or that they occurred as reported by the patients.

CBC FOOTAGE 1961
"Explorations"

George Page (V/O):
Penfield's work was certainly important, but it's now believed his conclusions were wrong. Memories are not stored in one exclusive region of the brain, but in many. Most of Karl Lashley's theories were wrong too, but at least one of his ideas still makes sense.

INT. DR. COHEN'S OFFICE

Dr. Cohen (O/C):
The storage of memories in the brain, just as Lashley concluded, cannot be localized so discretely. There is no special place in the brain that acts as the storehouse for memories. There are, it turns out, portions of the brain that are critical for memory, places such as the hippocampal system. But on current accounts, memory storage seems to be distributed across the cortex wherever the processing of information occurs, so that different aspects or elements of an event are stored in a distributed fashion across the different regions of the cortex responsible for those different aspects of processing.

ALLISON ANIMATION
Neural Net

George Page (V/O):
If we could look inside the brain, we'd find that memories are stored biologically. They're wired into the brain's basic circuitry; it's nerve cells.

George Page (V/O):
A smile, an urge,
a whisper, in all
of these, an electric
current in a neuron
stimulates the
release of chemicals
across that crucial
gap, the synapse.
These chemicals either
excite or inhibit
another neuron.
This process is the
key to learning and memory

Mod.17

Learning as Synaptic Change

FRENCH FOOTAGE CHILDREN SINGING

George Page (V/O):
The hippocampus probably serves learning as much as it does memory. It is, for instance, the brain region from which the classroom lesson is dispatched and possibly, retrieved. But what happens to that lesson after it's been passed on by the hippocampus? What happens to the nerve cells that "store" it?

FRENCH FOOTAGE-INSTITUT PASTEUR
Paris, France
CHANGEUX AND ASSISTANT

George Page (V/O):
In Changeux's lab in Paris, he and his team have been observing the process of learning in the growing brains of rats. Their experiments have shown that while learning encourages the creation of some neuronal connections, learning also involves the paring down, or elimination, of other connections. And so, pathways between cells become more effective in transmitting messages.

FRENCH FOOTAGE CONTINUED
Dr. Jean-Pierre Changeux

Dr. Changeux (O/C):
In the adult there is only one synapse from the fiber. In the newborn, there are about three to four.

RATS

George Page (V/O):
In baby rats, at least, excess synapses those gaps between nerve cells--are often discarded as learning advances. And an assembly of brain cells seems to rid itself of detours so that newly learned memories can be stored and retrieved efficiently.

INSTITUT PASTEUR LAB ASSISTANT

Dr. Changeux (V/O):
The elimination of some synapses would create order.

DR. CHANGEUX

Dr. Changeux (O/C):
That's the idea that learning, reading associated with the stabilization of some synapses and the elimination of other ones, learning would be...to eliminate an excess.

DR. HEBB'S YARD
Chester, Nova Scotia
DR. HEBB

George Page (V/O):
Learning, therefore, involves in part the streamlining of connections between nerve cells. Now what about the myth which claims that after the age of 25, the human brain loses 1000 brain cells a day? Donald Hebb is skeptical.

DR. HEBB

Dr. Hebb (O/C):
In spite of the loss of brain cells, the steady loss from the age of 25 or so onward, gives a strange picture. What it gives you is a picture of someone who is getting smarter and

Dr. Hebb (O/C):
smarter, more and more efficient as he or she gets older, and yet is losing brain cells at the same time? What seems to be going on is that with age, there are some cells lost. On the other hand, the ...individual is making better use of what he has.

BBC HUMAN BRAIN FOOTAGE
From: Memory
DR. LYNCH'S OFFICE
UCLA-IRVINE

DR. LYNCH

Dr. Lynch (O/C):
As you're sitting there at this table with me now, indeed you are sending electrical patterns down certain pathways and those electrical patterns are producing a structural change in your brain right now? Are you indeed physically rearranging your circuitries?

FRENCH FOOTAGE
CLASSROOM

CHILD AT DESK

George Page (V/O):
Dr. Gary Lynch, like others, believes that all learning--from the comprehension of a new word to the conceptualizatior of an idea, should leave a biological trail through the brain. It makes good sense to believe that the adding and subtracting of neuronal connections is what reinforces pathways and helps make lessons truly learned. But can such a process be observed under a microscope?

LITTLE BOY WITH GLASSES

BBC HUMAN BRAIN FOOTAGE
From: Memory

DR. LYNCH

Dr. Lynch (O/C):
What we're saying here is that an event which lasts half a second within five to ten minutes has produced a structural change in some ways as profound as the changes one sees after damage. So now we have a new ballgame.

DR. LYNCH'S LAB
RAT BRAIN CELLS

George Page (V/O):
For Gary Lynch, the "new ball game" was an experiment in which sections of rat brains were monitored before and after electrical stimulation. the jolt of electricity administered by his team of researchers is similar to what our brain cells experience with each new idea, word, lesson or thought. Would the electrical charge actually change the neurons themselves? Detailed electron micrographs allowed Lynch's team to see cells before and after the stimulation. If there was going to be any change at all, it was bound to occur here along the dark line, the synapse. Jean-Pierre Changeux had discovered that some synapses are eliminated. Would Gary Lynch find that others are created?

TWO ASSISTANTS

ELECTRON MICROGRAPHS

DR. LYNCH'S OFFICE
DR. LYNCH

Dr. Lynch (O/C):
For the first eight, nine, ten months, of this project, we found nothing. Every variable we looked for, every change that we thought was there, upon further examination disappears.

ELECTRON MICROGRAPHS

George Page (V/O):
But in the eleventh month, Gary Lynch and his team suddenly observed dramatic changes in certain cells. They had actually grown new synaptic connections with other cells. Before his eyes was the biological evidence that learning involves a physical change in the circuitry of the brain.

KANDEL INTERVIEW/BIN 661 3:38-3:15
KANDEL ON PHONE

George Page (V/O):
Dr. Eric Kandel at Columbia University has spent most of his professional life working to understand how transmissions between neurons result in learning and memory. His work has contributed greatly to our understanding of the activities of the neuron as it produces and secretes transmitting substances into the synaptic cleft.

EPILEPSY TAPE TV08631/1:11:38-1:11:55

George Page (V/O):
He has identified compounds which trigger activity in other neurons and examined the factors which make connections "plastic" or changeable with experience.

ORIGINAL BRAIN TAPE WITH APLYSIA
25 sec.

George Page[6] (V/O):
Dr. Kandel's research is probably best known for its use of the marine snail, Aplysia. This snail is especially useful for the study of learning at the cellular level because its neural system is relatively simple, and its neurons are large. Most importantly, Aplysia makes observable changes in its behavior as it learns, allowing researchers to look for corresponding changes in individual neurons.

KANDEL INTERVIEW/BIN 660/6:02-7:30
(90 sec)

Dr. Kandel (O/C):
We have now gotten to appreciate the universality of biological processes. So, for example, we have been interested in a mechanism, whereby short term memory is switched to long term memory. And we found that this involves a synthesis of new proteins, the turning on of genes and the growth of new synaptic connections. The specific molecules involved, the cyclic AMP, the dependent signalling pathway, in the cell, the Kreb transcriptional factors in the nucleus, and even some of the proteins

Dr. Kandel (O/C):
involved in the growth of new synaptic connections turn out to be operative in drysophila where people used a completely different approach to tackle the problem. Moreover the early findings that are emerging from the mouse, from Alsino Silva's work and ours, suggests that very similar molecules are operative in the mouse as well. So it gives one more and more confidence of course as we have reason to believe from study of development and the study of the immune processes that biological processes are amazingly conserved. So if you work out the details in any one organism, you are likely to define the steps that are of general importance, and if you work on two or three related organisms, you are very likely to be in a position of delineating the outlines of the mechanism underlying a particular component that you are interested in.

Mod.18

MODULE 18: LIVING WITH AMNESIA: THE HIPPOCAMPUS AND MEMORY

MIKE S. AT HOME
WORKING ON ENGINE

George Page (V/O):
In many ways, memory is what defines the richness of our lives; it provides an anchor between the past, the present, and the future. Without memory, there is only a vague understanding of one's existence and only a foggy notion of one's life.

Memory problems are the most common difficulty reported by people with neurological disorders or brain injuries. These memory failures can involve different parts of the brain, depending on the type of memory problem the person experiences.

This is Mike. He knows about memory loss because he has a condition called amnesia.

ANATOMICAL DIAGRAM OF HIPPOCAMPUS
(MUSIC)

George Page (V/O):
A unique role in human memory is played by the hippocampus, a structure in the temporal lobe that overlies the brain stem. When the hippocampus alone is damaged, as in the case of Mike, memories of experiences before the injury are fairly

HIPPOCAMPUS LIGHTS UP

(MUSIC)

MIKE WORKING ON ENGINE

George Page (V/O):
well retained. But there is an almost complete inability to add memories of personal experiences or events in the world outside since the injury. Meanwhile, other cognitive skills remain relatively intact.

DR. THOMAS BENNETT

Dr. Bennett (O/C):
I have known Mike for almost 12 years. When I first met him, it was about two years after his memory problem began. At that time, he was suffering from a great deal of depression because his memory problems were interfering with his ability to work and to lead a normal life. His problems began when he was a junior in high school. At that time, he had been president of his class, an A-B student, and very active in sports. He was involved in a car accident. He did not suffer a brain injury, but he did suffer a fracture to his back.

About four months later, because of medical complications related to the back

Dr. Bennett (O/C):
injury, he suffered an episode of status epilepticus. This was a period of uncontrolled epilepsy that lasted for 24 hours. This episode caused the damage to his hippocampus, and from that point on his memory problems were present.

MIKE S./KITCHEN

George Page (V/O):
Mike went on to recover physically, although he still has some occasional partial seizures, and with rehabilitation, his cognitive abilities returned to normal, except for his memory. Mike has extremely poor recall for his life's experiences since 1983.

MIKE KITCHEN

George Page (V/O):
Mike's memory difficulties are interesting because he has trouble remembering things people tell him and experiences he has had, but when it comes to working with his hands he seems to have no difficulty.

C/U MIKE

MIKE

Mike S. (O/C):
I think the difference is is hands-on. The more I touch it, the more it's imprinted upon the brain. Word of mouth, it just seems like it just blows on by. You've really got to grab it and touch it.

MIKE WITH FISHING REEL

(silence)

MIKE WITH REEL

Mike S. (O/C):
To live independently, I do everything in a 123456 step. I get up in the morning, I take my phenobarb and my Prozac. I go take a shower, you know, I feed the cat. It's in a 123 and at 2:00 I go to work. At 10:00 you know I'm doing vending machines. I do it in a sequence that is consistent every single day, seven days a week as much as I possibly can. When you throw something in there, like an 11 into the 123, 11, 456, I start losing track of things.

MIKE C/U

Mike S. (O/C):
Even though my memory has gotten a little bit better, when I sit there and trust my memory, one time, it will let me down. It'll leave me standing cold. There might be times

MIKE C/U

Mike (O/C):
I'll go for two or three days and remember quite a bit. And then the one time I trust it, boom, it will drop me like a rock. So I've got to pull it out, even though I think I can't forget it, and I've got to write it down, exactly...not just it was George that stopped by. It was George at 7:00, Tuesday morning, March 26, 1996, and he was talking about fishing and he wanted a ride. It's got to be explicit, detailed. If it's not detailed, it won't mean anything to me.

MIKE'S MOTHER DONNA

Donna (O/C):
Mike's future, I am sure, is going to be pretty good because he is a determined person, and he wants a good life and he's willing to work for it. Even though he has a lot of difficulty, there are things that have to be very structured and we have to write things down for him. If his dad and I weren't here, tomorrow, that is a big worry, because he does look to us for a lot of advice. And he went through a period of time when he knew it all, and didn't want any advice from us, but he has matured a lot, and he does expect us to be

Donna (O/C):
there when he needs us. And that's really important, that if we're not here, one of the blessings with Mike is that he makes a lot of friends, and he has a lot of really good friends that understand his problem and they work with him all the time. And we feel pretty comfortable that if we were gone, they'd take care of him.

MIKE AT WORK

George Page (V/O):
Mike has been able to assume a normal work life, by acquiring a job that does not require his hippocampal memory system. He does injection molding at a rubber company.

MIKE'S WORK SUPERVISOR
Jon Davidson

Supervisor (O/C):
Well, Michael's been employed here with Artemis for right at a year and he is an injection molding operator. We've taught him the packaging routine; we've taught him how to troubleshoot and diagnose certain equipment...fix problems, know what the material is to do or not to do. He's come a long ways in the last year that he's been here. I have to say this, that he carries a great deal of notepads

Supervisor (O/C):
and paper, with him, pencils. He has to document a lot in order to not forget. He's one of the very few that has a good initiative about him. He wants to learn and he tries to figure the problem out before he asks. He's a very good worker, probably one of the best workers that I have.

ANATOMICAL DIAGRAM OF HIPPOCAMPUS

(MUSIC)

George Page (V/O):
Researchers have been interested in determining how the hippocampus is involved in the storage of new memories. It now appears that the memories are not stored in the hippocampus. Instead, the hippocampus, in collaboration with other structures, consolidates memories in areas of the cortex that participate in the formation of experiences.

DR. BENNETT'S LAB
DR. BENNETT AND ANDY BANE

George Page (V/O):
One possibility is being researched by Dr. Bennett and his colleagues at Colorado State University. It is that an electrical phenomenon in the hippocampus, called long-term potentiation, or LTP, reflects the

NEURAL NETWORK

(MUSIC)

George Page (V/O):
hippocampus' role in memory consolidation. LTP was first discovered following brief, high frequency electrical stimulation to a pathway leading into the hippocampus. It was discovered that such stimulation produced a long-lasting facilitation of synaptic transmission in the affected cells. A similar phenomenon has been discovered in the cerebral cortex. This finding may provide verification of a theory proposed by Donald Hebb in 1949, that such changes in synaptic excitability during learning are responsible for memory. Many researchers now believe that LTP holds the secret for how memories are stored in the brain.

LAB/RAT PLACED IN MAZE

Their studies have involved rats. It is important for rats to remember is the spatial location of food or shelter. This ability seems to depend on the hippocampus. Rats are natural swimmers, and they can perform tasks that require swimming without difficulty.

WATER MAZE

George Page (V/O):
The animals are placed in the Morris Water Maze, a circular tub containing a sitting platform. This apparatus provides an ideal environment for testing memory. Since the water is opaque, the rat cannot see the platform. Animals are placed into the water from various starting points, to test their ability to remember the location of the platform.

COMPUTER WITH ANDY BANE

A computer displays and records the animal's path, the location of the platform and the time it takes the rat to find it.

COMPUTER GRAPHIC OF RAT'S PATH

Rats, treated with the drug dextromethorphan, which blocks the development of LTP in the hippocampus, never remember the location of the submerged platform. They seem to swim aimlessly around the tub until they are removed.

MIKE S. PHONE

George Page (V/O):
We are now beginning to understand how memories are stored in the brain, but this understanding is still primitive. The human memory system probably has a limitless capacity. Information that is years old can be retrieved quickly and efficiently. Our hopes and plans for the future are based on our memories of yesterday and today. It is difficult to imagine what life would be like without memory.

MODULE 19: ALZHEIMER'S DISEASE

ELEANOR ESTOK DIRECTING CHOIR

George Page (V/O):
When this film was made, Eleanor, at age 51, was in the early stages of Alzheimer's disease, a terminal illness with no known cure.

Eleanor (V/O):
I'm forgetful. I, I say something and I can say it right after that and not know that I've said it. And that's not too comfortable a feeling.

ELEANOR DIRECTING CHOIR

George Page (V/O):
Both for her own sake and to help others study Alzheimer's, she joined a research program at Johns Hopkins University in Baltimore. There she was studied by Dr. Barry Gordon until her death.

ELEANOR SITTING

Eleanor (O/C):
I didn't really know what Alzheimer's was. I know better now because I've been reading a lot of things about it. But uh, it's kind of scary.

ELEANOR

George Page (V/O):
Alzheimer's ultimately is defined as a global deterioration of an individual's personality and mind. The symptoms typically develop late in life and they represent

BRAIN MODEL

George Page (V/O):
a significant change from the person's prior, well-established abilities.

BRAIN MODEL

George Page (V/O):
Near the center of the brain is a tiny cluster of cells called the nucleus basalis. It's the headquarters for neurons that run throughout the cortex. Those neurons carry a chemical transmitter, acetylcholine, that causes other neurons to fire. In Alzheimer's, the nucleus basalis seems to deteriorate. An entire system of cells begins to develop plaques and tangles that interfere with chemical transmission. Then, the cells begin to die. When the nucleus basalis and its connections disappear, the cortex literally becomes starved for excitation, and its cells in turn begin to die.

NEURAL NET

DR. BARRY GORDON, M.D.
Johns Hopkins University

Dr. Gordon (O/C):
Something is going wrong where the nerve cells are gradually dying and their processes are dying. We know that that takes place in many regions throughout the brain, but there are some regions in particular that seem to

Dr. Gordon (O/C):
bear the brunt of it and cause a lot of the problems that patients with Alzheimer's have. Damage that occurs on the inner part of the temporal lobes, the hippocampus and other structures seems to contribute to the memory problem that patients with Alzheimer's have and that they typically start out having. Damage in the parietal and temporal regions, on both sides, on the left, seems to be associated with the language problems that patients with Alzheimer's have...on the right is more associated with the problems they have with vision and space, where they may lose themselves in space or not recognize familiar things or people. The dysfunction and damage occurring in the frontal lobes seems to be associated with the poor judgment and lack of insight that many patients with Alzheimer's have. And there still is the damage in the nucleus basalis and other structures which may be contributing to all those other kinds of problems because it's depriving the cortex of acetylcholine which is kind of an activator for the brain.

PET SCAN

George Page (V/O):
Frontal lobe involvement in Alzheimer's disease can be demonstrated using the PET scan.

NORMAL PET SCAN

George Page (V/O):
This PET scan shows the activity of the frontal lobes in a normal brain, at the top of the picture.

ALZHEIMER'S PET SCAN

This scan of the brain of an Alzheimer's patient, whose condition is well-advanced, shows the frontal lobes almost completely shut down.

JESSE SALB'S BRAIN MAPPINGS

George Page (V/O):
We can actually see what happens to awareness in inventor Jesse Salb's slow-motion maps of functioning brains. A normal brain on the right, an Alzheimer's patient on the left...both maps will show electrical activity as the brain responds to a sound. This peak of activity and this one are sensory responses, the brain actually hearing the sound. This peak, visible only in the normal brain, marks the point of realization, when the person becomes aware of the sound. The damaged brain of the Alzheimer's patient shows no response at all.

ELEANOR

George Page (V/O):
At this stage of her disease, Eleanor began to have problems with recalling even personal information.

Eleanor (O/C):
My family? I have three sons...two sons? Paul and John, two sons.

ELEANOR'S HUSBAND

Art Estok (O/C):
She'll sit down at the piano, in fact many a time I come in during the day, and she's sitting down at the piano playing and she has no problem reading, reading music.

ELEANOR PLAYING PIANO

Art Estok (V/O):
uh, then she can take the same newspaper, however, and read it three times and mention the same article to me three, on three different occasions.

DR. BARRY GORDON
JOHNS HOPKINS UNIVERSITY

Dr. Gordon (O/C):
I'm speaking now almost 12 years after Eleanor was last filmed for the segment that you saw. She lived another five years. Her course was marked by progressive deterioration. She went from being able to speak and making some contact with people to the point where she was babbling and not able to understand and unable to be understood. She however retained a lot

Dr. Gordon (O/C):
of her social skills and could still be taken frequently by her husband and just brought to the dinner table and so forth. However her course was also marred, as is typical with Alzheimer's patients, by hallucinations. She'd begin speaking to the chair, and seemingly responding to things that nobody could see were there. She, upon her passing, she and her family had willed that her brain be examined for research. And at autopsy her brain did show the typical signs of Alzheimer's disease.

ELEANOR DOING BLOCK DESIGN PUZZLE

Dr. Gordon (V/O):
And I'd like you to try and make that design.

Dr. Gordon (V/O):
No cure yet exists for Alzheimer's disease; however, research is proceeding along a number of lines to try to treat the disease, and ultimately to try to cure it. One important line of research is to realize that many of the problems that Alzheimer's patients have is are behavioral and might be taken care of or improved by behavioral treatments. There's also

Dr. Gordon (V/O):
now an approved drug for Alzheimer's disease that works by, we think, boosting the level of acetylcholine within the brain.

DR. GORDON

Dr. Gordon (O/C):
It's not a wonder drug; it doesn't improve everybody, and in many cases it only stabilizes the patient for a period of time. But at least it's a start. And on the horizon are other different kinds of drugs that are trying to, for example, stop some of the other breakdowns in nerve cells that we think occur in Alzheimer's disease. There's now new clues to the genetics of Alzheimer's disease. There's also been important clues showing that some blood proteins are related to the chance of getting Alzheimer's disease. What the exact significance of that isn't clear. But what is clear is that it gives us a way of tracking who is more likely to have problems and who in the family is more likely to have problems, as well. So we are hopeful, again, that the increasing pace of

RE-EDIT TRANSITION

Dr. Gordon (O/C):
medical research and of
therapeutic research
will help solve
some of the different
problems that occur in
Alzheimer's patients and
maybe get at some of
the root
problems that
these patients have.

Brain II - 2nd Edition

A SUPER MEMORIST ADVISES ON STUDY STRATEGIES: MODULE 20

WOMAN AT TELEPHONE

CU HANDS ON TELEPHONE

RAJAN MAHADEVAN VIEWING MATRIX

George Page (V\O):
For most of us, a seven digit number is about the limit of our short-term memory. But, for Rajan Mahadevan, processing and encoding a 49 number matrix into memory appears as a simple, routine task.

CU MATRIX

CU DR. FRANK VATTANO
Department of Psychology
Colorado State University

Dr. Vattano (O/C):
Okay, Rajan why don't we just start from left to right and go right down the various rows.

CU RAJAN MAHADEVAN

Rajan Mahadevan (O/C):
(Rajan recites the digits.)

CU MATRIX
CU RAJAN MAHADEVAN

Dr. Vattano (V/O):
Alright, uh...would you be able to repeat those backwards...coming from the bottom up?

CU RAJAN MAHADEVAN

Rajan Mahadevan (V/O):
I'll do the best I can.

CU MATRIX

Dr. Vattano (V/O):
Alright.

Rajan Mahadevan (V/O):
(Rajan recites digits.)
That's the last row...That's the one before that...

CU DR. D. BRETT KING
Department of Psychology
University of Colorado

Dr. King (O/C):
Now, not only is it exceptional that you can remember more than 99,000 of the first digits in "pi," but you also have the ability to jump in just anywhere at random within these digits, say for example, at 61,000, at that 61st thousandth digit, and can

begin in sequence from there. So I'd like to do that. We do have the values from "pi," and I'd like to just, without you able to see this of course, after your years of practice, to just pick out a sequence of approximately ten digits somewhere within the first say 10,000 digits of "pi," and then have you pick up for as far as you care to within a reasonable amount of time. I know you can go for hours, literally. The digit is: 2788659361.

DR. KING, DR. VATTANO, RAJAN MAHADEVAN IN ROOM

CU SHEET WITH DIGITS OF "PI"

DR. KING, DR. VATTANO, RAJAN MAHADEVAN IN ROOM

Rajan Mahadevan (O/C):
(Rajan recites the following digit.) Sorry, I was a little slow on that.

Dr. King (O/C):
No problem.

Rajan Mahadevan (O/C):
(Rajan recites digits.)

CU RAJAN MAHADEVAN

DR. KING, DR. VATTANO, RAJAN MAHADEVAN IN ROOM

Dr. King (O/C):
I think we get the point.

CU DR. VATTANO

Dr. Vattano (O/C):
Let's address the average college student, coming in to a university. They have had some experience with memorizing things, lines, formulas, etc. But here they are now taking four or five courses, they're trying to struggle to read material, to go to class, to memorize, to integrate for examinations to retrieve information. What advice,

knowing what you do about your extraordinary abilities, and what you also know about the literature on memory and information processing. What kinds of advice would you give students to assist them in this every day to day process of memorizing material?

CU RAJAN MAHADEVAN

Rajan Mahadevan (O/C):
Well, the first piece of advice that I would give them is to ask themselves why they are taking a particular course. Many times people take a course because it's the done thing or they have to do it rather than because they want to do it,

"Motivation for Study"

and motivation plays a very important role in learning and memory. For example, I can tell the students this, "Hey, you pick up a book, a 200 or 300 page book, a novel by your favorite author, just read through it once, and just by reading through it once, you will be able to recall a lot of details with amazing clarity even though you had no intention of memorizing it because you were already ready to read it and you were into it.

Now let's take say a page of text from a calculus book. People are going to struggle with that. I mean, motivation plays a very important role. That's the first thing. The second thing I would

"Active Listening"

tell them is active listening rather than passive listening in the classrooms. By active listening, I mean constantly

keep thinking about what the instructor is saying. What is he saying right now? What's the big picture? Why is he saying it? How is this relevant to all that's gone on in the previous class? Such active listening will help them recalling information in the class very efficiently. The third piece of advice that I would give them is, and this takes an incredible amount of motivation too, is that once a class is over, once they have completed an hour of class, ASAP review what went on in the class that very day, and not wait even...

"Immediate Review"

It's amazing how much people can forget even if they wait for a couple of days, and the advantage of reviewing as soon as possible on that very day, is that people are able to see that the connection or the trend that flows from one class to the next, to the next as the instructor has organized it and as students are meant to assimilate all that information. Attend classes very regularly, and I'd say attend each and every class that you can, and some study tips that I can give which I think people will find very useful is context plays a very important role in retrieving information from memory so it's important to learn a certain piece of information in certain important contexts. For example, I'd say if you study at home, choose one particular room where you can study all the time so that subliminal, there won't be any sort of,

"Attend Classes Regularly"

"Pay Attention to Context"

"Distribute Your Study"

subliminal perceptual distractions...if people are used to a room, see? And then what happens is that when they need to recall that material, they got to just mentally go back to the context, the room in which they were studying, and they will be able to retrieve that information. The second piece of advice I give is that frequently review your class material in the room in which the class is being conducted. It turns out that that has helped a lot of people in retrieving information from memory because the classroom again serves as a context. The next piece of advice I'd give is what psychologists call distributed practice as opposed to massed practice. Distributed practice simply means that do not spend too much time studying on one subject. So like if you said Frank, or if someone has five subjects in a semester, to study those subjects they should rotate the subjects. Maybe read one subject 40 minutes or 50 minutes, or one hour, and then read an unrelated subject for the next hour, and then either they can go back to the first subject or they can pick up a third subject and so on

Dr. Vattano (V/O):
and do that frequently.

Rajan Mahadevan (O/C):
and do that frequently. That's a lot better than

"Last Minute Review"

CU RAJAN MAHADEVAN

just cramming one subject...
It's a waste of time. Make sure that you review material before an exam. Review the material, say, let's consider the day before an exam. Review all the material for the exam once before you go to sleep, and the first thing after you get up the following morning. It turns out that if people do that, it strengthens memory traces because during sleep there is very little retroactive or proactive interference so the information that was scanned or learned just before a person goes to sleep gets consolidated at the period of sleeping, and then as soon as they wake up if they review that material again, then, the chances of recalling it when they want to, see, in an examination, would be very good.

George Page (V/O):
Although Rajan Mahadevan represents a rare case of extraordinary memory for numbers, research has shown that with the proper motivation and practice, we can all greatly improve our memory capacity and information processing ability.