Sleeping on Mars: A Hidden Challenge for Human Space Exploration

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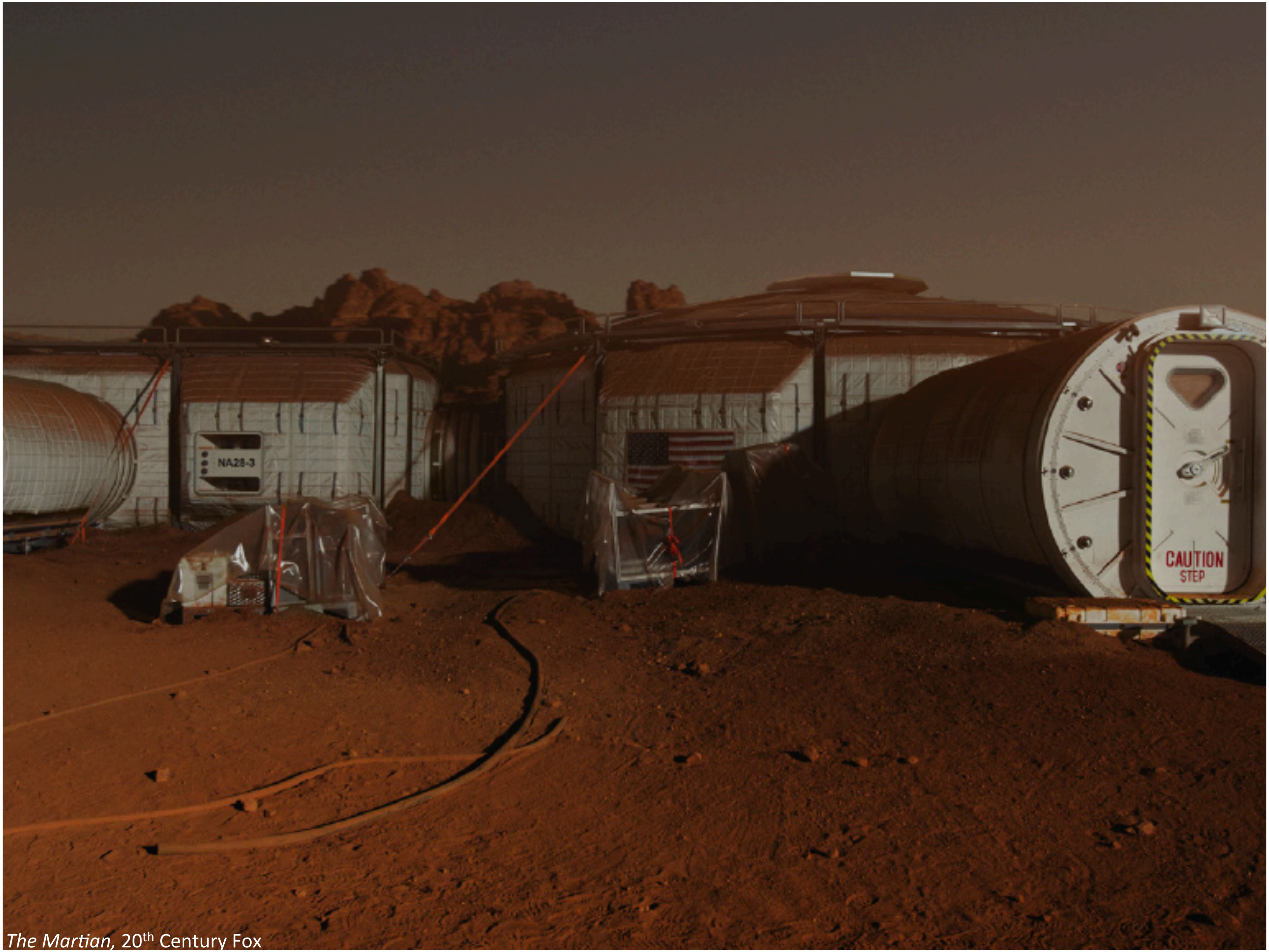
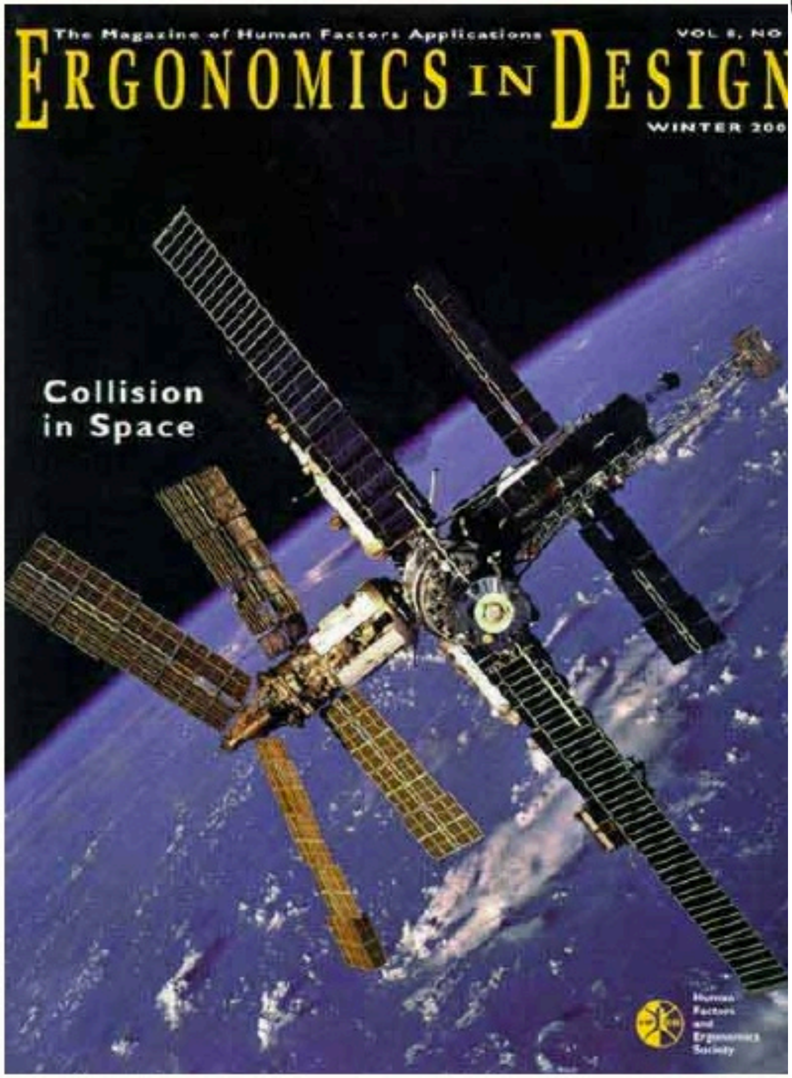
The Martian, 20th Century Fox



The Martian, 20th Century Fox

http://www.nasa.gov/sites/default/files/styles/1x1_cardfeed/public/images/139573main_image_feature_470_ys_full.jpg

"Although neither man was really tired after the first half of the picture-snapping, Conrad considered closing the hatch and resting until the next night pass. He asked the Hawaii CapCom if there was enough oxygen. The answer was yes. But the skies were clear over the United States, and they might want to take more pictures there. In that case, said Conrad, the hatch would stay open. Soon the crew marveled at the view of their home area-Houston. They passed quietly across Florida and out over the Atlantic with nothing to do. Suddenly, Gordon broke the silence to announce that they had just taken a catnap. 'There we were. . . , he was asleep hanging out the hatch on his tether and I was asleep sitting inside the spacecraft,' Conrad reported. 'That's a first,' John Young answered, 'first time sleeping in a vacuum.'"



Collision in Space

Human factors such as inadequate visual displays and operator fatigue played significant roles in the collision of Space Station *Mir* and *Progress 234*.

BY STEPHEN R. ELLIS

ON JUNE 25, 1997, THE Russian supply spacecraft *Progress 234* collided with the *Mir* space station, rupturing *Mir*'s pressure hull, throwing it into an uncontrolled attitude drift, and nearly forcing evacuation of the station. Like many high-profile accidents, this collision was the consequence of a chain of events leading to the final piloting errors that were its immediate cause.

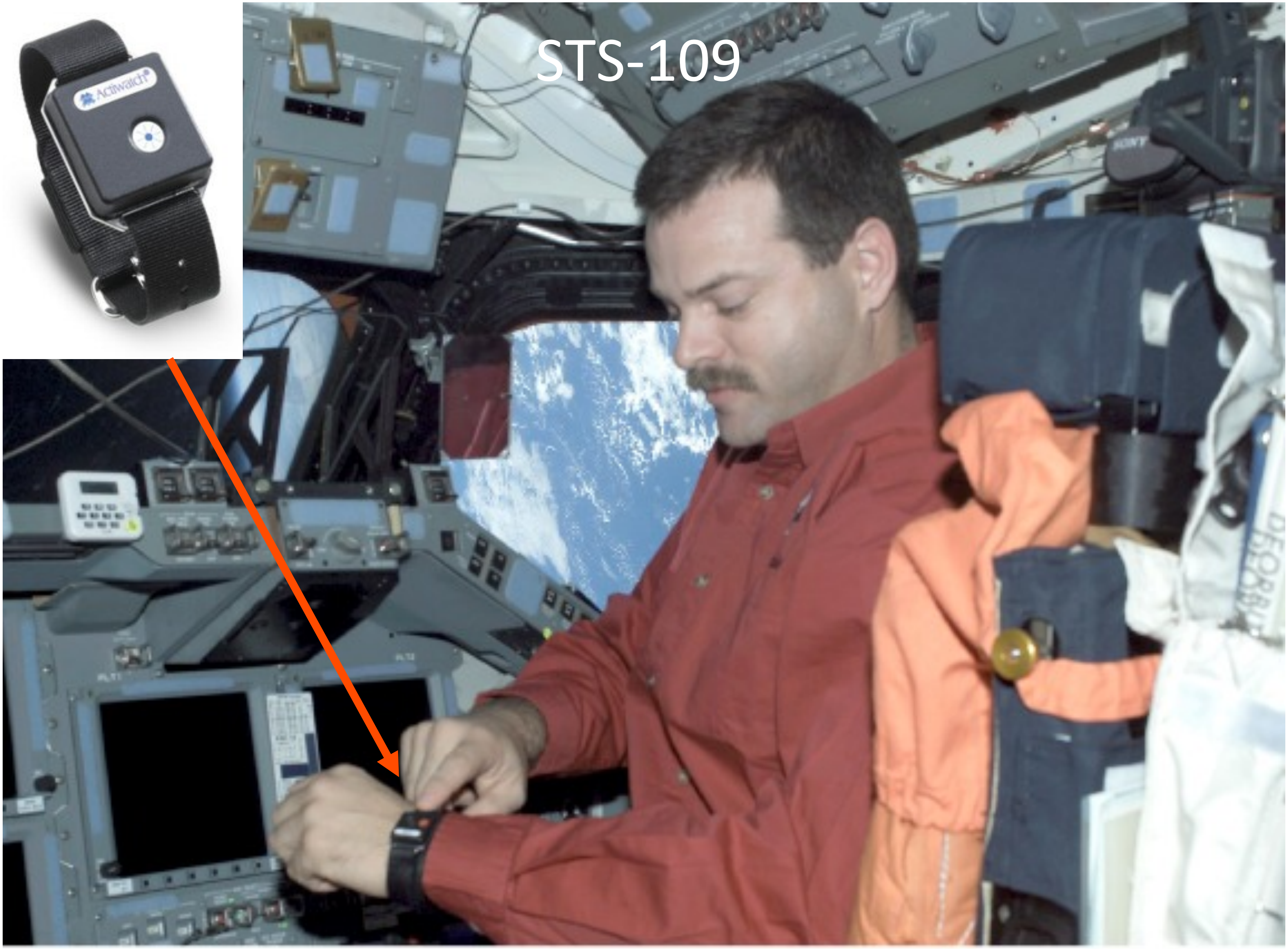
The discussion in this article does not resolve the relative contributions of the actions and decisions in this chain. Neither does it suggest corrective measures, many of which are straightforward and have already been implemented by the National Aeronautics and Space Administration (NASA) and the Russian Space Agency. Rather, its purpose is to identify the human factors that played a pervasive role in the incident. Workplace stress, fatigue, and sleep deprivation were identified by NASA as contributory factors in the *Mir-Progress* collision (Culbertson, 1997; NASA, forthcoming), but other contributing factors, such as requiring crew to perform difficult tasks for which their training is not current, could potentially become important factors in future situations.

The *Mir* Programs and Crew

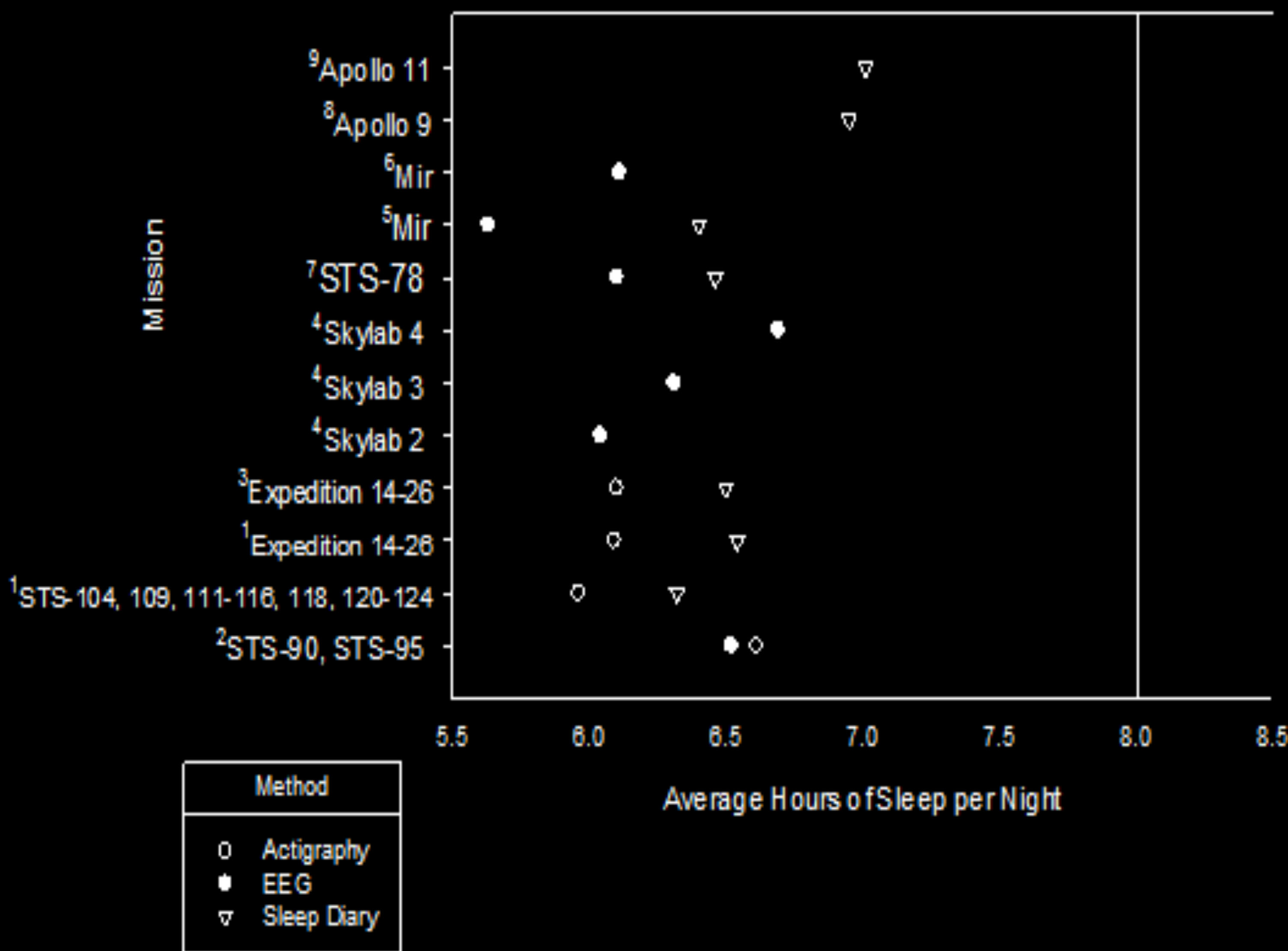
In 1995, NASA began sending astronauts to the Russian *Mir* space station as Phase 1 of an international program to learn to live and work in space, the International Space Station. NASA expected to benefit from unique Russian experience in very long duration space flight, use *Mir* to test and verify new technology, conduct scientific research requiring microgravity environments, and help keep the Russian space program afloat through an infusion of more than $400 million, support personnel, and the use of the space shuttle for supply. In particular, NASA hoped cooperating with the Russians would reduce the risks of long-duration space flight and eventual interplanetary missions. Initial research would be directed toward biological and materials science research requiring long-term exposure to a space station microgravity environment (Culbertson, 1997; Oberg, 1998).

Three crew members were on board *Mir* at the time of the collision (pictured in the photo on page 5). Vasili Tsibliyev, a former military jet pilot and *Mir* commander, received his pilot training at the Gritsevets Military School of Aviation and the Gagarin Air Force Academy between 1975 and 1987. He then followed a general space training course at the Gagarin Cosmonaut Training Center between 1987 and 1989. He had previous

STS-90


STS-109
Actiwatch

Houston we have a problem!



What makes us sleep?

- Circadian rhythm
- Homeostatic
  - Number of hours awake
  - Cumulative sleep debt
  - Sleep fragmentation

Modifiers of Physiological Response

- Individual differences in sleep need
- Sleep disorders

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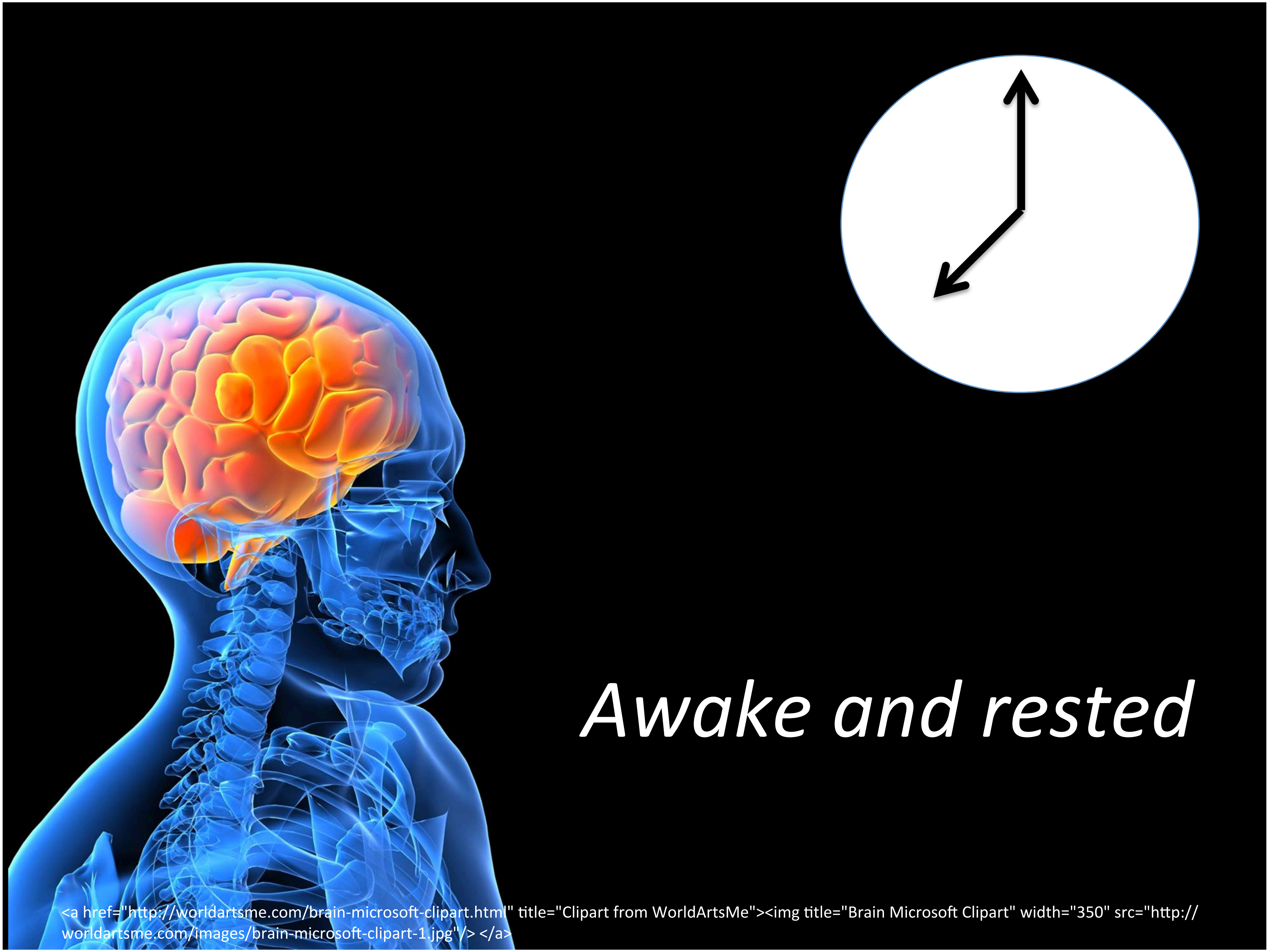

Awake and rested
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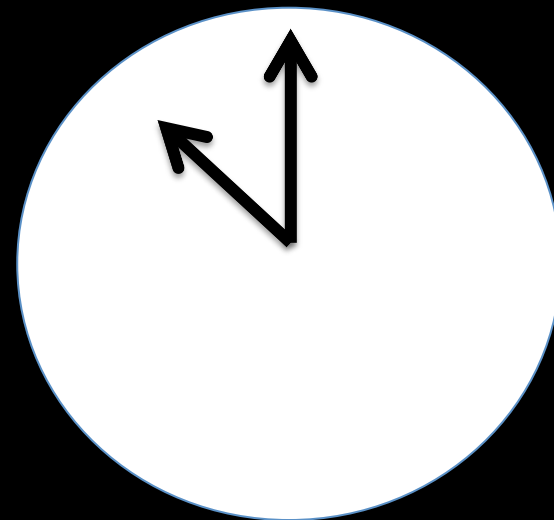

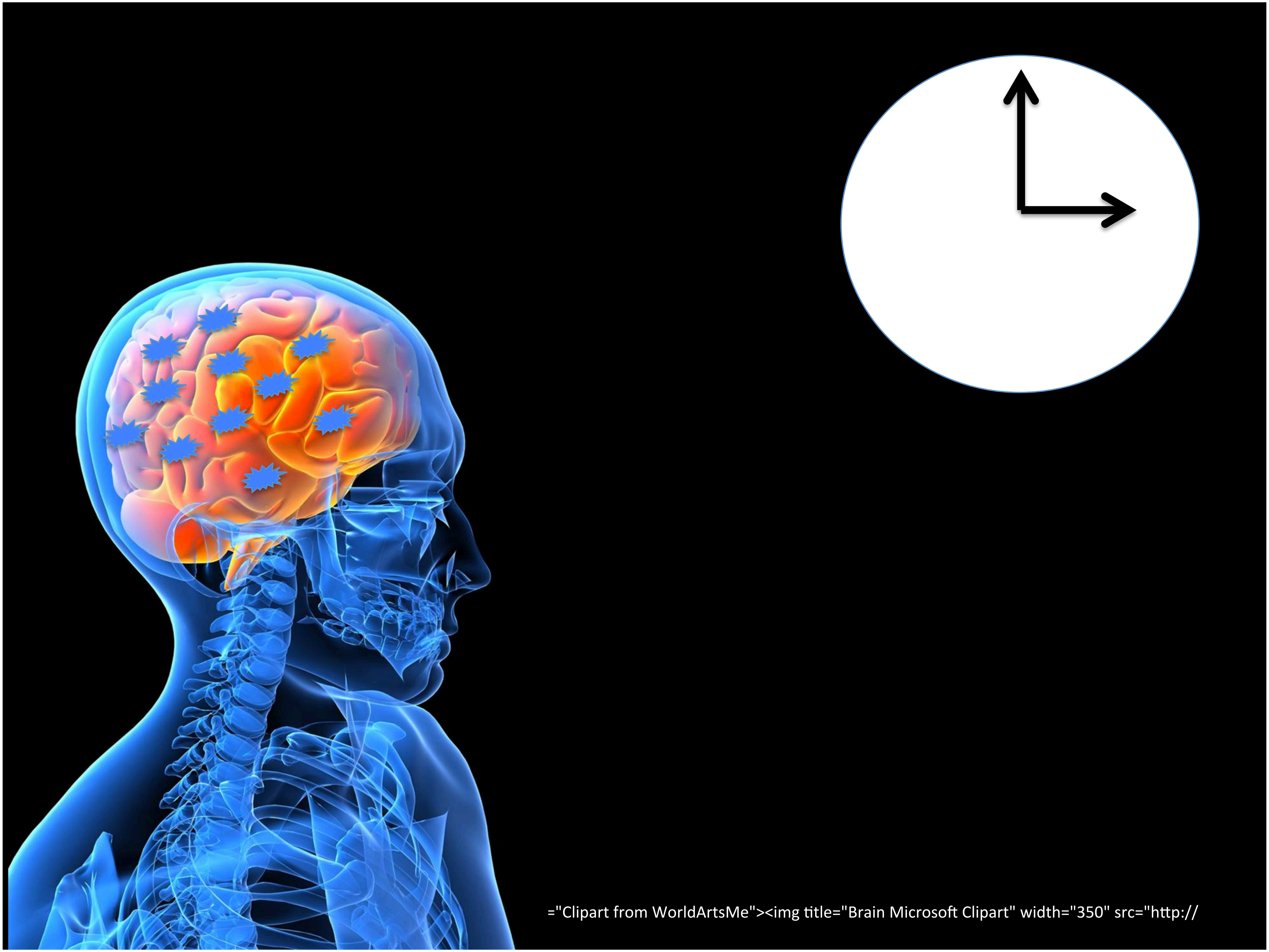
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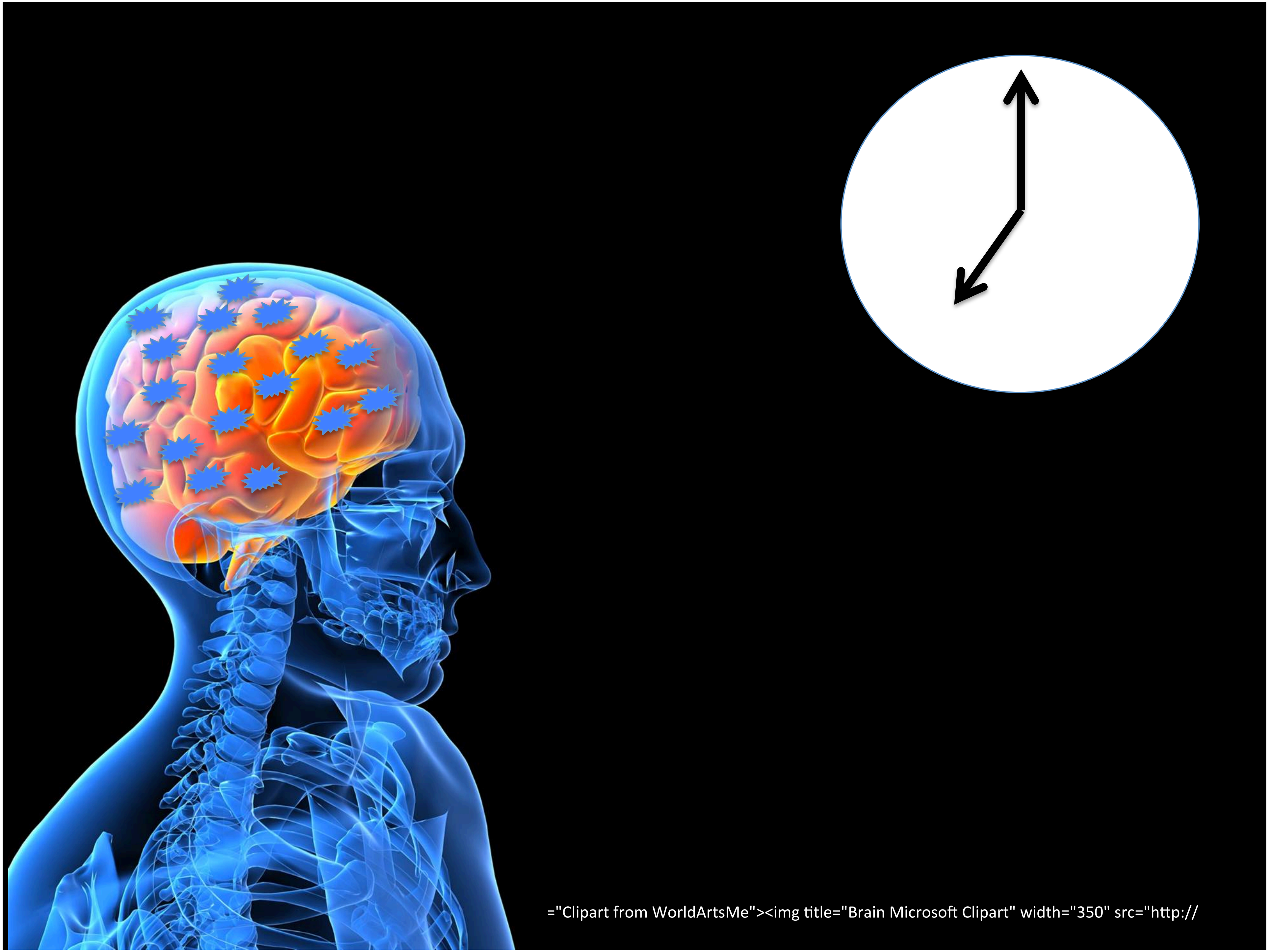
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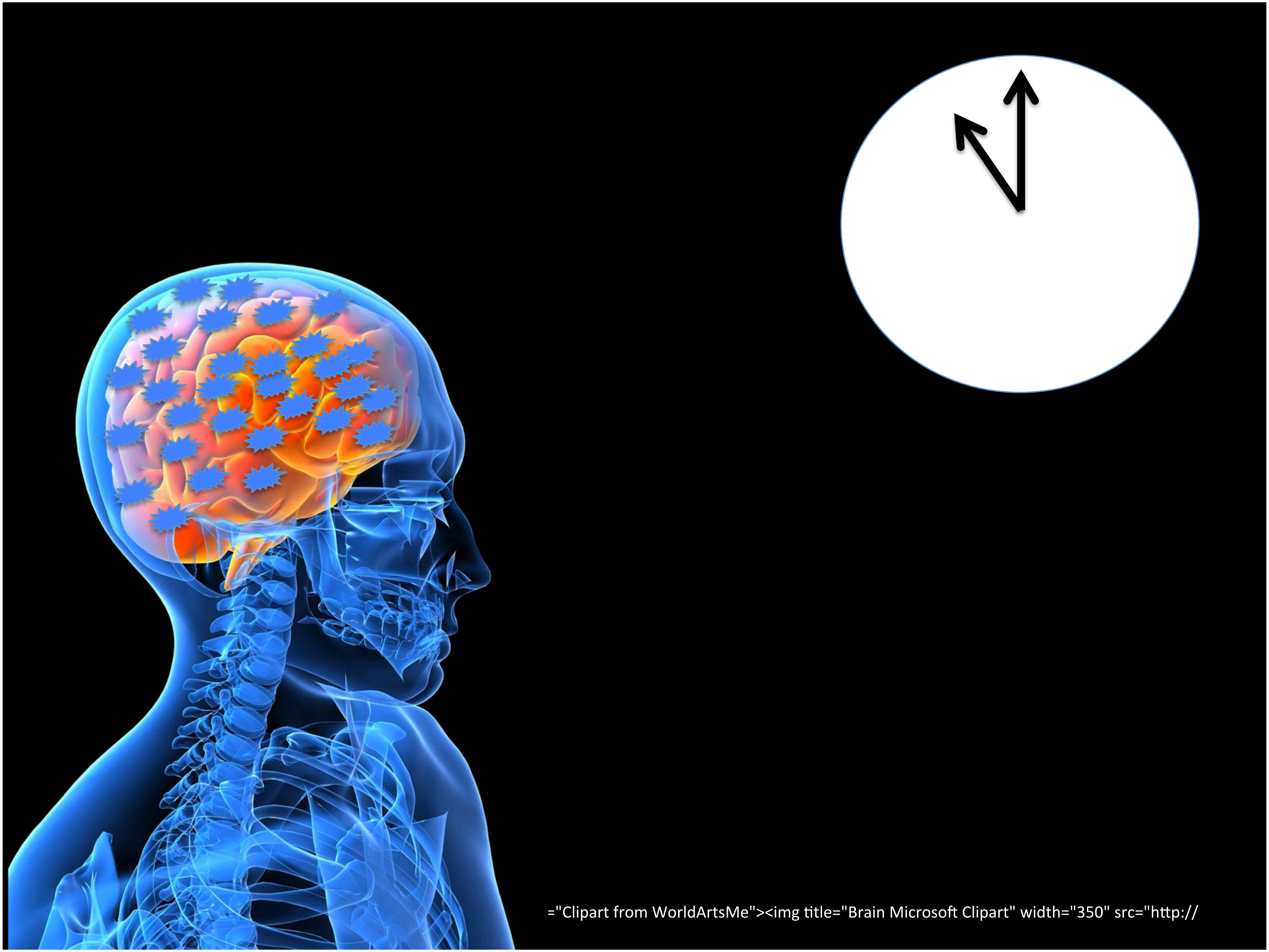
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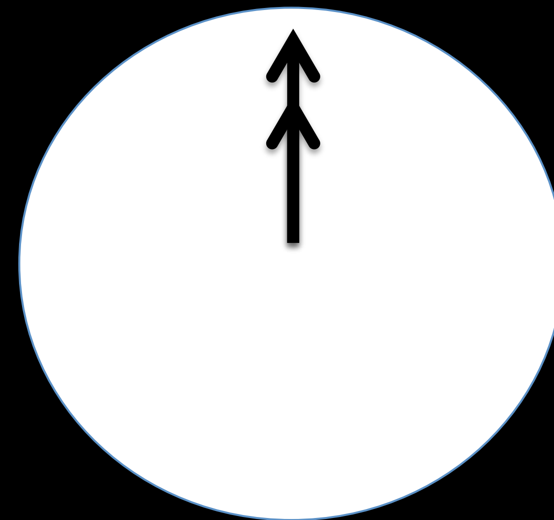

Sleep

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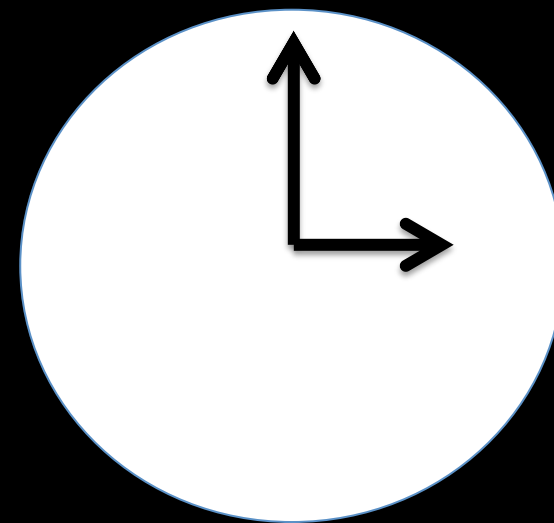

Sleep

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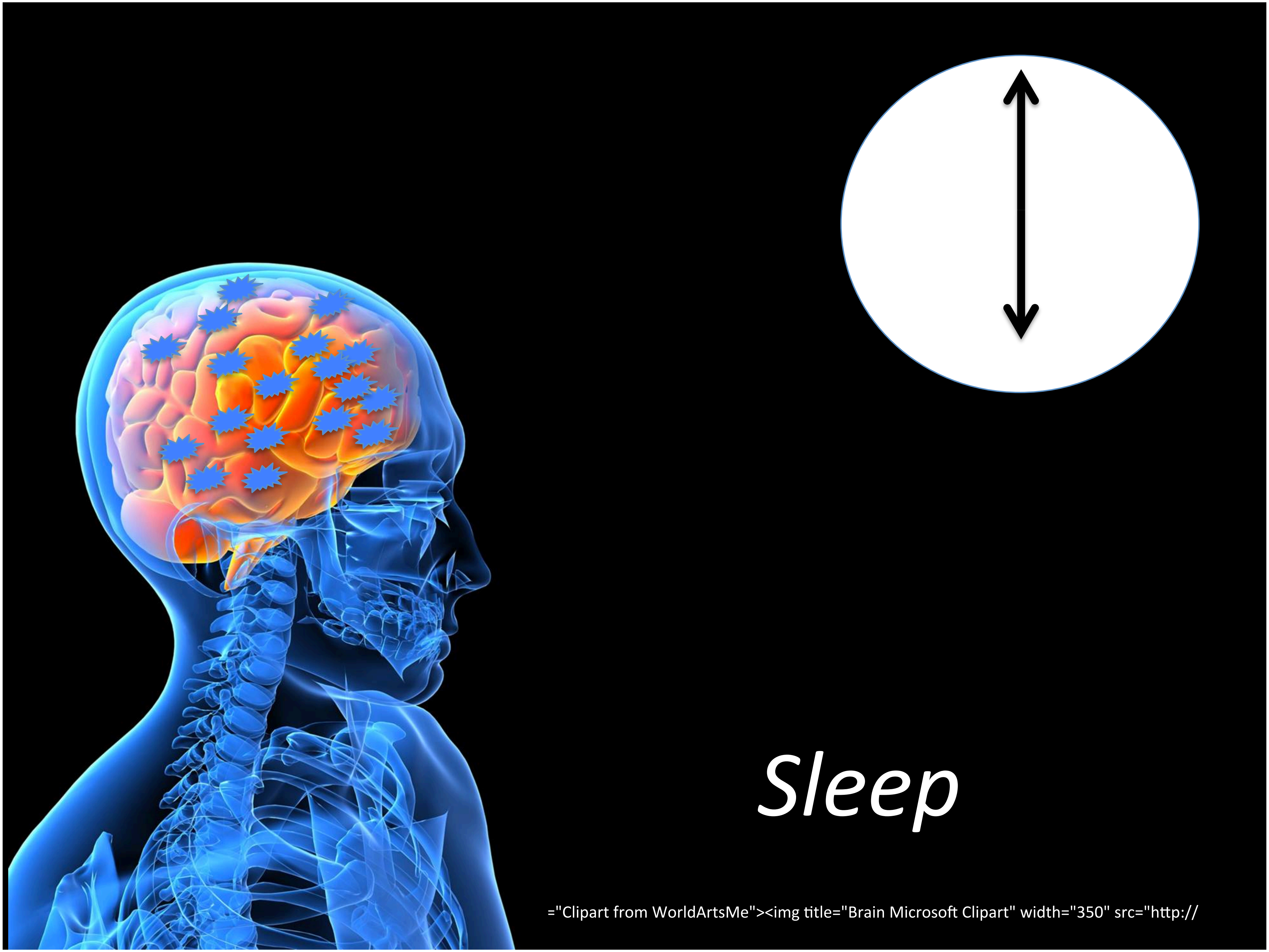
Sleep
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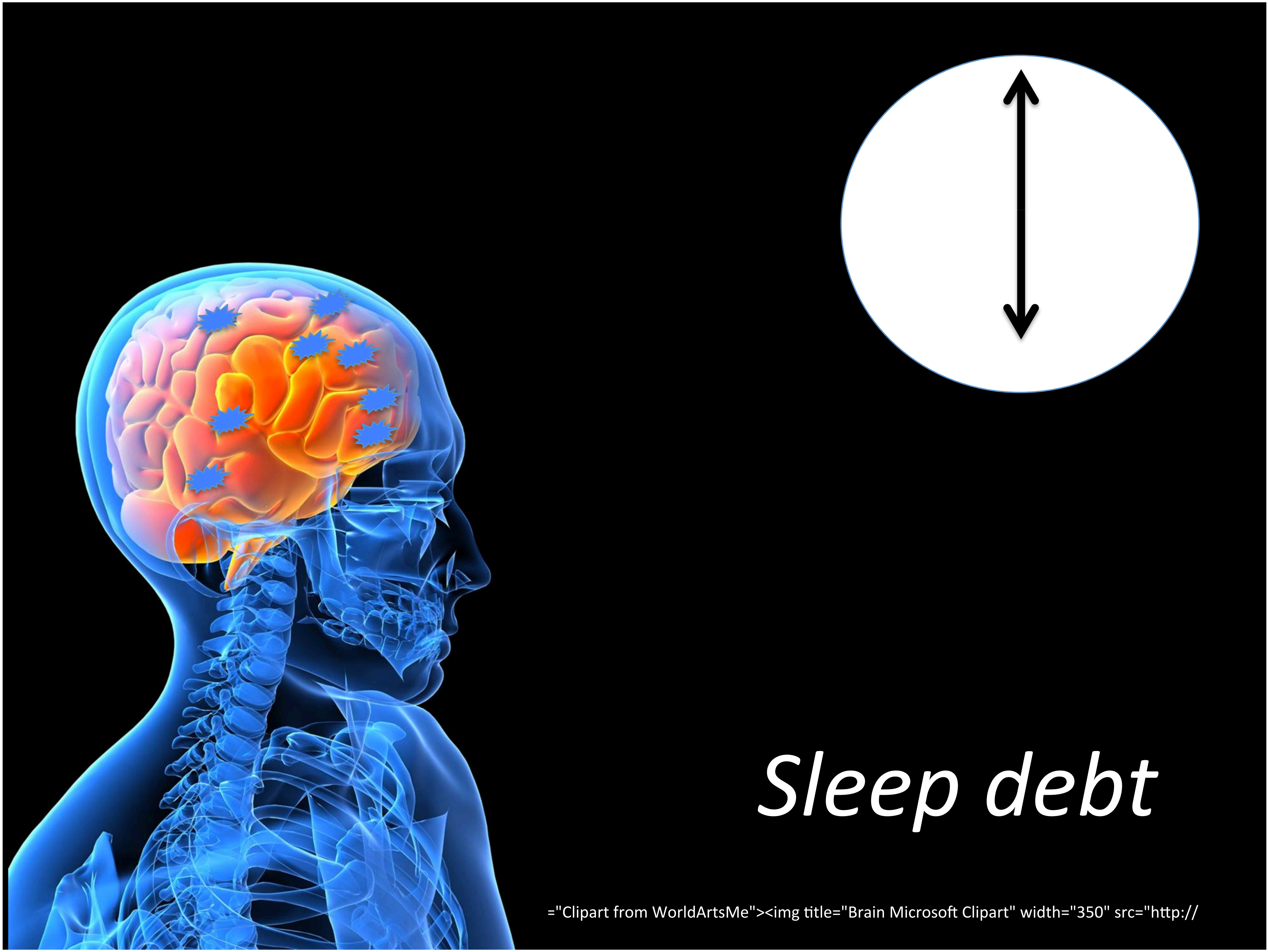
Sleep debt
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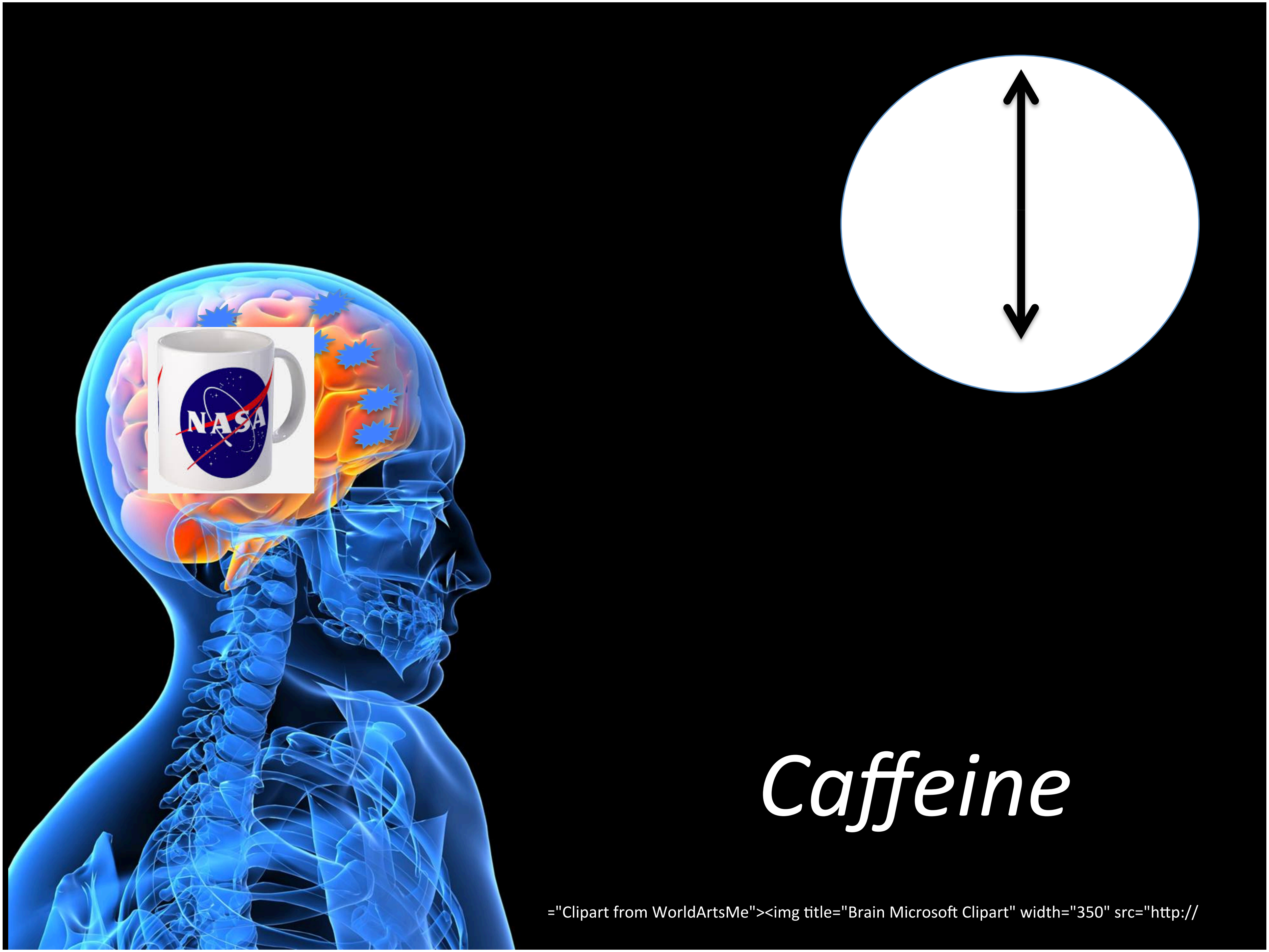
Caffeine
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Wide Awake on the Sea of Tranquillity **07.20.06**

This installment of Science@NASA's Apollo Chronicles explains why Neil Armstrong and Buzz Aldrin couldn't fall asleep in the Sea of Tranquillity.

Neil Armstrong was supposed to be asleep. The moonwalking was done. The moon rocks were stowed away. His ship was ready for departure. In just a few hours, the Eagle's ascent module would blast off the Moon, something no ship had ever done before, and Neil needed his wits about him. He curled up on the Eagle's engine cover and closed his eyes.

But he could not sleep.

Neither could Buzz Aldrin. In the cramped lander, Buzz had the sweet spot, the floor. He stretched out as much as he could in his spacesuit and closed his eyes. Nothing happened. On a day like this, sleep was out of the question.

The Eagle was not a sleepy place. The tiny cabin was noisy with pumps and bright with warning lights that couldn't be dimmed. Even the window shades were glowing, illuminated by intense sunshine outside. "After I got into my sleep stage and all settled down, I realized there was something else [bothering me]," said Armstrong. The Eagle had an optical telescope sticking out periscope-style. "Earth was shining right through the telescope into my eye. It was like a light bulb."

To get some relief, they closed the helmets of their spacesuits. It was quiet inside and they "wouldn't be breathing all the dust" they had tramped in after the moon walk, said Aldrin. Alas, it didn't work. The suit's cooling systems, so necessary out on the scorching lunar surface, were too cold for sleeping inside the Eagle. The best Aldrin managed was a "couple hours of mentally fitful drowsing." Armstrong simply stayed awake.


EHIP Battery Charger
EMU Battery Charger
REBA Charger
NOT FOR EYEWASH USE


POTABLE WATER HEATER
www.nasa.gov

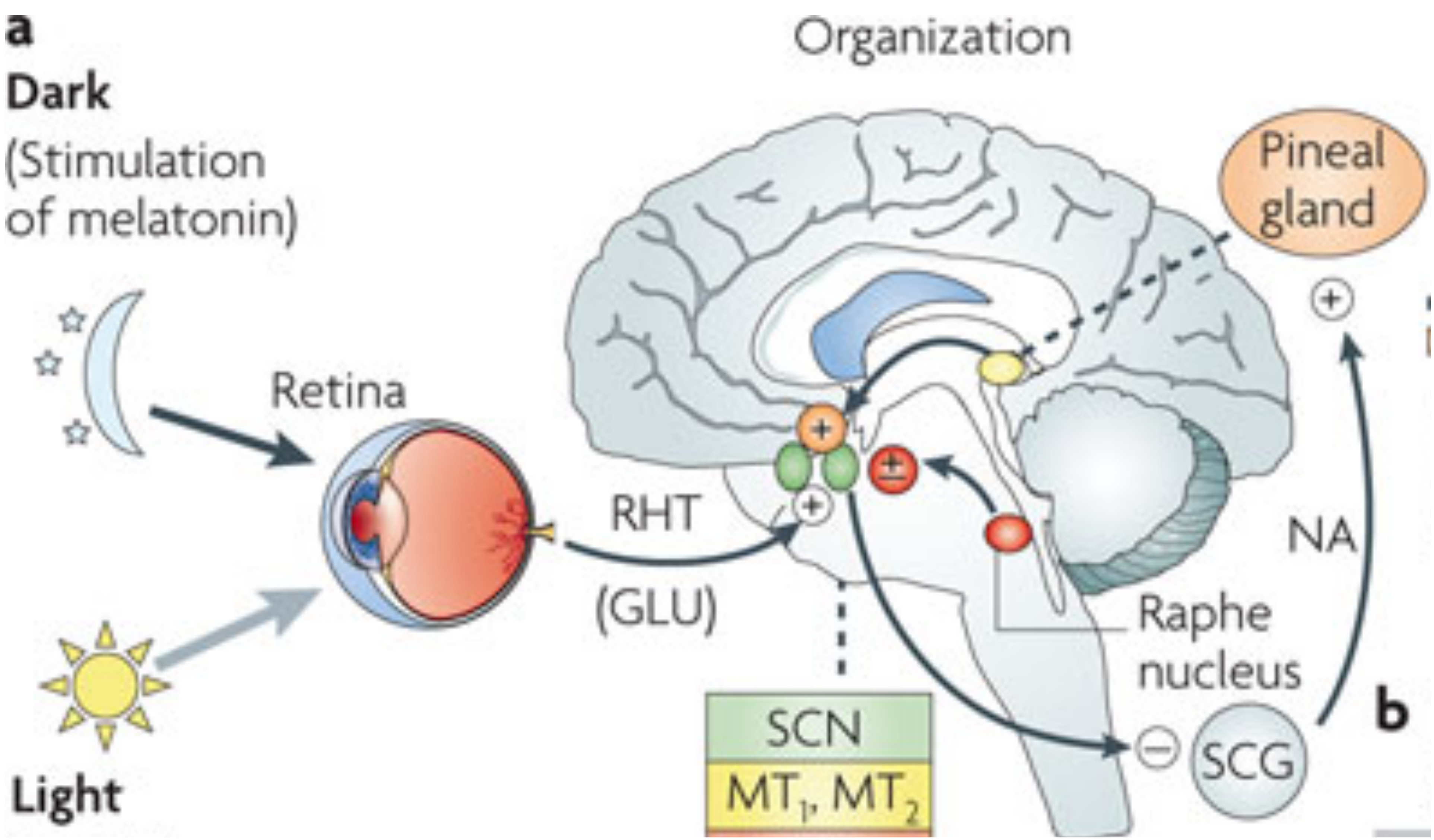
http://www.nasa.gov/audience/forstudents/5-8/features/to_sleep_feature.html

Physiological Sleep Drive

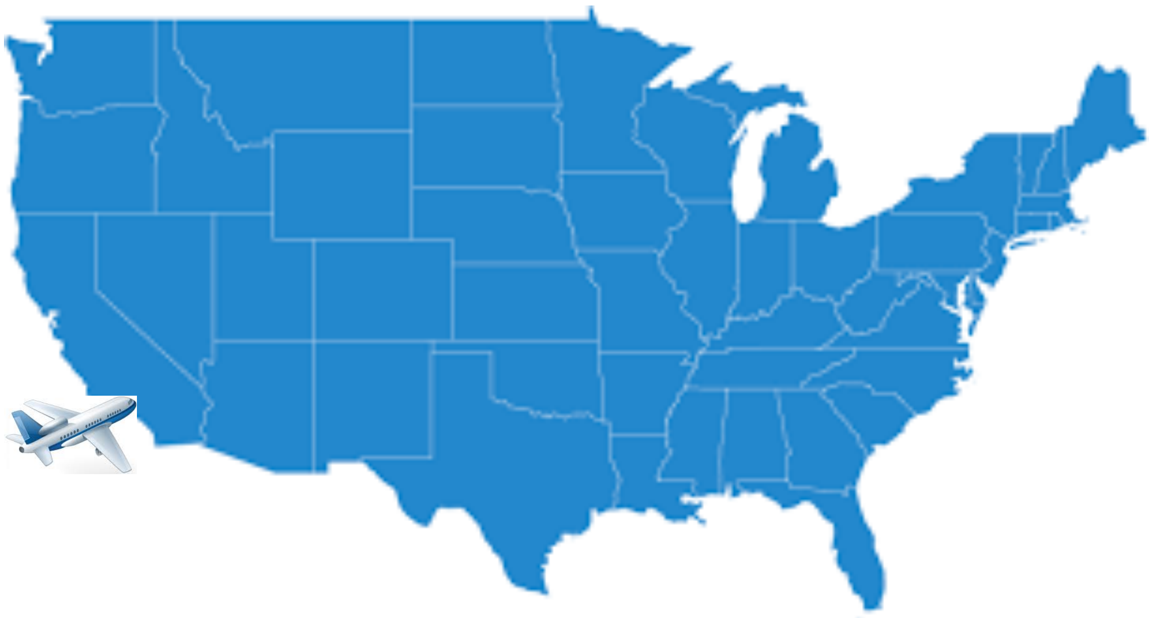
- Circadian rhythm
- Homeostatic
  - Number of hours awake
  - Cumulative sleep debt

Modifiers of Physiological Response

- Individual differences in sleep need
- Sleep disorders

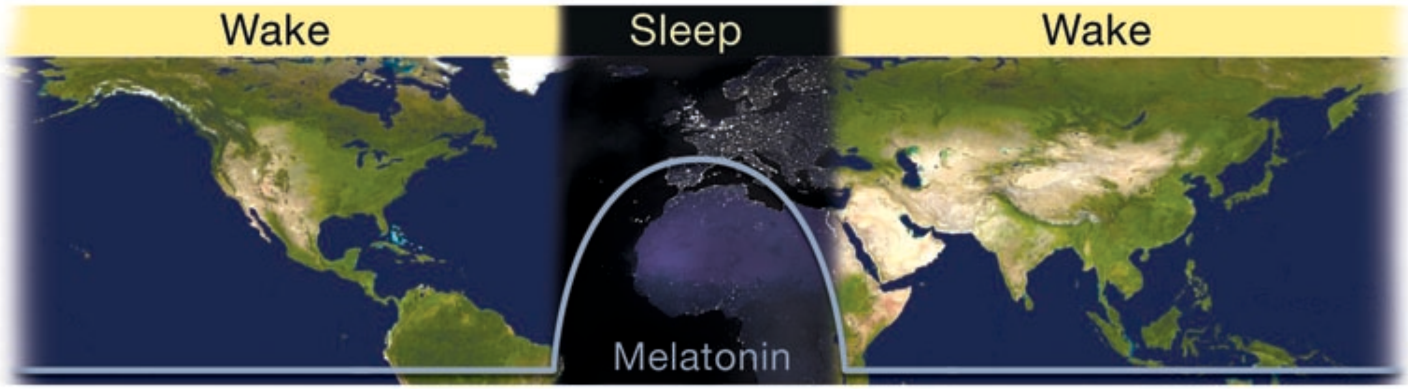


Bodinat *et al*. *Nature Reviews Drug Discovery* (August 2010)



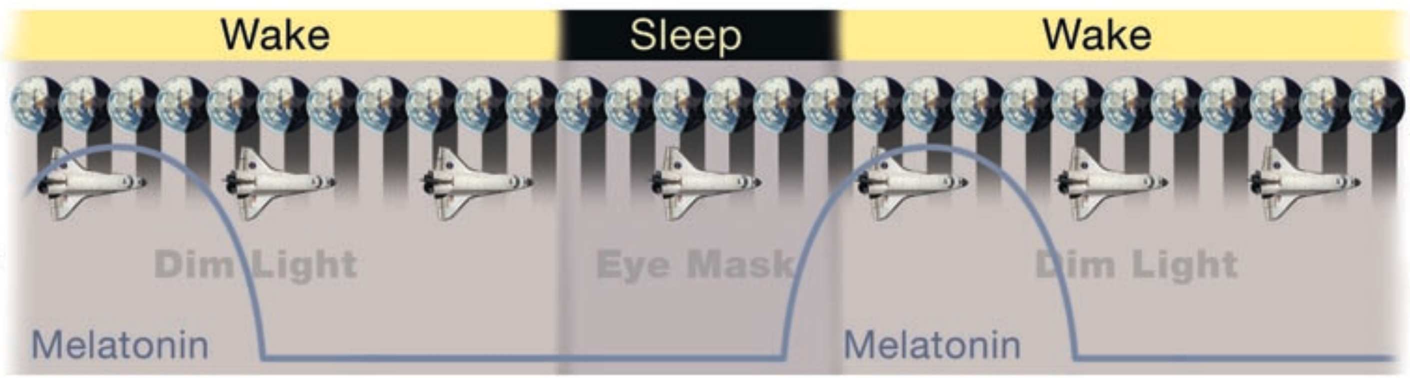
Earth Conditions

On a 24-hour external light/dark cycle, the body's circadian clock remains properly synchronized (e.g., hormones like melatonin are released at the appropriate time).



Space Conditions

On the orbiter's 90-minute light/dark cycle, weak interior ambient light does not sufficiently cue the body's circadian clock, which may then become desynchronized (e.g., inappropriately timed hormone release).



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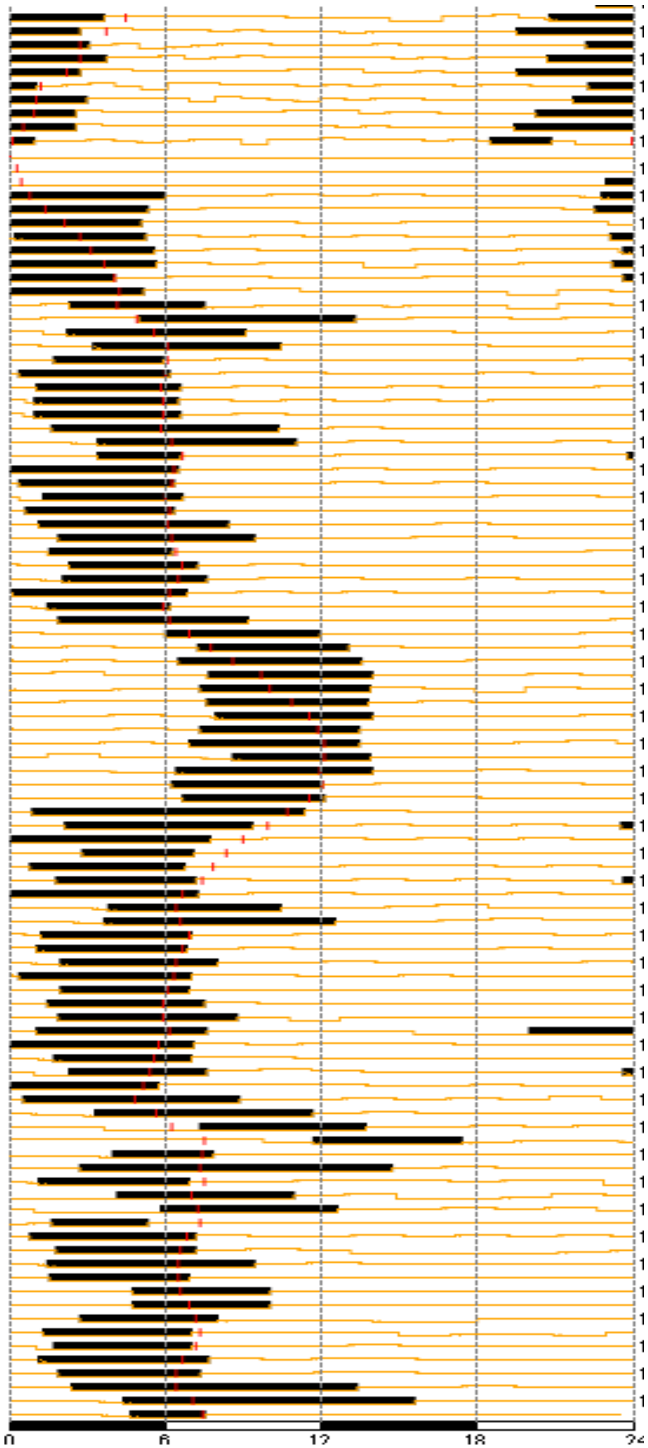

0
6
12
18
24


www.asc.csa.ca

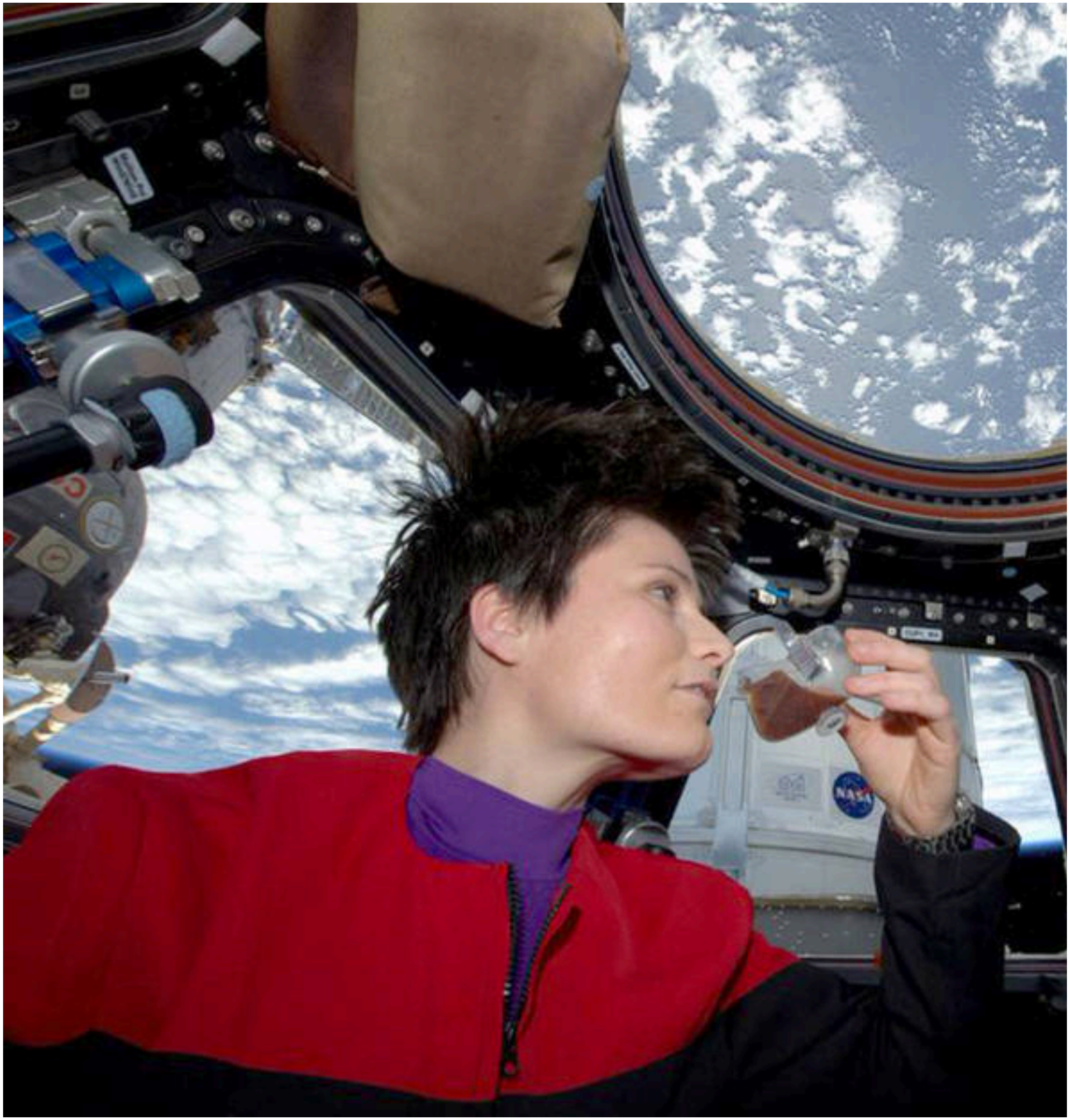
Effect of Predicted Circadian Alignment on Sleep Outcomes

	Aligned Mean (SD)	Misaligned Mean (SD)	p-value
Actigraphy Sleep Duration (h)	6.4 (1.2)	5.5 (1.4)	**<0.01**
Latency (m)	10.4 (15.1)	13.0 (24.9)	0.29
Number of Awakenings	1.7 (1.9)	1.8 (1.8)	0.36
Sleep Efficiency	89% (7%)	90% (7%)	0.18
Sleep Quality	66.8 (17.7)	60.2 (21.0)	**<0.01**
Alertness	57.9 (21.7)	53.5 (21.4)	0.14

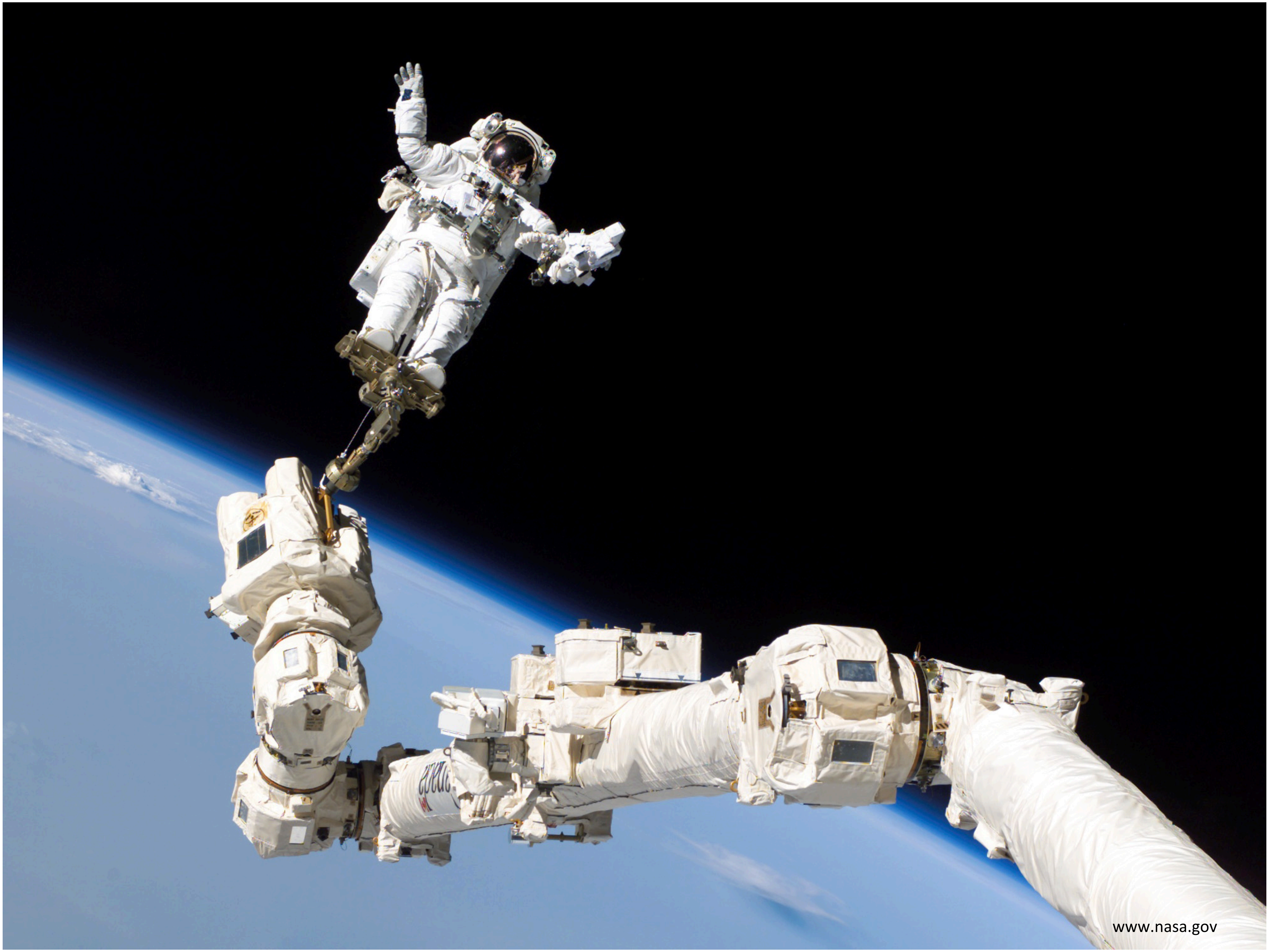
HMS

Flynn-Evans *et al., in preparation*

BWH



www.nasa.gov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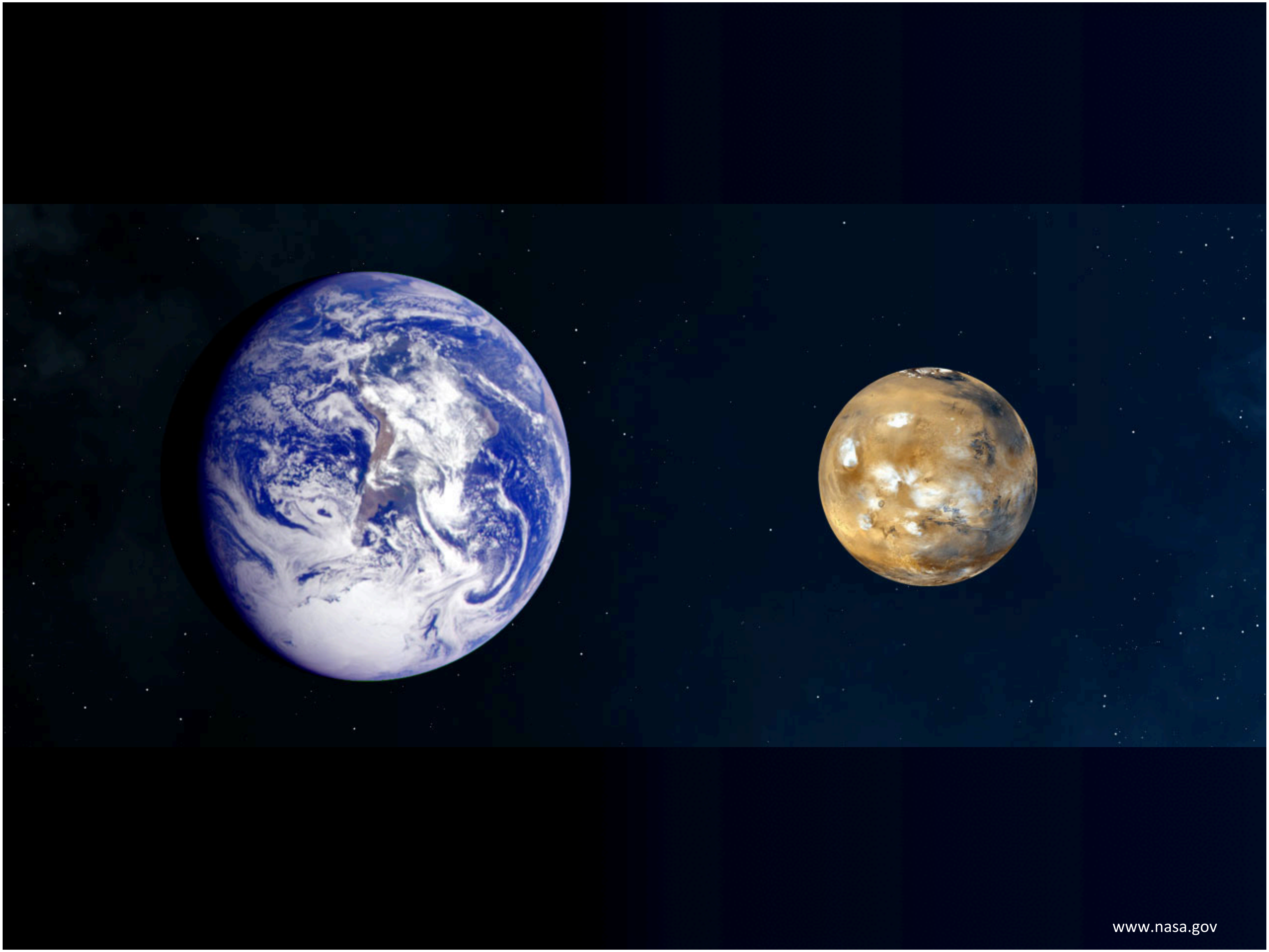
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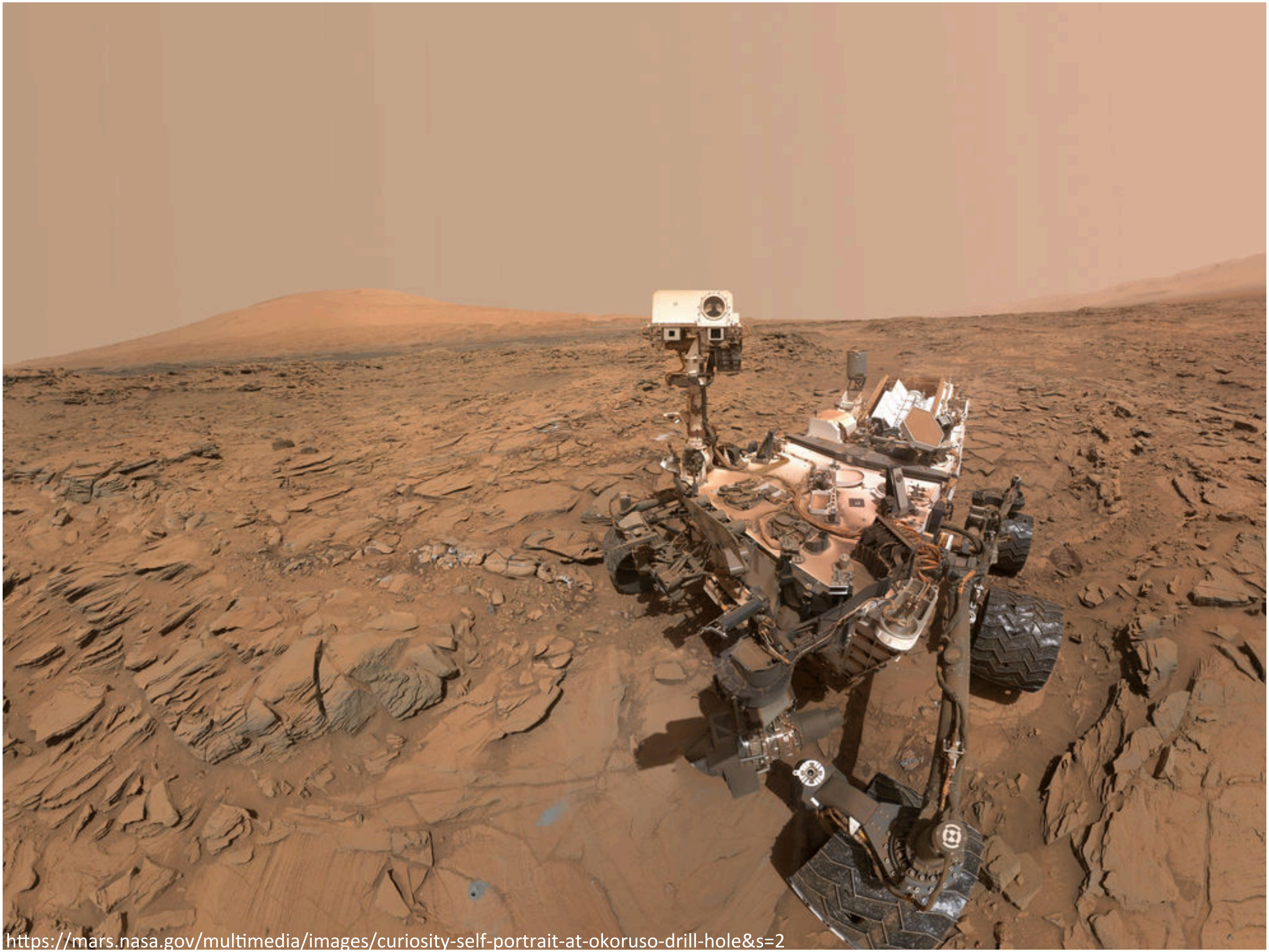
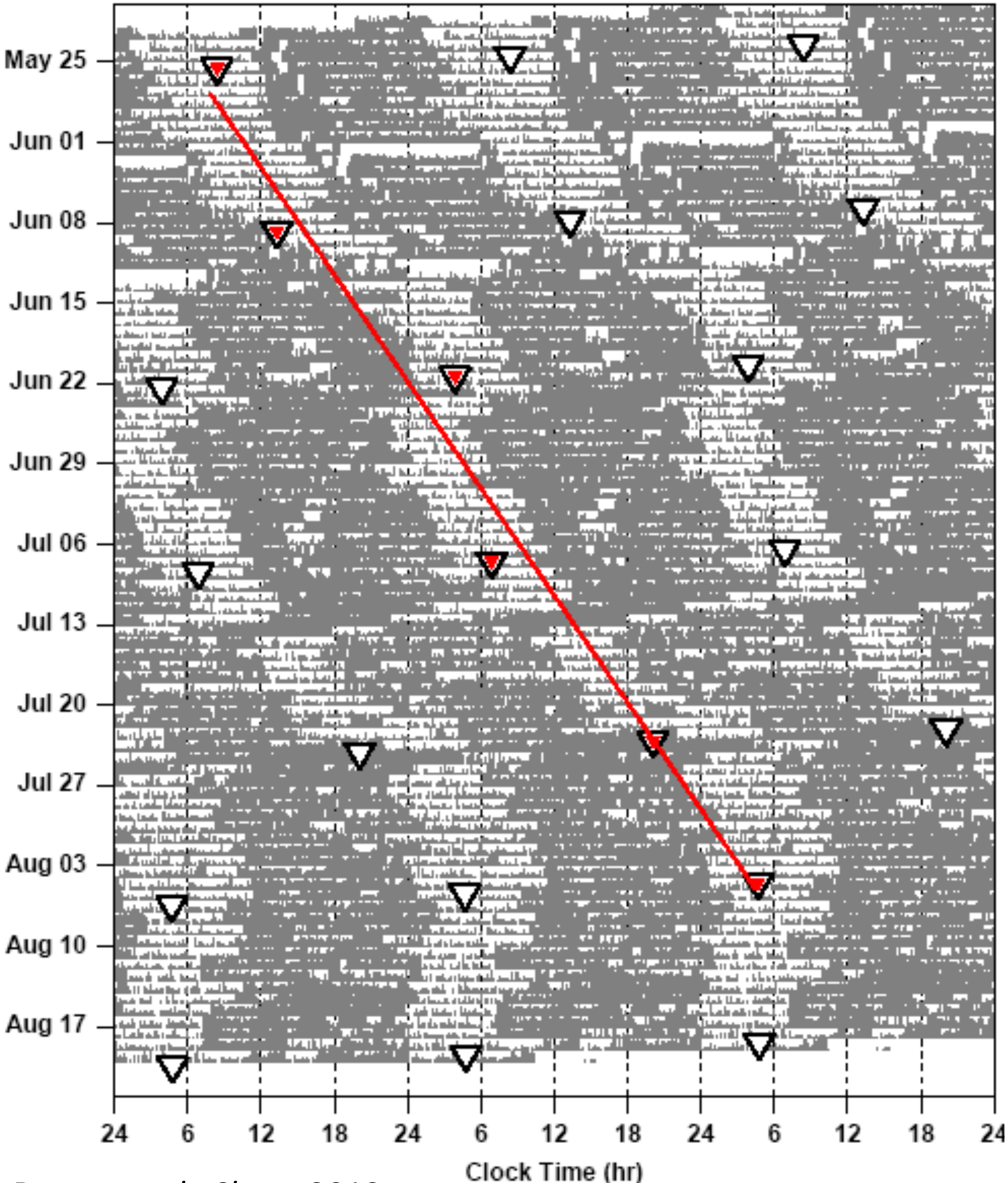
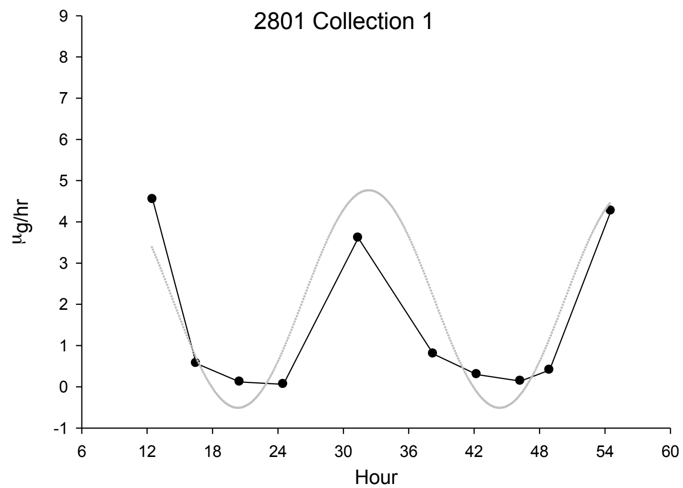


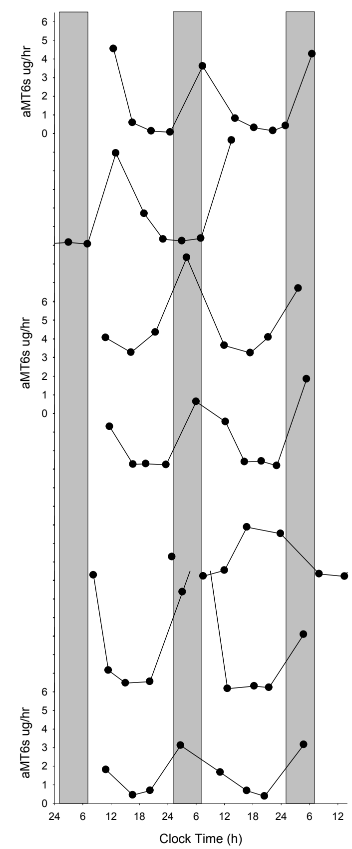
https://mars.nasa.gov/multimedia/images/curiosity-self-portrait-at-okoruso-drill-hole&s=2

University of Arizona

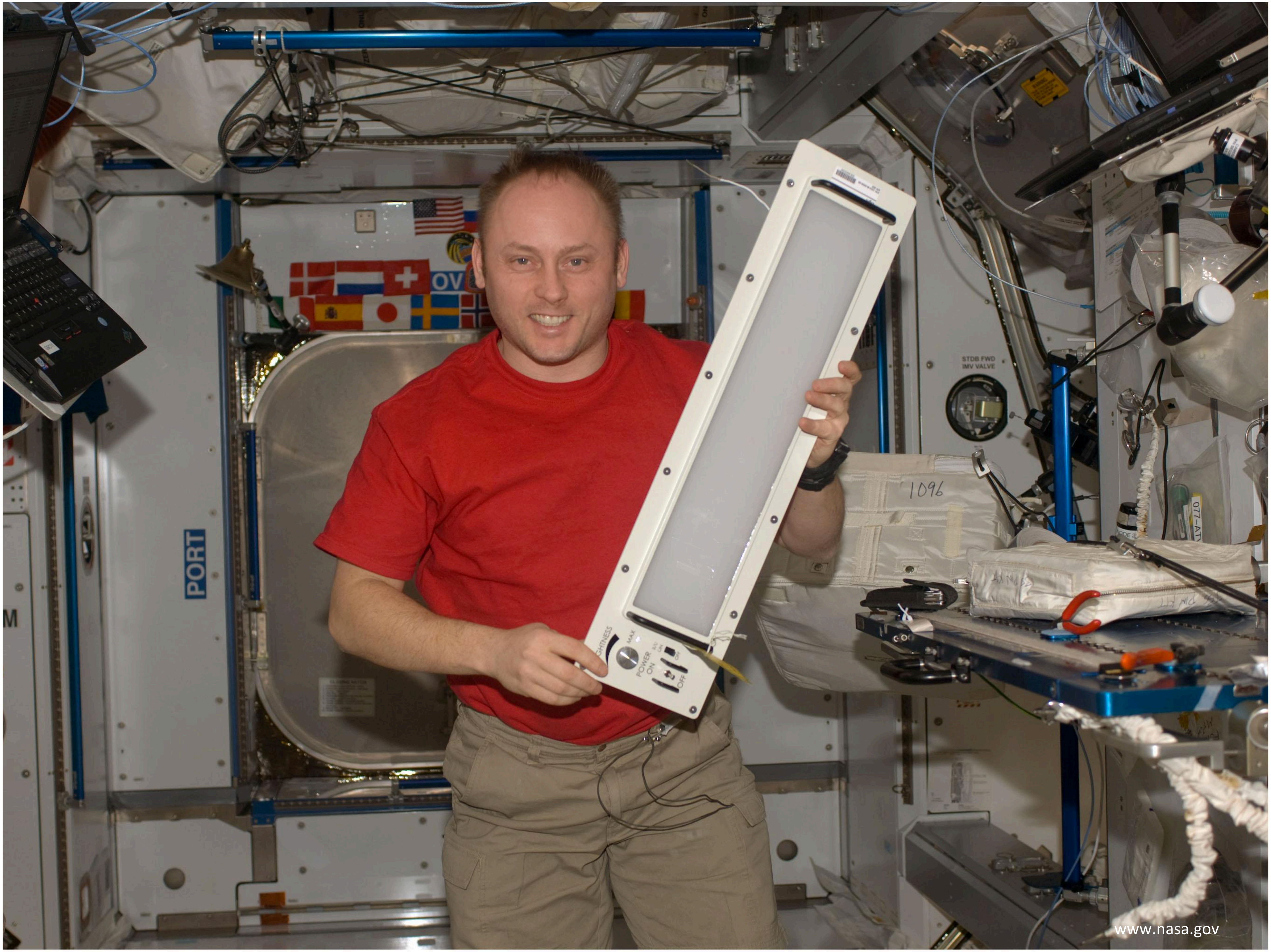
Credit University of Arizona







Barger *et al., Sleep,* 2012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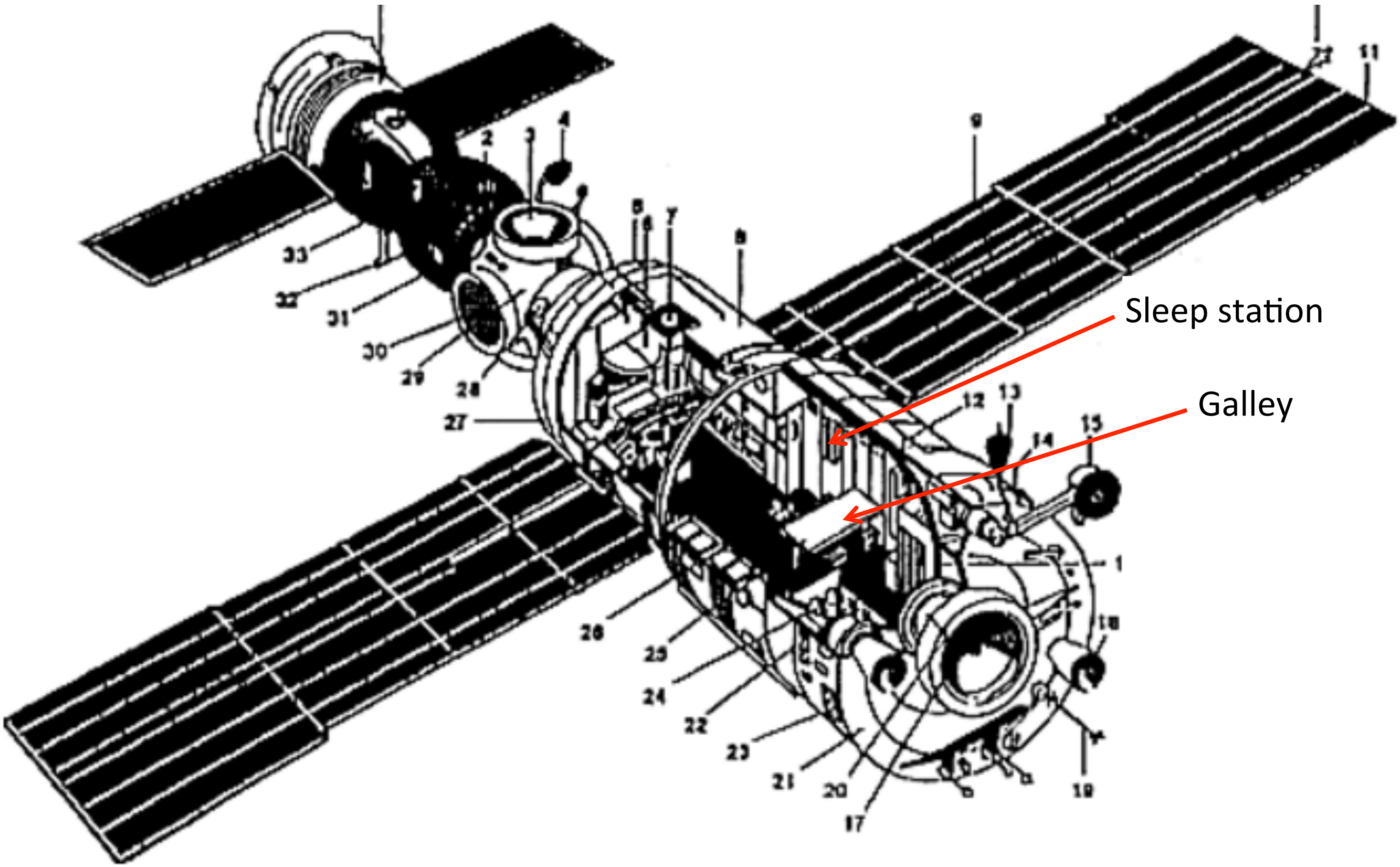
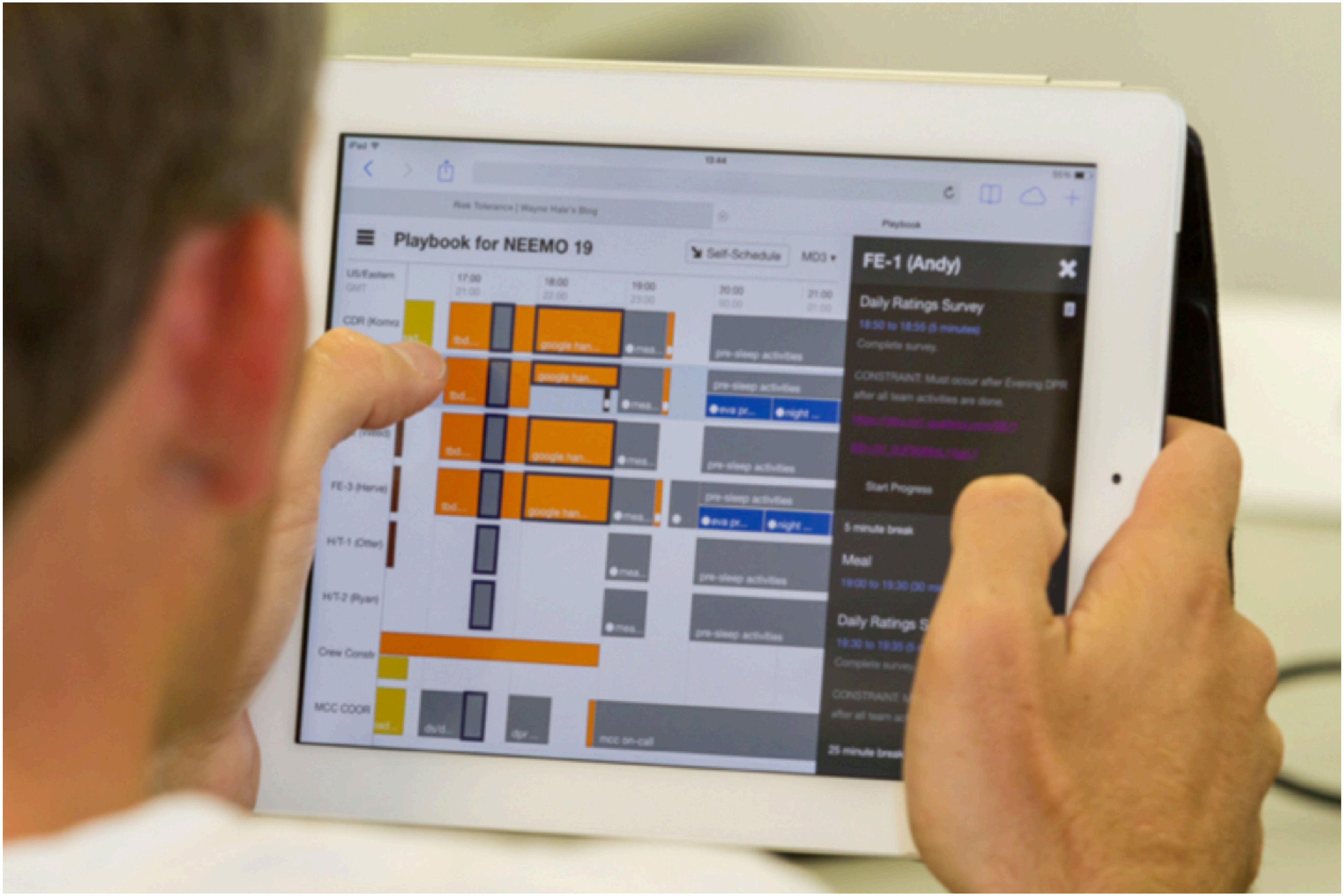
STDB FWD
IMV VALVE
1096
MAX
POWER
ON
OFF
www.nasa.gov



Core Module (Base Block)

www.nasa.gov

http://www.nasa.gov/content/stepping-stones-to-human-missions-beyond-u


Playbook for NEEMO 19
Self-Schedule
FE-1 (Andy)
Daily Ratings Survey
pre-sleep activities
google han...
Meal
mcc on-call

www.nasa.gov


National Aeronautics and
Space Administration
NASA
THE EVOLUTION OF A MARTIAN
www.nasa.gov


Thank You!
– Laura Barger Ph.D.
– Charles A. Czeisler, Ph.D., M.D.
– Elizabeth Klerman M.D., Ph.D.
– Kenneth P. Wright, Jr., Ph.D.
– David Dinges, Ph.D.
– Jason P. Sullivan
– Eymard Riel RPSGT
– Lorcan Walsh
– Conor O'Brien
– Sean Benedix
– Marty Bost
– Curtis Kershner
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– Scott Beckett
– Liza Burke
– Lauren Brogna
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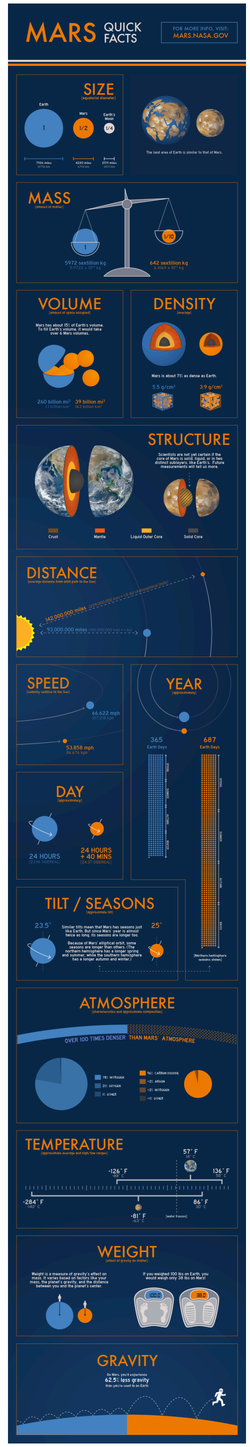
MARS QUICK FACTS
FOR MORE INFO, VISIT:
MARS.NASA.GOV
SIZE
[equatorial diameter]
Earth
Mars
Earth's Moon
1
1/2
1/4
7926 miles
12756 km
4220 miles
6792 km
2159 miles
3475 km
The land area of Earth is similar to that of Mars.
MASS
[amount of matter]
1
1/10
5972 sextillion kg
5.9722 x 10^24 kg
642 sextillion kg
6.4169 x 10^23 kg
VOLUME
[amount of space occupied]
Mars has about 15% of Earth's volume. To fill Earth's volume, it would take over 6 Mars volumes.
260 billion mi³
1.1 trillion km³
39 billion mi³
163 billion km³
DENSITY
[average]
Mars is about 71% as dense as Earth.
5.5 g/cm³
3.9 g/cm³
STRUCTURE
Scientists are not yet certain if the core of Mars is solid, liquid, or in two distinct sublayers, like Earth's. Future measurements will tell us more.
Crust
Mantle
Liquid Outer Core
Solid Core
DISTANCE
[average distance from orbit path to the Sun]
142,000,000 miles (229,000,000 km) = 1.5 AU (Astronomical Units)
93,000,000 miles (150,000,000 km) = 1 AU
SPEED
[velocity relative to the Sun]
66,622 mph
107,218 kph
53,858 mph
86,676 kph
YEAR
[approximately]
365
Earth Days
687
Earth Days
SPRING
SUMMER
AUTUMN
WINTER
[Northern hemisphere seasons shown]
DAY
[approximately]
24 HOURS
[23:56 SIDEREAL]
24 HOURS + 40 MINS
[24:37 SIDEREAL]
TILT / SEASONS
[approximate tilt]
23.5°
25°
Similar tilts mean that Mars has seasons just like Earth. But since Mars' year is almost twice as long, its seasons are longer too.
Because of Mars' elliptical orbit, some seasons are longer than others. (The northern hemisphere has a longer spring and summer, while the southern hemisphere has a longer autumn and winter.)
ATMOSPHERE
[characteristics and approximate composition]
OVER 100 TIMES DENSER THAN MARS' ATMOSPHERE
78% NITROGEN
21% OXYGEN
1% OTHER
96% CARBON DIOXIDE
<2% ARGON
<2% NITROGEN
<1% OTHER
TEMPERATURE
[approximate average and high/low ranges]
57° F
14° C
-126° F
-88° C
136° F
58° C
-284° F
-140° C
86° F
30° C
-81° F
-63° C
[water freezes]
WEIGHT
[effect of gravity on matter]
Weight is a measure of gravity's effect on mass. It varies based on factors like your mass, the planet's gravity, and the distance between you and the planet's center.
If you weighed 100 lbs on Earth, you would weigh only 38 lbs on Mars!
100.0
38.0
GRAVITY
On Mars, you'd experience
62.5% less gravity
than you're used to on Earth