



# Sleeping on Mars: A Hidden Challenge for Human Space Exploration

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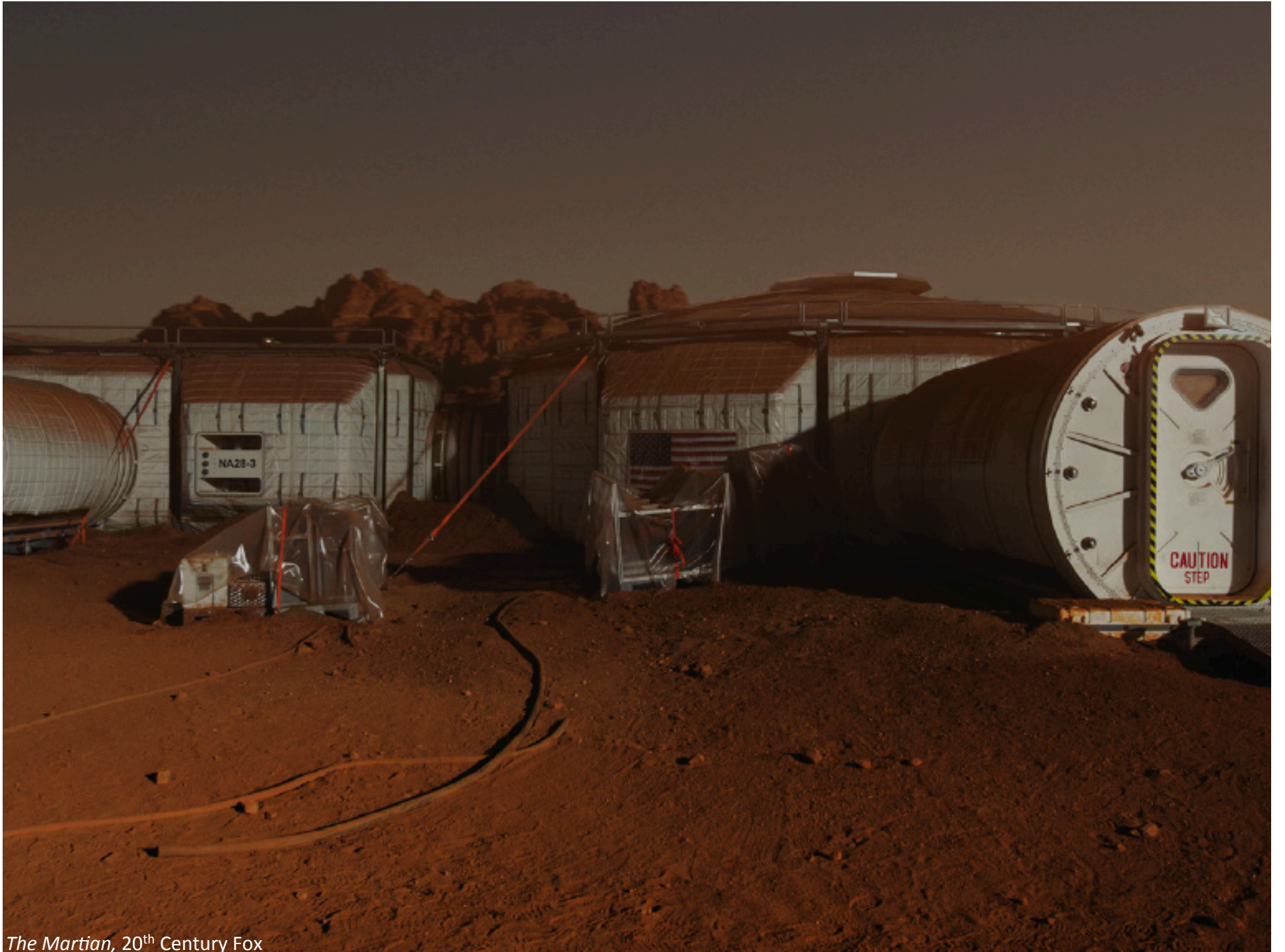
Fatigue Countermeasures Laboratory

NASA Ames Research Center



*The Martian*, 20<sup>th</sup> Century Fox





*The Martian*, 20<sup>th</sup> Century Fox





"VW Type2 T1c Kombi" by User Ermel on en.wikipedia - Photographed by Erik Meltzer in 2000.. Licensed under CC BY-SA 3.0 via Commons - [https://commons.wikimedia.org/wiki/File:VW\\_Type2\\_T1c\\_Kombi.jpg#/media/File:VW\\_Type2\\_T1c\\_Kombi.jpg](https://commons.wikimedia.org/wiki/File:VW_Type2_T1c_Kombi.jpg#/media/File:VW_Type2_T1c_Kombi.jpg)





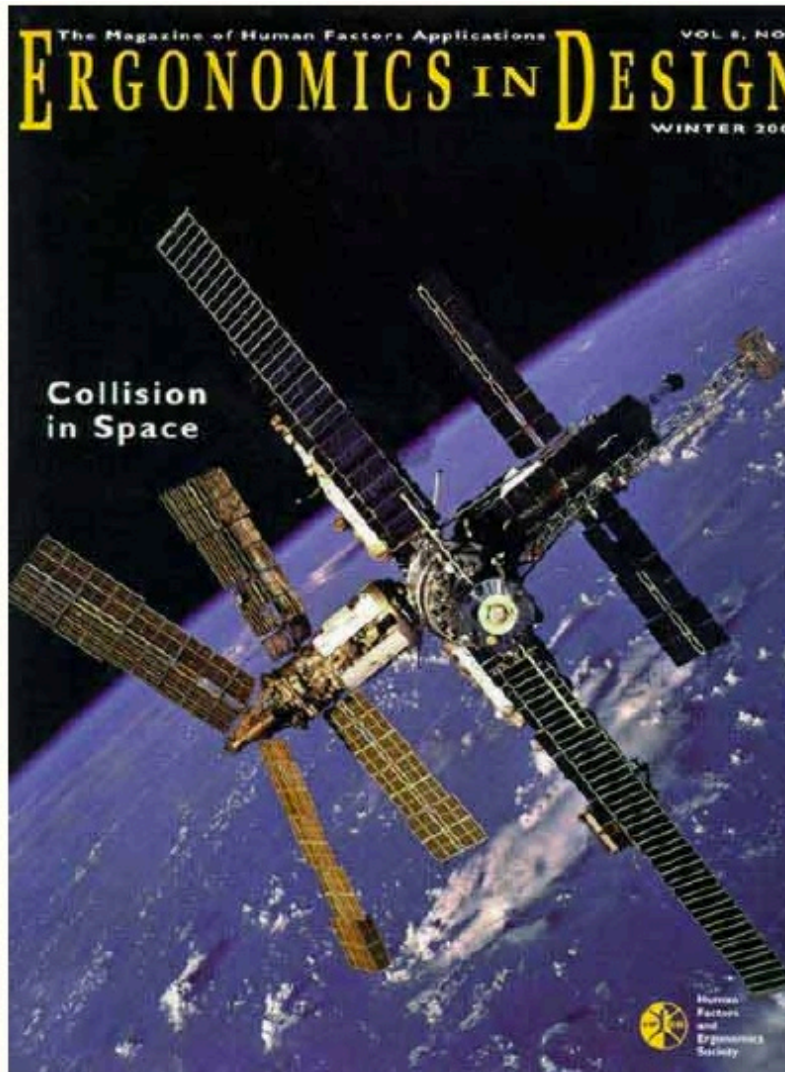
[http://www.nasa.gov/sites/default/files/styles/1x1\\_cardfeed/public/images/139573main\\_image\\_feature\\_470\\_ys\\_full.jpg](http://www.nasa.gov/sites/default/files/styles/1x1_cardfeed/public/images/139573main_image_feature_470_ys_full.jpg)

“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

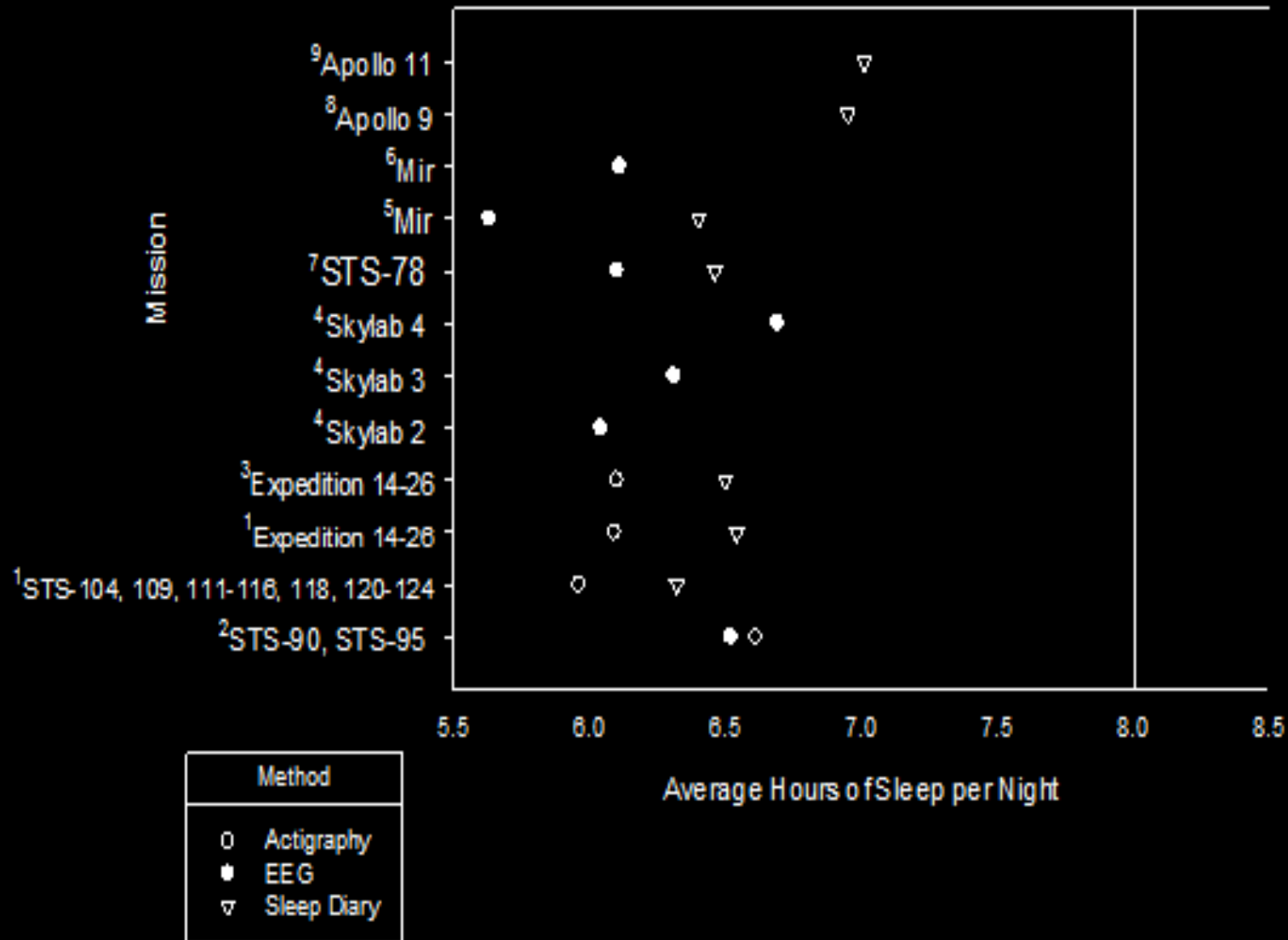




STS-109



# 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



# What makes us sleep?

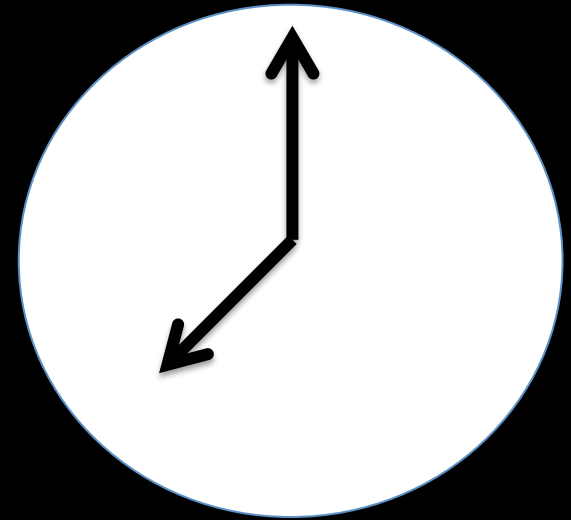
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## Modifiers of Physiological Response

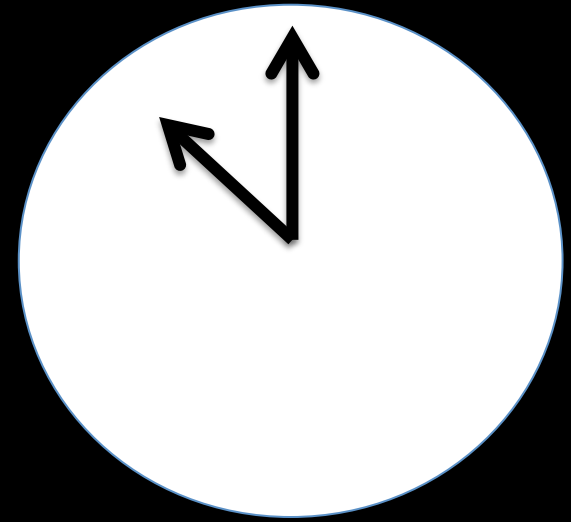
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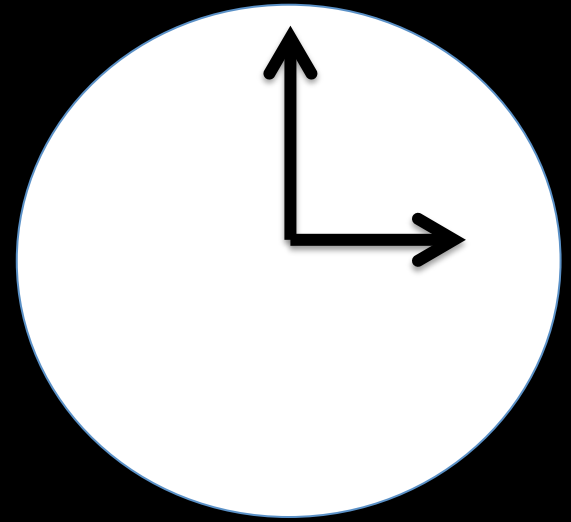


*Awake and rested*



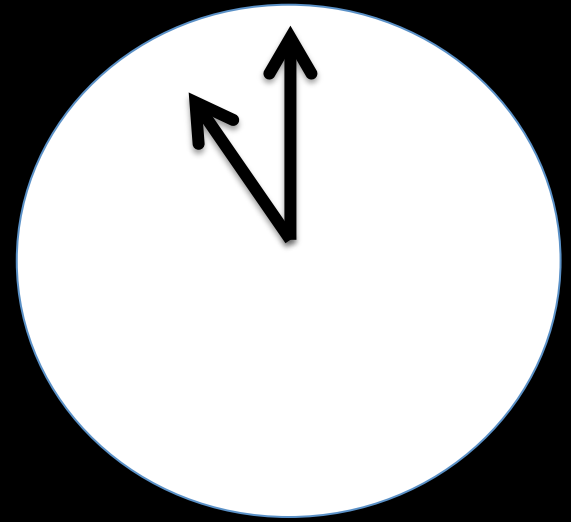
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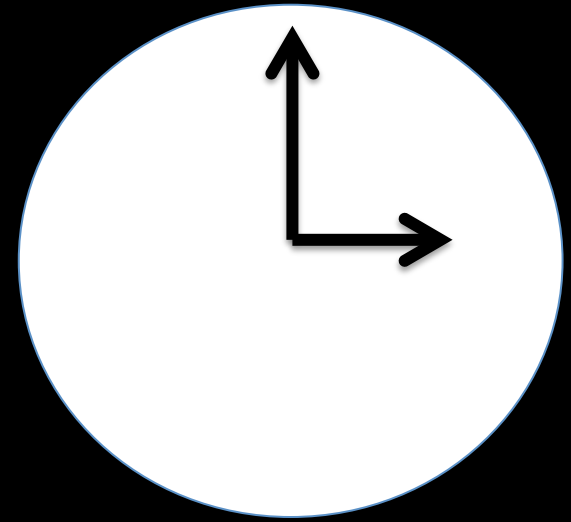
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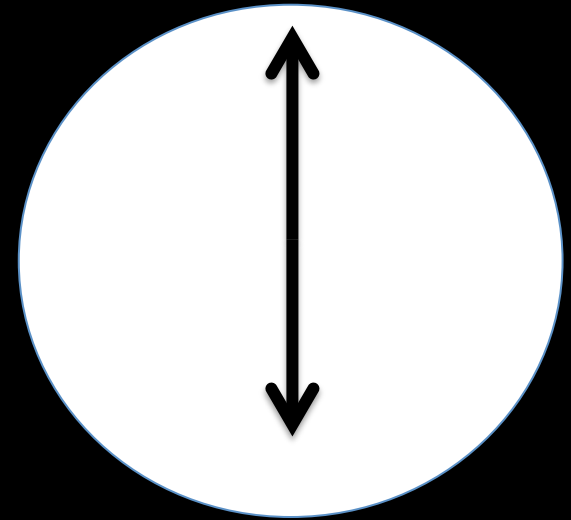




*Sleep*

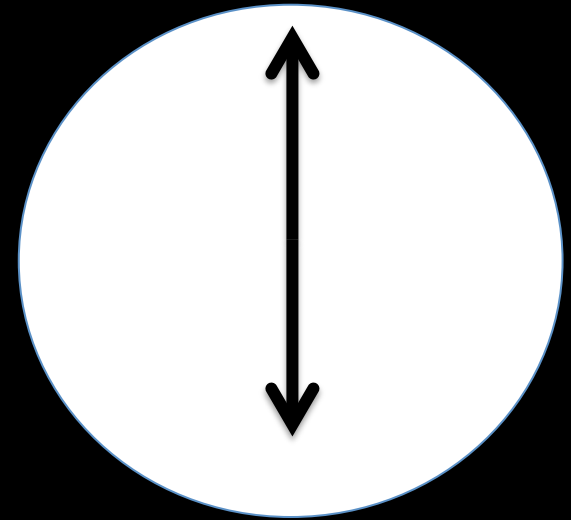
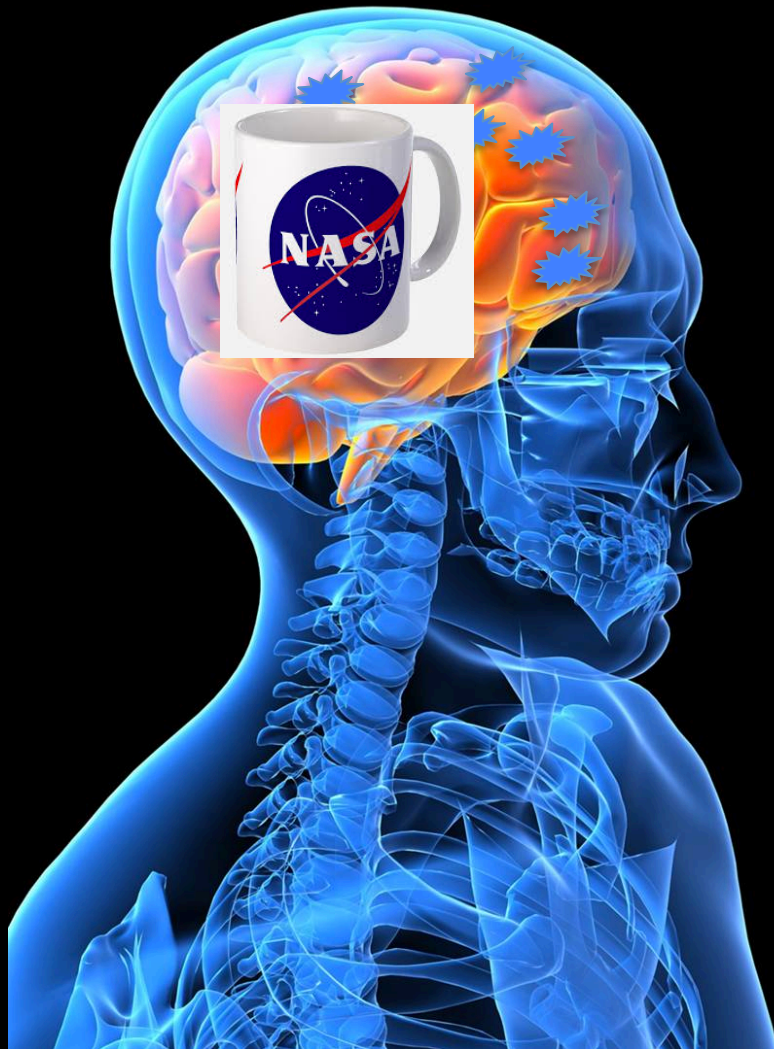
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*Sleep debt*

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*Caffeine*

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## Wide Awake on the Sea of Tranquility

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 Tranquility.**

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.











[http://www.nasa.gov/audience/forstudents/5-8/features/to\\_sleep\\_feature.html](http://www.nasa.gov/audience/forstudents/5-8/features/to_sleep_feature.html)



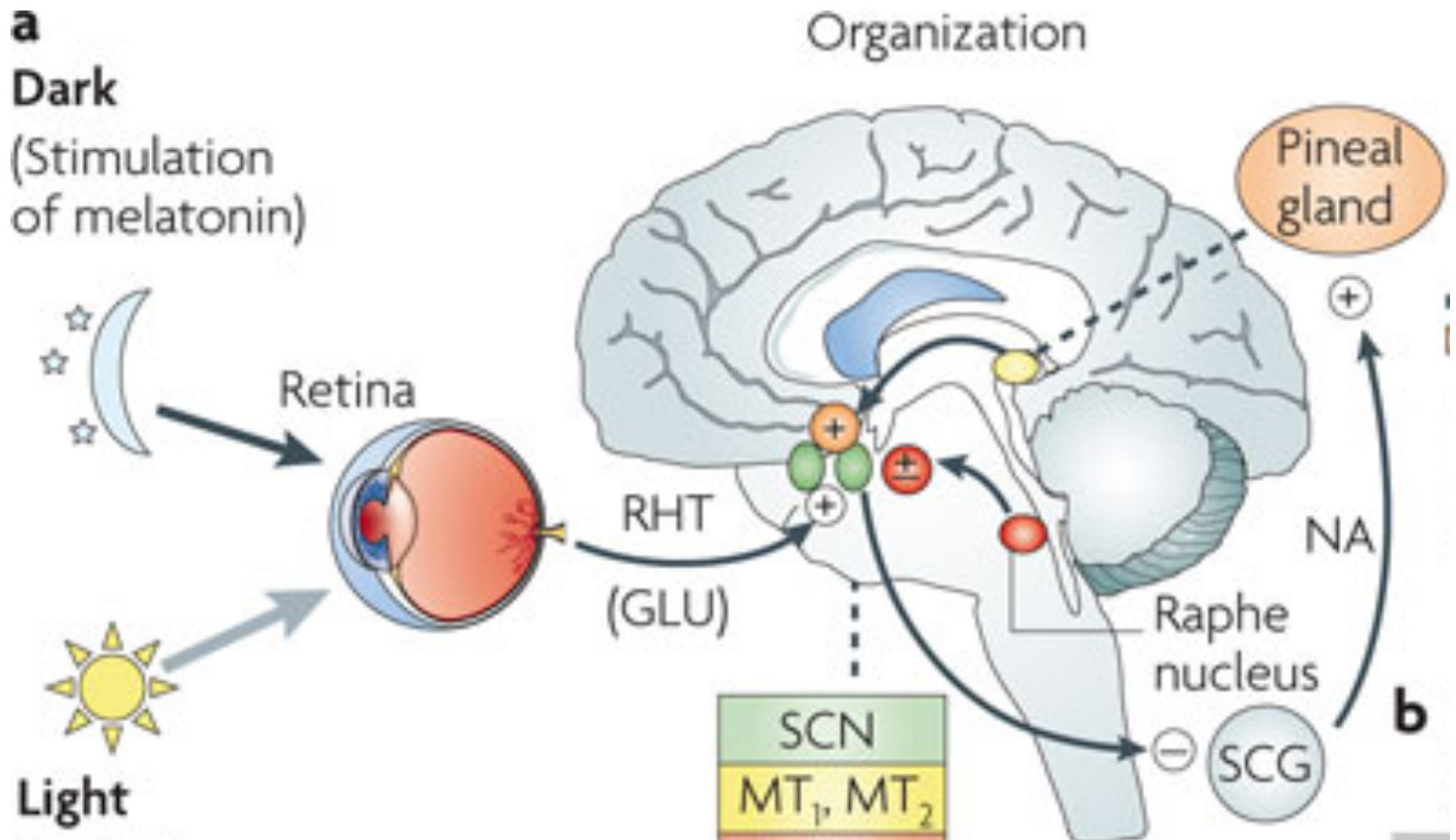
# Physiological Sleep Drive

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

## Modifiers of Physiological Response

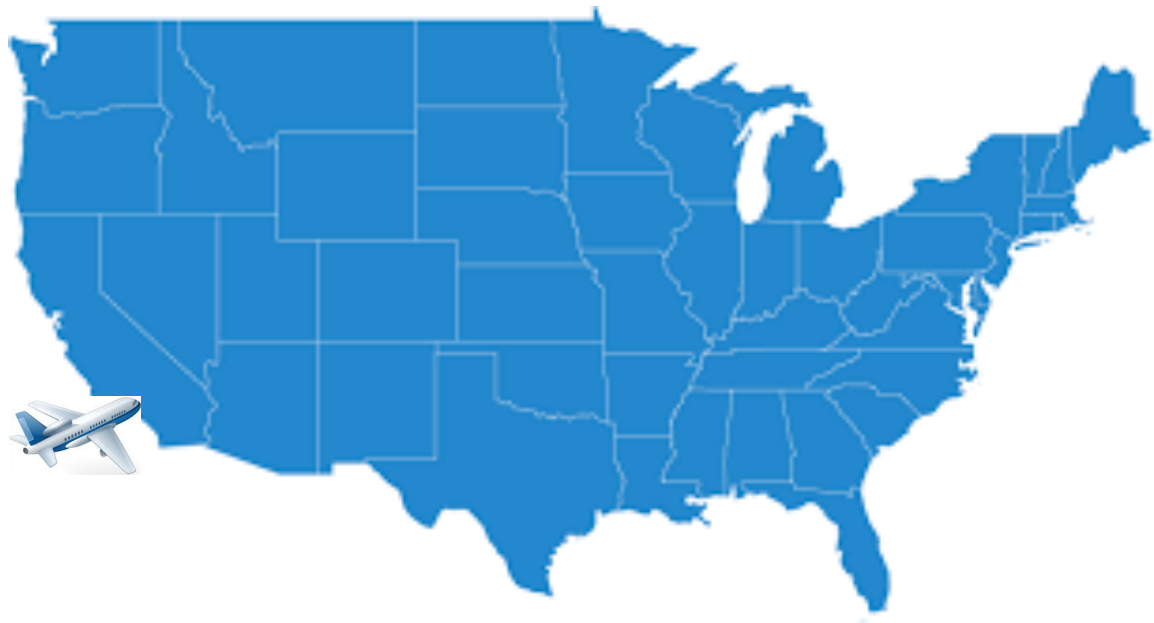
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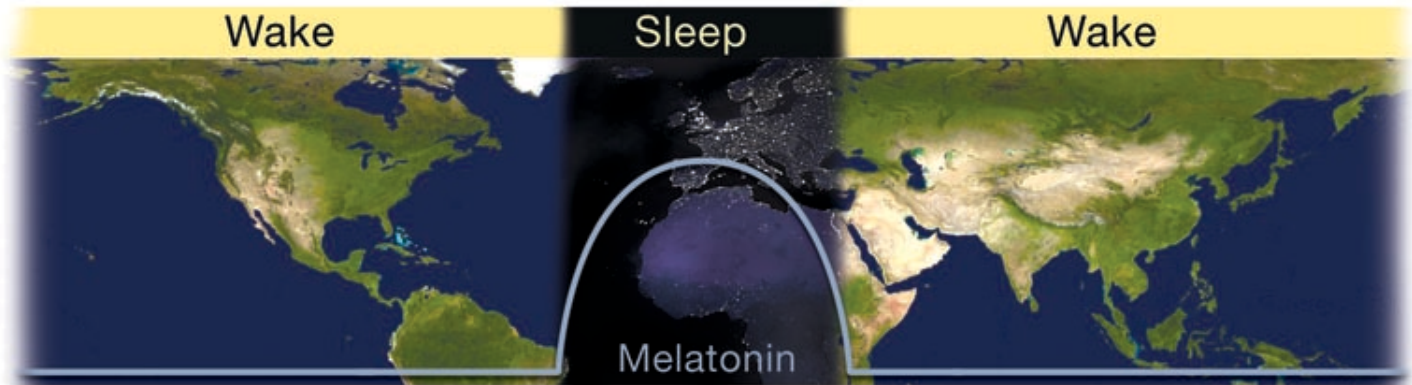
Bodinat *et al.* *Nature Reviews Drug Discovery* (August 2010)





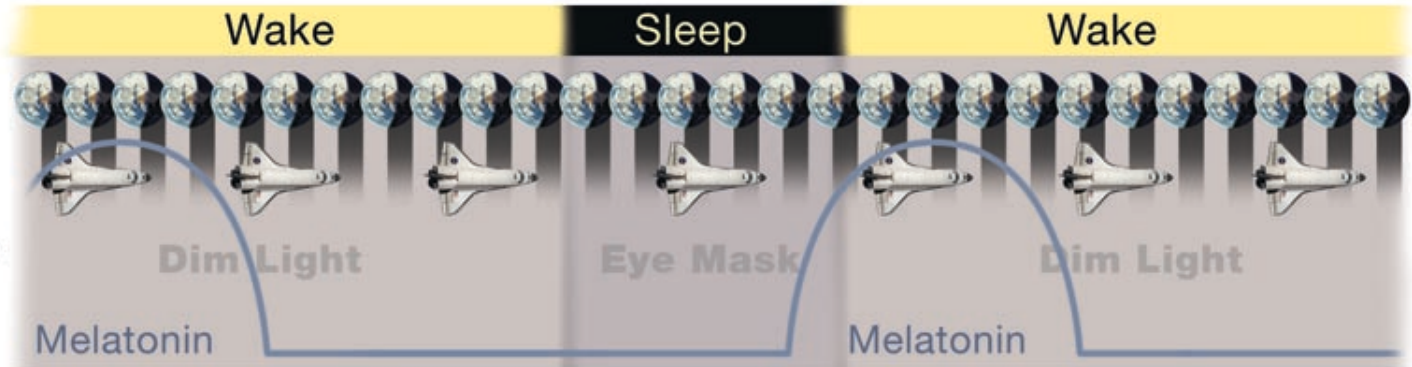
## Earth Conditions

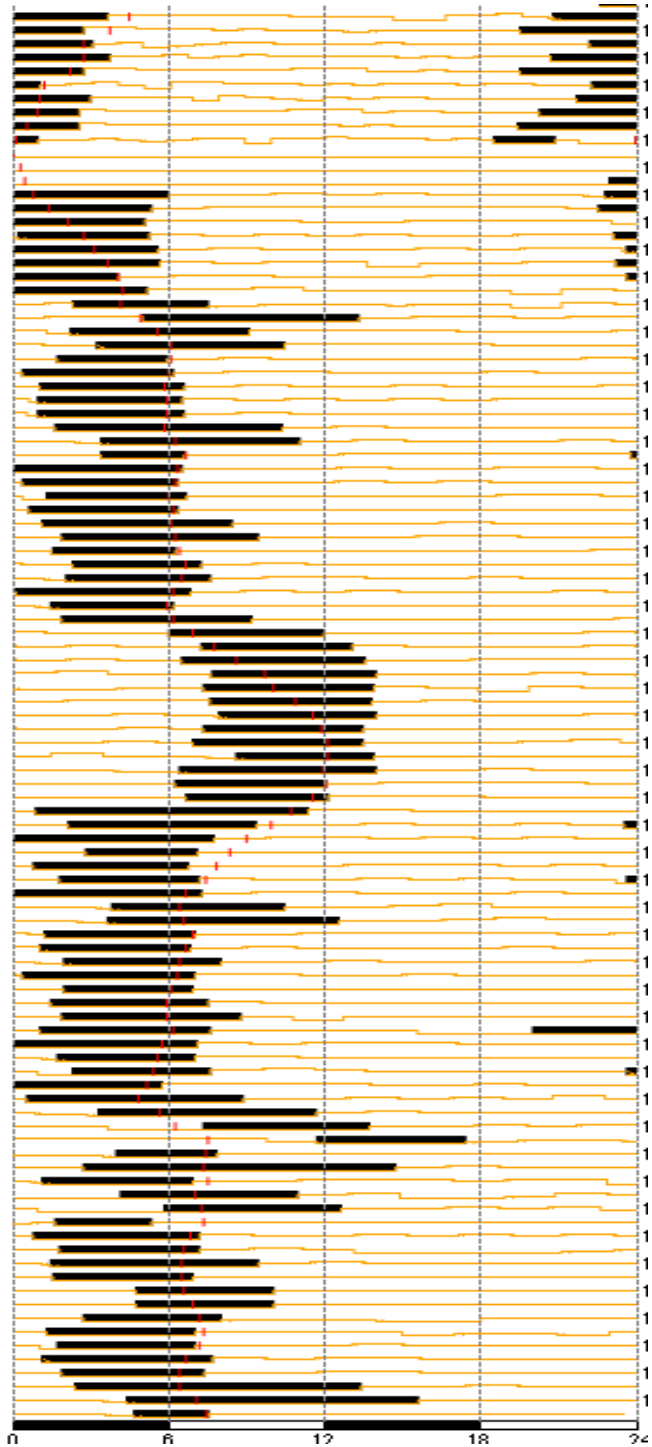
On a 24-hour external light/dark cycle, the body's circadian clock remains properly synchronized (e.g., hormones like melatonin are released at the appropriate time).



## 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).









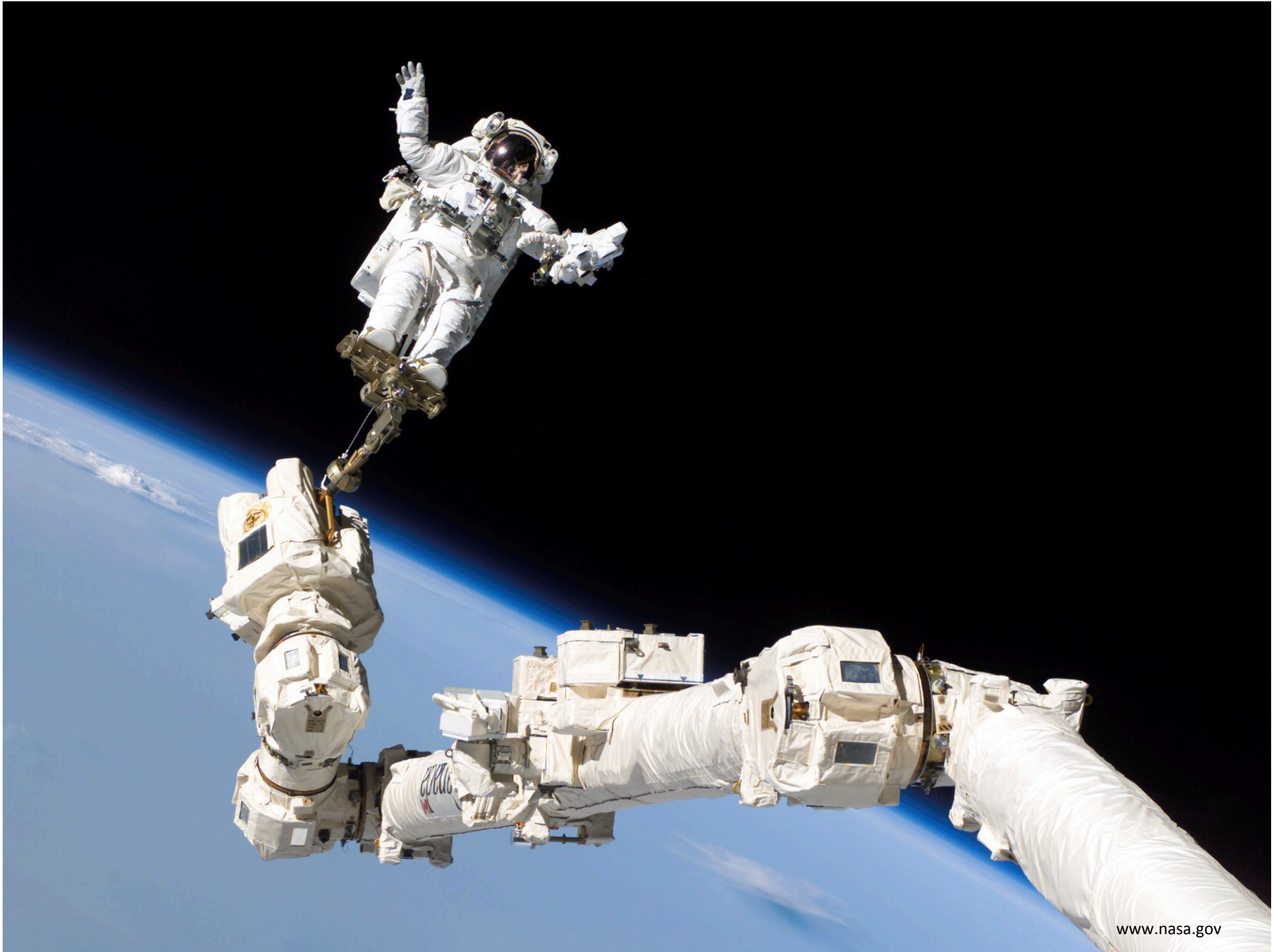
# Effect of Predicted Circadian Alignment on Sleep Outcomes

	Aligned	Misaligned	
	Mean (SD)	Mean (SD)	p-value
Actigraphy Sleep Duration (h)	6.4 (1.2)	5.5 (1.4)	<b>&lt;0.01</b>
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)	<b>&lt;0.01</b>
Alertness	57.9 (21.7)	53.5 (21.4)	0.14



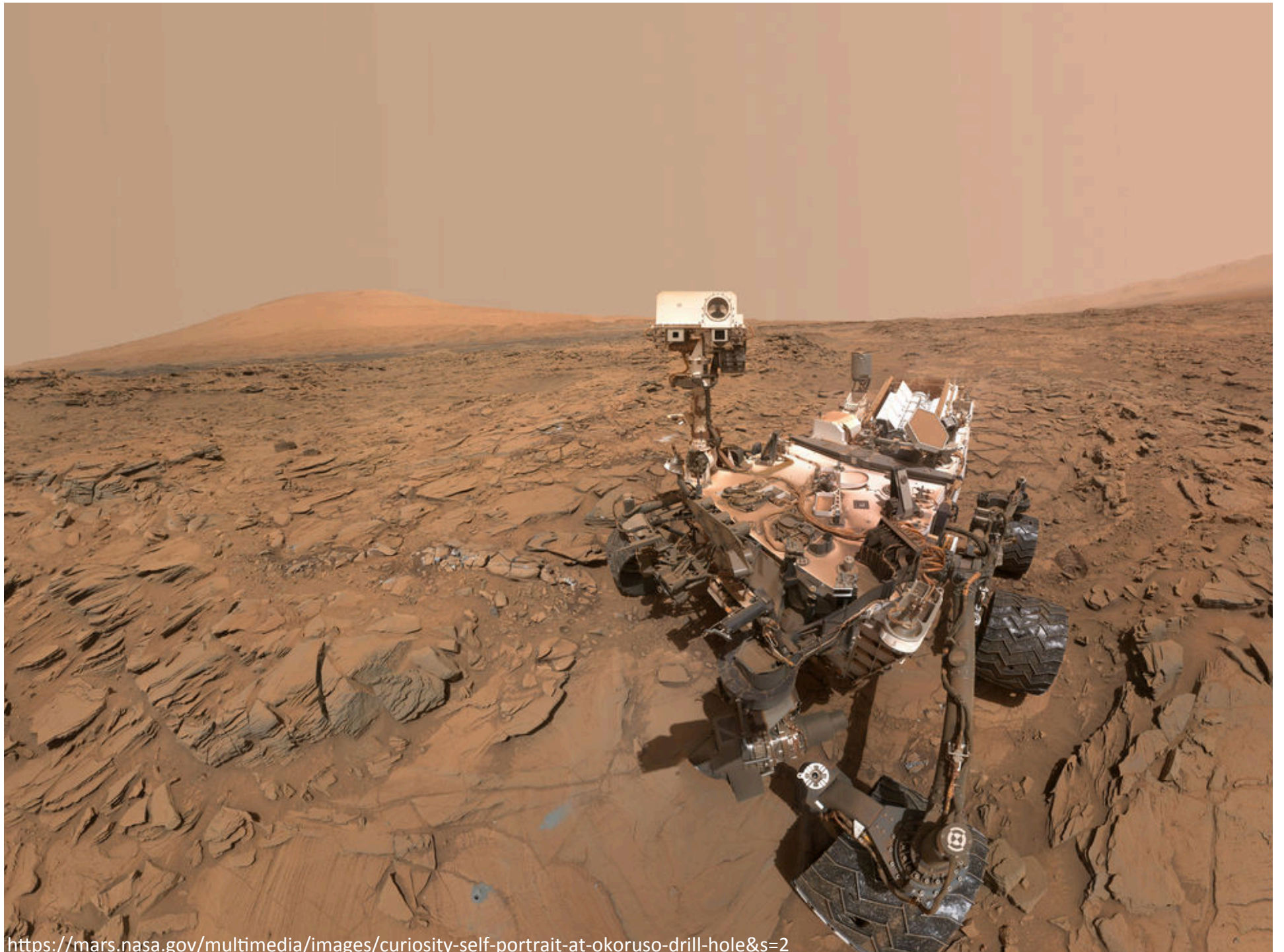












<https://mars.nasa.gov/multimedia/images/curiosity-self-portrait-at-okoruso-drill-hole&s=2>





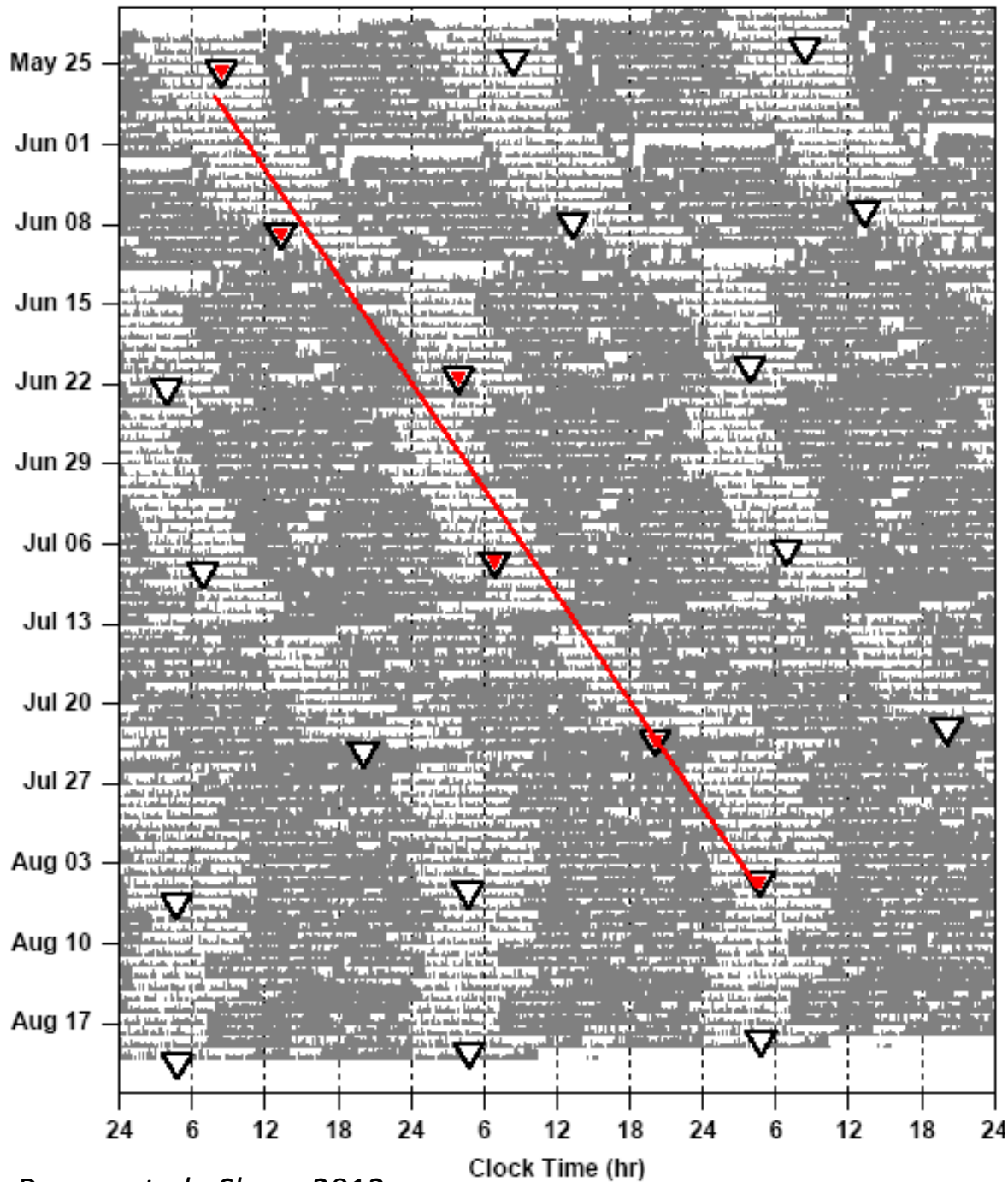
GARCIA-MONTUJO-BORRBE GENTRY

NIX MARS MISSION MURAL 200

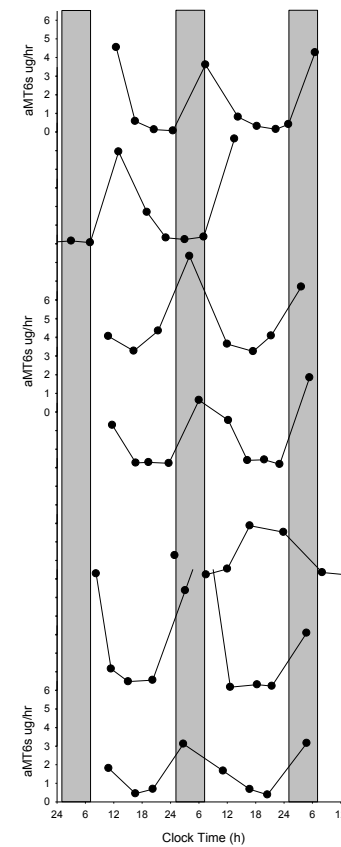
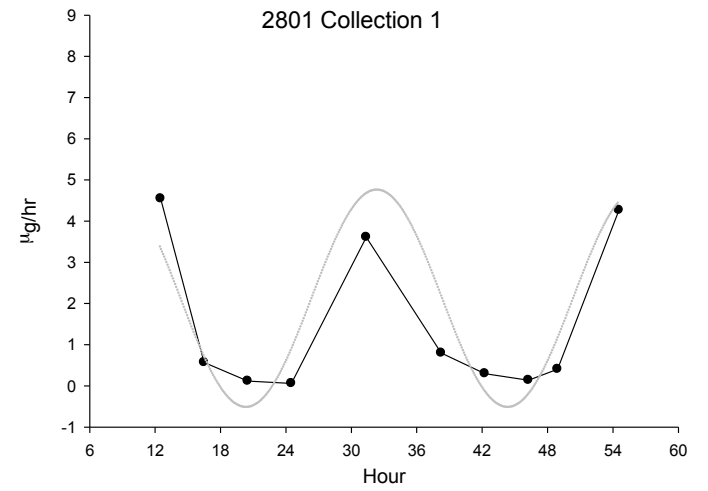




Credit University of Arizona

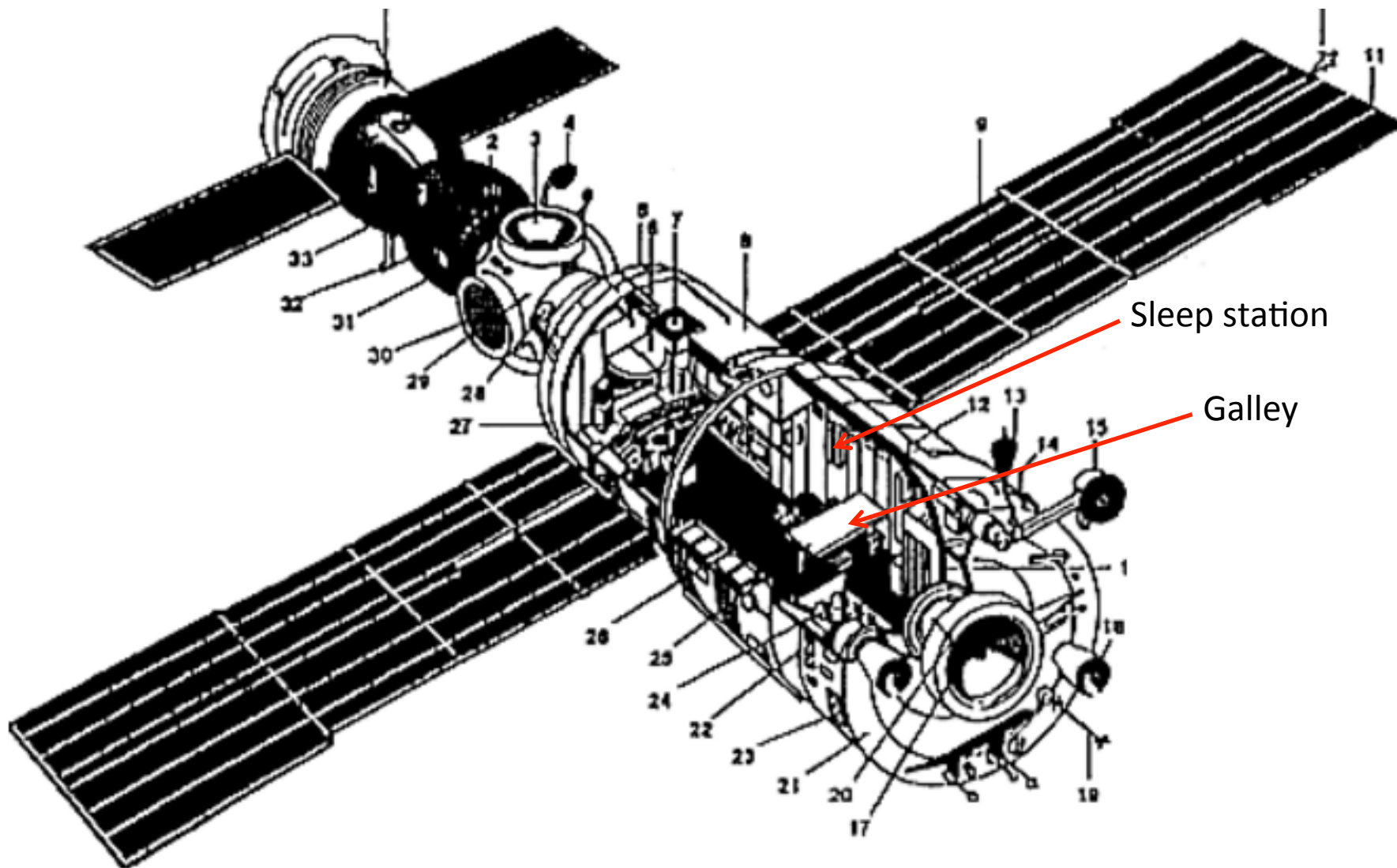


Barger *et al.*, *Sleep*, 2012







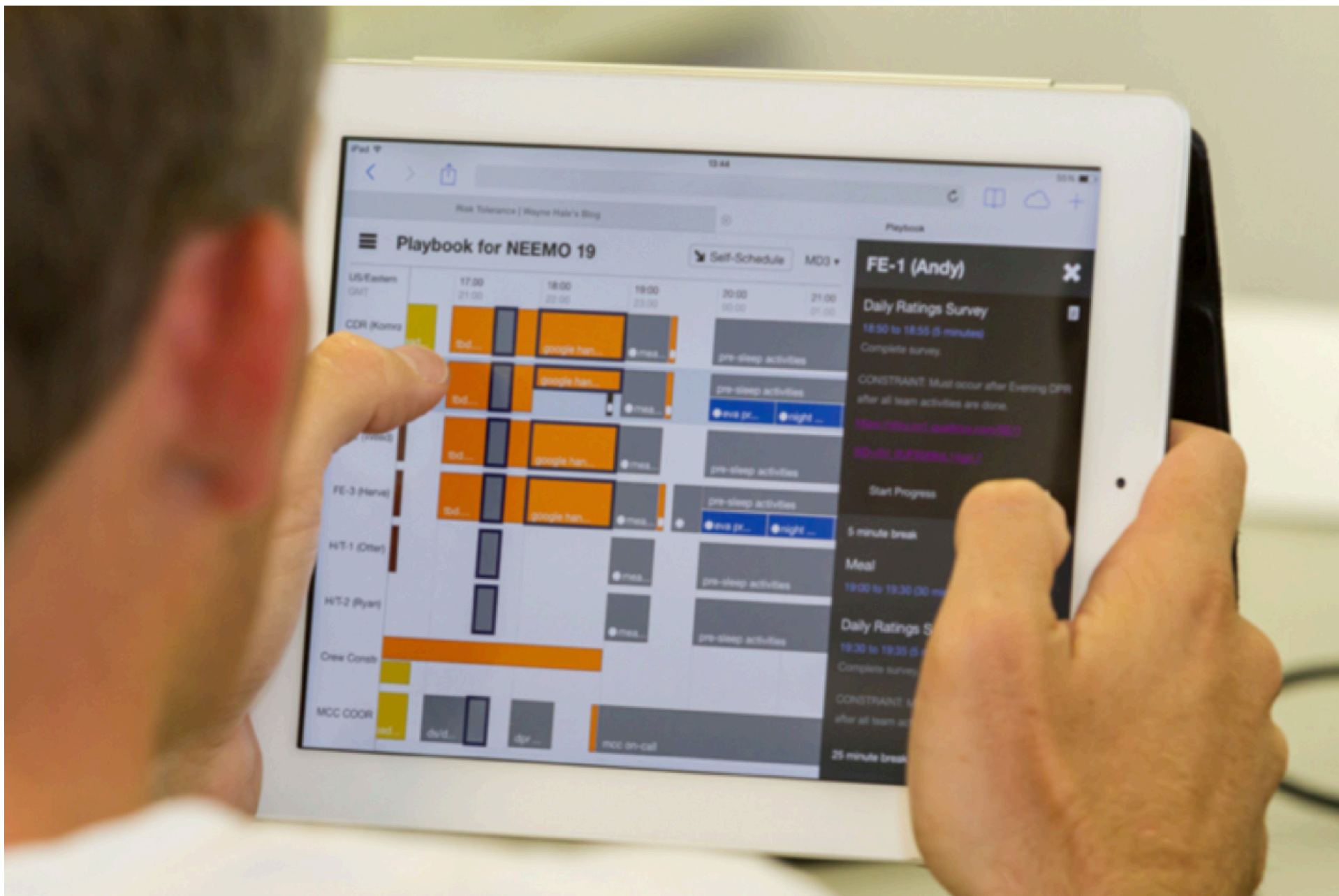


**Core Module (Base Block)**











National Aeronautics and  
Space Administration



# THE EVOLUTION OF A MARTIAN

[www.nasa.gov](http://www.nasa.gov)



# Thank You!

- Laura Barger Ph.D.
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- Curtis Kershner
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- Scott Beckett
- Liza Burke
- Lauren Brogna

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# MARS QUICK FACTS

FOR MORE INFO, VISIT [MARS.FAKR.COM](http://MARS.FAKR.COM)

### SIZE

Earth is 109 times larger than Mars.

Earth: 12,756 km (7,927 miles)  
Mars: 4,219 km (2,621 miles)

The size of Mars is similar to that of Pluto.

### MASS

Earth: 5,972,000,000,000,000 kg  
Mars: 642,000,000,000,000 kg

### VOLUME

Mars is only 15% of Earth's volume.

Earth: 1,083,211,367,000,000 km<sup>3</sup>  
Mars: 163,160,000,000,000 km<sup>3</sup>

### DENSITY

Mars is about 71% as dense as Earth.

Earth: 5,515 kg/m<sup>3</sup>  
Mars: 3,933 kg/m<sup>3</sup>

### STRUCTURE

Compared to Earth, the upper part of the Martian crust is 100% thicker.

Earth: Crust, Mantle, Liquid Outer Core, Solid Inner Core  
Mars: Crust, Liquid Outer Core, Solid Inner Core

### DISTANCE

Mars is 225 million km from the Sun on average.

225,000,000 km (140 million miles)

### SPEED

Mars travels at 24,000 mph.

24,000 mph

### YEAR

Mars has a year that is 687 Earth days long.

687 Earth Days

### DAY

Mars has a day that is 24.6 hours long.

24.6 HOURS

### GRAVITY

Mars has a gravity that is 38% of Earth's.

38% of Earth's Gravity

### TILT / SEASONS

Mars has a tilt of 25 degrees, which is similar to Earth's 23.5 degrees.

23.5° (Earth) / 25° (Mars)

### ATMOSPHERE

Mars has 100 times less atmosphere than Earth.

100x LESS ATMOSPHERE THAN EARTH

Gas	Earth (%)	Mars (%)
CO <sub>2</sub>	0.04	95
N <sub>2</sub>	78	2.6
O <sub>2</sub>	21	0.1
Ar	0.9	0.0001
H <sub>2</sub> O	0.0001	0.0000000001

### TEMPERATURE

Mars has a temperature range from -125°F to 57°F.

125°F, 57°F, 0°F, -125°F

### WEIGHT

Mars has a weight that is 38% of Earth's.

38% of Earth's Weight

### GRAVITY

Mars has a gravity that is 38% of Earth's.

38% of Earth's Gravity