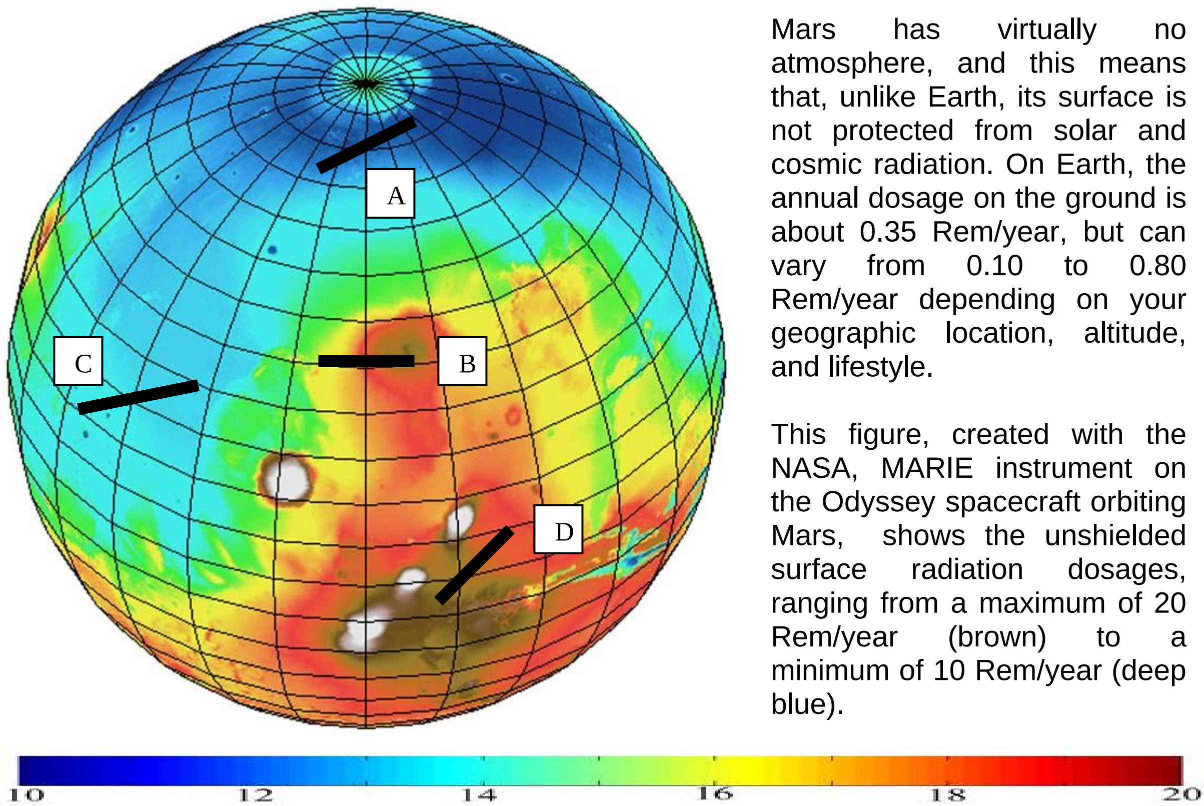

Mars has virtually no atmosphere, and this means that, unlike Earth, its surface is not protected from solar and cosmic radiation. On Earth, the annual dosage on the ground is about 0.35 Rem/year, but can vary from 0.10 to 0.80 Rem/year depending on your geographic location, altitude, and lifestyle.

This figure, created with the NASA, MARIE instrument on the Odyssey spacecraft orbiting Mars, shows the unshielded surface radiation dosages, ranging from a maximum of 20 Rem/year (brown) to a minimum of 10 Rem/year (deep blue).

Astronauts landing on Mars will want to minimize their total radiation exposure during the 540 days they will stay on the surface. The Apollo astronauts used spacesuits that provided 0.15 gm/cm^2 of shielding. The Lunar Excursion Module provided 0.2 gm/cm^2 of shielding, and the orbiting Command Module provided 2.4 gm/cm^2. The reduction in radiation exposure for each of these was about 1/4, 1/10 and 1/50 respectively. Assume that the Mars astronauts used improved spacesuit technology providing a reduction of 1/8, and that the Mars Excursion Vehicle provided a 1/20 radiation reduction.

The line segments on the Mars radiation map represent some imaginary, 1,000 km exploration tracks that ambitious astronauts might attempt with fast-moving rovers, and not a lot of food! Imagine a schedule where they would travel 100 kilometers each day. Suppose they spend 20 hours a day within a shielded rover, and they study their surroundings in spacesuits for 4 hours each day.

1) Convert 10 Rem/year into milliRem/day.

2) What is the astronauts radiation dosage per day in a region (brown) where the ambient background produces 20 Rem/year?

3) For each of the tracks on the map, plot a dosage history timeline for the 10 days of each journey. From the scaling relationship defined for one day in Problem 3, calculate the approximate total dosage to an astronaut in milliRems (mRems), given the exposure times and shielding information provided.

4) Which track has the highest total dosage in milliRems? The least total dosage? What is the annual dosage that is equivalent to these 20-day trips? How do these compare with the 350 milliRems they would receive if they remained on Earth?

Having a Hot Time on Mars!

1) Convert 10 Rem/year into milliRem/hour.

Answer: (10 Rem/yr) x (1 year/ 365 days) x (1 day/24 hr) = 1.1 milliRem/hour

2) What is the astronauts radiation dosage per day in a region (brown) where the background is 20 Rem/year?

Answer: From Problem 1, 20 Rem/year = 2.2 milliRem/hour.
20 hours x (1/20) x 1.1 milliRem/hr + 4 hours x (1/8) x 1.1 milliRem/hr = 1.1 + 0.55 = 1.65 milliRem/day

3) For each of the tracks on the map, plot a dosage history timeline for the 10 days of each journey. From the scaling relationship defined for one day in Problem 3, calculate the total dosage in milliRems to an astronaut, given the exposure times and shielding information provided. <u>The scaling relationship is that for each 20 Rems/year, the daily astronaut dosage is 0.66 milliRem/day (e.g. 0.66/20). The factor of 2 in the answers accounts for the round-trip.</u>

Track A dosage:

2x(12 Rems/yr x 10 days x (1.65 / 20)) = 2x(9.9) = 19.8 mRem.

Track B dosage:

2x(16 Rems/yr x 3.3days + 18 Rems/yr x 3.3days + 20 Rems/yr x 3.3days)(1.65/20) = 2x(14.8) = 29.6 mRem

Track C dosage:

2x(12 Rems/yr x 5 days x (1.65/20) + 14 Rems/yr x 5 days x (1.65/20)) = 2x(5.0 + 5.8) = 21.6 mRem

Track D dosage:

2x(18 Rems/yr x 5 days x (1.65/20) + 20 Rems/yr x 5 days x (1.65/20)) = 2x(7.5 + 8.25) = 31.5 mRem

4) For this 20-day excursion, Track D has the highest dosage and Track A has the lowest. The equivalent annual dosage for the lowest-dosage track is 19.8 milliRem x 365 days/10 days = 722 milliRem, which is about twice the annual dosage they would receive if they remained on Earth. For the highest-dosage trip, the annualized dosage is 1,149 milliRems which is about 3 times the dosage on Earth.