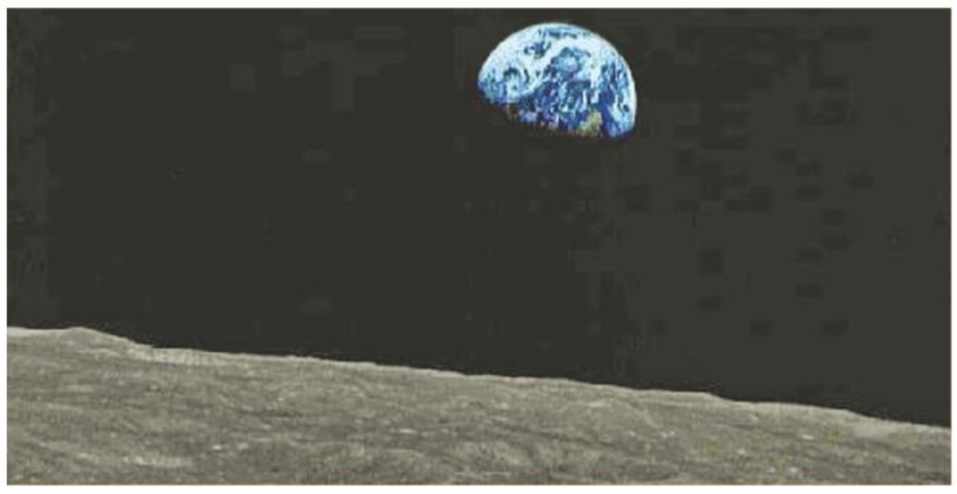
Recession of the Moon

DR. QUAMRUL HAIDER

THE gravitational force, which is the weakest of the four fundamental forces in nature, is an action-reaction force. So, just as Moon's gravitational force on Earth results in tidal friction (action) that eventually slows down Earth's rotational and orbital speeds (TDS May 21, 2013), Earth's gravitational force also exerts a frictional force (reaction) on the Moon. However, the effect of tidal friction is more drastic on Moon because of its relatively smaller size and mass. The Moon being a solid body undergoes deformation of its surface only, a phenomenon known as solid tide. Its shape becomes slightly elongated along the line toward the Earth.

Tidal friction has slowed the rotational and orbital speeds of the Moon long ago to the extent that it takes the same time to spin once on its axis as it takes to go around the Earth, i.e. lunar month and day are equal – 29.53 days. This is known as synchronous rotation and is similar to the situation with communication satellites placed in Earth's orbit with 24-hour period. The Moon, therefore, keeps only one side, the "near side," facing the Earth. Does this mean that the "far side", also known as dark side, is perpetually dark? No. It is illuminated as often as the near side. When there's a full moon the far side is the dark side, but when it's a new moon the far side is the illuminated side.



Earth as viewed from the Moon.

The Earth, as viewed from the Moon by the Apollo astronauts, always remained in the exact same position in the sky. Eventually we will also be in same situation as the Moon, probably after billions of years from now. It happened to the Moon much earlier because Earth's tidal force is stronger. Most of the natural satellites in the solar system are in synchronous rotation because of the tidal effects of their parent planets.

As Earth slows down it loses rotational kinetic energy. Energy conservation requires that Moon gain energy. In other words, Earth transfers energy to Moon through the tidal bulge and gravity. This extra energy gained by the Moon causes it to speed up and move farther away from us. Current estimates show that the Moon is receding from us at a rate of 3.8 cm per year. This rate has been determined by a technique known as Lunar Laser Ranging, which uses "corner mirrors" installed on the Moon by the Apollo astronauts in the 1960s.

Planetary models indicate that the closest distance between Earth and the Moon was 18,400 km. It took only 1.37 billion years for the Moon to reach its present distance of 384,400 km. As the Moon grows more distant, its orbital period about the Earth increases adding about 0.014 seconds per century to the lunar month.

If the present rate of recession continues, sometime in the distant future Moon will be so far away that its shadow will no longer reach Earth and total solar eclipse will cease to exist. Different planetary models predict that when both solar day and lunar month will become equal to 47 of our present days, tidal friction will cease. The Earth and Moon will then be tidally locked to each other and Earth will rotate synchronously with Moon and no further recession will occur. Each will perpetually keep the same face turned toward each other and Moon will be visible from one side of Earth only. In other words, Moon as viewed from Earth will appear suspended in the sky. It is estimated that this will happen when Moon will be approximately 645,000 km away from Earth.

Within the solar system, Pluto and its Moon Charon are already in synchronous rotation. Outside the solar system, many binary stars (similar to the Earth-Moon system) are also in synchronous rotation.

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FOOD

Feeding nine billion people

AN international team of scientists has developed crop models to better forecast food production to feed a growing population -- projected to reach 9 billion by mid-century -- in the face of climate change.

In a paper appearing in Nature Climate Change, members of the Agricultural Model Intercomparison and Improvement Project unveiled an all-encompassing modeling system that integrates multiple crop simulations with improved climate change models. AgMIP's effort has produced new knowledge that better predicts global wheat yields while reducing political and socio-economic influences that can skew data and planning efforts, said Bruno Basso, Michigan State University ecosystem scientist and AgMIP member.

"Quantifying uncertainties is an important step to build confidence in future yield forecasts produced by crop models," said Basso, with MSU's geological sciences department and Kellogg Biological Station. "By using an ensemble of crop and climate models, we can understand how increased greenhouse gases in the atmosphere, along with temperature increases and precipitation changes, will affect wheat yield globally."

The improved crop models can help guide the world's developed and developing countries as they adapt to changing climate and create policies to improve food security and feed more people, he added.

Source : **Science Daily**

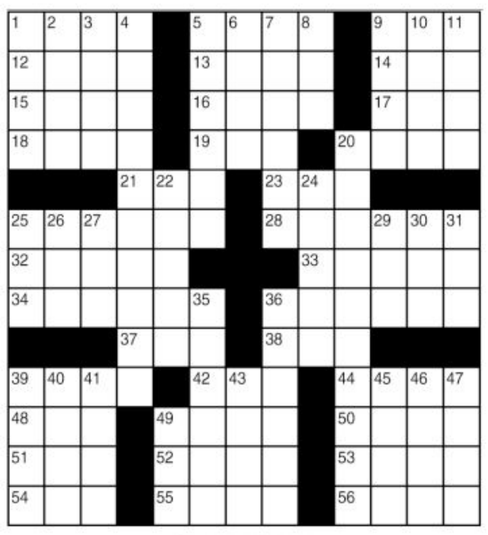
ACROSS
1 Item on stage
5 Relaxation
9 "Help!"
12 Emanation
13 Picture of health?
14 Demonic tyke
15 Dance lesson
16 Green land
17 Grazing area
18 Loafer, e.g.
19 Wrestling surface
20 Small horse
21 Tear
23 Eggs
25 Ought not
28 Plunder
32 Jellied dish
33 Flat
34 Neptune or Poseidon
36 Makes baby food, maybe
37 Id counterpart
38 Allow
39 "Ironside" star
42 Definite article
44 "Phooey!"
48 Past
49 Desktop symbol
50 Sheltered
51 Under the weather
52 Filly's brother
53 Mountain goat
54 Caustic chemical
55 TV trophy
56 "— and the Tramp"

DOWN
1 Just say no
2 Naomi's daughter-in-law
3 Sandwich treat
4 Empty threat
5 Free from a duty
6 Met melody
7 Tailor, humorously
8 Storm center
9 Missile shelter
10 Portent
11 Fix, in a sense
20 Evidence of white-collar crime
22 Disguised, for short
24 Cost
25 "More," to José
26 Work with
27 Hot tub
29 Word implied in "been there, done that"
30 Born
31 Golfer Ernie
35 E-business
36 More than enough
39 Kind of bond
40 Pre-swan
41 Portrayal
43 Ian or Celeste
45 Jessica of "Fantastic Four"
46 Prepared to drive
47 Alluring
49 Lemieux milieu

Solution time: 27 mins.

A	S	P		R	I	L	E		S	O	D	A
T	E	E		E	V	I	L		A	N	E	W
M	A	R	S	H	A	L	L		L	U	L	L
		J	O	A	N			O	A	S	I	S
P	L	U	M	B		B	E	R	M			
R	A	R	E		M	A	R	Z	I	P	A	N
I	V	E		V	E	R	S	O		E	M	U
M	A	R	R	I	A	G	E		O	D	I	N
		H	A	T	E		S	K	I	D	S	
R	E	P	E	L			B	E	R	G		
I	C	E	S		M	A	R	G	A	R	E	T
T	H	O	U		E	S	A	U		E	R	A
E	O	N	S		T	I	M	E		E	R	B

Yesterday's answer 5-4



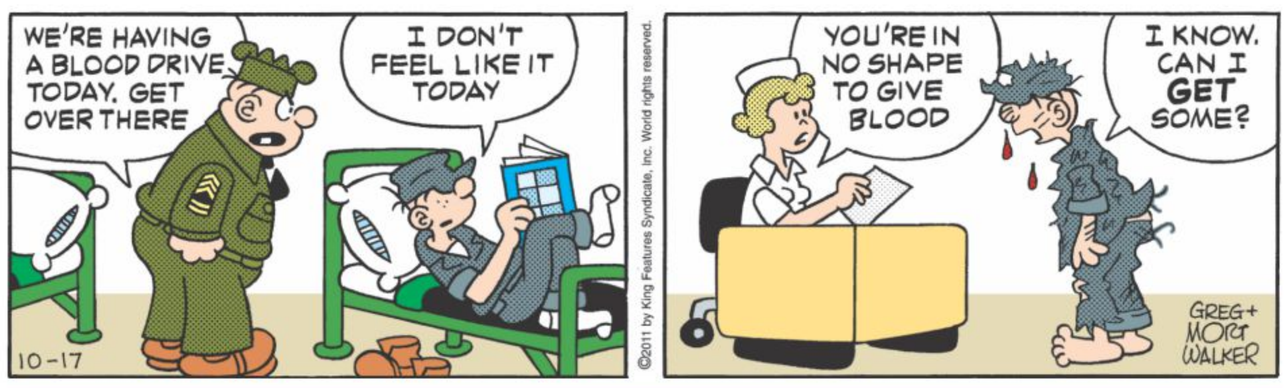
CRYPTOQUIP

JYFJ PFEYAHKFOIN DYNP AE MWNJJB MWNJNKJAHXE. PHW AKEJFKDN, YN HKIB OXBE GNEARKNW IFGINE.

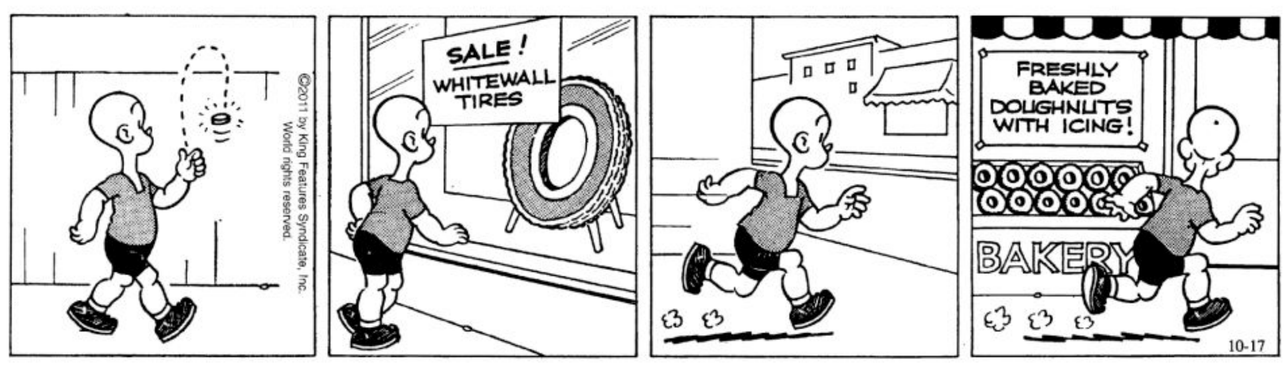
Yesterday's Cryptoquip: IF YOU SPILLED A WHOLE CUP OF PEKOE ON YOURSELF, I RECKON YOU'D END UP WEARING A TEA SHIRT.

Today's Cryptoquip Clue: Y equals H

BEETLE BAILY by Mort Walker



HENRY by Don Tranchte



QUOTABLE *Quotes*

"One of the penalties of refusing to participate in politics is that you end up being governed by your inferiors."

Plato