Electromicrobiology: Emerging discipline

S. Ashraf Ahmed

I started this article three years ago. Now the field has matured enough to complete the story. Yes, electricity from microorganisms! So it is called electro-microbiology, and I think it is destined to proliferate.

Electricity is the flow of electrons from high abundance to low abundance between two spots connected by a wire. The difference in electron pressure between these spots is called volts. In biology, most of the work such as heart beat, walk, talk or thought derives energy from the flow of electrons generated from oxidation of foodstuffs. These electrons sequentially jump or travel from one biological acceptor to another. Metal containing cytochromes, and several vitamin forms, differing by only few millivolts, act as biological electron acceptors. For humans and other oxygen-respiring organisms, the ultimate electron acceptor is oxygen to produce water and the biological form of energy called ATP.

Now scientists have identified wires produced by microorganisms through which electrons flow from one place to another.

Anaerobic bacteria strived on the earth, when there was no oxygen in the atmosphere, by transferring electrons to metals. Later, scientists found a clue to the role of bacteria in the corrosion and transformation of iron and steel. This led to the discovery of metal transforming Shewanella and Geobacter bacteria.

Microbial communities that transfer electrons between cells and across relatively long distances launch a new field of microbiology.

Recent nano-scale experiments have demonstrated that one of these bacterial cells can transmit electrons to another cell separated by many cell lengths! Scientists found that there are wires, multiples of them crisscrossing many cells. In the *Shewanella* bacteria long appendages called pili or nanowires are embedded lengthwise with flavins, a type of B2 vitamin, which are biological electron transporters. Its cell membranes are studded with iron containing cytochromes that can accept and donate electrons. So the electrons could travel long distance through the wires from one cell to another. Scientists also found that bacteria could deposit electrons to artificial electrodes!

Bacterial cells can transfer electrons in different ways too. Last year, an international effort (*Nature* 491:218 (2012)) demonstrated the existence of centimeter-long bacterial strings in marine sediments. Thousands of single bacteria were arranged end to end in a shared periplasmic sheath. The cell at the bottom could derive electrons from hydrogen sulfide from submerged thermal vents. The electrons could travel through the periplasmic space to the cell at the top that has access to oxygen. Oxidation of the electrons generates energy for survival of all the bacterial cells in the string.

It is the discovery that *Shewanella* and *Geobacter* and other bacteria can (1) grow in the absence of oxygen, (2) oxidise organic molecules to generate electrons, (3) reversibly deposit electrons to metals and electrodes, and (4) transport the generated electrons thousands of cell distances away allowed scientists to conceive the idea of making microbial circuits or living bioelectronic devices. Recent reviews (*The Scientist* 27(5): article #35299 (2013); *Ann Rev* Microbiol 66:391 (2012) by pioneers in the field discussed the potential use of *microbes* in making bio transistors, capacitors, environmental sensors, and wires for electronic devices.

While an in depth analysis of the electric properties of bacteria are being pursued by academic scientists (PNAS 109:10042), others are at work to harness a more economic and environmental benefit. Disposing of agricultural, domestic, human and animal waste has been an everlasting problem throughout human civilization. Discovery of bacterial reductive properties discussed above led scientists at the famous Craig Venter Institute and other universities to device microbial fuel cells that should convert sewer waste into electricity instead of generating wasteful foul gas and sludge in the conventional and expensive oxidation treatment plants.

The writer, a former Dhaka University teacher, is a biomedical scientist working in the USA.

BASELESS

What is the polar shift theory?

SHARMEEN RAHMAN

As the name suggests, polar shift is simply the shifting of the poles of the planet earth. As per Dr. David Morrison, director of NASA lunar science institute; reversal in rotation is impossible, it has never happened in the past nor shall ever take place.

Continents do move slowly but by taking time periods of millions of years. Most importantly, their movements are totally irrelevant to rotation of poles.

The magnetic or geomagnetic field of the earth (a field extending from the inner core of the earth to where it meets the solar wind) moves and changes in about 400,000 years. It has no harm to life on earth and remarkably no connection to the rotation of the earth as well. Neither is one expected anytime soon.

So, we can sit back and relax that there is no threat to our lives from the so called polar shift theory exaggerated in the year 2012. The illogical and baseless websites have simply misguided people and caused fear for no good reason.

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CLEAN WAY

Sustainable energy breakthrough

A University of Colorado Boulder research team has moved closer to what some call the Holy Grail of a sustainable hydrogen economy -- splitting water with sunlight.

The CU-Boulder team has devised a solar-thermal system designed to use a vast array of ground mirrors to concentrate sunlight onto a single point atop a central tower up to several hundred feet tall. The tower would gather heat to roughly 2,500 degrees Fahrenheit (1,350 Celsius) and then deliver it into a reactor containing chemical compounds known as metal oxides.

As the metal oxide compound heats up, it releases oxygen atoms, changing its material composition and causing the newly formed compound to seek out new oxygen atoms. The team showed that adding steam to the system would cause oxygen from the water molecules to adhere to the metal oxide surface, freeing up hydrogen molecules for collection as hydrogen gas. To get the steam, the concentrated sunlight beamed to the tower would heat the water to boiling.

Artist's conception of a commercial hydrogen production plant that uses sunlight to split water to produce clean hydrogen fuel.

Conventional theory holds that producing hydrogen through the metal oxide process requires (i) heating the reactor to a high temperature to remove oxygen(ii) then cooling it to a low temperature before (iii) injecting steam to re-oxidize the compound and release hydrogen gas for collection. The innovation here is that no swing in temperature is required. The whole process can be undertaken at the same temperature, and can be driven by turning a steam valve on or off.

With the new method, the amount of hydrogen produced to power fuel cells or for storage is entirely dependent on the amount of metal oxide (a combination of iron, cobalt, aluminum and oxygen), and how much steam is introduced into the system.

The researchers envision building reactor tubes roughly a foot in diameter and several feet long, filling them with the metal oxide material and stacking them on top of each other. A working system to produce a significant amount of hydrogen gas would require a number of the tall towers, each with its own reactor, to gather concentrated sunlight from several acres of mirrors surrounding each tower.

A paper on the National Science Foundation-funded research was published in the August 2 issue of *Science*.

Source: **Live Science**

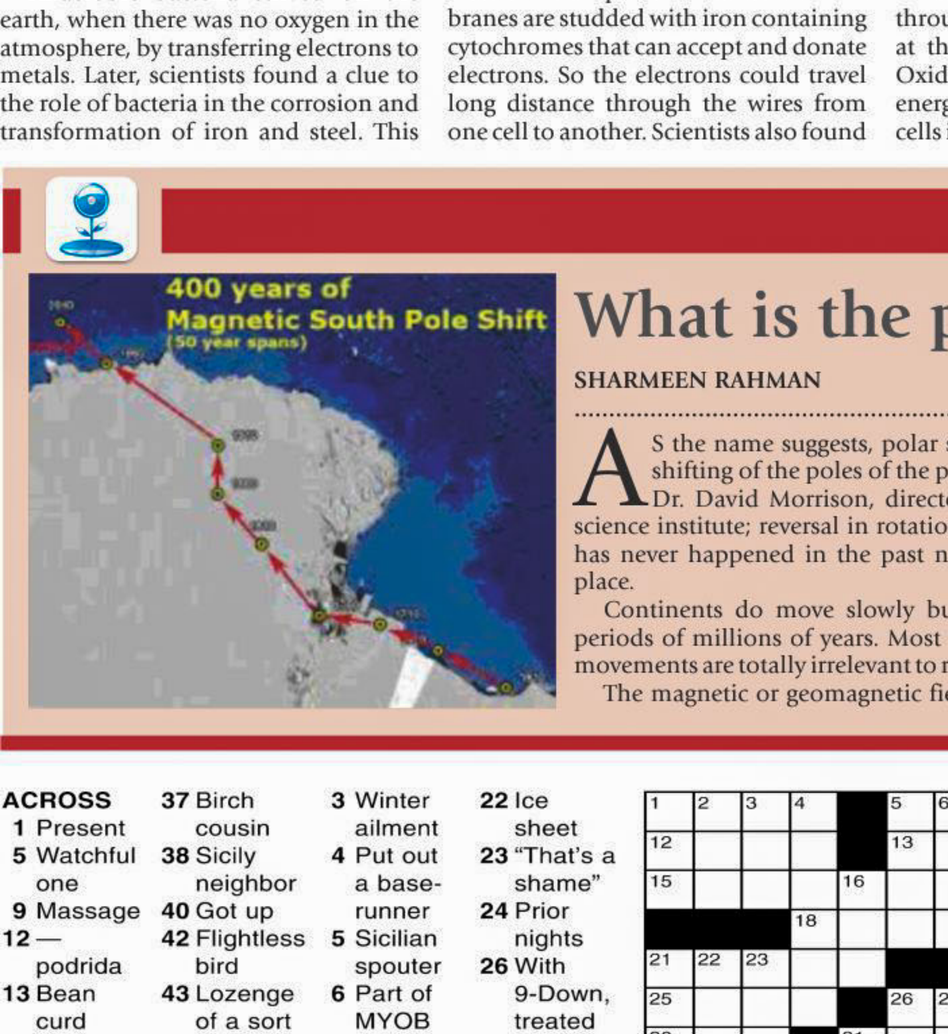
ACROSS
1 Present
5 Watchful one
9 Massage
12 — podrida
13 Bean curd
14 Raw mineral
15 Non-dieter's breakfast?
17 Work with
18 Paraphernalia
19 Frat party outfits
21 Following
24 2007 movie, "In the Valley of —"
25 Lummox
26 Flip-flop
30 Marker
31 Strength
32 Weeding tool
33 Reduces in status
35 Corn recipe
36 Gap
37 Birch cousin
38 Sicily neighbor
40 Got up
42 Flightless bird
43 Lozenge of a sort
48 First X or O?
49 Satanic
50 Fish's lung
51 "Raiders of the Lost —"
52 Logical
53 Vortex

DOWN
1 Deity
2 U.N. workers' grp.
3 Winter ailment
4 Put out a baserunner
5 Sicilian spouter
6 Part of MYOB
7 Small salamander
8 Rancher's foe
9 See 26-Down
10 — Minor
11 Honey bunch
16 That girl
20 Rowing prop
21 Alkali neutralizer
22 Ice sheet
23 "That's a shame"
24 Prior nights
26 With 9-Down, treated harshly
27 Lamb's dam
28 Top-rated
29 Sly look
31 Majestic homes
34 Decay
35 Vow
37 Blond shade
38 Beyond (Pref.)
39 Eastern potentate
40 Destruction
41 Lecherous look
44 Eggs
45 Disencumber
46 Antiquated
47 Thickness

Solution time: 21 mins.

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

Yesterday's answer 7-2



CRYPTOQUIP

L M P R T F M G P R Z P I R K J H M I U P O M H M I Y T Z F R L A T J K M Z P G Z S , G W T F J F R U G ' W S A A V R J F E A I V Y O R U E A I V Y O R U .

Yesterday's Cryptoquip: IF YOU WERE MAKING A SKETCH OF SOMEBODY'S INHALATION, I CLAIM THAT YOU'D BE DRAWING A BREATH.

Today's Cryptoquip Clue: W equals M

QUOTABLE *Quotes*

"To live is to choose. But to choose well, you must know who you are and what you stand for, where you want to go and why you want to get there."

Kofi Annan

BEETLE BAILY by Mort Walker

HENRY by Don Tranchte