of charged residues at the accessible surface, more hydrophobic and charged residues at the subunit interface, slightly more hydrogen bonds per residue in the overall structure and a reduced number of residues per monomer due to loop deletions.

Akihiko Yamagishi and coworkers (Tokyo Univ. of Pharmacy and Life Sciences) have developed a new way of designing thermostable mutant enzymes using phylogenetic tree. Mutant enzymes of 3-isopropylmaltate dehydrogenase exhibited higher thermostability than the enzyme from Sulfolobus tokodaii. A similar observation was recorded with glycinyltransfer RNA synthetase from Thermoplasma. The investigators have concluded that these results support the hyperthermophilic common ancestor hypothesis.

Taro Oshima and coworkers (Institute of Environmental Microbiology, Tokyo, Japan) demonstrated T. thermophilus to produce 16 different polypeptides (PAs), including long, branched and standard PAs. Long PAs effectively stabilize nucleic acids. When genes encoding PA biosynthesizing enzymes were knocked out, the mutants failed to grow at elevated temperatures, and supplementing with PAs restored growth. Investigations using PT enzymes supported a new pathway for PA biosynthesis.

Daniel Prieur and coworkers (Univ. of Occidental Bretagne, Plouzane, France) reported isolation of halophilic Thermococcus barophilus and ionizing radiation-resistant T. gunnatekulae. They have also isolated a virus (PAV1) from Pyrococcus abyssi that has a genome of 18098 bp with 24 ORFs.

Philip Hendry and coworkers (CSIRO Molecular and Health Technologies, Australia) have isolated Sulfolobus sp. JP2, that showed minor differences with S. solfataricus at the genomic level. Microarray analysis suggested the expression of genes related to sulphur oxidation, electron transport and carbon dioxide fixation. The strain was able to efficiently leach copper from chalcocite.

Radhey Gupta (McMaster Univ., Hamilton, Canada) presented work on the identification of many conserved signatures in widely distributed proteins that are unique to members of Aquificales that are not found in any other organisms. Further evidence was provided that Aquificales phylum is a late branching lineage within bacteria.

The conference also included 72 poster presentations on aspects such as diversity of thermophilic bacteria and archaea from various terrestrial and marine thermal environments, physiology and biochemistry, cloning and overexpression of thermostable proteins and enzymes, structure-function relationships of enzymes, biotechnological application of enzymes, genomics and proteomics, genetics and molecular biology. The conference gave ample opportunity to understand recent trends in research on thermophilic microorganisms, and investigations that are in progress all over the world on basic as well as applied aspects of thermophilic microorganisms.

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MEETING REPORT

Linking Indian rivers vs Bay of Bengal monsoon activity*

In a popular article on ‘Interlinking rivers: Is it the solution?’ (The Hindu, 26 August 2005), V. Rajamani brought out a possible consequence of the proposed interlinking of Indian rivers on the SW monsoon. The connection is that the run-off of Indian rivers to the Bay of Bengal (BOB) plays a critical role in the process of monsoon intensification by creating and sustaining a low-salinity layer on top of the BOB. The President of India, A. P. J. Abdul Kalam, as an advocate of the river-linking project showed keen interest in Rajamani’s article, particularly to the link between run-off to the BOB and the SW monsoon. In view of the importance of the project, the interest of the scientist-President and the scientific importance of the problem, a one-day meeting of earth scientists interested in the air–sea–land interactions was arranged for a focused discussion on the following: If the proposed river linkages were to reduce the total annual run-off into the BOB or the rate at which run-off is released into it, then do river linkages have any significant consequence on the Indian monsoon rainfall? This report is an outcome of the discussion meeting and the opinion expressed is the prevailing and collective knowledge of the participants (listed at the end) on the issue.

Owing to its unique geographic location, the BOB receives large quantities of freshwater from both local precipitation and river discharge. The estimated freshwater influxes into the BOB from local precipitation and through river discharge are 4700 and 3000 km/yr respectively. Ganga, Brahmaputra, Mahanadi and Eainway are the major rivers that discharge in the head BOB. The loss due to evaporation is about 3600 km/yr. Thus, on an annual scale, freshwater input exceeds the loss due to evaporation substantially. This tends to make the water of the BOB relatively less saline compared to other oceans and the low salinity is confined to the top ~10–20 m layer. There is a strong seasonal dependence, as the major fraction of the freshwater comes during the summer monsoon period, i.e. during June–September. During this time, southwesterly winds tend to accommodate the freshwater in the head BOB and the salinity decreases further, resulting in the occurrence of a quasi-permanent, low salinity layer north of 17°N. Once the southwest monsoon ends (in October), water starts flowing southwards. Eventually, BOB water spreads out over the equatorial and south Indian Ocean and also over the east Arabian Sea.

Density of sea water increases with salinity. The low-salinity layer at the BOB, is therefore a layer of less dense water floating on denser water below as a stratified layer. This inhibits vertical mixing and even strong monsoonal winds have limited success in inducing vertical mixing. Most of
the solar energy is trapped in this top 10–
20 m thick layer. Owing to high levels of
humidity in the air over the BOB during
monsoon, evaporative cooling is also small
compared to other oceans at comparable
wind speeds. Calculations as well as obser-
vations show that it only takes 4–5 clear-
sky days for the surface temperature to
increase by about 1°C over head BOB,
whereas the corresponding time is about
a month for other oceans, including the
Arabian Sea. Response of monsoon cloud
systems (convective) is a highly nonlinear
function of sea surface temperature (SST).
While convection nearly vanishes for SST
< 28°C, it peaks around 29°C. When
clouds form, solar insolation is cutoff, water
cools mainly due to evaporation and obser-
vations show that the minimum SST reached
during such periods is about 28°C over
the BOB. But given a few days of clear-
sky conditions, SST of BOB increases to
a value where the probability of convection
is high. Thus, the BOB manages to support a
high convection despite frequent clouding.

Eventually, the excess input (4100 km³)
of freshwater is balanced by the outflow of
low salinity (fresh) water from the BOB
to the southeastern Arabian Sea and to the
Indian Ocean. Experiments using an ocean
General Circulation Model suggest that the
impact on salinity is different between
the two inputs of freshwater. Effect due to
oceanic precipitation over the BOB tends
to spread throughout the BOB and then
into the eastern equatorial Indian Ocean.
The river run-off, however, is confined
largely to the coastal region and parts of
head BOB during the monsoon period,
and after October it flows along the east
coast of India and around Sri Lanka into
the southeastern Arabian Sea. Here it plays
an important role in the warming of the
Arabian Sea during the pre-monsoon months.

Thus, the effects of river water input into the
BOB are not just local, but spread out over a
large area on an annual scale.

A thin layer of low saline water, there-
fore, plays a critical role in maintaining
convection over the BOB. Therefore, re-
duced run-off, a certain consequence of
linking rivers in India to increase resi-
dence time of water on land, could affect
monsoon rainfall both in amount, duration
and spatial distribution. However, we are
not in a position at present to quantify the
effects precisely. There are several issues
here, including the present uncertainty
over the actual amount of river discharge,
amount of river discharge likely to be re-
duced due to river linking (it is not possible
to stop the flow completely), its geographic
location, etc. Another important aspect is
the amount of freshwater needed in the
top 10–20 m layer to inhibit vertical mixing.
There are interannual variations in monsoon
rainfall, and the BOB seems to be able to
maintain its stable layer against these
natural fluctuations. However, we need to
understand if any long-term trend could
result if river flow is gradually reduced.
Some of these issues cannot be answered
with our present understanding. Observa-
tional and numerical simulations are needed.

Stratification below the mixed layer
also affects the chemical and biological
processes in the Bay. It is worth noting
here that because the low salinity layer in
the BOB prevents vertical mixing, the
Bay is not a source of CO₂ to the atmos-
phere. Removing this lid (by reducing the
freshwater run-off) will lead to upwelling
of cooler and nutrient-rich deeper water
and the Bay also will become a source of CO₂
to the atmosphere, similar to the Arabian
Sea. In addition, because of the nutrient
supply from below, biological productivi-
ty is likely to increase in the Bay resulting
in the development of oxygen minimum
zone, as in the Arabian Sea. This will, in
turn, cause denitrification that releases N₂O
to the atmosphere, a more potent greenhouse
gas than CO₂. Thus, in addition to its
possible adverse effect on monsoon rain-
fall in India on a long-term, river linkages
may have the potential to accelerate global
warming on a short term.

The benefits of the monsoon rainfall to
the entire ecology of India as well as to
the human-centric economy need no reit-
eration. The adverse effects of reduced
run-off to the BOB because of river linkages
also appear to be real. We note here that
our arguments are based on simplistic in-
terpretation of presently available data
on SST, salinity and wind velocities over
the BOB. A more accurate relation between
the run-off input and monsoon phenomenon
will require more and credible datasets
on various ocean, atmosphere and land-
based physico-chemical and biological pa-
rameters and modelling them for their in-
terconnectedness.

ACKNOWLEDGEMENT. We thank the Indian
Academy of Sciences, Bangalore for support-
ing this societally relevant academic activity.

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