EDITORIAL

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....MOVING FROM SCIENCE TO DEVELOPMENT...

The Colours of Biotechnology: Science, Development and Humankind

Biotechnology and the world of colours have always been intertwined. Nature's hues and tints are capturec in their natural or synthetic state in a variety of market products. The flower markets of natural blood-rec roses and gene-designed blue roses recently released in Japan are apt examples.

To-date notwithstanding the awe-inspiring snip and tuck techniques of genetic engineering, the legendary '*Black Tulip*' of French author Alexandre Dumas still remains the '*Holy Grail of the Tulip world'.* Several types from *'Tulipa Queen of Night'* (1944) to *T.'Black Hero'* (1984*)* constitute '*the category of the 'blackest of the officially* '*purple*' *tulips*'.

Nature's wealth of colours have inspired celebrity painters and poets ---French-born Hilaire Belloc describes in verse the morphology of *The Microbe* with its '*seven tufted tails with lots of pink and purple spots.*'; anc schoolchildren to explore the microbial world through the '*looking-glass*' of Winogradsky's column with its *purple* and *green* bands ---consortia of the *green* and *purple* photosynthetic bacteria. Blue-greer cyanobacteria contribute to the economy of Nature's important biogeochemical cycles – the nitrogen cycle The Red Sea may derive its colour and name from the *red*-cyanobacterium -- *Trichodesmium erythraeum* but the destruction of numerous fish is due to the *Red Tide* population of the plant-like *red-brown* dinoflagellates.Pigments help classify the *brown*, *yellow*, *red* and *green* algae; and protozoa and yeasts such as *Euglena* and *Pichia*. Nature's colour artistry occurs throughout the biospectrum incorporating *interalia green* and *purple* bacteria, antibiotic-producing species of *Streptomyces* and *Nocardia*, fungi that colour cheeses, *blue-green* anoles, *rainbow* papaya and trout, and *green* fluorescent proteins responsible for the coloration of diverse corals and anemones. *Green, yellow, orange-red* and *purple-blue* chromoproteins are *the raison d'être* of fabled reef colours varying in the spectrum of daylight conditions. Verily, Nature's palette of pigments and paints underscores the need of bioresources centres to capture, classify and conserve the planet's biotreasury lest extinction result from benign neglect and commercial exploitation.

'Biomimicry…… is a new science that studies nature's best ideas and then imitates these designs anc processes to solve human problems. ……Organisms use two methods to create colour without paint: interna pigments and the structural colour that makes tropical butterflies, peacocks, and hummingbirds so gorgeous A peacock is a completely brown bird. Its "colours" result from light scattering off regularly spaced melanir rods, and interference effects through thin layers of keratin (the same stuff as your fingernails).'

New military clothing uses fluorescent colours, biosensors and bioinformatics at the nano-level to mimic natural phenomena of biomimicry and chameleonic colours. Geofabrics coloured for appropriate use contribute to landscape and urban management --- conservation of golf courses and park-lawns, anc safeguarding of soil embankments and floral gardens.

The creative and aesthetic instinct of humankind is embedded in *clean* and *green* technologies. The firs biodegradable *green* credit card was issued in 1997. 'Coral proteins put on the *red* light' in marine waters and coloured glow fish function as indicators of pollution in aquatic reservoirs. Colours used in biotextile grafts make attractive and acceptable use of bioceramic materials in dentistry, medicine orthopaedics, tissue engineering and veterinary science.

Genetic research has contributed to understanding human eye and skin colour. The genesis of coat colours

of cats, dogs, rabbits, ponies, etc. has been deciphered. The head colour of birds too. Coat colour alleles are used to produce sublines of mice for studies concerning ageing, cancer, cardiovascular, neurobiological and reproductive biology. The Big *Blue* mouse is used to research cancer and neurodegenerative disease. *Yellow* mice help localize gene mutations on specific chromosomes.Custom-made mice ---the *albino*, *cream*, *brown* and *black* models are research keys studying tumour biology. Indeed, 'the ability to follow coat colours' requires 'no complicated tools such as molecular genotyping' in 'the breeding and maintenance of mutant strains.'

Colours inspire, motivate and uplift humankind. Clinics and psychological facilities use soothing colours to aid convalescents. Colours exist in sports too. Winners express a sense of national achievement and pride in draping themselves in their national flags. In EURO 2004 – soccer and biopsychology met. To enhance local psychobiological advantage and patriotism the coach of the home team requested fans 'to wear something *red or green'* their national colours 'toface the *orange* shirts' of their opponents' in a qualifying match.

Corporate biotech is engaged in 'chasing the *rainbow.*' Former Vice-President Al Gore envisioned the *'pot of gold at the end of the biotechnology rainbow.'* Entrepreneurs, however, focus their quest '*somewhere over the genetic rainbow*'. UN policy-makers use colour-codes in combating, and designing solutions to problems of hunger and poverty. The UN Economic Commission for Africa in 2002 described 'Realizing the Promise of *Green* Biotechnology for the Poor' and 'Tackling the Diseases of Poverty through *Red* Biotechnology' --- technologies that involve using genetically-engineered mosquitoes with the potential to eradicate malaria and gene modified foods ---*golden rice* and *orange bananas*, enriched with vitamin A to counteract the onset of blindness.

'Ethical challenges of *green* biotechnology for developing countries' arise, and, 'whether transgenic plants should carry distinguishing markers, such as distinguishing colours, so that they can be identified and not intermixed with other plants of the same species' is under review for use in regulatory work. In space biology research, transgenic plants using *blue* and *green* colours are being developed as biosensors to indicate presence of certain kinds of stress.

Nutritionists talk of a *rainbow* diet rich in micronutrients and vitamins that make food naturally attractive and appetizing for a '*good feel*' status. Traditional medicine recommends eating naturally coloured foods possessing natural phytonutrients in their skin ingredients. A judicious choice of *red* (meat), *green* (salads) *yellow* (cereals and fruits) and *violet* (vegetables) foods contributes to the sustenance of long-term good health in combating artificial diabetes and obesity. *Blue* cheese and *black* truffles are delicacies without added food colorants; and supermarkets may soon offer carrots in *red* and *purple* with the *orange* variety. 'Research into different coloured carrots is not about making a fashion statement but about potential health improvements'.

In agro-trade, traffic-colours of *amber* and *green* define policies that distort trade of certain commodities. *Amber* box policies signify '*caution*' relating to 'price supports, marketing loans and subsidies, and livestock quantities'. *Green* box policies cover 'research, pest and disease control, and crop insurance and conservation programs'. *Blue* box policies --a temporary WTO category that accommodates transatlantic negotiations, are 'redefined *amber* box policies concerning production limiting programs'.

Biotechnologies described in coluors spotlight salient aspects of research for economic development. The Cordia-EuropaBio Convention 2003 in Vienna in '*Blue* Biotechnology - Exploitation of Marine Resources' focused on the 'Ocean of Opportunities' for sustaining development through rational use of marine bioresources. Europe's catalytic role in '*Green* Biotechnology in Africa' resides in collaborative biotech education, research, development, and market ventures.

In January 2004, a European Commission meeting at the Biosciences 'Technology Facility', University of York, UK, recognized that any 'biotechnology platform, developing bio-based products would have to be a concerted marriage of the '*White*' together with the '*Green*' and '*Blue*' biotechnology sectors'. Unlocking of bottlenecks could be achieved through programmes utilizing 'the synergies between *green, white* and *blue* biotechnologies.'

In 2005, the 12th European Biotechnology Congress will use 4 biotech motors: *white* (industrial); *red* (pharmaceutical), *green* (food and feed) and blue (environment) in '*Bringing Genomes to Life*' in Denmark.

The use of colour codes is seemingly the *lingua franca* of science policy in Germany. Sixty percent of the 253 biotechnological firms with some 43,000 employees in a survey by Hessen's Ministry of Economy were specializing in *red* biotechnology (diagnosis and treatment of diseases); 4% were specializing in *green*

biotechnology (agriculture, food production); and, 1% was in *grey* biotechnology (pure industrial processes with an environmental nuance). In Baden-Württemberg, over half of the biotech companies excel in *red* biotechnology with smaller numbers in the *grey* and *green* sectors. German market studies emphasize the *white* and *red* biotechnologies. *Red* biotechnology accounts for some 86% of all biotech companies. *Green* biotechnology with 27% is followed by *grey* biotechnology with 10%.

In the USA, a 5 colour-coded security system from *green* (low) through *blue* (guarded), *yellow* (elevated), and *orange* (high) to *red* (severe) has been decreed. Adoption of protective and self-defense responses involves all levels of vigilance and preparedness to combat and neutralize the threats of terrorism and those of bioterrorism that aim at destruction of that country's security and its peoples. Colour alert systems for air pollution (USA) and inclement weather (Mozambique) are indicators of time available for precautionary action by people susceptible to asthmatic and respiratory diseases as well as in offsetting loss of life and bioeconomic resources.

In satire, a '*five* (colour) *level Mad Cow alert*' exists. The alert levels range from eating cow parts (*green*) through limited beef consumption (*blue*) and exercise of planned protective measures (*yellow*) to symptomatic mooing and chewing of the cud (*orange*) to a switch to fermented food - tofu *(red*).

Using colours to describe biotechnology constitutes a new mechanism in:

- attracting school children to the microbial world in different environments;
- teaching biotechnology in graduate and medical schools; and
- providing soundbytes for use by non-technical policy-makers promoting the biotech powerhouse for sustainable development.

Dr. R. Colwell, Director, US National Foundation at a US-EC Biotech meeting in 2003 said: "If we could weave a Flag of Biotechnology, some say, it would feature three colours: red for medical applications, green for agricultural and white for industrial. In fact this flag may accrue even more colours over time as environmental and marine biotech and other applications add their stripes'.

In that context, the colour index below may be a useful guide with further additions as biotechnology and colours intertwine over time in promoting public perception and understanding of biotech applications for the cause of science, development, and the current and post human future of humankind.

Color Type	Area of Biotech Activities
Red	Health, Medical, Diagnostics
Yellow	Food Biotechnology, Nutrition Science
Blue	Aquaculture, Coastal and Marine Biotech
Green	Agricultural, Environmental Biotechnology – Biofuels, Biofertilizers, Bioremediation, Geomicrobiology
Brown	Arid Zone and Desert Biotechnology
Dark	Bioterrorism, Biowarfare, Biocrimes, Anticrop warfare
Purple	Patents, Publications, Inventions, IPRs
White	Gene-based Bioindustries
Gold	Bioinformatics, Nanobiotechnology
Grey	Classical Fermentation and Bioprocess Technology

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