powders consisting mainly of nano-scale icosahedral phase embedded in an FCC phase. This area promises to open up new application such as a new type of Al-base composite alloys which may replace many commercial composite alloys. Ti-based QC alloy was shown by Kelton's group to possess the potential for hydrogen storage. The use of Al-base QCs was being used as efficient coating material with increased wear-resistance and non-sticking property and it was patented by J. M. Dubbois's group (France) earlier. Surface properties of these QCs were discussed with interest.

Concluding remarks

The activities on quasicrystals are expected to continue and throw more light on unresolved issues. Apart from finding new systems of quasicrystals, a new type or class of quasicrystals along with more insight towards structure, stability, properties and new directions for potential technological applications seems to be happening. Therefore one can hope to get a better understanding and exciting results in this field by the 7th International Conference on Quasicrystals which is scheduled to be held in Stuttgart, Germany in 1999. It is pertinent to point out that the Indian scientists have made pioneering contributions in the area of quasicrystals[6]. As a recognition to Indian science, it has been recommended by the International Advisory Board to hold the 8th International Conference on Quasicrystals in India in the year 2001.

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RESEARCH NEWS

Is cAMP necessary for *Dictyostelium* development?

M. Azhar and Vidyanand Nanjundiah

'Redundancy' has become a major puzzle in this age of genetic engineering: if doing away with the activity of a gene does not cause any difference to the phenotype, why is that gene there in the first place?[1] The situation is especially embarrassing when an organism appears capable of carrying on, to all appearances normally, without a supposedly essential gene product. A recent paper by Wang and Kuspa[2] makes this point forcefully by showing that haploid amoebae of *Dictyostelium* can complete a normal life cycle in the absence of *acaA*, the gene that encodes aggregation-specific adenylyl cyclase. To understand why this is so startling, one needs to go back to the past.

Ever since 1967, when it was first discovered[3], a series of elegant experiments have added evidence upon evidence in favour of the thesis that adenosine 3′–5′ cyclic monophosphate (cAMP) is *the* agent of communication between *Dictyostelium* amoebae. Indeed, cAMP-based signaling in *Dictyostelium discoideum* came to be regarded as a paradigm for intercellular communication in all of developmental biology. (Here we are talking of an unusual 'first messenger' role for cAMP over and above that of the ubiquitous 'second messenger'.) The life cycle of *D. discoideum* involves feeding, aggregation (following starvation) and differentiation into two cell types. Differentiation is initially apparent as a spatially segregated pattern of presumptive stalk (prestalk) and presumptive spore (prespore) cells within the multicellular aggregate (the slug), and latter as a mass of spores supported by a stalk of dead cells[4]. Each spore can germinate and give rise to an amoeba that can feed, grow and divide by mitosis and the cycle begins anew. Aggregation is caused by the secretion of a diffusible chemical attractant[5] and by the cell-to-cell transmission of an oscillatory signal[6,7]. cAMP synthesized and released periodically by starved amoebae, is capable of attracting competent cells from a distance and can be relayed from one cell to another[8]. The beautiful concentric and spiral waves of cell density that are seen during aggregation are overlaid by waves of cAMP concentration[9]. This last finding appeared to clinch the case for cAMP as a combined chemoattractant and transmitter that both mediated long-range intercellular signaling and was responsible for aggregation.

More was to follow. Genes that encoded products required for aggregation were shown to be specifically inducible by extracellular cAMP, and by pulsatile stimuli at that[10]. Harking back to classic experiments that demonstrated a positive spatial correlation within the slug between the ability of cells to release chemoattractant and their eventual fate[11], it appeared that cAMP, by evoking a differential chemotactic response in the two presumptive cell types, could also be responsible for the spatial patterning of cell types in the slug[12]. Finally, in combination with another small molecule, DIF, cAMP was shown to act as an inducer of cell type-specific gene expression[13] – though, surprisingly, the cell type that was induced corresponded to regions in the slug where cAMP levels appeared to be, relatively speaking, on the lower side.

Adenylyl cyclase is the enzyme that catalyses the formation of cAMP from ATP. *D. discoideum* has two adenylyl cyclase genes. One is expressed during development (*acaA*) and other during spore germination (*acaG*). *acaA*$^-$ mutants are unable to aggregate, but the deficiency can be overcome by subjecting cells to a regime of extracellular cAMP pulses followed by a steady concentration[14]. Extracellular cAMP cannot enter the cell[15]

contacts than by attraction at a distance. Extracellular cAMP may be crucial for the formation of aggregates at the low cell densities that may occur under natural conditions. Also, because aggregation is the first step of a defensive response to a stressful environment, it stands to reason that more rapidly the subsequent development ensues, the better. In short, there is no doubt that the wild type combination of *acaA* and *pkaC* confers a higher fitness under certain conditions than the *acaA*$^-$ (*pkaC*) construct does. The implication is that cAMP is not 'redundant' in the usual sense of the term (the *acaA*$^-$ mutant is unable to develop). But, because normal development can be restored by over-expressing *pkaC* in an *acaA*$^-$ background, the system must have means available whereby it can make do without cAMP: not a backup pathway, perhaps, but certainly other gene products whose functions overlap with those of cAMP. The upshot is an organism that exhibits a degree of resilience far beyond anyone's expectation.

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Micro-organisms as fish feed in fish industries

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Aquaculture has emerged as an important industry during last decade and is practised in more than 150 countries in the world. Global aquaculture industry is worth about 30 billion US $ (ref. 1) and is growing at the rate of about 10%. Asia is considered to be cradle for aquaculture. Asian countries contribute 85% of the total production and Japan shares a major part of it. Considerable part of Japanese economy relies on the fish market. Various new efforts are always in action to improve the quality of the fish as well as to flourish the market. Feed and feeding are crucial elements of aquaculture. Feed cost ranges from 30 to 60% of the total culturing cost depending upon the type of fish and culture system. Various rotifers, plant extracts, stout's viscera, soyabean meal, etc. are normally employed as the feed. Although there are reports of micro-organisms causing mortality of fish fauna[2], from last few years thrust has been on the use of micro-organisms as the feed.

Various algae, yeasts and bacteria have been employed as a primary and/or secondary feed in the recent years. Algae such as *Chlorella*, *Haematococcus*, *Spirulina* were found to be useful for growing young fish. In the recent times, purple sulphur bacteria (PSB), *Rhodobacter capsulatus*, has been employed in the artificial feed of the fish larvae. Microbial cells as food supply additional nucleic acids, proteins, vitamins and various minerals along with the carotenoids. Micro-organisms are nutritious source of energy. *Phaffia rhodozyma*[3,4], *Rhodotorula* and other pigmented yeasts impart red fleshy colour to the meat of salmon, trout and Red seas bream and thus are used as the product quality feed. Astaxanthin is a major pigment present in *Phaffia*