MEETING REPORT

Three lectures by an entomoartist*

The Center for Contemporary Studies (CCS) was established in 2004 at the Indian Institute of Science (IISc), Bangalore. It regularly presents lectures by international experts in the human sciences with the purpose 'to forge useful and meaningful interaction between the natural sciences and human sciences with special focus on understanding the diverse research methodologies of different disciplines and create opportunities to rethink the foundations of our own disciplines …' (http://ces.iisc.ernet.in/hpg/ragh/ccs/).

In collaboration with the Center for the Study of Culture and Society, Bangalore, CCS offers a course entitled 'Production of knowledge in the natural and social sciences'. The course was held for the first time in 2006, then in 2008 and now for the third time in 2010. The 2010 course announcement speaks of how 'the philosophy of the course has moved, since 2006, from trying to breakdown canonical disciplinary walls, valuing dissent and defection from disciplines as a source of criticality, to a sense that *changing how one's own discipline is done* is the useful task perhaps of interdisciplinarity' (http://ces.iisc.ernet.in/hpg/ragh/ccs/Course03/announcement.html).

Barrett Anthony Klein, an entomologist and an artist, presented a talk on 'Sleeping in a society' in October 2010 at CCS. He also handled a module as part of the 2010 course which included two lectures: 'Visualizing nature' and 'Cultural entomology'.

Sleeping in a society

The inattentiveness of an 'absent-minded scientist' can be due to his/her preoccupation with research, but could occasionally be due to lack of sleep. Some humans without adequate sleep are also known to exhibit lapses in communicating information. What happens when a honey bee suffers from lack of sleep? Klein spoke about the effect of sleep deprivation in a honey bee society (Figure 1).

Do insects sleep?

Klein quoted the sleep researcher J. Allan Hobson who once wrote, 'Since less highly evolved animals never stop reacting to the outside world, these animals rest, but do not truly sleep'. Almost 2000 years earlier, Pliny the Elder wrote that insects do breathe and sleep. In 2002, Nitz *et al*. inserted two electrodes in the brain of a fruit fly and used a power spectral density analysis to study the differences between the waking state and quiescent state. Others have claimed that plants exhibit 'sleep motions', and the term sleep has even been applied to describe bacterial inactivity. Who sleeps and what does it mean to sleep?

'A sleeping organism tends to exhibit a specific posture during extended, recurrent, reversible bouts of relative immobility, during which its response threshold is increased', noted Klein. Arthropoda (insects, spiders, crabs) and others have been studied in connection with sleep. Research with fruit flies has helped in understanding human sleep-related disorders.

Honey bee sleep

Klein studied the European honey bee *Apis mellifera*. Honey bee workers change tasks as they age – typically from cell cleaners to nurse bees to food storers to foragers. The honey bee colony is primarily composed of female workers, but also has a single queen and occasionally male drones.

'Sleeping bees can be identified by their dorso-ventral discontinuous ventilatory motions', said Klein. His experiments revealed that periodic sleep comes with age and as bees change castes; the youngest adult bees sleep the longest and later tasks do not affect total sleep time. Also, the duration of sleep bouts increases when the bees sleep outside cells.

These bees do not exhibit sleep site fidelity, but they sleep outside cells closer to the edge of the hive and are colder when asleep. Sleeping away from the centrally located bustling brood comb may help increase the consolidated sleep of the bees, decrease pathogen spread and protect the less expendable young, or may be they sleep where they happen to work. Klein raised the question: what determines sleep patterns – is it caste, food availability or genetic stock?

He had conducted a study varying the time of food availability to learn whether there was flexibility in the sleep schedule of the honey bees. He found that bees devote the same total time to each behaviour (locomotion, body movement and others), irrespective of when a resource is available; only the timing of sleep changed.

The final hypothesis of Klein was that bees communicate less precisely without sleep. He used magnets to disturb the night sleep of bees with magnetic metal

Figure 1. Honey bee (*Apis mellifera*) sleeping in an observation hive, Liddell Field Station, Cornell University, Barrett Klein 2005. (Source: http://www.pupating.org; Courtesy: Barrett Anthony Klein.)

*A report on three lectures delivered by Barrett Anthony Klein at the Center for Contemporary Studies, Indian Institute of Science, Bangalore on 14 and 16 October 2010.

Figure 2. From left to right: Darwin's notebook, Haeckel's tree, Martin and Embley's (2004) tree (top right) and Boussau and Daubin's (2009) tree (bottom right). (Courtesy: Barrett Anthony Klein.)

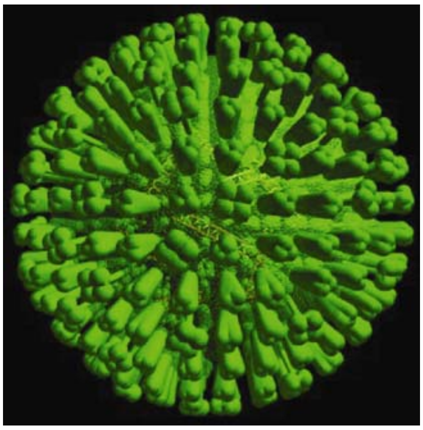

Figure 3. Influenza A computer-generated, Molly Lenore and Barrett Klein 1998. In The World of Infectious Diseases exhibit, American Museum of Natural History. (Source: http://www.pupating.org; Courtesy: Barrett Anthony Klein.)

fastened to their backs, and found that sleep-deprived foragers 'slept more and slept more deeply in the middle of the night following sleep deprivation'; this showed that the bees were likely recovering from lost sleep. Sleep deprivation, moreover, weakened the directional precision of the waggle dances which the bees use to indicate the direction and distance of food sources to their siblings. This is consistent with the hypothesis that one consequence of sleep deprivation within a society may include a breakdown of communication.

Visualizing nature

In 1859 Charles Darwin said: 'The affinities of all the beings of the same class have sometimes been represented by a great tree... As buds give rise by growth to fresh buds, and these if vigorous, branch out and overtop on all sides many a feebler branch, so by generation I believe it has been with the great Tree of Life, which fills with its dead and broken branches the crust of the earth, and covers the surface with its ever branching and beautiful ramifications' (http://tolweb.org/tree/phylogeny.html). Klein showed the sketch of this tree from one of Darwin's notebooks (Figure 2) and discussed the value of such visualizations throughout the history of science.

He pointed out that the images of Copernicus (of the heliocentric solar system), Robert Hooke (of the microscopic world) and others rendered visible subjects that had profound consequences on human thought. Haeckel's radical ideas of evolution came to light in his graphical representations of evolutionary trees.

Visualizing nature finds applications in: (i) medicine (e.g. the work of Arno Klein on brain mapping made the morphological features more accessible to doctors); (ii) education (e.g. visuals to explain how insects interact with humans); (iii) identifying surroundings (e.g. field guides); (iv) creating an impact (e.g. environmental awareness).

Klein indicated instances when photographs do not suffice: when beyond human visual range, when subjects are inaccessible (e.g. the rendition of a rhinoceros by Dürer or visions of extinct organisms by forensic biologists), when objects are hidden from view (e.g. the nest of a subterranean bee), when subjects are invisible (e.g. retrovirus), when salient features need to be emphasized, when phenomena are infrequent or ephemeral, when simultaneous display of complex information is needed, and for communicating abstract concepts or hypotheses.

Molly Lenore and Barrett Klein (1998) created a computerized picture of the Influenza A virus using information obtained from scientists (Figure 3).

Klein highlighted three purposes in visualizing science, viz. for data analysis, data mining and novel discovery. He presented case studies of the applications of fluorescent imaging, stimulated emission depleted microscopy, PET scan, microCT scans and ground-penetrating radar scans in science, as well as the use of robots in science. He also illustrated

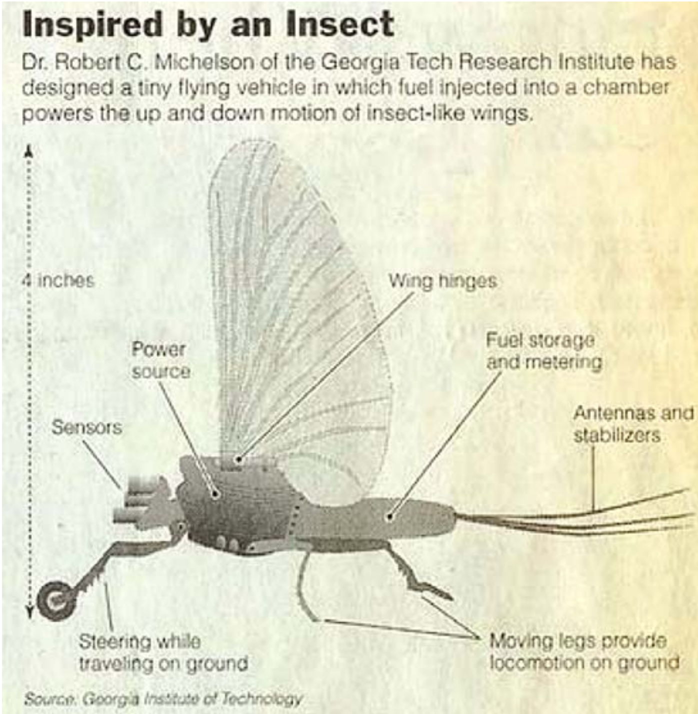

Figure 4. Mayfly, model of espionage, *The New York Times* (resource: Georgia Institute of Technology). (Source: http://www.pupating.org; Courtesy: Barrett Anthony Klein.)

Box 1. Insect inspirers.

Adornment of the body: Traditional Japanese women wore thick eyebrow make-ups called 'moth brows'.

Recreation: Crickets are made to battle each other in parts of Asia.

There are fly-fishing fanatics in the US and Japan, and Bill Logan takes 100 h to produce a single hyper-realistic fishing fly.

Status symbols: Scarab necklaces are worn in Egypt.

Music: In China, the Dong people sing the Circada song.

Films: 'The Deadly Bees', 'Insect Woman'.

A dialogue in 'Castles of Clay' (a documentary) remarked that, 'the empires of Africa went through the guts of termites'.

Advertisements: A luna moth featured in an ad for 'Lunesta' – a sleep aid.

Food: In an insectarium in Montreal, an insect chef makes insect food.

Model: Cockroach as a model system for robotics design – how they traverse non-uniform surfaces.

(Adapted from the lecture by Klein)

cases of 'visualization gone wrong'. The need for forensic software to trace modifications in images is one obvious response to graphical misconduct.

'If you can produce a graphic which doesn't require audience experience with that type of graphic to understand your idea, then you've succeeded' said Klein, highlighting the principles of graphical excellence. He pointed out that it would be interesting to critically assess each graphic in terms of accuracy, aesthetics and the interaction between the two.

Cultural entomology

Cultural entomology is the study of the influence of insects on different human endeavours, be it music, poetry, religion, mythology, recreation, politics or science and technology (e.g. Figure 4).

Klein explained how, throughout history, insects have inspired many ideas and the creation of many products (Box 1). He also gave an example of the French designer-artist Seguy, who tried to impress upon artists on how inherently beautiful insects are.

Why insects?

In responding to the question as to why insect images are ubiquitous, Klein gave four reasons: (i) Insects live (almost) everywhere and the reason for this is 'a huge open question in evolutionary biology'; (ii) Insects can produce negative associations in terms of loss, pain and/or disease (e.g. lice is a vector for typhus); (iii) Insects produce positive associations with regard to food and products (e.g. honey, silk, pharmacological actions of chemicals from insects); (iv) Insects can serve as symbols (e.g. the Egyptians consider the scarab beetle as a symbol of power and hard work); (v) Insects are beautiful and inspiring (usually a consequence of mate selection or chemical defence).

Stream bugs are considered to be bio-indicators; mutations indicate ill-health in the environment. Knowledge of the life cycle of insects can pinpoint, within a couple of hours, how an individual died (insects in forensics!).

Klein advised caution in directly applying the knowledge derived from a study of insects to humans – 'we do not want to adopt the behaviour of slave-making ants or the military operation of army ants', but we could learn from honey bees how to operate in a democratic way with effective interpersonal communication[1].

1. Seeley, T. D., *Honeybee Democracy*, Princeton University Press, Princeton, New Jersey, 2010.

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