bees at two sites where hives were surrounded by dense occurrences of aloes.

Nectar from this plant is considered to be important for bee honey reserves, although it is known to be dilute compared with other sources.

The researchers measured the crop volumes of bees at foraging sites around the aloe flowers and also at the entrance to their hives. They found that there was no significant difference in the crop volumes of bees at the flowering site and those entering the hive. However, when the researchers looked at the concentration of sugar. they found a considerable increase in the crop values of bees around the flowers, compared with the nectar within the flowers themselves. The sugar concentration of crop contents was also found to be similar in those bees entering the hives.

The crop content of bees departing the hive to gather more nectar was also found to be concentrated: this provides the food source for the foraging bees.

So how do the bees concentrate the nectar they are gathering?

Increased concentration of crop contents has previously been observed in solitary mason bees and carpenter bees. But neither the dilution of haemolymph in solitary bees or the excretion of dilute fluids by honeybees when transporting nectar has been found.

"Evaporation from the mouthparts provides the only explanation," the authors conclude. When heated under laboratory conditions, honeybees repeatedly regurgitate a droplet of nectar onto the proboscis and then withdraw the cooled droplet to achieve evaporative cooling of the head. In addition to the cooling effect, the process concentrates the crop contents of bees and is used by receiver bees to ripen honey before depositing it in cells.

"Honeybees foraging on aloes are likely to be evaporating dilute nectar on their tongues as they move between flowers and on the return flight to the hive," the researchers report. "The increased concentration is dramatic owing to the small nectar volumes carried and the very dry atmosphere prevailing during flowering," they write.

It's a potentially neat way of lightening the load but perhaps misleads hive-based workers as to the true quality of this winter nectar source.

Nigel Williams



Loaded: New evidence suggests honeybees collecting dilute winter nectar from some flowers in South Africa are able to concentrate the solution before and during transfer back to the hive. (Picture: Alan Skyrme/Alamy.)

Q & A

Eddy M. De Robertis

Eddy De Robertis is an embryologist who has been the Norman Sprague Professor of Biological Chemistry at the University of California at Los Angeles for the past 22 years. He is also an Investigator of the Howard Hughes Medical Institute. Born in Cambridge, MA (while his father was a postdoc at MIT), he was raised in Uruguay, where he completed MD studies at the age of 24. This was followed by a Ph.D. in Chemistry at the Leloir Institute in Buenos Aires, Argentina, where he learned about enzymes with H.N. Torres. His postdoctoral training was in Cambridge, England, under Sir John Gurdon. Following three years as a staff member at the MRC Laboratory of Molecular Biology in Cambridge (UK), he was appointed full Professor at the University of Basel. He later moved to UCLA, where his work has helped unravel the molecular mechanisms of embryonic induction that underlie dorsal-ventral tissue differentiation during vertebrate development.

Why did you become a biologist?

This was probably decided the day I was born. My Dad, Eduardo, was a scientist of note (co-discoverer of synaptic vesicles). At that time in South America, to become a biologist one studied Medicine, and if one was really good then became a professor of basic sciences. I was spared the youthful anxieties over career choices, and could concentrate exclusively on my studies and important things such as finding a good woman to raise a family with.

Do you have a favorite paper?

Many, but I would like to mention here a delightful little book that caused thousands to discover vocations in science. In the 1950s, most cultivated 12 year olds read *"The Microbe Hunters"* by Paul de Kruif. If you have a child of that age, this 1926 book is still in print. If you have not read it yourself, and wonder how Louis Pasteur, Robert Koch, Walter Reed and others invented microbiology, it is not too late to find out why the work we do is so important.

You trained in Xenopus development with John Gurdon – what attracted you to his lab?

It was pure luck. John Gurdon had been sent by the British Council on a goodwill lecture tour of South America. One day, as a first-year Ph.D. student, I found an archetypal Englishman standing alone in the corridor of the lab and many colleagues passing him by without even giving him the time of day. Trying to be civil, I asked who he was and whether he would like to hear about my work. I guessed that chatting about my humble tube SDS gels of purified enzymes was preferable to the indignity of being the invisible man. Some 45 minutes later, a secretary came to take him to Luis Leloir (a Nobel Laureate and our beloved Director), who had finally finished his daily experiment. We were treated to a spectacular Gurdonian lecture on the translation of microinjected mRNAs in frog oocytes. Even so, the lecturer was sent off unescorted to negotiate a bus ride across Buenos Aires at the peak of rush hour. So I drove my car by the bus stop, pretended it was a coincidence, and offered John a ride to his hotel. Three years later, I found myself explaining to a senior investigator how difficult it was to find a postdoctoral position. He instantly said I should apply to Gurdon. Why should such a great biologist consider lowly me, I asked. "Because a few days after his visit, the cultural attaché of the British Embassy called on the Director to say that if you ever wanted to study in Britain, a British Council fellowship would be made available to you, following up on a good word put in by Dr. Gurdon". I then asked why I had never been told of this before. "So that it would not go to your head", he replied. So I wrote, was welcomed, and six months later our growing family settled in Cambridge. I have remained an Anglophile ever since.

Did you enjoy the MRC Laboratory of Molecular Biology? The sole reason for moving to Cambridge was that Gurdon had the unique ability of doing molecular biology in a living test tube, the Xenopus oocyte. I had

no idea that the MRC Cambridge lab was the best possible place on Earth to learn molecular biology in 1975. Max Perutz, Francis Crick, Sydney Brenner, Aaron Klug, Fred Sanger and Cesar Milstein were all in peak form. One could actually talk to them at coffee or tea time, and I did (with perhaps the exception of Sanger who was all the time running his own gels while inventing DNA sequencing). We had monthly Cell Biology Club sessions organized by Tim Hunt at Clare College, and sometimes "Bull Sessions" organized by Bart Barrell at Sanger's Kings College rooms. Cambridge at that time was an exhilarating place for a young biologist.

What did you work on with

Gurdon? For the first three years, I worked on the reprogramming of somatic nuclei by oocytes cytoplasm, a topic that has recently experienced a renaissance. For the following three years, I was a junior MRC staff member and worked on nucleo-cytoplasmic transport. Gurdon is a wonderful teacher. Always considerate and courteous, he teaches his trainees to set difficult and ambitious goals, how to write a paper, deliver a lecture, and above all to keep working at the bench. I have been trying to emulate him ever since. Like him, when in town I operate on Xenopus embryos Tuesdays and Thursdays. Always.

What was the impact of the discovery of the homeobox? Huge. Until 1984, vertebrate embryologists had no way of identifying development-controlling genes. At the tender age of 33, I had the great fortune of landing a Cell Biology Professorship at the University of Basel, Switzerland. My colleague Walter Gehring was making amazing progress cloning genes in Drosophila. We had common seminars, and in truth I completed my developmental biology education there. Rick Garber cloned the Drosophila homeotic gene Antennapedia and one day he presented an in situ hybridization (done by Ernst Hafen) showing expression of this gene in the second thoracic segment of the Drosophila nervous system; it was an electrifying moment. We collaborated with Walter Gehring and Bill McGinnis who provided their Drosophila



probes to see if we could fish out a similar gene from *Xenopus* genomic libraries. On the first try, my postdoc Andres Carrasco isolated two positive clones. The first was *HoxC*-6, encoding a protein with a stretch of 60 amino acids, 55 of which were identical to the homeodomain of *Antennapedia*!

My sole regret is that I sequenced the second clone, which also encoded a homeobox, but I failed to recognize the sequence homologies (we did comparisons by eye at the time). Years later, at UCLA, Christopher Wright recognized the homeobox and the clone turned out to be a key gene in pancreatic development, Pdx-1. Before the homeobox it was assumed that the mechanisms of development of fruit flies and vertebrates would be entirely different. Afterwards, an unexpected unity was recognized in the developmental tool-kit of all animals. Before we knew it, the homeobox was being hailed as the Rosetta stone of developmental biology. And it was.

What are the big questions that remain to be answered in embryonic induction? One is to understand how morphogenetic fields self-regulate. If you cut an embryo or the limb bud mesoderm in half, it will regenerate the whole. We know that there are signaling centers secreting growth factors and growth factor antagonists that induce cell differentiation in a field of cells that are constantly communicating with each other over long distances. Contrary to what many cell biologists might think, cells normally do not lead solitary lives like those poor ones that are freshly plated on plastic Petri dishes. Within the body, individual cells are subsumed into larger fields of hundreds or thousands of cells that communicate to each other when to proliferate, differentiate or die. When the molecular mechanisms by which these conversations take place are elucidated, this will greatly advance our understanding of human disease, I think.

Another big question is how the antero-posterior, dorsal-ventral and left-right embryonic axes are seamlessly integrated to produce something as perfect as a human baby time after time. This might be considered as too broad a question to ask productively, but the early amphibian embryo starts as a single field of cells that is very amenable to experimental manipulation. One can deplete or overexpress gene products and then challenge these cells by transplanting them into new surroundings. Three principal techniques are available to biologists: genetics, biochemistry and cell transplantation. Of these, transplantation is the least appreciated. Therefore, I expect to continue grafting bits of embryos for as long as my eyes and hands permit.

What are the key questions for

'Evo-Devo'? One is to reconstruct the genetic tool-kit present in Urbilateria, the last common ancestor of invertebrates and vertebrates. It turns out this is a very difficult undertaking because present computer technology is not sufficiently developed yet. Two research groups are nevertheless making steady progress at reconstructing the genome of the common ancestor of all mammals. This is a good start. Another important question is whether segmentation in invertebrates presents the gene cycling behavior observed in the vertebrate embryo tailbud. I suspect this has not been documented yet because of technical difficulties. If invertebrate segmentation cycling were documented, it would imply that the urbilaterian ancestor was a segmented, burrowing animal. This would have important implications for the evolution of segmented body plans. Finally, there is presently a great opportunity to investigate the role of gene duplications and gene losses in the evolution of animal

phyla. Here 'big biology', through the sequencing of many complete genomes, is having an impact. The mere fact that we know that the entire ancestral chordate genome (for example, that of amphioxus) has been duplicated twice in mammals and three times in teleost fishes provides enough food for thought for the present. In the medium-term it will be important to have at least one complete genome from each animal phylum, and in the long-term to reconstruct the archetypal genome of Urbilateria. As we approach the 150th anniversary of The Origin of Species, these are very exciting times for the burgeoning field of Evo-Devo.

What advice would you give someone starting a career

in biology? Jump into it both feet forward. Get yourself admitted into the best lab possible. Wash dishes, plead, volunteer, or do whatever you need to do to secure an experienced advisor whose published work you found the most interesting read. Scientific training is like an apprenticeship in the medieval guilds, you have to learn the trade from a master. Before starting any new project read the textbooks in the field - physiology textbooks are always a good choice - and preferably old ones, which provide a fountain of unsolved questions. For cell biology, always start with E.B. Wilson, 1928, Be fearless, Do not take into consideration which areas offer best future employment opportunities, just get into the lab you find most exciting. Move to anywhere in the world where the best possible advisor is located. The world is your oyster twice: first as a graduate student and then as a postdoc. As a young man I was driven by the ambition of making something out of my life. As the years passed this morphed gradually into an unquenchable curiosity to discover the principles by which animals are constructed. This passion for cells and embryos has now become all-consuming. Believe me, the pursuit of scientific knowledge offers a wonderful life.

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Essay

Vision and the organization of behaviour

Jochen Zeil, Norbert Boeddeker and Jan M. Hemmi

What do visual neurons compute? A recent review [1] states that current models of the primary visual cortex (V1) of mammals explain less than 50% of neuron response variance and that "as much as 85% of V1 function has yet to be accounted for". In this essay, we shall consider some of the essential facts of natural vision and argue that the organization of behaviour plays a crucial role in shaping the design of visual neurons. We conclude that the specific movements and perspectives of animals need to be taken into account when using natural images or image sequences in the analysis of visual processing in neurons.

Under natural conditions, vision operates in a closed loop - the distribution of light across the retina constantly changes as we move. This intimate coupling between vision and behaviour has profound consequences for the design of visual processing mechanisms, the organization of behaviour and for the way we study both. Nervous systems have evolved under natural conditions to compute behaviourally relevant information and certain aspects of vision, especially motion vision, therefore need to be studied from the perspective of freely behaving animals. Yet, in most cases, our neurobiological knowledge is gathered in open loop experiments, with visual systems being disconnected from behavioural feedback. Most of what we know about the mechanisms of visual information processing has been gathered in abnormal situations where an animal's visual system does not experience its normal input stream. The consequences of this basic limitation are slowly becoming clear: the responses of neurons differ, depending on whether they are confronted with abstract or with naturalistic stimuli (for example