BETWEEN THE SPECIES

The Bee-haviour of Scientists: An Analogy of Science from the World of Bees

ABSTRACT

I am going to compare the strategies and communication bees use in order to locate and retrieve nectar to the world of science and the scientist. The analogy is intentionally anthropomorphic but I wish to argue that if successful bees made assumptions they would be similar to those of the scientist: flowers can be regarded as facts, nectar as knowledge, honey as technology and their 'waggle-dance' as communication of ideas. I would like to say that this is to be used as an analogy and should not be taken to be a statement of the scientific method as an emergent property of nature, as evolution ultimately does not care about what is true or false, whereas science does. However, what i do wish to convey is that in the same way that the life of bees can be limited by the process of their enquiries; science can also limit itself by the assumptions that are taken to be true or worthwhile in the quest for new knowledge.

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Introduction

Science when used in everyday language can mean one of at least four things; however, when we use the word 'science' we are usually referring to a combination of meanings.

1. An intellectual endeavour aimed at a rational, coherent understanding of the natural and social world.
2. A body of currently accepted knowledge that has been arrived at by specialised methods.
3. A community of scientists.
4. Applied science in the form of technology.

However, from a socio-historical perspective "science" is slightly more difficult to define, and from a philosophical perspective some would argue impossible. In order to say what science is means to say what science is not and this has famously been an open ended-question. Here I refer to the problem of demarcation and the many failed attempts to provide either a criterion of meaning for scientific statements or boundary criteria for scientific knowledge (Wittgenstein 1922, Schlick 1925, Carnap 1928, Popper 1959, Kuhn 1962, Feyerabend 1975).

One thing that most people can agree on is that "science" or the scientific method, whatever that maybe, has been successful in finding out things about nature. In fact, it is so successful the modern world would be unimaginable without the thumbprint of science all over it. From your waking alarm clock to the mechanisation of industry, all have, for better or worse, been shaped by science. However, the knowledge that has made the modern world possible has come at a price. To be scientifically minded or take a scientific perspective requires

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discipline and responsibility, it is not omniscient nor is it omnipotent in its capabilities. As Bertrand Russell wrote, science, by itself, cannot supply us with an ethic. It can show us how to achieve a given end, and it may show us that some ends cannot be achieved (Russell 1950, 406). However, the things to be achieved do not come from science. The fundamentalist version of science, known as “scientism,” has many forms, from the belief that science will be the saviour of humanity to the idea that all knowledge must be reducible to physical laws or measurable phenomena. To uncritically accept science as such an ideology in this way devalues science as an activity and as an idea. This view from a weak and strong notion of science is not too dissimilar to ideas about individual freedom. In the same way that “freedom” contains the notion of “social contract” meaning that we have to respect each others freedom and take responsibility for our own actions. It is through the lens of social contract, that “freedom” does not mean “do whatever you want” but is a measure of our limitations, from the amount of harm we inflict upon one another, to the things we can say, or the places we can go. For people who have an uncritical view of freedom this version does not seem as appealing, leading certain political parties to lobby for inequalities in social freedom. An example of this would be the 2008 Proposition 8 campaign that sought to restrict the definition of marriage to opposite sex couples only.

In a similar way, by having method as successful as science which has increased life expectancy, global communications, and quality of living, an intellectual forfeit is being paid in that some of us have given up on the very process that make these improvements possible. One of the failings of modernity has been that due to our increasing ability to control our environment it has become safer, and safer to believe almost anything,

which in turn has made it easier to pass on ideas of varying epistemological quality.

Science as a process is a peculiar mix of ideas, in a certain sense it is democratic and egalitarian in that all ideas are given a voice, treated the same and open to criticism but at the same time it is totalitarian in that regardless of how many people believe something to be true, or want something to be true, nature has the final word. From this fine balancing act science has found a method by which there is a natural selection of ideas in which only the fittest, most fertile theories make it to the level of “knowledge” which over time may become “fact.” Some philosophers and sociologists of knowledge do contest this idea, however, the strength of their claims seem to rely on either a straw man figure of how scientific knowledge is arrived at or a logic scheme that cannot be applied to their own argument for fear of contradiction.

However, this activity we call science, which is the process of positing testable theories, discovering truths, falsifying ideas, is active in increasing our overall knowledge of the world. As this process is circular, that increased knowledge feeds back into society normally as technology, allowing that society further advancement. I would like to argue that this process has an interesting analogy in the world of bees. I am not the first to use the bee as literary device for communicating ideas. Bernard Mandeville wrote *The Fable of the Bees: or, Private Vices and Public Benefits* (Mandeville 1705), regarded as a forerunner to many modern economic principles and also as an allegorical critique of Christian morality. In an analysis of Canguilhem’s work, the metaphorical comparison of the cellular theory of organic tissue is given to that of the beehive, in that they both share features of co-operative labour, an organised complex

whole, and self-evolving system of mutually dependent parts (Canguilhem 1969). Bachelard argues that this metaphor undergoes a transformation where it becomes scientifically operational and contains genuine scientific explanatory power (Bachelard 1938, 1949, 1984). Derrida, in his essay *White Mythology*, argues “poetic” devices such as metaphor and analogy play an indispensable role in the development of scientific ideas (Derrida 1974). Any deconstructive reading has to be self-reflexive and not just stop at the point of concept-metaphor inversion but has to take in the deconstructive process as a whole.

However, my use of bees is some what different. I am going to compare the strategies and communication bees use in order to locate and retrieve nectar to the world of science and the scientist. The analogy is intentionally anthropomorphic but I wish to argue that if successful bees made assumptions they would be similar to those of the scientist: flowers can be regarded as facts, nectar as knowledge, honey as technology, and their “waggle-dance” as communication of ideas. I would like to say that this is to be used as an analogy and should not be taken to be a statement of the scientific method as an emergent property of nature, as evolution ultimately does not care about what is true or false, whereas science does. What I do wish to convey is that in the same way that the life of bees can be limited by the processes of their enquiries, science can also limit itself by the assumptions that are taken to be true or worthwhile in the quest for new knowledge.

Bee Life

The typical bee colony can search six or more kilometers from the bee hive, and if there is a patch of flowers (a nectar source) within two kilometers of the bee hive, the bees have a better than fifty percent chance of finding it. How do they

do this? The hive initially sends out a handful of scout bees to search the surrounding area. When a scout bee finds a nectar source that seems strong, it comes back and does a waggle dance, the intensity of which is shaped, in some way, by the quality of the nectar supply at the site. The waggle dance draws the attention of other forager bees, which follow the primary scout, while other scout bees who have found inferior sites attract fewer followers and, in some cases, the scouting and foraging bees will abandon their sites altogether (Surowiecki 2004). The net result is that bee foragers end up distributing themselves' across different nectar sources optimising their chances of locating the best nectar source, meaning that they get as much food as possible relative to the time and energy they put into searching. It is a collective solution to the colony's food problem which has been shaped by evolution, allowing an efficient system that rewards survival to remain.

This brief description of how bees locate, communicate to other bees and retrieve nectar is a pertinent analogy to how science and scientists operate. If we assume the patch of flowers is a "truth/fact" waiting to be discovered about nature, the bees are "people" interested in discovering truths about nature, with the need for food being analogous to the "thirst for knowledge," the beehive is the world as we know it (things we know), the honey produced is an objectification of the things we know, and the waggle dance is how people communicate with one another and their community. From these analogies I think we can draw some interesting similarities.

Science operates with a few simple assumptions; these assumptions would tend to be "everyday" beliefs but due to our inability to perceive the world of the large/tiny, deal with astronomical distances, altered time perception or non-Newtonian

actions, science has to be highly critical of the assumptions it does make. Even if the very notion of time-space is up for question, what still seems to make science tick is the idea that there is an external, knowable world independent of our consciousness of it, nature is regular and describable (usually only through maths) and nature follows logical rules in that contradictions do not exist. Outside of these assumptions science operates in a guided but imperfect fashion, it cannot see into the future but has invented rules, methods, procedures and heuristics for limiting the error in the assumptions made.

Flower Patch as Fact

We must assume the bees have an instinctive knowledge that there is an outside world containing objects such as flowers independent of them. They, however, do not know where these flowers are or how many of them exist. Right here we have the gambit of the scientist, she knows that there is a world, independent of her and that that world contains ‘truths’, but like the bee, she does not know where these ‘truths’ are to be found or indeed, how many truths it contains. Science has to assume that the world exists in order for the enterprise to work; else what are meteorologists measuring when rain falls, seismologists when an earthquake happens or particle physicists when radium decays? The process of science is to establish what there is and how we know what there is, but because the relationship between these two tasks is extremely sensitive, nearly all scientists would say scientific statements are provisional, in that they could be wrong. The clause of *provisionality* does not mean that just because a known fact could be wrong, it is probably wrong. “Certainty” in science is a limiting factor for creativity and so one should always be cautious in claiming “truth.” Yet some statements we are surer about than others but to hold any statement beyond reproach is foolhardy and ultimately limit-

ing. So instead of saying “true” I would like to say “truth-like,” in that the more refined and sophisticated our methods become, the closer towards certainty we will tend in our knowing what there is and why we know it. This has its closest resemblance in the Popperian formulation of the scientific method but again due to the caveat of provisionality, I would not like to claim “truth” to any particular scientific method over-and-above how it performs in the face of scrutiny. Due to the extreme productivity and explanatory power of theories like general relativity, germ theory, and evolution, we can place greater faith in their approximation to the truth. We can have confidence in them as theories due to them possessing certain qualities i.e., they predict novel phenomena which have been verified, the assumptions contained within those theories are parsimonious, the theories are open to falsification, they have a large information content which makes them easier to disprove. A theory that claims to explain ten phenomena has a higher probability of being wrong than one that claims to explain one, yet if it can explain all ten including the one claimed by the rival theory it has a higher probability of being the “more correct” one. This was one of Popper’s criteria for theory selection (Popper 1963).

In comparison, I would argue that a theory such as the theory of Intelligent Design is not a good theory for explaining biological life on earth. It is incoherent with known observation, it lacks consensus not only across the Intelligent Design community but with the majority of scientific knowledge, it makes more assumptions about the world in its ontology and teleology than its evolutionary counterpart, and, ultimately, remains untestable.

In my analogy with the bees, the enduring facts that scientists uncover about the world are patches of flowers mapped

in a field of uncertainty. With our maps we can locate those flowers with varying ease and success, calling upon them when required. If we want to work out the force of a travelling car we locate the patch of flowers that tell us about objects in motion, if we want to synthesise a chemical compound we look for the flowers of atomic theory and so on. Yet outside of our current knowledge of any phenomenon we do not know if that is the final word on the matter or whether there might be a deeper truth to still be discovered. If there is, which most of the scientific community believes to be the case, where would we look for this deeper truth? For like the flowers, there may well be nothing but grass beyond our visible horizon and scientists will strive in vain to seek bigger and more colourful flowers. There is nothing necessary about humans understanding nature, the problems of the universe may be intractable, or the scope of human comprehension may be finite. In the same way there is nothing necessary about bees finding flowers, they will look; they will use all their resources and know-how to locate them but the field may just be too big.

Knowledge as Nectar

The bees' survival depends on their ability to locate and retrieve nectar/pollen from flowers. The nectar is used as fuel source for energy and the pollen is used for feeding larvae to ensure the continued survival of the hive. The bee's instinctive drive to collect nectar and pollen in order for the hive to be successful is akin to the scientists' mission to discover truths about the world so that humans will in many ways become richer for it. Not only will the discovery of new truths bring about advances in medicine and technology, but to include one more fact to the repository of knowledge that is "scientific" is a reward in itself. The proof for Fermat's theorem is in itself use-

less but in its discovery we have a new area of number theory mapped, one more mystery solved.

G. H. Hardy articulated this best in *A Mathematician's Apology* when he wrote:

I will only say that if a chess problem is, in the crude sense, 'useless', then that is equally true of most of the best mathematics... Judged by all practical standards, the value of my mathematical life is nil; and outside of mathematics it is trivial anyhow. I have just one chance of escaping a verdict of complete triviality, that I may be judged to have created something worth creating. And that I have created something is undeniable: the question is about its value (Hardy 1940, 151).

Knowledge is how humans survive and by-and-large it is knowledge produced by science that has helped humanity advance so far and has made the modern world possible. The more nectar that is located the more likely it is that the hive will survive, but because bees, like humans, can get it wrong, any investment in one line of thought, idea or ideology could have disastrous consequences for both animals. If a bee mistakes a selection of artificial flowers or a recycling bin full of drink cans for the real thing, then when she arrives back at the hive she will pass on the false belief that she has discovered a plentiful source of food. The information conveyed or evidence advanced in favour of her misguided belief would certainly stack up in the world of the bee, the waggle dance would indicate distance, colour, and sugar content of these supposed flowers. The initial scout bee will be followed by other forager bees and the claim to having discovered a patch of flowers will be investigated. Likewise, the scientist will think he has made a

discovery or breakthrough and, depending on the evidence offered in its support, other scientists, through experiment, peer review and consensus, will try and establish the truth-value of the original claim. When it is discovered by the forager bees that the artificial flowers have no pollen or cannot produce nectar or the recycling bin has been emptied leaving only residues of sugar, the claim is then abandoned in favour of competing sites for flowers.

A Hive of Knowledge

Let us assume that the beehive in this analogy is the community of scientists and rational people sharing in the assumptions of science. Luckily built into the bee's strategies for finding nectar is the scatter gun technique. Scout bees will independently explore all directions of their surrounding environment in order to discover flowers. Then, depending on their discoveries, they will report back what they have found. Ideally, the strongest candidate for the discovery of new flowers is followed by the community of the hive. If the scout bee is correct and has indeed located a lush new patch of flowers, the hive is then rewarded by having an additional source of nectar. The bees can eat, the larvae be fed and the process of finding more new flowers can continue. If the bee has excelled itself in its new discovery, the excess nectar of all the flowers is then transformed and stored as honey to be used in times of hardship to see the hive through.

Bees like scientists are involved whether they want to be or not in the continued maintenance and stability of their community. Bees, like most social insects, work for the survival of the group rather than themselves, hence worker bees are undeveloped females and are not needed to reproduce, but only to defend the queen-bee so she may reproduce herself. Humans

are a little more sophisticated than this but in principle the work of scientists is to add to knowledge, not to keep knowledge for themselves. If a new law or phenomenon is found, it is shared with the scientific community for evaluation and then with the wider community in which we are all share-holders. The discovery of new knowledge should not only benefit the individual scientist, with fame and wealth, but also anyone who invests in the discovery of new knowledge. However, within this framework, bees, like scientists, do not all have the same interests and values in what is worth investigating (i.e., where in the field to look for flowers). Science, conceptually speaking, does not bias in one direction, toward one aspect of reality or one subject. For this reason science has become minutely specialised in dissecting nature. Any single phenomenon can be approached from a number of angles, producing different hypotheses and predicting different outcomes. At the moment the Holy Grail of theoretical physics is to produce a “grand theory of everything,” or a unified field theory. Currently some of the competing ideas of how reality is constructed are energy as strings, membranes, fields of force, dark energy, and the search for the Higgs Boson particle. Now what might happen is that one of these theories, suitably developed and tested, will yield astounding results, combining all the known forces of nature into a single theory allowing as yet unimaginable acceleration in human development. This would be the equivalent of our bee finding a massive meadow of blue-bells; other forager bees would come along and verify that these were indeed blue-bells and begin harvesting the nectar to be later stored as honey. The nectar retrieved would be the knowledge we would obtain from such a theory and the honey would be the applications that such a theory would allow. Then again, the field might be barren and such a hypothetical meadow of blue-bells will remain chimerical; there might be no such thing as a “grand theory of every-

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thing” but for as long as people are willing to search, and search in different areas, it is always a possibility.

As with science, for every bee that actually finds a new patch of flowers there will be many that do not. It is all too easy to be wrong, and if the correct procedures are not in place for checking claims, any blind acceptance of what someone says can be fatal. Here a distinction should be made between not finding flowers and being a poor scout bee. If bees just looked in one corner of the field and never ventured elsewhere the hive would soon be bare of life, if the hive persisted with one bee’s claim to have found flowers in which it was mistaken, again, this would spell disaster for the population as a whole. As with science, one of its strengths lies in its diversity of enquiry, the self-critical nature of that inquiry and the value it places upon evidence. If science consisted solely of the investigation of trees, exploring the claims of a few individuals the whole enterprise of science would be short lived. The properties of trees would tell us something about the world but soon we would be inundated with “tree experts” and as important as trees are, they do not tell us much about biology, chemistry, anatomy, geology, or astronomy. The diversity of interests science cultivates is one of its strengths; where in the field we want to look for flowers, how we should look for flowers, in an ideal situation the scientists’ strategy for locating truths should reflect that of the bees’ search for flowers. This is why the bee foragers end up distributing themselves across different nectar sources optimising their chances of locating the best nectar source, meaning that they get as much food as possible relative to the time and energy they put into searching. Unfortunately, in the real world, due to investment cuts, lack of funding, and research interests that favour big business, the freedom of scientists to choose where to look and how to look is becoming ever more limited.

This may not be detrimental to science's relation to society as a whole, but it does do damage to science as a creative force for discovering facts and novel solutions.

The Bee-haviour of Scientists

One salient example of scientists operating in this fashion occurred in 1989 when two chemists (Pons and Fleischmann) working at the University of Utah claimed to have fused hydrogen atoms into helium which produced neutrons and generated heat by a process known as "cold fusion." If correct, the implications of this finding were of massive significance, a new source of limitless energy at relatively little cost in apparatus and materials. These claims generated a hive of excitement not only because of their implications but also due to the failure of generating energy through "hot fusion," at considerable expense to the American Government. Here another faux bed of flowers had failed to be detected and now interest grew in these rival claims of "cold fusion." The main sources for information about these experiments were the media, conferences, faxes, and e-mail rather than by established channels of science, so once the news broke out scientists all over the world tried to replicate the phenomenon of cold fusion but with incomplete information. Here, the waggle-dance was premature in its deployment, the required checks and testing had not been completed but because the potential for such a massive discovery was so great, scientists world-wide followed the waggle-dance and set about finding these flowers. What also intensified the desire to believe the waggle-dance of the two chemists was the potential for wealth and fame, that if one laboratory could prove beyond doubt the existence of cold fusion and file a patent for its design, they could then live the rest of their lives out on the nectar produced from those rare but powerfully scented flowers. Attempts to follow the waggle-dance of the Utah labora-

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tory, a lab at Brigham Young University, reported no excessive heat generation but they did record a production of neutrons. At a lab in Texas A&M, there were preliminary reports of a release of heat and at the Georgia Institute for Technology, the investigating team also found neutron production. Independent verification also came from labs in Hungary and Japan as to the existence of cold fusion. The initial reports coming back to the hive were favourable; such a flower patch might exist but due to lack of correspondence between what the waggle-dance promised and what was found in the field no one could claim with any certainty that these flowers were real. In the same year of 1989, the original claimants of the discovery published a paper in the *Journal of Electroanalytical Chemistry* as to the methods of their discovery. From discovery to publication of a new natural phenomenon this was very quick by scientific standards and would suggest the considerable interest in the claim. Here we are starting to see an instance where the excitement caused by the waggle-dance had out-accelerated any rational requirement to scrutinise the dance beyond what a few returning bees had to say. From this swarm of excitement, the University of Utah rushed a petition for a patent, the State of Utah allocated 5 million dollars to fund further research into cold fusion and the US congress was asked to contribute a further 25 million dollars. This highlights the significant economic value the discovery potentially had for the host country. The potential for limitless nectar and honey of a particular kind would seem too great to ignore or play cautiously when competing hives could be on the brink of similar discoveries.

Moving into the analysis of the results, it was found that the Texas A&M and Georgia Tech University results were due to faulty apparatus. Other independent studies conducted statistical comparison of results and found no corroboration between

the Utah claims and the claims coming from other research institutions. The American Physical Society met to discuss and review all the available data on the alleged phenomenon and the consensus was that there was no compelling evidence for the claims of cold fusion. Once the buzz of the initial findings and claims had died down, the waggle-dances of those returning scout bees were properly scrutinized. No bee could claim to have found flowers, the waggle-dance seemed to be incomplete as more and more returning scout bees testified that they looked where the waggle-dance instructed but no flowers were to be found.

To this day no one has been able to reproduce the phenomenon of cold fusion, although that's not to say it did not happen that one time in Utah. However, until better evidence is produced, we have to conclude it was more likely the result of human error and not a new phenomenon. Like the bees, that particular waggle-dance has been abandoned in favour of alternative dance patterns; however, some claims to the location of similar flowers cannot be investigated for now, for the cost at the moment remains too high. To travel to the parts of the field where it is suggested nuclear fusion or matter-anti-matter combustion lies is still too far for the majority of our bees at the moment, the flower patches of hydrogen fuel cells and nuclear power are in a more accessible location and for now this is where we retrieve our nectar.

Conclusion

The strength of the hive and its population should be a function of the hive's ability to locate and communicate the existence of flowers or flower-like objects. In the same way, humanity's success has come about by our ability to seek truths and communicate the knowledge for finding those truths to one

another. We can see this cause and effect with every great discovery: penicillin, x-rays, electricity, optics, DNA, the list is endless but we all feel their effects, to the point that in overdeveloped societies they have become too content with the massive storage of honey and stopped wondering about the existence of the flowers that make them possible. This attitude is reflected in a lot of uncritical philosophy of science, relativism, and religious fundamentalism. In this uncritical world, the waggle dance has become central and the actual investigation of the claims is regarded as unnecessary, due to the amazing success of a few brilliant bees we now have enough honey that most waggle dances can be entertained as genuine claims to having found flowers. Put another way, due to the success of science/technology we can control our environment to a point that anyone can believe what they want, from the effectiveness of homeopathy to the idea that all truth is a social construct.

I think many lessons can be learned if we turn our attention to the world of nature. Not only does it seem that the scientific method for discovering approximate truths or efficient solutions is hard-wired into the evolutionary process but that process also applies to ideas. I think when language was still in its embryonic stage amongst humans, our lives were very close to that of the bee and its hive. However, instead of craving nectar, we would have been seeking, food, water, warmth, shelter, and a mate. If any of those pioneers of human knowledge claimed to know where to get food or how to generate heat, the tribe would have had their own means of investigating, verifying, or falsifying such a claim. The upshot of a truth-like claim would have been improved conditions for the tribe and improved likelihood of survival. Jump forward a few hundred-thousand years and the situation is markedly different. The simple process of curiosity has condensed into a highly specialised institution of

science, with its own procedures, assumptions, and rules from which we have all benefited but unlike the bees who live day-to-day, we have discovered such fertile patches of flowers that we can stockpile honey indefinitely to the point where it is no longer a requirement to believe that those flowers exist or know how the honey is created. This though has had a limiting influence; because of the amazing effectiveness of science the wider community believes either that “truth” is relative and that science is one path to truth among many or that science has the answer to everything and is the key to human emancipation. But just like the bees, we cannot and do not know where the next patch of flowers are, if indeed there are anymore to be discovered. If anything is to be taken from this comparison, it is that in the same way that the life of bees can be limited by the processes of their enquiry into nature, science and the people invested in the critical rational method can also limit themselves by the assumptions that are taken to be true or worthwhile in the quest for new knowledge. As it would be a mistake to think who needs flowers when we have all this honey.

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