Are patterns a rule in nature?

'Nor is it our business to prescribe, to God how he should run the world...'

– *N. Bohr*[1]

Searching for patterns and investigating the basis of their emergence has been probably the major occupation in science. It is because the planets were found to go on circling in a regular pattern that the science of astronomy was born, because the fossils were found changing in a gradual and interpretable manner that the science of evolution started, and chemistry as a science survives because the electrons exhibit a regular pattern of movement around the nucleus; in a crude sense, patterns seem to be the raw material for the build-up of the systematic knowledge that we call science. It is not surprising that science could not have really grown as it has should not patterns exist in nature. In fact, science grows by continuously feeding on the patterns identified in nature.

It is easy to recognize that since patterns are an important raw material for its growth, science seems to have evolved its own ways of 'discovering' them so as to sustain its own growth. It appears that this ability of science has also contributed to its rapid growth as an inseparable element of human civilization. The more the patterns held out by science, the greater is the thrill for its practitioners and the more are the followers who get ensnared to investigate them. In this sense, every pattern shown or demonstrated has the same effect as a miracle would have on the spread of a religion or the religious belief. There is one difference, however: miracles are always questioned and science has its own and unfailing ways of disproving them while freshly discovered patterns are always celebrated, and accepted on the belief that science has a self-correcting mechanism. What is not realized is that often these patterns are constructs of the language and grammar of science which *per se* ensure immortality of these patterns. The self-correcting mechanism of science would certainly be operating to eliminate those artefacts which the language of science can clearly identify but not those which are themselves the creations of the possible artefacts of the language itself. Thus, it might be important to delineate the virtual patterns from those 'created' by science.

In this article, I intend to address two issues of patterns with respect to their genuineness versus the extent of illusion that science might have created about their existence. The first concerns the meaning and signal component of patterns to which scientists are attracted when they attempt to identify a pattern in any natural system. It will be argued that, since there have not yet been distinct criteria developed to demarcate patterns from non-patterns, scientists seem to often develop their own mechanisms of identifying patterns, which in turn ensure the survival of the science as such and of these mechanisms as they help generating more patterns. The second issue concerns the belief that our world and patterns in it should emerge from orderly processes. It will be argued that our world could be a result of many more random processes than science would subscribe to and that, as an enterprise, science has survived partly because it strongly believes and propagates the idea that patterns should emerge from an orderly process.

What is a pattern?

While it is indeed difficult to define what a pattern is, it is easy to visualize that every scientist would think of a pattern in accordance with the area of his speciality. There can be temporal patterns such as sunspot rhythms, circadian rhythms, periodicity in the recruitment of foraging ants, spatial patterns such as skin patterns, distribution of celestial objects within a galaxy, or in the universe, arrangement of leaves in a plant, spatial pattern of foraging in animals, spatiotemporal patterns such as the famous B–Z reactions, and derived or abstract patterns such as phylogenetic trees, frequency–size relations in living systems and inanimate objects, and so on. Undoubtedly all these are considered to have patterns of one kind or the other and hence have inspired investigations in their respective fields. But the signal component or the specific feature of the system that is considered to reflect the pattern might vary and hence there might not be a common agreement among all the scientists as to what they mean by a pattern. For this reason it appears that there is certain intuition or trained skill that drives a scientist to recognize the existence of patterns in his/her field of specialization. For the same reason it is difficult to immediately define the term pattern as it is also probably not necessary for the discussion or the argument to be developed. However, it would be seen that precisely this difficulty of defining a pattern *per se* is one of the major problems associated with the process of pattern finding in science.

Are patterns discrete?

There has generally been a view that the existence of pattern is an all or none phenomenon. In science we tend to say either a pattern exists or it does not, implying that the patterns are discrete. It is a surprise as to why science immediately recognizes and appreciates the demonstration of absolute 'yes' patterns more easily than that of 'poor' or 'no' patterns.

But a few interesting studies in psychology on the perception of patterns have demonstrated that given the set of all possible events in any dimension (space or time; see below), our mind clearly recognizes some as very good, some as very poor and others to range between these extremes. In other words, perceptually we are not biased to classify the range of patterns only into discrete classes of 'yes' or 'no' patterns. Rather we are capable of identifying a continuity in the patterns. This tendency to perceive continuity in patterns seems to rest not so much on our inability to demarcate them unambiguously as on a few basic features which inhere in and are associated with the patterns themselves.

For instance, Garner[2] created a set of 126 designs by placing five dots in all possible combinations in a 3 × 3 matrix of cells and offered to the respondents to classify them as 'good' or 'no' patterns. He found that these designs were almost unambiguously classified as good, poor and intermediate categories (Figure 1). The only two designs identified as good were very specific in the sense that they looked the same either when they were rotated by 90° or when they were imaged in the mirror; in essence, they were highly symmetric and had no alternatives at all that can be generated by rotating them through 90° or by imaging them. On the other hand, those that were classified as poor changed their shape/form when rotated or mirror-imaged and accordingly generated a large set of alternative forms on such transformations (Figure 2). The intermediate designs had features in between these two: they were less symmetric than the very good but more than the very poor ones and they had a few but more alternate forms than the very good designs. They concluded that good patterns are those which are unique, highly symmetric and hence have no alternatives, while poor patterns are those which have many alternatives. In fact, it is probably true that we feel a circle or a square a good pattern and an ink dot a poor pattern because there is only one way of writing a circle or square but may be a million ways of forming an ink dot.

What is interesting and particularly noteworthy of these studies is that this feature of negative association between the 'goodness' of a pattern and the number of alternatives it can have was also shown to be true even with temporal sequences such as a stretch of musical notes. These temporal sequences could also be classified unambiguously as very good, intermediate and poor.

Thus, the 'good' or 'poor' gestalt of patterns seems to be a continuous feature (virtue) irrespective of whether they are temporal or spatial patterns and that we indeed perceive them continuously. In other words, the patterns *per se* in nature do not seem to segregate on their own into discrete or absolute classes of 'yes' or 'no' patterns. Thus, if scientists are recognizing always the 'yes' category, it is probably because of their instinctive desire to look for the existence of patterns, a desire cultivated due to their profession; science accepts them because it can sustain its growth on the existence of patterns. The claims of discovering 'no' or 'poor' patterns are not as much rewarded in science as those of finding a 'good' pattern.

This attitude seem to have led to a peculiar situation: neither the continuity of patterns has been accepted as a norm nor have we developed an objective line to delineate 'good' versus 'poor' patterns along this continuum*. Consequently, as the exploration of 'good' patterns leads to their exhaustion, scientists hunt for more; they struggle to squeeze out some pattern even in the intermediate and poor patterns and pool that also in to the 'yes' patterns category. One immediate result of such pooling of almost everything into the 'yes' patterns category is that we are hardly left with any 'no' patterns in nature. This is exemplified by the fact that we have a pattern even in the random movement of a particle: the root mean square displacement of a randomly moving particle from its present position is proportional to square of the time[3]; in other words, there is a pattern even in its random movement.

Another consequence of such a tendency of looking for patterns and increasing the size of the pool of 'yes' patterns is that scientists frequently alter their tools suitably in their frustrating search for patterns. They explore the whole repertoire of explanations and/or tools that aid in forcing a pattern in what could otherwise be a messy world. They continuously dissect out, repeatedly attack and chip out chunks of details from the monolith of nature until they arrive at a pattern.

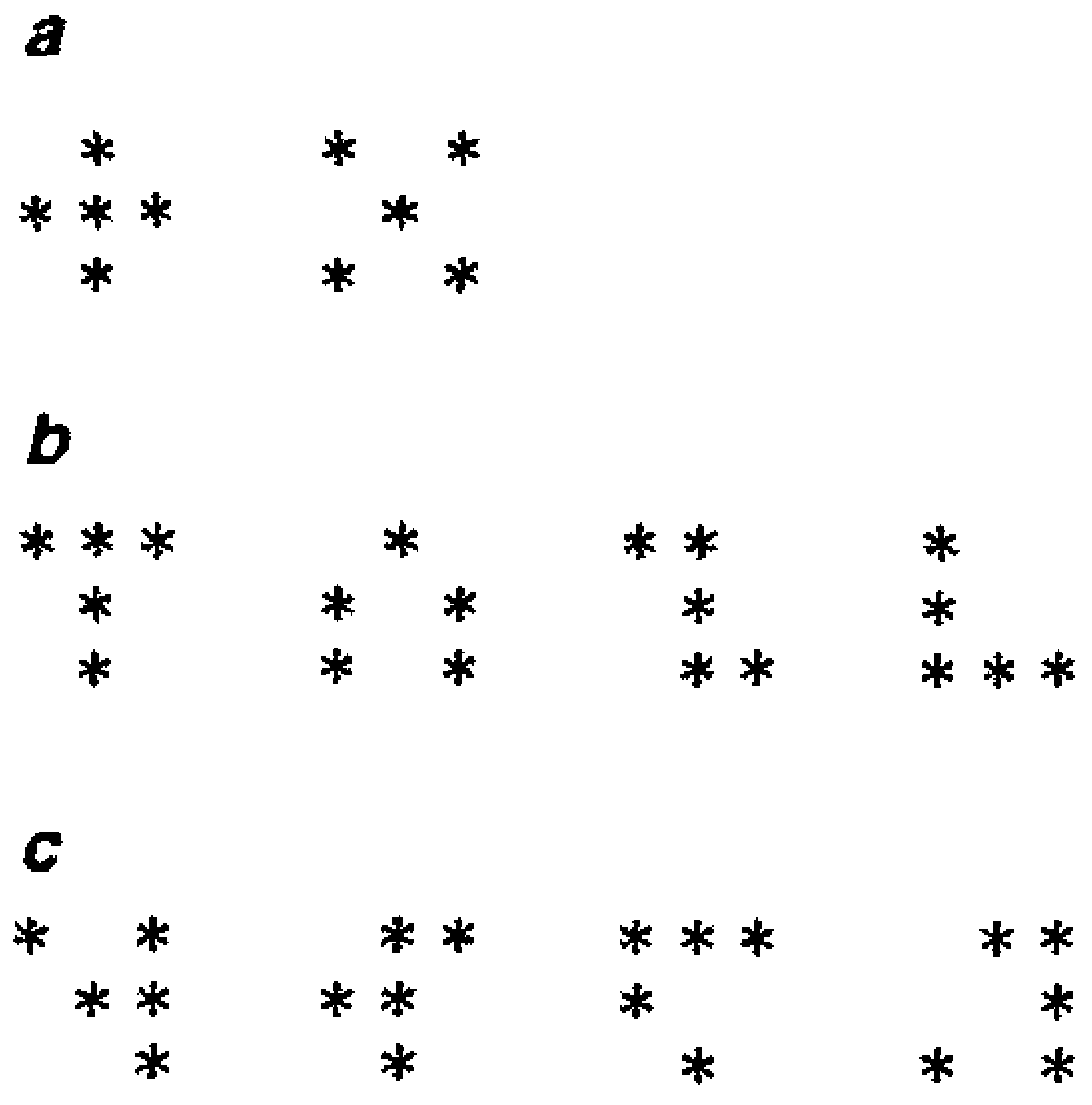

Figure 1. Three categories of patterns identified by the respondents: ***a***, good patterns: each of these remain the same when mirrored or rotated by 90°; ***b***, intermediate patterns: each of these will produce three other alternatives when mirrored and rotated; ***c***, poor patterns: each of these will produce seven equivalent patterns on reflecting or rotating by 90°.

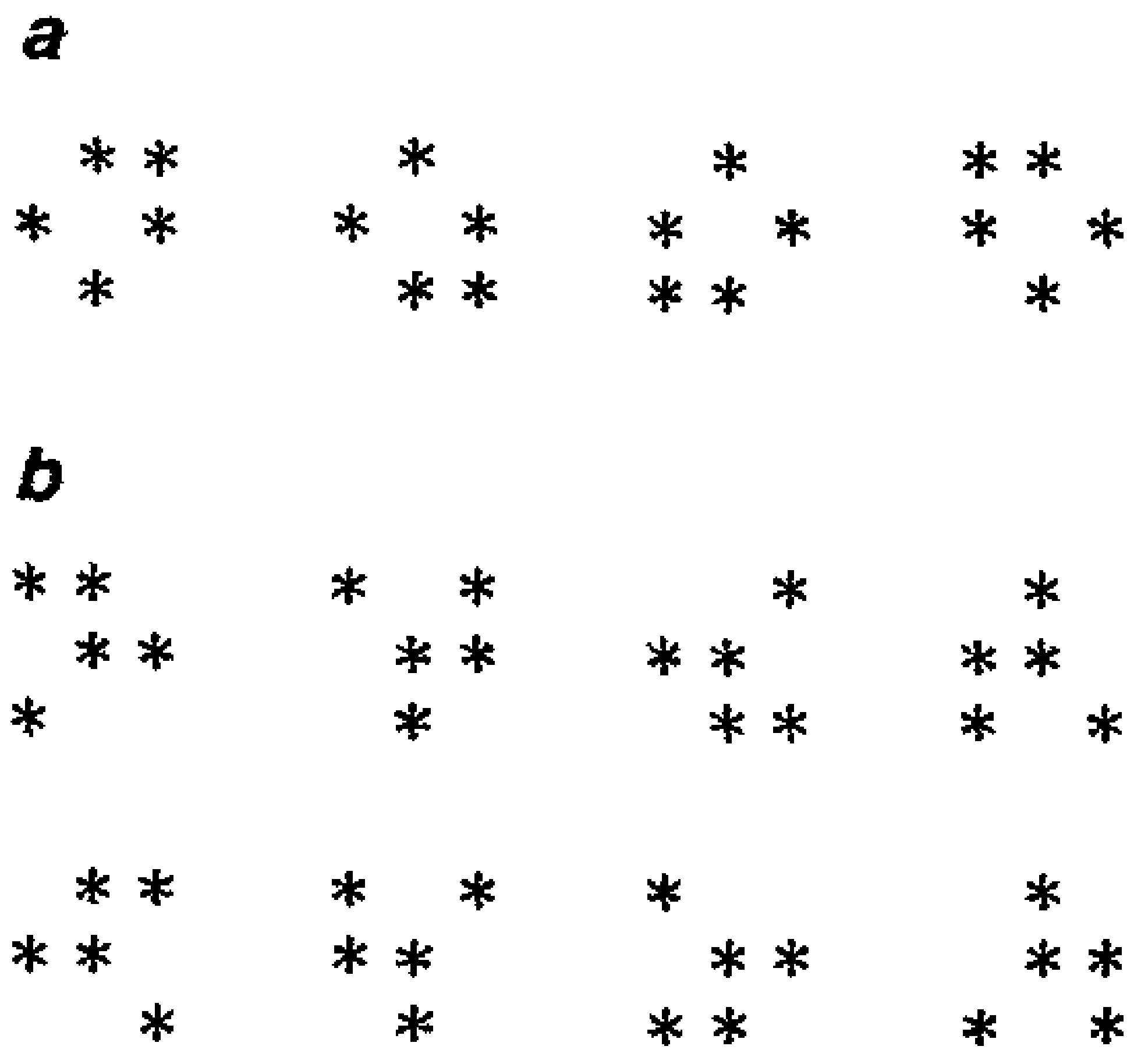

Figure 2. Alternate forms produced by poor and intermediate patterns of Figure 1: ***a***, alternate forms of one of the intermediate forms; ***b***, alternate forms of one of the poor patterns.

We do not know how many such chips of information are discarded and considered unimportant (noise) in the process of arriving at a final pattern. In other words, such a pattern is frequently forced to fit.

The process of pattern finding in this sense is probably no different from a sculptor visualizing the final product in a monolithic stone and chipping it accordingly. Scientists just replace the sculpting tools with the statistical tools. Science abounds in such situations: testing for fractal relations which involve transforming the coordinates to log values is possibly one such situation; such a transformation would obviously involve a lot of hiding of variations (information) than is revealed through the establishment of a fractal relation. The only difference between a sculptor and a scientist is that the former has an initial pattern fixed while the latter starts chipping to arrive at a shape. One strong argument of the scientist in favour of his actions is that he is objective as he has not fixed the final shape as a sculptor would do. But too frequently, he has the final patterns fixed even when testing for a null hypothesis. While testing for the existence of a normal distribution, or fractal relation etc., his null hypothesis is indeed 'it is not following normal' or 'it is not following fractal'. In other words, he has imagined the final shape of things to come as much as a sculptor would have.

Patterns and the processes generating them

It is a general attitude of science to attribute an order-generating process to any pattern. As argued above, since science has been highly perceptive to the orderly part than to the random part of the nature, it has been the tradition of science to always look for processes that generate such an order. Consequently, randomness *per se* as a process is thought to be either incapable of, or rarely contributing to, generating patterns in nature. Appallingly, it is very infrequent that randomness is thought of as an alternative force generating the order.

Consider a specific example of the following three sequences of heads and tails.

HTHTHTHTHTHT . . . A
HHTHHTHHTHHTHHT . . . B
HHHTTHHTHTTTHTHHTHH
HHHTTTH . . . C

Clearly, sequences A and B are more orderly and we tend to generally think that there is a pattern in them but not so with C. Note that all these are, in fact, a subset of all possible permutations expected from an unbiased randomly behaving coin. This means that all the three can be generated by a single random process. On the other hand, let us imagine that there is a process that exclusively generates series A. Such a process cannot generate B and C without alteration while

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*It might be argued that the statistical tests developed probably would do this job. But the statistical tests are applied to examine whether a 'pattern' observed or assumed along this continuum exists or not and not to delineate 'yes' from 'no' patterns. In other words, the statistical tests would only assess whether pattern of a given degree exists at a given point along this continuum.

a random process can generate all these *without any alterations. Thus, it* appears that 'dice throwing' (a random process) can generate all that is seen in nature, including all the 'yes' patterns, while an orderly process has limited consequences. The world of randomness can be exhaustive while that of orderly processes cannot be unless there are as many underlying processes as there are orders. And if the simplest of the explanation could be the best, we might have to consider randomness as a more powerful process than science considers it to be.

Let us consider an imaginary planet 'Binearth' in which all the 'Binets', the four-segmented organisms are created randomly from binary digits 0 and 1. If one considers all the possible combinations (see below) and classifies them as 'good' or 'poor' patterns then clearly, a majority of them fall into the 'good' category (though the decision on some of them might be contested, a sample of 25 postgraduate students indicated certain categorization from which a common consensus could be developed); clearly, 75% of these sequences (12 of the 16 marked bold below) can be shown to have some pattern. In fact, it is possible to argue reasonably as to why these are non-random.

0000 **0001** **0011** **0111** **1111** **1000**
1100 **1110** **1010** 1011 **1001** **0110**
0101 0010 0100 1101

Now *let us imagine that only a fraction* of these patterns have survived on this planet Binearth purely by a random *process such that still 75% of them are* non-random. Let us say a biologist from earth happens to study this planet and addresses the question 'is the arrangement of the segments in the life forms on Binearth regulated by any orderly process?'. He is obviously likely to conclude wrongly that life on this planet is not a consequence of random creation because among those alive there is a *greater proportion representing non-ran*dom arrangement of 0s and 1s. This is *especially true if* the process of extinction has lead to a random drift towards bias in the patterned organisms such that the percentage of the patterned organism is more than that expected purely by a random process. Obviously, these scientists would be even reluctant to think of randomness as a force generating the order seen in that planet.

It is clear to see that while the orderly *process would, in fact, limit the diversity* of the life forms, the random process results in a wide range inclusive of the non-random forms. The world of the random processes is more diverse and all-encompassing than that of an orderly process. Thus, if God likes to create diversity, he shall rather go for a random than for an orderly world. In fact, from an orderly world it is possible to eliminate randomness whereas it is difficult to eliminate order from a random world. This is reflected from the Ramsey theory.

On the 'Ramsey theory', Graham and Spencer[4] wrote thus: Fran Plumton Ramsey proved that complete disorder is an impossibility. Every large set of numbers, points or objects necessarily contains a highly regular pattern. Constellations and such patterns are implicit in any large structure, whether it is a group of stars, an array of pebbles or a series of numbers *generated by throws of a die. Given* enough stars, for instance, one can always find a group that very nearly forms a particular pattern: a straight line, a rectangle or for that matter a big dipper. In fact, the Ramsey theory states that any structure will necessarily contain an orderly substructure ... implies that complete disorder is an impossibility.

Could it be that a scientist sitting in such a random world is myopic for all the random part of it and only concentrates on the non-random component? That would be a tall claim. It is, however, likely that world could certainly be more random than we think it to be and the basic instinct of science to look for patterns for its own survival might be biasing our view of the world to be highly orderly. Finally, I am aware that the views expressed here are certainly highly personal and to borrow the words of Dr. S. Chandrasekhar,

> 'I am clearly treading on dangerous ground. But it does provide me the opportunity to draw attention to a fact which has been a source of considerable puzzlement to me'.
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> – *S. Chandrasekhar*[1]

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3. Berg, H. C., *Random Walks in Biology*, Princeton University Press, New Jersey, 1983.
4. Graham, R. and Spencer, J. H., *Sci. Am.*, 1990, 263(1), 80–85

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