

What in the World is Chaos?

by James Wanliss

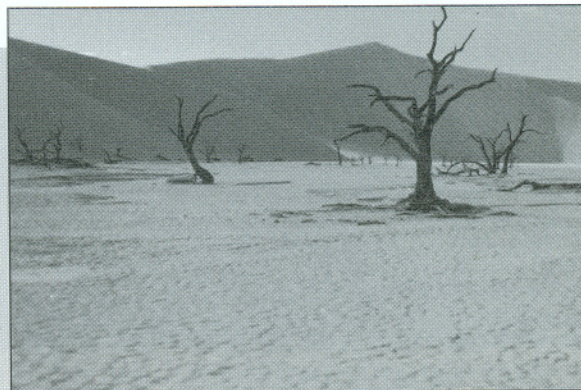
Three months ago I was privileged to visit Niagara Falls. The giant carved horse-shoe was magnificent and the beauty and the roar of the water were quite breathtaking. It is possible to stand very close to the water a little farther downstream, and quite often whole branches and other pieces of wood can be seen floating by after passing through the pounding power of the falls.

As I looked at that amazing scene, I imagined two pieces of wood rushing towards the precipice and then over the top. Now imagine seeing the same pieces of wood some time later, floating side-by-side as they rush by you some way beyond the falls. What can you guess about how close they were at the top of the falls?

The answer is nothing. At first glance this answer might appear obvious, but it is actually quite profound. The pieces of wood do not have to pass over the edge in the same position, or even at the same time. The future motion of pieces of wood placed together some distance above or below the falls, where the streamlines are stable and the water flows smoothly, is easy to predict accurately. However, close to the falls things begin to change dramatically. There the pieces of wood start to move erratically as a fluid motion that appears less ordered, ever more turbulent, drives them along. Soon predicting the position of each piece of wood is impossible. This is one example of a system displaying what is known as deterministic chaos. The rushing turbulence of the water and the swirling, twisting vortices seem at first glance to be totally random. However, the same laws of physics are at work in the smooth steady flows and the unruly turbulent flows. In essence, we should be able to predict the future position of the sticks in all types of fluid flows. Yet we cannot.

Chaos is found almost everywhere – a dripping tap beats steadily until very suddenly it becomes random; wild swirls develop in a steadily rising column of smoke; a stormy weather system brews

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 not
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unexpectedly. Space magnetic fields affecting satellites display chaos. Stock market data also show it, as do many electric circuits, the behaviour of an airplane in flight, and even the beating of the human heart. The word “chaos” used scientifically refers to a system with sensitive dependence on initial conditions. That is, small changes in the initial conditions can have large effects.

Imagine hitting a hockey puck across the ice, and then doing so again but twice as hard. One might expect that the puck slides twice as fast – this is a linear process with a predictable cause and effect relationship; small changes in initial conditions have little effect. It becomes more complicated when friction comes into play, since the energy the puck loses depends on the speed at which it is moving, and the speed depends in turn upon the friction.

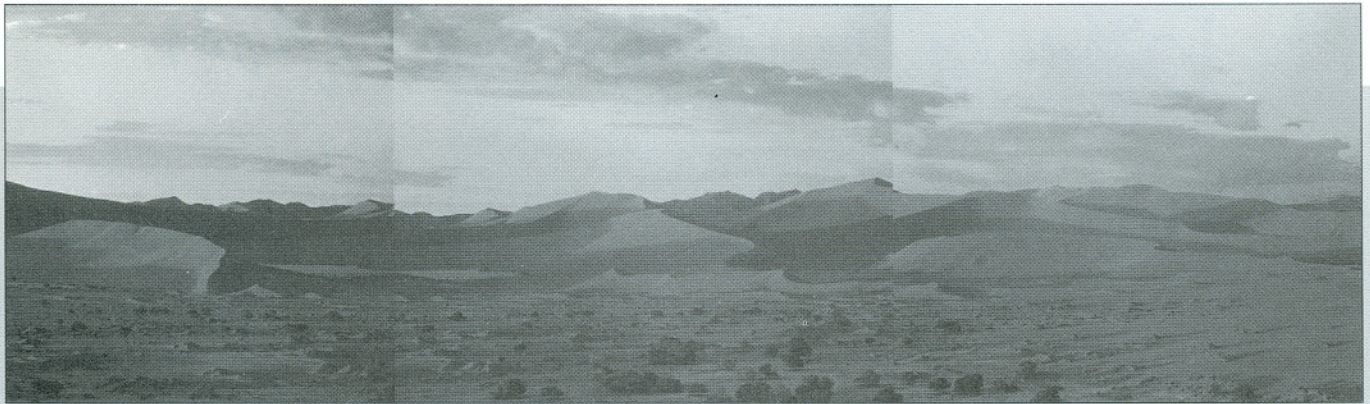
Similarly, the motion of a stick floating in turbulent water is a nightmare to predict since even the tiniest shift in the stick’s position can completely change its future course. This is nonlinearity; there exists a sensitive dependence on initial conditions.

You can hear this transition from regular to chaotic motion in your home, by listening to a dripping tap. When the tap drips slowly, you will hear the regular beat of the falling drops as they land in the wash basin. Now give the tap a very slight

turn; under the right conditions, you will hear alternate short and long beats. Give the tap another tiny turn and it will never settle down to uniform stable behaviour; it has become chaotic. Because of this fundamental unpredictability scientists are unable to accurately predict the dripping of a tap. In the same way, neither can they forecast weather beyond a couple of days.

Over the ages “chaos” has always meant disorder and randomness, total confusion and turmoil. Although this is how many of the processes I have mentioned appear to behave, the name is unfortunate since we know that they are not random; randomness does not describe what is happening. Chaos is not random. What initially appears as random noise may actually show a delicately fine design. This amazing design is seen in the beautiful graphics identified with chaotic systems. Such graphics are seen these days on calendars, on T-shirts, and even on movie screens. They are so beautiful because they are so complex, and show a similarity on all scales. That is, no matter how much one zooms in on the picture there is always more and more structure to see, and that structure somehow looks very similar to the original.

I spent time in the Namib desert in Namibia, where the immensity of the sand dunes is enhanced by their scale-indepen-



Judging distances is impossible

All photos courtesy of James Wanliss

dent properties. The dunes look as if they are really close as one walks in the desert, and yet after much walking one realises this is not true. Small dunes look very much like the large dunes, and so judging distances is impossible. All perspective is lost in the desert, unless there is something nearby with a known scale with which to compare. Without clues such as haziness, a dune a few hundred metres away can be indistinguishable from one a few kilometres away. Like dunes, clouds, rivers, trees and mountains also display a “fractal” nature, the term coined to describe such scale-independent shapes. This scale-independent fractal property is well-known in geology; in photographs, a reference such as a coin, a geological hammer or a person must usually be included.

The fractal geometry of chaotic systems is being used increasingly in fields as diverse as physiology and space physics, and has wide application in many areas, including the study of lasers, the interpretation of brain waves and the behaviour of economic markets, chemical reactions and nerve cells. Chaos theory is one of the most exciting and intriguing areas of science to develop in recent decades. It appears that chaotic behaviour is universal and cuts across interdisciplinary barriers. Results which define chaotic behaviour in one study, for example in the beating of the human heart, are such that we can apply the lessons learned there to other fields showing chaotic behaviour. Chaos

is not yet a mature theory, and research into the properties and applications is still young, though very promising.

The essential unpredictability of deterministic chaos implies that we need an infinite amount of logic to figure out what even the smallest piece of spacetime is going to do. This is surely a reflection of our infinite God. Chaos theory shows, as Christians already know, that the full structure of the world is more splendid than our language can express and our minds understand. The remarkable order and harmony of the creation clearly display the divine nature and power of God (Romans 1:19, 20).

Science is the development and ordering of definite knowledge about the physical universe. Science, says the reformer John Calvin, is “an excellent gift of God.” God has put the whole creation under the dominion of man (Psalm 8). God has given us intelligence and the divine mandate to subdue the world about us. Science, a gift of God, aids us in this endeavour. True science will never contradict the Bible, because science is the handmaiden of God, and the Bible is the Word of God. The entire universe which the sciences study is subject to the laws of divine creation, to the effects of the fall of man, and to the consequences of the redemptive work of Christ.

Sadly, humans are wont to rebel against God (Genesis 6:5). So it is not surprising that some people use scientific advances as a further excuse to reject

spiritual principles and a belief in the moral authority of God. At every turn sinful man tries to vindicate his explicit rejection of God. Unbelievers use chaos theory to try explaining how it was that all life evolved from nothing. Nothing under the sun changes – in Greek mythology, Chaos was the state of turmoil, or void, from which all things arose. Proceeding from the start of time, Chaos eventually formed a huge egg from which issued Heaven, Earth and Eros (love). Indeed, Chaos preceded the origin not only of the world, but also of the gods.

The Preacher says, “. . . there is nothing new under the sun” (Ecclesiastes 1:9, 10). Unbelievers desperately repeat the excuses their forebears foolishly uttered. They begin by rejecting God, and appeal to science for support. Christians – scientists and non-scientists alike – begin by affirming the existence of God. It is the purpose of God that the creation should serve to glorify Jesus Christ (Romans 11:36, Colossians 1). We know that everything in nature depends upon the will of God, and when we study it we see His power and glory displayed. Glory to God who has given us the ability, however imperfect, to learn of Him through science, and especially through His Holy Bible.

About the author:

James Wanliss came to Canada recently from South Africa. He is a graduate student in a Ph.D programme in physics at the University of Alberta.

