An increase in the magnitude of the electric charge, Q, with c and G remaining constant, implies a reduction in the area of the event horizon. By contrast, a decrease in the speed of light, c, would lead to an increase in event-horizon area. Thus the two contending alternatives for an increase in \( \alpha \) produce opposite outcomes as far as black-hole entropy is concerned.

It could be argued that a reduction in event-horizon area implies a violation of the generalized second law of thermodynamics, and so the fundamental electric charge therefore cannot increase. However, before we can be secure in that interpretation, several conditions must be satisfied. The black hole will radiate heat into its environment through the Hawking process, and, as Q changes, the temperature will also change. For the second law of thermodynamics to be violated, the black hole must not raise the entropy of the environment by more than its own entropy decreases. This condition is readily satisfied by immersing the black hole in a heat bath of equal temperature and allowing the heat radiation to change isentropically as the charge varies.

Furthermore, equation (3) is based on standard gravitational theory. In a non-standard theory that involves varying \( e \) or c, the formula for the area of the event horizon might differ. Also, the Hawking process may be modified in a way that alters the relationship between temperature, entropy and event-horizon area. Equation (3) must then be considered as an approximation of the limit for the small variation of ‘constants’. However, it is unlikely that minor modification of equation (3) will reverse the sign of the relationship between charge and event-horizon area.

Moreover, in the standard theory there is a maximal electric charge, given by \( Q = M^2 \), above which the event horizon disappears and the black hole is replaced by a naked singularity. A modified theory might alter the value of this maximal charge, but there will still be a limit above which any increase in charge will create a naked singularity, violating the cosmic-censorship hypothesis.

Our arguments, although only suggestive, indicate that theories in which \( e \) increases with time are at risk of violating both the second law of thermodynamics and the cosmic-censorship hypothesis. Thus, black-hole thermodynamics may provide a stringent criterion against which contending theories for varying ‘constants’ should be tested.

**Kinematics**

**Gliding flight in the paradise tree snake**

Most vertebrate gliders, such as flying squirrels, use symmetrically paired ‘wings’ to generate lift during flight, but flying snakes (genus Chrysopelea) have no such appendages or other obvious morphological specializations to assist them in their aerial movements. Here I describe the three-dimensional kinematics of gliding by the paradise tree snake, Chrysopelea paradisi, which indicate that the aerial behaviour of this snake is unlike that of any other glider and that it can exert remarkable control over the direction it takes, despite an apparent lack of control surfaces.

I determined the full three-dimensional gliding trajectory of wild-caught C. paradisi, a southeast Asian arboreal colubrid. Snakes were videotaped and photographed jumping from a horizontal branch at the top of a 10-metre-high tower in an open field at the Singapore Zoological Gardens. Two video cameras were positioned to record in stereo, allowing the three-dimensional coordinates of the head, midpoint and vent of the snake to be monitored throughout its trajectory.

C. paradisi prepares for take-off by hanging from a branch, with the anterior body looped into a ‘J’ shape. The snake jumps by accelerating up and pulling its anterior body towards the branch, straightening the body and dorsoventrally flattening it from head to vent. Its body width roughly doubles, with the ventral surface acquiring a slightly concave shape. As the snake gains speed while falling, the body pitches downwards and the head and vent are brought towards the midpoint to form an ‘S’ shape in the horizontal plane. The snake begins to undulate laterally, starting with the anterior body. The flight trajectory shallows (Fig. 1) as lift is generated. Throughout the trajectory, its body posture changes in a characteristic way during each undulatory cycle.

In a typical glide, the snake took off with a maximum upward acceleration of \( 14.4 \pm 0.8 \, \text{m s}^{-2} \) (mean \( \pm \) s.e.m.) and horizontal velocity of \( 1.7 \pm 0.1 \, \text{m s}^{-1} \) \( (n = 7) \) for both. During mid-glide, the snake undulated at a frequency of \( 1.3 \pm 0.1 \, \text{Hz} \), with a wave height (peak to trough) of 33\% snout–vent length \( (n = 7) \) for both. The airspeed (the speed along its longitudinal axis) and sinking speed were 8.1 \pm 0.2 m s\(^{-1}\) and 4.7 \pm 0.5 m s\(^{-1}\) \( (n = 8) \), respectively. The glide angle late in the trajectory was 31 \pm 3\% \( (n = 8) \), although the glide angle continued to change throughout.

C. paradisi is surprisingly adept at aerial manoeuvring. In contrast to many fliers, C. paradisi turns without banking. Instead, turns are initiated by movement of the anterior body, and occur only during the half of the undulatory cycle when the head is moving towards the direction of the turn. In one sequence, a snake (snout–vent length, 47 cm;
Communication

In any other snake and probably requires regulation is not known to occur together while simultaneously maintaining a coiled ventral shape; to my knowledge, this is thus potentially capable of using aerial locomotion effectively to move between trees, chase aerial prey or avoid predators.

C. paradisi’s aerial undulation is a modified form of a more typical ophidian terrestrial locomotion, although in air the frequency is one-third lower (relative to the same snake, n = 4) and the amplitude is higher. The timing of the start of lateral undulation in relation to the shallowing of the trajectory suggests that lateral undulation helps to generate the snake’s lift. Aerial locomotion in snakes is probably more complicated than terrestrial locomotion because gliding involves lateral undulation while simultaneously maintaining a concave ventral shape; to my knowledge, this combination of movement and postural regulation is not known to occur together in any other snake and probably requires specialized neuromuscular control.

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Nitrogen cycle — with one exception that I know of, such representations in recent soil-science textbooks ignore two features of the nitrogen cycle that have come to light: dissolved organic nitrogen as a potentially important loss term for soil nitrogen, and the apparently widespread ability of plants (including crop plants) to take up dissolved organic nitrogen.

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