the detriment of the rest. The first chapter gives a brief sketch of Chinese history, the second of the system of administration; various chapters are then devoted to popular customs, to education, medicine, music, dress and food, architecture, honours, names, superstitions, religions, &c. There is also an excellent map. To the general reader who desires some accurate information respecting a country which is coming nearer to us every day, or to the student who wants a *vade mecum*, no better volume can be recommended.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

On the Occurrence of Great Tides since the Commencement of the Geological Epoch

MR. BALL says very truly that the fundamental question is, what traces of great tides ought we to expect to find if those great tides had really existed? Mr. Darwin says, coarse-grained rocks, and different forms of vegetation calculated to resist the action of the accompanying great winds. Mr. Ball, in reply, remarks that high tides in the Avon are accompanied by fine sediment. He thinks with others that the high tides would have produced a vastly greater amount of sediment than is being formed at present. I quite agree with Mr. Ball about the fine sediment, but I am not at all clear that high tides mean great marine denudation. By far the largest portion of the work done by the sea as a denuding agent is due not to the wearing action of currents, or to the pounding of materials on a beach at low water, but to the direct action of the sea on the cliffs. This force is estimated as about a ton per square foot on the average in winter, on the west coast of Great Britain. This undermines the cliff at the sea level, and then the top part falls partly by its own weight, but still more through the effect of the air compressed in the caves and cracks, which by its elasticity spread the blow over a very large surface through the crack and joints of the rock. Now to undermine cliffs with a given force of wind and wave, it seems clear that the maximum effect would be produced where the tides are very small, for there the force is constantly applied at the same spot. With a rise and fall of 100 feet, each portion of the cliff would be subjected to the force of the waves for so short a time that in all probability caves would never be formed at all, and the height of the tide would be an actual protection to the land. As a matter of fact, those places where the tides are highest show, as far as I know, no signs of excessive denudation. I spent two days last year on the Bay of Fundy, where the tides are higher than anywhere in the world, and I was very much struck with the absence of any evidence of great denudation due to the tide. The cliffs at the Joggins are about high-water mark, with a long beach which slopes very gradually. The force of the waves, such as they are, is spent in hammering this beach and grinding it into fine sand and mud; the mud is carried about in suspension by the tide, and the sand is shifted about, but the denuding effect is exceedingly small. The consequence is that the cliffs are pounded by the waves for such a short time each tide that they suffer mainly from atmospheric denudation, the sea doing little more than keeping their base clear, and in many places not even doing that.

Similar phenomena are presented by the highest tides in Great Britain—those on the Severn. Here at Clifton on the Avon the tide rises 30 feet; there are no waves; the banks are covered with a thick coating of mud and denudation is nil. At Aust Cliff, again, on the Severn, where the soft red marls are peculiarly liable to erosion, the height of the tide is again a protection. The cliff is about high-water mark, and the force of the waves is expended on the beach. The case is the same at Watchet, and a good many other places on the Severn. I do not know of any part of the Severn remarkable for excessive denudation, owing to the high tides. There is a strong resemblance between the Bay of Fundy and the Severn: there are the cliffs at high-water mark, the same long beaches, the same shifting sands and mud in suspension; similar causes have produced similar results. In narrow inlets like the Bay of Fundy and the estuary of the Severn, these high tides mean rapid currents and small waves; but along shores freely exposed to the ocean, the highest tides might be accompanied by very feeble currents. But if, as Mr. Darwin says, the high tides were accompanied by trade winds about $3\frac{3}{7}$ times as strong as the present ones, the battering power of the waves and the strength of the currents would be very greatly increased, and plains of marine denudation, it might be supposed, would be very rapidly formed. What would be likely to happen if such winds and waves began now to act on our shores? Should we have reason to expect that England would in a comparatively short time disappear beneath the waves? A very rapid destruction of our present cliffs would undoubtedly begin, though, as I pointed out before, this would be attributable mainly to the wind, and not to the tide; the cliffs would be driven back to about the ordinary high water mark, leaving a long shelving beach extending to a few feet below the low water mark. The cliffs would then for far the greater portion of each tide be entirely free from marine denudation, and their rate of wasting would depend on the power of the sea to tear up the long solid sloping beach, and restore comparatively deep water at the base of the cliffs. But this process is an exceedingly slow one, because there can be no undermining or assistance from compressed air, and I should anticipate that marine denudation would then be actually slower than it is at present. There would, of course, be abundance of very fine sediment formed during the first wearing back of the cliffs by the grinding of the materials between tide marks; but when once the cliffs had reached the high water line, the amount of sediment would depend chiefly on the amount of atmospheric denudation, supposing that the sea kept the base of the cliffs clear. We should, in fact, have a repetition of the phenomena presented to us now by the Bay of Fundy and the Severn. Thus far, then, it seems to me that no argument can be drawn from the fineness of the early sediments against the existence of high tides in the Geologic period; nor, on the other hand, does the quantity of sediment seem to me a strong argument in favour of it. But Mr Darwin's argument that the vegetation of the Carboniferous period could not possibly have held out against the violent winds which necessarily accompanied these high tides seems to me unanswerable. One has only to reflect on the effect produced by our present winds to feel convinced that if the winds and tides went together they were certainly Pre-Carboniferous, and almost equally certainly Pre-Devonian.

J. G. GRENFELL

Clifton College, December 29, 1882

Sir George Airy on the Forth Bridge

As Sir George Airy's last letter may, like his first, provoke replies from distinguished American and continental engineers, it may save your correspondents' time and your own valuable space if I add a few final words in explanation.

1. Sir George says:—"The danger of buckling in a horizontal direction with a length of 340 feet, remains undiminished unless it is counteracted by bracing unknown to me." Now Sir George evidently has forgotten that some time ago he was furnished with photographs of a large model of the bridge taken with the view of showing the said bracing, and that his attention was specially directed to the point.

2. Sir George thinks "it desirable that attention should be called to the magnitude of the forces concerned," and speaks of a wind-pressure of 75 tons, and an end-pressure of 600 tons. Now he clearly has forgotten that before he wrote his first letter a "stress diagram" was sent to him, on which it was noted that the wind-pressure provided for was 2207 tons on each span, and that the estimated end-pressure on the strut referred to was 2380 tons.

3. Sir George holds the engraver responsible for some of the alarmist statements in his first letter. I must remark, therefore, that it was pointed out that the bridge would have been perfectly safe had the details of the design been as he assumed. For evidence that a 340 feet tubular strut of 12 feet diameter would not fail in the manner stated by him, he was referred to Hodgkinson's experiments as published in the *Philosophical Transactions*, and Clark's work on the Britannia bridge; and further, he was lent the *Transactions* of the American Society of Civil Engineers for last year, containing the most recent experiments on long wrought iron columns. Any or all of these documents would have shown him that the Forth bridge