

### Animal Locomotion

MR. WALLACE'S last letter seems to call for a word of explanation from me. I did not refer to the up stroke of the bird's wing because this was not the point in dispute. But in reply to Mr. Wallace's latest stricture—that I appear “to ignore the great downward reaction, added to gravitation, during every up stroke”—I would say (1) that the downward reaction is not great, (a) because, as Mr. Wallace has himself observed, of the valvular action of the feathers; (b) because of the convex form of the upper surface of the wing; and (c) in some cases, because the wing is less expanded in the up stroke. (2) As to the effect of gravitation, this was already allowed for in determining the resultant motion consequent on the down stroke, and must not be reckoned twice. Just as with an arrow shot from a bow, so with the bird; the motion consequent on the down stroke lasts long enough for the wings to be raised before it is spent. Mr. Wallace is certainly right in saying that the down stroke should counteract the downward reaction of the up stroke, but this downward reaction being slight cannot require “a highly-inclined upward motion,” and what is more, it cannot require that the under surface of the wing should be directed forwards as Dr. Pettigrew asserts.

Again, I do not say the movement of the wing as a whole is downward and backward, but that the action of its surface is in that direction. The Duke of Argyll is no doubt correct in maintaining that the wing as a whole moves in a perpendicular line, or perhaps with a slight forward overlap.

I cordially agree with Mr. Wallace that the matter is not to be settled by “discussing theoretically, but by observation and experiment;” still the elementary principles of mechanics may surely be heard in evidence without disadvantage even at the outset of the inquiry.

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