

## "OF INSECTS"

OF all insects, no one is more wonderful than the spider, especially with respect to their sagacity<sup>1</sup> and admirable way of working. These spiders, for the present, shall be distinguished into those that keep in houses and those that keep<sup>2</sup> in forests, upon trees, bushes, shrubs, etc.;<sup>3</sup> for I take 'em to be of very different kinds and natures (there are also other sorts, some of which keep in rotten logs, hollow trees, swamps and grass).

Of these last, everyone knows the truth of their marching in the air from tree to tree, and these sometimes at five or six rods distance sometimes. Nor can anyone go out amongst the trees in a dewy morning towards the latter end of August or the beginning of September,<sup>4</sup> but that he shall see hundreds of webs, made conspicuous by the dew that is lodged upon them, reaching from one tree and shrub to another that stands at a considerable distance; and they may be seen well enough by an observing eye at noonday by their glistening against the sun. And what is still more wonderful, I know I have several times seen, in a very calm and serene day at that time of year, standing behind some opaque body that shall just hide the disk of the sun and keep off<sup>5</sup> his dazzling rays from my eye, multitudes of little shining

1. A large fragment has been broken from the top margin of the MS. The words "respect to their sagacity," which were contained on this fragment, have been taken from Smyth's edition ("Flying Spider," p. 5). Another fragment from the upper left corner, with the end of "admirable," was missing even when Smyth transcribed the essay. He consulted an earlier copy of the text for a missing word at the corresponding place on the verso side of the leaf (see Smyth, p. 10, n. 3; and below, p. 159, n. 3), and it is probable he used this copy to confirm "admirable" as well. The copy to which Smyth refers has not been located.

2. The words "those that keep" have been taken from Smyth's edition ("Flying Spider," p. 6); they are lost with the fragment broken from the MS.

3. The words "and those that keep in rotten logs" are interlined at this point. Although JE did not delete them, he repeats them in the next sentence, which he also added above the line.

4. JE revised the text, deleting "the beginning" and altering "of" to "in"; but the interlined words which complete the revision are illegible.

5. At this point in the MS there is a marked change of ink color, from a brownish gray to a truer gray. The change might mark the beginning of a second "sitting" after JE had laid the essay aside for a short time.

webs and glistening strings of a great length, and at such a height as that one would think they were tacked to the sky by one end, were it not that they were moving and floating. And there often appears at the end of these webs a spider floating and sailing in the air with them, which I have plainly discerned in those webs that were nearer to my eye. And once [I] saw a very large spider, to my surprise, swimming in the air in this manner, and others have assured me that they often have seen spiders fly. The appearance is truly very pretty and pleasing, and it was so pleasing, as well as surprising, to me, that I resolved to endeavor to satisfy my curiosity about it, by finding out the way and manner of their doing it; being also persuaded that, if I could find out how they flew, I could easily find out how they made webs from tree to tree.

And accordingly, at a time when I was in the woods, I happened to see one of these spiders on a bush. So I went to the bush and shook it, hoping thereby to make him uneasy upon it and provoke him to leave it by flying, and took good care that he should not get off from it any other way. So I continued constantly to shake it, which made him several times let himself fall by his web a little; but he would presently creep up again, till at last he was pleased, however, to leave that bush and march along in the air to the next; but which way I did not know, nor could I conceive, but resolved to watch him more narrowly next time. So I brought [him] back to the same bush again; and to be sure that there was nothing for him to go upon the next time, I whisked about a stick I had in my hand on all sides of the bush, that I might break any web going from it, if there were any, and leave nothing else for him to go on but the clear air, and then shook the bush as before; but it was not long before he again to my surprise went to the next bush. I took him off upon my stick and, holding of him near my eye, shook the stick as I had done the bush, whereupon he let himself down a little, hanging by his web, and [I] presently perceived a web out from his tail and a good way into the air. I took hold of it with my hand and broke it off, not knowing but that I might take it out to the stick with him from the bush; but then I plainly perceived another such string to proceed out at his tail.

I now conceived I had found out the whole mystery. I repeated the trial over and over again till I was fully satisfied of his way of working, which I don't only conjecture, to be on this wise, viz.: They, when they would go from tree to tree, or would sail in the air, let themselves hang down a little way by their web; and then put out a web at their tails,

which being so exceeding rare when it first comes from the spider as to be lighter than the air, so as of itself it will ascend in it (which I know by experience), the moving air takes it by the end, and by the spider's permission, pulls it out and bears it out<sup>6</sup> of his tail to any length, and if the further end of it happens to catch by a tree or anything, why, there's a web for him to go over upon. And the spider immediately perceives it and feels when it touches, much after the same manner as the soul in the brain immediately perceives when any of those little nervous strings that proceed from it are in the least jarred by external things. And this very way I have seen spiders go from one thing to another, I believe fifty times at least since I first discovered it.

But if nothing is in the way of those webs to hinder their flying out at a sufficient distance, and they don't catch by anything, there will be so much of it drawn out into the air, as by its ascending force there will be enough to carry the spider with it; or, which is all one, till there is so much of this web which is rarer than the air as that the web, taken with the spider, shall take up as much or more space than the same quantity [of air]. Of which, if it be equal they together will be in perfect equilibrium or poise with the air, so as that when they are loose therein they will neither ascend or descend, but only as they are driven by the wind; but if they together be more, will ascend therein: like as a man at the bottom of the sea, if he has hold on a stick of wood, or anything that is lighter or takes up more space for the quantity of matter than the water. If it be a little piece, it may not be enough to carry him and cause him to swim therein, but if there be enough of it, it will carry him up to the surface of the water (if there be so much as that the greater rarity shall more than counterbalance the greater density of the man); and if it doth but just counterbalance,<sup>7</sup> put the man anywhere in the water and there he'll keep, without ascending or descending. 'Tis just so with the spider in the air as with the man in the water, for what is lighter than the air will swim or ascend therein, as well as that which is lighter than the water swims in that. And if the spider has hold on so much of a web that the greater levity of all of it shall more than counterpoise the greater

6. Smyth: "and draws [?] it out."

7. Smyth: "if it be Doth but just Cause to balance." JE neglected to delete "be" when he revised his original wording.

A slight change of ink color is found at this point in the MS. The following portion through the unnumbered corollary below is in a thinner gray ink, and is written with a sharper pen. It might have been written in a third "sitting."

gravity of the spider, so that the ascending force of the web shall be more than the descending force of the spider, the web, by its ascending, will necessarily carry the spider up unto such a height, as that the air shall be so much thinner and lighter, as that the lightness of the web with the spider shall no longer prevail.

Now perhaps here it will be asked how the spider knows when he has put out web enough, and, when he does know, how does he get himself loose from the web by which he hung to the tree. I answer: there is no occasion for the spider's knowing, for their manner is to let out their web until the ascending force of their web and the force the wind has upon it, together with the weight of the spider, shall be enough to break the web by which the spider hangs to the tree, for the stress of all these comes upon that, and nature has so provided, that just so much web as is sufficient to break, that shall be sufficient [to] carry the spider. And [this] very way I very frequently have seen spiders mount away into the air, with a vast train of glistening web before them, from a stick in my hand, and have also shewed it to others. And without doubt they do it with a great deal of their sort of pleasure.

There remain only two difficulties. The one is, how should they first begin to spin out this so fine and even a thread of their bodies? If once there is a web out it is easy to conceive how if the end of it were once out, how the air might take it and so draw it out to a greater length. But how should they at first let out of their tails the end of a fine string, whereas<sup>8</sup> in all probability the web, while it is in the spider, is a certain liquor with which that great bottle tail of theirs is filled, which immediately upon its being exposed to the air turns to a dry substance and very much rarifies and extends itself. Now if it be a liquor, it is hardly conceivable how they should let out a fine string, except by expelling a small drop at the end of it; but none such can be discovered. To find out this difficulty I once got a very large spider of the sort; for in lesser ones I could not distinctly discern how they did that, nor can one discern their webs at all except they are held up against the sun or some dark place. I took this spider and held him up against an open door, which, being dark, helped me plainly to discern, and shook him. Whereupon, he let himself down by his web—as in the [first] figure, by the web *cb*—and then fixed with his tail one end of the web that he intended to let out into the air to the web by which he let himself down, at *a*; then, pulling away his tail, one end of

8. Smyth: "when."

the web was thereby drawn out, which being at first exceeding slender, the wind presently broke it at *d*, and drew it out, as in Figure the second, and it was immediately spun out to a very great length.

The other difficulty is, how when they are once carried up into the air, how they get down again, or whether they are necessitated to continue, till they are beat down by some shower of rain, without any sustenance—which [is] not probable nor agreeable to nature's<sup>9</sup> providence. I answer: there is a way whereby they may come down again when they please by only gathering in their webs in to them again, by which way they may come down gradually and gently. But whether that be their way or no, I can't say—but without scruple, that or a better, for we always find things done by nature as well or better than [we] can imagine beforehand.

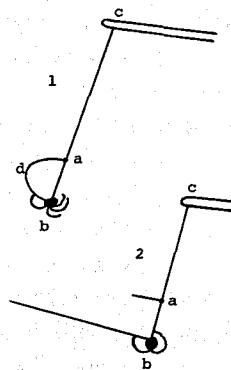
*Corol.* We hence see the exuberant goodness of the Creator, who hath not only provided for all the necessities, but also for the pleasure and recreation of all sorts of creatures, and even the insects and those that are most despicable.

<sup>1</sup>Another thing particularly notable and worthy of being inquired into about these webs is that they, which are so exceeding small and fine as that they cannot be discerned except held in a particular position with respect to the sun or against some dark place when held close to the eye, should appear at such a prodigious height in the air when near betwixt us and the sun, so that they must needs some often<sup>2</sup> appear as big as a cable would do, if it appeared exactly *secundum rationem distantiae*. To solve, we ought to consider that these webs, as they are thus posited, very vividly reflect the rays of the sun, so as to cause them to be very lightsome bodies; and then see if we can't find any parallel phenomena in other lightsome bodies. And everybody knows

9. Smyth: "natural."

1. The following paragraph is written in a distinctive reddish-brown ink. JE might have inserted it into the essay at this point at some time after the rest was written (see above, p. 148); it is related in content to the beginning entries in the shorter numbered series in "Natural Philosophy" (see below, p. 219).

2. Smyth: "of 'em."



Figs. 1, 2

that a candle in the night appears exceedingly bigger at a distance than it ought to do, and we may observe in the moon towards the new,<sup>3</sup> when that part of it that is not enlightened by the sun, is visible, how much the enlightened part thereof is enlarged and extended beyond the circumference of the other parts. And astronomers also know how exceedingly the fixed stars are beyond their bounds to our naked eye, so that without doubt they appear many hundreds of times bigger than they ought to do. The reason may be that the multitude and powerfulness of the rays affects a greater part of the retina than their share,<sup>4</sup> that which they immediately strike upon. But we find that a light that so does when it is alone, and when no part of the retina is affected by anything else but that, so that the least impression is felt by it, won't do so—or at least not so much—in the midst of other perhaps greater light, so that other parts of the retina are filled with impressions of their own. But these webs are instances of the latter, so that this reason does not seem fully to solve this so great a magnifying, though without a doubt that helps. But the chief reason must be referred to that incurvation of the rays passing by the edge of any body, which Sir Isaac Newton has proved.<sup>5</sup>

One thing more I shall take notice of, before I dismiss this subject, concerning the end of nature in giving spiders this way of flying; which, though we have found in the corollary to be their pleasure and recreation, yet we think a greater end is at last their destruction. And what makes us think so is because that is necessarily and naturally<sup>6</sup> brought

3. Where the large fragment is missing from the top margin of the MS, Smyth's edition supplies the words "lightsome bodies and everybody knows," and the words "may observe in" in this and the preceding sentence. Also, the word "do" in the phrase "ought to do" is missing from the MS because of a fragment broken from the upper right corner. Smyth supplied the word from an earlier copy of the MS (see above, p. 154, n. 1).

4. Smyth: "their space"; JE crowded the words between the lines. The explanation JE suggests here is that proposed by Descartes (*Dioptrics*, discourse vi. See also Jacques Rohault, *Physica*, Pars I, cap. 32, sec. 25–26). He might have received it from reading Whiston, *Astronomical Lectures*, Lect. III, Phenomenon 4, pp. 24–25.

5. I.e., the diffraction of the rays. Newton discussed diffraction in *Optics*, Bk. III; but used the word "inflection" to refer to the phenomenon in the *Optics* and elsewhere, except in the *Principia*, 1713 ed., Bk. I, prop. 96, Scholium, where he uses "inflectio." JE probably received "incurvation" from Whiston, *Newton's Mathematick Philosophy*, p. 266. See discussion of Whiston's influence on JE, above, p. 32.

Between this and the next paragraph there is a blank space about three-centimeters wide across the page, which JE might have left for a more complete discussion of Newton's optical theory. The ink of the following paragraph and the two numbered corollaries is probably the same as the gray ink in the unnumbered corollary on the first page of the manuscript.

6. Smyth: "actually."

to pass by it, and we shall find nothing so brought to pass by nature but what is the end of those means by which is brought to pass; and we shall further evince it by and by, by shewing the great usefulness of it. But we must show how their destruction is brought to pass by it.

I say then, that by this means almost all the spiders upon the land must necessarily be swept first and last into the sea. For we have observed already that they never fly except in fair weather; and we may now observe that it is never fair weather, neither in this country nor any other, except when the wind blows from the midland parts, and so towards the sea. So, here in New England, I have observed that they never fly except when the wind is westerly, and I never saw them fly but when they were hastening directly towards the sea. And [the] time of the flying being so long, even from the middle of August to the middle of October—though their chief time here in New England is in the time as was said before, to wit,<sup>7</sup> the latter end of August and the beginning of September—and they keep flying all that while towards the sea, [they] must needs almost all of them get there before they have done. And the same indeed holds true of all other sorts of flying insects, for at that time of year the ground, trees and houses, the places of their residence in summer, being pretty chill, they leave 'em whenever the sun shines pretty warm, and mount up into the air and expand their wings to the sun. And so, flying for nothing but their ease and comfort, they suffer themselves to go that way that they find they can go with greatest ease, and so wheresoever the wind pleases. And besides, it being warmth they fly for, and it being warmer flying with the wind than against it or sideways to it—for thereby the wind has less power upon them—and as was said of spiders, they never flying but when the winds that blow from the midland parts towards the sea bring fair weather, they must necessarily, flying so long a time, all the while towards the sea, get there at last. And I very well remember, that at the same time when I have been viewing the spiders with their webs in the air, I also saw vast multitudes of flies, many of 'em at a great height, all flying the same way with the spiders and webs, directly seaward. And I have many times, at that time of year, looking westward, seen myriads of them towards sun setting, flying continually towards the sea; and this, I believe, almost everybody, if not all,<sup>8</sup> of my own country will call to mind that they have also seen. And as to other sorts of flying insects,

7. Smyth: "towards."

8. Smyth: "specially."

such as butterflies, millers, moths, etc., I remember that, when I was a boy, I have at the same time of year lien on the ground upon my back and beheld abundance of them, all flying<sup>9</sup> southeast, which I then thought were going to a warm country. So that, without any doubt, almost all manner of aerial insects, and also spiders which live upon them and are made up of them, are at the end of the year swept and wafted into the sea and buried in the ocean, and leave nothing behind them but their eggs for a new stock the next year.<sup>1</sup>

*Corol.* 1. Hence also we may behold and admire at the wisdom of the Creator, and be convinced<sup>2</sup> that is exercised about such little things, in this wonderful contrivance of annually carrying off and burying the corrupting nauseousness of our air, of which flying insects are little collections, in the bottom of the ocean where it will do no harm; and especially the strange way of bringing this about in spiders (which are collections of these collections, their food being flying insects) which want wings whereby it might be done. And what great inconveniences should we labor under if there were no such way. For spiders and flies are so exceeding multiplying creatures that if they only slept or lay benumbed in [winter] and were raised again in the spring, which is commonly supposed, it would not be many years before we should be as much plagued with their vast numbers as Egypt was. And if they died for good and all in winter they, by the renewed heat of the sun, would presently again be dissipated into those nauseous vapors which they are made up of, and so would be of no use or benefit in that [in] which now they are so very serviceable.

*Corol.* 2. Admire also the Creator in so nicely and mathematically adjusting their multiplying nature, that notwithstanding their destruction by this means and the multitudes that are eaten by birds, that they do not decrease and so, little by little, come to nothing; and in so adjusting their destruction to their multiplication that they do neither increase, but taking one year with another, there is always just an equal number of them.

Another reason why they will not fly at any other time but when a

9. MS: "very all flying"; Smyth: "busy all flying."

1. About one centimeter of blank space was left on the MS between this paragraph and the corollary below.

2. In the MS two words or abbreviations, perhaps "from Pvd," are jotted in the blank space above this first line of the corollary and encircled. They do not appear to be intended as an interlineation at this point, although Smyth took them to be such. He read the construction as, "be convinced from providence there is exercised. . . ."

dry wind blows, is because a moist wind moistens the web and makes it heavier than the air. And if they had the sense to stop<sup>3</sup> themselves, we should have hundreds of times more spiders and flies by the seashore than anywhere else.<sup>4</sup>

3. Smyth: "fly."

4. These last two sentences are in the hand and ink of JE's draft of his "Spider" letter of Oct. 31, 1723, and were evidently added at the time he wrote the draft.

## THE "SPIDER" LETTER

Windsor, Oct. 31, 1723<sup>1</sup>

Sir:<sup>2</sup>

In the postscript of your letter to my father you manifest a willingness to receive anything else that he has observed in nature worthy of remark;<sup>3</sup> that which is the subject of the following lines by him was thought to be such: he has laid it upon me to write the account, I having had advantage to make more full observations. If you think, Sir, that they are not worthy the taking notice of, with greatness and goodness overlook and conceal. They are some things that I have happily seen of the wondrous and curious works of the spider. Although everything pertaining to this insect is admirable, yet there are some phenomena relating to them more particularly wonderful.

Everybody that is used to the country knows of their marching in the air from one tree to another, sometimes at the distance of five or six rods, though they are wholly destitute of wings: nor can one go out in a dewy morning at the latter end of August and beginning of September but he shall see multitudes of webs reaching from one tree and shrub to another; which webs are commonly thought to be made in the night because they appear only in the morning by reason of the dew that

1. Published through the courtesy of the New York Historical Society, New York City.

2. The letter was almost certainly addressed to Judge Paul Dudley, Fellow of the Royal Society of London, and Associate Justice of the Superior Court of Massachusetts (see above, pp. 151-53).

3. In his paper, "Observations on some of the Plants in New-England, with remarkable Instances of the Nature and Power of Vegetation," Paul Dudley reports the following instance of the power of vegetation, citing "The Reverend Mr. Edwards of Windsor" as his source: "In the year 1669, a single Pumpkin Seed was accidentally dropp'd in a small Pasture where Cattle had been fodder'd for some Time. This single Seed took Root of itself, and without any Manner of Care or Cultivation; the Vine run along over several Fences, and spread over a large Piece of Ground far and wide, and continued its Progress till the Frost came and kill'd it. This Seed had no more than one Stalk, but a very large one; for it measured eight Inches round; from this single Vine, they gathered two hundred and sixty Pumpkins; and, one with another, as big as an half Peck; enough to fill a large Tumbrel, besides a considerable Number of small and unripe Pumpkins, that they made no Account of." *Philosophical Transactions*, 33 (1724), p. 197.