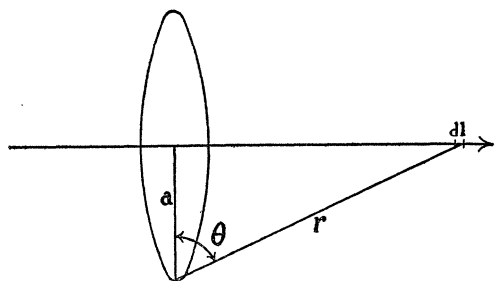


wire carrying a current is, as we know, tangent to a circle through whose center the wire passes at right angles, and is numerically equal to $2C/a$, where C is the current in absolute units, and a the distance in centimeters of the point from the axis of the wire.

While the approximate direction of the force is easily found experimentally, its numerical value is determined only by integrating the effects of all parts of the current. And since the force is in a plane at right angles to the wire, it is not an easy matter to make clear to students beginning the subject why it is necessary to consider parts of the wire off this plane.

This is one of the many places where the electron theory can be used to marked advantage, and besides, if, as many believe, it is the correct theory—or embraces a larger number of facts than any other—then it should be used both in this case and in all others.

Let electrons, all moving in the same direction with the constant velocity V centimeters per second, be uniformly distributed along a straight wire, and let E be the total amount of electricity per centimeter length of the wire. Then, assuming the field of force from each electron to be the same in all directions, that is, moving slowly and undisturbed by other electrons, the rate of change of induction, due



to the electricity at all parts of the wire, through a circle at right angles to it of radius a ; or in other words, the work required to carry a unit magnetic pole once around this circle (see the figure) is given by the equation

$$\frac{dF}{dt} = 2 \int_0^\pi \frac{Edl}{r^2} 2\pi a V \cos \theta.$$

But $\cos \theta dl = r d\theta$, $1/r = \cos \theta/a$, and $EV = C$, the current.

Hence

$$\frac{dF}{dt} = 4\pi C \int_0^{\pi/2} \cos \theta d\theta = 4\pi C,$$

and therefore the force on a unit pole at any point on the circumference of a circle of radius a is

$$\frac{4\pi C}{2\pi a} = \frac{2C}{a}.$$

However, presumably the field due to each electron is influenced by all others, and so influenced that it is confined to a plane at right angles to the wire, but equal in every direction from it. From this it follows at once that

$$\frac{dF}{dt} = 4\pi EV = 4\pi C,$$

and

$$f = \frac{4\pi C}{2\pi a} = \frac{2C}{a}.$$

According to this conception, which I believe to be the correct one, the magnetic force at any point is due entirely to that part of the current nearest to this point; the more distant parts having no direct effect whatever. But, of course, as just explained, all electrons produce their full effects indirectly by compressing each other's fields into planes at right angles to the wire.

While the above contains nothing new in physics, it is given because it, or some modification of it, may be of use in the class-room.

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REFLEX PROTECTIVE BEHAVIOR IN *BUFO* *VARIABILIS*

DURING the past year, while studying the *Opalinae* parasitic in the recta of different species of frogs and toads, I have had to kill many of these batrachians. In each case the backbone and spinal cord were cut behind the head and the brain destroyed by "pithing" with a needle. In this way *Rana fusca*, *Rana esculenta*, *Rana agilis*, *Bufo variabilis*, *Bombinator igneus*, *Bombinator pachypus* and *Hyla arborea* have been killed. In all but one of these species I find that, on cutting the

ventral skin to open the abdomen, the hind legs kick vigorously. The exceptional species is *Bufo variabilis*, about a dozen of which I killed in Naples.

The living *Bufo variabilis* is very sluggish. When handled, especially if roughly handled, it remains perfectly quiet, only distending the body to a great size by inflating its lungs. One can prick or cut the animal and produce no effect except a further distention, till the skin is stretched taut as a drum-head. Even cutting the spinal cord never produces much action and often produces none.

The interesting thing is that after one has cut the spinal cord and has destroyed the brain, the animal refuses to react by observable movements to any sort of abuse or injury, remaining as quiet as would an animal upon which no operation had been performed.

Bufo variabilis, like most toads, has very perfect protective coloration. It is further protected by the poisonous secretions from its skin glands. (I have had *Rana esculenta* die from being left twelve hours in a small aquarium, in a little water, with this toad.) The toad's habit of remaining quiet, even under abuse, is probably connected with its protective coloration and poisonous skin secretions, and is doubtless a recent acquisition. This reaction, or rather lack of reaction, in the normal animals may be either "conscious," or reflex, or both. In the animal whose brain has been destroyed it must be purely reflex.

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WÜRZBURG, BAVARIA,
July 3, 1907

BOTANICAL NOTES

THE ORIGIN OF ANGIOSPERMS

WITHIN the past few months two important papers have appeared upon the origin of the higher seed plants (angiosperms). The first is by E. A. Newell Arber and John Parkin, of Cambridge University, and appeared in the *Journal of the Linnean Society, Botany* (vol. 38, pp. 29-80, July 11, 1907). In it the authors first refer to the recent progress in our ideas as regards the phylogeny of the gymnosperms, which are evidently closely related to

the *Pteridophyta*, and to the increasing isolation of angiosperms. Just as we find closer affinities between gymnosperms and *Pteridophyta*, we find the gap between *Pteridophyta* and angiosperms increased, until "it may be said that no definite theory as regards the origin of angiosperms has up to the present been elaborated." While "the gap that originally existed between the phanerogams and vascular cryptogams was now bridged, in its place there appeared a wide gulf between the gymnosperms as a whole and the angiosperms."

After a summary reference to certain principles of evolution (the law of corresponding stages, homoplasy and mutation) the authors discuss "primitive features among living angiosperms," basing their discussion upon the theory that the typical angiospermous flower is essentially a strobilus. They regard "the simpler, unisexual flowers, including apetalous forms, as derived from an amphisporangiate strobilus by reduction." They restrict the term "flower" to the angiosperms alone, and regard it as typical "when it possesses both micro- and megasporangia, as well as a perianth which in many cases has an attractive function."

In their critical examination of Engler's theory they hold that *Piperales*, *Amentiferae*, and *Pandanales* are not primitive in type, but that they are reductions from hermaphrodite types with well developed perianths. They regard *Apetalae* as forms "reduced from amphisporangiate strobili, in each case possessing a perianth," and not as primitive plants from which the petalous forms have evolved. In further criticism of Engler's theory, while admitting its merit of simplicity, they affirm that "its application as a working hypothesis does not assist us in our search for a clue to the phylogeny of the angiosperms as a whole: nor does it help to bring this group into line with any of those now known to us in the fossil state."

For the theory which they adopt, namely, "that the monosporangiate apetalae were derived by reduction from an amphisporangiate strobilus possessing a distinct perianth" they affirm that it "leads us back naturally to a