trary meanings. Biologists say they understand one another, and therefore I suppose they do; but I wish, in pity, they would enlighten me. Why do Lamarckians and neo-Darwinians say "inherit" when they mean "vary"? Why do Mendelians and biometricians say "inherit" when they mean "reproduce"? Meanwhile, I cannot help suspecting that something is wrong. Consider what has happened—Lamarck's theory and half a century of stasis; Darwin's brilliant lucidity and twenty years of progress, with biology in its splendour, a great intellectual force; Weismann's effort, and nearly half a century of controversy, with interest in the subject limited to some (not all) zoologists and botanists, and of these few a majority resentful of trespassers.

I propose in two or three letters to adopt the physiological classification when dealing with three or four biological subjects. Biologists, I hope, will be tolerant towards one who uses this classification because, admittedly, he does not understand the difficult language they speak. G. ARCHDALL REID.

9 Victoria Road South, Southsea, January 16.

Atmospheric Refraction.

DR. BALL is surely wrong in suggesting in NATURE of January 5, p. 8, that the difference between Mr. Mallock's figure for the radius of curvature of a nearly horizontal ray and that given by Dr. de Graaff Hunter is accounted for by any consideration of the curvature of the wave-front. If such were the case, then an observer looking towards the sea horizon would see a ray of light in different directions for different initial curvatures of the wave-front. Suppose an observer from the bridge of a ship were looking at a searchlight placed at sea-level at the extreme limit of visibility. The rays of the searchlight beam would be plane waves, those coming from the barrel of the searchlight spherical. Does Dr. Ball wish us to infer that in such circumstances the visible beam would appear to the observer to issue from a point *above* the projector?—for that is what his suggestion leads to.

To my mind, a great deal of the confusion between refraction figures given by different authorities lies in their attempt to connect refraction with variations of temperature before they have properly considered the subject from the point of view of variations in refractive index. If we assume that, over the sea at all events, the refractive index stratification is one which is spherical and concentric with the earth, then the general equation of any ray of light is

$$pn = \text{constant},$$

where n is the refractive index and p the perpendicular upon the tangent to the ray from the earth's centre (see Herman, "Geometrical Optics," p. 305, or Heath, "Geometrical Optics," p. 329).

If r is the distance of any point upon the ray from the earth's centre, h the height of the point above the earth's surface, and R the earth's radius, then $r = \mathrm{R} + h$.

Now n must be some function of the height $= f(h) = f(r - \mathrm{R})$, and hence the "$p, r$" equation of the ray is

$$pf(r - \mathrm{R}) = \text{constant} = \mathrm{C}.$$

The radius of curvature of the ray is thus

$$\sigma = r\frac{dr}{dp},$$

$$= -\frac{r\{f(r-\mathrm{R})\}^2}{\mathrm{C}} \Big/ \frac{df}{dr},$$

or

$$= -\frac{rn^2}{\mathrm{C}} \Big/ \frac{dn}{dh}.$$

As we are dealing with a ray which is nearly horizontal, variations in r and n^2 cannot have large effects upon σ. The variations in r might amount to 1 part in 200,000 if the ray never gets above 100 ft. above the surface of the sea; the refractive index, which at the sea-level is 1·00029, could scarcely be reduced below 1·00027 in the same height, so that variations in n^2 could not exceed 4 parts in 100,000. It follows that the curvature of such rays is essentially proportional to the refractive index gradient. Since by Dale and Gladstone's law $n-1$ is proportional to ρ, the density, the curvature of the ray-path becomes immediately proportional to the density-gradient. If we attempt to translate density-gradient into temperature-gradient, I see no means of doing so other than by making the assumption that the atmosphere is statically in equilibrium, in which case the formulæ given in my letter in NATURE of January 5 result immediately. But I have the gravest doubts of the legitimacy of such an assumption for the lower levels of the air. A steady motion leading to a dynamical relationship between pressure, density, and temperature is much more likely, but is, from the mathematician's point of view, a hopeless thing to try to set down owing to the impossibility of dealing with all the factors of the problem, such as rate of radiation of heat-energy from the earth or sea, rate of thermal conduction in the air, nature of the upward air-currents, and so on.

If however, we leave all such considerations aside and deal only with the established connections between curvature of the ray-path and the density-gradient, then we can only admit uniform curvature if we are prepared to admit that the density of the air in its lower levels is a linear function of the height. To such an admission I take the strongest exception. It is quite insufficient to account for a refraction of the visible sea horizon above the true horizontal—a phenomenon which, as every seaman knows, is by no means uncommon. T. Y. BAKER.

Admiralty Research Laboratory, Teddington, Middlesex, January 7.

The Colours of Tempered Steel.

THE well-known and characteristic tints that appear on the surface of a tarnishable metal when it is heated in contact with air have been usually regarded as interference colours due to the formation of a thin film of oxide on the surface of the metal. The correctness of this explanation has, however, recently been questioned (A. Mallock, Proc. Roy. Soc., 1918), and rightly so, as a continuous film on a strongly reflected surface cannot on optical principles be expected to exhibit such vivid colours as those observed.

I have recently made some observations which shed a new light on this subject. It is found that the *missing colours* complementary to the tints seen by reflected light appear as light *scattered* or *diffracted* from the surface of the metal. In other words, if a plate of blue-tempered steel be held in a beam of light and viewed in such a direction that the regularly reflected light does not reach the eye, the metal shows a straw-yellow colour, and not the usual blue. It will be understood that the scattered light, being distributed over a large solid angle, appears much feebler than the regularly reflected colour, and in order to observe the effect satisfactorily the metal should have a smoothly polished surface before being heated up. Scratches and other irregularities show the ordinary colour of the film, and not the complementary tint. The most attractive effects are those exhibited by a heated copper plate, both on account of the vividness