and added about $1,000,000 more. He stated, however, at the time that the probable total cost would be about $9,500,000, an increase of size of the work having raised the expense some 8 per cent. That even this estimate was too low was proved in 1875, when the directors sought and obtained an appropriation, raising the sum to $13,000,000. Up to the present time, $6,000,000 has been expended, for which we have to show two anchorages, two completed towers, and the connecting wires across the river. There are yet the wire and superstructures, additional stone and masonry, land and labor, to be paid for, the total outlay for which, according to estimates obtained by the New York *Sun*, will swell the entire cost to $17,569,000.

It will be interesting to compare this with the cost of tunnelling. The clear span of the bridge across the river measures 1,595 feet; so that for the actual means of transit, the cost is about $11,015 per foot. Even measuring from anchorage to anchorage, a distance of 3,475 feet, the cost reaches $5,056 per foot. Let us contrast these figures first with those shown in the results of submarine tunnelling. The first Chicago waterworks tunnel, 5 feet in diameter and two miles in length, cost $457,844, or some $43 per foot; the second bore, 7 feet in diameter and of the same length, about $39 per foot. These are of course too small for traffic purposes, but may be quoted to aid us in reaching an idea of relative cost. The Thames tunnel can hardly be used for comparative purposes, since it was the forerunner of submarine excavation, and was worked upon over a period of some 36 years. Its total cost was $2,000 per foot. Lately a very heavy tunnel belonging to the London Underground Railway has been finished under the London Docks. The work was exceedingly difficult, and the quantity of water to be pumped out enormous. The final cost was £390,000 per mile, or about $369 per foot. Lastly, we have the estimates of the English channel tunnel, 31 miles in length, which amount to $20,000,000, or about $122 per foot.

Now we may glance at land tunnels. The Mont Cenis tunnel cost about $300 per lineal foot, inclusive of equipment of road, etc.; the Kilsby (England) double track railroad tunnel, in the construction of which great difficulties in the form of quicksands were encountered, $262.50; the Hoosac tunnel, $300; Underground Railway, Fourth avenue, New York city, $285; Bletchingly (England) double track tunnel, $120; the very difficult Hauenstein tunnel between Basle and Berne, Switzerland, $133; the contract price of the St. Gothard tunnel now in progress is £1,896,945, or about $189 per foot. Many more examples might be given, but the above will suffice to show that in all probability $350 per lineal foot would be a large estimate for a tunnel under the East river. Supposing for the sake of comparison that the total length of excavation be equal to the total length of the bridge, 3,475 feet (it obviously would be much less), its cost would be, at the above figures, some $1,200,000. Consequently, for the sum now estimated as the probable cost of the bridge, New York might have at least fourteen tunnels crossing the river at as many principal streets.

Meanwhile the success of the bridge as an engineering work is by no means assured; nor is it certain that the estimate of $17,569,000 will not still further be exceeded. The distance from the pier to the City Hall terminus on the New York side is 2,381 feet; on the Brooklyn side the distance from tower to terminus is 1,881 feet. The whole aggregates 660,000 square feet, or some 200 city lots, largely covered with buildings, to which title must be acquired. The estimate given fixes $25,000 each for the lots; but in cities where real estate fluctuates so greatly as in New York and Brooklyn, it must be clear that any such calculation is merely an approximation.

Again—and we cannot gainsay the wisdom of the conclusion—the Board of Directors of the bridge are strongly opposed to take any risk of inferior material on account of an apparent economy in its cost. It has been a question for some time past whether the cables shall be made of Bessemer and open hearth steel, or crucible cast steel only. There appeared from the engineer's report a saving of some $250,000 to be effected by the use of the former. Thus the Roeblings offered crucible steel at 9 cents per lb. gold, or for $612,000, and Bessemer steel at 6¾ cents, or $459,000 in all. The strain withstood by each, per square inch of section, was respectively 179,019 lbs. and 178,163 lbs.

Mr. Abram S. Hewitt, in a letter to the Board referring to Bessemer steel, said: "The peculiarity of that material is that it is apt to have weak spots of which there is no external indication. This is probably due to the enclosure of bubbles of air in the mass, or possibly to the oxidation of minute particles of the material while the air is being driven into it under high pressure. No amount of visual inspection can determine in what part of the ingot, the rod, or strand of wire, such defects will occur, and I have seen Bessemer rods break under apparently very inadequate strain." Finally, the Board, after carefully considering the question, concluded not to use Bessemer steel—and this even after proposals for the same had been invited—and awarded the contract to supply crucible cast steel wire to Mr. J. Lloyd Haigh (he being the lowest bidder), at the price of 8 7/10 cents gold per pound.

We said, nearly five years ago, that the probable cost of the East river bridge would be $20,000,000. At present the indications are that our prediction will be realized; and judging by the rate of increase in previous years during the progress of the work, even the large sum we named may be insufficient to cover the actual cost of constructing the bridge.

## THE MIGRATIONS AND DISPERSAL OF ANIMALS.

One of the most important considerations in studying the past history of the earth, as shown by the distribution of animals, is that which leads us to examine, first, what means animals of every class have for dispersal, and second, what barriers Nature interposes to prevent the same. It is a necessary part of the great struggle for existence, which pervades all life, that the creature shall encounter not merely active enemies but passive ones: not merely those which directly threaten its existence, but those which prevent its self-maintenance by cutting off its access to the necessary means of so doing: and against these last the organism is often compelled by force of necessity to oppose itself. Animals, even those which breed most slowly, increase with a rapidity out of all proportion to the available food in any specified district which they may inhabit; and therefore all are obliged to struggle against the obstacles which prevent them wandering in search of fresh hunting grounds or pastures.

Whether a certain natural phenomenon is or is not a barrier to further dispersion depends very greatly upon the class of animals inhabitating the region which it limits. Thusthe elephant will climb the loftiest peaks and mountains, traverse rivers, and range the densest forests; the tiger can endure the widest extremes of heat and cold, and can swim moderate distances; but on the other hand, the monkeys, for example, must remain within the limits of forest vegetation, while the antelopes and zebras cannot exist otherwise than on the deserts.

Mr. Alfred Wallace, in his "Geographical Distribution of Animals," the underlying theory of which work we recently reviewed, devotes some very interesting pages to the above topic, considering in some detail the various obstacles to animal emigration. Climate seems to be a potent boundary to the travels of mammals, as there are such animals as the polar bear and walrus, which cannot live, in a state of nature, far beyond the polar ocean. But it is believed that it is not so much the climate itself as the change of vegetation consequent on climate which renders it effective as a barrier. It appears that valleys and rivers are often insurmountable obstacles, as animals which naturally exist on hills would be checked by the difference of vegetation and of insect life, and also by the unhealthy atmosphere often found in valleys. An arm of the sea over twenty miles wide cannot be traversed by land animals, by swimming; but on the other hand, long voyages are often made by mammals that are involuntary passengers on uprooted trees and ice floes. Bats and the cetacea have exceptional means of dispersal. The latter, however, find themselves opposed by temperature, as the polar species cannot cross the equator, nor can those indigenous to the tropics venture into the cold polar waters.

It would seem that no barrier could limit the range of birds, and that consequently they must be the most ubiquitous of living things; but this is far from being the case. The petrels and gulls are the greatest wanderers over the ocean, and the sandpipers and plovers roam over immense extents of coasts; but there are many species which are wholly checked by natural obstacles. The ocean presents an almost absolute barrier to prevent the birds of one continent passing over to another. Large numbers of birds cannot exist outside the forest countries; others cannot soar above the mountain ranges which bound their inhabited region. Again, the prevalence of their enemies is a potent barrier to birds dwelling in or crossing any region; and where nest-hunting quadrupeds, such as monkeys, abound, they are comparatively scarce.

We now reach that very interesting phenomenon known as migration; and here must be drawn a distinction between the true migrations of fishes and birds and the periodical movements of certain mammalia. Thus, in summer, monkeys ascend the Himalayas to heights of 10,000 and 12,000 feet; in dry seasons antelopes move southward toward the Cape of Good Hope. These differ from the great movements of fishes and birds, since such take place in large bodies and often to considerable distances. Migration may be looked upon as an exaggeration of a habit, common to all locomotive animals, of moving about in search of food; and in birds, it is especially exaggerated by their powers of flight and the necessity of providing soft insect food for their unfledged young. In North America, every grade of migration is found, from that peculiar to species which merely shift the limits of their range a few hundred miles (so that in the central parts of the area the species is a permanent resident), to others which move completely over 1,000 miles of latitude. So that, in all the intervening districts, such species are only known as birds of passage. There are many curious facts peculiar to migration, notably that of birds returning, year after year, to build nests in the same spot: a local attachment which prevents their wandering into localities unsuitable for them. Also that the old birds migrate first, the young following at random. This indicates the absence of imperative instinct in the habit, and it also accounts for the diminution in numbers of the young that return. On the succeeding year, however, the young profit by their experience, and fly when the old birds do. Another curious fact, however, in favor of instinct, is that "agitation" of caged birds at the time when their wild companions are migrating. This, however, Mr. Wallace considers to be due to a social excitement, due to the anxious cries of the migrating birds, and to be ascribable to some strong social emotion, gradually developed in the race by the circumstance that all who, for want of such emotion, did not join their fellows inevitably perished. The long flights of some birds, without apparently stopping on the way, is thought to be inexplicable, as well as their finding their nesting place of the previous year from a distance of many hundreds or even a thousand miles. But the observant powers of animals are very great; and birds flying in the air may be guided by the physical features of the country, spread out beneath them, in a way that would be impracticable to purely terrestrial animals.

Reptiles are scarcely more fitted for traversing seas than mammals; but lizards evidently possess some unknown means, probably while they are in the egg state, of passing the ocean, since they are found to inhabit many islands where there are neither mammals nor snakes. Fishes are not without means of dispersal over land. Some are carried through the air by hurricanes; those living in subterranean waters have been thrown up by volcanoes. Geese and ducks often eat fish eggs without impairing the vitality of the same, carrying them meanwhile over long distances. Molluscs often attach themselves to animals or to fragments of wood and stone, and so are transported.

Winged insects possess more varied means of dispersal than any other highly organized animals. Many fly to immense distances; others are carried off by storms; and the floating trees which serve as rafts for mammals are the homes of myriads. Immense numbers of tropical insects are brought to the London docks in foreign woods; and they have often emerged from furniture, after lying dormant for many years. They will survive wonderfully hard usage. Many species can withstand hours of submersion in strong spirit; others can go for months without food.

But on the other hand, wide as is the distribution of insects, the barriers opposed to the same are equally great. Hundreds of species of *lepidoptera* can subsist, in the larval state, only on one species of plant; so that, on perfect insects being carried to a new country, the existence of the race would depend on the presence of the same or of some closely allied plant. Again, some require succulent vegetable food all the year round, and hence are confined to the tropics; some are dependent on water plants, some on mountain vegetation. Many are parasites of other insects; all have enemies in every stage of their existence; and the abundance of any one of these may render their survival impossible in a country otherwise well suited to them.

We have thus briefly reviewed the means which animals have for their dispersal about the globe, and the barriers which Nature has interposed to limit their wanderings. What effect these obstacles have exerted in determining the present distribution of animals, we shall consider in a future article drawn from the same source.

## THE CAUSE OF THE DELAY IN ISSUING THE PATENTS.

We are in receipt of numerous letters from inventors, inquiring the cause of the delay on the part of the Patent Office in forwarding their patents, and also calling our attention to the fact that notices of their inventions have not appeared in these columns. In reply to all, we would state that, for the last two months, the Patent Office has encountered considerable difficulty in having the photo-lithographic copies of the drawings prepared. The acting commissioner has issued a circular, which is forwarded to individual patentees, in which each is informed "that, on account of the imperfection of the photo-lithographic copy of the drawing which was to accompany the patent, the Office was compelled to return the drawing to the photo-lithographic company for reprint. As soon as a perfect drawing can be procured, the patent will be forwarded to your address."

As fast as we receive copies of the delayed patents, we shall prepare and publish the usual notices. The difficulty has now existed since October 31; and while a few patents of subsequent dates have reached us, the large majority have yet to come.

### A Prepared Codfish Patent Litigation.

The patent of Mr. Elisha Crowell, under which he claims a royalty on all cod and other fish deprived of skin and bones and packed in boxes, etc., for transportation, is to be contested by the wholesale fish dealers of this city. Mr. Crowell has heretofore issued stamps, which the trade purchased and affixed to the boxes of fish, at the rate of ¼ cent per pound. The dealers now claim that this tax inflicts injury on their business, and that Mr. Crowell has no legal right to exact it. As a large number of merchants are associated in these legal proceedings, and as it is reported that other fish dealers throughout the country will co-operate with them, it is probable that Mr. Crowell's claims will be vigorously fought in the courts.

### Six Tons of Gold.

Three million dollars in double-eagles recently arrived in this city on a Baltimore and Ohio railway car. The treasure, which weighed six tons, was brought overland from San Francisco, to be deposited in the New York Sub-Treasury. It filled fourteen iron safes, and was guarded by a squad of soldiers, and was in charge of eight Treasury Department clerks.

In our description of the Tomlinson axle box, on page 54, present volume of the SCIENTIFIC AMERICAN, the address of Mr. Tomlinson should have been: "Care of G. L. Kelty, 80 and 82 White street," instead of "C. L. Kelly," which was the name and address given in part of the edition.

Persons desiring further information may address Mr. Tomlinson as above, or Mr. James E. Crane, 76 Park Place, N. Y., or Wm. Knifton, Black Hawk, Gilpin county, Col.