S100: Science: a foundation course
S100/19: Natural selection

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Clip transcript: The effect of selection on natural populations.

Richard Holmes:
Now if a new character arises by the mutation of a gene such as the long hair in Persian cats the fate of the gene in the population will depend on its usefulness to the animal carrying it. Now we can calculate how useful this gene is if we take a figure such as a thirty percent advantage we can work out how soon this gene should gain ascendency over the original wild type gene in the population simply be doing some sums. However we can do it very much more quickly if we in fact, use a computer. Now here we have a curve which we have obtained from a computer by feeding it information of this kind. Now we've said here is an organism, a mutant in the organism, which confers a thirty percent advantage on the species. Now you can see on this basis for the first twenty generations the frequency of the gene in the population remains extremely low and then it begins to rise rapidly and after about thirty-seven generations you see that it is about fifty percent of the population, let's say half the population has this gene. And then after a hundred generations or so it is practically a hundred percent. The gene has in fact taken over and the wild-type gene has been squeezed out. Now this curve actually relates to the occurrence of the melanic mutation to give the variety Carboneria in the Peppered Moth. Now this mutation will be expected to give an advantage to the animal in the city and for the details of how this works out in reality I hand you over to Dr Varley.

Peggy Varley:
Moths fly by night but we can catch them because they're attracted to light sources, often from quite far away. This moth trap has a bulb which emits a brilliant greenish light which is why I haven't turned it on for you. It also emits ultraviolet light which is attractive to moths and they fly towards it and then try to settle below the bulb which takes them into the trap. Now if I take away the top of the trap you can see that the moths come to rest under these egg cartons and when they're disturbed, many of them fly away, as they're doing now. In May to July, some of the moths we catch are specimens of the Peppered Moth and I have two here. Although they look very different these two are in fact varieties of the same species the Peppered Moth, differing from just one gene. If the black is crossed with the pale then the black is dominant. A hundred years ago the black form was very rare which is why we call the pale form variety Typica and we recognise the black as being a mutant.

About twenty years ago, Dr Kettlewell of Oxford University carried out a survey of the Peppered Moth populations. This map shows his results. The circles represent his sampling sites, the area represents the total number of moths he caught, and the black and white segments show the relative proportions of the black, of the pale and dark mutants. Now let's look at the distribution. Here in the industrial Midlands and the North and the South and South East the dark form is far more common than the light form and this is also true downwind of these industrial areas. But in the west of Britain the pale form is the common one. Now how can we explain this? We must think about how the moths live. They fly by night but in the day they rest on tree trunks. This trunk has grey bark and it has lichen growing over it and the pale Peppered Moth is quite inconspicuous. The dark form here is rather more obvious. In industrial districts the tree trunks are black, black with soot, and here the pale form is very conspicuous whereas the dark form is almost impossible to see.

Doctor Kettlewell and Professor Tinbergen took a film of these moths in the wild and you can see in this how we can explain the difference in the distribution.

In Doctor Kettlewell's first series of experiments he marked live moths with paint then released them and counted the numbers recovered at a light trap. In the second set of experiments he fixed moths to the bark of trees and observed what happened to them. Here in a Dorset wood it's easy to see the dark moth against the lichen covered tree but difficult to see the pale form. The birds go for the moths they can see, in this case the melanic form. The lighter moths, on the other hand, remain beautifully camouflaged. Then Doctor Kettlewell repeated the experiment in an industrial area and of course the opposite happened. The pale typical form is easily spotted by the birds and gobbled up whereas the black mutant is overlooked. These melanic moths have completely escaped detection by the birds.

So birds hunting for insects by sight act as the agents of Natural Selection. They pick out the conspicuous forms and leave the ones which disappear against their background. And so in a hundred years with the spread of atmospheric pollution and the appearance of more and more trees with sooty bark the dark mutant has replaced the pale form in large areas of this country.