NIGEL COLLINS

Foot and mouth

During the spring of 2001 many people saw and smelt the smoke from pyres on which slaughtered cattle and sheep were being burnt. This was one consequence of an outbreak of foot and mouth disease. This article explains what causes the disease and how it initially spread. You can bring the story up to date for yourself and draw parallels with what you learn about human diseases in GCSE science.

The agent responsible for foot and mouth disease was first identified in 1898. The virus itself was not isolated but was described as too small to filter. It was thought to be a very small bacterium.

Foot and mouth disease causes fever in cattle and all cloven-hoofed animals, followed by the development of blisters, or vesicles, mostly on the feet or the mouth. It is an acutely contagious disease caused by a virus (see Box 1) which can be spread very easily by people, vehicles and livestock movements. It can also spread on the wind.

Only a small dose of virus is needed to infect an animal. The incubation period is usually 2–14 days. Once an animal has the disease it will in turn release large amounts of the virus. As shown in Figure 1, all sorts of excretions can spread infection. Animals differ a lot in the quantity of airborne virus particles they can generate, with pigs producing 1000 times more than cattle or sheep (Figure 2).

Foot and mouth is not a fatal disease, except in young cattle, but it reduces the productivity of affected animals. This may mean less milk or poorer meat production. Eradication and control of the disease are expensive, as are the economic losses resulting from trade restrictions during an epidemic. Countries such as the UK, which have been free of the disease for long periods, go to great lengths to maintain their disease-free status. Foot and mouth is endemic (always present) in some parts of the world (see Figure 3).

ERADICATION IN EUROPE

Prior to the recent outbreak, foot and mouth was eradicated in Europe by a combination of culling

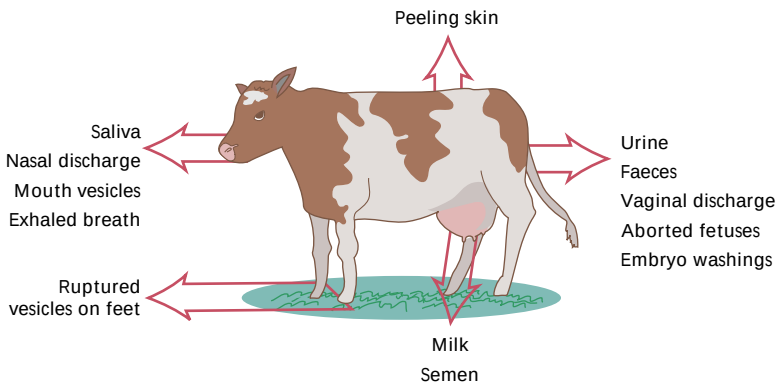

Figure 1 *Ways in which foot and mouth virus is excreted.*

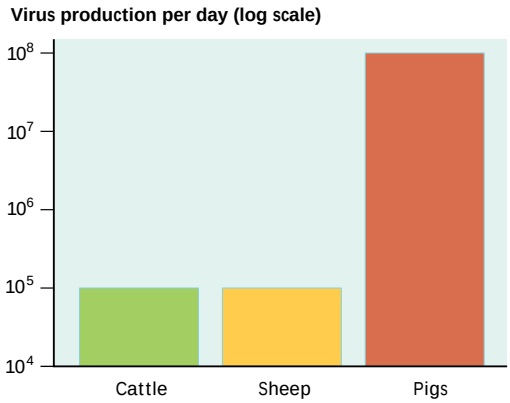

Figure 2 *Airborne excretion of foot and mouth virus by different animals.*

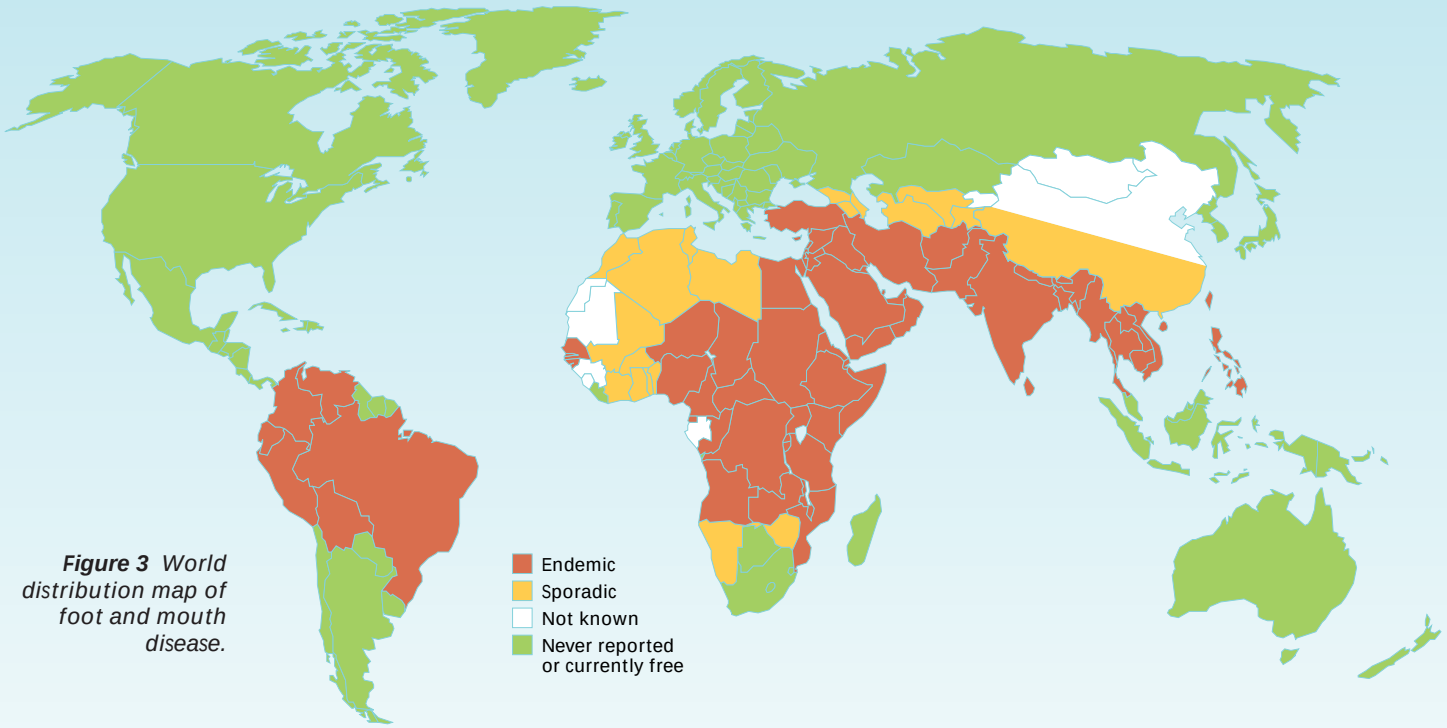

Figure 3 *World distribution map of foot and mouth disease.*

and vaccination. During the 1950s and 1960s animals in parts of continental Europe were vaccinated each year because the immunity lasted for less than a year. This dramatically reduced the incidence of the disease (see Figure 4 which shows outbreaks between 1951 and 1990). Routine vaccination of cattle ended in 1990–91, so all cattle born in Europe since then have no immunity to the disease.

Middle Eastern strains of foot and mouth caused many small outbreaks in the last decade, in Bulgaria, Italy, Greece and Turkey. These were all dealt with by culling affected animals and those nearby, without the use of vaccination. Nevertheless, it seems that in the end an outbreak on the scale of that of 2001 was almost inevitable.

ROUTES OF TRANSMISSION OF THE VIRUS

The disease is highly contagious and can be spread in various ways:

- contact with infected animals;
- contact with contaminated animal products;
- contact with contaminated people;
- contact with contaminated equipment;
- windborne transmission.

It seems likely that the initial outbreak in 2001 at a farm in Northumberland started when pigs were given food which included contaminated materials. The affected pigs were sent for slaughter in Essex, where a vet spotted them. It is thought that by then

BOX 1 VIRUSES

Viruses are minute infectious agents, which cause a number of serious diseases. They can only multiply when they are inside the living cells of a host organism. They are very simple in structure: some genetic material surrounded by a protective coat of protein. Sometimes the coat includes parts of the cell membranes of cells from which the virus particles have escaped. The coat may be elongated or based on a compact sphere.

In the cells of most animals the genetic material is DNA. RNA is present as well but this is involved with protein synthesis. In the case of viruses, RNA may replace DNA as the inherited material — viruses never contain both.

Animal viruses attach to receptor molecules on cells, but only the genetic material enters the cell. The viral genes then start to take over parts of the machinery of the cell in order to make more viruses. They make the components of the protective coat and also make copies of themselves. These are all assembled into new virus particles inside the cell. In the closing phases of this process the viral genes often encode an enzyme that will break down the host's cell membrane, so that the new viruses can escape.

The virus can remain viable for a long time in lymph nodes and bone marrow. It is thought that contaminated carcasses imported from South America caused the 1967 outbreak.

A case on the Isle of Wight in 1981 was caused by viruses blown across the English Channel from an outbreak in pig units in Brittany. It had been anticipated and was quickly controlled.

● Why was it unfortunate that the 2001 outbreak started in February/March?

Figure 4 *Outbreaks of foot and mouth disease in Europe, 1951–90.*

BOX 2 A TOUGH TRAVELLER

Foot and mouth disease is caused by a picorna virus (*pico* is short for very small and *rna* refers to its genetic material). The strain of the virus that caused the British outbreak is type O, Pan Asian strain. A version first appeared in India in 1990, although some reports say the precise strain appeared first in Thailand and Cambodia in January 2000. It spread rapidly to Taiwan and Malaysia and on to Japan and Korea by Easter 2000. It occurred in Turkey in January 2000 and in Greece by the summer. It reached South Africa last September, apparently in a barge of pig food.

The virus can survive for long periods of time in dark, moist conditions but is rapidly inactivated by a combination of desiccation, extreme pH and high temperatures (Table 1).

Foot and mouth virus is very sensitive to pH. Below pH 6 and above pH 9 it is rapidly destroyed. Acids (such as citric acid) or bases (sodium carbonate or caustic soda) are effective at inactivating the virus, especially when combined with detergents.

Table 1 *Survival of the virus at various temperatures (optimal pH of 7.2–7.6)*

Temperature (°C)	Survival
4	1 year
22	8–10 weeks
37	10 days
56	< 30 minutes

Table 2 *Survival times of the virus under various conditions on a farm*

Conditions	Survival
Dry faeces	14 days
Slurry	6 months
Urine	39 days
Ground: summer	3 days
winter	20 days

animals on the farm may have had the disease for several days and therefore have been releasing virus particles. Sheep which had caught the disease had been distributed via markets around the UK, to Cumbria, the Welsh Borders and Devon. Once these sheep mixed with others there was direct infection and then windborne transmission to nearby farms.

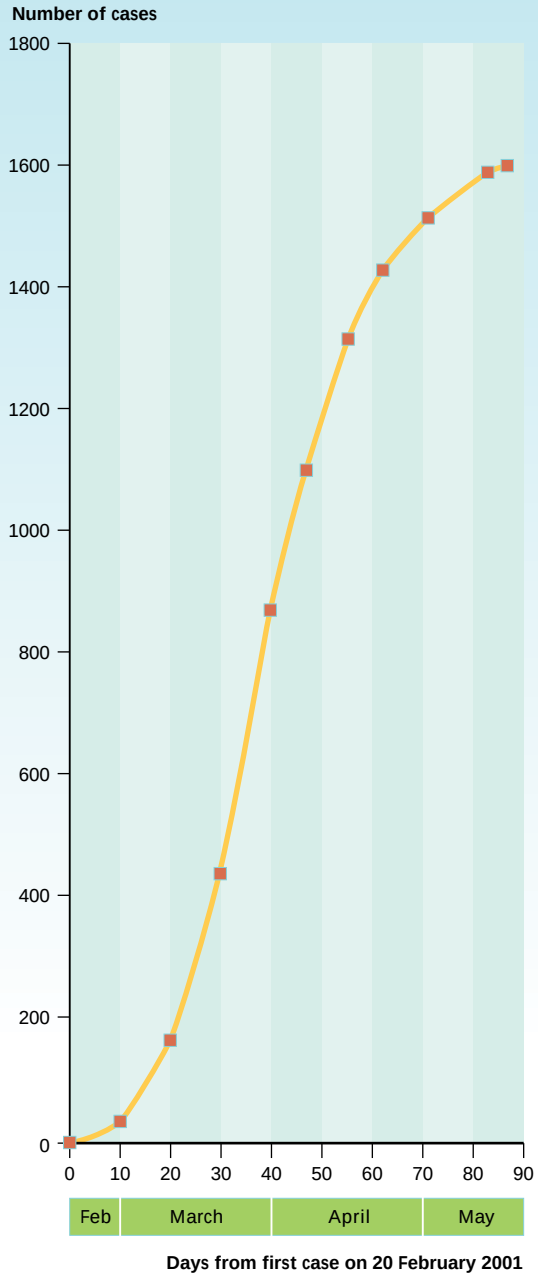

Figure 5 *Confirmed cases of foot and mouth.*

THE COURSE OF THE EPIDEMIC

Figure 5 shows the number of cases up until May 2001. By the time you read this you will know what happened across the summer. Bring the graph up to date. Predictions in March included the possibility that 50% of livestock in the UK would have to be slaughtered — did this happen? When did the epidemic peak? How many animals were slaughtered in all? How far did the disease spread? And was vaccination brought back into use? ■

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Outbreak!

Sometimes a story unfolding in the news provides you with a chance to collect data and explore the science behind it. The epidemic of *Escherichia coli* food poisoning in Lanarkshire in 1996/97 was such an event. The outbreak of foot and mouth disease this year is another.

The *E.coli* outbreak was reported in many newspapers and it was possible to collect detailed information about the number of suspected cases, the number of confirmed cases and the number of deaths, almost day by day. These data are collected together in Table 1. Plot a graph with time on the horizontal axis and other values on the vertical axis. Where data are collected against specific dates, it is often far easier to work out and then plot days from the start, rather than the calendar dates. Compare your graph with a similar one for foot and mouth disease (page 8).

In the early days of the foot and mouth outbreak the Ministry and Agriculture, Fisheries and Food (**www.maff.gov.uk**) published confirmed cases in date order, so it was possible to backtrack to generate Table 2, from which the graph on page 8 was plotted. Each day they also published total confirmed cases, although the time of publication was shifted from 15.00 to 19.00 in late March.

Table 1 E. coli *in Lanarkshire, 1996*

Date	Days from start	Number with symptoms	Confirmed cases	Deaths (total)
27/11	10	85		1
28/11	11	100	62	5
29/11	12	132		5
3/12	16	280	148	5
4/12	17	305	166	6
5/12	18	335	176	7
6/12	19	359	193	7
9/12		386	204	9
10/12		390	209	10
12/12		396	216	11
13/12				12
18/12				13
30/12				16
31/12		409	?409	16

In all 18 people died.

Table 2 *Cases of foot and mouth disease, 2001*

Day no.	Date	Confirmed cases		Slaughter		Disposal
		That day	Accumulated	Dead	Awaiting	Awaiting
1	20/2	1	1			
5	24/2	1	7			
10	1/3	6	33			
15	6/3	5	80			
20	11/3	27	169			
25	16/3	17	274			
30	21/3	43	439	272 824	130 636	79 540
35	26/3		624	419 323	243 692	103 573
40	31/3		875	587 000	353 000	166 000
47	7/4	22	1105	764 000	440 000	266 000
55	15/4	14	1320			
62	22/4	9	1435			
71	1/5	7	1518	2 361 000	116 000	132 000
83	13/5	4	1593	2 679 000	68 000	37 000
87	17/5	0	1603	2 847 000	65 000	26 000

It should be possible to add further data to a spreadsheet like that shown here. Even if the day by day data are not available from the MAFF website, newspaper reports will contain some details. Table 2 includes some data about the numbers of animals slaughtered, awaiting slaughter or slaughtered and awaiting disposal. Differences between these values are important because they reflect how quickly people were dealing with infected animals. The sooner an animal is slaughtered and buried in a pit or burnt, the better.

During March groups of scientists worked with computer models that simulated the likely progress of the outbreak. One group emphasised the importance of slaughter within 24 hours of an animal being diagnosed with foot and mouth, estimating that this could reduce the final size of the epidemic by 25–50%. It was estimated that there might be a total of between 900 and 4400 cases, with the outbreak lasting until at least June and possibly into July. Extend the spreadsheet to describe what actually happened. ■

Nigel Collins

● **Find out how white blood cells fight virus infections.**

GCSE
You need to be able to
- present numerical data;
- identify trends and explain patterns in results.