FOOD POISONING

AND

FOOD HYGIENE.

A fascinating essay, but rather much "padology"—certainly the most interesting (so far).

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(4th M.B.)
Summary:

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Food poisoning is the term applied to acute gastro-enteritis associated with abdominal pain and the sudden onset of vomiting often with diarrhoea, shock and prostration, and sometimes with fever (8). The characteristics and duration of the syndrome are determined by the particular poison in the food.

There are three main causes. The first, giving 3% of incidents, is food poisoned by chemicals. Occasionally this may happen when "the spirit of murder works in the very means of life", as in Lord Randal's "eels boil'd in broo". Roman empresses used poisoned oysters to discourage unwanted lovers. Lucrezia Borgia won the leading reputation in Renaissance poisoning. Recently in Britain, antimony, copper, mercury, zinc, chromium, arsenic, lead and cadmium have been used to colour foods, as have coal-tar dyes, picric acid, Victoria yellow, Manchester yellow, aurantia and aurine (Davies).

Foods may be contaminated by their containers: galvanised iron utensils leaving toxic traces of zinc and antimony in foods cooked in them, water storage tanks repainted with naphthalene-containing paint (Campbell), cadmium-plated jugs and ice-box trays, sodium cyanide polish on silverware and SO₂ in bottled plums have been incriminated. These metallic poisons produce symptoms within thirty minutes of ingestion.

The second group comprises items which are intrinsically poisonous and are eaten by mistake. Plants are the commonest. In 480 B.C. poisonous fungi killed the wife and children of Euripides. Claviceps purpurea kindles St. Antony's fire. Solanin in green potatoes provokes vomiting and diarrhoea. Rhubarb leaves contain oxalates. Water hemlock was made famous by Soc./...
by Socrates, and the fava bean by other judicial murders in Africa. Worthy of respect are alkaloids of toadstools and mushrooms such as Amanita phalloides with a mortality of 60 - 100%, laburnum seeds, deadly nightshade, yew, and the flowers of azalea, oleander and rhododendron whose pollen poisons honey in the Black Sea region as Xenophon's greedy Greeks found at Trebizond in 400 B.C. - all these cause food poisoning. Shellfish off the American West Coast, having consumed dinoflagellate food, transmit curare-like substances. Poisonous too are the roe of pike and the muscle of the spawning sturgeon, the Japanese globe fish, some types of turtle flesh, and the Chinese puffer-fish (aptly named wu-dung).

Some viruses may cause diarrhoea, often with vomiting and systemic upset. Echo virus types 7, 14, 18, and 20, spread by human carriers, the virus of viral hepatitis sometimes introduced to foodstuffs by rats (Doig), and "viruses undetected by existing methods" (1) may cause food poisoning.

Bacterial food poisoning is, however, the most important and most common. Bacterial contamination may result in an infection or an intoxication. Cholera, dysentery and enteric fevers are excluded.

Botulism, caused by Clostridium botulinum, is uncommon (2000 recorded cases) and therefore "not of great Public Health importance" (4). It is, however, very lethal, claiming a mortality of almost 70% in America, 25% in Europe (4). The organism was first described in 1896 in Belgium, after a "festive gathering of a village music club" with raw ham on the menu (1). Cl. botulinum has five strains, types A - E. It is found
widely, preferring virgin soils remote from an apparently unsuccessful competition with organisms from human or animal manure (5). Of strains pathogenic to man, in Russia type A alone has been found; in S. Africa only type B (1). Type E spores are widespread in the sediment of coastal waters off Holland, Japan and the Sea of Azov (1), in fresh water (5), occasionally in the gut of some farm animal and very rarely in the faeces of healthy people (1).

Spore germination is quick in alkaline or neutral foods, or in those with a low salt content (1). In Europe, meats such as the large German-type "botulus" or meat pastes as in the Loch Maree outbreak are incriminated most often. In America the home-canning industry with its inadequate sterilization has cooperated with the widespread soil distribution of botulinus to taint vegetables and fruits, e.g. olives, peas, beans, spinach and corn. In Japan, Alaska and Canada uncooked fish is often the vehicle. Rarely mamalian meat is responsible in Japan (1).

In all cases, three factors contribute to botulism, a) failure to eliminate the organism by rigorous cooking - all strains except type E have heat-resistant spores -, b) provision of a period of anaerobiosis, c) failure to destroy the heat-labile exotoxin formed - the toxin is destroyed by boiling for ten minutes.

The nature of the exotoxins is not fully known. All seem capable of dissociation and repolymerisation in various ways (10). Type A, an unstable globulin protein of M.W. about 10^6, is the most common and the most potent and gave a 100% mortality at Loch Maree. It is produced by proteolytic strains, so that contaminated
meat is usually but not always offensive, and the cans are swollen with gas. Type B, a non-globular protein, is found in raw fish, but even with gross contamination mortality is only 20% (10). Types C and D cause animal botulism only. Type E, an extremely potent toxin, is encountered when eating raw and rotten fish - a Japanese and Eskimo custom (1). The other contaminating organisms produce proteases which enhance the toxin's strength (1).

When the toxins in the food are ingested, the digestive juices may inactivate or destroy them. Or their partial disruption, by secreted or bacterial proteases or by acid, may heighten their effect (5). Heckley considers that they are absorbed in fragmented forms. The toxin is easily absorbed from the stomach (Dible) and proximal small gut (1). It passes via the lymphatics and thoracic duct to the blood stream (1). The site of action is at the myoneural junction through either a) the inhibition of acetylcholine production or release (3), or b) the blockage of impulse conduction in the terminal unmyelinated part of the neurofibrils (1), of both somatic and autonomic efferents.

Within one to four days of ingesting the toxin its effect on the motor cranial and parasympathetic nerves produces diplopia and failure of accommodation, dysphagia and dysarthria, constipation, often cardiac arrest and respiratory paralysis. First there may be vomiting and severe thirst. Headache, malaise and vertigo may follow, but fever and diarrhoea are unusual. Loss of consciousness, delirium and coma are terminal only, associated with acute encephalitis. Recovery is more likely if the patient survives/
survives the first week. Deaths after this, and relapses, may
be due to live organisms multiplying in the wall of the gut or
in the body tissues (Dolman) with continued toxin production.

Laboratory diagnosis of botulism lies in a) the isolation
of the organism from faeces or vomit, or b) finding the toxin in
the food. After intraperitoneal injection mice die very
rapidly unless given neutralising antitoxin. Treatment consists
in giving polyvalent antitoxin. Gastric lavage with bicarbonate
is said to prevent acid reactivating residual type E toxin, and
to destroy the alkali-labile toxins (1).

_Clostridium welchii_ is a "filth and illth" organism causing
less than 10% of outbreaks (1). Gross contamination of food is
necessary to produce symptoms. The bacterium or its spore is
found in almost 20% of raw meat samples (1) infected by soil,
kitchen dust (1) blowflies,

There are three groups implicated, heat-stable spores of
type A strain, some heat-labile strains and type F, a sub-group
of type C, again with very heat-stable spores). The latter
gained notoriety in Germany, causing "enteritis necroticans",
an enterotoxaemia characterised by a diffuse inflammatory sloughing
of the intestinal mucosa below the duodenum and by rapid death, (2).
_Clostridium bifermentans_ can also cause enteritis (11).

_Clostridium welchii_ multiplies rapidly in stews, soups, gravies and
pre-heated meats left at room temperature or rewarmed, or made
anaerobic by intrinsic reducing substances, aerobic bacteria on
the surface and the absence of non-sporing heat-labile bacteria
inside.
The symptoms which develop within the day are admonitory rather than punitive - like 16th century herbal mixtures, "clisteria multum laxativa" (Jusserand). Abdominal cramps and diarrhoea, both usually mild, last between twelve hours and two days (2). Fever and vomiting are infrequent.

"I must blow my nose ...... in a piece of tissue-paper which I afterwards burn" (Dylan Thomas). Present in the nose of almost 50% of people (1), Staphylococcus aureus "probably causes more cases of food poisoning at the present time than all the other types concerned" in America (4) (10). In England in contrast it causes less than 25% of all general outbreaks (Hobson). Long summers, permanently warm kitchens, and bulking and processing foods increase its incidence.

Only a few strains (notable phage types 3 and 4) produce the heat-stable enterotoxins. There are at least two antigenic types of toxin, one being part of a protein of M.W. 24,000 (1). They have a high lysine component (10).

Staphylococci are essentially parasites of man. Dogs may become carriers of these strains (1), and cows with obvious or latent mastitis may excrete phage 4 staphylococci into milk (1). Otherwise the staphylococcal cornucopia is man with his nasal droplets, his furunculosis and impetigo (2), his septic or non-septic cuts and abrasions, cracks, chaps and even, in some cases of heavy nasal carriage, his intact skin (1).
Staphylococci are found in most foods, in ice-boxes, in pickles, but especially in items which are handled after cooking. Processed meats account for more than 60% of this type of poisoning in England (1). In America cured hams account for 50% of meat-borne outbreaks. Meat-pies, tongue and mince are also guilty. Toxin production is increased in carbohydrate foods (3) hence the risks from cream pastries, custards and mayonnaise. Milk and milk products, including fresh cheese, Gouda and Cheddar matured cheese, cause 10% of outbreaks in Britain and America (1). Confucius "does not eat a thing whose colour or odour is not right"; so although he might escape botulism he would not escape Staphylococcal food poisoning which produces no obvious changes in the food.

The toxin may be a proteolytic enzyme resembling the lecithinase of Cl. welchii (11). It resists tryptic digestion when eaten. It probably acts on the sensory nerve endings of the gut, or on the smooth muscle of the wall. Within five hours, a sudden severe abdominal pain is followed by violent vomiting and continuous retching with prostration. Recovery is invariable and within the day. There is no specific therapy (3). Experimental work with volunteers shows a graded susceptibility to the toxin, one extreme being absolute immunity. Dolman’s test, intraperitoneal injections of kittens, is used to detect the toxin.

Streptococcal food poisoning is rare. Strep. pyogenes, types A, C, D, and G, from the human nose or throat, or from a milking cow with streptococcal mastitis may be the agents. Sixteen hours or less after food containing the multiplying streptococci is ingested the enterotoxic symptom of abdominal pain and diarrhoea
(rarely vomiting) begin.

Sometimes a strain of Strep. viridans (1) or Strep. faecalis (3) is pathogenic. Rarely Shigella (sonnei more often than flexneri) may produce typical food poisoning symptoms (4)(5). Gastro-enteritis may follow gross contamination of food by yet other bacteria, B. cereus (1), P. vulgaris and P. morgani (the last two commonly in epidemics in children) (3), and the Arizona paracolon bacillus; pathogenic strains of E. coli (O groups 26, 55, 111, 119, 125-8) may colonise almost the whole intestine excluding all other coliforms, and become endemic in institutions and hospitals, many of the staff remaining symptomless excreters. But in these cases the irritant toxins are probably breakdown products of the food itself (5).

Of those outbreaks attributable to bacteria, the Salmonella group causes 95% of all, and 60% of general outbreaks in Britain (H). There are over 400 serological types of Salmonella (2), a profusion recalling Newton, "the course of Nature seems delighted with transmutations".

What are some of these types? S. typhimurium is exposed by phage typing as the commonest and most important in Europe, the Americas, Australia and N. Zealand. It is less so in Asia and tropical Africa where the wide variety of Salmonellae has no dominant type and where explosive food-borne outbreaks are rare(1). In Britain it causes 70% of all Salmonelllosis (2) and over 90% of family and sporadic outbreaks (H). It has a wide host range including mice, rats, poultry, canaries, pigeons and pheasants; it can cause sub-clinical infection or severe septicaemic illness in many species of animal including
man (infrequently man can be a carrier (P)). Thus here is an exception to the rule that those Salmonellae with a wide host-range cause only bowel illness with no systemic symptoms (1).

Other Salmonellae were 30% responsible in 1961 (D). The second commonest cause of Salmonellosis in England (Hu) is S. Enteritidis, isolated in 1888 by Gaertner from infected beef. Its hosts include cattle and rats. Used in "Ratin 'virus' rat Poison", it may be excreted by these intended victims and infect man (1). S. gallinarum and S. pullorum parasitise poultry, "the largest single animal reservoir of Salmonella" (H). Hogs are the hosts of S. cholerae-suis, a particularly virulent type for man with 20% mortality (10). S. dublin causes outbreaks especially in cattle and milking cows (H) but is found often in the livers of healthy cattle (1). In one outbreak S. dublin gave 170 people gastro-enteritis, (11). Shanghai's wild rats most often harbour S. bledgdam (1). In the tropics and sub-tropics cold blooded animals are also Salmonella reservoirs, important because of their occasional domesticity: 47% of house-lizards in Dar-es-Salaam are faecal excreters of Salmonella (1).

Man himself is a host to S. paratyphi B (8), (Paratyphi A only rarely causing simple food poisoning); thus of a random group of Bantu children 44% excreted Salmonellae during one year of investigation (Hu). Perhaps certain animal-host strains are becoming adapted by mutation to parasitism on and carriage by man.

The reservoir therefore includes animals both wild and tame. When an endogenous strain infects its usual animal host, the latter sustains a severe or fatal illness resembling
enteric fever in man, and permanent carriers may result. An 
exogenous infection causes mild or no symptoms but subsequent 
intermittent excretion of the organism (1). It is the ripples 
from these events which provide outbreaks of Salmonella 
food poisoning in man.

What are the routes of transmission? Rats and mice foul 
human food directly with their infected urine and faeces. 
Salmonellae may remain viable in rat faeces for almost six 
months (1). Domestic pets such as tortoises, cats and 15% of 
dogs are carriers (B). Insects such as rat fleas (5), lice, 
cockroaches and houseflies can also harbour Salmonellae (1).

Hens, ducks and turkeys are often reservoirs, possibly 
because almost 30% of the bone, fish and meat meal imported for 
their food contains Salmonellae (H). In America fowls "constitute 
the greatest reservoir of Salmonella infections amongst domestic 
animals" (11). Their carcases may be directly responsible 
for human spread, although healthy carriers have the organisms 
usually only in organs not eaten by man. More important vehicles 
are their eggs, often destined for bakeries, dried foods and 
egg powders, with "bulking, mass contamination and export. In 
1942 nearly 30% of dried egg from America contained Salmonella; 
Chinese dried egg is also notorious (1). The hen's egg is at 
risk only on cloacal passage or as the wet shell cools in the 
contaminated surround. However the duck, "an extremely dirty 
bird, meandering through mud and filth, a loose and dirty 
feeder, laying her eggs wherever she may feel inclined" (9), 
may infect the egg in her ovaries or oviducts (2)(3) via a Salmonella 
septicaemia. Thus about 1% of duck eggs are infected with S.
typhimurium or enteritidis (1). The surprisingly low figures are attributed partly to lysozyme of egg albumin which inhibits bacterial multiplication for a week. The egg membrane even at room temperature resists penetration for about seven days (1); and the shell's dry mucilaginous surface coating, unless removed by excess washing or handling, forms the outermost defence (3) (although there are pores 8-10μ in diameter). Refrigeration completely blocks penetration and multiplication (1).

The second important source of Salmonella contamination is farm livestock. Salmonella is excreted by 1% of healthy cattle (2). It spreads to other cattle through befouled pastures and drinking water where the organism may survive for six months (2). Milk and meat are the consequent means of spread. Milk may receive its inoculum directly from a cow suffering from a Salmonella septicaemia or mastitis, or from the cow's own faeces-smirched udder, or via a human vector or carrier. It thus infects unpasteurised milk, butter, cheese and other products (8)(2).

Meats infected usually appear normal, as van Ermengen's meat inspector found to his cost (1). He was "asked to give his opinion on some suspect sausages. Judging from their excellent appearance, their good smell and their rosy colour, he pronounced them suitable for consumption and to demonstrate their harmlessness, he himself ate three slices". They contained S. enteritidis, and he died after five days of acute enteritis. Indeed sausages, classically qualified "fulsome, coarse and bloody" by Aristophanes, average today a 5% (10% according to Hoy) incidence of contamination in England (1). This contamination
is uneven: the ultimately fatal S. enteritidis was in only four sausages out of the whole day's batch in van Ermengen's case, quoted above. S. cholerae-suis, however, is the commonest culprit in sausages (8).

Mince is equally at risk. The sterile meat from the middle is mixed with contaminated surface meat by the contaminated mincer. For this food a bacterial count of ten million aerobes per gram of meat is considered safe (3).

Liver, often from healthy animals, also has a high rate of contamination by Salmonella, especially S. dublin (1). Its association with liver fluke has been reported (although not confirmed in Edinburgh's abattoir at Gorgie - Norval).

Made-up, "tenderised" meats, with their partial autolysis, attract man and bacteria such as S. enteritidis (8). Hams and meat pies present the technical difficulty of thoroughly cooking the meat inside without over-cooking the surface meat or the pastry; boneless meat after pooling and bulk treatment of many carcases (1), meat sandwiches and salami, all these are Trojan horses harbouring pathogens under an appetising exterior. Thus Germany, where raw meats and sausages are popular dishes, had an average of about seventy Salmonella food poisoning outbreaks per annum in the 1920's compared with Britain's thirty or so (P).

Other types of food exposed to dust and droplets are salads, mayonaise, dried egg, sliced melon, smoked or pickled fish from polluted rivers and estuaries, oysters from beds sited at sewage outlets, Molly Mallone's cockles and mussels and other shellfish.

Fruits are rarely vehicles, since peeling removes the surface
contaminants, and their substance does not encourage bacterial growth. Isolated infections may emerge if the tough bacteria-proof skin is broken or bruised (3).

Lastly food may receive an inoculum from a human source (1) - a carrier with no history of food poisoning or a convalescent carrier. Salmonellae are excreted for one month after the illness by 50% of patients, for two months by 10% and longer by children. In one study in Brisbane the organisms were found in \(3\frac{1}{2}\%\) of children under two \(\text{year}\) (1). Salmonellae are found infrequently in sputum and sinus discharge; eight different species were found in the tonsils of 8% of Mexican children who had undergone tonsillectomy. Their presence in such sites might suggest inhalation as an exceptional route of infection especially in babies (1). An even more esoteric route suggested is through the conjunctiva; animal experiments show that the number of bacteria needed for infection via this site is quite low (1). The bite of the flea, louse or sandfly may introduce Salmonellae in association with typhoid, relapsing fever or bartonellosis in some countries (5)(1)(Hu). However the recognized portal is the mouth.

The Salmonellae colonise the intestine. On lysis they liberate their heat-stable endotoxins, lipo-polysaccharide complexes, from the cell wall (3). These cause a violent local irritation of the gut mucosa, and between eight and thirty-six hours later the illness and toxaemia become apparent. Severe headache is the first symptom; it is followed by abdominal pain, violent diarrhoea and tenesmus with or without nausea and vomiting. There is fever in the acute form, (8). Usually recovery takes one week.
Treatment includes specific antibiotics or chemotherapy to destroy the organisms, and maintenance of fluid and electrolytes, especially in the young and very old.

The illness may run a more serious course, however. The people at risk include those at the extremes of age, and those with other debilitating diseases such as cancer or diabetes (Hu). In these the gut colonization progresses to bacteraemia or septicaemia. In 1% of cases (1) the patient's restlessness, thirst and cramps terminate in coma and death. If the patient survives, there may be complications such as chronic cholecystitis, a purulent meningitis especially in infants, abscesses, pneumonia, empyema, pericarditis or endocarditis (1)(2)(3); Salmonella osteitis has also been found, particularly among African children with sickle-cell anaemia (2). After such systemic attacks associated more often with S. cholerae-suis and S. enteritidis (1) patients may become healthy carriers (1).

Diagnosis depends on a positive stool culture (3) or leucocytes and organisms in the faeces.

At the other extreme, up to 60% of those who have eaten infected food may escape symptoms completely (1). This variation is due to a) the small number and weak strain of organism ingested - large numbers are required for infection varying in one experiment from 50 million organisms of a S. anatum strain, to 1 million for S. bareilly (1), b) the type of food which has been the medium, c) general human resistance to infection (children in hospital being very susceptible), d) the number of anaerobic Gram-negative commensals already present in the host gut (experimentally one dose of oral streptomycin gave a 100,000 fold reduction in the
minimum infective dose of S. enteritidis and S. typhimurium), and lastly, e) growth inhibiting substances in the lower gut, such as volatile fatty acids, and formic, acetic and butyric acids (1).

As in Staphylococcal food poisoning, the overall morbidity is over 75%. But these outbreaks grow yearly more numerous, retarding the progress of that ideal of Emerson and Everyman, which is simply a "matter of having good days".
"Man has hedged himself with a 'pax' which much that is predatory respects. Bacteria still attack and feed on him and breed within him" (Sherrington). His defence against food poisoning organisms rests in clean, protected food, especially, as we have seen, meat and milk. Food hygiene in turn rests on the education in, and practice of personal hygiene, and in comprehensive public hygiene, with pure water and sanitary sewage disposal (1).

Water, "the great menstruum of life", has many uses; to list these is to descry its possible abuses. It is drunk, washed with, mixed with food in home and factory, and harnessed to sewage disposal. In the water of sparsely-inhabited areas bacteria are inhibited by certain factors. These include the ultraviolet rays in daylight, the acidic substances from soil, the low pO₂ of stagnant water, predatory protozoa, and ill-defined specifically bactericidal substances in some rivers e.e. the Ganges (famous for its phages), Saône, Rhône and Isère (1). To these man adds, where possible, chlorination and sand or biologically-activated filtration, - where not, boiling or water-cleansing tablets (Hunt).

But although well-guarded reservoirs, water-filtration plants etc. are nowadays municipal necessities for well-controlled food hygiene, 90% of the world's population still have no piped water supply (U.N.O.). People still rely on water "with the momentary taste of Being, from the well amid the waste", be it from stream, canal or well. In the districts around Nanking 74% of all water used comes from contaminated ponds and canals (S). In Ceylon during the last war the Navy found that a main reservoir supplying a port was also a local bathing pool and a laundry (11).
Thus almost 5,000 years after the Ancient Cretans introduced piped water supply, there is still no clear distinction between water main and sewer, and the height of ground water still dictates the incidence of disease.

Freud detects the beginnings of creative art in the infant's pride over his stools. He did not explain why it is that the expression "Eat excrement", used throughout the world as abuse (Malinowski), is indeed equally widely practised.

At sea, disposal of faeces and garbage is easy. "The seaman for generations has unwittingly observed the fundamental sanitary law of keeping his ingests apart from his egests by passing his excrement straight over the side of the ship, where it cannot possibly pollute food or flies" (11); and given reasonable food and space, Hawkins the Elizabethan perceived, sailors stayed alive, well and free from infective "fluxes". On land, overstream latrines embody this principle; in New Guinea, "understanding the house" includes remembering to remove a floor slat before urinating or discarding rubbish into the sea. Venice solved her larger-scale sanitary problems similarly, by "dumping her sewage directly into the sea, where the salt, sunlight and tides dealt with noxious bacteria (M). In inland areas, human ordure-disposal has remained a problem. In underdeveloped countries it is collected and used untreated as fertiliser. Its safe use after controlled conversion to fertiliser is a recent and localized advance.

"Progress... is not a law of nature" (H.A.L. Fisher's "History of Europe"), and elementary food hygiene is often the zygote
of superstition and minimal direct observation. Among some primitive tribes today "the superstitious fear of the magic that may be wrought on man through the leavings of his food has had the beneficial effect of inducing many savages to destroy refuse which, if left to rot, might through its corruption have proved a real, not a merely imaginary, source of disease and death" (Frazer). Significantly the Maoris regarded disease as a punishment and consequence of social wrong-doing; perhaps for this reason the Maya washed often (von Hagen).

The Jews, influenced by their "mighty seers of yore" and by the lessons taught by "Völkerwandlungen" through the Middle East, took food and public hygiene very seriously (Garrison). Ritual ablutions feature prominently in the Talmud; washing hands on rising in the morning is enjoined as an act of elementary hygiene and as a rite of consecration. The same twofold motive enters into the ritual washing of hands prescribed before meals (Epstein). For "to neglect the body is to offend against God, and to wash daily is a religious duty". Every Jewish soldier was obliged to carry a tool which he used to bury his excreta (Guthrie).

In the Koran Mahomet states: "Cleanliness is piety". Further East Confucius recommended thorough cooking of raw meat, especially when offering it to ancestors, and his compatriots invented toilet paper. Hesiod likewise informed fellow-Greeks that Zeus and "other deathless gods heed not, but spurn the libation poured with unwashed hands". "Neither make water at springs, but heedfully avoid it, neither ease thyself therein. For it is not well so to do."

But if Socrates, "unwashed and slovenly" if we believe Aristophanes, paid little heed to these revelations, neither did his
compatriots. In ancient Athens and other large towns there accumulated refuse and ordure inviting disease - municipal dumps where unwanted babies were left to die. Plato criticised these conditions and wanted urban commissioners to provide for city sanitation; for "water is easily corrupted". And in the Politics of Aristotle, "prudently conducted states" were given similar advice. However, Athens remained democratically dirty, and "over the whole department of her sanitation it is best to draw a veil" (Zimmern).

Roman sanitation set an early example. Underground sewers were dug - "few things impressed Greeks who visited Rome so much as the Cloaca Maxima" (M), still in use after 2,500 years of continuous service. Her system of aqueducts bringing in 300,000,000 gallons per day (Singer) allowed Rome's inhabitants a quantity of water of per head (100 Gals) unrivalled by any city since (Guthrie). Food markets were officially inspected for unsound food. But "the victorious trumpet peel dies fitfully away": open refuse pits and trenches were used for routine and for the 5,000 animals and men often slaughtered during a day's gladiatorial show. These formed around Rome a "cordon malsanitaire" promoting the numerous altars and shrines to the Goddess of Fever. Only 150 public toilets were for use (at a fee) and Roman fullers used Roman urine for working up cloth (M).

The Byzantines carried on and developed the Roman system of water supply, but added little new (Runciman).

The Dark and Middle Ages in Europe saw a laissez-faire policy. Through the relatively small towns and villages wandered animal scavengers, the pig in particular "being an active member of the Local Board of Health". The sun was an efficient antiseptic
and the open fields an acceptable compost heap for these dwarf conurbations. In the towns themselves bonfires were periodically lit, and periodically burned down many wooden houses. A Master Stow noted "the virtue that a great fire hath to purge the infection of the air" (M) - an example of direct observation. Public baths were not uncommon, and 15th-century London authorized hot baths in private houses. The 13th Cent. "Regimen" of Salerno, the first popular manual of Private Health and dedicated to the English monarch, advised "wash the hands frequently....lodge in clean light quarters away from stagnant water or excrement". At the court of Elizabeth Tudor Sir Richard Harington re-invented water-closets, no novelty in Ancient Crete (3,000 B.C.); found too before 1500 B.C. in such Indus cities as Harappa and Mahenjo-Daro, they were not to become general in England until after 1830.

But as towns continued to expand, the sewage problem piled up. According to a contemporary, "Whatever filth is made during the night is placed in the morning before men's eyes to be trodden underfoot, than which it is impossible to imagine anything fouler" (M). Hillside Sienna, which notably lacked drains, stank at all times of the day. Versailles Palace was built without latrines; there were only xxx portable commodes on wheels. Her corridor walls (inevitably) became common urinals (M). The mediaeval public bath disappeared before the onslaught of contact syphilis. The Jews abandoned Mosaic sanitary rules and ritual ablutions. In America, Ben Franklin rallied compatriots: "Tolerate no uncleanness in body, clothes or habitation."

But in the vast Industrial Revolution Hygiene withered. Industrialism, the main creative force of the 19th Cent., produced
the "most degraded urban environment the world had yet seen ... In both old and new quarters a pitch of foulness and filth that the lowest serf's cottage scarcely achieved in mediaeval Europe ... and while in the 16C. it was an offence in many English towns to throw rubbish into the streets, in early industrial towns this was the regular method of disposal"(M). In Manchester there was on average one toilet for every x 212 people. Open drains represented comparative municipal affluence, while the river Irwell flowing through Manchester was "considerably less a river than a flood of liquid manure "(M). In 1873 Osler noted as dangerous to public health the open sewers of Berlin. Cities became rich and stank. As Galbraith writes: "The greater the wealth the thicker will be the dirt". Personal hygiene was as poor. In Edinburgh, city of Gardy-loo, the answer to the question "When were you last washed ?" was another question,"When was I last in prison?"(Cole). And Florence Nightingale commenting that "women are woefully deficient in sanitary knowledge" attributed to "defective household hygiene" the tragic child mortality figures, which formed 3 of the total: the fly was an impartial caller on cellar cess-pool and infants' food.

Very slowly (perhaps because superstition and religion had been supplanted by materialism), the inhabitants of the industrial towns observed and reacted. And the arts of Hygieia were painstakingly relearned. As the 19C. passed, street cleaning in London became a public service, and the bathroom made its way back into the house. New York built reservoirs and aqueducts to become the first big modern city to achieve an ample supply of pure water (1842). Paris instituted her celebrated sewers in 1856. In England, where sewage is still
commonly discharged into the sea, filtration beds were first used at Wimbledon in 1876, and the bacterial system of purification in 1896.

But the advancing broom of hygiene left its untouched areas. In the East, conditions are alarming. In rural Burma manure is removed only when convenient, and villages become veritable quagmires during the rainy season. In most of India, the sun and monsoon, the vulture and pie dog, the burning ghat and the "untouchable" sweeper are the sanitary team (Lloyd). Edinburgh University staff visiting Baroda survived having their plates washed in mud pits by well-meaning servants (Collee). Promiscuous defaecation is common - side streets, banks of ponds, canals or rivers, or the margins of water tanks being the chosen sites. Public latrines are ill-kept and insanitary (S). From the same cause, Japan has widespread bowel disease. In Samoa more than 3/4 of the villages have no latrines, and in the others there is "ample evidence" that they are not used. Flies flourish, and intestinal infections are maximal - 71% of Indochinese carry roundworms, 77% Trichuris trichiura (S). Clearly the breaking of the life cycle of parasites, which is one of the aims of proper sewage disposal, is unaccomplished. Even up-to-date Americans picnicking on "exquisitely-packaged food from a portable icebox by a polluted stream, go on to spend the night in a park which is a menace to public health;... and amid the stench of decaying refuse reflect on the curious unevenness of their blessings" (Galbraith). In Britain before 1920 it was "unusual for workers' houses to be provided with baths at all" (W. M. Frazer), and even on April
30th 1965 the B.B.C. news announced that 3,000,000 people in Britain still have none.

The leader-writer in The Times, who declared that mid-19th Cent. Britons "would prefer to take chances of cholera and the rest than be bullied into health", was only echoing an older Bosnian proverb: "It is easier to destroy our villages than to change our customs." For the ideas of modern preventative medicine and the traditions of old cultures are not easily balanced. And the obstacles to progress are ignorance, pride and conservatism. The former crutches for hygiene, superstition and religion, are out-dated, if not completely broken.

The modern goal, approached via scientific research and public awareness, should be food free from chemical poisons, pathogenic bacteria, bacterial toxins and parasites such as amoebae, flukes, tape-worms, round-worms and the echinococcus.

On the farm the live animal must be inspected and those infected cured or slaughtered. The efficient inspection system in Britain results only rarely in "emergency-slaughtered" animals, formerly causing outbreaks of enteritis, an aetiology common in Germany (P). The contamination of pastures having been prevented by this means, concentrated foods must be examined. Transport from farm to abattoir often results in a four-fold rise in the faecal carrier-rate in the animals (because of surface infection by hair, hooves and anal leakage (1)). There is a tendency for the carrier state to become a septicaemia (2).

With the large numbers of carcases being handled, abattoirs and butchers' shops have great potential for disseminating infection. Thus in Britain meat becomes contaminated mostly after slaughter, and usually by S. typhimurium rather than S.
enteritidis and dublin, usual in sick animals. Recent research in Edinburgh has shown sausages to contain 25,000,000 organisms per gm. (reduced to 500,000 by bacteriological supervision); 95% of this contamination comes from wooden benches and from workers' clothes (Board). In Sweden the 1955 outbreak of S. typhimurium infection, causing 90 deaths and 9,000 illnesses, originated from one abattoir (H)(1). Large centralised abattoirs favour a standardised inspection of slaughtered meat. Slaughtering by electrical stunning minimises contamination of the carcases after bruising, and the haemorrhagic splashing of the premises. Contamination during evisceration is lessened by using "separate impervious receptacles" for carcases and offal (L).

Storage of meat should by by refrigeration (the law requires a temperature of less than 50°F (L)), and preferably under U/V light to diminish surface contamination (3). Bacterial growth is restricted by food-drying, salt-or sugar-curing and smoking (whereby volatile bactericidal substances are adsorbed on to the surface).

The milk industry has also met and overcome its specific problems. The modern milkman "takes sanitary precautions that a mid-Victorian London surgeon did not trouble to take before performing a major operation"(M). Aseptic techniques result in 200 organisms/ml. of clean, fresh milk, in place of the 100,000/ml. in fresh but dirty milk, "a dangerous food" (Crofton). For with bad hygiene milk can spread diseases such as typhoid, dysentery, diphtheria (these originating from human contamination), and streptococcal, salmonella, brucella and tubercle infections (from infected cows). Strict cleanliness means herd inspections, hosed cowsheds, and swept approaches, dairies at least 60ft. from
midden or mire, hygienic milking techniques and sterile equipment from pail to bottle-filler, pasteurization - surprisingly uncommon in Australia (S), refrigeration (at $0^\circ$C the bacterial count of fresh milk drops (B)), rapid distribution: these aid the intrinsic bacteriostatic properties, antibodies and agglutinins, of fresh milk itself (B)(1): all contribute, in Britain, to the present safety of milk, as do the checks. These tests include the coliform count - measuring faecal contamination -, the methylene-blue reduction test - indicating the presence of strongly-reducing enterobacteria -, and phosphatase activity - signifying inefficient pasteurization.

The premises must be free from rats and flies. The latter are unable to swallow solids, and, rubbing their regurgitations and defaecations into the food, are ubiquitous agents of disease. In warmer countries flies are a much greater menace. In Guatemala Aldous Huxley records "iguanas flayed and gutted in a neat row on the pavement - a pale meat crusty with flies". In Ceylon their swarms appear just after the monsoon, heralding bowel disease (S). During the Spanish-American war they were blamed for the 20,000 cases of enteric fever (Christian). Modern M. O.s warned their troops about "the foul regurgitations and filthy feet of faecal-feeding flies".

The law takes official cognizance of animal pets in the spread of disease: "Live animals must not come into contact with meat and fish".

But the human animal employed in the food industry has made bacterial contamination of food an everyday occurrence (11). Notifications have risen from 550 in 1944 to 4,000 in 1950 (9).
Meanwhile "coughing and sneezing in the presence of food, picking the nose or spots on the hands, face or head" (9), inadequate washing facilities (or their lack of use), dirty towels, the blowing open of paper bags, the casual wipe of a dropped edible, the disdain of lifting by tongs instead of fingers, etc. etc.; continue.

According to an official pis-aller, "food-workers should refrain from spitting, smoking, chewing tobacco and using snuff while handling food"; each "must keep his person, his clothes and overalls as clean as possible", and an "open cut or abrasion must be covered by a waterproof dressing" (L):

"But gret harm was it, as it thoughte me,
That on his shine a mormal hadde he;
For blankmanger that made he with the beste" (Chaucer's Cook).

Food handlers are now legally bound to report infections such as enteric fever, salmonellosis, dysentery or Staph. infections likely to cause food poisoning (F&D). But perhaps the ideal may be sighted when food workers and their families volunteer for routine stool cultures and report any intestinal and respiratory illnesses for immediate bacteriological investigation. And when employers show more interest in histories of clean health before workers are enrolled as well as afterwards.

The premises where food is handled should fulfil the demands of hygiene. Toilets should be good, numerous and near (one closet for 25 people in a factory (L)). They must not be adjacent to kitchens and rooms where "open foods" and food equipment are kept, because of the risk of transfer of organisms by man, dust, or the aerosol set up by flushing the pan (1). This agrees with the teaching in the army that "as the mouth and the anus are at
opposite ends of the body, so should the kitchen and latrines be at opposite ends of the camp". Individual towels, soap and hot water should be provided. Solutions containing Benzalkonium chloride or other antiseptics, e.g. "Zalponin" (Z), destroy skin coliforms, and reduce the total bacteria by 46%. But Staphylococci remain ever ready to emerge from skin folds and sebaceous glands leaving hands "bacteriologically dirtier" than before washing, (Z).

Dust and food-borne infection go hand in hand. To their liaison in S. Africa was attributed in part the countless gastric upsets and the 57,684 reported typhoid cases of the Boer War (Osler). The dust-swept Tibetan plateau was the site of the frequent bowel infections of pre-war Everest expeditions (Hunt). The dust of modern kitchens, too, contains organisms such as Cl. welchii (I) and the ubiquitous Streps. and Staphs: the latter survive well in dry surroundings, remaining viable for nearly six months, but fortunately with loss of virulence (Henton). The hospital ward technique of oiling floors could well be introduced into food establishments in an attempt to restrict contaminated dust. Floor disinfectants may also be used, although "the ever-popular and much-promoted pine fluids are commended only for their smell" (B.M.J.). Although we have progressed from the days when Erasmus visited England and found "the floors of houses covered by mouldy straw, strewn with dirt, bones, and the vomit, urine and droppings of domestic animals" (M), modern floors of rough concrete still encourage dirt and bacteria and discourage cleaners. Many premises today still lag behind the 17C Dutch houses where the (törrubbingxund) kitchens' large windows threw light on tiled floors, and the scrubbing and scouring of the hausfrau became proverbial (M).

Kitchen equipment and utensils themselves must not harbour
bacteria. Kitchen garbage cans, made "of impervious materials" (F&D), should be well-covered, in good repair and regularly sterilized by steam or disinfectants. Dishes and cutlery should be stored when not in use. After use they should be rinsed in hot water, washed in detergent at 120°-140°F, then for 30 seconds in boiling water, and finally allowed to dry on metal - not wooden - draining boards before being re-stored; dishtowels are not encouraged (11).

"it is not the nature of the objective that makes for speedy action. All that matters is that there should be an objective at all" (C.P. Snow). Now that science (not superstition) has delineated the many causes and the epidemiology of food poisoning and the importance of food hygiene, an asepsis reminiscent of surgery seems not excessive. With more awareness of, and widespread practice in, such principles, we may yet eat, drink and be merry, and not die tomorrow.
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