PUBLIC HEALTH PAST AND PRESENT

Dirt, disgust and disease: a natural history of hygiene

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Hygiene has been studied from multiple perspectives, including that of history. I define hygiene as the set of behaviours that animals, including humans, use to avoid infection. I argue that it has an ancient evolutionary history, and that most animals exhibit such behaviours because they were adaptive. In humans, the avoidance of infectious threats is motivated by the emotion of disgust. Intuition about hygiene, dirt and disease can be found underlying belief about health and disease throughout history. Purification ritual, miasma, contagion, zymotic and germ theories of disease are ideas that spread through society because they are intuitively attractive, because they are supported by evidence either from direct experience or from authoritative report and because they are consistent with existing beliefs. In contrast to much historical and anthropological assertion, I argue that hygiene behaviour and disgust predate culture and so cannot fully be explained as its product. The history of ideas about disease thus is neither entirely socially constructed nor an ''heroic progress'' of scientists leading the ignorant into the light. As an animal behaviour the proper domain of hygiene is biology, and without this perspective attempts at explanation are incomplete. The approaches of biological anthropology have much to offer the practice of cultural history.

> In every street the pipes gushed out where decaying rat carcases drank everything in, tails dangling and whiskers bristling with greenish lumps. Bellies in the air, they floated amid apple peels, asparagus stalks and cabbage cores…it was like a vast infection of tooth decay, like the flatulence of a rotting stomach, like the emanations of a man who has drunk too much, like the dried sweat of rotting animals, like the sour poison of a bedpan…this avalanche of excretions tumbling down the length of the purulent streets…let off its nocturnal fragrances.[1] (p 253)

This extract from a satirical article which appeared in *Le Figaro* in 1880 captures something of the disgust the citizens of Paris must have felt for the state of their streets at that time. Barnes, in his new book on the great stinks of Paris, uses this description to illustrate what he claims to be a major historical paradox. How can it be, he asks, that this disgust, ''which was shaped by changing cultural norms and rules through history, can manifest itself in such a gut-level seemingly unconscious way''?[1]

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Historians and anthropologists have long wrestled with the question of why and how certain objects and events come to be classed as dirty and disgusting and what, if anything, is their connection with disease. Some have taken the ''master narrative'' approach in which heroic figures such as Hippocrates, Chadwick, Snow, Pasteur and Koch led an ignorant public from filth into the hygienic light of scientific rationalism.[2 3] Douglas rejected such thinking as ''medical materialism'', proposing instead that the objects and events that societies classed as dirty were those that did not fit the local cosmology, and hence had to be rejected:

> Dirt then, is never a unique, isolated event. Where there is dirt there is a system. Dirt is the by-product of a systematic ordering and classification of matter, in so far as ordering involves rejecting inappropriate elements.[4]

Modern historians of science such as Barnes and Tomes offer a ''revisionist'' view which takes a relativistic approach to the social production of ideas. For example, Tomes proposes that we should see ideas, such as the germ theory of disease, as not as having an ontological life of their own but as social constructions, embedded within local structures of meaning.[5] For them, like Douglas, dirt is a cultural construction.

In this paper I argue that medical historians, whether materialist or revisionist, are missing an important point. There is a link between dirt, disgust, hygiene and disease, but it is a link that predates history, that predates science and culture, that even predates *Homo sapiens*. Disgust has a long evolutionary history; the reason it is part of our psyche is neither primarily cultural nor historical, but biological. Animals that were equipped with behavioural tendencies which led them to avoid the objects and events that were associated with the risk of disease gained an adaptive advantage; hence any genes that favoured hygienic behaviour tended to outperform those that did not. Whilst the specifics of what we find disgusting are, of course, shaped by experience and culture, there is an overall biological pattern to our revulsions. Disgust of dirt is a part of human nature.

To tell this alternative, biological history of dirt, disease and hygiene, I take a long view. I describe the evolutionary origins of disease avoidance behaviour in animals and present evidence as to the role of disgust in the prevention of disease in humans. I then take examples from the historical literature to make a first, necessarily brief, attempt at weaving this fact of our nature back into historical narrative. The approach I take is neither materialist nor revisionist, but epidemiological. If

ideas spread best in susceptible hosts, then being equipped with disgust makes us susceptible to culturally transmitted ideas, such as the value of purity and hygiene and the dangers of dirt, miasma and germs. I conclude that, from this perspective, Barnes' paradox is not a paradox at all. Dirt and disgust are both gut feeling and cultural construction – two related facets of the natural history of hygiene.

FOUR BILLION YEARS OF HYGIENE

The story of hygiene begins, not with *Homo sapiens*, but with the earliest animals. Animals need nutrients in order to survive; they can get those nutrients either by eating plants or other animals.[6] Other animals are tempting targets because they are concentrated sources of nutrition. An animal which eats an animal smaller than itself is a predator. An animal that eats an animal larger than itself is a parasite.[7] Animals pursuing and eating each other lead to evolutionary arms races, where each species attempts to outwit the other with new adaptations.[8]

We have no record of the earliest parasites, but perhaps they were akin to the modern-day phages, which are viral parasites of bacteria and the most common life form on the planet. Phage insert themselves into their bacterial hosts' cellular machinery and use it to reproduce themselves.[9] Bacteria defend themselves with capsules that resist attack and cellular responses for evicting invaders. Indeed, much of the modern bacterial genome concerns defences against phages.[10]

Whilst all animals have physiological defences against parasite invasion, this can hardly be called ''hygiene''. We have reserved the term for behaviours which help to avoid the risk of being invaded by parasites, whether these are microscopic, such as viruses and bacteria, or macroscopic, such as helminths and scabies mites.[11] Hygienic behaviour can thus include grooming to remove ectoparasites, avoiding contact with potentially parasitised others, and avoiding or removing substances or other species in the environment that are likely to harbour pathogenic parasites.[12]

Tracing the early history of hygiene is difficult because behaviours do not fossilise. However, perhaps our earliest common ancestor with the roundworms who lived some 590 million years ago[13] was hygienic. Their extant cousins, the well-studied nematode worms, *Caenorhabditis elegans* demonstrate disease avoidance behaviour. With only 302 neurons, they can detect the presence of pathogenic *Bacillus thuringiensis* in the environment and avoid it.[14] Ants are hygienic: they groom themselves to remove fungal pathogens and dispose of diseased and dead conspecifics.[15 16] Bees remove dead and diseased brood, defecate away from the nest and employ antibacterial compounds to keep nests free of parasites.[17] Caribbean spiny lobsters (*Panulirus argus*) avoid other lobsters with viral infections.[18]

It is likely that all vertebrates exhibit hygiene behaviour. Bullfrog (*Rana catesbeiana*) tadpoles avoid other tadpoles with signs of candidiasis,[19] and whitefish, *Coregonus* sp, have evolved the ability to respond to the presence of *Pseudomonas fluorescens*, a virulent egg parasite, by avoiding it.[20] Bats groom to remove ectoparasites,[21] as do most other mammals, fish and birds. Birds and mammals keep their nests free of faecal material, whilst racoons, badgers, lemurs and tapirs use latrine sites. Sheep avoid grazing near faecal remains, and one reason that reindeer and caribou migrate is to avoid parasites in heavily dunged fields.[22] Some chimpanzees have been seen engaged in penile hygiene after mating[23] and mother chimps have been observed wiping the behinds of their infants after they have defaecated.[24]

Clearly, no one taught these animals microbiology or parasitology. How, then, could such behavioural tendencies have arisen? The long, gradual process of evolution was their teacher – quite simply, the genes of animals that failed to defend themselves effectively against disease were selected out of the gene pool, while those that contributed to good strong hygiene instincts survived and multiplied disproportionately well. Appropriate hygienic behaviour thus became typical to each species in its niche.

Do humans have these hygiene instincts too[i]? After a series of research projects looking into hygiene motivation around the world (India, Africa, Netherlands, UK) we found evidence for this idea.[11] When interviewed about the ''why'' of their hygiene habits, people found it hard to explain their reactions. Faced with faeces, bodily fluids, rotten food and slimy worms most people would say that they couldn't explain, they just felt they were ''Yuk!''. It seemed that there was a powerful feeling of disgust involved, impelling people to avoid filthy, sticky, oozing, teaming matter. We hypothesised that at its core disgust is what humans call the urge to avoid disease-relevant stimuli. We suggested that such behaviours happen largely independent of conscious decision-making, and that the perception of a disgusting cue should almost automatically produce a hygienic reaction.

THAT'S DISGUSTING!

We tested the hypothesis that disgust evolved to motivate humans to avoid disease in a web-based experiment placed on the BBC's website http://www.bbc.co.uk/science/humanbody/mind/surveys/disgust/. The site asked people to score how disgusting they found a series of photos. Within the series we randomly mixed seven sets of pairs of images, made to be similar in appearance, but in each case one of the pictures contained a disease threat, whilst the other did not. Hence, for example, the results for a bowl of bright blue viscous liquid were compared with those for a greeny, red-flecked version, which looked somewhat like bodily fluids. A clean burn was contrasted with an infected wound. An empty train was compared with a full one. Disgust scores for a photo of a healthy-looking person were compared with the scores for an image of the same person manipulated to look spotty and feverish. The study was completed by more than 40 000 participants from 165 countries.

The results were consistent with our hypothesis: all of the images with disease relevance scored significantly higher for disgust than those with none.[26] Disgust sensitivity scores declined with the age of the respondent and were significantly higher overall in females (which may be due to their role in child care). We concluded that disgust is probably common to all humans in all cultures, and that it serves to help us to avoid those things that were associated with risk of disease in our evolutionary past. Disgust is thus the name we give to the motivation to behave hygienically. It is thought that this basic emotion became extended at some point in evolutionary history – other studies have found evidence for a further domain of disgust where immoral acts and associations can occasion revulsion.[11 27 28]

HYGIENE IN HISTORY

If producing hygienic behaviour is a natural function of the human psyche, a psychological predisposition designed by evolution to keep us safe from disease that originates from before we were human, and from before the dawn of culture, then we would expect to find that, unlike his caricature, prehistoric man would have behaved hygienically. He would have groomed himself to remove parasites and kept his living

[i]Note that the definition of the word ''instinct'' is much debated amongst biologists and philosophers of biology (see Mameli[25] for a recent contribution). Here we take it to mean automated behaviours produced by specific cues in the environment that do not require the involvement of higher level processes such as cognition.

areas free of the humid wastes that can harbour them. He would have defaecated away from his shelter and avoided close contact with the bodily fluids of others (except when there were overriding reasons to do so, such as when mating or caring for a child). He would have tended to avoid those of his fellows exhibiting signs of sickness (unless they were related) and dead bodies, and also strangers (because they might carry novel pathogens).

Evidence of early hygiene behaviour among humans is hard to come by. The earliest signs of the interment of the dead date from the middle Palaeolithic era. Neanderthals used seashell tweezers possibly to pluck hair[29] and early cave paintings show beardless men, suggesting that grooming began early, perhaps to remove facial parasites.[30] Hygiene artefacts are amongst the earliest material goods recovered; for example, an ivory comb in the collection of the Metropolitan Museum of New York dates back to predynastic Badarian Egypt of 3200 BCE. Excavations of the earliest city states of the Indus basin dating from 3000 BC found drainage and toilet structures.

Cleansing aids have a long history. Early cavewoman may have discovered she could remove stubborn stains with the washed out residue of animal fat and ash from roasting meat. However, the first recorded use of soap is from Babylonian times, although the use of oil and a scraper, known as a strigil, was a more common way of cleaning the skin in the Greek and Roman eras. Roman plumbing and toilet facilities are well documented.[31]

If early humans kept themselves and their surroundings clean, did they also avoid diseased others, as other vertebrates do? An ancient Mesopotamian text shows how an exorcist explained the sickness of a patient: ''He has come into contact with a woman of unclean hands…or his hands have touched one of unclean body''.[32] A Babylonian letter of the 17th century BC counsels not sharing a chair, a bed or a cup with a lady suffering from a disease.[33] Perhaps the gut feeling of disgust provided the motive to avoid the sick, giving impetus to the search for a rational explanation.

Are these early hygiene behaviours a product of nature or culture? I have argued that hygiene predates culture; however, once humans evolved the cognitive ability to use symbols and language to make representations, then it became possible for ideas about hygiene to begin to accumulate and to begin to influence human behaviour.

AN EPIDEMIOLOGY OF IDEAS

Sperber suggests that the process by which ideas or mental representations spread through society is epidemiological.[34] Some representations spread better than others and hence are more widely distributed, because human cognitions and communicative abilities work better on some ideas than on others. The ideas that tend to be favoured in this way, all other things being equal, are those which make intuitive sense.[35] So, for example, beliefs that nasty, steaming, humid, smelly, excreted stuff is bad for you might spread much more easily than ideas proposing the opposite. Of course, as in epidemiology, not all other things are equal; host susceptibility is not the only factor that determines spread. Other factors include how well a new idea sits with an existing belief system, how well it fits in with what people have already observed and whether the source of the new idea is trusted or authoritative.[34 36 37]

Can we trace this epidemiology of infectious ideas in the early recorded history of hygiene? In the Middle Eastern contagion examples above, the belief that disease could be passed on would have come from observation. However, the idea was believable because of the intuition that the sick were to be avoided. A similar example is provided by purification rituals. In Mesopotamian times Kippuru was a healing ritual of purification through the application and wiping off of a flour paste. It came to mean purification in general, as in the Hebrew word ''Kippur''. The idea that it was good to remove disgusting matter – pollution – made intuitive sense. Powerful priest-healers related their feats of healing based on this principle, which gave authority to the idea, helping it to spread widely.

The intuition that polluting matter should be removed or avoided can be found woven throughout religious and cultural history.[4] The Laws of Manu, part of the four sacred Vedas of Hindu scripture of circa 200 BC, prescribed the avoidance of the 12 impurities of the body, viz:

> Oily exudations, semen, blood, urine, faeces, the mucous of the nose, ear wax, phlegm, tears, the rheum of the eyes and sweat... (135)

The intuition that dirt was bad helped carry filth into the realm of morality. Many biblical passages make this link, for example:

> Wash me clean of my guilt, purify me from my sin (Psalms 51:2)

The Koran agreed:

> God loves those that turn to him in repentance and strive to keep themselves clean (2:223)

The Greek word ''miasma'' grew from similar religious and moral origins into a naturalistic theory of disease. Originally meaning ''stain'' or pollution of sin which offended the gods, it came to be used as a term for the foul airs and atmospheres that were thought to cause disease.[38] Hippocrates (460–377 BC) exhorted that to stay healthy one needed to stay away from the airs, waters and places that contained dangerous vapours or miasmas.[39] The idea hopped from the Greeks via Galen and the monasteries to medieval science:

> …bad, rotten and poisonous vapours from elsewhere: from swamps, lakes and chasms, for instance, and also (which is even more dangerous) from unburied or unburnt corpses – which might well have been a cause of the epidemic...[40]

And thence into the 19th century in the UK:

> Disease caused by…atmospheric impurities produced by decomposing animal and vegetable substances, by damp and filth, and close and overcrowded dwellings.[2]

The belief that miasma caused disease was an extremely infectious idea – one that continued to inhabit the population of Western Europe for over 2000 years. Behind this belief again lay disgust – the intuitive aversion to bad smells from putrid, fetid, damp environments. The intuition hardened into belief through an accumulation of observations – that people did, indeed, often catch fevers in swampy environments.

However, by the mid 19th century in Europe new observations began to accumulate that made it harder to believe that disease was caused by breathing bad air. Agriculturalist Justus van Leibig's experimentation with the decomposition of vegetable matter led him to propose that:

> …disease was due to a spreading internal rot…that came from an external rot…that could be transferred to others.[41]

For a short while the zymotic theory of disease gained acceptance.[41] The new idea was that disease was caused, not by bad air, but through a chemical process involving direct contact. The theory had the characteristics of an infective idea because it was intuitively appealing, as rot was certainly disgusting. It also fitted with the existing idea and experience of rot spreading in vegetables. Reports of putrefaction and sepsis creeping their way through diseased flesh that were provided by the practitioners of the increasingly invasive surgery and dissection of the mid 1800s[42] added weight to the new explanation of how the disgusting caused disease.

There is much debate over the details of how and when the germ theory of disease took hold. A key development was, of course, the microscope. Yet it was more than 300 years after Leewenhoek demonstrated the teeming animalcules in the white matter between his ''usually very clean'' teeth,[3] that belief in germs became an established norm in Western medical discourse. The idea that living organisms were responsible spread in fits and starts through Europe and America[1–3 42 43] over the second half of the 19th century. Germ theory had some, but not all, of the components of an infectious idea. It did make intuitive sense; if disease was being caused by an invasion of the body by living organisms this was exquisitely disgusting, and hence to be avoided at all costs. However, since people could have no direct experience with germs it remained for the scientists to provide convincing evidence. Perhaps it was only the wide publication of pictures of microbes from the labs of Koch, Pettenkoffer, Yersin and their colleagues in the scientific and then the popular press, that germ theory really began to take hold. With the dawn of vaccination and antimicrobials, it became hard to deny the testimony of respected scientists that germs were responsible for at least some types of infectious disease.[3]

Germ theory spread unevenly across much of the world, sometimes to replace and sometimes to live side-by-side or hybridise with local beliefs about the origins of disease. A Chinese text of 1911 on germ theory taught that tuberculosis was caused by ''xijun'', which translates literally as ''tiny fungus'' or ''mould''. TB is still commonly described as being due to ''ji laochong'', or wasting worms.[44] In modern Hindi germs are ''kitanu'', which means ''little insect'', and in Dioula (Burkina Faso) they are ''banakisse'' or seeds of disease. But in Burkina Faso germ theory has not banished other ideas about disease. The intuition that dirt causes disease is, of course, well established. However, diarrhoea in children is also thought to be caused by contamination of the mothers' milk by sperm if sexual relations have been resumed post-partum, and by worms and by feeding the wrong food; however, only ''toubaboukonoboli'' or ''white's diarrhoea'' is thought to be caused by germs.[45]

This epidemiologic spread of Western ideas into other cultures is underpinned by the same intuition – that it could not be good for one to be invaded by disgusting tiny insects, fungus or seeds (germs). Pictorial representations of germs are now much more common, making them ''observable'' (for example as cartoons in advertisements for Lifebuoy soap screened throughout India in recent years). Finally, germ theory gained ground because it was taught by respected others who were known to have real cures for disease, in this case, the powerful colonisers, with their science and their microscopes.

DISCUSSION: DIRT AS A CULTURAL CONSTRUCTION

I have suggested that hygiene and disgust originated well before culture and history; hence it would be wrong to think of disgust as being entirely a cultural construction. It may be just as useful to study how a biological capacity for disgust has influenced cultures as to explore how cultures have influenced what people find disgusting.

In the end, why does it matter whether disgust is innate, a cultural construction or both, as I would argue? In my view the issue is fundamental, firstly for our intellectual traditions, both in history and in the humanities, and secondly, due to its practical and policy implications.

The work of Mary Douglas on the cultural construction of purity and pollution has inspired a school of historical and cultural investigation that insists that cultures are what create dirt, taboo and transgression. Douglas has the local cosmology, or world order, coming first, with dirt as its product. For her dirt is matter out of place, an anomaly that has to be banished because it threatens the order of the system.[4] Cultural commentators on filth such as Cohen[46] and Miller[47] continue in the Douglasian tradition, puzzling over the same paradox as Barnes: how can something as visceral as disgust be produced by history and culture? Yet if the dirty is what disgusts us, then this is surely wrong: dirt arose before culture and history, and therefore cannot just be its product.

Tomes, Barnes and others also follow Douglas in setting up an opposition between a materialist reading of the history of ideas about pollution, hygiene and disease and a revisionist one. For them, contingent local processes of idea assimilation provide a better explanatory framework than the grand progress of science. In this account of the natural history of hygiene I have rather proposed an epidemiological process of the spread of ideas which admits multiple determinants. Innate psychological susceptibility to ideas linking disgust and hygiene provide one determinant. Whilst it may not exactly have been a grand progress, the scientific method of observation and falsification did allow real advances in understanding, which influenced and continues to influence, the content of culture. However, we have also seen contingent local processes of assimilation of new ideas adapting to local cultures. In this sense, ideas about hygiene and disease are, indeed, cultural constructs. Taken together, these three factors provide a useful, and to some extent, testable set of hypotheses about the advance of ideas.

It may be argued that this is an overly simplistic rendition of the history of a complex set of ideas about dirt, disgust, disease and hygiene. In this short piece I have proposed a small set of key determinants of historical processes, when of course there are many other factors. Geography, genetics, demography, environment and technology are amongst many further determinants of the patterns of ideas we are seeking to explain.[48] Yet every scientific endeavour requires making hypotheses and mechanisms explicit, which requires simplification.[49]

If we accept a role for innate psychology in the content of our culture, then there are important practical implications as well as intellectual ones. If disgust arose to help us deal with ancestral disease threats, then it may not be a good guide to the best way to avoid disease in our modern environments. When evolutionarily novel infections such as HIV/AIDS arise, our evolved responses to avoid the infection may mislead. For example, quarantine and the avoidance of physical contact were intuitive but not useful responses to a sexually transmitted disease with a long latency period. Those who care for others find dealing with bodily fluids difficult and disgusting and find little support, since the topic is still taboo. Recognising that such reactions are a part of our nature could help towards appreciating the emotional labour involved – and be an important step towards more humane caring and caring for carers. Politicians have a sorry history of making capital by exploiting a tendency to xenophobia – disgust of the outsider.[47] Regular epidemics of panic about contamination in food also

What this paper adds

- I propose that disgust of the dirty predates history and hence cannot be its product
- I suggest that patterns in the history of ideas can be understood using the methods of epidemiology.
- Host susceptibility to intuitive ideas, such as the undesirability of the disgusting, is an important component in the history of ideas about the causation of disease.

Policy implications

- Disgust tends to guide theorising in public health but can mislead, for example, quarantine is not a good response to HIV/AIDS.
- Dealing with disgust is a part of the emotional labour involved in the caring professions and should be recognised as such.
- Scientists and policy makers need to be aware that ancient psychological tendencies that were appropriate for early society are not always a good guide to decision-making in today's environments.

owe more to an innate disgust of contamination than any rational science of relative risk. Scientists need to understand how such ancient psychological factors influence the historical progress of science, and can impact on their own beliefs.

In the end I am arguing for two things, for a return of human nature to a legitimate place in the humanities,[50] and for history to embrace biology and its methods, including those of biological anthropology and epidemiology, and hence take its natural place as one of the life sciences.[51 52]

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