

Microorganisms: normal flora



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The concept of infection in the host- parasite relationship is expressed in the body's normal flora. Normal flora is a population of micro-organisms that infect the body without causing disease. Some organisms establish a permanent relationship, as *E. coli* is always found in large intestines of humans; others like streptococci are transient. Symbiotic associations between body and its normal flora exist at different levels. These may be in the form of mutualism or commensalisms. *Lactobacillus* in human vagina is examples of mutualism. They derive nutrition from vaginal environment and the acid produced by them prevents the overgrowth of other microbes. *E. coli* exists as a commensal, though may also sometimes exist in mutualistic association.

Normal flora exists on skin oral cavity, upper respiratory tract, latter part of small intestine and the large intestine. In intestines there are *Bacteroides*, *Clostridium* (spores), Streptococci, Gram positive rods including *Enterobacter*, *Klebsiella*, *Proteus* and *Pseudomonas*, *E. coli* , *Candida albicans*. Normal flora undergoes changes in response to internal environment of the body.

Typically, when one says “ I have an infection” they mean to say “ I have a disease”, however the latter is not quite so socially acceptable. In fact, we are all “ infected” with a variety of microorganisms throughout our entire lives. Incredibly, our bodies are actually composed of more bacterial cells than human cells; while the human body is made up of about 10^{13} human cells, we harbor near 10^{14} bacteria. This group of organisms, traditionally referred to as “ normal flora” (although they are not plants) is composed of a fairly stable set of genera, mostly anaerobes. While each person has a

relatively unique set of normal flora, members of the Streptococcus and Bacteroides make up a large percentage of the inhabitants. These organisms contribute to our existence in several ways. These normal flora may:

- i. Help us by competing with pathogens such as Salmonella
- ii. Help us by providing vitamins or eliminating toxins (e. g. Bacteroides)
- iii. Harm us by promoting disease (e. g. dental caries)
- iv. Cause neither help nor harm (e. g. “ commensals”).

One of the most important functions of our normal flora is to protect us from highly pathogenic organisms. For example, in a normal (bacterially inhabited animal), about 10^6 Salmonella must be ingested in order to cause disease. However, when an animal has been maintained in a sterile environment all of its life (a “ gnotobiotic” animal), the same level of disease can be produced by as few as 10 Salmonella. This dramatic difference is simply due to competition (wikiAnswers. com).

To a microorganism, the human body seems very much like the planet Earth seems to us. Just like our planet, our bodies contain numerous different environments, ranging from dry deserts (e. g. the forearm) to tropical forests (e. g. the perineum) to extremely hostile regions (e. g. the intestinal tract). Each environment possesses certain advantages and disadvantages and different microorganisms have adapted to certain regions of the body for their particular needs.

In developed countries, computers are used in the bedside area for multiple functions, including ordering, checking laboratory and image results, recording patients' conditions,

and accounting. Moreover, most computer devices, such as keyboards and mice, in many countries are not water-proof and not specially designed for hospital disinfection needs. Therefore, there is a good possibility that computer interface surfaces may serve as reservoirs for nosocomial pathogens. Besides, the rate of hand washing compliance in healthcare institutions is low (~40%), which is presumably related to the contamination of inanimate surfaces of medical equipments and hospital environment with nosocomial pathogens (Boyce JM, Pittet 2002). Studies have shown that the hands or gloves of healthcare workers (HCWs) can be contaminated after touching inanimate objects in patient rooms or after touching environmental surfaces near patients (Bhalla A et al., 2004 ; Hartstein AI et al., 1988). One study reported that microbial contamination of computer interface surfaces was so prevalent that various microorganisms were isolated from more than 50% of the keyboards of hospital computers (Rutala WA et al., 2006).

The levels of contamination varied with the proximity to the patients, the texture of inanimate surfaces and the frequency of contact. The hospital ward computer is found being less likely to be contaminated than bedside computers (Neely AN et al., 2005). Schultz et al. have reported that 95% of keyboards in close proximity to patient sites had bacterial contamination. However, only 5% of these were pathogens known to be associated with nosocomial transmission (Schultz M et al., 2003). Most previous studies have reported the contamination of computer interface surfaces by potential

pathogens such as Methicillin-resistant *Staphylococcus aureus* (MRSA) (Boyce JM et al., 1997; Bures S et al., 2000) and *Acinetobacter baumannii* (Neely AN et al., 1999), but few have studied the relationship between contamination of the ward computers and clinical isolates in hospitals with improved hand hygiene compliance and during a non-outbreak period. Clinically, *A. baumannii*, *P. aeruginosa*, and MRSA cause the most common nosocomial infections and their presence correlates with environmental surface contamination (Engelhart S et al., 2002; Sekiguchi J et al., 2007). We conducted a hospital-based surveillance study of these three important pathogens on computer interface surfaces in different ward settings and then examined the relationship of contaminated computer interface surfaces with the presence of clinical isolates in these wards during a non outbreak period.

Skin provides good examples of various microenvironments. Skin regions have been compared to geographic regions of Earth: the desert of the forearm, the cool woods of the scalp, and the tropical forest of the armpit. The composition of the dermal micro flora varies from site to site according to the character of the microenvironment. A different bacterial flora characterizes each of three regions of skin: (1) axilla, perineum, and toe webs; (2) hand, face and trunk; and (3) upper arms and legs. Skin sites with partial occlusion (axilla, perineum, and toe webs) harbor more microorganisms than do less occluded areas (legs, arms, and trunk). These quantitative differences may relate to increased amount of moisture, higher body temperature, and greater concentrations of skin surface lipids. The

axilla, perineum, and toe webs are more frequently colonized by Gram-negative bacilli than are drier areas of the skin.

The number of bacteria on an individual's skin remains relatively constant; bacterial survival and the extent of colonization probably depend partly on the exposure of skin to a particular environment and partly on the innate and species-specific bactericidal activity in skin. Also, a high degree of specificity is involved in the adherence of bacteria to epithelial surfaces. Not all bacteria attach to skin; staphylococci, which are the major element of the nasal flora, possess a distinct advantage over viridans streptococci in colonizing the nasal mucosa. Conversely, viridans streptococci are not seen in large numbers on the skin or in the nose but dominate the oral flora.

The microbiology literature is inconsistent about the density of bacteria on the skin; one reason for this is the variety of methods used to collect skin bacteria. The scrub method yields the highest and most accurate counts for a given skin area. Most microorganisms live in the superficial layers of the stratum corneum and in the upper parts of the hair follicles. Some bacteria, however, reside in the deeper areas of the hair follicles and are beyond the reach of ordinary disinfection procedures. These bacteria are a reservoir for recolonization after the surface bacteria are removed.

Staphylococcus epidermidis

S. epidermidis is a major inhabitant of the skin, and in some areas it makes up more than 90 percent of the resident aerobic flora.

Staphylococcus aureus

The nose and perineum are the most common sites for *S. aureus* colonization, which is present in 10 percent to more than 40 percent of normal adults. *S. aureus* is prevalent (67 percent) on vulvar skin. Its occurrence in the nasal passages varies with age, being greater in the newborn, less in adults. *S. aureus* is extremely common (80 to 100 percent) on the skin of patients with certain dermatologic diseases such as atopic dermatitis, but the reason for this finding is unclear.

Micrococci

Micrococci are not as common as staphylococci and diphtheroids; however, they are frequently present on normal skin. *Micrococcus luteus*, the predominant species, usually accounts for 20 to 80 percent of the micrococci isolated from the skin.

Diphtheroids (Coryneforms)

The term diphtheroid denotes a wide range of bacteria belonging to the genus *Corynebacterium*. Classification of diphtheroids remains unsatisfactory; for convenience, cutaneous diphtheroids have been categorized into the following four groups: lipophilic or nonlipophilic diphtheroids; anaerobic diphtheroids; diphtheroids producing porphyrins (coral red fluorescence when viewed under ultraviolet light); and those that possess some keratinolytic enzymes and are associated with trichomycosis axillaris (infection of axillary hair). Lipophilic diphtheroids are extremely common in the axilla, whereas nonlipophilic strains are found more commonly on glabrous skin.

Anaerobic diphtheroids are most common in areas rich in sebaceous glands. Although the name *Corynebacterium acnes* was originally used to describe skin anaerobic diphtheroids, these are now classified as *Propionibacterium acnes* and as *P. granulosum*. *P. acnes* are seen eight times more frequently than *P. granulosum* in acne lesions and are probably involved in acne pathogenesis. Children younger than 10 years are rarely colonized with *P. acnes*. The appearance of this organism on the skin is probably related to the onset of secretion of sebum (a semi-fluid substance composed of fatty acids and epithelial debris secreted from sebaceous glands) at puberty. *P. avidum*, the third species of cutaneous anaerobic diphtheroids, is rare in acne lesions and is more often isolated from the axilla.

Streptococci

Streptococci, especially β -hemolytic streptococci, are rarely seen on normal skin. The paucity of β -hemolytic streptococci on the skin is attributed at least in part to the presence of lipids on the skin, as these lipids are lethal to streptococci. Other groups of streptococci, such as α -hemolytic streptococci, exist primarily in the mouth, from where they may, in rare instances, spread to the skin.

Gram-Negative Bacilli

Gram-negative bacteria make up a small proportion of the skin flora. In view of their extraordinary numbers in the gut and in the natural environment, their scarcity on skin is striking. They are seen in moist intertriginous areas, such as the toe webs and axilla, and not on dry skin. Desiccation is the major factor preventing the multiplication of Gram-negative bacteria on intact skin.

Enterobacter, Klebsiella, Escherichia coli, and Proteus species are predominant Gram-negative organisms found on the skin. Acinetobacter spp also occurs on the skin of normal individuals and, like other Gram-negative bacteria, is more common in the moist intertriginous areas.

Nail Flora

The microbiology of a normal nail is generally similar to that of the skin. Dust particles and other extraneous materials may get trapped under the nail, depending on what the nail contacts. In addition to resident skin flora, these dust particles may carry fungi and bacilli. Aspergillus, Penicillium, Cladosporium, and Mucor are the major types of fungi found under the nails.

Oral and Upper Respiratory Tract Flora

The oral flora is involved in dental caries and periodontal disease, which affect about 80 percent of the population in the Western world. Anaerobes in the oral flora are responsible for many of the brain, face, and lung infections that are frequently manifested by abscess formation.

The pharynx and trachea contain primarily those bacterial genera found in the normal oral cavity (for example, α - and β -hemolytic streptococci); however, anaerobes, staphylococci, neisseriae, diphtheroids, and others are also present. Potentially pathogenic organisms such as Haemophilus, mycoplasmas, and pneumococci may also be found in the pharynx. Anaerobic organisms also are reported frequently. The upper respiratory tract is so often the site of initial colonization by pathogens (Neisseria meningitidis, C. diphtheriae, Bordetella pertussis, and many others) and

could be considered the first region of attack for such organisms. In contrast, the lower respiratory tract (small bronchi and alveoli) is usually sterile, because particles the size of bacteria do not readily reach it. If bacteria do reach these regions, they encounter host defense mechanisms, such as alveolar macrophages, that are not present in the pharynx.

(A) Scanning electron micrograph of a cross-section of rat colonic mucosa. The bar indicates the thick layer of bacteria between the mucosal surface and the lumen (L) (X 262,) (B) Higher magnification of the area indicated by the arrow in Fig. A, showing a mass of bacteria (B) immediately adjacent to colonized intestinal tissue (T), (X2, 624.) (Figure from Davis CP: Preservation of bacteria and their microenvironmental association in the rat by freezing. Appl Environ Microbiol 31: 310, 1976, with permission.)

More information is available on the animal than the human micro flora. Research on animals has revealed that unusual filamentous microorganisms attach to ileal epithelial cells and modify host membranes with few or no harmful effects. Microorganisms have been observed in thick layers on gastrointestinal surfaces and in the crypts of Lieberkuhn. Other studies indicate that the immune response can be modulated by the intestinal flora. Studies role of the intestinal flora in biosynthesis of vitamin K and other host-utilizable products, conversion of bile acids (perhaps to cocarcinogens), and ammonia production (which can play a role in hepatic coma) show the dual role of the microbial flora in influencing the health of the host. More basic studies of the human bowel flora are necessary to define their effect on humans (Samuel 1996). Browse on Medical Microbiology

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Depiction of the human body and bacteria that predominate

The skin flora are the microorganisms which reside on the skin. Most research has been upon those that reside upon the 2 square meters of human skin. Many of them are bacteria of which there are around 1000 species upon human skin from 19 phyla (Grice et al., 2009; Pappas, 2009). The total number of bacteria on an average human has been estimated at 10¹² (Todar) . Most are found in the superficial layers of the epidermis and the upper parts of hair follicles.

Skin flora are usually non-pathogenic, and either commensals (are not harmful to their host) or mutualistic (offer a benefit). The benefits bacteria can offer include preventing transient pathogenic organisms from colonizing the skin surface, either by competing for nutrients, secreting chemicals against them, or stimulating the skin's immune system (Cogen et al., 2008). However, resident microbes can cause skin diseases and enter the blood system creating life threatening diseases particularly in immunosuppressed people (Cogen et al., 2008). Hygiene to control such flora is important in preventing the transmission of antibiotic resistant hospital-acquired infections.

A major nonhuman skin flora is *Batrachochytrium dendrobatidis*, a chytrid and non-hyphal zoosporic fungus that causes chytridiomycosis, infectious disease thought to be responsible for the decline in amphibian populations.

Ecology of the 20 sites on the skin studied in the Human Microbiome Project:

There are three main ecological areas: moist, dry and sebaceous.

Propionibacteria and Staphylococci species were the main species in sebaceous areas. In moist places on the body Corynebacteria together with Staphylococci dominate. In dry areas, there is a mixture of species but b-Proteobacteria and Flavobacteriales are dominant. Ecologically, sebaceous areas had greater species richness than moist and dry one. The areas with least similarity between people in species were the spaces between fingers, the spaces between toes, axillae, and umbilical cord stump. Most similarly were beside the nostril, nares (inside the nostril), and on the back (Grice et al., 2009).

Pseudomonas aeruginosa is an example of a mutualistic bacteria that can turn into a pathogen and cause disease: if gains entry into the blood system it can result in infections in bone, joint, gastrointestinal, and respiratory systems. It can also cause dermatitis. However, *Pseudomonas aeruginosa* produces antimicrobial substances such as pseudomonic acid that are exploited commercially such as Mupirocin. This works against staphylococcal and streptococcal infections. *Pseudomonas aeruginosa* also produces substances that inhibit the growth of fungus species such as *Candida krusei*, *Candida albicans*, *Torulopsis glabrata*, *Saccharomyces cerevisiae* and *Aspergillus fumigatus* (Kerr, 1994). It can also inhibit the growth of *Helicobacter pylori* (Krausse et al., 2005). So important is its antimicrobial actions that it has been noted that “ removing *P. aeruginosa* from the skin, through use of oral or topical antibiotics, may inversely allow for aberrant yeast colonization and infection” (Cogen et al., 2008). Another aspect of bacteria is the generation of body odor. Sweat is odorless but

Propionibacteria in adolescent adult sebaceous glands can turn its amino acids into propionic acid. Staphylococcus epidermidis create the other source of body odor: isovaleric acid (3-methyl butanoic acid) (Ara et al., 2006). In addition to these, people with strong foot odor this is due to Bacillus subtilis (Ara et al., 2006).