TABLE 145e-1 EXAMPLES OF MICROBIAL LIGAND-RECEPTOR INTERACTIONS

Microorganism	Type of Microbial Ligand	Host Receptor
Viral Pathogens		
Influenza virus	Hemagglutinin	Sialic acid
Measles virus		
Vaccine strain	Hemagglutinin	CD46/moesin
Wild-type strains	Hemagglutinin	Signaling lymphocytic activation molecule (SLAM)
Human herpesvirus type 6	?	CD46
Herpes simplex virus	Glycoprotein C	Heparan sulfate
HIV	Surface glycoprotein	CD4 and chemokine receptors (CCR5 and CXCR4)
Epstein-Barr virus	Envelope protein	CD21 (CR2)
Adenovirus	Fiber protein	Coxsackie-adenovirus receptor (CAR)
Coxsackievirus	Viral coat proteins	CAR and major histocompatibility class I antigens
Bacterial Pathogens		
Neisseria spp.	Pili	Membrane cofactor protein (CD46)
Pseudomonas aeruginosa	Pili and flagella	Asialo-GM1
	Lipopolysaccharide	Cystic fibrosis transmembrane conductance regulator (CFTR)
Escherichia coli	Pili	Ceramides/mannose and digalactosyl residues
Streptococcus pyogenes	Hyaluronic acid capsule	CD44
Yersinia spp.	Invasin/accessory invasin locus	β_1 Integrins
Bordetella pertussis	Filamentous hemagglutinin	CR3
Legionella pneumophila	Adsorbed C3bi	CR3
Mycobacterium tuberculosis	Adsorbed C3bi	CR3; DC-SIGN[a]
Fungal Pathogens		
Blastomyces dermatitidis	WI-1	Possibly matrix proteins and integrins
Candida albicans	Int1p	Extracellular matrix proteins
Protozoal Pathogens		
Plasmodium vivax	Merozoite form	Duffy Fy antigen
Plasmodium falciparum	Erythrocyte-binding protein 175 (EBA-175)	Glycophorin A
Entamoeba histolytica	Surface lectin	*N*-Acetylglucosamine

[a]A novel dendritic cell–specific C-type lectin.

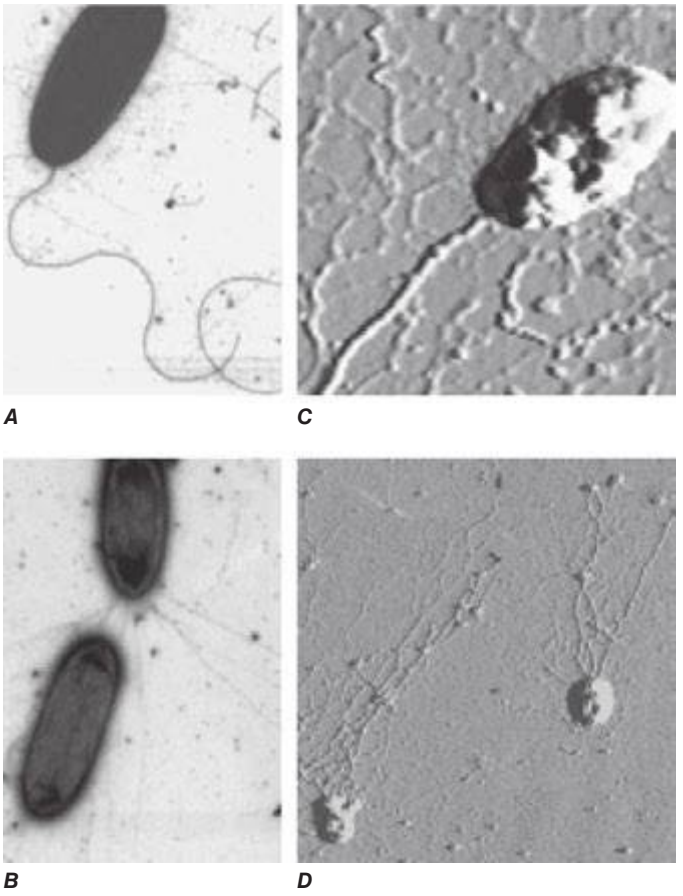

FIGURE 145e-1 Bacterial surface structures. ***A*** and ***B.*** Traditional electron micrographic images of fixed cells of *Pseudomonas aeruginosa*. Flagella (***A***) and pili (***B***) project out from the bacterial poles. ***C*** and ***D***. Atomic force microscopic image of live *P. aeruginosa* freshly planted onto a smooth mica surface. This technology reveals the fine, three-dimensional detail of the bacterial surface structures. *(Images courtesy of Drs. Martin Lee and Milan Bajmoczi, Harvard Medical School.)*

surface receptors for entry, including the herpesvirus entry mediator (related to the tumor necrosis factor receptor), members of the immunoglobulin superfamily, the proteins nectin-1 and nectin-2, and modified heparan sulfate.

BACTERIAL ADHESINS Among the microbial adhesins studied in greatest detail are bacterial pili and flagella (Fig. 145e-1). *Pili* or *fimbriae* are commonly used by gram-negative bacteria for attachment to host cells and tissues; studies have identified similar factors produced by gram-positive organisms such as group B streptococci. In electron micrographs, these hairlike projections (up to several hundred per cell) may be confined to one end of the organism (polar pili) or distributed more evenly over the surface. An individual cell may have pili with a variety of functions. Most pili are made up of a major pilin protein subunit (molecular weight, 17,000–30,000) that polymerizes to form the pilus. Many strains of *Escherichia coli* isolated from urinary tract infections express mannose-binding type 1 pili, whose binding to integral membrane glycoproteins called *uroplakins* that coat the cells in the bladder epithelium is inhibited by D-mannose. Other strains produce the Pap (pyelonephritis-associated) or P pilus adhesin that mediates binding to digalactose (gal-gal) residues on globosides of the human P blood groups. Both of these types of pili have proteins located at the tips of the main pilus unit that are critical to the binding specificity of the whole pilus unit. Although immunization with the mannose-binding tip protein (FimH) of type 1 pili prevents experimental *E. coli* bladder infections in mice and monkeys, a human trial of this vaccine was not successful. *E. coli* cells causing diarrheal disease express pilus-like receptors for enterocytes on the small bowel, along with other receptors termed *colonization factors*.

The type IV pilus, a common type of pilus found in *Neisseria* species, *Moraxella* species, *Vibrio cholerae*, *Legionella pneumophila*, *Salmonella enterica* serovar Typhi, enteropathogenic *E. coli*, and *Pseudomonas aeruginosa*, often mediates adherence of organisms to target surfaces. Type IV pili tend to have a relatively conserved aminoterminal region and a more variable carboxyl-terminal region. For some species (e.g., *N. gonorrhoeae*, *Neisseria meningitidis*, and enteropathogenic *E. coli*), the pili are critical for attachment to mucosal epithelial cells. For others, such as *P. aeruginosa*, the pili only partially mediate the cells' adherence to host tissues and may in some circumstances inhibit colonization. For example, a recent study of *P. aeruginosa* colonization of the gastrointestinal tract of mice evaluated a bank of mutants in which all nonessential genes were interrupted; those mutants that were