Characteristics of Pathogenic *Neisseria* spp. Isolated from Homosexual Men

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Oropharyngeal, urethral, and rectal cultures for pathogenic *Neisseria* spp. were collected from 815 homosexual men attending a community clinic in Chicago. Meningococci were characterized by serogrouping and antimicrobial susceptibility testing. Gonococci were auxotyped, and susceptibilities to penicillin and tetracycline were determined. Of the 815 men tested, 42.5% carried meningococci in the oropharynx. Gonococci were recovered from the urethra, rectum, and oropharynx of 18.5, 16.3, and 5.6%, respectively. Meningococci were also recovered from the urethra (6 patients) and the rectum (15 patients). Some of these isolates were identical to the isolates from the oropharynxes of the same patients, whereas others were distinct from the oropharyngeal isolates by serogroup or antimicrobial susceptibilities. Serogroups B, W135, and C comprised over 90% of the meningococci. Almost 80% of the gonococcal strains required minimal inhibitory concentrations greater than 0.06 µg of penicillin per ml, whereas greater than 90% of the meningococci were inhibited at this concentration. Auxotyping demonstrated three major auxotypes: Zero (required none of the nutrients tested), 60%; arginine requiring, 19.4%; and proline requiring, 12.3%. Only four strains (1.2%) required arginine, hypoxanthine, and uracil.

In recent years, it has become clear that homosexual men are at increased risk for both common and uncommon sexually transmitted diseases. Numerous studies have revealed not only the expected high incidences of gonorrhea and syphilis in this population, but also the acquisition of various enterobacterial, parasitic, and viral infections by sexual contact (7, 8, 10, 22). Recent reports have indicated that both *Neisseria gonorrhoeae* and *N. meningitidis* can be isolated from the oropharynx, urethra, and rectum of homosexual men (7, 8, 13, 14, 22, 26). We have described the clinical and epidemiological features of pathogenic *Neisseria* spp. in homosexual men attending a community clinic (13). This study has yielded a collection of almost 700 isolates of gonococci and meningococci from oropharyngeal and anogenital sites. The present report concerns the characterization of these isolates, including comparative antimicrobial susceptibilities, meningococcal serogroups, and gonococcal auxotypes. In addition, data on patients from whom extrapharyn-

geal meningococci were obtained are presented.

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MATERIALS AND METHODS

As previously described (13), specimens for the isolation of pathogenic *Neisseria* spp. were collected from oropharyngeal, urethral, and rectal sites of 815 homosexual men attending the Howard Brown Memorial Clinic in Chicago during the year from July 1978 through June 1979. This clinic is a community-operated facility for the diagnosis and treatment of sexually transmitted diseases and serves a predominantly homosexual male clientele. Gonococci and meningococci were isolated and identified by standard methods as described previously (13). All *N. gonorrhoeae* isolates were auxotyped on a modified Catlin medium (20). Minimal inhibitory concentrations (MICs) of penicillin G and tetracycline were determined by the agar dilution method on Trypticase soy agar (BBL Microbiology Systems, Cockeysville, Md.) containing 7.5% de-complemented horse serum (20). Inocula of approximately 10⁶ organisms were delivered to the plates with a Steers replicator. Results were determined after 24 h of growth in 5 to 7% CO₂ at 35°C.

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FIG. 1. Distribution of MICs of penicillin G against *N. gonorrhoeae* and *N. meningitidis* isolates from homosexual men. *N. gonorrhoeae* isolates numbered 325 (40 oropharyngeal, 151 urethral, and 134 rectal isolates); *N. meningitidis* isolates numbered 369 (347 oropharyngeal, 6 urethral, and 16 rectal isolates).

Gonococci were also tested for beta-lactamase production with a chromogenic cephalosporin 87/312 (Glaxo Laboratories, Greenford, Middlesex, England) (8). *N. meningitidis* isolates were subcultured onto freshly prepared Trypticase soy agar with 10% decomplexed horse serum and then were incubated for 6 to 18 h at 35°C in 5 to 7% CO₂. Organisms were serogrouped by the slide agglutination technique, using purified, serogroup-specific meningococcal antisera to groups A, B, C, X, Y, Z, W135, and 29E, kindly provided by N. Vedros (*Neisseria* Repository, Berkeley, Calif.). MICs of penicillin G, tetracycline, sulfisoxazole, and rifampin were determined for all meningococci as described above. Penicillin G, tetracycline, and rifampin were obtained from the Ames Division of Miles Laboratories, Elkhart, Ind. Sulfisoxazole was kindly provided by Hoffmann-La Roche Inc., Nutley, N.J. Each gonococcal and meningococcal isolate from different sites of individual patients was counted separately, even when isolates were the same by auxotype, serogroup, or antimicrobial susceptibility. Analysis of the data with similar isolates from the same patient being counted only once did not alter the auxotype or susceptibility distributions shown in the figures.

RESULTS

As we previously reported (13), *N. meningitidis* was isolated from the oropharynxes of 42.5% of the 815 homosexual men tested. *N. gonorrhoeae* was isolated from the oropharynx, urethra, and rectum of 5.6, 18.5, and 16.3% of the patients tested, respectively (13). Meningococci accounted for 89% of the oropharyngeal isolates. Of the pathogenic *Neisseria* spp. isolated from extrapharyngeal sites, 6 (3.8%) of the 157 urethral isolates and 16 (10.7%) of the 150 rectal isolates were *N. meningitidis*. The remainder of the isolates from each site were *N. gonorrhoeae*.

Since penicillin G and tetracycline are the two major drugs of choice for treatment of uncomplicated gonococcal infection, MICs of these two antimicrobial agents were determined for all *Neisseria* isolates. Gonococci and meningococci differed markedly in their susceptibility to penicillin G (Fig. 1). Approximately 82% of the meningococci were inhibited by 0.052 µg of penicillin per ml, whereas only 25% of the gonococcal isolates were inhibited at this concentration ($P < 0.001$). The majority of gonococci had penicillin MICs of at least 0.12 µg/ml. When gonococcal penicillin susceptibilities were examined by the site of isolation, oropharyngeal isolates tended to be more resistant to penicillin; 70.2% of the 40 oropharyngeal isolates grew at 0.12 µg/ml, compared with 56.3% of the 151 urethral isolates and 60.3% of the 134 rectal isolates (data not shown). These trends, however, were not significant. None of the gonococcal isolates produced beta-lactamase enzymes. The distribution of susceptibilities to tetracycline was similar for the two species (Fig. 2). Ninety percent of the meningococci and 91% of the gonococci were inhibited by 2.0 µg of tetracycline per ml. Two isolates of *N. meningitidis* (one a serogroup C, the other a serogroup W135) required the highest tetracycline MICs (greater than or equal to 16 µg/ml).

All *N. gonorrhoeae* isolates were characterized further by auxotyping (Table 1). Ninety-two percent of the 325 isolates belonged to one of three major auxotypes: 60% did not require any of the compounds tested (Zero auxotype), 19.4% required proline only (Pro auxotype), and 12.3% required arginine, with this particular require-

FIG. 2. Distribution of MICs of tetracycline against *N. gonorrhoeae* and *N. meningitidis* isolates from homosexual men. *N. gonorrhoeae* isolates numbered 325 (40 oropharyngeal, 151 urethral, and 134 rectal isolates); *N. meningitidis* isolates numbered 369 (347 oropharyngeal, 6 urethral, and 16 rectal isolates).

TABLE 1. Auxotypes of *N. gonorrhoeae* isolates from homosexual men^a

Auxotype	No. of isolates	% of total
Zero	195	60.0
Pro	63	19.4
Arg(Orn ⁺)	40	12.3
Arg(Orn ⁺)-Pro	11	3.4
Pro-Hypx	10	3.1
Met	2	0.6
Arg-Hypx-Ura (AHU)	4	1.2

^a Auxotyping was performed by the method of Morello et al. (20). Isolates were tested for their requirements for arginine (Arg), proline (Pro), methionine (Met), histidine (His), leucine (Leu), lysine (Lys), valine (Val), hypoxanthine (Hypx), uracil (Ura), and thiamine pyrophosphate (TPP). (Orn⁺) denotes that ornithine could fulfill the arginine requirement. Zero indicates the lack of a requirement for any of the compounds tested.

ment also filled by ornithine [Arg(Orn⁺)auxotype]. Only four isolates (1.2%) required arginine, hypoxanthine, and uracil (AHU auxotype). These four isolates were obtained from three patients: one patient had symptomatic urethral infection, the second had asymptomatic rectal infection, and the third had symptomatic urethral and asymptomatic rectal infection. All AHU isolates were inhibited by 0.021 µg of penicillin per ml, the lowest concentration tested. The distribution of gonococcal auxotypes was similar for urethral and rectal sites (Table 2). However, among the oropharyngeal isolates, there was a smaller percentage of Pro auxotype strains and a greater proportion of Arg(Orn⁺) auxotype strains. Examination of the penicillin susceptibilities of the three major auxotypes (Fig. 3) revealed some differences. Whereas the majority of Zero and Arg(Orn⁺) auxotype strains tended to be more resistant to penicillin, the Pro auxotype organisms showed a distinct bimodal distribution of penicillin MICs; 42% of the Pro auxotype isolates had MICs in the 0.030 to 0.052 µg/ml range, and 32% had MICs in the 0.21 to 0.36 µg/ml range. The observed differences in penicillin susceptibilities among the three auxotypes were statistically significant ($P < 0.01$).

TABLE 2. Distribution of gonococcal auxotypes by site of isolation

Auxotype	No. of isolates (%) at site of isolation		
	Oropharynx	Urethra	Rectum
Zero	26 (65.0)	93 (61.5)	76 (56.7)
Pro	3 (7.5)	30 (19.9)	30 (22.4)
Arg(Orn ⁺)	9 (22.5)	19 (12.6)	12 (9.0)
Others	2 (5.0)	9 (6.0)	16 (11.9)

FIG. 3. Distribution of penicillin G susceptibilities for the three major auxotypes among isolates of *N. gonorrhoeae* from homosexual men. Data on 298 isolates (92% of the 325 isolates recovered) are depicted.

All strains of oropharyngeal meningococci isolated from these patients were characterized by serogrouping (Table 3). Serogroup B strains comprised almost three-fourths of the oropharyngeal isolates, followed in frequency by serogroups W135, C, and 29E. Only four isolates were consistently nongroupable because they autoagglutinated in saline.

Since sulfonamides and rifampin have been recommended for the prophylaxis of close contacts to meningococcal disease (4, 5), all oropharyngeal isolates of *N. meningitidis* were tested for susceptibility to these agents (Fig. 4). Of the 347 oropharyngeal meningococci isolated, 90% were inhibited by 5 µg or less of sulfisoxazole per ml. Thirteen isolates (3.8%) required MICs of sulfisoxazole in the 50 to 100 µg/ml range. Eight of these more resistant isolates belonged to serogroup C, which has been associated his-

TABLE 3. Serogroup distribution of oropharyngeal isolates of *N. meningitidis* from homosexual men

Serogroup	No. of isolates	% of total
B	252	72.7
C	21	6.0
X	4	1.2
Y	6	1.7
Z	1	0.3
W135	42	12.1
29E	17	4.8
Naa ^a	4	1.2

^a Nongroupable (i.e., autoagglutinable in saline).

FIG. 4. Distribution of MICs of sulfisoxazole and rifampin for isolates of *N. meningitidis* from the oropharynges of homosexual men. Data on the 347 oropharyngeal isolates are shown.

torically with greater sulfonamide resistance than other serogroups (5). The majority of the organisms tested were exquisitely susceptible to rifampin, with almost 50% inhibited by 0.03 μ g/ml or less. Only five isolates required MICs of rifampin of 1.0 μ g/ml or more; three of these were serogroup B, one was a serogroup Y, and one was a serogroup W135.

Table 4 summarizes the characteristics of the 22 meningococcal isolates from extrapharyngeal sites in 21 patients. Fifteen patients (no. 1 to 15) had meningococci isolated from the rectum; nine of these (no. 1 to 9) also had *N. meningitidis* isolated from the oropharynx. Among these nine patients, the meningococcal isolates recovered from the two sites were probably the same in four (no. 1 to 4) and different in the other five (no. 5 to 9), as determined by serological grouping or antimicrobial susceptibility testing or both. Similarly, five patients (no. 16 to 20) had *N. meningitidis* isolated from urethral as well as oropharyngeal cultures. In three of these patients, the organisms were probably identical (no. 16 to 18). In two (no. 16 and 17), gram-negative diplococci were present in smears of the urethral discharge, and one (no. 16) also had concurrent urethral gonorrhea. One patient (no.

21) had the same meningococcal strain (serogroup W135) isolated from all three sites; he also had symptomatic urethral gonorrhea. Isolation of meningococci from either urethral or rectal sites was not uniformly associated with urethral or rectal symptoms or with positive Gram-stained smears of urethral exudates.

DISCUSSION

Previous reports (7, 8, 12-14, 26) have indicated that both *N. meningitidis* and *N. gonorrhoeae* are isolated frequently from homosexual men. Oropharyngeal cultures for pathogenic *Neisseria* spp. collected from 815 homosexual men over a 10-month period yielded *N. meningitidis* from 42.5% and *N. gonorrhoeae* from 5.6% (13). Similar rates were observed among homosexual students attending the University of Chicago Health Service, in a group of homosexual prostitutes seen at a drug abuse clinic (M. Bohnhoff, M. H. Graves, W. M. Janda, S. A. Lerner, and J. A. Morello, Abstr. Annu. Meet. Am. Soc. Microbiol. 1978, C15, p. 279), in homosexual men attending a sexually transmitted diseases clinic in New York (26), and among homosexual men tested in a 4-year gonorrhea screening program in New York City (8). Historically, meningococcal carriage rates in the community range from about 3 to 15%, depending upon the population examined, the time of year, and the prevalence of "virulent" strains. The reasons for the heavy meningococcal colonization we have observed in homosexual men are not known. Since the organism is maintained in the population by droplet spread, more frequent intimate contacts may facilitate the colonization of the oropharynx by meningococci. Asymptomatic infections with other viral or chlamydial (10) agents may render the oropharyngeal mucosa more susceptible to meningococcal colonization. Our previous study (13) showed a statistically significant ($P < 0.001$) relationship between the presence of meningococci and the absence of gonococci from the throat. The two species were coisolated from the throats of only 11 of the 382 patients who had *Neisseria* spp. recovered from oropharyngeal cultures (13). The presence of meningococci in the throat may interfere with the ability of gonococci to establish infection. Mutually exclusive colonization may reflect competition for essential nutrients or for binding sites on the mucosa. The elaboration by meningococci of possible "anti-gonococcal" substances may also play a role (16).

Urethral and rectal cultures from homosexual men may yield meningococci as well as gonococci (7, 8, 13, 14). In our survey of 815 men, 6 urethral cultures (0.7%) and 16 rectal cultures (1.9%) grew *N. meningitidis* (13). In light of the

TABLE 4. Summary of patients with extrapharyngeal isolates of *N. meningitidis*

Site(s) of isolation	No. of patients	Patient no. and serogroup at each site	Comparative antibiogram ^a	Symptoms ^b	Concurrent gonorrhea ^c
Rectal/oral	9	1. B/B	Same	—	—
		2. B/B	Same	—	—
		3. 29E/29E	Same	—	—
		4. B/B	Same	Rectal	—
		5. C/B	Different	—	—
		6. 29E/B	Different	—	—
		7. Naa/B ^d	Different	Rectal	—
		8. B/C	Different	—	—
		9. B/B	Different	—	—
Rectal only	6	10. B		—	Oral/urethral
		11. B		—	—
		12. B		Rectal	—
		13. B		—	—
		14. X		—	—
		15. W135		—	—
Urethral/oral	5	16. B/B	Same	Urethral	Urethral
		17. C/C	Same	Urethral	—
		18. Y/Y	Same	Urethral	Rectal
		19. B/Naa ^d	Different	Urethral	—
		20. C/B	Different	—	—
Urethral/rectal/oral	1	21. W135/W135/W135	Same	Urethral	Urethral

^a Based on MIC data for penicillin G, tetracycline, sulfisoxazole, and rifampin.^b Symptoms associated with the site of meningococcal isolation.^c Indicates the site of concurrent gonococcal infection, if present.^d Nongroupable (i.e., autoagglutinable in saline).

high oropharyngeal isolation rate for *N. meningitidis* and the varieties of sexual practices, such isolations should be expected. Meningococci can cause a purulent urethritis that is indistinguishable from gonorrhea (19). In addition, both *N. gonorrhoeae* and *N. meningitidis* were coisolated from the urethral discharges of two patients (Table 4, no. 16 and 21) in the present study. Isolation of meningococci from the anal canal generally occurs more frequently than from the urethra (7, 8, 13, 14), and the organism has been isolated from both symptomatic and asymptomatic patients. Oro-genital and subsequent anogenital sexual contacts and direct oral-anal contacts are probably responsible for infection with *N. meningitidis* at anogenital sites.

Serogroup determinations of *N. meningitidis* isolates from these men reflected the current prevalence of serogroup B strains, as well as the emergence of serogroup W135 as a frequently isolated "new" serogroup (Table 3). Serogroups B and W135 also comprised the majority of isolates from anogenital sites (Table 4). Although the virulence of serogroups A, B, C, and Y is well recognized, W135 strains caused nearly one-third of the cases of meningitis and meningococcemia in New York City during 1973 to 1978 (9). Similarly, results from our laboratory indicate that, during the period of the present study, 27% of systemic meningococcal isolates

belonged to serogroup W135 (unpublished data). This serogroup has been isolated from patients with pneumonia and septic arthritis, and has caused significant morbidity in both pediatric and adult populations (1, 9, 11, 15, 17). Demonstration of serogroup W135 in a significant percentage of carriers (12.1% in the present study) may warrant consideration for including serogroup W135 antigen in polyvalent meningococcal vaccines for individuals at risk.

Although *N. gonorrhoeae* strains have become increasingly resistant to penicillin over the last 3 decades (25), *N. meningitidis* isolates have remained susceptible to those agents used for treatment of disease (penicillin G) and for prophylaxis of close contacts (sulfonamides and rifampin). Almost 80% of the gonococcal isolates in the present study required MICs greater than 0.060 µg of penicillin per ml, indicating moderate resistance to penicillin, whereas greater than 90% of the meningococci were inhibited at this concentration (Fig. 1). Although no high-level, beta-lactamase-mediated resistance was detected in the gonococcal isolates, surveillance of *N. gonorrhoeae* isolates for the production of beta-lactamase enzymes is essential, particularly in homosexual men. Because of the prevalence of gonococcal infection in these men, the frequency of sexual contacts, and the high degree of mobility in today's society, introduction

of resistant strains could lead to their rapid spread. Conceivably, gonococcal strains carrying transmissible resistance plasmids could transfer their resistance not only to other gonococci, but also to meningococci (2, 6, 24). The isolation of both gonococci and meningococci from extrapharyngeal sites, particularly the rectum, could also lead to the acquisition of antibiotic resistance plasmids from enteric bacteria.

Another finding of the present study was the rarity of AHU-requiring *N. gonorrhoeae* strains among the isolates obtained from homosexual men. Only 4 (1.2%) of the 325 isolates recovered belonged to the AHU auxotype (Table 1). Ongoing auxotyping studies in this laboratory indicate that about 14% of isolates from heterosexuals with gonorrhea who visit the University of Chicago Clinics are AHU auxotypes, whereas about 54% of the isolates from disseminated gonococcal infections are AHU strains (unpublished data). AHU-requiring *N. gonorrhoeae* strains have been shown to cause a significant proportion of disseminated gonococcal infections (18, 20) as well as asymptomatic urethral gonococcal infections in men (3). It is noteworthy that only 1 patient of 151 with urethral gonorrhea in our study population was asymptomatic at the time of clinic presentation (13). Handsfield et al. (12) have also recovered AHU strains from 48% of 282 heterosexual men and women, but from only 9% of 69 homosexual or bisexual men. Furthermore, none of the homosexual men and 7% of the heterosexual men had asymptomatic urethral gonorrhea (12). Low rates of asymptomatic urethral gonococcal infection in homosexual men have also been reported from San Francisco sexually transmitted disease clinics (23). Recent evidence has indicated that gonococci isolated from homosexual men are more resistant to the inhibitory effects of fecal lipids (21) and that AHU auxotype strains are very susceptible to inhibition by free fatty acids (18). The absence of AHU-requiring gonococci from homosexual men may reflect selective pressures against these lipid-sensitive fastidious auxotypes in favor of more lipid-resistant strains. The infrequent isolation of AHU-requiring organisms from homosexual men may also indicate the inability of these gonococci to compete effectively with the resident bacterial flora at oropharyngeal and rectal sites. These environments may be hostile to more auxotrophic gonococci while allowing the more nutritionally competent prototrophic strains to predominate in infectious processes.

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LITERATURE CITED

1. Brandstetter, R. D. 1981. *Neisseria meningitidis* serogroup W135 disease in adults. J. Infect. Dis. 246:2060-2061.
2. Catlin, B. W. 1960. Interspecific transformation of *Neisseria* by culture slime containing deoxyribonucleate. Science 131:1257-1258.
3. Crawford, G., J. S. Knapp, J. Hale, and K. K. Holmes. 1977. Asymptomatic gonorrhea in men: caused by gonococci with unique nutritional requirements. Science 196:1352-1353.
4. Devine, L. F., and C. R. Hagerman. 1970. Spectra of susceptibility of *Neisseria meningitidis* to antimicrobial agents in vitro. Appl. Microbiol. 19:329-334.
5. Eickhoff, T. C. 1971. *In vitro* and *in vivo* studies of resistance to rifampin in meningococci. J. Infect. Dis. 123:414-420.
6. Eisenstein, B. I., T. Sox, G. Biswas, E. Blackman, and P. F. Sparling. 1977. Conjugal transfer of the gonococcal penicillinase plasmid. Science 195:998-999.
7. Faur, Y. C., M. H. Weisburd, and M. E. Wilson. 1975. Isolation of *Neisseria meningitidis* from the genito-urinary tract and anal canal. J. Clin. Microbiol. 2:178-182.
8. Faur, Y. C., M. E. Wilson, and P. S. May. 1981. Isolation of *N. meningitidis* from patients in a gonorrhea screening program: a four-year survey in New York City. Am. J. Public Health 71:53-58.
9. Galaid, E. I., C. E. Cherubin, J. S. Marr, S. Schaeffer, J. Barone, and W. Lee. 1980. Meningococcal disease in New York City, 1973-1978: recognition of groups Y and W135 as frequent pathogens. J. Am. Med. Assoc. 244:2167-2171.
10. Goldmeier, D., and S. Darougar. 1977. Isolation of *Chlamydia trachomatis* from throat and rectum of homosexual men. Br. J. Vener. Dis. 53:184-185.
11. Hammerschlag, M. R. 1978. Infections in children due to *Neisseria meningitidis* serogroup W135. J. Pediatr. 92:503-509.
12. Handsfield, H. H., J. S. Knapp, P. K. Diehr, and K. K. Holmes. 1980. Correlation of auxotype and penicillin susceptibility of *Neisseria gonorrhoeae* with sexual preference and clinical manifestations of gonorrhea. Sex. Transm. Dis. 7:1-5.
13. Janda, W. M., M. Bohnhoff, J. A. Morello, and S. A. Lerner. 1980. Prevalence and site-pathogen studies of *Neisseria meningitidis* and *N. gonorrhoeae* in homosexual men. J. Am. Med. Assoc. 244:2060-2064.
14. Judson, F. N., J. M. Ehret, and T. C. Eickhoff. 1978. Anogenital infection with *Neisseria meningitidis* in homosexual men. J. Infect. Dis. 137:458-463.
15. Kim, K. S., C. W. Hoffpauir, and A. Janney. 1978. Meningitis caused by *Neisseria meningitidis* type W135. J. Pediatr. 93:326.
16. Kingsbury, D. T. 1966. Bacteriocin production by strains of *Neisseria meningitidis*. J. Bacteriol. 91:1696-1699.
17. Kleiman, M. B., J. Reynolds, J. Steinfeld, S. D. Allen, and J. W. Smith. 1978. Meningitis caused by *Neisseria meningitidis* serogroup 135. J. Clin. Microbiol. 8:621-622.
18. Knapp, J. S., and K. K. Holmes. 1975. Disseminated gonococcal infections caused by *Neisseria gonorrhoeae* with unique nutritional requirements. J. Infect. Dis. 132:204-208.
19. Miller, M. A., P. Millikin, P. S. Griffin, R. A. Sexton, and M. Yousuf. 1979. *Neisseria meningitidis* urethritis: a case report. J. Am. Med. Assoc. 242:1656-1657.
20. Morello, J. A., S. A. Lerner, and M. Bohnhoff. 1976. Characteristics of atypical *Neisseria gonorrhoeae* from disseminated and localized infections. Infect. Immun. 13:1510-1516.
21. Morse, S. A., P. G. Lysko, L. McFarland, J. S. Knapp, E. Sandstrom, C. Critchlow, and K. K. Holmes. 1982. Gonococcal strains from homosexual men have outer membranes with reduced permeability to hydrophobic molecules. Infect. Immun. 37:432-438.
22. Owen, W. F. 1980. Sexually-transmitted diseases and

- traumatic problems in homosexual men. *Ann. Intern. Med.* **92**:805-808.
23. **Sands, M.** 1980. Non-symptomatic urethral gonorrhea in homosexual men. *Sex. Transm. Dis.* **7**:206.
24. **Sarrubi, F. A., and P. F. Sparling.** 1974. Transfer of antibiotic resistance in mixed cultures of *Neisseria gonorrhoeae*. *J. Infect. Dis.* **130**:660-663.
25. **Sparling, P. F.** 1977. Antibiotic resistance in the gonococcus, p. 111-135. *In* R. B. Roberts (ed.), *The gonococcus*. John Wiley & Sons, Inc., New York.
26. **William, D. C., C. M. Schapiro, and Y. M. Felman.** 1980. Pharyngeal carriage of *Neisseria meningitidis* and anogenital gonorrhea: evidence for their relationship. *Sex. Transm. Dis.* **7**:175-177.