pneumonia and 20 per cent of cases of the undifferentiated infection of the upper respiratory tract.[16b]

Studies of the Commission on Acute Respiratory Diseases[10] have demonstrated that primary atypical pneumonia can be transmitted to and passed in human volunteers by means of bacteria-free filtrates of sputum and throat washings. In approximately one fourth of the volunteers respiratory illnesses developed, with pulmonary infiltration being demonstrated roentgenographically. Clinically the experimentally induced infections resembled the naturally acquired disease. The average period of incubation was ten to twelve days. There was no evidence that bacteria played any part in initiating the infections or during the course of the disease.

The clinical and the experimental evidence thus indicate that primary atypical pneumonia is a virus infection of the respiratory tract. Further investigation is necessary, however, to determine whether or not one agent or more than one is concerned in the production of the naturally acquired disease.

CONCLUSIONS

In conclusion, the outstanding problem in the field of diseases of the respiratory tract relates to the common infections of the respiratory tract which are so frequent in occurrence and which appear to vary in type from the "common cold" at one extreme to "atypical pneumonia" at the other. These infections are thought to be caused by viruses as yet uncharacterized, but they may be segregated into a group at the present time only by the exclusion of cases due to the known bacteria and viruses. Clinical classification is unsatisfactory at best, since it is based mainly on severity, extent of involvement of the respiratory tract and prominence of localizing symptoms and signs. An attempt at differentiation, however, has been useful as a means of selecting cases for etiologic investigation. It now appears probable that three entities, termed the "common cold," "undifferentiated acute respiratory disease" and "primary atypical pneumonia," can be separated from the larger group. Each of them can be transmitted to well human beings by the inoculation of bacteria-free filtrates of secretions of the respiratory tract. The possible existence of a fourth entity, "nonbacterial exudative tonsillitis and pharyngitis," is indicated by clinical studies.

The Campaign Against Rheumatism.—In every country surveyed the same findings have been made: (1) rheumatic diseases outranked all others as a cause of chronic morbidity; (2) rheumatic diseases annually involve each country in great expense; (3) adequate facilities for the care of most rheumatic patients are nonexistent. In the United States as elsewhere the total army of rheumatic victims is relatively neglected. Compare their prospects with that of others, for example, the tuberculous: for our 680,000 tuberculous patients there are available about 100,000 free beds and $100,000,000 for care and research. But for our 6,850,000 rheumatic patients there are available only about 200 free beds and $200,000 for care and research. In other words, although there are 10 times as many rheumatic as tuberculous patients the latter have available 500 times more beds and money. Thus the tuberculous patient, happily thereby a "vanishing race," receives 5,000 times as much attention as the nonvanishing rheumatic.—Hench, P.S.: *Annals of Internal Medicine,* February, 1948.

SEARCH FOR EXTRAHUMAN SOURCES OF POLIOMYELITIS VIRUS

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The best evidence of the transmission of the virus of poliomyelitis at the present time supports a person to person transfer. In spite of the logic of this thesis, based essentially on the well known fact that virus is present in the human oropharynx and intestinal tract for varying periods, one must not forget that the evidence was arrived at through processes of elimination rather than by scientifically proved experiments. Consequently, it is difficult, if not impossible, in determining the transmission of this disease, to rule out extrahuman factors completely, especially since epidemiologic observations have emphasized for years that outbreaks of poliomyelitis are correlated with seasonal influences, such as rainfall, temperature and prevalence of insects and animals.

In reviewing the literature on this subject one is impressed by the vast number of incriminations of various extrahuman factors, based at best on epidemiologic impressions gained through observations of limited accuracy, and also by the paucity of reports, either positive or negative, in which it is indicated that confirmation has been sought through actual investigation. Thus, the value to other investigators of the reporting of negative results is emphasized by the fact that so few reports on this subject exist.

Milk has been condemned in several epidemics, but entirely without laboratory support. Neustaedter and Thro[1] reported that poliomyelitis developed in monkeys infected with dust from a sickroom. Kling[2] and Toomey and his co-workers[3] seem to be the only ones reporting that the virus of poliomyelitis has been isolated from water. Sewage is not truly extrahuman, since it represents human excreta which may contain virus. Virus has actually been found in sewage by Paul, Trask and associates,[4] by Toomey[5] and by Kling and associates.[6] These isolations were almost invariably made from samples taken near the source of outlet and not far from hospitals containing patients with poliomyelitis. Jungeblut

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2. Kling, C.: In Search of Poliomyelitis Virus in Drinking Water, Internat. Bull. Econ. M. Research & Pub. Hyg. **A40:** 161, 1939

3. (*a*) Toomey, J. A.; Takacs, W. S., and Tischer, L. A.: Attempts to Recover Poliomyelitis Virus from Fruit, Well Water, Chicken Cords, and Dog Stools, J. Pediat. **23:** 168, 1943. (*b*) Toomey, J. A.; Takacs, W. S., and Weaver, H. M.: Isolation of Poliomyelitis Virus from Creek Water by Direct Transmission to the Cotton Rat, Am. J. Dis. Child. **70:** 293 (Nov.-Dec.) 1945.

4. Paul, J. R.; Trask, J. D., and Culotta, C. S.: Poliomyelitis Virus in Sewage, Science **90:** 258, 1939. Paul, J. R., and Trask, J. D.: The Virus of Poliomyelitis in Stool and Sewage, J. A. M. A. **116:** 493 (Feb. 8) 1941.

5. Toomey, J. A.: Attempts to Isolate Poliomyelitis Virus from Stools of Human Beings and Experimental Animals, Arch. Pediat. **56:** 693, 1939.

6. Kling, C.; Olin, G.; Fahraens, J., and Norlin, G.: Sewage as a Carrier and Disseminator of Poliomyelitis Virus, Acta med. Scandinav. **112:** 217 and 250, 1942.

and associates[7] have reported that rodent-paralyzing agents were isolated from wild mice in several different areas, but considerable doubt exists as to the identity of these strains as agents associated with the human disease. Leake[8] attempted to recover the virus from stools of dogs and chickens, with negative results, as did Toomey and associates,[3a] who also failed to isolate the virus from fish.[9] That the antibodies are present in the serum of animals has been reported by Hammon,[10] Gordon,[11] Brown and Francis[12] and others, but it is significant that the serums were tested against only the mouse-adapted Lansing strain of poliomyelitis virus. The significance of these observations in terms of specific virus effect is not established.

The possibility that some insect plays a role in the transmission remains the most likely of all the extrahuman prospects. Rosenau and Brues[13] and Anderson and Frost[14] reported experimental transmission with the biting fly, Stomoxys calcitrans, but were unable to repeat their results a year later.[15] Sawyer and Herms[16] likewise were unsuccessful with this insect, as was Francis[17] with another biting fly, Lyperosia irritans. Howard and Clark[18] reported negative results of experiments with mosquitoes and lice, and Kling and Levaditi[19] found that flies and bedbugs were negative for virus. Simmons, Kelser and Cornell[20] and Cornell and Davis[21] were unable to transmit infection from monkey to monkey with the mosquitoes Aedes aegypti and Culex pipiens.

Flexner and Clark[22] and Howard and Clark[18] reported that monkey cord virus survived in the housefly, Musca domestica, for several days. Bang and Glaser[23] found that the Lansing strain of virus persisted in the housefly for two days but not in species of Lucilia, Muscina, Calliphora or Sarcophaga. The housefly yielded a strain of spontaneous mouse encephalomyelitis virus twelve days after feeding on the virus. The virus was not isolated from adults when the larvae were infected. Rendtorff and Francis[24] also reported that the Lansing strain was recovered from houseflies as long as two days after a single meal of virus but observed a marked decrease of this virus with time, indicating no multiplication of the agent. The virus was shown to be in the fly and to be excreted in the fecal and vomit spots.

Various workers have recently reported that the virus of poliomyelitis was isolated from captured wild flies —Paul and associates,[25] Toomey and co-workers,[26] Sabin and Ward[27] and Trask and associates.[28] A significant observation was reported by Ward, Melnick and Horstmann,[29] who exposed food to flies in an epidemic area and then fed it to chimpanzees. In these animals infection developed without clinical disease but with persistence of the virus in the gastrointestinal tract.[30]

In this laboratory, in the course of investigating epidemics of poliomyelitis during the past five years, attempts have been made to evaluate the significance of some of the possible extrahuman sources of virus. The efforts to be reported here represent attempts to isolate the virus from various materials, serologic studies to detect antibodies for the virus of poliomyelitis in animals and laboratory experiments with insects.

ATTEMPTS TO ISOLATE THE VIRUS

Mice.—Six pools of mice, representing 33 animals, have been tested for the presence of virus. The mice were captured in or near the homes of patients in three epidemic areas, Michigan, in 1942,[31] and Fort Worth and Texarkana, Texas, in 1943.[32] One animal appeared to be paralyzed. Nervous tissue and several inches of the lower part of the intestine were ground with alundum and filtered through Mandler candles. The bacteriologically sterile filtrates were inoculated intracerebrally in rhesus monkeys, white Swiss mice and cotton rats. No specimen produced signs of the disease.

Rats.—The nervous and intestinal tissues of 112 wild rats, rattus norvegicus, have been tested.[33] The animals were obtained from epidemic areas in rural districts of Michigan, in Texas and in Buffalo and Detroit. Mandler filtrates of 35 pools representing the total number of rats were inoculated intracerebrally in rhesus monkeys, Swiss mice and cotton rats. All specimens failed to transmit infection, with the exception of one pool of brains, cords and intestines from rats captured at the city dump in Fort Worth, Texas, in 1943.[32] A Mandler

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30. Since this paper was presented, Melnick and Penner (Proc. Soc. Exper. Biol. and Med. **65:** 342, 1947) have shown that a human strain of poliomyelitis virus, naturally present in stools of patients, when fed to Phormia regina, could be found, after this feeding, in the flies for two weeks and in their excreta for three weeks, whereas murine-adapted strains of poliomyelitis virus and Theiler's TO strain of spontaneous encephalomyelitis of mice disappeared after a few days.

31. (*a*) Pearson, H. E., and Rendtorff, R. C.: Studies of the Distribution of Poliomyelitis Virus: I. In the Environment of Sporadic Cases, Am. J. Hyg. **41:** 164, 1945; (*b*) II. In a Small Town, ibid. **41:** 179, 1945.

32. Pearson, H. E.; Brown, G. C.; Rendtorff, R. C.; Ridenour, G. M., and Francis, T., Jr.: Studies of the Distribution of Poliomyelitis Virus: III. In an Urban Area During an Epidemic, Am. J. Hyg. **41:** 188, 1945.

33. Brown and Francis.[12] Pearson and Rendtorff.[31] Pearson and others.[32]

filtrate of the ground tissues from these animals produced paralysis in 1 of 2 cotton rats on the ninth day and in 1 of 6 mice on the thirtieth day. A rhesus monkey inoculated intracerebrally with the same original suspension had marked weakness of both legs and slight weakness of both arms by the ninth day. On autopsy of this animal some neuronophagia and neuronolysis was observed, but an attempt to pass the infection to a second monkey was unsuccessful. The brain and cord of the paralyzed mouse was passed to 4 cotton rats and 10 mice. Paralysis developed again in 1 cotton rat, but further passage was unsuccessful. However, the agent was passed in 9 successive mouse inoculations, inciting typical hind- or foreleg paralysis in the animals. Unfortunately, the percentage of mice in which paralysis developed never exceeded 20 to 25, making it impossible to identify the agent by means of the technic of cross immunization or cross neutralization. The strain has been preserved, and further attempts are being made.

Muskrats.—Three muskrats inhabiting the waters of Three Rivers, Mich., during the epidemic of 1946 were trapped. The rivers in this area were excessively contaminated with fecal material since they received raw sewage from the entire town. The pooled brains and cords and individual suspensions of the intestines of these animals were inoculated intracerebrally in 2 cotton rats and 15 white mice. No signs were observed in the test animals.

Chickens.—Chicken droppings were collected in two epidemic areas of rural Michigan[31] and in Fort Worth, Texas,[32] where chickens represented the major animal species apart from man. Four pools were rendered bacteriologically sterile and were then inoculated intracerebrally and intranasally in rhesus monkeys. All pools failed to produce signs of virus infection.

On four occasions chickens which were limping or were totally unable to walk were observed in yards of homes where poliomyelitis was occurring. Histories revealed that several other chickens had recently died after being lame for a period. The brains and spinal cords were removed aseptically, ground in a mortar and inoculated intracerebrally in white mice. In none of these mice did signs develop.

Cows.—Seven pools of cow feces, representing four epidemic areas, three in Michigan and one in Texas,[34] were processed for intracerebral and intranasal inoculation of rhesus monkeys. One of the cows had a history of recent lameness. All specimens failed to produce signs of virus infection.

Hogs.—Droppings from hogs which were maintained by households in which the disease occurred were collected on two occasions.[31a] Four pools of ether-treated feces were inoculated intracerebrally and intranasally in rhesus monkeys, with negative results.

Table 1.—*Attempts to Isolate Virus from Naturally Caught Flies*

Pool	Type of Fly	Flies	Source	Type of Monkey Inoculated	Route *	Result †
1	Miscellaneous	57	Ohio	Rhesus	i.p., i.n.	—
2	Miscellaneous	130	Ohio	Java	i.p., i.n.	—
3	Sarcophagidae	56	Texas	Cebus	i.c.	—
4	Calliphoridae	43	Texas	Cebus	i.c.	—
5	Musca domestica	52	Texas	Cebus	i.c.	—
6	Sarcophagidae	200	Texas	Cebus	i.c., i.n.	—
7	Sarcophagidae	125	Texas	Cebus	i.c., i.n.	—
8	Calliphoridae	57	Texas	Cebus	i.c.	—
9	Musca domestica	127	Texas	Cebus	i.c., i.n.	—
10	Call. and Mus. dom.	34	Texas	Cebus	i.c., i.n.	—
11	Sarc., Call., Mus. dom.	67	Texas	Cebus	i.c., i.n.	—
12	Sarc., Call., Mus. dom.	95	Texas	Cebus	i.c., i.n.	—
13	Sarc., Call., Mus. dom.	140	Texas	Cebus	i.c., i.n.	—
14	Sarc., Call.	210	Texas	Cebus	i.c., i.n.	—
15	Sarc., Call., Mus. dom.	223	Texas	Rhesus	i.c., i.p.	? —
16	Sarc., Call., Mus. dom.	251	Texas	Rhesus	i.c., i.p.	? —
17	Sa., Ca., M. dom., Tabanus, Stomoxys calcitrans	759	Mich.	Rhesus	i.c., i.p.	? —
18	Stomoxys calcitrans	1,000	Ohio	Rhesus	i.c., i.p.	—
19	Sa., Ca., M. dom., Fannia	1,006	Ohio	Rhesus	i.c., i.p.	—
20	Sarc., Call., Mus. dom.	345	Ark.	Rhesus	i.c., i.n.	—
21	Musca domestica	757	Ark.	Rhesus	i.c., i.p.	—
22	Calliphoridae	291	Ark.	Rhesus	i.c., i.p.	—
23	Sarcophagidae	389	Ark.	Rhesus	i.c., i.p.	—
24	Sarc., Call., M. dom., Stom.	626	Ohio	Rhesus	i.c., i.p.	—
25	Musca dom., related flies, miscellaneous	41	Mich.	Rhesus	i.c., i.p., i.n.	—
26	Phaenicia sericata	165	Mich.	Rhesus	i.c., i.p., i.n.	—
27	Phormia regina and terrae-novae	17	Tenn.	Rhesus	i.c.	—
28	Phaenicia sericata	452	Tenn.	Rhesus	i.c.	—
29	Phaenicia sericata	115	Tenn.	Rhesus	i.c.	—
				Philippine	i.c.	—
30	Phaenicia sericata	572	Tenn.	Rhesus	i.c.	—
				Philippine	i.c.	—
31	Sarcophaga spp.	23	Tenn.	Rhesus	i.c.	—
				Philippine	i.c.	+
32	Misc. spp.	41	Tenn.	Rhesus	i.c.	—
				Philippine	i.c.	—
33	Phaenicia sericata	64	Tenn.	Rhesus	i.c.	—
				Philippine	i.c.	—
34	Musca domestica	21	Tenn.	Rhesus	i.c.	—
				Philippine	i.c.	—
35	Sarcophaga spp.	30	Tenn.	Rhesus	i.c.	—
				Philippine	i.c.	—
36	Sarcophaga spp.	99	Tenn.	Rhesns	i.c.	—
				Philippine	i.c.	—
37	Phaenicia sericata	278	Tenn.	Rhesus	i.c.	—
				Philippine	i.c.	—
38	Phormia regina and terrae-novae	61	Tenn.	Rhesus	i.c.	—
				Philippine	i.c.	—

* The abbreviations are as follows: i.p., intraperitoneal; i.n., intranasal; i.c., intracerebral.
† A negative sign means that the inoculated animals showed no evidence of virus infection; a plus sign, that definite symptoms of poliomyelitis developed after inoculation.

34. Pearson and Rendtorff.[31] Pearson and others.[32]

Horse.—The stool of a horse which had been in close contact with a patient [31a] was tested for virus by intracerebral and intranasal inoculation of a rhesus monkey. No virus was detected.

Cats.—An interesting set of circumstances surrounded a group of three houses on the outskirts of Buffalo during the epidemic of 1944, where observations were being made by Dr. E. M. Bridge and Dr. E. Neter. In the three houses there occurred 1 definite case of poliomyelitis and 3 cases of minor illness which may have been abortive poliomyelitis. Two children had recently visited the homes; in one definite symptoms developed, and in the other, probably the abortive form of the disease. Of 13 cats residing in these homes, 9 had died within the past few weeks, 3 were well and 1 had flaccid paralysis of the legs. Through the cooperation and assistance of Drs. Bridge and Neter, these 4 remaining animals were killed, and the nervous tissue was removed and sent to us; it was then stored in dry ice until tested by intracerebral and intraperitoneal inoculation in a rhesus monkey. The animal remained perfectly well for the test period of thirty days.

Sewage.—Six specimens of sewage, 5 gallon (19 liter) quantities, were obtained in Fort Worth, Texas, during the epidemic of 1943.[32] A sample of raw sewage, a sample of the final effluent and 4 samples representing various areas of the town were chosen. Each sample was concentrated to a volume of approximately 1 quart (1 liter) by lowering the p_H to 4.2 and precipitating with crystalline egg albumin. The concentrates were preserved by freezing until tested. From 100 to 125 cc. of each was treated with ether to remove the bacteria and then inoculated at least twice in rhesus monkeys intraperitoneally and intranasally in 10 cc. and 2 cc quantities, respectively. The specimen from raw sewage was tested in 3 animals. All were negative for virus.

During the epidemic in Denver, 1946, six daily 1 quart samples of sewage were taken from three sources, the hospital outlet, the stream before it entered the treatment plant and the final effluent.[35] Two hundred cubic centimeters of each daily specimen from each location was used for a pool totaling 1,200 cc., which was then concentrated *in vacuo* to 40 cc. After ether treatment, each of the three pools was inoculated twice intracerebrally in 3 rhesus monkeys. All 3 pools gave negative results.

A pool of soil, totaling 80 Gm., from three truck farms irrigated by the Platte River, which contains the final effluent of the entire city of Denver, was suspended to 10 per cent in distilled water and concentrated *in vacuo*. After treatment with ether, the pool was inoculated intracerebrally in 3 rhesus monkeys, which remained well.

Since sludge from the sewage treatment plant is used extensively as fertilizer in and around Minneapolis, 2 specimens were obtained during the epidemic of 1946. A specimen of three year old sludge, which is usually used on farms, and a specimen of fresh sludge, 40 Gm. of each, were suspended in saline solution and treated with ether. Both were inoculated intracerebrally and intraperitoneally in Philippine monkeys. The animals remained well.

Water.—Nine large samples of water, usually several gallons each, were collected from lakes, ponds, rivers and city water supplies near epidemic areas in Cleveland, Akron, Ohio, Fort Worth, Texas, and several small towns of Michigan.[36] Each specimen was evaporated in sausage casings exposed to electric fans until concentrated to approximately 10 per cent of the original volume and then was inoculated intraperitoneally and intranasally in rhesus monkeys. In 2 monkeys symptoms suggesting infection developed, but the second rhesus passage was uneventful. The other inoculations produced no evidence of infection.

One 15 gallon (56 liter) specimen from the wells of the Perrysburg, Ohio, water department was collected over a twenty-four hour period during the epidemic of 1944. The specimen was concentrated *in vacuo* to a volume of 1 liter, while being maintained at a temperature of 40 F. and a p_H between 6 and 7. It was dialyzed and inoculated intracerebrally in white mice and 3 rhesus monkeys. No virus was recovered.

Milk.—Three specimens of raw milk from farms on which poliomyelitis had occurred [31a] were treated with ether and inoculated intracerebrally and intraperitoneally in rhesus monkeys. All the animals remained free of disease.

Insects.—Forty-three pools of insects, representing approximately 15,300 individual insects, trapped in areas under study,[34] have been tested in monkeys. Two pools of ants and two of cockroaches, with estimated numbers of 6,000 and 140, respectively, were obtained from each of two homes in which cases had occurred. A pool of ticks was made up of larvae, nymphs and adults numbering 150 obtained from a woody area frequented by a patient. Thirty-eight pools, representing seven epidemic areas, were made up of flies trapped in or around the residences of persons suffering with the disease. Many pools were made up of single species of flies. In some instances several kinds were included. In all cases the pools were ground in mortars with alundum, shaken with ether for several days and then, if bacteriologically sterile, inoculated intracerebrally as well as intraperitoneally or intranasally in monkeys.

Java, Capuchin, rhesus or Philippine monkeys were employed, and 10 pools were injected into both rhesus and Philippine monkeys. Table 1 demonstrates the results of these tests. It will be seen that, of all the pools of naturally caught flies, only one specimen, consisting of 23 flies from an unsanitary rural area, all in the genus Sarcophaga, was shown to contain the virus. This specimen produced symptoms of poliomyelitis in a Philippine monkey but was negative in a rhesus monkey. Two other specimens of flies caused questionable symptoms in the first animal inoculated, but the agent could not be passed to a second monkey. The results have been thought to be open to criticism in that rhesus monkeys were used for most tests, and the statement has been made that they are insusceptible to fly virus.

In the past a wide variety of flies has been incriminated in the pools which have yielded virus; the actual species involved have usually not been ascertained. Nevertheless, Musca domestica, the common house fly, has not been prominent in the collections, while the blow fly (Calliphora vomitoria) and several other species have been.

The usual assumption has been that flies acquire their contamination from human excreta, but no direct evidence that they do has been presented. A certain significance might be applicable if the species of flies

35. Ziutek, A. R.: Unpublished data.

36. Francis, T., Jr.; Krill, C. E.; Toomey, J. A., and Mack, W. N.: Poliomyelitis Following Tonsillectomy in Five Members of a Family, J. A. M. A. **119**: 1392 (Aug. 22) 1942. Pearson and Rendtorff.[31] Pearson and others.[32]

which habitually feed on human stools were known. Accordingly, fresh normal adult human stools were placed as bait in cone-shaped fly traps in numerous areas throughout Michigan during a period when poliomyelitis was not prevalent. The field identifications of the collections made are given in table 2.

TABLE 2.—*Species of Flies That Were Trapped with Human Stools as Bait*

	Number Trapped
Phaenicia sericata and a small number of Lucilia spp	2,048
Phormia regina and Protophormia terrae-novae	629
Sarcophaga spp.	616
Muscina stabulans and Muscina assimilis	333
Caliphoro erythrocephala and Calliphora vomitoria	107
Cynomyopsis cadaverina	29
Musca domestica	17
Stomoxys calcitrans	7
Callitroga macellaria	6
Fannia canicularis	1
Miscellaneous identified and unidentified specimens	856

The same results were obtained from trappings of flies in rural Tennessee during an epidemic where ample opportunity to feed on feces was provided. It was obvious that the "blow," "flesh" and "green bottle" flies, and not the house fly, were abundantly attracted to human excreta as used in our methods of collection. One should not be misled, however, into believing that the house fly is not attracted to human excrement under some circumstances. These data show that the species encountered were those which had been present in previous collections described as containing the virus, and they support the idea that the human stool is a likely source of the virus.

In order to complete the chain of evidence and prove that flies are capable of acquiring the virus from human excreta, collections were made in Ann Arbor in traps baited with fresh stool from a patient with acute poliomyelitis. The stool was proved to contain the virus by inoculation of a monkey, and flies trapped at the same time but not allowed to feed on the stool were shown to be free of the virus. After separating into species the flies which had fed on the virus-containing stool, seven pools were inoculated intracerebrally in both rhesus and Philippine monkeys and one pool in rhesus monkeys only. One specimen consisting of 183 Phaenicia sericata produced symptoms in both types of monkeys. Another pool of 7 Phormia regina and 1 Callitroga macellaria produced symptoms in a Philippine monkey but none in the rhesus. Two other pools, one containing 13 small feces-inhabiting flies of several species, including Gymnodia arcuata and Myiospila meditabunda, 1 Fannia canicularis, 3 Muscina assimilis and 3 Musca domestica, and the other containing 11 undetermined muscids, 14 Muscina assimilis and Muscina stabulans, 6 Callitroga macellaria and 2 Musca domestica, produced symptoms in rhesus but not in Philippine monkeys. It is interesting that not just one but several species of flies were capable of acquiring the virus, while the house fly was essentially uninvolved. It is also of interest that three pools of flies produced symptoms in rhesus monkeys and that two of these pools did not produce disease in Philippine monkeys. Other workers have clearly expressed the opinion that rhesus monkeys are not susceptible to infection with virus from naturally caught flies.

The evidence clearly demonstrates that the stool of a patient with poliomyelitis can serve as a source of virus for certain flies, which thus become potential vectors of the infectious agent.

Virus was not isolated from normal liver and fruit bait on which the disease-conveying flies subsequently fed, but it is felt that this step in the transmission still offers possibilities which further experimentation should clarify.

It should be added that the virus isolated from flies in this manner has been repeatedly passed in monkeys and has been identified by means of monkey neutralization tests as serologically similar to the Rockford, Ill. (1945) and Minneapolis (1946) strains. It also has a high intracutaneous pathogenicity in monkeys.

SEROLOGIC STUDIES

From time to time the serums of animals associated with the households of patients and having a history of recent illness have been tested for neutralizing antibodies to the mouse-adapted Lansing strain of poliomyelitis virus. Two cows, a rabbit, a horse and several chickens have been found entirely lacking in antibodies.

Forty-six wild rats from epidemic areas of Buffalo and Detroit whose tissues were examined for virus were first bled and their serums tested for Lansing strain neutralizing antibodies.[12] The serums of 45 of these rats showed no evidence of antibodies, but the serum of the remaining rat repeatedly neutralized the Lansing strain of virus. Two other rats were found to maintain circulating antibodies to a strain of Theiler's spontaneous mouse encephalomyelitis virus.

SUMMARY

Attempts to isolate the virus of poliomyelitis from various extrahuman sources in epidemic areas have been made by inoculation of monkeys and of cotton rats and mice.

Thirty-three wild mice, 112 wild rats, 3 muskrats, 4 cats, 1 horse, many chickens, cows and hogs, and 43 pools of insects, 38 of which were flies, representing approximately 15,300 individual specimens, have been so tested.

In addition 24 samples of sewage, 2 of sludge, 1 of soil, 10 of water and 3 of milk have been examined.

The animals, the insects and the other specimens were collected during epidemics of the disease and usually from locations in close proximity of patients.

A mouse-paralyzing agent was isolated from one pool of tissues from wild rats caught in Fort Worth, Texas, in 1943. It has not been identified.

Of 38 pools of flies, one collection of 23 Sarcophaga spp. from rural Tennessee, 1945, was shown to contain poliomyelitis virus.

In all other attempts to isolate the virus the results were negative.

The serums of 2 cows, a horse, a rabbit and 46 wild rats have been tested for neutralizing antibodies to the Lansing strain of virus. All were negative with the exception of that of a wild rat obtained from Detroit in 1944, which had definite virus-neutralizing capacity.

Fly trappings, using fresh normal adult human stool as bait, have shown that certain flies, Phaenicia, Phormia, Sarcophaga, Muscina and Calliphora, are the predominant genera attracted to human feces with the methods of collection used; the common house fly, Musca domestica, is not.

Virus from feces of a patient with poliomyelitis was actually taken up by flies and recovered by inoculation of rhesus monkeys.

ABSTRACT OF DISCUSSION

DR. R. R. SPENCER, Washington, D. C.: This meeting is a high point in the progress of knowledge of viruses. I shall limit my discussion to the possibility that viruses are related to cancer, presented by Dr. Kidd. The virus field and the cancer field are converging. It is difficult to believe that all types of cancer are due to a single invasive parasitic virus, and discussion is meaningless until more is learned about cells, which are the units of life, and by cells I mean virus particles, as well as body cells. Viruses are rather complex. Certainly, no one has yet grown the mammillary cancer virus; if there be a virus, in tissue culture or in chick embryo, although many of the parasitic viruses have been. Probably it comes down to a question of definition. If you mean by virus, external invasive parasitic organisms, I doubt that mammillary cancers are due to that kind of agent. If, on the other hand, you mean filterable intracellular components, perhaps detached genes or plasmagenes, then each type of cancer may have its own specific kind of intracellular component. There is no clearcut dichotomy anywhere in biology. In other words, there is a gradual change in structure and function all the way from the simplest forms of living things to the most complex, and one should not attempt to make clearcut definitions too quickly. One final point, cancer transplants elicit a rich blood supply and a supporting stroma, as every pathologist knows. They do not, however, elicit a nerve supply. The hyperplasia that results from infection seems to be definitely a defensive mechanism. I do not believe the hyperplasia of cancer is defensive. The body, certainly in the early stages of cancer, does not seem to recognize its presence. I like therefore to think of cancer as an "autoparasite." Regardless of all theories that Dr. Kidd mentioned as to the causation of cancer, and regardless of all the various inciting agents that are known, the end result is always the same. It is one of our own cells that has turned parasite.

Dr. James P. Leake, Washington, D. C.: With reference to Dr. Smadel's paper, I shall make a nonpathologic comment, that for one very important disease, smallpox, the key diagnosis is not in the laboratory but clinical. It must be prompt. Any case of purpura with fever should be considered smallpox as far as precautions are concerned, such as vaccination of those that are in the entourage, until another diagnosis is clear. In the second place, the dependent diagnosis should be made principally not on history, not on the character of the lesions, but on the distribution of the lesions. All of us can be mistaken at times, but it is safer to take precautions.

Dr. E. W. Schultz, Stanford University, Calif.: Little reference has been made to the limitations of specific therapy of virus diseases. It is important to remember in this connection that antibodies are much too large to enter cells and that there is little reason to expect therapeutic effects with immune serums after the invasion of susceptible cells has occurred. The same applies in general to chemotherapy. It would appear that future attempts to control these diseases will have to center largely around possible means of modifying the native susceptibility of vulnerable cells or preventing their initial invasion by the timely use of prophylactic agents. Virus diseases, more than any other group of diseases, depend on prophylactic measures for their control. Once infection has occurred the disease is largely out of control.

Dr. J. E. Smadel, Washington, D. C.: Viruses differ from one another. Nevertheless, all viruses have certain biologic properties in common, since they are obligate intracellular parasitic microbes. There is a tendency to think that the similarities in basic biologic properties extend to close similarities in physical, chemical and immunologic properties. The fallacy of this generalization has been touched on but not emphasized. The electron micrographs of Dr. Wyckoff do not bring out these differences in viruses as well as do other methods. Thus, certain of the plant viruses have a relatively simple chemical structure, being composed solely of nucleoprotein, which behaves as a single antigenic substance. On the other hand, the large virus of vaccinia contains protein, nucleoprotein, carbohydrate, lipid and minerals; in fact, it has the biochemical characteristics of bacteria or protoplasm. The complexity of this virus is further indicated by the fact that it contains at least five different antigenic structures. These viruses represent the two ends of the spectrum, agents in between show varying grades of similarity to the end viruses. I wish to reiterate the heresy which I mentioned earlier—don't ask for isolations. The Army has had greater experience in attempts at isolation of viruses than any other group in the United States. We consider it relatively unprofitable for the routine diagnosis of virus and rickettsial disease.

TRANSURETHRAL RESECTION FOR VESICAL DYSFUNCTION IN CASES OF TABES DORSALIS

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In 1941, we reported the results of a study of vesical dysfunction in cases of tabes dorsalis and analyzed the results of transurethral resection in 35 of the cases.[1] In these cases, the results of transurethral resection were very good. We recently have made a follow-up study of these 35 cases and of 44 additional cases of tabes dorsalis in which transurethral resection has been performed since Dec. 31, 1940. These two groups of cases form the basis of the present report.

In making such a study, it must be emphasized that it is impossible in every case to distinguish accurately vesical dysfunction caused by the tabetic state alone from that which results from hypertrophy of the prostate gland or other obstruction of the vesical neck in a case in which tabes dorsalis is only a coincidental finding and of no urologic importance. It is true that the extremes of these conditions are rather easily recognized, but intermediate conditions may be difficult to classify. The chief reason for this difficulty lies in the basic neuromechanics and obstructive factors involved in the disability. The neurophysiology of normal micturition has been described elsewhere,[2] and it is so well known that description here seems unnecessary. The tabetic process damages the posterior spinal ganglions, the posterior sensory roots and the posterior sensory columns of the spinal cord. This may block not only the impulses which pass through the sensory component of the simple spinal reflex arc and which control micturition (the level of which is in the sacral portion of the cord) but also may block the impulses which pass through the sensory part of the suprasegmental conditioning reflex and mediate vesical control by means of subconscious or conscious inhibitory impulses from the higher levels. With involvement of the sensory component of the lower reflex arc, it is apparent that more and stronger impulses would be necessary to incite reflex vesical contraction. This would result in progressive vesical distention, loss of tone and atony. Damage to the sensory component of the suprasegmental conditioning reflex would interfere with the stimuli which incite the proper flow of inhibitory impulses down the corticospinal tracts to supply subconscious and voluntary control of the lower reflex arc for micturition. In other words, the patient might not experience the desire to micturate until greater and greater distention of the bladder occurs, and the micturition could begin without the patient's being aware of it.

It is easy to visualize how such a lesion can give rise to urinary retention and incontinence. The bladder

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From the Section on Urology, Mayo Clinic (Dr. Emmett) and the Mayo Foundation (Dr. Beare, Fellow in Urology).

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2. Emmett, J. L., and Dunn, J. H.: Transurethral Resection in the Surgical Management of Cord Bladder, Surg., Gynec. & Obst. **83**: 597-612 (Nov.) 1946.