

On the production of gas-containing cavities in the internal organs of the body / by J.H. Bryant and W.C.C. Pakes.

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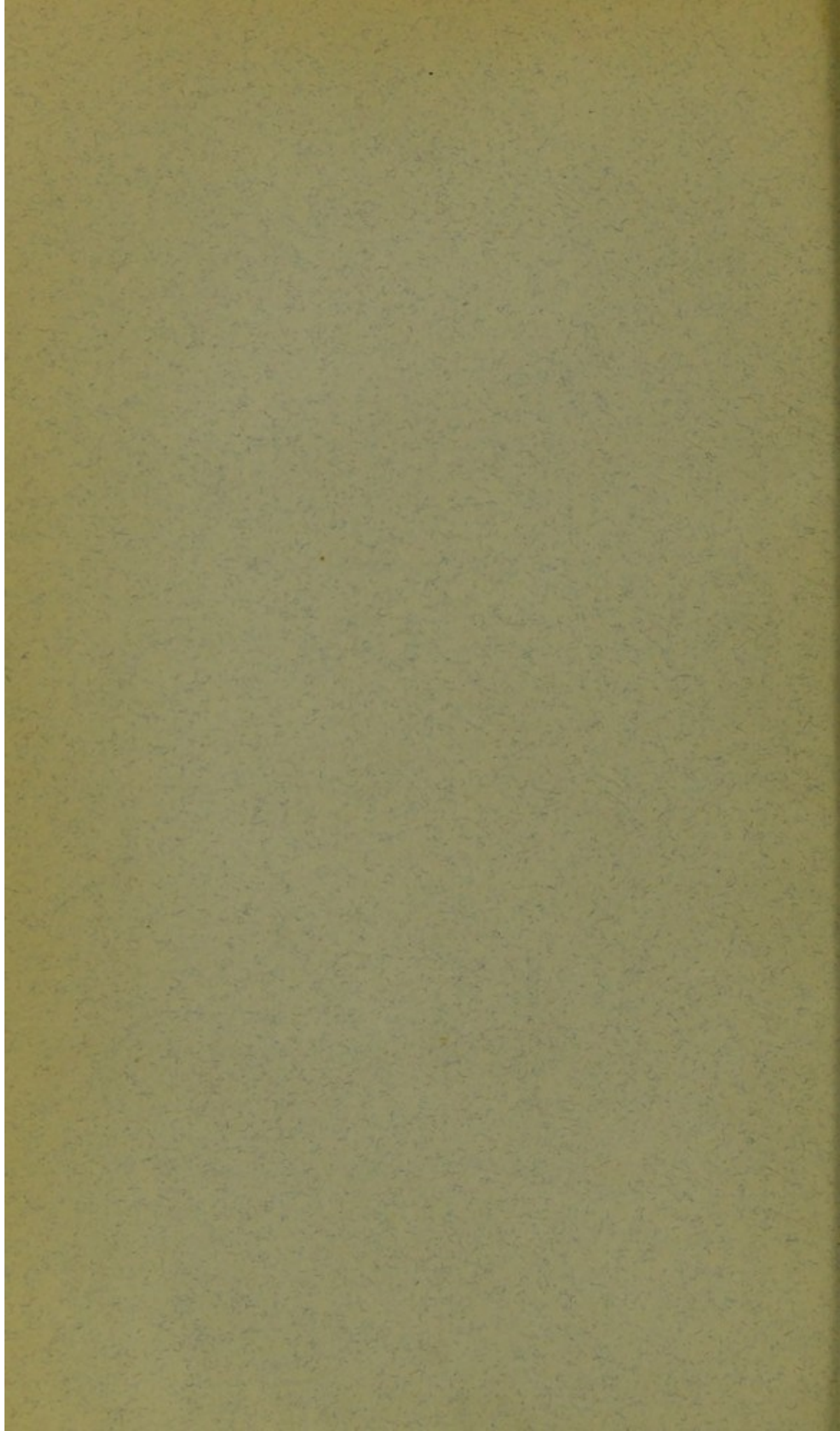
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ON THE PRODUCTION OF
GAS-CONTAINING CAVITIES IN THE
INTERNAL ORGANS OF THE BODY.

BY J. H. BRYANT, M.D.,

AND

W. C. C. PAKES.

WE have long felt that the formation of Gas-containing Cavities in the Internal Organs was an ante-mortem rather than a post-mortem change. For some time we were on the look out for a suitable case to investigate thoroughly from every point of view. Such a case as we fully report below came under our notice in February, 1897, and, as will be seen, there is very good evidence in this case at least in favour of the ante-mortem theory. In addition to satisfying ourselves on this point we have worked out, as far as possible, the pathology of the condition as illustrated by our own case and by similar cases which have been published.

CASE 1.—E. R., female, æt. 51. Admitted 1st February, 1897, for abdominal pain, under the care of Dr. Pitt, who has kindly allowed us to use the clinical notes of the case. She has had fifteen children, has always enjoyed good health, and has been temperate in her habits. Fourteen days before admission she was feeling quite well until she was suddenly attacked with severe pain in the abdomen, followed by jaundice. Her tongue became very dry: she was obliged to take to her bed and have warm flannels applied to her abdomen. Her bowels have been

regular and the motions were normal in appearance. For the last three days she has been passing porter-coloured urine and micturition has caused much pain.

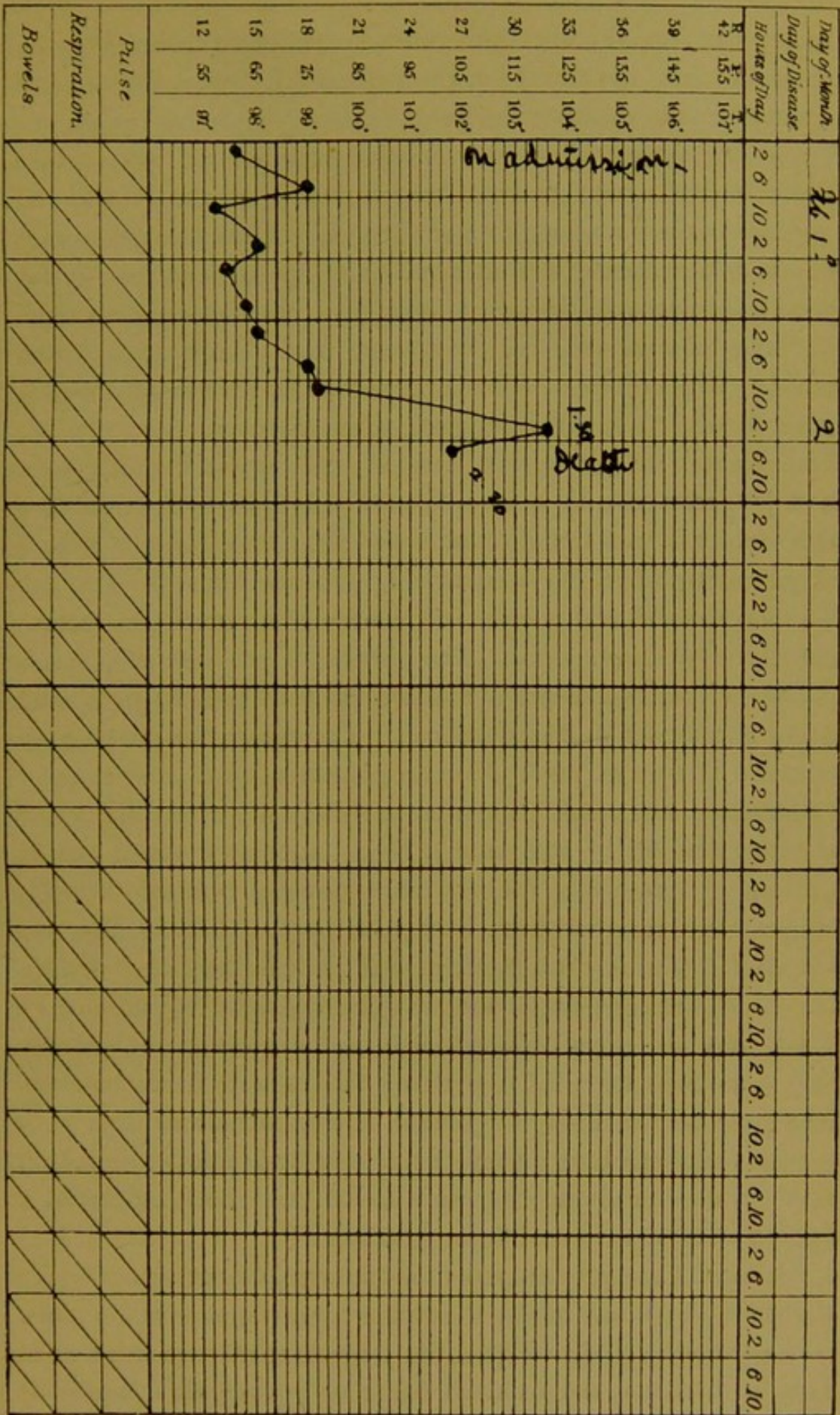
Condition on admission.—Pulse 80, respiration 40, temperature 97·6°. She was brought up to the hospital in an ambulance, and appeared to be suffering from severe pain in her abdomen. Her breathing was extremely rapid. She was an enormously fat woman, and was jaundiced. Her tongue was very dry and she felt extremely thirsty. She was quite unable to move and was groaning with the pain in her abdomen. Her liver was thought to be enlarged, but it was impossible to make a satisfactory examination. There was no ascites. No cardiac impulse could be seen and the sounds were feeble and indistinct, suggesting fatty degeneration and infiltration of the myocardium. There was slight bronchitis.

Urine 1010, acid; a trace of albumen present. No sugar, blood, or bile found.

Progress and treatment.—She was put to bed at once and placed on her right side, this being the most comfortable position for her. At 12 p.m. the abdominal pain was less.

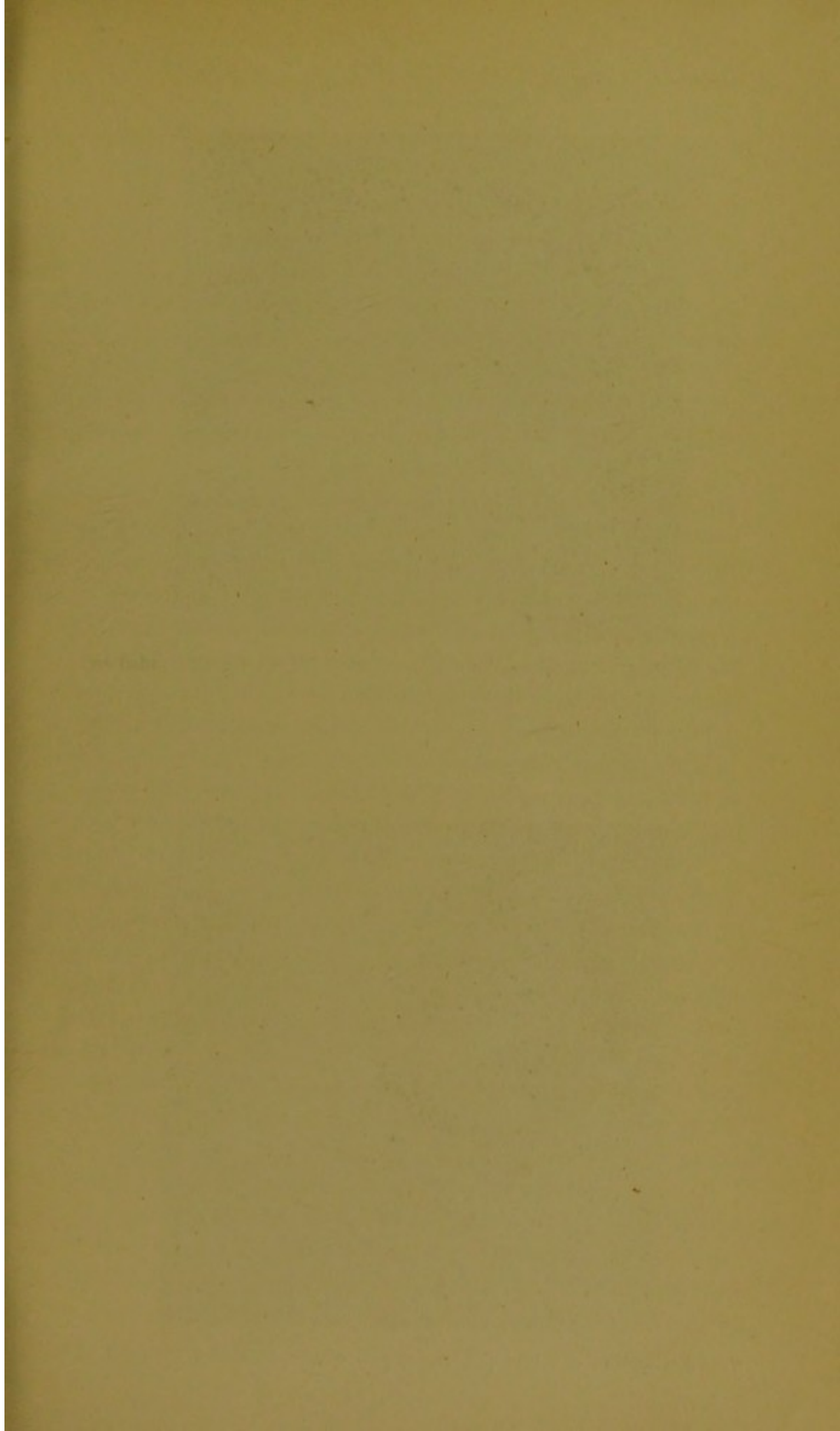
February 2nd. She slept the greater part of the night and said she felt better. The abdomen was found to be quite supple, but was still tender on palpation. An enema was given, but it was partly returned without bringing away any fæces. She was seen by Dr. Pitt in the afternoon and he diagnosed gall-stones. Later in the afternoon she passed a large quantity of urine. At 10 p.m. she was sleeping comfortably; temperature 99·2°, pulse 92, respiration 36. At 1.30 a.m., February 3rd, temperature 103·6°, pulse 116, respiration 68. The heart action was very irregular, and she began to get blue. At 2.30 a.m., temperature 101·8°. The cyanosis had increased, the breathing became slower and gasping in character, and she died at 3.15 a.m.

Autopsy.—Eleven hours after death (aerial temperature 10° C.) rigor mortis was well marked, and there was no evidence of post-mortem decomposition. Brain, forty-seven ounces, healthy. No pleurisy. The bronchial tubes were full of muco-pus. About one and a half ounces of blood-stained fluid were found in the pericardial



sac. Numerous little thin transparent blebs containing gas projected from the surface of the pericardium (visceral) and gave a sensation of crackling like surgical emphysema on rubbing the finger over them. The right ventricle was invested with a thick layer of fat, and its wall which was infiltrated with fat appeared to be in a condition of fatty degeneration. The muscle of the left ventricle was also pale and appeared to have undergone fatty degeneration and infiltration. The endocardium lining the cavities and covering the valves was deeply stained with blood. The intima of all the vessels was also deeply stained with blood. The liver weighed seventy-five ounces; it was a little lighter in colour than normal, was very soft, and on being handled gave rise to a sensation of emphysema-like crackling. On section it was found to be very soft, and a large number of small cavities and cysts containing gas were found. The gall-bladder was soft and friable and contained a number of faceted gall-stones and muco-pus. The common duct was dilated and full of calculi, the lower end being blocked by a large calculus about two inches in circumference. The spleen weighed sixteen ounces; it was very soft, and on palpation gave a sensation of emphysema-like crackling similar to that in the liver. On section it was found to be soft, and a large number of small cavities containing gas were seen. The kidneys weighed nineteen ounces; the capsules peeled off with ease. Both organs were very soft, especially the right, in fact so soft that when held in the hand, the long axes being at right angles to the palm of the hand, they no longer retained their reniform shape but collapsed into a globular form. On pressing them emphysematous crackling could be obtained. On section it was difficult to distinguish cortex from medulla: they were soft and friable, numerous small cysts containing gas were found, and both appeared to be in a state of advanced decomposition.

Sections of the liver prepared for microscopical examination and stained with gentian violet showed a large number of the small cavities which contained gas, the largest about one-third of an inch in diameter, the smallest being only perceptible under the microscope. Many of the cavities were circular, some were oval,



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Organs of the Body.*

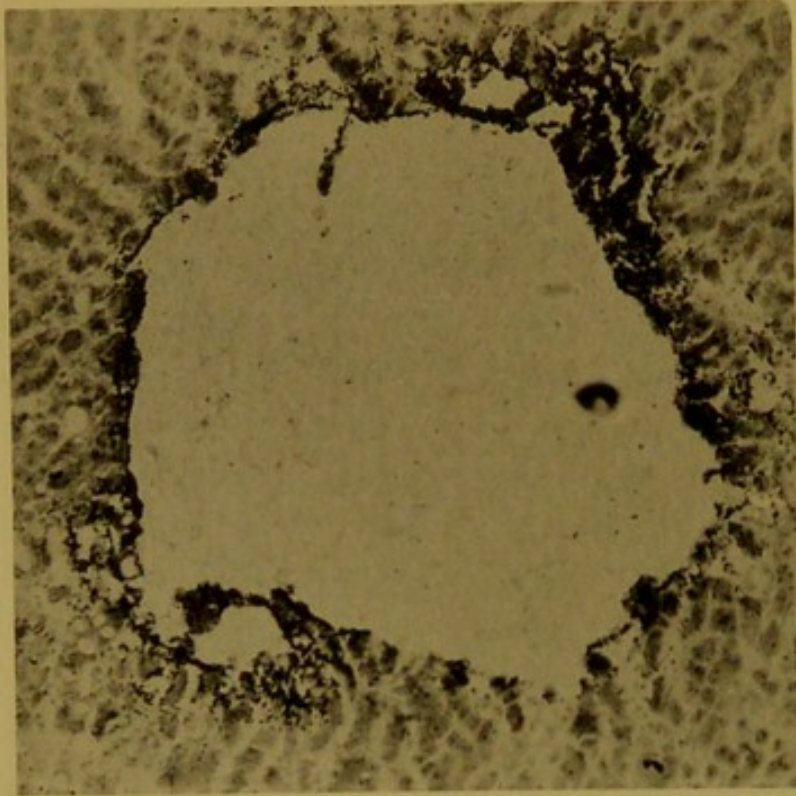


FIG. 1.—Section of Liver showing a gas-containing cyst surrounded by colonies of Bacilli. $\times 60$.

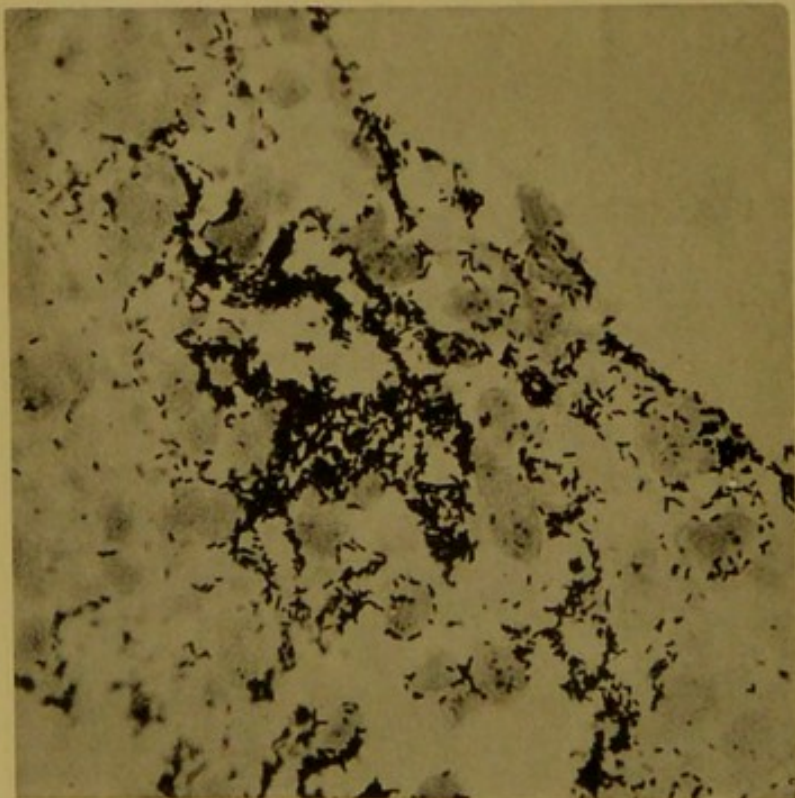


FIG. 2.—Section of Liver showing a part of the edge of a cyst. $\times 250$.

and others irregular in form, but the majority had quite smooth and regular edges. No definite lining membrane could be detected in any way resembling the intima of a dilated blood-vessel or the epithelial lining of a bile-duct. There was no increase of connective tissue and no collection of inflammatory cells bordering the cysts: they appeared to be in the parenchyma of the organ, and liver cells were found in all cases bordering them. These bordering cells seemed to be more closely packed together and more elongated than those in a normal lobule, suggesting not only actual destruction but also compression by the gas. Close up to the edge of the cavities and also lying just inside them a large number of short irregular bacilli stained a deep violet colour was seen forming distinct and continuous wreaths; these organisms, however, were not in a uniformly thick layer, for in places they were arranged together in distinct clumps; a few single bacilli and also large masses of them were seen lying free in some of the spaces. In addition small clumps of bacilli were found with commencing cavities in their centres in the parenchyma of the organ, which did not appear to have any definite relation to either portal veins, or hepatic veins, or bile-ducts. A few columns of organisms, however, were found as if lying in vessels cut in their longitudinal axes. It could be definitely made out that there was no general distribution of the bacilli between the liver cells throughout the section; they were distinctly arranged in groups as described above. The liver cells did not stain readily nor did their nuclei, and they had a very cloudy and finely granular appearance; a few showed the presence of hæmatin granules and some had undergone fatty degeneration.

A section of the spleen showed a general dissemination of the bacilli throughout. They did not appear to be confined to the periphery of the gas-containing spaces as in the liver, or to be arranged in clumps.

The bacilli were short with rounded ends, varying in length from one and a half to three times their breadth. Many were joined together and appeared like elongated diplococci; a few were considerably longer than the majority, being almost five

times as long as broad. By no method of staining could capsules be found.

Bacilli in the sections subjected to Gram's method did not retain the stain.

Bacteriological examination.—The spleen contained a large number of bacilli, many of which were in the form of diplo-bacilli. None of these retained the stain after treatment by Gram's method. Many of them had what appeared to be a slightly developed capsule.

Cultivations made from the spleen resulted in a pure culture of the bacillus coli communis. Anaerobic cultivations produced only this bacillus. There was no sign of the bacillus aerogenes capsulatus.

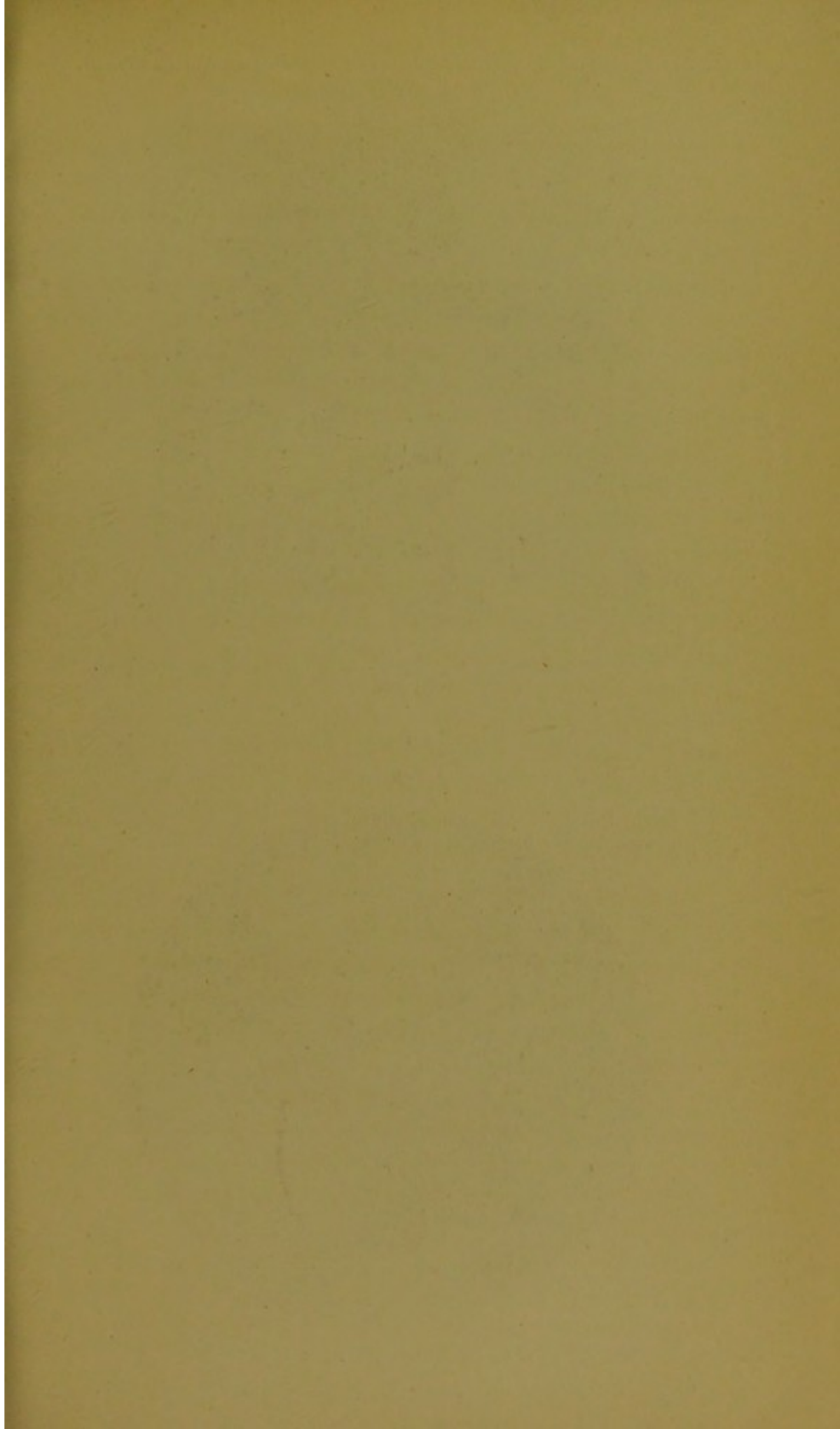
The bacillus thus obtained produced abundant indol in broth after forty-eight hours' growth. It clotted milk in twenty-four hours with an acid reaction. On agar streak-cultivations an opalescent moist growth was seen. Gelatin was not liquefied, but a spreading flat growth was produced with crenate edges. The colonies on gelatin plates were quite typical. Abundant gas was produced in gelatin shake-cultures. Young agar-cultures gave fairly motile bacilli possessing from four to eight flagella when stained by Pitfield's or McCrorie's method.

The organism possessed a marked virulence.

1. A guinea-pig weighing about 500 grams was inoculated intraperitoneally with 1 c.c. of a twenty-four hours old broth-culture. It was dead next day and typical colon bacilli were found in large numbers in the blood in the heart, the spleen, and peritoneal fluid.

2. A guinea-pig was inoculated intraperitoneally with .006 grams of a twenty-four hours old agar-cultivation, and died at the end of twenty hours. The bacillus coli communis was found in large numbers in the blood in the heart, the spleen, and peritoneal fluid.

3. A rabbit weighing about 1500 grams was inoculated intraperitoneally with 1 c.c. of a twenty-four hours old broth culture of the organism, and died the next day. The bacillus coli



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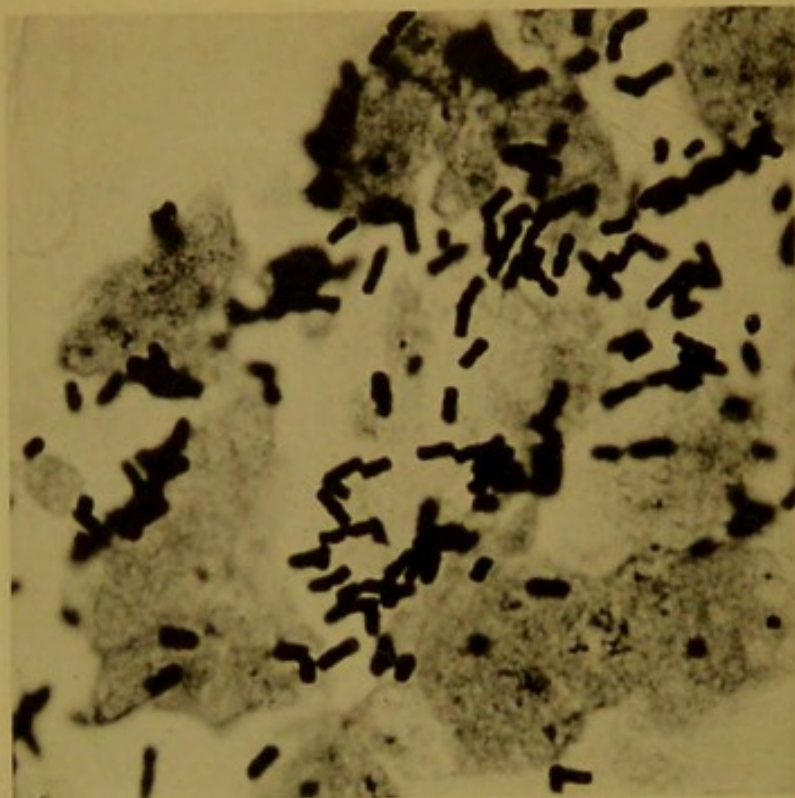


FIG. 3.—Section of Liver, similar to fig. 2, but more highly magnified.
× 1,000.

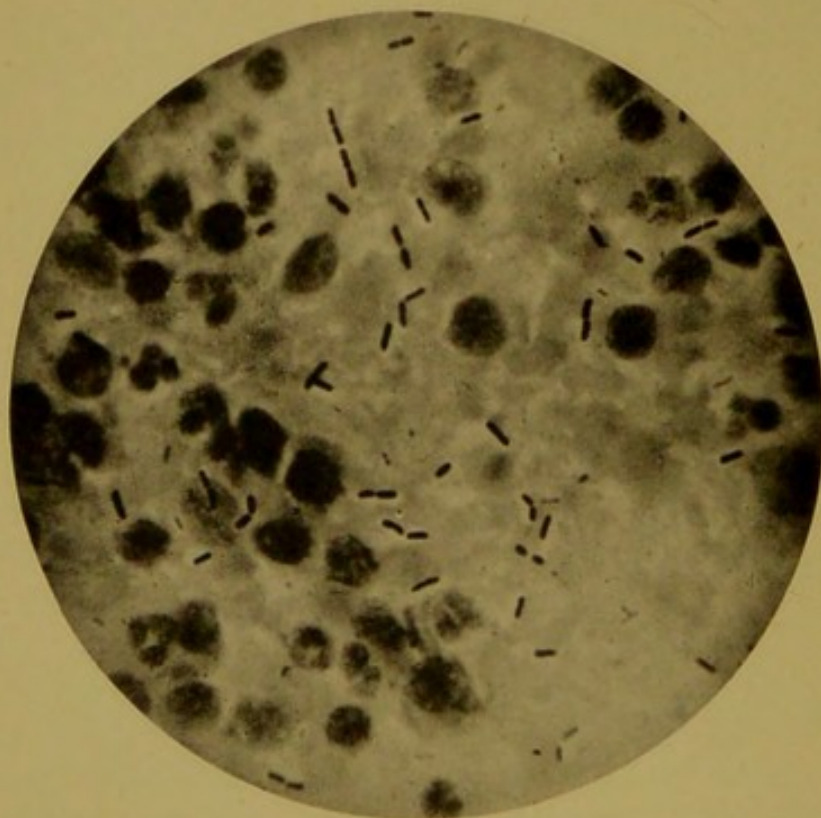


FIG. 4.—A Spleen Rub. × 600.

E. C. BONSFIELD, Fecit.

communis was found in the blood in the heart, the spleen and peritoneal fluid.

4. A rabbit weighing about 1600 grams was inoculated intraperitoneally with about .006 grams of a twenty-four hours old agar-culture. It died the next day, and the bacillus coli communis was found in the blood in the heart.

5. A guinea-pig weighing about 500 grams was inoculated subcutaneously with a bacillus coli communis obtained from normal fæces. An abscess containing bacillus coli communis was found at the seat of inoculation. The abscess was opened, and the animal got well. It was then inoculated intraperitoneally with .006 grams of a twenty-four hours old agar-culture of the organism obtained from the heart-blood of guinea-pig No. 2. On the following day it was very ill, but in three days it had recovered. About a fortnight later it was killed. No bacillus coli communis could be found in the blood in the heart, the spleen, or liver, but a few were found in the peritoneal fluid.

It will be seen from the above description of the histological appearances of the affected organs, and the results of the bacteriological examination, that our case was due to the bacillus coli communis. We have not been able to find a similar case amongst the literature on the subject which has been definitely proved to be due to this micro-organism alone.

I.—CASE IN WHICH THE BACILLUS COLI COMMUNIS WAS PROBABLY PRESENT.

CASE 2.—A somewhat similar case has been described by L. Heydenreich, but no bacteriological examination was made and the liver was the only organ affected.

A soldier suffering from typhoid fever died of cardiac failure in the third week of the disease. Clinically it was only a severe case of typhoid fever without complications. There were no signs pointing to any disease of the liver. At the autopsy, extensive ulceration of the lower part of the ileum was found, the mesenteric glands were swollen and the spleen was enlarged, the kidneys hyperæmic, and the lower lobes of the lungs oedematous and in a condition of hypostatic congestion.

The liver was only slightly enlarged; on section it resembled in appearance a section of black bread. Numerous small round or oval cavities, varying in size from a poppy-seed to a pea, were found scattered throughout its substance. The microscope showed still smaller cavities. The capsule was normal, the parenchyma was coffee-brown in colour, and no definite lobulation could be distinguished; the section was smooth, moist, shiny, and slightly hyperæmic; pieces of it floated in water. Microscopic examination showed that the cavities were usually surrounded by well-defined vessel

walls, some showed a thin, scarcely visible, membrane, whilst others were surrounded by connective tissue and partly by cells, and others by liver cells alone.

These former conditions the author explains by the supposition that the cavities originated in the capillaries, whose thin walls remained or burst, and that others without a membrane originated outside the vessel walls.

The liver walls were swollen, cloudy, slightly granular, with indistinct nuclei which were difficult to stain; some of the cells contained hæmatin granules and others showed signs of fatty degeneration. Sections treated with gentian violet and picric acid showed the tissues stained a yellow colour and numerous short regular bacilli stained a dark violet, these latter were seen to be congregated in enormous numbers at the peripheries of the cavities, around which they formed a kind of wreath, generally complete but here and there massed together. In some parts of the section clumps of bacilli were seen in the tissues without corresponding cavities or with small commencing microscopic cavities in the centre or at the end of the masses. No cavities were found without bacilli around them. In places clumps of bacilli were seen actually in the cavities. All these micro-organisms resembled typhoid bacilli in form and size but not in their staining properties.

The fact that the bacillus stained so well, and the very free production of gas, led to the assumption that it was the *bacillus coli communis*, or a nearly derived from the intestinal canal.

It was thought that the condition was most unlikely to have been an ante-mortem change, partly on account of the absence of any sign of hyperplasia, proliferation of connective tissue, irritation or inflammation, and partly from the fact that no objective symptoms during life, such as pain, jaundice or evidence of portal obstruction had been noticed.

In favour of the change being a post-mortem one was the time after death of the autopsy, viz., twenty-eight to thirty hours, and the temperature of the room in which the corpse had been during this time, viz., 18° to 20° C.

In this case the liver was the only organ affected, and that was put down to the fact that the liver contains a considerable amount of glycogen and sugar and that the *bacillus coli communis* in particular has the property of producing gas from glucose.

Gœbel describes two cases in which the *bacillus coli communis* was found but not in pure culture, as will be seen below.

II.—CASES IN WHICH THE *BACILLUS AEROGENES CAPSULATUS* WAS FOUND.

CASE 3.—The micro-organism which has most frequently been found associated with this condition is the *bacillus aerogenes capsulatus*, first described by Welch and Nuttall in 1892, and obtained from the emphysematous tissues and blood of a man who died of aneurysm of the aorta, which had perforated by a small opening through the anterior thoracic wall, and given rise to repeated external hæmorrhages. No subcutaneous emphysema was noticed before death. The autopsy was performed in cool weather, eight hours after death. There was no evidence of post-mortem decomposition, or of emphysema of the subcutaneous tissues of the body. The blood vessels and heart contained abundant gas. The blood was lake coloured, and the endocardium of the heart and the intima of the blood vessels were deeply stained. Gas was also found in the blood-stained serum in the pericardial sac and in the peritoneum. Gas bubbles were present in

the myocardium, liver, spleen and kidneys, and in the ante-mortem thrombus in the aneurysmal sac. The gas burned with a bluish, almost colourless flame, a slight detonation being heard at the time of ignition.

Frozen sections of the fresh liver showed the small cavities, visible to the naked eye, to be surrounded by liver cells, much disintegrated and in a state of fatty degeneration. Bacilli were present throughout the liver, but were by far most abundant in and near the small cavities.

Cultivations from the blood and tissues resulted in the growth of a strict anaerobic bacillus (*Bacillus aerogenes capsulatus*). No aerobic organism grew.

CASE 4.—Graham, Steward, and Baldwin report the case of a married woman, *æt.* 35, who was perfectly well until fourteen hours before death, when she was seized with a severe chill, which lasted more than four hours, and was followed by a pain in the region of the uterus and ovaries, and by vomiting and purging. She was seen five hours after the onset, and was then found to be restless, and to be suffering from pain in the lower abdominal region, and with a slight flow of bright red blood from her uterus. She was conscious and talked up to three minutes before death, which was sudden. An hour after death the body was found to be emphysematous all over.

The autopsy was performed twenty-four hours after death. The uterus gave evidence of a recent abortion. The vessels, tissues and organs of the body were enormously distended with gas, which ignited with an explosive sound, and was determined by chemical examination to be hydrogen. Bacilli were obtained from the blood in very large numbers, and were identified as the *Bacillus aerogenes capsulatus*. This case certainly shows the ante-mortem invasion of the micro-organism at least in the subcutaneous tissues. The uterine lesion would suggest this organ as the probable point of invasion.

CASE 5.—P. Ernst reports the case of a woman who developed putrid endometritis and septic peritonitis after the removal of a macerated four months foetus. No development of gas was noticed in the tissues during life. At the autopsy, three hours after death, the entire uterine wall crepitated. Coagula in the right iliac vein and conus pulmonalis contained gas. Gas was also found in the liver and myocardium.

CASE 6.—The liver was similarly affected in another case, the autopsy on which was made eighteen hours after death. The cause of death was peritonitis resulting from traumatic perforation of the intestine in a hernial sac. The patient died four hours after a hernio-laparotomy. Green discoloration of the liver, and other parts, indicated post-mortem decomposition. Gas was found in the liver, and gas blebs in the intestinal mucosa.

Microscopical examination of the liver showed a disappearance of the nuclei and degenerative changes around masses of bacilli. The bacillus found and cultivated was the *Bacillus aerogenes capsulatus*.

Goebel reports three cases, in all of which the *Bacillus aerogenes capsulatus* was found.

CASE 7.—1. This was a case of pyelonephritis, secondary to papilloma of the bladder and abscess of the prostate and seminal vesicles. Gas blebs were found in the myocardium, liver, spleen, adrenals and stomach. Around many, but not all, of the blebs in the heart and liver, the cells were necrotic. Necroses were not present in the spleen around the gas holes.

The *Bacillus aerogenes capsulatus*, streptococci, and the *Bacillus coli communis* were found.

CASE 8.—2. A case of enlarged prostate, which had been catheterised. General arteriosclerosis, pulmonary emphysema, lobular pneumonia and embolism of branches of the pulmonary arteries were found, in addition to gas blebs beneath the mucous membrane of the urinary bladder. Necroses were absent from the walls of these blebs. The bacillus aerogenes capsulatus was found; no other micro-organisms were described.

CASE 9.—3. A case of pyæmia, following endo-phlebitis of the cutaneous veins of the left foot. Gas blebs were found beneath the gastric and intestinal mucosa, and necroses were present in the neighbourhood of the blebs. The bacillus aerogenes capsulatus, the staphylococcus pyogenes aureus, and the bacillus coli communis were found.

Gœbel's general conclusion was that the bacillus aerogenes capsulatus of Welch and Nuttall, and the bacillus emphysematosus of Fraenkel were identical.

CASE 10.—Williams (Welch and Flexner's paper). A case of pyonephrosis. At the autopsy thirty-one hours after death the pelvis, calices, and ureters of both kidneys were dilated and filled with pus. Many small gas-containing cavities were found in the liver and myocardium. (Schaumleber.)

Cultures of the bacillus aerogenes capsulatus were obtained from the liver.

CASE 11.—(Case 21, Welch and Flexner's paper.) A negro, æt. 51, who for eleven years whilst in the epileptic ward of Bay View Asylum, Baltimore, used to have one or two attacks daily. On June 3rd he was in his usual health. At 5 a.m., on June 4th, he was found unconscious in bed; bubbles of reddish froth were seen to be issuing from his mouth and nose. He died twenty minutes later. An hour after death the body was swollen and emphysematous. Six hours later it was still more swollen. The autopsy was performed twelve hours after death. There was no rigor mortis. The upper part of the body was very swollen, the upper lids were puffed and emphysematous. The tissues of the penis and scrotum were distended with gas. The abdomen was distended and tympanitic. Gas was found in the peritoneal cavity free from putrefactive odour. It burnt with a blue flame and detonated on ignition. The large veins contained gas and the cavities of the heart were distended with blood and gas. Gas bubbles in large numbers were found in the liver and spleen. On section of the kidneys blood mixed with gas exuded from the cut vessels. Gas could be also squeezed from the lungs, and it burnt with a blue flame. The bacillus aerogenes capsulatus was found.

CASE 12.—(Case 22, Welch and Flexner's paper.) A man who died in the third week of typhoid fever. The autopsy was performed eighteen hours after death. No post-mortem decomposition. No emphysema or tympanites at the time of death. At the post-mortem examination emphysema of the neck, chest, axillæ and scrotum was found. The heart and blood-vessels contained gas. The endocardium was stained red. The serous sacs contained gas and blood-stained serum. The mediastinal tissues were emphysematous. The liver and spleen contained small gas cavities but were less distended with gas than the kidneys. There was no perforation or peritonitis. There was typical typhoid ulceration of the intestine. The bacillus aerogenes capsulatus was seen on cover-glass preparations and was obtained by culture.

CASE 13.—(Case 23, Welch and Flexner's paper). A man who died in the second week of typhoid fever. On the day before his death marked tympanites was noticed. The autopsy was performed eight hours after death. There was no odour or discolouration indicating decomposition. There was no swelling of the body. There was some slight emphysematous crackling on the outer side of the forearm below the elbow, on the wrists, and along the outer side of the thigh. There was no gas in the heart, vessels, or any organ except the liver, which was large, pale, and everywhere perforated with small gas holes. The gall-bladder and bile-ducts contained gas. The walls of the gall-bladder and the surrounding connective tissue were emphysematous.

Microscopical examination showed extensive necrosis of the liver. There was no perforation of the intestine. The presence of the bacillus aerogenes capsulatus was shown by microscopical examination, culture and inoculation. In this case it was thought that the gas-forming bacilli invaded the liver by means of the bile-ducts.

CASE 14.—(Adami's case.) A. C., æt. 45, a lumberman. For six years he had suffered from dull aching pains in the loins. He was temperate, and had no other complaint. Four weeks prior to his admission, while drawing wood, he felt a soreness over his whole body. On the following day pain superseded the soreness, and it was so severe that he had to take to his bed. He suffered from chills, his urine became red coloured (bilirubin), and a week before his admission, on April the 9th, he became jaundiced.

Condition on admission. He complained of extreme weakness, but was in no pain. Temperature 102°, pulse 120, respiration 28. The abdomen was pendulous, and it was tender, especially over a small area three inches to the left and five inches above the umbilicus, where an indistinct mass could be felt, which was dull on percussion. There was tenderness in the left groin. The urine contained albumen and bilirubin. The fæces were liquid, and contained blood and pus cells. Soon after admission he vomited coffee-ground material, and the vomiting continued until his death, which occurred five days after his admission.

On the 14th he was in great pain, and was constantly coughing. The abdomen was enlarged and tympanitic, and the tympanitic note could be obtained one and a half inches above the edge of the liver. The blood was examined and showed marked leucocytosis, the red corpuscles did not form rouleaux, and there was well-marked poikilocytosis.

The necropsy was performed twenty-eight hours after death, the body having been in the cold chamber since death. Perforative appendicitis was found, with localised suppurative peritonitis, and suppurative thrombosis of the branches of the superior mesenteric vein, which had spread along other branches and given rise to retroperitoneal abscess. When the abdomen was opened there was an abundant escape of gas. Bubbles of air or gas were noticed in the veins of several of the abdominal viscera. The liver and kidneys floated in water. "The liver was not much above the normal size, and presented rounded edges. Its surface was smooth, with a dark slaty background, mottled over thickly with pale yellowish circular patches 2 to 5 m.m. across. On section, it was extremely emphysematous, and crackled on pressure, and when a lighted match was brought close to the cut surface, and pressure was exerted on the organ, the expelled gas caused a series of explosions. The cut surface had a reddish-brown colour on the

whole, but varied from light red to even a greenish tinge. It exhibited numerous small whitish areas of necrosis, with softened centres, and also numerous sharply-defined bullæ (where the gas had been). These averaged 3 to 5 m.m. across. It was noted that although the mesenteric veins exhibited so extreme a condition of suppurative thrombosis, no thrombi were to be seen in the large vessels of the liver."

The spleen was soft and had an emphysematous feel, but did not present any marked bullæ. The kidneys did not show any marked bullæ, but many whitish areas of necrosis; no abscess formations were found. Large bacilli corresponding in every respect with those described by Welch as the *bacillus aerogenes capsulatus* were found. Sections of the liver, spleen and kidneys showed large colonies of these bacilli. A minute diplococcus was also found on the surface of the media.

Adami looks upon this case as one in which the *bacillus aerogenes capsulatus* commenced to grow before the death of the patient, the development of tympanites the day before death and the localised necrosis in the liver and kidney pointing to an ante-mortem invasion.

CASE 15.—(Jamieson's case.) A. L., a French Canadian, æt. 23, was admitted on April 22nd, 1896, into the Montreal General Hospital. Ten days prior to admission he fell over a wash tub and injured his side and he lost consciousness. Vomiting came on later and lasted for several days. Two days before admission a swelling was noticed in the left side, and he had a severe chill.

Condition on admission. Well nourished. Pulse 84, respiration 24, temperature 98·8°. On the left side a bulging was noticed in the lower thoracic and upper abdominal region; it extended across to the right nipple line and below to the level of the umbilicus. A firm smooth mass was felt in this region, which was dull on percussion. On April 23rd it was aspirated and a few drops of chocolate-coloured fluid were withdrawn, which was found to consist chiefly of blood corpuscles. A diagnosis of hæmatoma with pre-existing kidney disease, was made. The urine contained blood until May 3rd, when it was found to be clear and to contain a trace of albumen. On May 6th he was much worse and was operated on, an incision being made in the left lumbar region. A large amount of gas and dark red putrid fluid was evacuated. The patient died before the end of the operation.

The necropsy was performed twenty-four hours after death. The body was well nourished. The appendix had been removed. "The left kidney was converted into a large sac filled with gas and grumous, fœtid and bloody contents." The sac was over twelve inches in its vertical diameter. The kidney was in a condition of putrid pyonephrosis and perinephritis. The right kidney showed evidence of acute parenchymatous nephritis. The spleen was enlarged and crepitant. The liver presented on its surface "numerous greyish brown circular areas the size of pin points, these are sharply defined and the centres in many appear to contain a minute gas bubble. These rapidly increased in number and size when exposed to the air. On squeezing, a brownish frothy blood abundantly exudes. (Liver floated in preserving fluid, and after a few hours was much distended, with abundant froth about it.)" The gall-bladder contained about a drachm of frothy bile. The heart contained a little froth mixed with blood clots.

A microscopical examination of the liver blood showed the presence of bacilli, with mostly square ends, but some with rounded ends about 3 to 5 μ in length. They occurred mostly in pairs and were surrounded by a clear space. A guinea-pig was inoculated intraperitoneally with 1 c.c. of liver blood, and died in about thirty-six hours, with subsequent rapid gas formation. At the end of twenty-four hours the body was blown up to twice its normal size and the tissues and organs were found to be in an emphysematous condition. The microscopical examination showed bacilli similar in form and size to those found in the liver blood. Anaerobic cultures were taken from the human body on two per cent. glucose agar, and after thirty-six hours a growth with gas-formation was obtained. Bacilli in pure culture were found on microscopical examination, corresponding to the description of the bacillus aerogenes capsulatus.

Williams points out that there was good evidence of an ante-mortem invasion, as was evidenced by the previously dull tumour becoming tympanitic, and the escape of gas which took place at the time of the operation.

CASE 16.—(Hamilton and Yates.) T. S., æt. 22, a student in arts, was admitted on November 7th, 1896, to the Royal Victoria Hospital for spitting of small quantities of blood, and for spots on the body. The illness started on November 2nd, a few bright red spots of the size of a pin's head being noticed about the left ankle. On the 7th he lost large quantities of blood from his nose, mouth and throat.

Condition on admission. Temperature 102.4°, pulse 100, respiration 24. Hæmorrhages were found all over the body. The blood was sterile: red blood corpuscles 4,840,000; white blood corpuscles 6,000; hæmoglobin 87 per cent. He was under observation for five days, and gradually got worse, delirium supervening just before death, which occurred on the morning of November 13th, eleven days after the onset.

The necropsy was performed ten hours after death. There were marked signs of purpura. The coronary vessels were injected with air; there also appeared to be interstitial emphysema. The right auricle was especially distended with gas. Frothy clots were found in the large vessels. The vessels of the lungs were full of air mixed with blood. Very little gas escaped when the abdominal cavity was opened. "The liver floated easily in water; it was friable in places, emphysematous and somewhat spongy at parts. The surface was smooth, except where air bullæ were plainly visible." The vessels of the spleen contained air, and it floated just below the surface of the water. The right kidney floated in water. The bladder contained some frothy urine.

Coverslip preparations and cultures made at the time of the necropsy showed the presence of the bacillus aerogenes capsulatus. The staphylococcus pyogenes aureus was obtained from smear-cultures on agar of the heart, spleen, kidney and liver. A bacillus smaller than the colon bacillus was also obtained from the spleen.

The bacillus aerogenes capsulatus was not considered to be the primary infection.

CASE 17.—Nicholls reported two cases. (1) A woman, æt. 55, who had had cholecystotomy and cholecystenterostomy performed. The autopsy was performed six hours after death. The blood of the heart contained bubbles of gas and the heart-muscle had a parboiled appearance. Spleen 165 grms.,

soft, with tense capsule; on section, soft, with multiple minute hæmorrhages. Frothy blood exuded from the vessels. Frothy blood also exuded from the vessels of the kidneys. The liver was large, and on section it was soft and had a parboiled appearance. Necrotic areas about the size of a pinhead were found and also a few larger abscesses the size of small marbles. On pressure the exuded blood was found to contain gas. Cultures from all the viscera gave the bacillus aerogenes capsulatus. In this case the infection was probably from the intestine into the gall-bladder and then into the liver and other viscera. The gas production in this case was considered to be post-mortem.

CASE 18.—(2) A woman, æt. 53, suffering from strangulated hernia, died under an anæsthetic from inhalation of the gastric contents. The autopsy was performed twenty-seven hours after death. The body was that of a very stout female. Frothy fluid exuded from the nose and mouth. On opening the body the tissues over the sternum crackled and both pus and frothy fluid escaped; gas also escaped from the peritoneal cavity. On the surface of the lungs bubbles of gas could be seen resembling interstitial emphysema. Numerous gas bubbles were seen on the pericardium. The blood in the heart and large vessels contained gas. The spleen weighed 250 grms.; crepitated to the touch; on section, it was pale, soft, and riddled with cavities with ragged walls. The left kidney crepitated to the touch. Liver 3,000 grms.; no crepitation; on section, fatty, pale, and friable; no gas cavities. Microscopical section of the spleen showed numerous cavities and the presence of a large number of large thick bacilli. Section of the kidney showed numerous cavities round which bacilli were massed in large numbers. Anaerobic cultures from the spleen yielded a growth of the bacillus aerogenes capsulatus. Aerobic cultures gave a few staphylococci and a small motile bacillus positive to Gram, liquefying gelatine but not gas producing. In this case the bacillus aerogenes capsulatus may have gained access during life, but development of gas was certainly after death.

III.—CASES IN WHICH THE BACILLUS MALIGNI ŒDEMATIS WAS FOUND.

CASE 19.—Bremer, 1888, described a case as one of malignant œdema. A woman, after abortion, developed emphysematous swelling of her right pectoral region and adjacent areas. The autopsy was performed seventeen hours after death. Extensive gas-development was found in the blood-vessels, tissues, thoracic and abdominal viscera, with an enormous number of bacilli devoid of spores in the uterus, blood, organs and serous cavities. The bacilli resembled the bacillus œdematis maligni. Guinea-pigs inoculated with sero-sanguineous fluid died in twenty-four hours with lesions similar to those produced by the bacillus œdematis maligni.

CASE 20.—Frænkel, in his paper, mentions a case of Wicklein's, in which a micro-organism resembling the bacillus œdematis maligni was found.

IV.—CASES IN WHICH THE BACILLUS WAS NOT IDENTIFIED.

CASE 21.—Frænkel also mentions a case of Rosenbach's in which a spore-forming bacillus was found, but which could not be cultivated.

CASE 22.—(Bond's case.) Man, æt. 73, who died October 2nd, 1896. Autopsy twenty-two hours after death. No bacteriological examination was made. Beneath the capsule of the liver minute cyst-like projections could be seen. On being handled, this viscus imparted a spongy crepitant sensation,

resembling that of lung, and it floated in water. On section it was seen to be riddled with innumerable cavities, varying in size from microscopic ones to others 6 m.m. in diameter. The walls of the cavities had no definite capsules, and were ragged in appearance.

The pericardium over the left ventricle presented an emphysematous appearance, and was crepitant to the touch. There was no frothing of the blood in the heart. There was no gas formation in any of the organs.

Microscopically there was marked fatty degeneration of the cells and the periphery of the lobules. The liver cells and their nuclei stained badly. The air-containing cavities were irregularly distributed, were devoid of any lining membrane, and appeared to have been formed by a mere bursting asunder of the liver parenchyma. No necrosis or small cell infiltration could be seen. Sections stained with methylene blue showed the presence of large numbers of bacilli among the compressed liver-cells bounding the cavities. No bacilli could be seen in any of the larger bile-ducts, branches of the portal vein, or hepatic artery; a few could be seen in the connective tissue of the portal spaces. Considerable areas of liver tissue were found quite free from bacilli.

There was no clinical evidence suggesting the time of invasion of the micro-organism, and no pathological evidence of the point of invasion.

CASE 23.—(Hebb's case.) A woman, æt. 24, was admitted into the Westminster Hospital under Dr. Sturges on April 20th, 1883, for persistent vomiting. She was eight months pregnant, was comatose, and her urine was loaded with albumen. Premature labour was induced by Dr. Potter, and she died on April 27th. The autopsy was performed thirty-six hours after death. The body, with the exception of the lower extremities, was much swollen, partly from œdema and partly from decomposition. The liver weighed fifty-two ounces, and in appearance resembled a sponge; it was soft in consistence, of a dirty-yellow colour, and had a honeycombed appearance from the presence of numerous cystoid interspaces which ramified throughout the hepatic tissue. The kidney was similarly affected, but to a lesser degree.

Microscopical examination showed the blood vessels of the liver to be choked with bacilli, which stained not only with any aniline dye, but also with stain which was supposed to be characteristic of the bacillus tuberculosis.

The case was brought forward to show that this condition of liver was produced by micro-organisms introduced into the body before death.

The perusal of the preceding twenty-three cases leads to the conclusion that more than one organism is responsible for the production of gas in the internal organs of the body. Of sixteen of these cases in which the bacillus aerogenes capsulatus was found in four it was definitely stated that no bacillus coli communis was present. In two the bacillus aerogenes capsulatus was obtained in pure cultivation, and in two the bacillus coli communis was present in conjunction with this organism. In Heydenreich's case the bacillus aerogenes capsulatus appeared

to be absent, whereas the organism present was probably the bacillus coli communis. In our case we are satisfied that the bacillus aerogenes capsulatus was not present, and we feel convinced that the bacillus coli communis which we found in pure cultivation was the cause of the production of gas. In one case the bacillus of malignant œdema appears to have been the cause, and in four cases the organism is either unknown or undetermined.

The distribution of the gas in the body is extremely variable. In two it is described as being universal. The liver was definitely stated to have been affected in fifteen cases, the spleen and kidneys each nine times, the myocardium six times, the intestine and stomach three times, the penis and scrotum, lungs, cavities of the heart each twice, and once the uterus, suprarenals, urinary bladder, skin of the neck, chest and axilla, serous cavities and coronary arteries. It will be seen that the organ most commonly affected is the liver, and although it is not mentioned in all the cases, in one case (18) it is distinctly stated that the liver was not affected.

Accepting that the gas is produced by one of the organisms previously mentioned, is it possible to arrive at any explanation for this production? At first sight the great preponderance of cases which have affected the liver might bear out the suggestion of Heydenreich that the glycogen in the liver was the most important factor; this view, however, is untenable since Case 18 showed no gas in the liver, although the spleen, kidneys, veins and lungs were all emphysematous.

In the majority of cases two kinds of organisms at least have been found. These have included the bacillus aerogenes capsulatus associated with the bacillus coli communis, staphylococci, streptococci, or other organisms not designated. It will be seen that the bacillus aerogenes capsulatus and the bacillus coli communis are both gas producers in artificial media, whereas the other organisms do not produce gas. When either the bacillus aerogenes capsulatus or bacillus coli communis is associated with the other organisms mentioned, it is quite obvious that it is the cause of the gas production. When

the bacillus aerogenes capsulatus and the bacillus coli communis are found together, it seems to us to be quite probable that each will take its share in the formation of the gas.

Adami says, speaking of the bacillus aerogenes capsulatus : "At the same time it is clear that in this, as, if I mistake not, in all cases, the presence of this gas-producing germ was of the nature of a secondary infection, and indeed I am inclined to doubt whether under ordinary conditions the bacillus can grow in the human organism without the simultaneous presence of aerobic microbes."

This cannot, we think, apply to all cases, since, as we have pointed out in two of the cases the bacillus aerogenes capsulatus was the only organism found in the tissues. We conclude therefore that the bacillus aerogenes capsulatus can grow and produce gas in the tissues of the body without being associated with any other organism. This means that under certain circumstances some of the tissues of the body are under anaerobic conditions. This is not to be wondered at, since, during the præ-agonistic stage, great changes are taking place in the tissues, and it is easy to conceive that the organs and tissues may become virtually free from oxygen on account of the greatly impaired blood supply. While agreeing with Adami as to the doubt that the bacillus aerogenes capsulatus can grow in the human organism under ordinary conditions without the simultaneous presence of aerobic microbes, we maintain that the conditions are not ordinary, and therefore his contention is untenable.

We should think that it is very doubtful whether the bacillus aerogenes capsulatus is really a pathogenic organism in the ordinary acceptation of the term. Pathogenicity being, however, a relative term, it may become pathogenic on account of the lowered vitality and resistance of the patient. A similar phenomenon is found with the proteus vulgaris—this organism is not pathogenic to man, but is sometimes found in thrombi which occur in patients who have suffered for some considerable time from a wasting disease.

On the whole we should consider that the invasion is a præ-agonistic one, and that the development of gas in the tissues during life depends upon the length of the præ-agonistic stage.

We think this opinion is borne out when the causes of death in the twenty-three cases are seen :—

- Case 1. Fatty degeneration.
 2. Enteric—third week.
 3. Aneurysm of aorta.
 4. Recent abortion.
 5. Miscarriage of macerated four months' fœtus.
 6. Peritonitis resulting from traumatic perforation of intestine in hernial sac.
 7. Pyelonephritis.
 8. Enlarged prostate, catheterisation.
 9. Pyæmia.
 10. Pyonephrosis.
 11. Epilepsy.
 12. Enteric—third week.
 13. Enteric—second week.
 14. Perforative appendicitis with localised suppurative peritonitis.
 15. Putrid pyonephrosis, acute parenchymatous nephritis.
 16. Purpura.
 17. Cholecystotomy and cholecystenterostomy.
 18. Strangulated hernia.
 19. Abortion.
 20, 21 and 22. Not stated.
 23. Abortion.

It appears to be somewhat strange that in two of the cases at least the bacillus aerogenes capsulatus was found to have invaded the tissues whilst the bacillus coli communis was absent. Nearly all observers agree that the organism which most frequently and most early invades the moribund tissues is the bacillus coli communis. In these two cases, however, strange as it may be, the bacillus coli communis had not gained access to the tissues, although the bacillus aerogenes capsulatus had done so. This cannot be accounted for from the fact that they will not grow in the presence of one another, since, in artificial media, they do so quite readily, at least for one or two generations.

From the analysis of these cases there appears to be a certain relation between the initial disease and the organs affected, *e.g.*, in case 3 the disease was aneurysm of the aorta and the myocardium was affected; cases 4, 5, and 19 were abortions, and

in all three the uterus and veins were affected ; and in two of the cases the distribution was stated to be universal. This is significant on account of the recognised relation between abortion and septicæmia. On the other hand, although Case 18 would be distinctly described as of intestinal origin, it is equally emphatically stated that the liver was not affected.

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