ENTEROBACTERIACEAE

Enterobacteriaceae family contains a large number of genera that are biochemically and genetically related to one another. This group of organisms includes several that cause primary infections of the human gastrointestinal tract. Members of this family are major causes of opportunistic infection (including septicemia, pneumonia, meningitis and urinary tract infections). Examples of genera that cause opportunistic infections are: *Citrobacter*, *Enterobacter*, *Escherichia*, *Hafnia*, *Morganella*, *Providencia* and *Serratia*.

*Escherichia coli* live in the human gut and are usually harmless but some are pathogenic causing diarrhea and other symptoms as a result of ingestion of contaminated food or water. Enteropathogenic *E. coli* (EPEC). Certain serotypes are commonly found associated with infant diarrhea.

Enterotoxigenic *E. coli* (ETEC) produce diarrhea resembling cholera but much milder in degree. They also cause "travelers' diarrhea".

Enteroinvasive *E. coli* (EIEC) produce a dysentery (indistinguishable clinically from shigellosis, see bacillary dysentery).

Enterohemorrhagic *E. coli* (EHEC). These are usually serotype O157:H7. These organisms can produce a hemorrhagic colitis (characterized by bloody and copious diarrhea with few leukocytes in afebrile patients). The organisms can disseminate into the bloodstream producing systemic hemolytic-uremic syndrome (hemolytic anemia, thrombocytopenia and kidney failure) which is often fatal.

The commonest community acquired ("ascending") urinary tract infection is caused by *E. coli*.

*Shigella* (4 species; *S. flexneri*, *S. boydii*, *S. sonnei*, *S. dysenteriae*), all cause bacillary dysentery or shigellosis, (bloody feces associated with intestinal pain). The organism invades the epithelial lining layer but does not penetrate. Usually within 2 to 3 days, dysentery results from bacteria damaging the epithelial layers lining the intestine, often with release of mucus and blood (found in the feces) and attraction of leukocytes (also found in the feces as "pus"). However, watery diarrhea is frequently observed with no evidence of dysentery. Shiga toxin (chromosomally-encoded), which is neurotoxic, enterotoxic and cytotoxic, plays a role.

*Salmonella* infections most often cause vomiting or diarrhea, sometimes severe. In rare cases, Salmonellosis, the common salmonella infection, is caused by a variety of serotypes (most commonly *S. enteritidis*) and is transmitted from contaminated food (such as poultry and eggs). It does not have a human reservoir and usually presents as a gastroenteritis (nausea, vomiting and non-bloodey stools). The disease is usually self-limiting (2 - 5 days). Like *Shigella*, these organisms invade the epithelium and do not produce systemic infection. *Salmonella typhi* is transmitted from a human reservoir or in the water supply (if sanitary conditions are poor) or in contaminated food. It initially invades the intestinal epithelium. The
organisms penetrates (usually within the first week) and passes into the bloodstream where it is disseminated in macrophages. Typical features of a systemic bacterial infection are seen. The Vi (capsular) antigen plays a role in the pathogenesis of typhoid. Antibiotic therapy is essential.

*Yersinia enterocolitica* - the organisms are invasive (usually without systemic spread). Typically the infection is characterized by diarrhea, fever and abdominal pain. *Y. enterocolitica* infections are seen most often in young children. *Y. enterocolitica* can be transmitted by fecal contamination of water or milk by domestic animals or from eating meat products.

*Klebsiella pneumoniae* is often involved in respiratory infections. The organism has a prominent capsule aiding pathogenicity.

*Proteus* is another common cause of urinary tract infection; the organism produces a urease that degrades urea producing an alkaline urine.

**ENTEROBACTERIACEAE - GRAM STAIN**

*Enterobacteriaceae* are Gram-negative, short rods, non-sporulating, facultative anaerobes.

*Escherichia coli*, a Gram-negative bacillus, stained according to Gram stain protocol, the small rods characteristic of this organism.
*Klebsiella pneumoniae* is a Gram-negative, non-motile, encapsulated rod shaped bacterium found in the normal flora of the mouth, skin, and intestines.

**Fig. 3 Shigella flexneri – Gram stain.**

*Shigella* is Gram-negative, nonmotile, nonspore forming, rod-shaped bacteria closely related to *Escherichia coli* and *Salmonella*. The causative agent of human shigellosis, *Shigella* causes disease in primates, but not in other mammals. It is only naturally found in humans and apes. During infection, it typically causes dysentery.

**Fig. 4 Yersinia enterocolitica – Gram stain.**

*Yersinia enterocolitica* is a species of gram-negative coccobacillus-shaped bacterium, belonging to the family *Enterobacteriaceae*. *Y. enterocolitica* infection causes the disease *yersiniosis* which is a zoonotic disease occurring in humans as well as a wide array of animals such as cattle, deer, pigs, and birds.

**Fig. 5 Salmonella typhi – Gram stain.**

*Salmonella typhi* are motile by means of peritrichous flagella. *Salmonella typhi* lives only in humans. Persons with typhoid fever carry the bacteria in their bloodstream and intestinal tract. In addition, a small number of persons, called carriers, recover from typhoid fever but
continue to carry the bacteria. Both ill persons and carriers shed *Salmonella Typhi* in their feces (stool).

![Proteus vulgaris – Gram stain.](image)

*Proteus vulgaris* is Gram-negative bacterium that inhabits the intestinal tracts of humans and animals. It can be found in soil, water, and fecal matter. It is known to cause wound infections and other species of its genera are known to cause urinary tract infections.

**BURRI´S INDIA INK METHOD**
**(CAPSULE VISUALISATION)**

Most bacterial capsules are composed of polysaccharide however some genera produce polypeptide capsules. The polymers which make up the capsule tend to be uncharged and as such they are not easily stained. For this reason we use a negative stain to visualize them. That is, we use a stain which stains the background against which the uncolored capsule can be seen. Burri’s India ink method, uses India ink to color the background and crystal violet (or safranin) to stain the bacterial cell.

**Capsule Stain Procedure**

1. Place a single drop of India ink on a clean microscope slide, adjacent to the frosted edge.
2. Using a flamed loop and sterile technique, remove some *K. pneumoniae* (or the organism you want to stain) from your tube or plate and mix it into the drop of India ink.
3. Place the end of another clean microscope slide at an angle to the end of the slide containing the organism. Spread out the drop out into a film.
4. Allow the film to air dry. DO NOT heat or blot dry! Heat will melt the capsule!
5. Saturate the slide with crystal violet for 1 minute.
6. Rinse the slide gently with water.
7. Allow the slide to air dry. DO NOT heat or blot dry! Heat will melt the capsule!
8. Observe the slide under the microscope.
Burri’s India ink method – results:
The background will be dark.
The bacterial cells will be stained purple.
The capsule (if present) will appear clear against the dark background (Fig. 46).

![Fig. 7 K. pneumoniae - Burri’s India ink method.](image)

**ENTEROBACTERIACEAE - CULTIVATION ON BLOOD AGAR**

Enteric organisms cultivated on blood agar usually reveal large, smooth, shiny, circular, raised colonies which may or may not be hemolytic or pigmented. Proteus species often exhibit swarming.

![Fig. 8 Escherichia coli.](image)

*Escherichia coli* cultivated on blood agar. Colonies are without hemolysis but many strains isolated from infections are beta-hemolytic.
**Fig. 9 Klebsiella pneumoniae.**

Non-hemolytic (gamma-hemolytic), mucous colonies of *Klebsiella pneumoniae* on blood agar.

**Fig. 10 Proteus mirabilis.**

*Proteus mirabilis* on blood agar - for most strains of *P. mirabilis* and *P. vulgaris* is typical their **ability to swarm** (RAUSS phenomenon) over the surfaces of solid cultivation media (the spreading growth covers other organisms in the culture and thus delays their isolation).

**Fig. 11 Salmonella enterica** - non-hemolytic colonies on blood agar.
ENTEROBACTERIACEAE – CULTIVATION ON ENDO AGAR

Endo agar is a differential and slightly selective culture medium for the detection of coliform and other enteric microorganisms. The selectivity of Endo agar is due to the sodium sulfite/basic fuchsin combination which results in the suppression of gram-positive microorganisms. Endo agar is culture medium for the differentiation of lactose fermenters from the nonfermenters. Coliforms ferment the lactose producing pink to rose-red colonies and similar coloration of the medium. The colonies of organisms which do not ferment lactose are colorless to faint pink against the pink background of the medium.

Typical colonial morphology on Endo Agar is as follows:

E. coli........................................pink to rose-red, green metallic sheen
Enterobacter/Klebsiella...............large, mucoid, pink
Proteus......................................colorless to pale pink
Salmonella...............................colorless to pale pink
Shigella....................................colorless to pale pink
Gram-positive bacteria ..........no growth to slight growth

A - Lactose positive colonies of Escherichia coli on Endo agar, metallic sheen.
B - Lactose positive colonies of Klebsiella pneumoniae on Endo agar.
C - Lactose negative colonies of Shigella flexneri on Endo agar.
D - Lactose negative colonies of Salmonella enterica on Endo agar.

Fig. 13 Enterobacteria - growth on Endo agar.
Table 1 Examples of Lactose positive and Lactose negative enterobacteria.

<table>
<thead>
<tr>
<th>GROWTH</th>
<th>INHIBITION OF GROWTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>LACTOSE POSITIVE examples</td>
<td>LACTOSE NEGATIVE examples</td>
</tr>
<tr>
<td>• <em>Escherichia coli</em> (most strains)</td>
<td>• <em>Salmonella enterica ssp. Enterica</em></td>
</tr>
<tr>
<td>• <em>Klebsiella pneumoniae</em></td>
<td>• <em>Shigella spp.</em></td>
</tr>
<tr>
<td>• <em>Entrobacter cloaca</em></td>
<td>• <em>Proteus</em> spp.</td>
</tr>
<tr>
<td></td>
<td>• <em>Citrobacter freundii</em> (some strains)</td>
</tr>
<tr>
<td></td>
<td>• <em>Morganella morganii</em></td>
</tr>
<tr>
<td></td>
<td>• <em>Providencia</em> spp.</td>
</tr>
<tr>
<td></td>
<td>• staphylococci</td>
</tr>
<tr>
<td></td>
<td>• streptococci</td>
</tr>
<tr>
<td></td>
<td>• enterococci</td>
</tr>
</tbody>
</table>

Inhibition of Gram-positive microorganisms is achieved by the sodium sulfite and basic fuchsins contained in the formulation.

**ENTEROBACTERIACEAE – CULTIVATION ON DEOXYCHOLATE CITRATE AGAR**

Deoxycholate Citrate Agar is a selective medium recommended for the isolation of enteric pathogens particularly *Salmonella* and *Shigella* species. This medium is selective for enteric pathogens owing to increased concentrations of both citrate and deoxycholate salts. Sodium deoxycholate at pH 7.3 to 7.5 is inhibitory for gram-positive bacteria. Citrate salts, in the concentration included in the formulation, are inhibitory to gram-positive bacteria and most other normal intestinal organisms. Lactose helps in differentiating enteric bacilli, as lactose fermenters produce red colonies while lactose non-fermenters produce colourless colonies. Coliform bacteria, if present form pink colonies on this medium. The degradation of lactose causes acidification of the medium surrounding the relevant colonies and the pH indicator neutral red changes its colour to red. *Salmonella* and *Shigella* species do not ferment lactose but *Salmonella* may produce H2S, forming colorless colonies with or without black centers (Fig. 53).
**ENTEROBACTERIACEAE:**

**BIOCHEMICAL PROPERTIES - TRIPLE SUGAR IRON AGAR (TSI, HAJN)**

The Triple Sugar-Iron agar test is designed to differentiate among the different groups or genera of the Enterobacteriaceae. To facilitate the observation of carbohydrate utilization patterns, TSI Agar contains three fermentative sugars, lactose and sucrose in 1% concentrations and glucose in 0.1% concentration. Due to the building of acid during fermentation, the pH falls.

The acid base indicator Phenol red is incorporated for detecting carbohydrate fermentation that is indicated by the change in color of the carbohydrate medium from orange red to yellow in the presence of acids. In case of oxidative decarboxylation of peptone, alkaline products are built and the pH rises. This is indicated by the change in colour of the medium from orange red to deep red.

Sodium thiosulfate and ferrous ammonium sulfate present in the medium detects the production of hydrogen sulfide. Sodium Thiosulfate is reduced to hydrogen sulfide, and hydrogen sulfide reacts with an iron salt yielding the typical black iron sulfide. Ferric Ammonium Citrate is the hydrogen sulfide (H₂S) indicator.

**Principle:**
Carbohydrate fermentation is indicated by the production of gas and a change in the colour of the pH indicator from red to yellow. To facilitate the detection of organisms that only ferment glucose, the glucose concentration is one-tenth the concentration of lactose or sucrose.
The meagre amount of acid production in the slant of the tube during glucose fermentation oxidizes rapidly, causing the medium to remain orange red or revert to an alkaline pH. In contrast, the acid reaction (yellow) is maintained in the butt of the tube since it is under lower oxygen tension.

<table>
<thead>
<tr>
<th>Result</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red/Yellow</td>
<td>Glucose fermentation only, peptone catabolized.</td>
</tr>
<tr>
<td>Yellow/Yellow</td>
<td>Glucose and lactose and/or sucrose fermentation.</td>
</tr>
<tr>
<td>Red/Red</td>
<td>No fermentation, Peptone catabolized.</td>
</tr>
<tr>
<td>Yellow/Yellow with bubbles</td>
<td>Glucose and lactose and/or sucrose fermentation, Gas produced.</td>
</tr>
<tr>
<td>Red/Yellow with bubbles</td>
<td>Glucose fermentation only, Gas produced.</td>
</tr>
<tr>
<td>Black precipitate</td>
<td>Glucose fermentation only, Gas produced, H₂S produced.</td>
</tr>
<tr>
<td>Yellow/Yellow with bubbles and black precipitate</td>
<td>Glucose and lactose and/or sucrose fermentation, Gas produced, H₂S produced.</td>
</tr>
<tr>
<td>Red/Yellow with black precipitate</td>
<td>Glucose fermentation only, H₂S produced.</td>
</tr>
<tr>
<td>Yellow/Yellow with black precipitate</td>
<td>Glucose and lactose and/or sucrose fermentation, H₂S produced.</td>
</tr>
</tbody>
</table>

Table 2 Triple Sugar Iron Agar - interpretation of results.
UREASE TEST

This test is used to identify bacteria capable of hydrolyzing urea using the enzyme urease. The hydrolysis of urea forms the weak base, ammonia, as one of its products. This weak base raises the pH of the media above 8.4 and the pH indicator, phenol red, turns from yellow to pink.

![Urease Test](image)

*Proteus mirabilis* is a rapid hydrolyzer of urea (center tube). The tube on the right was inoculated with a urease negative organism and the tube on the far left was uninoculated. *Helicobacter pylori* has urease activity that hydrolyse urea (making so a good environment—NH$_4$—for surviving in acidic environment - stomach).

SIMMON´S CITRATE AGAR

This is a defined medium used to determine if an organism can use citrate as its sole carbon source. It is often used to differentiate between members of *Enterobacteriaceae*. In organisms capable of utilizing citrate, the *enzyme citrase* hydrolyzes citrate into oxaloacetic acid and acetic acid. If CO$_2$ is produced, it reacts with components of the medium to produce an alkaline compound. The alkaline pH turns the pH indicator (bromthymol blue) from green to blue.

![Simmon´s citrate Agar](image)
This is a positive result, the tube on the right is citrate positive. *Klebsiella pneumoniae* and *Proteus mirabilis* are examples of citrate positive organisms. *Escherichia coli* and *Shigella dysenteriae* are citrate negative.

**WIDAL REACTION**

Widal reaction is specific reaction consisting in agglutination of typhoid bacilli when mixed with serum from a patient having typhoid fever or other salmonella infection and constituting a test for the disease. Widal Test is an agglutination test which detects the presence of serum agglutinins (H\textsuperscript{1} and O\textsuperscript{2}) in patients serum with typhoid and paratyphoid fever. When facilities for culturing are not available, the Widal test is the reliable and can be of value in the diagnosis of typhoid fevers in endemic areas. It was developed by Georges Ferdinand Widal in 1896.

The patient’s serum is tested for O and H antibodies (agglutinins) against *Salmonella* antigens.

![Widal Test](image)

**Fig. 18 Widal Test.**

The main principle of widal test is that if homologous antibody is present in patients serum, it will react with antigen in the reagent and gives visible agglutination in the tube. The antigens used in the test are H and O antigens of *Salmonella Typhi*.

The titre of the patient serum using Widal test antigen suspensions is the highest dilution of the serum sample that gives a positive result (Titers are expressed by the denominator only, for example 1:256 is written 256). The sample which shows the titre of 100 or more for O

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\textsuperscript{1} H – flagellar antigen

\textsuperscript{2} O – somatic antigen
agglutinations and 200 or more for H agglutination should be considered as clinically significant (active infection).

Demonstration of 4-fold rise between the two is diagnostic. H agglutination is more reliable than O agglutinin. Agglutinin starts appearing in serum by the end of 1st week with sharp rise in 2nd and 3rd week and the titre remains steady till 4th week after which it declines.

**BACTERIAL SEROTYPING**

**Serotyping (serological typing)** is based on the long-standing observation that microorganisms from the same species can differ in the antigenic determinants expressed on the cell surface. Serotyping is one of the classic tools for epidemiological study and is applied to numerous species that express different serotypes, such as: *Escherichia coli, Salmonella* species, *Shigella* species, *Yersinia*.

Antisera for serotyping (examples):

![Fig. 19 Polyvalent antisera.](image)

Polyvalent antisera to *Escherichia coli* serotypes 026, 055, 086, 0111, 0119, 0125, 0126, 0127, and 0128 for bacterial serotyping.

![Fig. 20 Monovalent antisera.](image)

**Monovalent antiserum** to *Escherichia coli* serotype 0111 for bacterial serotyping.

Where polyvalent and monovalent antisera are available, start by testing agglutination with polyvalent sera, then with the specific monovalent sera corresponding to the mixture giving marked agglutination.
Principle of Bacterial Serotyping test

Antigen-antibody complexes are formed when a bacterial culture is mixed with a specific antiserum directed against bacterial surface components (agglutination). The complexes are usually visible to the naked eye which allows for easy determination of O and H antigens by slide agglutination. After full serotyping of the Salmonella culture the name of the serotype can be determined by using the Kauffmann-White Scheme

Slide Agglutination – Procedure

The slide agglutination test is done on a glass slide and read with the naked eye in front of a light source against a black background.
1. Add a small drop of antiserum on a glass slide and mix it with the Salmonella culture.
2. Tilt the slide for 5 - 10 seconds.
3. A positive reaction is seen as visible agglutination (Fig. 60 – left), whereas a negative reaction is seen as homogeneous milky turbidity (Fig. 60 – right).

Fig. 21 Serotyping - Slide Agglutination.

ENTEROTEST - PRINCIPLE

The final identification of enterobacteriaceae studies the phenotypical demonstration of those biochemical properties, which are specific for the individual pathogens. Enterotest is a system that permits the differentiation of Enterobacteriaceae by several simultaneous biochemical reactions. Microorganisms are identified by colour change after 18 - 24 hours of incubation at 35 ± 2°C (according to Colour Scale for ENTEROtest 16) (Fig. 60).

Fig. 22 ENTEROtest 16.
Group of biochemical tests aligned that they allow numeric identification based on statistical probability of the result of one test. In the positive result the well is attributed the cipher according to the position in the triplet (1, 2 or 4).

Addition of ciphers in triplet gives the number and each result of the triplet gives a subsequent one position of the code that is the combination of numbers of tested triplets. This code is corresponding to one bacteria (526663 – *Serratia marcescens*). For the identification use the differentiation table, or the Code book or the Identification programme.

**SOURCES:**


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http://himedialabs.com/TD/M065.pdf
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CAMPYLOBACTER, HELICOBACTER

These two groups of Gram-negative organisms are both curved or spiral shaped and are genetically related.

CAMPYLOBACTER JEJUNI

Campylobacteriosis is one of the commonest bacterial disease causing diarrhea. The organism infects the intestinal tract of several animal species (including cattle and sheep) and is a major cause of cause of abortions. It is transmitted to man in milk and meat products. The organism is invasive but generally less so than Shigella. The sites of tissue injury include the jejunum, the ileum, and the colon. ³C. jejuni appears to achieve this by invading and destroying epithelial cells. Bacteremia is observed in a small minority of cases. Treatment with antibiotics, therefore, depends on the severity of symptoms. Erythromycin can be used in children, and tetracycline in adults. Quinolones are effective if the organism is sensitive. Trimethoprim/sulfamethoxazole and ampicillin are ineffective against Campylobacter.

CAMPYLOBACTER - GRAM STAIN

Campylobacter jejuni is a small spiral/curved (“seagull-shaped”) non-spore forming, Gram-negative pathogen (0.2-0.5 μm), stain very lightly with carbolfuchsin.

Fig. 23 Campylobacter jejuni.

CAMPYLOBACTER - CULTIVATION

Campylobacter infection is diagnosed when a culture of a stool specimen yields the bacterium. Campylobacter jejuni are oxygen sensitive and can grow only under conditions of reduced oxygen tension and grows best at 42°C. They have a single polar flagellum at one

³ C - Campylobacter
or both ends of the cell. It is frequently isolated using selective media. It is also, catalase, oxidase and H₂S positive.

![Fig. 24 Campylobacter jejuni - colonies.](image)

Colonies of *C. jejuni* are small, nonhemolytic, mucoid, usually grayish, and flat with irregular edges. Campylobacter CSM Agar (Charcoal-Based Selective Medium) is a blood free selective medium for the primary isolation of *Campylobacter* species from human fecal specimens (Fig. 61).

**HELICOBACTER PYLORI**

Approximately one-half of the world’s population is estimated to be infected with *Helicobacter pylori* (*H. pylori*), a Gram-negative, curved bacterial rod, which has been associated with symptoms ranging from peptic ulcer disease and dyspepsia to gastric adenocarcinoma and mucosa-associated lymphoid tissue (MALT) lymphoma. Due to the potentially severe consequences of infection, accurate diagnosis and prompt initiation of therapy are important for successful disease resolution.

**HELICOBACTER - GRAM STAIN**

Microscopy of Gram-stained smears – *H. pylori* are curved gram-negative rods. The spiral morphology and flagellar motility assist in penetration into the viscous mucus layer, where the more pH-neutral conditions allow growth of the gastric *Helicobacter* species.

![Fig. 25 Helicobacter pylori - Gram stain.](image)
**HELICOBACTER - CULTIVATION**

Isolation of *H. pylori* by culture of a biopsy specimen is definitive evidence of active infection and isolates can subsequently be tested for susceptibility to various antimicrobial agents.

![Helicobacter pylori - colonies](image)

*H. pylori* can grow on different solid media containing blood or blood products (blood or lysed blood agar plates). *H. pylori* is a fastidious microorganism and requires complex growth media. Often these media are supplemented with blood or serum. These supplements may act as additional sources of nutrients and possibly also protect against the toxic effects of long-chain fatty acids. Commonly used solid media for routine isolation and culture of *H. pylori* consist of Columbia or brucella agar supplemented with either (lysed) horse or sheep blood. A key feature of *H. pylori* is its microaerophilicity, with optimal growth at O₂ levels of 2 to 5% and the additional need of 5 to 10% CO₂ and high humidity. *H. pylori* forms small (1 mm), translucent smooth colonies (Fig. 64).

**UREASE TEST**

Urease test is used for the presumptive evidence of the presence of *Helicobacter pylori* in tissue biopsy material. This is done by placing a portion of crushed tissue biopsy material directly into urease broth.

![Urease test results](image)
A positive urease test is considered presence of *Helicobacter pylori*. Many organisms have a urease enzyme which is able to split urea in the presence of water to release ammonia and carbon dioxide. The ammonia combines with carbon dioxide and water to form ammonium carbonate which turns the medium alkaline, turning the indicator phenol red from its original orange yellow color to bright pink (Fig. 65).

**UREA BREATH TEST**

Urea breath test, a common noninvasive test to detect *Helicobacter pylori* also based on urease activity. This is highly sensitive and specific test.

**Principle of Urea Breath Test:** Patient ingests radioactively labeled (13C) Urea. If infection is present, the urease produced by *Helicobacter pylori* hydrolyzes the urea to form ammonia and labeled bicarbonate that is exhaled as CO₂. The labeled CO₂ is detected either by a scintillation counter or a special spectrometer (Fig. 66).

![Urease Breath Test Principle](image)

**HELICOBACTER HEILMANNII**

The diverse species *Helicobacter heilmannii* was originally designated *Gastrospirillum hominis* and is a *Helicobacter* species with a wide host range. It has been isolated from several domestic and wild animals, including dogs, cats, and nonhuman primates, and is also observed in a small percentage of humans with gastritis.

![Helicobacter heilmannii](image)


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http://thunderhouse4-yuri.blogspot.sk/2013/02/helicobacter-heilmanii.html