= recD) . Hence , recD = b2819 = JW2787 . Note , however , that most databases have their own numbering system , e.g. the EcoGene database uses EG10826 for recD . Finally , ECK numbers are specifically used for alleles in the MG1655 strain of E. coli K @-@ 12 . Complete lists of genes and their synonyms can be obtained from databases such as EcoGene or Uniprot .

= = Proteomics = =

= = = Proteome = = =

Several studies have investigated the proteome of E. coli . By 2006 , 1 @,@ 627 (38 %) of the 4 @,@ 237 open reading frames (ORFs) had been identified experimentally .

= = = Interactome = = =

The interactome of E. coli has been studied by affinity purification and mass spectrometry (AP / MS) and by analyzing the binary interactions among its proteins .

Protein complexes . A 2006 study purified 4 @,@ 339 proteins from cultures of strain K @-@ 12 and found interacting partners for 2 @,@ 667 proteins , many of which had unknown functions at the time . A 2009 study found 5 @,@ 993 interactions between proteins of the same E. coli strain , though these data showed little overlap with those of the 2006 publication .

Binary interactions . Rajagopala et al . (2014) have carried out systematic yeast two @-@ hybrid screens with most E. coli proteins , and found a total of 2 @,@ 234 protein @-@ protein interactions . This study also integrated genetic interactions and protein structures and mapped 458 interactions within 227 protein complexes .

= = Normal microbiota = =

E. coli belongs to a group of bacteria informally known as coliforms that are found in the gastrointestinal tract of warm @-@ blooded animals . E. coli normally colonizes an infant 's gastrointestinal tract within 40 hours of birth , arriving with food or water or from the individuals handling the child . In the bowel , E. coli adheres to the mucus of the large intestine . It is the primary facultative anaerobe of the human gastrointestinal tract . (Facultative anaerobes are organisms that can grow in either the presence or absence of oxygen .) As long as these bacteria do not acquire genetic elements encoding for virulence factors , they remain benign commensals .

= = = Therapeutic use = = =

Nonpathogenic E. coli strain Nissle 1917 , also known as Mutaflor , and E. coli O83 : K24 : H31 (known as Colinfant) are used as probiotic agents in medicine , mainly for the treatment of various gastroenterological diseases , including inflammatory bowel disease .

= = Role in disease = =

Most E. coli strains do not cause disease , but virulent strains can cause gastroenteritis , urinary tract infections , and neonatal meningitis . It can also be characterized by severe abdominal cramps , diarrhea that typically turns bloody within 24 hours , and sometimes fever . In rarer cases , virulent strains are also responsible for bowel necrosis (tissue death) and perforation without progressing to hemolytic @-@ uremic syndrome , peritonitis , mastitis , septicemia , and gram @-@ negative pneumonia .

There is one strain , E.coli # 0157 : H7 , that produces the Shiga toxin (classified as a bioterrorism agent) . This toxin causes premature destruction of the red blood cells , which then clog the body 's

filtering system , the kidneys , causing hemolytic @-@ uremic syndrome (HUS) . This in turn causes strokes due to small clots of blood which lodge in capillaries in the brain . This causes the body parts controlled by this region of the brain not to work properly . In addition , this strain causes the buildup of fluid (since the kidneys do not work) , leading to edema around the lungs and legs and arms . This increase in fluid buildup especially around the lungs impedes the functioning of the heart , causing an increase in blood pressure .

Uropathogenic E. coli (UPEC) is one of the main causes of urinary tract infections . It is part of the normal flora in the gut and can be introduced in many ways . In particular for females , the direction of wiping after defecation (wiping back to front) can lead to fecal contamination of the urogenital orifices . Anal intercourse can also introduce this bacterium into the male urethra , and in switching from anal to vaginal intercourse , the male can also introduce UPEC to the female urogenital system . For more information , see the databases at the end of the article or UPEC pathogenicity .

In May 2011 , one E. coli strain , O104 : H4 , was the subject of a bacterial outbreak that began in Germany . Certain strains of E. coli are a major cause of foodborne illness . The outbreak started when several people in Germany were infected with enterohemorrhagic E. coli (EHEC) bacteria , leading to hemolytic @-@ uremic syndrome (HUS) , a medical emergency that requires urgent treatment . The outbreak did not only concern Germany , but also 11 other countries , including regions in North America . On 30 June 2011 , the German Bundesinstitut für Risikobewertung (BfR) (Federal Institute for Risk Assessment , a federal institute within the German Federal Ministry of Food , Agriculture and Consumer Protection) announced that seeds of fenugreek from Egypt were likely the cause of the EHEC outbreak .

= = = Treatment = = =

The mainstay of treatment is the assessment of dehydration and replacement of fluid and electrolytes . Administration of antibiotics has been shown to shorten the course of illness and duration of excretion of enterotoxigenic E. coli (ETEC) in adults in endemic areas and in traveller ? s diarrhoea , though the rate of resistance to commonly used antibiotics is increasing and they are generally not recommended . The antibiotic used depends upon susceptibility patterns in the particular geographical region . Currently , the antibiotics of choice are fluoroquinolones or azithromycin , with an emerging role for rifaximin . Oral rifaximin , a semisynthetic rifamycin derivative , is an effective and well @-@ tolerated antibacterial for the management of adults with non @-@ invasive traveller ? s diarrhoea . Rifaximin was significantly more effective than placebo and no less effective than ciprofloxacin in reducing the duration of diarrhoea . While rifaximin is effective in patients with E. coli @-@ predominant traveller ? s diarrhoea , it appears ineffective in patients infected with inflammatory or invasive enteropathogens .

= = = Prevention = = =

ETEC is the type of E. coli that most vaccine development efforts are focused on . Antibodies against the LT and major CFs of ETEC provide protection against LT @-@ producing ETEC expressing homologous CFs . Oral inactivated vaccines consisting of toxin antigen and whole cells , i.e. the licensed recombinant cholera B subunit (rCTB) -WC cholera vaccine Dukoral have been developed . There are currently no licensed vaccines for ETEC , though several are in various stages of development . In different trials , the rCTB @-@ WC cholera vaccine provided high (85 ? 100 %) short @-@ term protection . An oral ETEC vaccine candidate consisting of rCTB and formalin inactivated E. coli bacteria expressing major CFs has been shown in clinical trials to be safe , immunogenic , and effective against severe diarrhoea in American travelers but not against ETEC diarrhoea in young children in Egypt . A modified ETEC vaccine consisting of recombinant E. coli strains over expressing the major CFs and a more LT @-@ like hybrid toxoid called LCTBA , are undergoing clinical testing .

Other proven prevention methods for E. coli transmission include handwashing and improved sanitation and drinking water , as transmission occurs through fecal contamination of food and water

supplies .

= = = Causes and risk factors = = =

Working around livestock
Consuming unpasteurized dairy product
Eating undercooked meat
Drinking impure water

= = Model organism in life science research = =

= = = Role in biotechnology = = =

Because of its long history of laboratory culture and ease of manipulation , E. coli plays an important role in modern biological engineering and industrial microbiology . The work of Stanley Norman Cohen and Herbert Boyer in E. coli , using plasmids and restriction enzymes to create recombinant DNA , became a foundation of biotechnology .

E. coli is a very versatile host for the production of heterologous proteins , and various protein expression systems have been developed which allow the production of recombinant proteins in E. coli . Researchers can introduce genes into the microbes using plasmids which permit high level expression of protein , and such protein may be mass @-@ produced in industrial fermentation processes . One of the first useful applications of recombinant DNA technology was the manipulation of E. coli to produce human insulin .

Many proteins previously thought difficult or impossible to be expressed in E. coli in folded form have been successfully expressed in E. coli . For example , proteins with multiple disulphide bonds may be produced in the periplasmic space or in the cytoplasm of mutants rendered sufficiently oxidizing to allow disulphide @-@ bonds to form , while proteins requiring post @-@ translational modification such as glycosylation for stability or function have been expressed using the N @-@ linked glycosylation system of Campylobacter jejuni engineered into E. coli .

Modified E. coli cells have been used in vaccine development , bioremediation , production of biofuels , lighting , and production of immobilised enzymes .

= = = Model organism = = =

E. coli is frequently used as a model organism in microbiology studies . Cultivated strains (e.g. E. coli K12) are well @-@ adapted to the laboratory environment , and , unlike wild @-@ type strains , have lost their ability to thrive in the intestine . Many laboratory strains lose their ability to form biofilms . These features protect wild @-@ type strains from antibodies and other chemical attacks , but require a large expenditure of energy and material resources .

In 1946 , Joshua Lederberg and Edward Tatum first described the phenomenon known as bacterial conjugation using E. coli as a model bacterium , and it remains the primary model to study conjugation . E. coli was an integral part of the first experiments to understand phage genetics , and early researchers , such as Seymour Benzer , used E. coli and phage T4 to understand the topography of gene structure . Prior to Benzer 's research , it was not known whether the gene was a linear structure , or if it had a branching pattern .

E. coli was one of the first organisms to have its genome sequenced ; the complete genome of E. coli K12 was published by Science in 1997 .

By evaluating the possible combination of nanotechnologies with landscape ecology , complex habitat landscapes can be generated with details at the nanoscale . On such synthetic ecosystems , evolutionary experiments with E. coli have been performed to study the spatial biophysics of adaptation in an island biogeography on @-@ chip .

Studies are also being performed attempting to program E. coli to solve complicated mathematics

problems , such as the Hamiltonian path problem .

= = History = =

In 1885 , the German @-@ Austrian pediatrician Theodor Escherich discovered this organism in the feces of healthy individuals . He called it Bacterium coli commune because it is found in the colon . Early classifications of prokaryotes placed these in a handful of genera based on their shape and motility (at that time Ernst Haeckel 's classification of bacteria in the kingdom Monera was in place) .

Bacterium coli was the type species of the now invalid genus Bacterium when it was revealed that the former type species (" Bacterium triloculare ") was missing . Following a revision of Bacterium , it was reclassified as Bacillus coli by Migula in 1895 and later reclassified in the newly created genus Escherichia , named after its original discoverer .

= = = Databases = = =

Bacteriome E. coli interaction database
coliBASE (subset of the comparative genomics database xBASE)
EcoGene (genome database and website dedicated to Escherichia coli K @-@ 12 substrain MG1655)
EcoSal Continually updated Web resource based on the classic ASM Press publication Escherichia coli and Salmonella : Cellular and Molecular Biology
ECODAB The structure of the O @-@ antigens that form the basis of the serological classification of E. coli
Coli Genetic Stock Center Strains and genetic information on E. coli K @-@ 12
EcoCyc ? literature @-@ based curation of the entire genome , and of transcriptional regulation , transporters , and metabolic pathways
PortEco (formerly EcoliHub) ? NIH @-@ funded comprehensive data resource for E. coli K @-@ 12 and its phage , plasmids , and mobile genetic elements
EcoliWiki is the community annotation component of PortEco
RegulonDB RegulonDB is a model of the complex regulation of transcription initiation or regulatory network of the cell E. coli K @-@ 12 .
Uropathogenic Escherichia coli (UPEC)

= = = General databases with E. coli @-@ related information = = =

5S rRNA Database Information on nucleotide sequences of 5S rRNAs and their genes
ACLAME A CLAssification of Mobile genetic Elements
AlignACE Matrices that search for additional binding sites in the E. coli genomic sequence
ArrayExpress Database of functional genomics experiments
ASAP Comprehensive genome information for several enteric bacteria with community annotation
BioGPS Gene portal hub
BRENDA Comprehensive Enzyme Information System
BSGI Bacterial Structural Genomics Initiative
CATH Protein Structure Classification
CBS Genome Atlas
CDD Conserved Domain Database
CIBEX Center for Information Biology Gene Expression Database
COGs
BacDive ? the Bacterial Diversity Metadatabase