

# SCOPE AND HISTORY OF MICROBIOLOGY

## CHAPTER 1



Courtesy Kenneth Ingham

## **Bio 308 General Microbiology**

**Notes and syllabus are on web site:**

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**Text Book: Microbiology- Principles and Explorations**

**Jacquelyn G. Black- 7 or 8<sup>th</sup> edition**

**An Infection, Unnoticed, Turns Unstoppable** For a moment, an emergency room doctor stepped away from the scrum of people working on Rory Staunton, 12, and spoke to his parents. Your son is seriously ill,” the doctor said. How seriously?” Rory’s mother, Orlaith Staunton, asked. The doctor paused. “Gravely ill,” he said. How could that be? Two days earlier, diving for a basketball at his school gym, Rory had cut his arm. He arrived at his pediatrician’s office the next day, Thursday, March 29, vomiting, feverish and with pain in his leg. He was sent to the emergency room at NYU Langone Medical Center. The doctors agreed: He was suffering from an upset stomach and dehydration. He was given fluids, told to take Tylenol, and sent home. Partially camouflaged by ordinary childhood woes, Rory’s condition was, in fact, already dire. Bacteria had gotten into his blood, probably through the cut on his arm. He was sliding into a septic crisis, [an avalanche of immune responses to infection](#) from which he would not escape. **On April 1, three nights after he was sent home from the emergency room, he died in the intensive care unit. The cause was severe septic shock brought on by the infection, hospital records say. Because sepsis, a leading cause of death in hospitals, can at first look like less serious ailments, a campaign to aggressively identify it for early treatment has been undertaken by a consortium of 55 hospitals in the New York region, including NYU Langone.** Yet nowhere along Rory’s journey, from boy with a bellyache on Thursday to gravely ill boy on Friday night, did anyone act on strong indications that he might be fighting for his life. Critical information gathered by his family doctor and during his first visit to NYU Langone was not used, was not at hand or was not viewed as important when decisions were made about his care, records show. Moments after an emergency room doctor ordered Rory’s discharge believing fluids had made him better, his vital signs, recorded while still at the hospital, suggested that he could be seriously ill. Even more pointed signals emerged three hours later, when the Stauntons were at home: the hospital’s laboratory reported that Rory was producing vast quantities of cells that combat bacterial infection, a warning that sepsis could be on the horizon. The Stauntons knew nothing of his weak vital signs or abnormal lab results. “Nobody said anything that night,” Ms. Staunton said. “None of you followed up the next day on that kid, and he’s at home, dying on the couch?” NYU Langone declined to discuss any aspects of Rory’s care or hospital procedures. “Our deepest sympathies go out to the family at this difficult time,” said Lisa Greiner, a hospital spokeswoman. The Stauntons shared Rory’s medical records with a reporter for The New York Times who had met the boy last summer in a social setting. A full airing of the case, along with a commitment to reforms, his parents said, could save lives. They have hired a lawyer, Thomas A. Moore, but have not decided how they will proceed. **The bacteria *Streptococcus pyogenes* is part of the human ecosystem, normally dwelling in the throat or on the skin, areas where the body is well defended. Also known as Group A streptococcus, the strain typically causes strep throat or impetigo.** But if it is able to penetrate soft tissue or blood, “it moves very quickly,” said [Dr. Michael B. Edmond](#), the chairman of the division of infectious diseases at Virginia Commonwealth University. “The mortality rate is high. The clinical findings early in the infection can be relatively subtle.”

**Oregon man bitten by stray cat diagnosed with the plague** PORTLAND, Ore. (AP) — Health officials have confirmed that an Oregon man has the plague after he was bitten while trying to take a dead rodent from the mouth of a stray cat. The unidentified Prineville, Ore., man was in critical condition on Friday. He is suffering from a blood-borne version of the disease that wiped out at least one-third of Europe in the 14th century — that one, the bubonic plague, affects lymph nodes. There is an average of **seven human plague cases in the U.S. each year**. A map maintained by the Centers for Disease Control and Prevention shows that most cases since the 1970s have been in the West, primarily the southwest. The plague bacteria cycles through rodent populations without killing them off; in urban areas, it's transmitted back and forth from rats to fleas. There's even a name for it, the "enzootic cycle." The bacteria thrive in forests, semi-arid areas and grasslands, which plague-carrying rodents from wood rats to rock squirrels call home. Once a coin flip with death, the plague is now easier to handle for humans in the U.S. **The national mortality rate stood at 66 percent before World War II, but advances in antibiotics dropped that rate to its present 16 percent.** "The reality is that, in rural areas, part of the role of cats is to keep the rodent population controlled around our homes and barns" said Karen Yeargain of the Crook County Health Department. The Prineville man, who is in his 50s, remained in critical condition Friday at a Bend hospital. His illness marks the fifth case of plague in Oregon since 1995. State public health veterinarian Dr. Emilio DeBess said the man was infected when he was bitten by the stray his family befriended. The cat died and its body is being sent to the [CDC](#) for testing. DeBess has collected blood samples from two dogs and another cat that lives with the man's family. DeBess also collected blood samples from neighbors' pets and from animals in the local shelter to determine whether the area has a plague problem. More than a dozen people who were in contact with the sick man have been notified and are receiving preventive antibiotics.

# **Chapter 1 Scope and History of Microbiology**

**Microbes have a major impact on human health**

**In 1962, the U.S. Surgeon General, William H. Stewart, stated, “The war against infectious disease has been won.”**

**In the subsequent decades, emerging diseases and increasing antibiotic resistance have made it clear that in reality not only is the war far from won, its outcome is not longer certain**

**The above (1962) is the basic climate that I started my Ph.D. studies in microbiology**

# Roles of Microbes

- Pathogens
- Food chain
  - Autotrophs
  - Decomposers
- Digestive
- Foods and fermentation
- Antibiotics
- Biotechnology
- Bioremediation
- Disease Research

**Microbes help maintain the balance of nature-** mostly microorganisms **decompose releasing nitrogen or breaking down industrial wastes or breaking down cellulose in the digestive tract of grazing animals.**

**Microorganisms are important in many human endeavors:**

**Foods** (fermentation products (a long list that will be dealt with later in the course), **antibiotics, products of genetic engineering, removal of toxic wastes** and on and on. In future years many industrial processes carried out by chemical reactions will be done by bacterial (e.g., plastics).



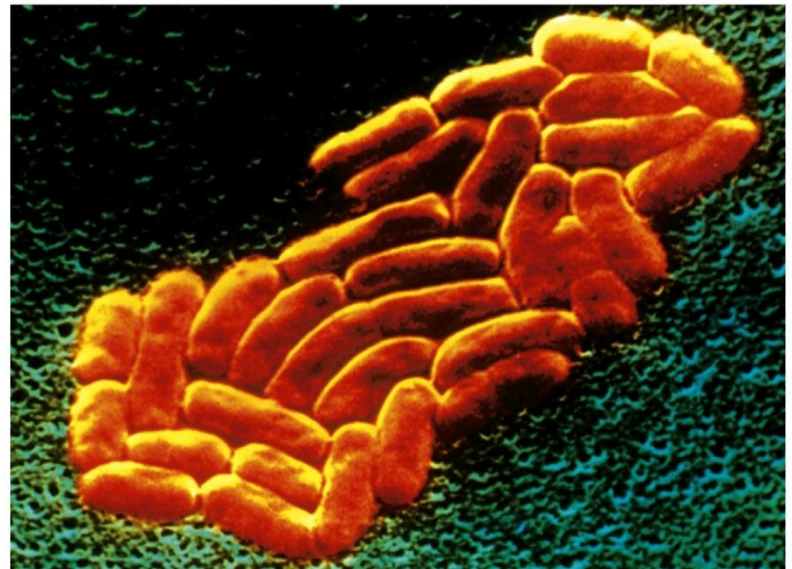
# Roles of Microbes

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# Microbe Types

- Prokaryotes – 2  
Domains/Superkingdoms
- Bacteria
  - Some pathogens
  - Science of Bacteriology
- Archaea
  - Environmental  
extremophiles
  - Novel biochemistry

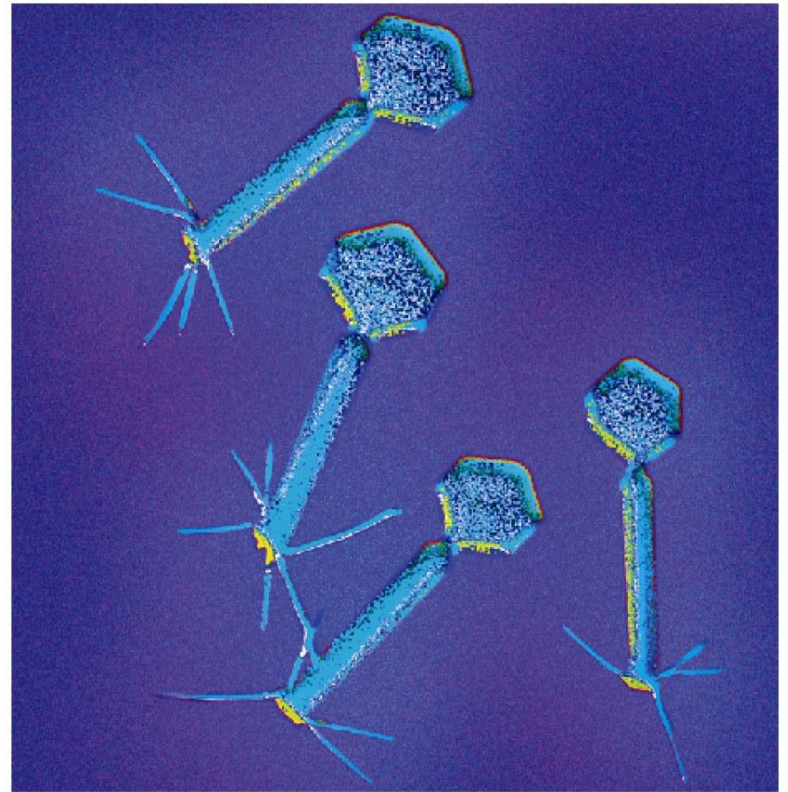


SEM

CNRI/Photo Researchers, Inc.

# Viruses (Acellular)

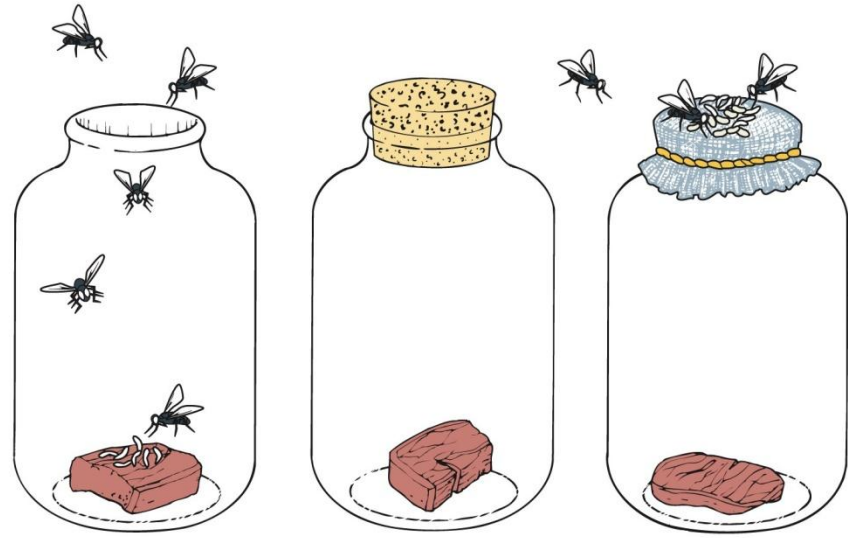
- Simple structure
  - Capsid
  - Nucleic acid
- Obligate intracellular growth
- Science of Virology
- Smaller relatives
  - Viroids
  - Prions



TEM

# Spontaneous Generation versus Biogenesis

- Redi
- Spallanzani
- ? Role of oxygen
- Pasteur
  - Biogenesis wins!
  - Fermentation
  - Pasteurization
  - Rabies vaccine



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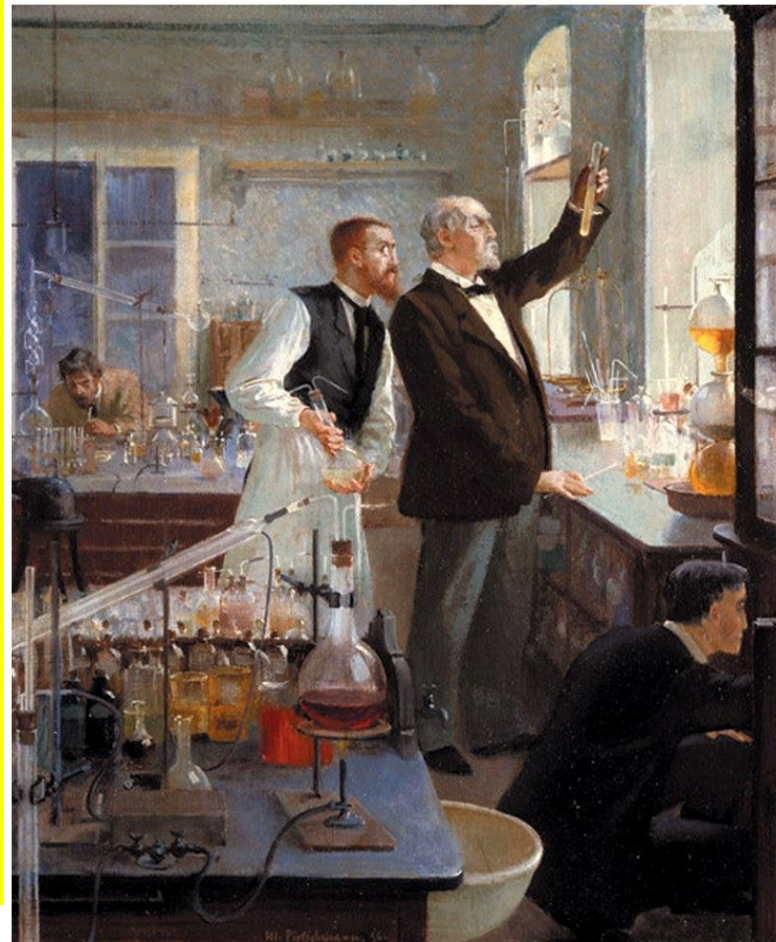


Figure 1-7 Microbiology, 6/e  
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Fig. 1.7 A “swan-necked” flask that Pasteur used in refuting the theory of spontaneous generation

# Germ Theory

- Theory definition
- Koch
  - Culture
  - Postulates
- Semmelweis
- Lister





**Father's age seen as crucial to baby's disease risk** LONDON (Reuters) - **A father's age, not a mother's, when a baby is conceived is the single largest factor in the risk of passing on new gene mutations to children and may help explain why childhood autism rates are rising, scientists said on Wednesday.** In a study which turns conventional thinking on its head, researchers sequenced the genomes of 78 Icelandic families with children diagnosed with autism or schizophrenia and found a father's age was crucial to the genetic risk of such disorders. "Conventional wisdom has been to blame developmental disorders of children on the age of mothers," said Kari Stefansson, chief executive of the private firm deCODE Genetics in Reykjavik, whose work was published in the journal Nature. **"(But) our results all point to the possibility that as a man ages, the number of hereditary mutations in his sperm increases."** He said this age-linked increase in mutations proportionally increased the chance a child might carry a harmful mutation that could lead to conditions like autism and schizophrenia. **"It is the age of fathers that appears to be the real culprit," he added.** Women who conceive later in life are at higher risk of having babies with Down syndrome and other rare chromosomal abnormalities, but Stefansson said his study showed men transmitted far more new gene mutations to children than women. The finding chimes with the results of three American studies published in April which found that spontaneous mutations could occur in a parent's egg or sperm cells that raised the risk of autism, and that fathers were four times more likely than mothers to pass these mutations on.

**CDC: Alarming increase seen in West Nile cases ATLANTA (AP)** — U.S. health officials reported Wednesday **three times the usual number of West Nile cases for this time of year and one expert called it "one of the worst" outbreaks since the virus appeared in this country in 1999. So far, 1,118 illnesses have been reported, about half of them in Texas, according to the Centers for Disease Control and Prevention. In an average year, fewer than 300 cases are reported this early. There have also been 41 deaths. "We're in the midst of one of the largest West Nile outbreaks ever seen in the United States," said Dr. Lyle Petersen, a CDC official. Never before have so many illnesses been reported this early, said Petersen, who oversees the CDC's mosquito-borne illness programs. Most infections are usually reported in August and September, so it's too early to say how bad this year will end up, CDC officials said. They think the mild winter, early spring and very hot summer have fostered breeding of mosquitoes that pick up the virus from birds they bite and then spread it to people.**

**West Nile virus was first reported in the U.S. in 1999 in New York, and gradually spread across the country over the years. It peaked in 2002 and 2003, when severe illnesses reached nearly 3,000 and deaths surpassed 260. Last year was mild with fewer than 700 cases. Only about one in five infected people get sick. One in 150 infected people will develop severe symptoms including neck stiffness, disorientation, coma and paralysis.**

**In recent years, cases have been scattered across the country. Hot spots are usually in southeast Louisiana, central and southern California, and areas around Dallas, Houston, Chicago and Phoenix.**

**Those areas seem to have a combination of factors that include the right kinds of virus-carrying mosquitoes and birds, along with large numbers of people who can be infected, health officials say. The best way to prevent West Nile disease is to avoid mosquito bites. Insect repellents, screens on doors and windows and wearing long sleeves and pants are some of the recommended strategies. Also, empty standing water from buckets, kiddie pools and other places to discourage breeding.**

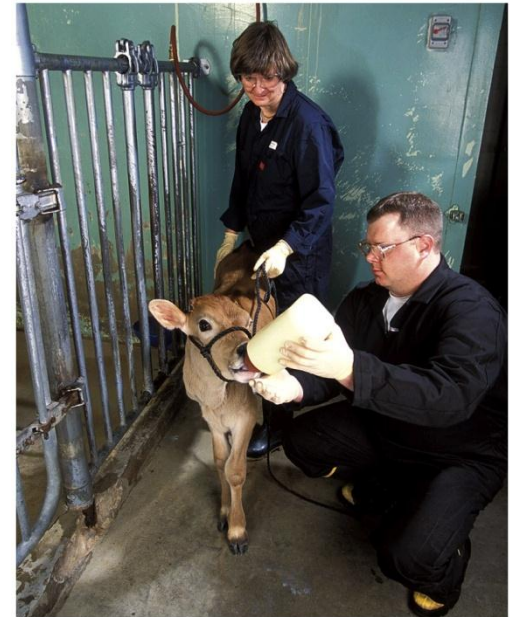


# Fields of Microbiology

- Infection Control
- Chemotherapy
- Industrial Microbiology
- Biotechnology



Peggy Greb/Courtesy USDA



Stephen Ausmus/Courtesy USDA

**THE GERM THEORY OF DISEASE**-microorganisms can invade other organisms and cause disease. Because the prevailing theory of the day was spontaneous generation, i.e., that life forms arise from non-living things, e.g., fruit flies are made from bananas.

Thus, it was difficult for people to believe the germ theory. The demonstration by a number of individuals that life only comes from preexisting life put an end to the idea of spontaneous generation.

It is worthwhile mentioning that spontaneous generation, although totally incorrect, follows Occam's razor ( "All other things being equal, the simplest solution is the best. ").

**Although Occam's razor is a good general idea- It only becomes science when it is testable. In addition to testability science is hypothesis driven.**

**A hypothesis is a tentative explanation to account for an observed condition or event.**

Hence, a **testable hypothesis** is one for which evidence can be collected to support or refute the hypothesis.

In science, a **theory** is a mathematical or logical explanation, or a testable model of the manner of interaction of a set of natural phenomena, capable of predicting future occurrences or observations of the same kind, and capable of being tested through experiment or otherwise falsified through empirical observation. It follows from this that for scientists "theory" and "fact" do not necessarily stand in opposition. For example, it is a fact that an apple dropped on earth has been observed to fall towards the center of the planet, and the theories commonly used to describe and explain this behavior are Newton's theory of universal gravitation (see also gravitation), and general relativity.

**An explanation that cannot be tested is not science.**

**Louis Pasteur, a chemist, is considered as a giant in the history of microbiology. In addition to his contribution to the spontaneous generation/germ theory debate he contributed a great deal to the development of the field of microbiology.**

A. Pasteurization of wine so that pure seed cultures could be used in wine production

B. major contribution to the germ theory of disease in demonstrating that microorganisms caused silk worm disease and Anthrax..

C. He developed a rabies vaccine (and thereby demonstrated the value of vaccination) and on and on.

It is worthwhile mentioning that Pasteur popularized the correct explanation of many things he was not the initial author of any of the above ideas.

**Robert Koch** – developed a method for pure culture. Probably as important as his work on tuberculosis, for which he was awarded a Nobel Prize (1905), are Koch's postulates, which say that *to establish that an organism is the cause of a disease, it must be:*

1) found in all cases of the disease examined, 2) prepared and maintained in a pure culture capable of producing the original infection, 3) even after several generations in culture be retrievable from an inoculated animal and cultured again.

We will visit Koch's postulates again when we discuss disease.

The finding that there are **asymptomatic carriers** of typhoid and cholera made Koch modify the third part of his postulates to be less dogmatic.

# WORK TOWARD CONTROLLING INFECTIONS

1. Ignaz Semmelweis (Devils, Doctors and Drugs is a very interesting biography of Semmelweis). He was an obstetrician who pioneered aseptic technique and died of sepsis.

His trials at trying to popularize the idea that aseptic technique could defeat childbed fever (streptococcal infection that accompanies childbirth) is a classic example of the difficulty in trying to establish a new principle in the medical community.

2. Lister (who was later made a Lord because of his findings) applied carbolic acid (phenol) to aseptic technique in the operating room

3. Domagk- Sulfa drugs- 1939

4. Fleming, Chain and Florey- Penicillin-1945

# Immunology-Milestones

1. Elie Mechnikoff- Cellular Immunology- identified **white blood cells as phagocytic** immune agents of the blood.
2. Edward Jenner- showed that an 8 year old could be protected against small pox by introduction of cowpox virus obtained from the lesions of milk maids that had contracted cowpox. Termed the word vaccination (*vacca*-latin name for cow).
3. Pasteur use a dried spinal cord of rabbits infected with rabies to develop an anti-rabies vaccine. Drying of the spinal cord effectively attenuates (weakens) the virus.
4. Gerald M Edelman and Rodney Porter-for their discoveries concerning the **chemical structure of antibodies- 1972**
5. Cesar Milstein, Georges Kohler and Niels Jerne-for theories concerning the specificity in development and control of the immune system and the discovery of the principle for **production of monoclonal antibodies- 1984**
6. Tonegawa- for his discovery of the genetic principle for generation of **antibody diversity-** Received the Nobel prize in 1987.
7. Doherty and Zinkernagel- Recognition of virus-infected cells by immune defenses. Drs. Doherty and Zinkernagel **discovered that T cells simultaneously recognize MHC self-protein and a foreign antigen** on the surface of virally infected cells. - We will learn about these findings in the immunology part of the course. Received the Nobel prize in 1996.

# Bacterial genetics molecular biology-Nobel Prizes

## The Nobel Prize in Physiology or Medicine 1933

Thomas H. Morgan

The Nobel Prize in Physiology or Medicine 1933

### Thomas H. Morgan



"for his discoveries concerning the role played by the chromosome in heredity"-  
First Nobel Prize in what would become  
Molecular Biology/Molecular Genetics

Morgan was born in Lexington, Kentucky, to Charlton Hunt Morgan and Ellen Key Howard Morgan.<sup>[2][4]</sup> Part of a line of Southern planter elite on his father's side, Morgan was a nephew of Confederate General John Hunt Morgan and his great-grandfather John Wesley Hunt had been the first millionaire west of the Allegheny Mountains. Through his mother, he was the great-grandson of Francis Scott Key, the author of the "Star Spangled Banner", and John Eager Howard, governor and senator from Maryland.<sup>1</sup>



# Bacterial genetics molecular biology-Nobel Prizes

1. Lederberg- **Bacterial Conjugation**- 1959
2. Watson Crick and Wilkins- **Structure of DNA**- 1962
3. Jacob, Lwoff and Monod - **mRNA**-1965
4. Berg- **Recombinant DNA**-1980
6. Smith Nathans and Arber- **Restriction enzymes for cutting DNA**
7. Sharp and Roberts- **Splicing**-1993
8. Prusiner- **Prions**-1997
9. Barry J. Marshall and Robin Warren "for their discovery of the bacterium *Helicobacter pylori* and its role in gastritis and peptic ulcer disease"-2005
11. Craig Mello and Andrew Fire of Stanford University received the Nobel Prize for the discovery of **RNAi**
12. 2007 Mario Capecchi, Sir Martin Evans and Oliver Smithies- for their discoveries of principles for introducing specific gene modifications in mice by the use of **embryonic stem cells**.
13. 2008 Luc Montagnier and Françoise Barré-Sinoussi work on identifying the virus that causes AIDS. Harald Zur Hausen- **human papilloma virus is the major cause of cervical cancer**
14. 2009 Nobel Prize in Chemistry awards Venkatraman Ramakrishnan, Thomas A. Steitz and Ada E. Yonath for having showed **what the ribosome looks like and how it functions at the atomic level. All three have used a method called X-ray crystallography to map the position for each and every one of the hundreds of thousands of atoms that make up the ribosome.**
15. 2010 Robert G. Edwards for the development of ***in vitro* fertilization**
16. **2011 Nobel Prize in Medicine- Bruce Beutler, Jules Hoffman and Ralph Steinman-** *"for their discoveries concerning the activation of innate immunity"* and the other half to Ralph M. Steinman *"for his discovery of the dendritic cell and its role in adaptive immunity"*.