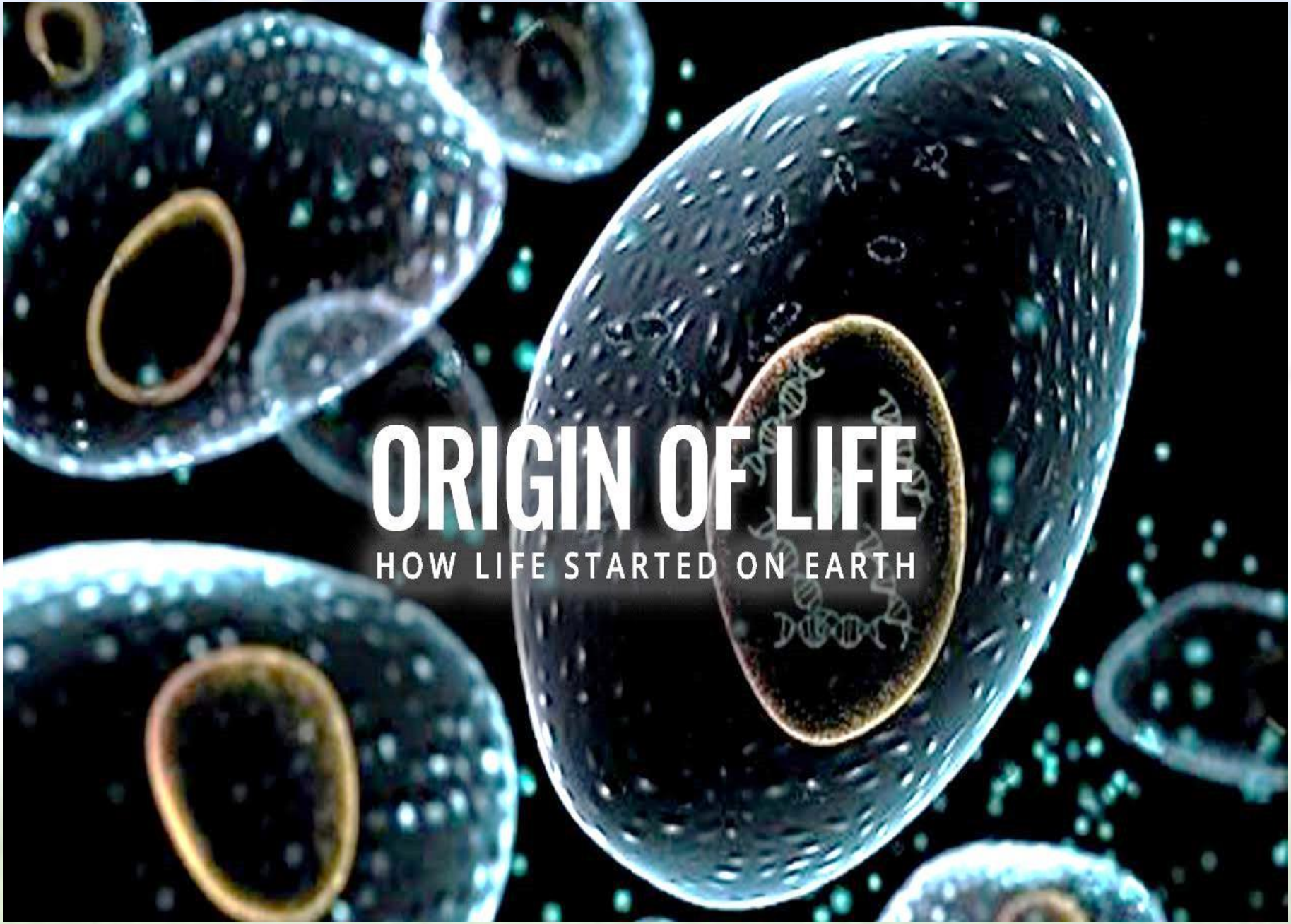
ORIGIN OF LIFE
HOW LIFE STARTED ON EARTH

ORIGIN OF LIFE

Several theories have been put forward about the origin of life (biogenesis).

1. Theory of Spontaneous Generation or Abiogenesis:-
Before the end of 17th century it was held by both scientists & philosophers that **life originated repeatedly from non living materials by spontaneous generation** e.g. it was believed that by larvae were developed from rotten meat and frogs, snakes and crocodiles from mud when warmed by sun.

2. Theory of Special Creation :- Life was created by God. According to Christian belief, God created the universe, plants, animals in six natural days- I Heaven; earth II; Sky and water III; Land and land plants IV; Sun, moon and stars V ; Birds & fishes VI Land animals and humans.

Hindu mythology believes that **the world was created by Brahma-gods, demons and humans from his head, birds from breast, goats from mouths, herbs, fruits and roots from hair.**

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3. Theory of Catastrophism:-It states that there have been several creations, each preceded by a catastrophe due to some geological disturbance. Each catastrophe completely destroyed the life, and each creation consisted of life quite different from that of previous one.

4. Spore (Interplanetary or Cosmozoic) Theory:- Proposed by Richter.

It states that life has reached the earth from some other heavenly body (Planet) in the form of **resistant spores/panspermia** of simple organisms in meteorites. Finding fertile soil here, they grew and then evolved into various existing forms.

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5. Oparin-Haldane Theory/Chemical Evolution :-

"Life always comes from pre-existing life." It is also called theory of protobiogenesis. The theory was proposed by Russian scientist Oparin and British turned Indian scientist Haldane.

Chemical Evolution:-It has following major events:

1. Formation of Inorganic Molecules : With slight lowering of the surface temperature of the earth, the lighter elements interacted to form H_2O, CH_4, NH_3, CO, CO_2, and HCN. Metal carbides, nitrites and oxides also formed on the surface.

Free oxygen disappeared and the environment became reducing. Initially water existed as superheated steam. On cooling it came down as hot water rain but evaporated again. It continued for several centuries till the surface of earth came to have hot water oceans and lakes with a large no: of dissolved salts coming from atmosphere, bottom, shore-line and volcanoes.

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2. Formation of Simple Organic Molecules:

The primitive inorganic molecules later interacted with one another to form simple organic molecules, namely, **sugars, fatty acids, glycerol, amino acids and organic bases (pyrimidines and purines).**

3. Formation of Complex Organic Compounds :-

The small simple organic molecules came together and combined to form large complex biological molecules eg. simple sugar units combined to form :

starch molecule, amino acid units joined to form polypeptides and proteins, fatty acids & glycerol united to form fats, nitrogen bases, sugars & phosphates combined into nucleotides which polymerized into nucleic acids.

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4. Formation of Molecular Aggregates:-

Large organic molecules synthesized abiotically on primitive earth later came together, and, due to intermolecular attraction, formed as colloidal aggregates called **coacervates .**

Biological Evolution :

5. Formation of First Primitive Living Systems:-

Some of the coacervates having DNA and RNAs evolved further. They developed lipoprotein membrane enzyme mediated reactions, own internal enviornment, grow and multiply. They are called eobionts.

6. First Cells/Living Beings :-

Eobionts evolved into first true cells and living being. They were prokaryotic unicells which had naked DNA, protein manufacturing machinery, mode of energy liberation and its utilisation. The first prokaryotes were Anaerobes and chemoheterotrophs.

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- ✓ Some of the early prokaryotes got converted into chemoautotrophs. They developed the ability to synthesize organic materials from reducing inorganic substances of the medium.
- ✓ Certain prokaryotes developed bacterio-chlorophyll and later chlorophyll. The pigment could trap solar energy which could be used in synthesis of organic materials from inorganic substances. The process is called photosynthesis. The first photoautotrophs were anaerobic and performed photosynthesis. **Aerobic photoautotrophs developed around 3300- 3500 million years ago in the form of cyanobacteria.** They performed oxygenic photosynthesis. Oxygen accumulated in the atmosphere. The atmosphere became oxidising.

7. Development of Eukaryotes:-

Eukaryotes evolved around 1600 million years back. They came into existence due to (a) Evolution from prokaryotes through mutations

(b) Symbiotic association of different types of prokaryotes

Evidences of chemical evolution

Miller and Urey Experiment:

- ✓ Stanley L. Miller and Harold C. Urey performed an experiment to describe the origin of life on earth. They were of the idea that the early earth's atmosphere was able to produce amino acids from inorganic matter.
- ✓ The two biologists made **use of methane, water, hydrogen, and ammonia** which they considered were found in the early earth's atmosphere. The chemicals were sealed inside sterile glass tubes and flasks connected together in a loop and circulated inside the apparatus.
- ✓ One flask is half-filled with water and the other flask contains a pair of electrodes. The water vapor was heated and the vapor released was added to the chemical mixture. The released gases circulated around the apparatus imitating the earth's atmosphere.
- ✓ The water in the flask represents the water on the earth's surface and the water vapor is just like the water evaporating from lakes, and seas. The electrodes were used to spark the fire to imitate lightning and storm through water vapor.

Evidences of chemical evolution

- ✓ The vapors were cooled and the water condensed. This condensed water trickles back into the first water flask in a continuous cycle.
- ✓ Miller and Urey examined the cooled water after a week and observed that 10-15% of the carbon was in the form of organic compounds. 2% of carbon had formed 13 amino acids.

Criticism of the Miller Urey Experiment

- ✓ The experiment failed to explain how proteins were responsible for the formation of amino acids. A few scientists have contradicted that the gases used by Miller and Urey are not as abundant as shown in the experiment.
- ✓ They were of the notion that the gases released by the volcanic eruptions such as oxygen, nitrogen, and carbon dioxide make up the atmosphere. Therefore, the results are not reliable.

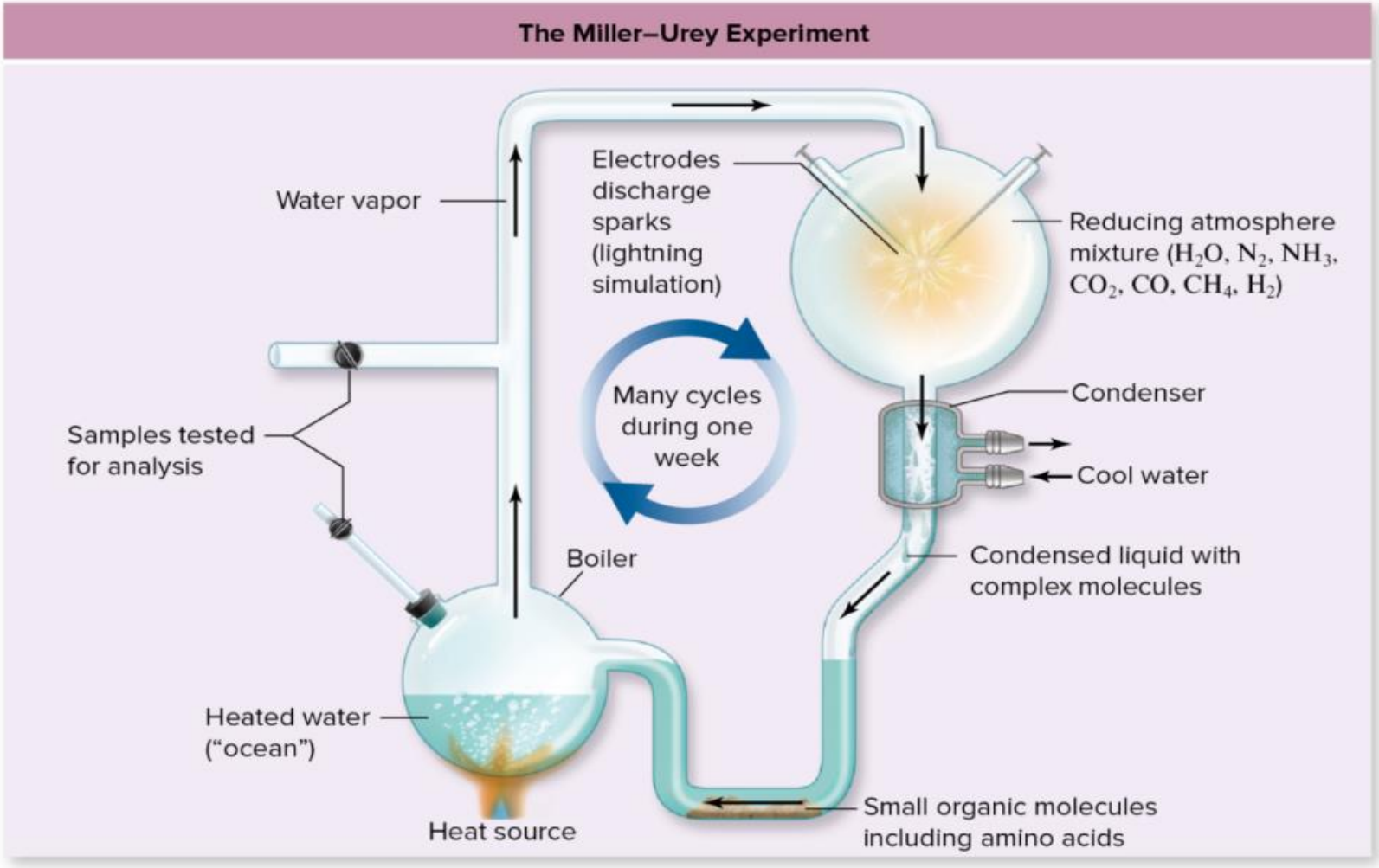

Figure 25.3 The Miller–Urey experiment. The apparatus consisted of a closed tube connecting two chambers. The upper chamber contained a mixture of gases thought to resemble the primitive Earth's atmosphere. Electrodes discharged sparks through this mixture, simulating lightning. Condensers then cooled the gases, causing water droplets to form, which passed into the second heated chamber, the "ocean." Any complex molecules formed in the atmosphere chamber would be dissolved in these droplets and carried to the ocean chamber, from which samples were withdrawn for analysis.

Theories of evolution

- Term evolution was given by **Herbert Spencer**
- Means: **“Unfold and literally means the process of continuous change”.**

Theories of evolution

- ✓ **Lamarckism/ inheritance of Acquired characters**
- ✓ **Darwinism/Natural selection**
- ✓ **Mutation theory of evolution**
- ✓ **Neo-Darwinism/modern concept/ synthetic theory of evolution**

Lamarckism/ inheritance of Acquired characters

- Lamarckism :-It is the first theory of , proposed by Jean Baptiste de Lamarck, a biologist in 1801 and 1809 (in book t organisms Philosophic Zoologique) proposes that organisms undergoes changes for adapting themselves to environment and the characters thus acquired are passed on to the next generation.

This theory can be summarised into four proportions

i) Internal Vital Force-All the living things and their component parts are continually increased (in shape and size) due to internal vital force

(ii) Environmental effect and new needs-Environment influences the organisms and brings about changes in their habits. Thus the new needs produce a new movements in the body that brings about modifications of existing organs and formation of new organs. It is also known as doctrine of desires .

(iii) Use and Disuse of Organs-Constant use of an organ would lead to better developed organ whereas disuse of organ results in its degeneration.

(iv) Inheritance of acquired characters- The traits acquired due to internal vital force, change in environment, new needs, use and disuse of organs are passed on to the next generation. After several generations it gives rise to a new species.

Lamarckism/ inheritance of Acquired characters

Examples-

(i) Giraffe-Long neck and high fore limbs of Giraffe developed due to stretching for obtaining foliage from trees when ground vegetation became sparse.

(ii) Aquatic birds-Stretched their toes and developed webs.

(**iii) Flightless birds**-Ancestors of these birds were capable of flying due to some external factors like food and well protection e.g. ostrich, emu, kiwi.

(iv) Claws of carnivorous mammals: Lions, Cats & dogs are retractile due to fast running & form well adaptation for their carnivorous habits.

(v) Snakes-Lizards are ancestors of snakes. They escape from mammals to live in narrow holes or crevices and in thick jungles.

(v) Deer-Deer became fast runners on the advent of carnivorous mammals by development of limbs and streamlined body.

Lamarckism/ inheritance of Acquired characters

Criticism-(i) Doctrines of internal vital force and desires or expectancy are unscientific.

(ii) Mutations are not inherited e.g. Weisman (1883-1885) removed the tail of mice for generation but their was no reduction in the size.

(iii) Payne 1911 kept Drosophila in dark for generations but could not detect any defect eyes or eye sight.

(iv) The acquired traits not inherited. Every generation has to learn speaking, writing, walking, reading etc.

(v) As found out by Weismann, transmission of traits occur only through germ cells and not somatic cells which come to have acquired characters.

Darwinism/Theory of Natural Selection

Darwinism/Theory of Natural Selection: Charles Darwin (1809-1882) was an English naturalist. He got an opportunity to travel on Beagle for voyage of world exploration.

- ✓ Darwin explored the fauna and flora of number of continents and islands. Later Beagle sailed to Galapagos island where Darwin observed great variations among the organisms that lived on these islands. The common bird of Galapagos Islands, the finches were markedly different from the finches of main land.

Darwinism/Theory of Natural Selection

- ✓ Alfred Russell Wallace investigated the flora and fauna of South East Asia and South America In 1858 he sent his conclusions to Darwin in a paper titled "**On the tendency of varieties to Depart Indefinitely from the original Type."**
- ✓ Darwin published his observations & conclusions under the name **“origin of species”.**

Darwinism/Theory of Natural Selection

Postulates of Natural selections:

1. **Enormous Fertility in Organisms/ production of offspirngs):**

All organisms multiply in geometric ratio, but the population of every species remain more or less constant because space and the available food to them remains constant.

For example, Insects lay hundreds of eggs at a time. Plants produce thousands of seeds.

Darwinism/Theory of Natural Selection

2. Struggle for existence-Due to rapid multiplication, struggle for existence occurs for keeping the organism more or less in the limited number that could survive.

It can be of three types.

(i) **Intraspecific Struggle-** It is the struggle between the individuals of same species because their requirements like food, shelter, breeding places etc. e.g. cannibalism.

(ii) **Interspecific Struggle-**It is the struggle between the members of different species. It normally for food & shelter e.g, fox hunts out a rabbit, while the fox is preyed upon by a tiger,

(iii) **Environmental Struggle-It** is the struggle between the organisms and the environmental factors, such as drought, heavy rains, extreme heat or cold, earth quakes, disease etc.

Darwinism/Theory of Natural Selection

3. Limitation for food and space-The resources of earth are limited. Therefore populations of different species can not increase a certain limit.

4.Variation-No two individuals are exactly alike, not even identical twins The variation in characters between progeny may be advantageous, harmful or neutral (neither harmful nor beneficial).

5. Survival of the Fittest- Nature selects those, provided with more beneficial variation, to survive, while the offspring possessing harmful variations are wiped away from the nature. **Herbert Spencer coined the term survival of the fittest of this process,**

6. Origin of New species-The offspring which survive possesses more variations than their parents and the same is true to succeeding generation.

In course of time, the offspring with accumulation of variation may turn to a new species

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Darwinism/Theory of Natural Selection

ADAPTATIONS/EXAMPLES OF NATURAL SELECTION

- ✓ **Industrial Melanism-**It is the appearance of dark or melanic forms of some organisms like moths in the industrial regions where soot emission from burning of coal has been heavy so as to colour the back ground.
- ✓ Kettlewell,1958 has reported melanic forms of 70 species of moths from Britain and Europe. The of best studied type is Peppered Moth (*Biston betularia*).
- ✓ Prior to industrial revolution the temperate areas had rich lichen flora on tree trunks. Light grey variety of Peppered Moth was abundant as it could hide itself amongst lichens.
- ✓ With industrial revolution, lichens began to disappear and tree trunks became darker.
- ✓ In 1845, *Corbonaria*/melanic or black variety was noticed and by 1895, 99% of Peppered Moth belonged to this variety. In recent periods, where soot emission has decreased (due to control and use of electricity), both lichens and light variety of peppered moth have appeared in large number.

Darwinism/Theory of Natural Selection

2. Resistance to pesticides-

- ✓ In 1945, when DDT was introduced, it was found to be highly effective against household pests, such as mosquitoes, houseflies, body lice etc.
- ✓ Within a few years, populations of mosquitoes and flies were found to be mostly resistant to it.
- ✓ Other pesticides have also caused the development of resistant forms so that there is a constant evolution of newer forms of pesticides and development of resistant varieties later on.

Darwinism/Theory of Natural Selection

3. Sickle cell Anaemia:

Homozygous form Hb^sHb^s is lethal. Even then Heterozygous state Hb^AHb^S persists in certain parts of d world because it has an forms (Hb^A Hb^A) in malearia infected areas. The malarial parasite is unable to enter RBCs of heterozygous individual.

4. Glucose-6-Phosphate Dehydrogenase Deficiency-(Favism)

Beans cause premature destruction of RBC. The deficiency has survival value in malaria infested areas as the parasite is unable in complete schizogony in such RBC, Because haemoglobin becomes denatured and deposited over the erythrocyte membrane.

MUTATION THEORY OF EVOLUTION

- ✓ This theory of evolution was proposed by a Dutch botanist, Hugo de Vries (1848-1935 A.D.) in 1901 A.D. in his book entitled "*Species and Varieties, their origin by Mutation"*.
- ✓ He worked on evening primrose (*Oenothera lamarckiana*) and proposed that new species arises from the pre existing species in a single generation by sudden appearance of marked inheritable difference called mutation.
- ✓ Evolution is a discontinuous and Jerky process in which there is a jump from one species to another and not a gradual process as held by Lamarck & Darwin.

MUTATION THEORY OF EVOLUTION

(1) Experiment: Hugo de Vries cultured *Oenothera lamarckiana* in botanical garden at Amsterdam. The plants were allowed to self pollimate and next generation was obtained. The plants of next generation were again subjected to self pollination to obtain second generation, process was repeated for a number of generations.

(ii) Observations: Majority of plants of first generation were found to be like the parental type and showed only minor variations but 800 out of 50,000 members were found to be very different in characters like flowers, shape and arrangement of buds, size of seeds etc. These markedly different plants were called "elementary species' He also found the numerical chromosomal changes in the variants upto 30 (Normal diploid number is 14).

MUTATION THEORY OF EVOLUTION

iii) Conclusions:

(a) Evolution is a dis-continuous process and occurs by mutation (sudden and inheritable large difference from the normal and are not connected to normal by intermediate forms)

(b) **Mutability** is fundamentally different from fluctuations

(c) **Elementary species** are produced in large number, So as to increase the chances of selection by nature.

MUTATION THEORY OF EVOLUTION

Evidences in favor of Mutation theory:

(a) Appearance of a short-legged sheep in single generations.

(b) Appearance of hornless cattle from horned parent in single generation.

(c) It can explain the inheritance of vestigial and over specialized organs.

Evidences against Mutation theory:

(a) It is not able to explain the phenomena of mimicry and protective coloration.

(b) Rate of mutations is very low i.e. one per living organism.

Neo-Darwinism or Modern concept or synthetic theory of evolution

Neo-Darwinism or Modern concept ar synthetic theory of evolution. Neo Darwinism modified version of theory of Natural selection and is a sort of reconciliation between Darwinism and de Vries theories.

Postulates of Neo-Darwinism

(a) Genetic variability: Variability is opposing force of heredity and is essential for evolution or the variations form the raw material for evolution. Various sources of genetic variability gene pool are:

1. Chromosomal aberrations: These include the morphological changes in the chromosomes without affecting the number of chromosomes. These results changes either in the number of (deletion and duplication) or in the position of genes (inversion).

These are of four types: Deletion ; Duplication; Inversion; Translocation

Neo-Darwinism or Modern concept or synthetic theory of evolution

(2) Numerical Chromosomal change. These includes change in the no. of chromosomes. These may be euploidy (gain or loss of one or more) aneuploidy, may be hypoploidy or hyperploidy, may be monosomy (loss of one chromosome) of genomes. Hyperploidy may be trisomy (gain of one chromosome) or tetrasomy (gain of two chromosome).

(3) Gene Mutation. (Point Mutation) These are invisible changes in chemical nature (DNA) of a gene and are of three types:

- ✓ **Deletion** involves loss of one or more nucleotide pairs.
- ✓ **Addition** involves gain of one or more nucleotide pairs.
- ✓ **Substitution** involves replacement of one or more nucleotide pairs by other base pairs, these may be transition or transversion type.

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Neo-Darwinism or Modern concept or synthetic theory of evolution

(4) Recombination of Genes: Thousands of new combinations of genes are produced due to crossing over, chance arrangement of bivalents at equator during metaphase-I and chance fusion of gametes during fertilization.

(5) Hybridization: It involves the inter-breeding of two genetically different individuals to produce a hybrid.

(6) Genetic drift: It is the elimination of genes of some original characteristics of a species by extreme reduction in a population due to epidemics or migration.

The chances of variations are also increased by random mating

Neo-Darwinism or Modern concept or synthetic theory of evolution

(b) Natural Selection:

- Natural selection of Neo-Darwinism differs from the Darwinism in that it does not operate through "Survival of the fittest" but operates through differential reproduction and comparative reproductive success

(c) Reproductive Isolation:

- Any factor which reduces the chances of inter breeding between the related group of organisms is called an isolating mechanism Reproductive isolation is must so as allow the accumulation of variations leading to speciation by preventing bybridisation. In the absence of reproductive isolation, these variants freely interbreed which lead to inter-ming of their genotypes. So reproductive isolation helps in evolutionary divergences.

Neo-Darwinism or Modern concept or synthetic theory of evolution

There are many forms of reproductive isolation:

(1) Mechanical Isolation: The reproductive isolation is due to difference in the morphology of genitalia, or reproductive organ of the two populations. It is very commonly found in insect species

(2) Geographical Isolation: It is inability of related groups of living organisms to reproduce due to some physical barriers like sea, mountains, deserts etc.

(3) Ecological Isolation: Reproductive isolation due to difference in their habitats e.g. animals found in intertidal zone and below the low tide mark.

(4) Temporal Isolation: Mating inability between the members of related species due to interspecific sterility due to accumulation of the independent gene mutation for structural and functional character.

Gene Pool

Gene Pool: It is the sum total of all genes and their alleles present in a population. New alleles are produced due to mutations. They may spread through natural selection/sexual selection of individual having them. Some alleles may be lost due to emigration or genetic drift.

Genetic Basis of Adaptation

Lederberg's Replica Plating Experiment showed the genetic basis of adaptations in bacteria by culturing bacterial cell.

Lederberg experiment has following steps:

(1) They grew bacteria on an agar plate and obtained a plate having overall bacterial colonies. This plate was called "**Master piece".**

(2) They formed several replicas from this master plate. For this they took a sterilized velvet disc. Mounted on a wooden block, which was gently pressed on the master piece. Some of the bacterial cells from each colony sticked to the velvet cloth.

(3) Now by pressing this velvet on a new agar plates, they obtained exact replicas of the master plate. This is so because the bacterial cell were transferred from one plate to another by the velvet.

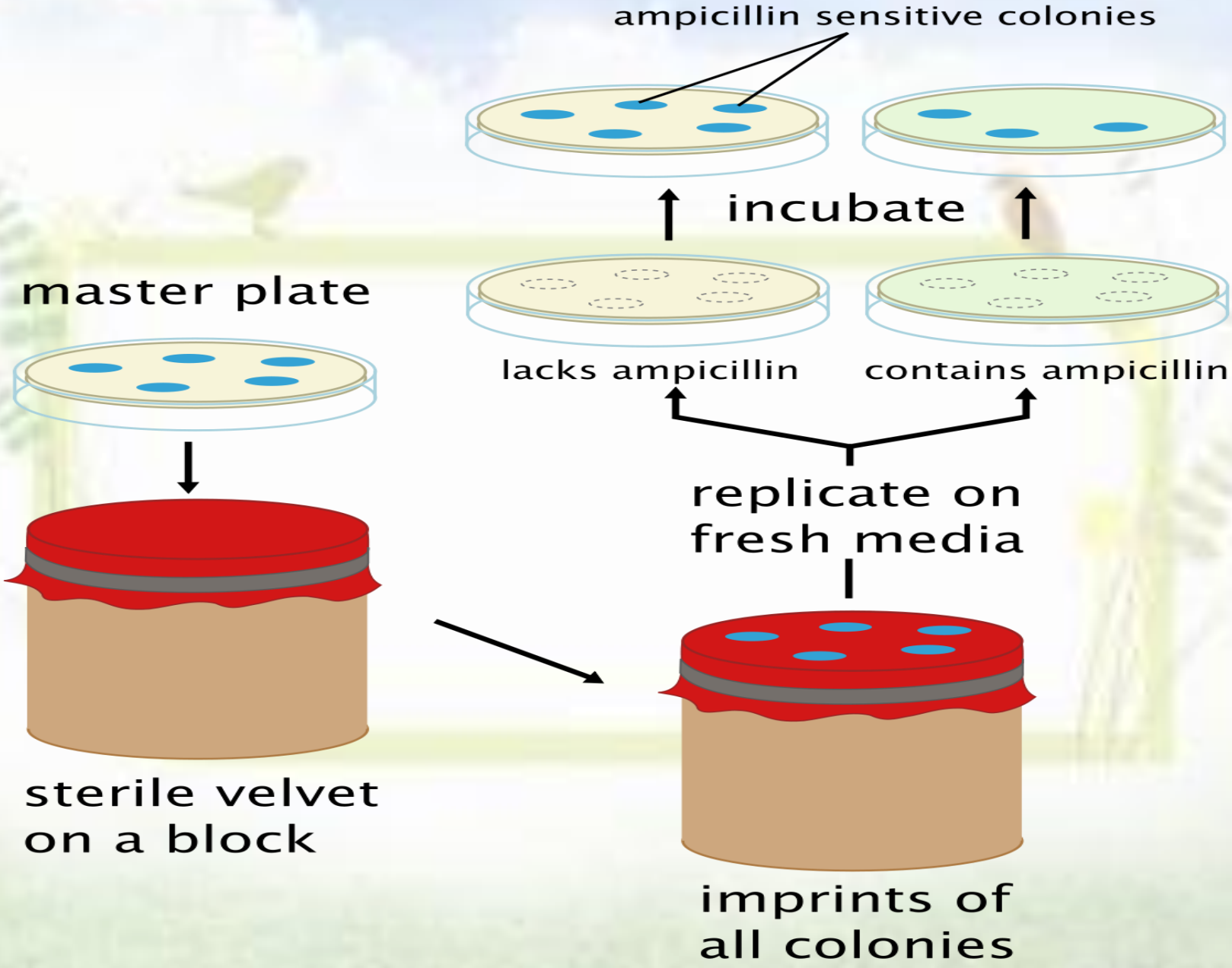
(4) Then they tried to make replicas on the agar plates containing an antibiotic penicillin. A few colonies were able to grow on the agar plate and were said to be penicillin resistant, while other colonies did not grow on antibiotic penicillin medium, were said to be sensitive colonies.

Genetic Basis of Adaptation

Thus, there was an adaptation in some bacterial cells to grow in a medium containing the antibiotic penicillin. This adaptation had developed in certain bacteria by chance gene mutation and not in response to penicillin.

Significance:

Lederberg's replica plating experiment provides a support to Neo-Darwinism and proved that the penicillin- resistance adaptation in the bacterial cells originated due to selection of pre-existing mutant forms of bacteria by nature. Penicillin-resistant bacterial cells had no advantage to multiply in an environment when there was no penicillin.


ampicillin sensitive colonies
incubate
master plate
lacks ampicillin
contains ampicillin
replicate on
fresh media
sterile velvet
on a block
imprints of
all colonies

Speciation

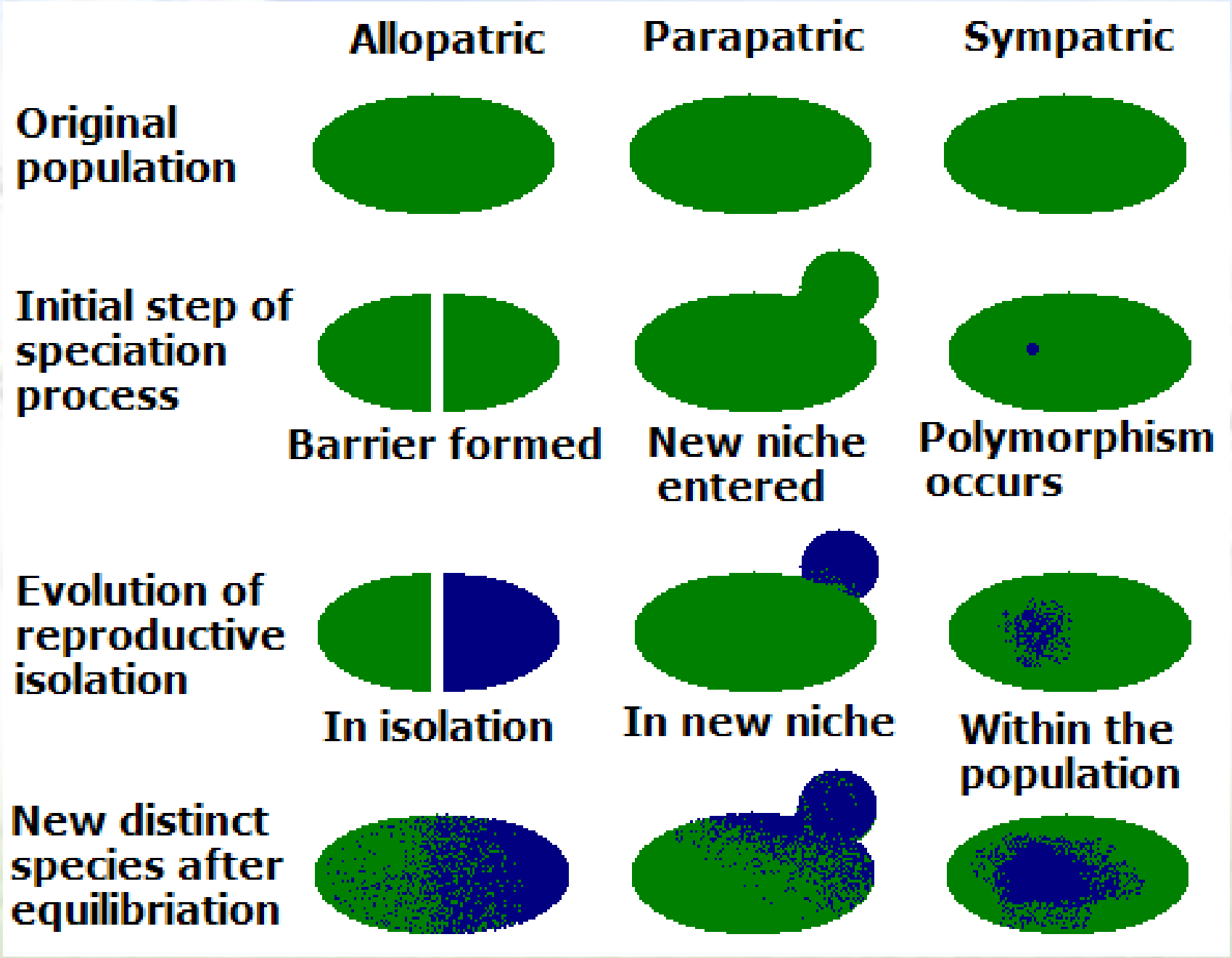
Speciation means origin of new species. A species is defined as a group of individuals having some basic similar characters, distinct from other groups of individuals, interbreeding under natural conditions to produce fertile offspring and showing a common gene pool. Such species are reproductively isolated.

Speciation is of two types:

(1) Allopatric Speciation: When an original population is geographically isolated into two or more groups and the natural selection operates separately within each group. These groups become more and more different and finally become different species. These are called allopatric species.

(2) Sympatric Speciation: The species found within the same geographical area and within an original population are called sympatric species.

(3) Parapatric speciation: New species evolve in contiguous, yet spatially segregated habitats. Parapatric speciation maintain a zone of contact and do not cease the exchange of genes completely.


Allopatric
Parapatric
Sympatric
Original population
Initial step of speciation process
Barrier formed
New niche entered
Polymorphism occurs
Evolution of reproductive isolation
In isolation
In new niche
Within the population
New distinct species after equilibriation

Thank you