Scope: This will enable for learning the basic concepts of life and gradual evolution of human and other animals.

Objective: This paper aims at introducing students to the fundamentals of Evolutionary Biology.

#### UNIT- I

Historical Review of Evolutionary Concept: Pre-Darwinian ideas – List of contributors influencing Darwin indicated as a *timeline*. Lamarckism – Merits and demerits. Darwinism – Merits and demerits, Post-Darwinian era –Modern synthetic theory; biomathematics and the theory of population genetics leading to Neo-Darwinism

#### UNIT-II

Life's Beginnings: Chemogeny – An overview of pre-biotic conditions and events; experimental proofs to abiotic origin of micro- and macro-molecules. Current concept of chemogeny – RNA first hypothesis. Biogeny – Cellular evolution based on proto-cell models (coacervates and proteinoid micro-spheres). Origin of photosynthesis – Evolution of oxygen and ozone buildup. Endosymbiotic theory – Evolution of Eukaryotes from Prokaryotes

#### UNIT-III

**Evidences of Evolution:** Paleobiological – Concept of Stratigraphy and geological timescale; fossil study (types,formation and dating methods). Anatomical – Vestigial organs; Homologous and Analogous organs (concept of parallelism and convergence in evolution). Taxonomic – Transitional forms/evolutionary intermediates; living fossils. Phylogenetic – a) Fossil based – Phylogeny of horse as a model. b) Molecule based – Protein model (Cytochrome C); gene model (Globin gene family)

#### UNIT-IV

Sources of Evolution – Variations as Raw Materials of Change: Types of variations – Continuous and discontinuous; heritable and non-heritable. Causes, classification and contribution to evolution – Gene mutation; chromosomal aberrations; recombination and random assortment (basis of sexual reproduction); gene regulation. Concept of micro- and macro-evolution – A brief comparison

#### UNIT-V

**Forces of Evolution – Qualitative Studies Based on Field Observations:** Natural selection as a guiding force – Its attributes and action Basic characteristics of natural selection. Colouration, camouflage and mimicry, Co-adaptation and co-evolution, Man-made causes of change – Industrial melanism; brief mention of drug, pesticide, antibiotic and herbicide resistance in various organisms. Modes of selection, Polymorphism, Heterosis and Balanced lethal systems. Genetic Drift (Sewall Wright effect) as a stochastic/random force – Its attributes and action. Basic characteristics of drift; selection vs. drift, Bottleneck effect. Founder principle.

#### References

- 1. Ridley, M. (2004). Evolution (3rd ed.). Blackwell.
- 2. Hall, B. K., & Hallgrimson, B. (2008). Strickberger's Evolution (4th ed.). Jones and Barlett
- 3. Zimmer, C., & Emlen, D. J. (2013). Evolution: Making Sense of Life. Roberts & Co.

### Unit I Lecture plan

Sl No	Lecture duration (h)	Topics to be covered	Support material
1	1	Pre-Darwinian ideas	T1, 13
2	1	List of contributors influencing Darwin- indicated in timeline	T1, 17
3	1	Lamarckism- merits and demerits	T1 18
4	1	Darwinism- merits and demerits	T1 19-20
5	1	Post Darwinian era- modern synthetic theory	T1 23
6	1	Biomathematics	T1 39
7	1	Theory of population genetics leading to neo Darwinism	T2 39
8	1	Discussion of important topics	
9	1	Unit Test	
		Total hours for unit 19h	

### References:

- T1: Ridely M (2004) Evolution 3 edition, Blackwell publishers
- T2: Hall BR and Hallgrimsom (2008), Strickbergers evolution (4 edition) Jones Barlett
- R1: Zimmer C and Emler DJ (2013) Evolution, making sense of life Roberts and co

### Unit II Lecture plan

Sl No	Lecture	Topics to be covered	
INO	(h)		material
1	1	An overview of pre-biotic conditions	
2	1	Experimental proofs of abiotic origin of micro and macro molecues	T1, 52
3	1	Current concepts of chemogeny	T1 55
4	1	RNA first hypothesis	T1 56
5	1	Cellular evolution proto cell model	T2 64
6	1	Origin of photosynthesis	T2 73
7	1	Evolution of oxygen and ozone build up	T2 80
8	1	Endo symbiotic theory	T1 101
9	1	Evolution of eukaryotes from prokaryotes	T1 104
10	1	Unit test	
		Total hours for unit II10h	

### <u>Unit III Lecture plan</u>

Sl No	Lecture duration (h)	Topics to be covered	Support material
1	1	Concepts of stratigraphy and geological time scale	T1, 141
2	1	Fossils study- types and formation	T1, 143
3	1	Vestigial organs	T1 149
4	1	Homologous and analogous organs	T2 151
5	1	Taxonomic transitional forms	T2 98
6	1	Evolutionary intermediates	T1 160
7	1	Living fossils	T1163
8	1	Fossil based phylogeny- Horse model	T2 118
9	1	Molecule based protein model	T2 127
10	1	Unit test	
		Total hours for unit III10h	

### Unit IV Lecture plan

Sl No	Lecture duration (h)	Topics to be covered		Support material
1	1	Types of variation continuous and discontinuous		T1, 181
2	1	Heritable and non heritable variations		T1, 184
3	1	Causes, classification and contribution to evolution		T2114
4	1	Gene mutation		R 2 136
5	1	Chromosomal aberrations		R2 177
6	1	Recombination and random assortment		R2 171
7	1	Gene regulation		R2 209
8	1	Concepts of micro and macroevolution- comparison		T1 203
9	1	Unit test		
		Total hours for unit IV	9h	

### Unit IV Lecture plan

Sl No	Lecture duration (b)	Topics to be covered	Support material
1	1	Natural selection as guiding force	R1 61
2	1	Basic characteristics of natural selection	R1 63
3	1	Coloration, camouflage and mimicry	R1 69
4	1	Adaptation and co evolution	R1 74
5	1	Manmade causes of changes	R1 72
6	1	Industrial melanism	R2 214
7	1	Drug, antibiotics, pesticide resistance in living organisms	R2 216
8	1	Mode of selection	R2 234
9	1	Polymorphism	R2 237
10	1	Genetic drift (Sewal Wright effect)	R1 174
		Total hours for unit V10h	

#### Syllabus:

**Historical Review of Evolutionary Concept:** Pre-Darwinian ideas – List of contributors, Lamarckism – Merits and demerits. Darwinism – Merits and demerits, Post-Darwinian era –Modern synthetic theory; biomathematics and the theory of population genetics leading to Neo-Darwinism

#### **Pre Darwinism Ideas**

Throughout the middle Ages, there was one predominant component of the European world view: stasis.

- All aspects of nature were considered as fixed and change was unconceivable.
- No new species had appeared, and none had disappeared or become extinct.

The social and political context of the Middle Ages helps explain this world view:

- Shaped by feudal society hierarchical arrangement supporting a rigid class system that had Changed little for centuries
- Shaped by a powerful religious system life on Earth had been created by God exactly as it existed in the present (known as fixity of species).

This social and political context, and its world view, provided a formidable obstacle to the development of evolutionary theory. In order to formulate new evolutionary principles, scientists needed to:

- Overcome the concept of fixity of species
- Establish a theory of long geological time

From the 16th to the 18th century, along with renewed interest in scientific knowledge, scholars focused on listing and describing all kinds of forms of organic life. As attempts in this direction were made, they became increasingly impressed with the amount of biological diversity that confronted them.

These scholars included:

- John Ray (1627-1705) put some order into the diversity of animal and plant life, by creating the concepts of species and genus.
- Carolus Linnaeus (1707-1778) added two more categories (class and order) and created a complex system of classification (taxonomy) still used today; also innovated by including humans in his classification of animals.
- Georges-Louis Leclerc (1707-1788) innovated by suggesting the changing nature of species, through adaptation to local climatic and environmental conditions.
- Jean-Baptiste Lamarck (1744-1829) offered a comprehensive system to explain species changes; postulated that physical alterations of organic life would occur in relation to changing environmental circumstances, making species better suited for their new habitat; also postulated that new traits would be passed on to offspring (the theory known as inheritance of acquired characteristics).

Therefore, the principle of "fixity of species" that ruled during the Middle Ages was no longer considered valid.

In the mid-19th century, Charles Darwin offered a new theory which pushed further the debate of evolutionary processes and marks a fundamental step in their explanation by suggesting that evolution works through natural selection.

#### Lamarckism

- The theory of acquired characteristics put forth by Jean-Baptiste P.A. Lamarck (1744-1829), a French botanist, zoologist and biological philosopher. According to him, evolution occurs because organisms can inherit traits acquired by their ancestors.
- Giraffes can only survive by eating leaves high up on trees so they stretch their necks to reach the leaves and this stretching of the neck is passed on to later generations.
- The basic tenet of Lamarckism has been rejected. Darwinism (the theory of the origin of species and the development of higher organisms from lower forms through natural selection, the survival of the fittest, and the evolution of humans from an ancestor

common to himself and the apes) has prevailed, together with the principles of transmission genetics

#### De merits of Lamarckism

- Lamarckism could not explain the following areas
- Though the tendency to increase in size has been shown in many forms, there are also instances where there is reduction in size. For example, trees that are primitive, are large in size, while the shrubs, herbs and grasses that evolved later are smaller in size.
- If new organs were to develop in response to a new need, then man should have developed wings by now.
- Changes acquired during the lifetime of an organism cannot be inherited by the offspring. For example, if a man loses his arm in war, he does not produce children without an arm. According to August Weismann, somatic changes acquired during the lifetime of the organisms are non- heritable, whereas, changes in the germplasm or reproductive cells are inheritable by the offspring.

#### Darwinism

The main aspects of the theory of natural selection – Darwinism are as follows.

- 1. Rapid multiplication.
- 2. Limited food and space causing straggle for existence.
- 3. Natural selection or survival of the fit and elimination of the unfit.
- 4. Origin of new species.

#### **1. Rapid Multiplication:**

Every living organism in this world reproduces itself. The rate of increase of the organisms is always in a geometric proportion. Darwin illustrated this point with the example of the slowest

breeder among animals, the elephant. An elephant starts breeding at its 30th year continues to do so until it is 90 years.

It lives up to 100 years. So in its life time it produces 6 offsprings. Darwin calculated that if all these survive, within about 750 years there would be about 19 million elephants. Oysters produce about 80 million eggs in a season. A pair of sparrows would produce 275 billion individuals in about 10 years if there is no death.

#### 2. Struggle for existence:

The rate of multiplication and existence of organisms are more or less common for all living things. But the food supply and space remain unchanged, in other words they are limited. Under these conditions, there starts a competition among the organisms to fulfil their needs of food and space. This is known as struggle for existence. It may be interspecific, that is between the members of different species or intraspecific between members of the same species or between them and the environmental factors.

#### **3. Variations:**

Every organism has its own specific characteristics and relationship with its environment, the variability caused by 'variations' may be large or small. Large variations are known as 'macrovariations'. Small variations are termed as 'microvariations'. Variations may be favourable or harmful. Those with useful variations survive while the others perish.

#### 4. Natural selection or Survival of the Fitest:

The organisms with favourable variations are best adapted to the environment in which they live. They have a better chance of survival and perpetuation of their race. This principle is called Natural Selection or survival of the fit. While the organisms without any useful variations or with harmful variations are ill suited to the environment and hence they die and perish. This is known as the 'elimination of the unfit.

An example of adaptation of a species to a changing environment is amply illustrated by the birds known as "Darwin's Finches". Darwin observed 13 species of this bird each with special

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adaptation for its particular mode of life. Those that fed on insects had long slender beaks by which they could peck small insects from small crevices and eat them.

#### 5. Origin of Species:

As already stated, the organisms with favourable variations transmit the same from generation to generation. With every generation the variations get distinct and refined. Due to the cumulative effect of these distinct variations, organisms emerge as new species in course of time. Thus new species are the evolutionary products of preexisting forms, by developing useful variations. Objections to theory of natural selection.

The role of natural selection has no doubt been regarded as a chief factor in evolution. But it cannot be the sole factor to bring about evolution. Darwin himself accepted the insufficiency of natural selection being the sole arbiter for evolution.

#### **Demerits Darwinism: of theory of natural selection**

- Darwin believed evolution by the accumulation of slow and small variations. But in many instances the occurrence of such variations when they are not fully developed are of no use to the individuals in the struggle for existence. For instance, the eye in the case of animals is useful only in a fully formed condition and surely all the features of the eye according to Darwin could not have come into existence at one go. It should have been by accumulation of several mutations. But then each change by itself is of no advantage.
- In many instances the adaptations of individuals seem to be more of a disadvantage rather than any use. For instance the antlers in deer are more obstructive because of their huge size than of any use, when the animal has to run to avoid from predators. In this instance natural selection indeed should have limited the structures not to grow beyond a point of usefulness.
- The main drawback in Darwin's theory is that he assumed that the organisms are having favourable and unfavourable variations. The main aspect in the mechanism of evolution is the origin of variations. Only then one can explain the role of natural selection. Natural selection according to Darwin is only an arbiter to decide which variation is favourable or

unfavourable. But the crux of evolutionary theory is to explain how a variation can arise. Further, Darwin also did not distinguish between heritable and non heritable variations.

- Natural selection theory does not satisfactorily attribute the reasons for the presence of vestigial organs. For example appendix in human beings. These organs should have been eliminated by natural selection during the course of evolution.
- If all the species were to be evolved by the accumulation of small variations, there should have been transitional forms in almost all the species. But this is not the case. Darwin however explained this away by attributing it to the faulty preservation of fossils. In areas where no interlinking forms were found, Darwin used the term "missing links". For instance between man and monkey.
- Natural selection as believed by Darwin was only a selective force and not a creative force. Many of the current observations have indeed shown that the environment not only chooses favourable variations but also is a causative agent for variations.

### THE MODERN SYNTHETIC THEORY OF EVOLUTION: NEO-DARWINIAN THEORY



The Modern Synthetic theory of Evolution explains the evolution of life in terms of genetic changes occurring in the populations that leads to the formation of new species. It also explains about the genetic population or mendelian population,

gene pool and the gene frequency. The concepts coming under this synthetic theory of evolution includes the genetic variations, reproductive and geographical isolation and the natural selection.

The Modern Synthetic populations, of Evolution, describes the merging of the Darwinian evolution with the Mendelian genetics, resulting into a unified theory of the evolution. This theory is also referred as the Neo-Darwinian theory. Synthetic theory of Evolution was introduced to us by few legendary evolutionary biologists naming T. Dobzhansky, J.B.S. Haldane, R.A. Fisher, Swall Wright, G.L. Stebbins, Ernst Mayr in the years 1930 and 1940.

The Modern Synthetic theory of Evolution showed a number of changes as to how the evolution and the process of evolution are conceived. The theory gave a new definition about the evolution as "the changes occurring in the allele frequencies within the populations," which emphasizes on the genetics of evolution.

The modern synthetic theory includes the scientific evidence from the genetics. It explains the concepts which occur when the allele frequency of the population changes. According to this theory, when the changes are great enough, there is a formation of new species. A species is a group of individuals which are capable of interbreeding and producing a fertile offspring.

#### **Factors of Modern Synthetic Theory of Evolution**

There are some factors describing the modern theory of synthetic evolution which are as explained below-

In addition to these reactions, the other factors affecting the working of the process are Migration of the individuals from one form of the population to other, hybridization between the races of species increase the genetic variability of the population.

#### 1. Recombination or Variation

Recombination of the new genotypes from the existing genes. The gene combinations having same individuals with two kinds of alleles, mixing of the chromosomes during sexual reproduction of two parents produce new individuals, an exchange of the chromosomal pairs of alleles during the meiosis which is called as crossing over produce the new form of gene combinations. Chromosomal mutations like deletion, inversion, duplication, translocation, polyploidy result in the recombination.

#### 2. Mutation

The changes that occur in the gene due to phenotypic effect differential as the mutation. This produces a various number of changes that may be harmful. Many of the mutant forms of genes are recessive to the normal genes in a homozygous condition. These mutations cause variations in offsprings.

#### 3. Heredity

The transmission occurring in the variations from the parents to their offsprings is a primary mechanism in the evolution. The organisms which possess hereditary properties are favored in the struggle for the existence. By this, the offsprings benefit from the characteristics of parents.

#### 4. Natural selection

Natural selection produces a change in the frequency of the genes from one generation to the other favoring the differential form of the reproduction. The natural selection process creates an adaptation.

#### **Biomathematics and Population genetics and neo Darwinism**

Evolutionary biology has been the subject of extensive mathematical theorizing. The traditional approach in this area, which includes complications from genetics, is population genetics. Most population geneticists consider the appearance of new alleles by mutation, the appearance of new genotypes by recombination, and changes in the frequencies of existing alleles and genotypes at a small number of gene loci. When infinitesimal effects at a large number of gene loci are considered, together with the assumption of linkage equilibrium or quasi-linkage equilibrium, one derives quantitative genetics.

Ronald Fisher made fundamental advances in statistics, such as analysis of variance, via his work on quantitative genetics. Another important branch of population genetics that led to the extensive development of coalescent theory is phylogenetics. Phylogenetics is an area that deals with the reconstruction and analysis of phylogenetic (evolutionary) trees and networks based on inherited characteristics. Traditional population genetic models deal with alleles and genotypes, and are frequently stochastic.

Many population genetics models assume that population sizes are constant. Variable population sizes, often in the absence of genetic variation, are treated by the field of population dynamics. Work in this area dates back to the 19th century, and even as far as 1798 when Thomas Malthus formulated the first principle of population dynamics, which later became known as the Malthusian growth model.

The Lotka–Volterra predator-prey equations are another famous example. Population dynamics overlap with another active area of research in mathematical biology: mathematical epidemiology, the study of infectious disease affecting populations. Various models of the spread of infections have been proposed and analyzed, and provide important results that may be applied to health policy decisions.

As in the synthetic theory of evolution, natural selection can be understood in terms of changing allelic frequencies in a population. Thus, the ability to study allelic frequencies in a population is vital to the study of evolution. The Hardy-Weinberg Law is essential to the study of population genetics. It states that in a sexually reproducing population, allelic frequencies, and therefore phenotype, should remain constant under the following 5 conditions:

- 1. large population size
- 2. no mutation
- 3. no immigration or emigration
- 4. random mating
- 5. random reproductive success

A population that meets all of these conditions is said to be in Hardy-Weinberg equilibrium.

Natural populations rarely experience Hardy-Weinberg equilibrium. Natural selection ensures that mating and reproductive success is not random, large populations are rarely found in isolation, and all populations experience some level of mutation. However, the Hardy-Weinberg

Law is still very useful. The fact that populations that meet those 5 conditions will have unchanging phenotypes (will not evolve) is proof that variability and inheritance alone are not enough to cause evolution; natural selection must drive evolution. The law also allows us to estimate the effect of selection pressures by measuring the difference between actual and expected allelic frequencies or phenotypes.

#### **KARPAGAM ACADEMY OF HIGHER EDUCATION**

**CLASS: III BSC BT COURSE NAME: EVOLUTIONARY BIOLOGY** UNIT: I BATCH-2017-2020

#### COURSE CODE: 17BTU503B

#### **Possible questions**

- 1. Explain Darwin's theory of evolution with suitable examples
- 2. Explain Pre-Darwinism and write in detail about the merits and demerits of Darwinism
- 3. Explain: Lamarckism, its merits, demerits and advantages over Darwinism
- 4. Explain modern synthetic theory and compare it with Neo-Darwinism
- 5. Write an essay on origin of life on Earth..
- 6. Explain the pre-biotic conditions and events on Earth and evolution of macromolecules
- 7. Define Lamarckism
- 8. What are the demerits of Darwinism?
- 9. Describe coacervates
- 10. Write short notes on heterosis
- 11. Explain Modern synthetic theory of evolution
- 12. Discuss Miler's experiment and its significance
- 13. Discuss the role of biomathematics in evolution

#### Syllabus

**Life's Beginnings:** Chemogeny – An overview of pre-biotic conditions and events; experimental proofs to abiotic origin of micro- and macro-molecules. RNA first hypothesis. Biogeny – Cellular evolution based on proto-cell models Origin of photosynthesis – Evolution of oxygen and ozone buildup. Endosymbiotic theory – Evolution of Eukaryotes from Prokaryotes

### LIFE'S BEGINNING: CHEMOGENY

In 1864, Louis Pasteur described his experiments showing that microbial life could not originate spontaneously in the absence of preexisting life. This work is considered a landmark in modern science because it settled a longstanding controversy over spontaneous generation

### Spontaneous generation is the idea that organisms could form miraculously from nonliving material.

But Pasteur's results posed a new riddle for evolutionary biologists: If life could only arise from life, how did living organisms initially appear on the planet?

The answer came in the 1920's when A.I. **Oparin** of Russia and J.B.S. **Haldane** of England independently presented compelling arguments that the origin of life could be explained, not as the result of rapid spontaneous generation of whole organisms in a few weeks, but from a long and gradual process of chemical evolution.

Much progress has been made since the 1920's, but, as with most complex scientific questions, many uncertainties remain and many new avenues of inquiry have been uncovered.

Today, research into the origin of life is interdisciplinary with workers trying to answer four main questions:

 What was the Earth's physical environment like when life first evolved?
What sorts of chemical reactions could produce the building blocks of life and could these occur naturally in the early Earth's environment?

3. How could the complex organic molecules be compartmentalized into a contained unit?

4. *How did the genetic code evolve?* 

#### What Was The Earth's Early Environment?

Life has dramatically changed the Earth. Organisms have altered the composition of the atmosphere, affected the types and concentration of minerals and ions in the seas, and even worked and churned the soil. So, if we want to understand the conditions in which life first appeared, we cannot rely on just an examination of present day Earth. We use two pieces of information:

1. Rocks buried deep in earth.

2. The four inner, or terrestrial, planets (Mercury, Venus, Earth and Mars) and our moon were formed from similar materials in the same way. Because they have a similar history, anything we learn about the formation of Mars, Venus, Mercury, or the moon will inform us about early Earth.

Solar system formed about 4.6 billion years ago (abbreviated b.y.a.) when a swirling cloud of gas and dust began to contract.



In the early years after the formation of the solar system, the terrestrial planets continued to be bombarded by smaller bodies of various sizes as the last of the particulate material from the formation of the planets was swept-up by their gravitational pull.

This **bombardment**, measured from radioactive dating of the moon's craters, and by comparing lunar, martian, and mercurian cratering records, gradually declined in intensity until it reached present-day levels about 3.5 billion years ago.

The effect of the bombardment on the origin of life was significant. Bombardment affected:

- 1. the temperature of the early Earth
- 2. the composition of the atmosphere
- 3. delivered biogenic elements to Earth (biogenic elements are those chemicals common to all living organisms like phosphates)
- 4. Finally, the high energy released could also have delayed the origin of life.

Let's look at each of these effects in more detail:

About 3.9 b yeas, the earth had solidified but the violent bombardment would have prevented the continuous existence of life on the planet before **3.8** billion years ago. Large impacts would have produced globally lethal conditions by boiling large volumes of ocean water effectively sterilizing the surface of the planet with steam. This has been called **the impact frustration of the origin of life**.

The interesting thing is that the oldest fossils from rocks in Greenland are about 3.8 billion years old. This means that life was existed on the planet almost as soon as it was physically possible for it to do so.

Whatwastheatmospherelike3.8billionyearsago?What chemical elements were present and in what quantities?It turns out that the answers to these questions are also tied up with the bombardment.

As the planet cooled, an atmosphere formed. When scientists initially tried to work out what was in the first atmosphere they reasoned that, because most of the matter in the solar system is hydrogen the early atmosphere of Earth must have been rich in hydrogen. Therefore, they

concluded other elements (such as carbon, oxygen, nitrogen, and sulfur) would be bound to hydrogen in their reduced forms as

CH4 (methane), NH3 (ammonia), H2S (hydrogen sulfide), and H2O (water)

BUT if such an atmosphere did exist it would have been blasted away by meteor impacts during the bombardment phase.

The more probable source of the atmosphere present 3.8bya would have been gases released from the cooling rocks such as we now get from volcanoes and other vents through the crust. Based on an analysis of gases vented by modern volcanoes, it seems likely that this early atmosphere consisted mostly of water vapor (H2O) and carbon dioxide (CO2) and nitrogen gas (N2).

Note that this atmosphere is very different from the one we have today.

- Today, the atmosphere contains only about 0.03% CO2.

- The reduction of CO2 in the atmosphere is the result of the action of living organisms. Much carbon exists today in the form of minerals rather than as CO2 in the atmosphere. Most carbonate minerals are remains of skeletons of once-living organisms.

Where did the oxygen come from? -Photosynthesis
Nitrogen on early Earth would have been at approximately its same percentage as Earth's present atmosphere.

4.Traceamountsof hydrogen(H), methane(CH4), hydrogen sulfide(H2S), hydrogen cyanide(HCN),and formaldehyde(CH2O) wouldhavebeenpresent.As the Earth cooled, water vapor condensed as rain and formed oceans and seas.

In addition to an atmosphere very different from the one we know, lightning, volcanic activity (crust thiner), and ultraviolet radiation (no ozone) were much more intense when the Earth was young.

#### What Was the Origin Of Complex Organic Molecules?

We are going to make an assumption: the chemical components found in all living prokaryotic and eukaryotic cells was present in the ancestral organism from which all life derived. In other words: the spontaneous interaction of the molecules present in the early earth's atmosphere formed more complex organic molecules, such as amino acids, sugars, fatty acids, and nitrogen bases - the building blocks of life as we know it today. As these organic compounds accumulated they formed an "organic soup" in which additional reactions could take place. The energy needed to drive the formation of these organic molecules was derived from the sun's radiation, electrical discharges in the form of lightening, and heat from the cooling earth.

#### Synthesizing the Chemical Components of Living Organisms

Important point - Laboratory simulations cannot establish that the kind of chemical evolution that has been described here actually created life on primordial earth, but only that some of the steps could have key happened.

#### **Proteins**

Proteins are made up of subunits, called **amino acids** so we must first talk about how to make amino acids.

There are 20 different types of amino acids used in living organisms, but all have the same central structure consisting of a carboxyl group (COO-), an amino group (NH3), and a carbon with a hydrogen and a variable side chain. For example:



Alanine:



Isoleucine:

1953 experiment by Stanley Miller. While a graduate student at the University of Chicago, Miller began work to test the Oparin-Haldane hypothesis by creating laboratory conditions comparable to those of the early Earth.

First he created a "comic strip version" of primitive Earth.

In a flask he put:

1. water (for the primeval sea),

2. methane (CH3), ammonia (NH3), and hydrogen for the atmosphere (note there is no O2 no CO2).

3. He sealed it off and exposed it to sparks for lightning and other forms of high energy such as UV radiation and heat (from Earth's interior)

4. A condenser cooled the atmosphere, raining water and any dissolved compound back into the flask (= the sea).



After one week, Miller analyzed the contents of the solution and found a variety of organic compounds, including molecules such as formaldehyde (O-CH2)

This molecule continues to react to form formic and then acetic acid (CH3-COOH) Eventually the experiment yielded amino acids:

For example, Adding an amino group (in other words an ammonia) to acetic acid and you have an amino acid **glycine**:

But getting from amino acids to proteins is difficult:

1. Amino acids are asymmetrical molecules that exist in right and left-handed forms that are mirror images of each other: the L-isomer and the D-isomer. When amino acids are made in the

laboratory a mixture of L- and D-amino acids is found. However, the amino acids present in living organisms are all L-isomers.

2. To make a protein, the amino acids attach COOH end of one to the NH3 end of another. To do so, they must lose a molecule of water. Amino acids aren't likely to link up with one another and form such chains on their own and the reaction rarely happens spontaneously. Furthermore, it is unlikely that a water-producing reaction would occur if the amino acids are in water. (Remember: In the living cell, specific enzymes catalyze these dehydration reactions. But we don't have enzymes yet!)

Perhaps organic polymers were synthesized and accumulated on rock or clay surfaces. If the conditions are hot and dry enough, the water molecule can be lost and amino acids can join.

Using this process, Sidney Fox and his research group at the University of Miami have formed substances like proteins, called **protenoids**, by drying warm mixtures of amino acids. They suggest that volcanic activity could have generated high temperature to form proteins on the early Earth, even if only temporarily and locally. It is possible to imagine waves or rain splashing dilute solutions of chemicals onto fresh lava or other hot rocks on the early earth and then rinsing proteinoids back into the water.

Problem with this idea: High temperatures pose a problem, because organic molecules tend to break down as they are heated.

An alternative idea suggests that clay, even cool clay, may have been used. Clay has some interesting properties:

1. It has a slight charge that can attract and hold other molecules. 2. Clays may contained small amounts of metal atoms, such as copper, iron, or zinc. These metal atoms function as catalysts facilitating the dehydration reactions that link amino acids together. 3. Clay also seems to be able to store energy absorbed from radioactive decay and then discharged this energy at times when the clay changes temperature or degree of dehydration.

One more problem: Proteins are twisted or folded to form a macromolecule with a specific comformation, or three-dimensional shape. This comformation determines the function of the protein. For example, the unique shape of an enzyme permits it to "recognize" and act on the substance it regulates. The shape of the molecule is determined by the order of amino acids in the chain -- how do we get the very precise order of amino acids in early earth's environment?

2. NucleotidesandNucleicAcidsEach nucleotide is composed of 5-carbon sugar, a nitrogen containing base (and by that I meaneither a single ring called a pyrimidine or a double ring called a purine)andaphosphategroupThere are three kinds of nucleotide-based molecules:

a. Adenosine phosphates - such as ATP (Adenosine triphosphate) - the energy carrier used by the cell.

b. **Nucleoside coenzymes** - such as NAD+ and others that transport hydrogen atoms and electrons during metabolism.

c. **Nucleic Acids** - responsible for the storage transmission and translation of genetic information. Such as **Deoxyribonucleic acid** (DNA) and **ribonucleic acid** (RNA).

Considering the atmosphere of the primitive earth to have contained water vapor, carbon dioxide, carbon monoxide, methane, and ammonia and/or nitrogen, then in the presence of an energy source, such as sunlight or lightning, a number of small molecules like hydrogen cyanide, HCN, are formed. These then undergo spontaneous reaction with other HCN molecules, again in the presence of some energy source and produce adenine and guanine bases (often abbreviated A and G) easily. The other two common bases, cytosine (C) and uracil (U), can also be formed in such experiments, although with more difficulty.

The next step is to combine the nucleotides with other chemicals to make more complex structures like RNA and DNA. For RNA, for example, the adenine or guanine has to be attached to the sugar molecule called ribose and a phosphate group. Ribose and other sugars can be synthesized in the lab from the molecules present in the early earth's atmosphere.

Phosphate is, however, a problem - phosphates appear to have been rare on early Earth.3. Simple Sugars and Carbohydrates

Most cells use **carbohydrates** directly or indirectly for energy and as major structural materials. Carbohydrates are monomers or polymers of a sugar. A **sugar** is composed of carbon, hydrogen, oxygen in a 1:2:1 ratio.

4. Fatty Acids and Lipids

Lipids, which function in the storage of energy and are key components of cell structures such as membranes, are mostly composed of fatty acids.

Fatty acids can be formed simply by adding several carbons to acetic acid. A fatty acid is a long unbranched hydrocarbon with a carboxyl group (-COOH) at the end:



**Extraterrestrial Organic Synthesis** 

It is possible that some organic compounds reached the early earth from space - this is called **panspermia**.

In 1969, a meteor struck near Murchinson, Australia. Analysis of the meteorite fragments revealed the presence of a variety of organic molecules including amino acids, pyrimidines, and molecules resembling fatty acids. Initially, there were even serious proposals that the organic material was biogenic in origin, but consensus was soon reached that abiotic chemical synthesis was the most plausible explanation.

This is significant for two reasons:

1. Heavy bombardment of meteors could have delivered a significant amount of essential compounds to the surface of the Earth.

2. The fact that these compounds could appear under abiotic, extraterrestrial conditions makes it seem more likely that similar compounds had been able to form on the primitive Earth.

We don't know yet how much organic matter was supplied to the oceans by natural synthesis on Earth and how much by meteor infall. That ratio is not as important as the fact that the right materials were present on the earth for further reactions to act on.

#### The Evolution Of Cell Membranes

All life on this planet is cellular life. All cells are bounded by membranes that encapsulate the macromolecular machinery of the life process. How did the first membrane structures on Earth appear?

Cell membranes of all living organisms contain hydrocarbon chains, which constitute an oil-like layer that forms a barrier between the internal and external compartments of cells. Proteins, which provide the enzymatic and transport activities that are primarily functions of membranes, are embedded in this fluid barrier. Therefore, to understand the origin of membrane structure we need to know how lipids and their hydrocarbon moieties provide the essential barrier properties of membranes.

Membrane lipids are typically phospholipid molecules. One of the most common, a constituent of most membranes, is phosphatidylcholine. That just means phosphate is chemically bound to glycerol and choline. The glycerol, in turn, is linked to two fatty acids, each consisting of an acidic carboxyl group (-COOH) attached to a long hydrocarbon chain. other common membrane phospholipids include phosphatidylethanolamine and phosphatidylserine.

Because they are relatively complex, phospholipids probably did not form the earliest membranes. Do molecules simpler than phospholipids assemble into membranes?

Certain molecular structures are polar, with relatively strong electrical charges expressed by their component atoms; others are nonpolar. Polar structures tend to be soluble in water and are usually referred to as **hydrophilic**. Nonpolar structures are **hydrophobic**; that is they tend to be soluble in oil and not in water. Some compounds (particularly lipids) that have both hydrophilic and hydrophobic residues on the same molecules are referred to as **amohiphilic**.

Hydrocarbons, by themselves, are nonpolar molecules. However, if oxygen is added to a long hydrocarbon chain, the molecules become amphiphilic, since oxygen is typically polar. All lipids have oxygen in their molecular structure, usually as carboxyl and phosphate - oxygen containing groups, chemically linked to nonpolar hydrocarbon chains.

*Self-assembly of Lipids into Bilayers* - Amphiphilic molecules have a remarkable property: they self-assemble into stable bilayer structures. When lipid such as phosphatidylcholine is dried, for example, the lipid molecules form lamellar structures. (*Lamellar* means that the structure has layers of molecules.) If water is then added, water molecules penetrate between the lipid layers along hydrophilic planes, causing the lipid to swell. The swelling produces a variety of fairly stable structures such as lipid cylinders, each of which contains thousands of concentric lipid bilayers.

Why do lipid components form a stable bilayer structure in an aqueous environment? For thermodynamic reasons. Hydrocarbon chains can't dissolve in water, and oil do not mix. When lipid molecules are placed in water their hydrocarbon chains tend to stay in contact with one another away from the water. This tendency, which is called the hydrophobic effect, stabilizes the bilayer structure.

If lipid remains in contact with water, stable spherical structures called **liposomes** form. Liposomes represent a good model for the first types of membranes to appear in the origin-of life saga.

The first cells required some mechanism by which a membrane could encapsulate a system of replicating macromolecules. Although this seems difficult, the drying-wetting procedure offers

an easy solution. If membrane-forming lipids are dried in the presence of large molecules, the molecules are sandwiched between alternating lipid bilayers. Upon rehydration, a substantial fraction of the the molecule are encapsulated within vesicular membrane structures. This has the additional advantage of concentrating molecules from dilute solutions. A primary function of amphiphilic compounds is to provide closed microenvironments. If macro molecular catalytic-information system were encapsulated within a vesicular membrane, the components of the system would share the same microenvironment. This would be a step towards true cellular function. Encapsulation would also produce individuals; each cell would be different from its neighbors.

A second role of early membranes was probably related to energy production, because energyyielding processes are necessary to provide for growth of the catalytic-information system. In contemporary cells, membranes are central to energy production. Chloroplast membranes capture light energy by means of embedded pigment systems. The chemiosmotic synthesis of ATP that takes place on membranes.

That is there are cell membranes - selectively permeable membranes separating metabolicpathwaysfromtheoutsideenvironment.The basic structure of a cell membrane is phospholipid bilayer with proteins dispersed andembedded in it:

There are various simple ways to get lipid bilayers -- the problem is ingetting the proteins embedded into them:



#### The Origin Of Heredity

Laboratory simulations and the presence of organic molecules in stony meteorites indicate normal chemical processes could give rise to aggregates of organic molecules that are reminiscent of the molecular components of organisms. But a key problem remains - these aggregates pf organic molecules have a limited time of existence. They will eventually deteriorate and break down. Once they are gone, chemical processes are the only mechanism we have described to produce more. Making that enormous jump from chemical evolution to real organisms requires a mechanism for these systems to reproduce themselves - some mechanism of heredity that would pass along not just key molecules but also instructions for making more of these molecules. If we can solve this problem we will have solved one of the great mysteries of the origin of life.

Clues to the origin of life are not easy to find when looking at contemporary organisms. In all contemporary cells, the information about how to build proteins (which, in turn, either catalyze the production of or makeup key structures) is encoded in the double helix of deoxyribonucleic acid (DNA). That information is copied when it is transcribed into a molecule of ribonucleic acid (RNA). Then translated into a particular sequence of amino acids that make up a polypeptide chain. When the chain is folded it becomes a protein. The function of that protein (becoming part of a structure or performing some metabolic catalysis) is determined by the specific type and

order of the amino acids in the polypeptide chain. The order in which the amino acids are strung together is crucial because it determines how the chains will fold and twist into the threedimensional shapes of individual proteins. On the molecular level in contemporary cells, reproduction, then, is the replication of the DNA (since this molecule encodes all of the information of life) when the cell divides.

But here is the problem - when we look at modern organisms, we see that DNA cannot replicate itself, but must be copied by specific enzymes. These replication proteins, in turn, are controlled by the transcription and translation of the DNA. If proteins are necessary to reproduce DNA but to produce proteins we need DNA, which came first in evolution? DNA or proteins?



This chicken and egg problem has puzzled scientists for some time. At first it seemed as if proteins came first. After all, proteins are so fundamental to life, they seemed to some the necessary first step in the evolution of life. As we have seen, this hypothesis is supported by the fact that the building blocks of proteins, amino acids, are relatively easy to produce in laboratory simulations of prebiotic evolution. Sidney Fox has demonstrated that it is possible to assemble these amino acids into polypeptide chains and protenoids. But to be effective as biological structures or enzymes, proteins must have a very specific sequence of amino acids. If by some enormous stroke, a single copy of an effective protein spontaneously arose, it would be a dead end. Even if successfully assembled, proteins have no way of copying themselves. they cannot replicate themselves and pass on information about how to make more of their specific structure.

A. G. Cairns proposed a possible solution in the early 1980s. he suggested that naturally occurring microscopic mineral crystals in clays might have served as the basis for replication until the time when nucleic acids evolved and took over the function of replication. Clay

microcrystals consist of flat plates of silicate lattices with regular arrays of ionic sites occupied by various metals. When such a crystal is contained in a droplet of water, the metal ions form irregular patterns of electrostatic potential that can attract particular molecules to the surfaces of the lattice and catalyze chemical reactions. Which reactions are catalyzed depends upon the precise arrangement of the metal ions. Molecules synthesized in this manner could be released back to the water. Because a crystal grows by incorporating silicate and metal ions from the surrounding water, the new materials are similar in composition to the original parts of the crystal that generated them. Thus crystals could, in principle, both replicate information and transfer it to other molecules. What is uncertain is whether they could have done so with sufficient precision to serve as a basis for the evolution of life. According to this theory, the clay lattice first directed the synthesis of primitive enzymes. For a long time, the clay crystals functioned as primitive genetic material, but at some point, by as yet unspecified mechanisms, RNA evolved and took over the role of replicating and transferring information. Once RNA appeared, it was so much better as a genetic material that clay-based life was quickly out competed by RNA-based life and driven to extinction. This scenario is plausible, but critical experiments to test some of its key assumptions have not yet been performed.

#### Ribozymes

Gerald Joyce's lab at Scripts Research Institute in La Jolla California were working with synthetic RNAs. At first they thought the snippet of RNA had ruined their experiment. But this piece of RNA proved to be unusually talented. Within an hour of its formation, it had commandeered the proteins in the test tube and started making copies of itself. Before long, the copies began to make copies. Another piece of the puzzle was in place:

RNA + proteins made by inorganic processes cause the RNA to replicate and begin to produce proteins

Finally DNA favored because easier to repair.

#### **RNA first hypothesis**

The RNA World Hypothesis is a concept put forth in the 1960s by Carl Woese, Francis Crick and Leslie Orgel. It proposes that earlier life forms may have used RNA alone for the storage of genetic material.

Walter Gilbert, a Harvard molecular biologist, was the first to use the term "RNA World" in an article published in 1986. The hypothesis posists that DNA later became the genetic material as a result of evolution because RNA was a relatively unstable molecule. According to the RNA World Hypothesis, around 4 billion years ago, RNA was the primary living substance, largely due to RNA's ability to function as both genes and enzymes.

The main reasoning behind the hypothesis is that RNA is capable of selfreplication and could therefore have carried genetic information across generations independently. This concept has been highly debated in the scientific world over the last 50 years.

Experts now generally agree that non-living chemicals could not have given rise to bacterial cells in a single step and that intermediate, pre-cellular life forms must therefore have existed. Of the possible pre-cellular life models considered, the most popular is the RNA World.

In 1968, Sir Francis Crick proposed that RNA must have been the primary genetic material as it is capable of self-replication, owing to its ability to act as an enzyme. Moreover, RNA can also be converted to DNA by reverse transcription, which further strengthens the idea that the RNA world could have been the initial pathway to cells.

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#### **Ribozymes and the RNA world**

It was previously thought that the only biomolecules that could catalyze essential chemical reactions in cells were proteins. However, Sidney Altman, Thomas Cech and colleagues discovered a class of RNAs that is capable of catalyzing chemical reactions — ribozymes. Altman and Cech were awarded the Nobel Prize in Chemistry in 1989 for this discovery.

The discovery of ribozymes supported the RNA World Hypothesis. The strongest argument for proving the hypothesis is perhaps that the ribosome, which assembles proteins, is itself a ribozyme. Despite the fact that the ribosome is composed of both RNA and protein, the processes involved in translation are not catalyzed by protein, but by RNA, indicating that early life forms may have used RNA to catalyze chemical reactions before they used proteins.

### **Origin of photosynthesis**

The **evolution of photosynthesis** refers to the origin and subsequent evolution of <u>photosynthesis</u>, the process by which light energy synthesizes <u>sugars</u> from <u>carbon dioxide</u>, releasing <u>oxygen</u> as a waste product. The process of Photosynthesis was discovered by Jan Ingenhousz, a Dutch-born British physician and scientist, first publishing about it in 1779.

The first photosynthetic organisms probably <u>evolved</u> early in the <u>evolutionary history of life</u> and most likely used <u>reducing agents</u> such as <u>hydrogen</u> or electrons, rather than water.

The biochemical capacity to use water as the source for electrons in photosynthesis evolved in a <u>common ancestor</u> of extant <u>cyanobacteria</u>.

The geological record indicates that this transforming event took place early in Earth's history, at least 2450–2320 million years ago (Ma), and, it is speculated, much earlier.
Available evidence from geobiological studies of <u>Archean(>2500 Ma) sedimentary</u> <u>rocks</u> indicates that life existed 3500 Ma, but the question of when oxygenic photosynthesis evolved is still unanswered. A clear paleontological window on cyanobacterial <u>evolution</u> opened about 2000 Ma, revealing an already-diverse biota of blue-greens.

<u>Cyanobacteria</u> remained principal <u>primary producers</u> throughout the <u>Proterozoic Eon</u> (2500–543 Ma), in part because the redox structure of the oceans favored photoautotrophs capable of <u>nitrogen fixation</u>

<u>Green algae</u> joined blue-greens as major primary producers on <u>continental shelves</u> near the end of the <u>Proterozoic</u>, but only with the <u>Mesozoic</u> (251–65 Ma) radiations of dinoflagellates, coccolithophorids, and diatoms did <u>primary production</u> in marine shelf waters take modern form. Cyanobacteria remain critical to <u>marine ecosystems</u> as primary producers in oceanic gyres, as agents of biological nitrogen fixation, and, in modified form, as the <u>plastids</u> of marine algae.<sup>[7]</sup>

Early photosynthetic systems, such as those from <u>green</u> and <u>purple sulfur</u> and <u>green</u> and <u>purple</u> <u>nonsulfur bacteria</u>, are thought to have been anoxygenic, using various molecules as <u>electron</u> <u>donors</u>. Green and purple sulfur bacteria are thought to have used <u>hydrogen</u> and <u>sulfur</u> as an electron donor. Green nonsulfur bacteria used various <u>amino</u> and other <u>organic acids</u>. Purple nonsulfur bacteria used a variety of nonspecific organic molecules.

The main source of <u>oxygen</u> in the <u>atmosphere</u> is <u>oxygenic photosynthesis</u>, and its first appearance is sometimes referred to as the <u>oxygen catastrophe</u>.

Geological evidence suggests that oxygenic photosynthesis, such as that in <u>cyanobacteria</u>, became important during the <u>Paleoproterozoic</u> era around 2 billion years ago. Modern photosynthesis in plants and most photosynthetic prokaryotes is oxygenic. Oxygenic photosynthesis uses water as an electron donor, which is <u>oxidized</u> to molecular oxygen

 $(O_2)$  in the <u>photosynthetic reaction center</u>.

Several groups of animals have formed symbiotic relationships with photosynthetic algae.

These are most common in corals, sponges and sea anemones. It is presumed that this is due to the particularly simple body plans and large surface areas of these animals compared to their volumes.

In addition, a few marine mollusks *Elysia viridis* and *Elysia chlorotica* also maintain a symbiotic relationship with chloroplasts they capture from the algae in their diet and then store in their bodies. This allows the mollusks to survive solely by photosynthesis for several months at a time.

Some of the genes from the plant cell nucleus have even been transferred to the slugs, so that the chloroplasts can be supplied with proteins that they need to survive.

#### **Ozone and Oxygen**

Stratospheric ozone was formed naturally by chemical reactions involving solar ultraviolet radiation (sunlight) and oxygen molecules, which make up 21% of the atmosphere. In the first step, solar ultraviolet radiation breaks apart one oxygen molecule (O2) to produce two oxygen atoms (2 O).

In the second step, each of these highly reactive atoms combines with an oxygen molecule to produce an ozone molecule (O3). These reactions occur continually whenever solar ultraviolet radiation is present in the stratosphere. As a result, the largest ozone production occurs in the tropical stratosphere.

The production of stratospheric ozone is balanced by its destruction in chemical reactions. Ozone reacts continually with sunlight and a wide variety of natural and human produced chemicals in the stratosphere. In each reaction, an ozone molecule is lost and other chemical compounds are produced. Important reactive gases that destroy ozone are hydrogen and nitrogen oxides and those containing chlorine and bromine.

Some stratospheric ozone is regularly transported down into the troposphere and can occasionally influence ozone amounts at Earth's surface, particularly in remote, unpolluted regions of the globe.

Tropospheric ozone-

Near Earth's surface, ozone is produced by chemical reactions involving naturally occurring gases and gases from pollution sources. Ozone production reactions primarily involve hydrocarbon and nitrogen oxide gases, as well as ozone itself, and all require sunlight for completion. Fossil fuel combustion is a primary source of pollutant gases that lead to tropospheric ozone production. The production of ozone near the surface does not significantly contribute to the abundance of stratospheric ozone. The amount of surface ozone is too small in comparison and the transport of surface air to the stratosphere is not effective enough. As in the stratosphere, ozone in the troposphere is destroyed by naturally occurring chemical reactions and by reactions involving human-produced chemicals. Tropospheric ozone can also be destroyed when ozone reacts with a variety of surfaces, such as those of soils and plants.

Stratosphere ozone is good ozone because it protect us from Sun's biologically harmful ultraviolet rays and also formed by reaction of natural components.

Tropospheric ozone is bad ozone, formed by the reaction of man made pollutants, harmful to plants and animals.

#### **Cellular Evolution**

Living things have evolved into three large clusters of closely related organisms, called "domains": Archaea, Bacteria, and Eukaryota. Archaea and Bacteria are small, relatively simple cells surrounded by a membrane and a cell wall, with a circular strand of DNA containing their genes. They are called prokaryotes.

Virtually all the life we see each day — including plants and animals — belongs to the third domain, Eukaryota. Eukaryotic cells are more complex than prokaryotes, and the DNA is linear and found within a nucleus. Eukaryotic cells boast their own personal "power plants", called <u>mitochondria</u>. These tiny organelles in the cell not only produce chemical energy, but also hold the key to understanding the evolution of the eukaryotic cell.



The complex eukaryotic cell ushered in a whole new era for life on Earth, because these cells evolved into multicellular organisms. But how did the eukaryotic cell itself evolve? How did a humble bacterium make this evolutionary leap from a simple prokaryotic cell to a more complex eukaryotic cell? The answer seems to be symbiosis — in other words, teamwork.

Evidence supports the idea that eukaryotic cells are actually the descendents of separate prokaryotic cells that joined together in a symbiotic union. In fact, the mitochondrion itself seems to be the "great-gr



#### KARPAGAM ACADEMY OF HIGHER EDUCATION

 CLASS: III BSC BT
 COURSE NAME: EVOLUTIONARY BIOLOGY

COURSE CODE: 17BTU503B UNIT

#### UNIT: II BATCH-2017-2020

#### **Possible questions**

- 1. Explain Modern synthetic theory of evolution
- 2. Give a detailed account on Miler's experiment and its significance
- 3. Elaborate the endosymbiotic theory of evolution
- 4. Explain the evolution of eukaryotes form prokaryotes
- 5. Define fossils
- 6. What is microevolution?
- 7. Describe paleontology
- 8. Explain the origin of photosynthesis
- 9. What is a protocell model?
- 10. Discuss cellular evolution based on proto-cell model
- 11. Explain geographical timescale
- 12. Explain Modern synthetic theory of evolution
- 13. Discuss Miler's experiment and its significance
- 14. Describe in detail about the endosymbiotic theory
- 15. Explain the evolution of eukaryotes form prokaryotes

Paleobiological – Concept of Stratigraphy and geological timescale; fossil study). Anatomical – Vestigial organs; Homologous and Analogous organs (concept of parallelism and convergence in evolution). Taxonomic – Transitional forms/evolutionary intermediates; living fossils. Phylogenetic – a) Fossil based – Phylogeny of horse as a model. b) Molecule based – Protein model (Cytochrome C); gene model

#### THE EVIDENCE FOR EVOLUTION

#### Anatomy and embryology

Darwin thought of **evolution** as "descent with modification," a process in which species change and give rise to new species over many generations. He proposed that the evolutionary history of life forms a branching tree with many levels, in which all species can be traced back to an ancient common ancestor.



Branching diagram that appeared in Charles Darwin's *On the origin of species*, illustrating the idea that new species form from pre-existing species in a branching process that occurs over extended periods of time.

In this tree model, more closely related groups of species have more recent common ancestors, and each group will tend to share features that were present in its last common ancestor. We can use this idea to "work backwards" and figure out how organisms are related based on their shared features.

#### **Homologous features**

If two or more species share a unique physical feature, such as a complex bone structure or a body plan, they may all have inherited this feature from a common ancestor. Physical features shared due to evolutionary history (a common ancestor) are said to be **homologous**.

To give one classic example, the forelimbs of whales, humans, birds, and dogs look pretty different on the outside. That's because they're adapted to function in different environments. However, if you look at the bone structure of the forelimbs, you'll find that the pattern of bones is very similar across species. It's unlikely that such similar structures would have evolved independently in each species, and more likely that the basic layout of bones was already present in a common ancestor of whales, humans, dogs, and birds.



The similar bone arrangement of the human, bird, and whale forelimb is a structural homology. Structural homologies indicate a shared common ancestor.

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Some homologous structures can be seen only in embryos. For instance, all vertebrate embryos (including humans) have gill slits and a tail during early development. The developmental patterns of these species become more different later on (which is why your embryonic tail is now your tailbone, and your gill slits have turned into your jaw and inner ear)^22start superscript, 2, end superscript. Homologous embryonic structures reflect that the developmental programs of vertebrates are variations on a similar plan that existed in their last common ancestor.



The small leg-like structures of some snakes species, like the*Boa constrictor*, are vestigial structures. These remnant features serve no present purpose in snakes, but did serve a purpose in the snakes' tetrapod ancestor (which walked on four limbs).

Sometimes, organisms have structures that serve no apparent function but are homologous to useful structures in other organisms. These reduced or nonfunctional structures, which appear to be evolutionary "leftovers," are called **vestigial structures**. Examples of vestigial structures include the tailbone of humans (a vestigial tail), the hind leg bones of whales, and the underdeveloped legs found in some snakes (see picture at right)^33start superscript, 3, end superscript.

#### **Analogous features**

To make things a little more interesting and complicated, not all physical features that look alike are marks of common ancestry. Instead, some physical similarities are **analogous**: they evolved independently in different organisms because the organisms lived in similar environments or experienced similar selective pressures. This process is called **convergent evolution**. (To *converge* means to come together, like two lines meeting at a point.)

For example, two distantly related species that live in the Arctic, the arctic fox and the ptarmigan (a bird), both undergo seasonal changes of color from dark to snowy white. This shared feature doesn't reflect common ancestry – i.e., it's unlikely that the last common ancestor of the fox and ptarmigan changed color with the seasons^44start superscript, 4, end superscript. Instead, this feature was favored separately in both species due to similar selective pressures. That is, the genetically determined ability to switch to light coloration in winter helped both foxes and ptarmigans survive and reproduce in a place with snowy winters and sharp-eyed predators.



Arctic fox and ptarmigan. Both are white-colored and shown in snowy winter landscapes.

#### **Determining relationships from similar features**

In general, biologists don't draw conclusions about how species are related on the basis of any single feature they think is homologous. Instead, they study a large collection of features (often, both physical features and DNA sequences) and draw conclusions about relatedness based on these features as a group. We will explore this idea further when we examine phylogenetic trees.

#### **Molecular biology**

Like structural homologies, similarities between biological molecules can reflect shared evolutionary ancestry. At the most basic level, all living organisms share:

- The same genetic material (DNA)
- The same, or highly similar, genetic codes
- The same basic process of gene expression (transcription and translation)
- The same molecular building blocks, such as amino acids

These shared features suggest that all living things are descended from a common ancestor, and that this ancestor had DNA as its genetic material, used the genetic code, and expressed its genes by transcription and translation. Present-day organisms all share these features because they were "inherited" from the ancestor (and because any big changes in this basic machinery would have broken the basic functionality of cells).

Although they're great for establishing the common origins of life, features like having DNA or carrying out transcription and translation are not so useful for figuring out *how* related particular organisms are. If we want to determine which organisms in a group are most closely related, we need to use different types of molecular features, such as the nucleotide sequences of genes.

#### **Homologous genes**

Biologists often compare the sequences of related genes found in different species (often called **homologous** or **orthologous** genes) to figure out how those species are evolutionarily related to one another.

The basic idea behind this approach is that two species have the "same" gene because they inherited it from a common ancestor. For instance, humans, cows, chickens, and chimpanzees all have a gene that encodes the hormone insulin, because this gene was already present in their last common ancestor.

In general, the more DNA differences in homologous genes (or amino acid differences in the proteins they encode) between two species, the more distantly the species are related. For instance, human and chimpanzee insulin proteins are much more similar (about 98% identical) than human and chicken insulin proteins (about 64% identical), reflecting that humans and chimpanzees are more closely related than humans and chickens^55start superscript, 5, end superscript.

#### Biogeography

The geographic distribution of organisms on Earth follows patterns that are best explained by evolution, in combination with the movement of tectonic plates over geological time. For example, broad groupings of organisms that had already evolved before the breakup of the supercontinent <u>Pangaea</u> (about 200200200 million years ago) tend to be distributed worldwide. In contrast, broad groupings that evolved after the breakup tend to appear uniquely in smaller regions of Earth. For instance, there are unique groups of plants and animals on northern and southern continents that can be traced to the split of Pangaea into two supercontinents (Laurasia in the north, Gondwana in the south).



Marsupial mammals on Australia likely evolved from a common ancestor. Because Australia's has remained isolated for an extended period time, these mammals have diversified into a variety of niches (without being outcompeted by placental mammals).

The evolution of unique species on islands is another example of how evolution and geography intersect. For instance, most of the mammal species in Australia are marsupials (carry young in a pouch), while most mammal species elsewhere in the world are placental (nourish young through a placenta). Australia's marsupial species are very diverse and fill a wide range of ecological roles. Because Australia was isolated by water for millions of years, these species were able to evolve without competition from (or exchange with) mammal species elsewhere in the world.

The marsupials of Australia, Darwin's finches in the Galápagos, and many species on the Hawaiian Islands are unique to their island settings, but have distant relationships to ancestral species on mainlands. This combination of features reflects the processes by which island species evolve. They often arise from mainland ancestors – for example, when a landmass breaks off or a few individuals are blown off course during a storm – and diverge (become increasingly different) as they adapt in isolation to the island environment.

#### Fossil record

**Fossils** are the preserved remains of previously living organisms or their traces, dating from the distant past. The fossil record is not, alas, complete or unbroken: most organisms never fossilize, and even the organisms that do fossilize are rarely found by humans. Nonetheless, the fossils that humans have collected offer unique insights into evolution over long timescales.



Earth's rocks form layers on top of each other over very long time periods. These layers, called strata, form a convenient timeline for dating embedded fossils. Strata that are closer to the surface represent more recent time periods, whereas deeper strata represent older time periods.

How can the age of fossils be determined? First, fossils are often contained in rocks that build up in layers called **strata**. The strata provide a sort of timeline, with layers near the top being newer and layers near the bottom being older. Fossils found in different strata at the same site can be ordered by their positions, and "reference" strata with unique features can be used to compare the ages of fossils across locations. In addition, scientists can roughly date fossils using <u>radiometric dating</u>, a process that measures the radioactive decay of certain elements.

Fossils document the existence of now-extinct species, showing that different organisms have lived on Earth during different periods of the planet's history. They can also help scientists reconstruct the evolutionary histories of present-day species. For instance, some of the best-studied fossils are of the horse lineage. Using these fossils, scientists have been able to reconstruct a large, branching "family tree" for horses and their now-extinct relatives^66start superscript, 6, end superscript. Changes in the lineage leading to modern-day horses, such as the reduction of toed feet to hooves, may reflect adaptation to changes in the environment.



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#### Direct observation of microevolution

In some cases, the evidence for evolution is that we can see it taking place around us! Important modern-day examples of evolution include the emergence of drug-resistant bacteria and pesticide-resistant insects.

For example, in the 1950s, there was a worldwide effort to eradicate malaria by eliminating its carriers (certain types of mosquitos). The pesticide DDT was sprayed broadly in areas where the mosquitoes lived, and at first, the DDT was highly effective at killing the mosquitos. However, over time, the DDT became less and less effective, and more and more mosquitoes survived. This was because the mosquito population evolved resistance to the pesticide.



The evolution of DDT resistance in mosquito populations was observed directly in the 1950s as a result of a campaign to eradicate malaria. Resistance to the pesticide evolved over a few years through natural selection:

1) Within mosquito populations, a few individuals had alleles that made them resistant to the pesticide, DDT. The majority of individuals had alleles that did not confer resistance.

2) When DDT was sprayed, individuals carrying the resistance allele survived, while those carrying the non-resistant allele died.

3) Over several generations, more resistant offspring were born and the population evolved. The population now contained more resistant than non-resistant individuals.

Emergence of DDT resistance is an example of evolution by <u>natural selection</u>^77start superscript, 7, end superscript. How would natural selection have worked in this case?

- 1. Before DDT was applied, a tiny fraction of mosquitos in the population would have had naturally occurring gene versions (**alleles**) that made them resistant to DDT. These versions would have appeared through random **mutation**, or changes in DNA sequence. Without DDT around, the resistant alleles would not have helped mosquitoes survive or reproduce (and might even have been harmful), so they would have remained rare.
- 2. When DDT spraying began, most of the mosquitos would have been killed by the pesticide. Which mosquitos would have survived? For the most part, only the rare individuals that happened to have DDT resistance alleles (and thus survived being sprayed with DDT). These surviving mosquitoes would have been able to reproduce and leave offspring.
- 3. Over generations, more and more DDT-resistant mosquitoes would have been born into the population. That's because resistant parents would have been consistently more likely to survive and reproduce than non-resistant parents, and would have passed their DDT resistance alleles (and thus, the capacity to survive DDT) on to their offspring. Eventually, the mosquito populations would have bounced back to high numbers, but would have been composed largely of DDT-resistant individuals.

In parts of the world where DDT has been used extensively in the past, many of the mosquitoes are now resistant. DDT can no longer be used to control the mosquito populations (and reduce malaria) in these regions.

Why are mosquito populations able to evolve rapid resistance to DDT? Two important factors are large population size (making it more likely that some individuals in the population will, by random chance, have mutations that provide resistance) and short lifecycle. Bacteria and viruses, which have even larger population sizes and shorter lifecycles, can evolve resistance to drugs very rapidly, as in antibiotic-resistant bacteria and drug-resistant HIV.

#### Summary

Multiple types of evidence support the theory of evolution:

- Homologous structures provide evidence for common ancestry, while analogous structures show that similar selective pressures can produce similar adaptations (beneficial features).
- Similarities and differences among biological molecules (e.g., in the DNA sequence of genes) can be used to determine species' relatedness.
- Biogeographical patterns provide clues about how species are related to each other.
- The fossil record, though incomplete, provides information about what species existed at particular times of Earth's history.
- Some populations, like those of microbes and some insects, evolve over relatively short time periods and can observed directly.



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#### **Possible questions**

- 1. Give a detailed account on analogous, vestigial and homologous organs
- 2. Explain DNA based phylogeny
- 3. Explain in vestigial organs of animals
- 4. Explain protein and nucleic acid based phylogeny
- 5. Explain geological timescale
- 6. Define paleobiology
- 7. What are hologous organs
- 8. Define analogous organs
- 9. Elaborate transitional forms
- 10. Describe evolutionary intermediates
- 11. Explain protein based phylogeny
- 12. What is he function of cytochrome C
- 13. Explain the homology of hemoglobin gene family
- 14. Explain rRNA sequence homology
- 15. Discuss types of ribosomalRNAs and their importance in evolutionary studies

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### LASS: III BSC B1COURSE NAME: EVOLUTIONARY BIOLOGYCOURSE CODE: 17BTU503BUNIT: IVBATCH-2017-2020

**Sources of Evolution – Variations as Raw Materials of Change:** Types of variations – Continuous and discontinuous; heritable and non-heritable. Causes, classification and contribution to evolution – Gene mutation; chromosomal aberrations; recombination and random assortment (basis of sexual reproduction); gene regulation. Concept of micro- and macro-evolution – A brief comparison

#### **Genetic Variation**

Populations exposed to selection often evolve rapidly. Alleles that confer increased survival and reproductive ability in the new conditions rapidly increase in frequency while alleles that were conditions rapidly increase in frequency, while alleles that were common decrease in frequency. How does the genetic variation arise?

One of the central tenets of the modern model of evolution is that variation does not arise in response to need. Instead, genetic variation is present in natural populations before it is exposed to 1 p pp p selection, in the form of rare alleles.

New sources of selection results in an increase in allele frequencies that confer high fitness. An alternative view is that new alleles that confer high fitness arise in response to exposure to selection. This is the "Neo-Lamarckian" view. Two different experiments with bacteria originally provided evidence that variation does not arise in response to need. Luria and Delbruck looked at variation among bacteria for resistance to a phage.

They reasoned that if variation arises in response to need, the incidence of new resistance in cultures of originally nonresistant bacteria should not vary greatly among independent cultures. should not vary greatly among independent cultures. They started multiple cultures of nonresistant bacteria, allowed them to multiply, and then exposed the bacteria to phage to test for resistance. Under the hypothesis that variation arises in response to need, they would expect all variation to arise after exposure.

As a result they'd expect little variation in the number of resistant colonies among cultures. Their expectation: 2 2 Under the hypothesis that variation arises randomly, not in response to need, resistance could appear in any generation, and thus some cultures would have many resistant

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bacteria (as a result of early mutation) and some cultures would have none (as result of no mutation) yp g . They expected great variation in the number of resistant colonies among cultures: 3 This is what Luria and Delbruck found. In the second experiment, Joshua and Esther Lederberg used replica plating to determine if penicillin resistance in bacterial colonies was present before exposure to penicillin or only arose after exposure to penicillin.

They cultured nonresistant bacteria and then exposed them to penicillin. Their technique allowed them to determine if the original colonies from which the resistant bacteria were derived were resistant before exposure to penicillin. Their results showed that resistance did not arise during exposure t i illi 4 to penicillin. Resistance arose in the culture before exposure to penicillin. 3 Mutation - the alteration of a region of DNA or chromosome; and altered state of a region of DNA or chromosome Types of mutations: base pair substitution base pair substitution - a single base pair change in DNA also a single base pair change in DNA, also called a point mutation Point mutations can result in single amino acid changes (nonsynonymous 5 mutation) or no change in amino acid – (synonymous mutation)

Nonsynonymous mutations may have small or large effects on the properties of the protein product of the gene. A single base pair addition or deletion is a frameshift mutation - the result is a change in reading frame of RNA product of the gene and many amino acid changes in the

protein product and many amino acid changes in the protein product - usually usually results in a nonfunctional protein product.

IntragenicrecombinationOriginalSequence:ATTGATCGATCGATCTATGCTAACTAGCTAGATACGRecombinationcanalsoresultinsequencechangesMutationSequence1:ATGGATCGATCGATCTATGCTACCTAGCTAGATACGMutationSequence2:ATTGATCGATGGATGCTAACTAGCTACCTACGRecombinationATGGATCGATGGATGC 7SequenceTACCTAGCTACCTACG

The amino acid changes resulting from the original two point mutations are combined in a single protein as a result of recombination. Unequal crossing-over results in sequence duplications and deletions. Unequal crossing-over usually occurs in regions where there are tandem repeats. The result can be a reduction in the number of repeats or an increase in the number of repeats. 8 High numbers of tandem repeats make a region liable to unequal crossing-over and additional duplications. It can give rise to gene families (multiple copies of variants of a single gene) and new functional genes.

5 Transposable elements - sequences of DNA that can be inserted into regions of the genome Insertion of a sequence of bases into a functional gene or the regulatory region of a functional gene can destroy normal functioning of that gene. Transposable elements can result in the movement of neighboring genes that were not initially part of the transposable elements.

Recombination between transposable elements 9 transposable elements can result in deletions or inversions of base pair sequences. Examples of mutations: Sickle-cell anemia - a single base pair substitution that results in a single amino acid change in the  $\beta$  chain of Hb Precocious puberty - a single amino acid change in the gene for the receptor for luteinizing hormone results in males that show signs of puberty as early as age

4. Cystic fibrosis - a fatal disease that occurs in 1 in every 2500 births among northern Europeans is due to a mutation in a chloride ion channel protein. Different mutations account for the same condition: a deletion of 3 base pairs results in the deletion of a single amino 10 p g acid, a conversion of an arginine codon into a stop codon, an alteration in a splicing enzyme has resulted

in the deletion of an exon from the mRNA transcribed from the gene. Retinitis pigmentosa - a degenerative disease of the retina - can be caused by mutations in at least 8 different genes.

6 Hemophilia - caused by mutations in two different genes for blood clotting proteins. The mutations can be base pair substitutions, small deletions, small duplications. Twenty percent of the cases of hemophilia A are caused by an inversion of a long sequence of bases within one of the genes. Huntington's disease - a fatal neurological disorder - is due to an excessive number of repeats of the sequence CAG - normal forms of the genes have 10 to 30 repeats, mutants have more than 75 Although most mutations are have deleterious effects on the 11 Although most mutations are have deleterious effects on the encoded protein some have beneficial effects and have been important in evolution FOXP2 - encodes a transcription factor - mutations in this gene can cause severe speech and language disorders. Humans differ from chimpanzees at two base pairs that result in nonsynonymous amino acid changes.

The amount of change in this gene is unusuallyg y y g g high relative to synonymous changes in the gene suggesting the gene may have been important in the evolution of human speech abilities. 12 7 Mutation rates can be estimated by their appearance in laboratory stocks or by counting the number of offspring born Estimating Mutation Rates in each generation with genetic disease caused by a dominant allele - these are likely to be underestimates of the frequency of point mutations because synonymous mutations result in the same phenotype as nonmutants. 13 Mutation rates can be estimated indirectly by counting the number of differences between two descendants of a common ancestor and counting the number of generations since their origin. This method assumes that no selection has been involved in the change in allele frequency with each species. Mutation rates can be estimated by assuming that deleterious mutations are removed by selection. The forward mutation rate (A a) is given the symbol  $\mu$ . The reverse mutation rate (a A) is given the symbol.

The reverse mutation rate (a A) is given the symbol v. Without mutation, deleterious dominant alleles should be removed by selection until they are absent from the  $\mu$  A a v 14 y y population. So the mutation rate is equal to the observed frequency of the deleterious dominant alleles (p) in the population. v = p 8 Deleterious recessive mutations will be removed from the population very

slowly once they become rare. The rate of removal is 2 2 spq  $\Delta = p$  And, when the recessive allele is rare the p = f(A), q = f(a) Deleterious recessive alleles are reintroduced by mutation at rate  $\mu p$  So, in a population in which mutation adds the allele and selection removes it we should have 2 1 p - sq allele is rare the denominator is ~1. 2  $\mu$  p spq = 15 2  $\mu$  = sq If the deleterious recessive allele is lethal (s=1), the mutation rate is equal the observed frequency of homozygotes. Rates of mutation of individual base pairs are low but when summed over the entire genome the effect is considerable. With 1 6 i 1 i i h ff i 16 With 1.6 mutations per sexual generation in the effective genome, a population of 1 million humans will have 1.6 million new mutations in each generation. Although most will be deleterious or neutral, if only a small fraction were beneficial there would be considerable raw material for evolution. 9 Most mutations have little or no effect Mutations and Fitness on fitness. A few are beneficial and a few are very deleterious. 17 The effects of a mutation can vary among environments. An allele that increases fitness in a cool environment may decrease fitness in a warm environment.





The sickle-cell allele confers hig yg h fitness to the heterozygote where malaria is common but is neutral in heterozygotes where malaria is not common. Experiments with Drosophila showed that a mildly deleterious allele became up to 10 times more deleterious when populations were crowded and had fewer resources. 18 Thus, many alleles that have little or no effect on fitness in the current environment may be beneficial or harmful if the environment changes. For example, alleles for pesticide or antibiotic resistance may have little effect on fitness until the agent is applied.

The same is likely true for many other mutations. 10 The effects of slightly beneficial mutations in different genes can be combined to produce more adaptive combinations. Mutations in different individuals can be combined is kl i l bined quickly in sexual species. In asexual species combination of mutations depends upon multiple independent mutations 19 within a genetic lineage.

Sex allows much faster adaptation through the rapid combination of slightly beneficial mutations. DDT resistance Changes in Karotype Karyotype - a description of the chromosomal constitution of and organism - number, size, shape, internal arrangement Changes in ploidy - the number of sets of chromosomes Aneuploidy - loss or gain of one or more chromosomes in a set -

this is usually deleterious because of genic imbalance- Down Syndrome in humans is the result of 3 copies of chromosome 21 - trisomy 21 Polyploidy - having one or more extra sets of chromosomes 2N diploid 3N triploid 4N tetraploid etc 20 - diploid, 3N - triploid, 4N - tetraploid, etc. Polyploid organisms can have problems with meiosis. An autopolyploid has multiple sets of chromosomes from the same species. An allopolyploid has multiple sets of chromosomes from different species.

11 An odd number of each set of chromosomes results in problems with synapsis and segregation. Many of the resulting cells receive an unbalanced (aneuploid) set of chromosomes. Aneuploid gametes 21 Aneuploid gametes produce aneuploid zygotes that usually have problems because of genic imbalance. Autopolyploids with even numbers of chromosomes can al d so produce aneuploid gametes.

22 12 Hybrid organisms receive two different sets of chromosomes, one from each parent species. They are usually sterile because differences in gene arrangements among chromosomes results in improper synapsis and aneuploid gametes. Duplication of Duplication of whole sets of chromosomes (allopolypoidy) may result in gametes that have balanced 23 have balanced sets of chromosomes. Allopolyploids with a diploid number of sets of chromosomes from each parent (2NA + 2NB) produce gametes that are euploid with one set of chromosomes from each parent (NA + NB). Such organisms are potentially interfertile or self-fertile but they can t' produce fertile offspring in backcrosses with either parent produce fertile parent produc

Gamete (NA + NB) combined with gamete (NA) produces an allotriploid (2NA + NB) that produces unbalanced sets of genes in gametes. Thus, allopolyploids are reproductively isolated from each of 24 their parent species. They can only reproduce with other allopolyploids or through self-fertilization.

They are new species as soon as they are formed. Many species of plants and some animals are polyploid. At least 50% of all flowering plants are polyploid. 13 Chromosome rearrangements Breakage and reunion of chromosomes can change gene order or change the distribution of genes

among chromosomes. Such changes generally have little or no effect on the phenotype of the org g qy anism.

Some rearrangements can have effects on the frequency of recombination and fertility. An inversion of gene order: ABCDEFG ABEDCFG results in a loop arrangement in the 25 arrangement in the chromosomes during synapsis A paracentric inversion is an inversion of a portion of a chromosome that does not include the centromere. In a heterozygote, synapsis of the genes within the inversion is only possible if one of the homologs forms a loop.

Cross-overs can occur within the inversion, but the chromatids involved in the cross-over will be genetically imbalanced and either be dicentric or acentric. They will have problems during 26 acentric. They will have problems during segregation and the gametes that receive them will not be viable. Only the non-recombinant chromatids will produce viable gametes - thus preserving the original gene combinations.

A pericentric inversion is an inversion of a portion of a chromosome that includes the centromere. In a heterozygote, synapsis of the genes within the inversion is only possible if one of the homologs forms a loop. Cross-overs can occur within the inversion, but the chromatids involved in the cross-over will be genetically imbalanced. They will have problems during segregation and the gametes that 27 during segregation and the gametes that receive them will not be viable. Only the non-recombinant chromatids will produce viable gametes - thus preserving the original gene combinations.

A translocation is a movement of genes from one chromosome to another. Reciprocal translocations involve a swap of genes between two chromosomes. A heterozygote for a reciprocal translocation is genetically balanced and viable, but during gamete production synapsis of the chromosomes produces a cross-shaped pattern. 28 15 At anaphase centromeres are pulled to opposite poles. There are three possible ways the centromeres can associate - alternate, adjacent-1, and adjacent-2.

Only alternate segregation will result in genetically balanced gametes. balanced gametes. Thus, the only viable gametes from a translocation heterozygote will have chromosomes identical in

genetic constitution to the sets received from its parents. Thus, translocation heterozygotes will not exhibit independent assortment of these pairs of 29 independent assortment of these pairs of chromosomes.

This also preserves gene combinations. Translocation heterozygotes are partially sterile and this may form the basis for partial post-zygotic isolation between closely related species. Chromosome number can change through fission or fusion of chromosomes or pieces of chromosomes. 30 16 Karyotypic changes through fission and fusion can be dramatic. Such changes can be the cause of reproductive isolation between related species. 31 The karyotypes of primates differ by gene rearrangements within chromosomes (as shown by banding patterns) and difference in chromosome number due to fusion or fission of chromosomes.

Microevolution:

- The generation-to-generation change in frequencies of alleles within a population is called **microevolution**. Its evolution on the smallest scale.
- Mechanisms of microevolution:
  - Natural Selection
  - Sexual Selection
  - Artificial Selection
  - Genetic Drift
  - Gene Flow



Predator eats the more easily seen beetles lacking the brown gene...

...resulting in an increase in brown gene frequency.

Change in allele frequencies resulting from natural selection, genetic drift, gene flow, and mutation. Macroevolution: The large-scale patterns, trends, and rates of change among families and other more inclusive groups of species.

**Macroevolution** is evolution on a scale at or above the level of <u>species</u>, in contrast with microevolution which refers to smaller evolutionary changes of allele frequencies within a species or population. Macroevolution and microevolution describe fundamentally identical processes on different time scales.

The process of speciation may fall within the purview of either, depending on the forces thought to drive it. Paleontology, evolutionary developmental biology, comparative genomics and genomic phylostratigraphy contribute most of the evidence for macroevolution's patterns and processes

- Macroevolution: major patterns and changes among living organisms over long periods of time.
- The evidence comes from 2 main sources: fossils and comparisons between living organisms.



#### **Possible questions**

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1. Give note son point mutation

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- 2. What are the different types of chromosomal aberrations?
- 3. Elaborate RNA first hypothesis
- 4. What are genetic variations? Give examples
- 5. Define recombination and random assortment
- 6. Explain macroevolution
- 7. Write notes on recombination
- 8. What is polymorphism?
- 9. What are the causes of genetic variations?
- 10. Write short notes on no inheritable variations
- 11. Explain the role of variations in evolution?
- 12. Explain chromosomal aberrations

Natural selection as a guiding force – Its attributes and action Basic characteristics of natural selection. Colouration, camouflage and mimicry, Co-adaptation and co-evolution, Man-made causes of change – Industrial melanism; brief mention of drug, pesticide, antibiotic and herbicide resistance in various organisms. Modes of selection, Polymorphism, Heterosis and Balanced lethal systems. Genetic Drift

#### **Forces of evolution**

#### Natural Selection:

According to Darwin 'the fittest' forms that are allowed to survive are chosen by 'Natural Selection' (an imaginative concept which includes all real aspects of the natural environment that supports the life of organisms). The forces of natural selection will encourage only those that have suitable variations as adaptive features, to survive. Darwin designated them as 'fittest' forms. All other organisms having non adaptive or deleterious modifications shall be disqualified. Natural selection will eliminate such organisms from the populations. The selected group of modified individuals will occupy the next level in the evolutionary ladder. Darwin strongly believed that using the natural selection concept, all evolutionary processes in the living world can be explained. As an example he differed from the explanation provided by Lamarck while explaining the lengthening of neck in giraffe. According to Darwin the population of giraffes had individuals having varying neck lengths. Those that had longer necks had more survival value, since they had more food and remained healthy. Gradually natural selection encouraged them to survive. Thus in course of time the average length of the neck increased.

#### **Objections to Darwinism**

While the ideas of Darwin, related to reproductive capability, prevalence of variations, concept of struggle and survival of suitable forms are all commonly accepted, there are certain drawbacks in his original theory.

1. Darwin could not explain, the origin and cause for variations while insisting their importance in progressive evolution.

2. He overemphasized the importance of the 'fittest' organisms. During later periods it has been suggested that 'fit' and fitter forms can also exist along with the fittest.

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3. As the principle of inheritance as explained in the later years were not available during Darwin's time. Hence he believed in the theory of 'pangenesis'. According to this concept from every organ in the body very minute such replicate structures will orginate. Later they are transferred to

the gonads for transmission to future generations.

4. 'Over-specialization' as in Irish deer and its consequent harmful effect on animals had not been accounted for by Darwin

#### The Evolution of Theory

The theory of evolution is one of the great intellectual revolutions of human history, drastically changing our perception of the world and of our place in it. Charles Darwin put forth a coherent theory of evolution and amassed a great body of evidence in support of this theory. In Darwin's time, most scientists fully believed that each organism and each adaptation was the work of the creator. Linneaus established the system of biological classification that we use today, and did so in the spirit of cataloguing God's creations.

In other words, all of the similarities and dissimilarities among groups of organisms that are the result of the branching process creating the great tree of life (*see Figure 1*), were viewed by early 19th century philosophers and scientists as a consequence of omnipotent design.



Figure: A phylogenetic "tree of life" constructed by computer analysis of cyochrome c molecules in the organisms shown; there are as many different trees of life as there are methods of analysis for constructing them

However, by the 19th Century, a number of natural historians were beginning to think of evolutionary change as an explanation for patterns observed in nature. The following ideas were part of the intellectual climate of Darwin's time.

• No one knew how old the earth was, but geologists were beginning to make estimates that the earth was considerably older than explained by biblical creation. Geologists were

learning more aboutstrata, or layers formed by successive periods of the deposition of sediments. This suggested a time sequence, with younger strata overlying older strata.

- A concept called <u>uniformitarianism</u>, due largely to the influential geologist Charles Lyell, undertook to decipher earth history under the working hypothesis that present conditions and processes are the key to the past, by investigating ongoing, observable processes such as erosion and the deposition of sediments.
- Discoveries of fossils were accumulating during the 18th and 19th centuries. At first naturalists thought they were finding remains of unknown but still living species. As fossil finds continued, however, it became apparent that nothing like giant dinosaurs was known from anywhere on the planet. Furthermore, as early as 1800, Cuvier pointed out that the deeper the strata, the less similar fossils were to existing species.
- Similarities among groups of organisms were considered evidence of relatedness, which in turn suggested evolutionary change. Darwin's intellectual predecessors accepted the idea of evolutionary relationships among organisms, but they could not provide a satisfactory explanation for how evolution occurred.
- Lamarck is the most famous of these. In 1801, he proposed organic evolution as the explanation for the physical similarity among groups of organisms, and proposed a mechanism for adaptive change based on the inheritance of acquired characteristics. He wrote of the giraffe:

"We know that this animal, the tallest of mammals, dwells in the interior of Africa, in places where the soil, almost always arid and without herbage, obliges it to browse on trees and to strain itself continuously to reach them. This habit sustained for long, has had the result in all members of its race that the forelegs have grown longer than the hind legs and that its neck has become so stretched, that the giraffe, without standing on its hind legs, lifts its head to a height of six meters."

In essence, this says that the necks of Giraffes became long as a result of continually stretching to reach high foliage. Larmarck was incorrect in the hypothesized mechanism, of course, but his example makes clear that naturalists were thinking about the possibility of evolutionary change in the early 1800's.

- Darwin was influenced by observations made during his youthful voyage as naturalist on the survey ship *Beagle*. On the Galapagos Islands he noticed the slight variations that made tortoises from different islands recognizably distinct. He also observed a whole array of unique finches, the famous "Darwin's finches," that exhibited slight differences from island to island. In addition, they all appeared to resemble, but differ from, the common finch on the mainland of Ecuador, 600 miles to the east. Patterns in the distribution and similarity of organisms had an important influence of Darwin's thinking. The picture at the top of this page is of Darwin's own sketches of finches in his Journal of Researches.
- In 1859, Darwin published his famous *On the Origin of Species* by Means of Natural Selection, a tome of over 500 pages that marshalled extensive evidence for his theory. Publication of the book caused a furor every copy of the book was sold the day that it was released. Members of the religious community, as well as some scientific peers, were outraged by Darwin's ideas and protested. Most scientists, however, recognized the power of Darwin's arguments. Today, school boards still debate the validity and suitability of Darwin's theory in science curricula, and a whole body of debate has grown up around the controversy (see the WWW site <u>Talk.Origins</u> for an ongoing dialogue). We do not have time to cover all of Darwin's evidence and arguments, but we can examine the core ideas. *What does this theory of evolution say?*

Darwin's Theory

Darwin's theory of evolution entails the following fundamental ideas. The first three ideas were already under discussion among earlier and contemporaneous naturalists working on the "species problem" as Darwin began his research. Darwin's original contributions were the mechanism of natural selection and copious amounts of evidence for evolutionary change from many sources. He also provided thoughtful explanations of the consequences of evolution for our understanding of the history of life and modern biological diversity.

• Species (populations of interbreeding organisms) change over time and space. The representatives of species living today differ from those that lived in the recent past, and populations in different geographic regions today differ slightly in form or



- behavior. These differences extend into the fossil record, which provides ample support for this claim.
- All organisms share common ancestors with other organisms. Over time, populations may divide into different species, which share a common ancestral population. Far enough back in time, any pair of organisms shares a common ancestor. For example, humans shared a common ancestor with chimpanzees about eight million years ago, with whales about 60 million years ago, and with kangaroos over 100 million years ago. Shared ancestry explains the similarities of organisms that are classified together: their similarities reflect the inheritance of traits from a common ancestor.
- Evolutionary change is gradual and slow in Darwin's view. This claim was supported by the long episodes of gradual change in organisms in the fossil record and the fact that no

naturalist had observed the sudden appearance of a new species in Darwin's time. Since then, biologists and paleontologists have documented a broad spectrum of slow to rapid rates of evolutionary change within lineages.

The primary mechanism of change over time is natural selection, elaborated below. This mechanism causes changes in the properties (traits) of organisms within lineages from generation to generation.

#### **The Process of Natural Selection**

Darwin's process of natural selection has four components.

- Variation. Organisms (within populations) exhibit individual variation in appearance and behavior. These variations may involve body size, hair color, facial markings, voice properties, or number of offspring. On the other hand, some traits show little to no variation among individuals—for example, number of eyes in vertebrates.
- 2. Inheritance. Some traits are consistently passed on from parent to offspring. Such traits are heritable, whereas other traits are strongly influenced by environmental conditions and show weak heritability.
- 3. High rate of population growth. Most populations have more offspring each year than local resources can support leading to a struggle for resources. Each generation experiences substantial mortality.
- 4. Differential survival and reproduction. Individuals possessing traits well suited for the struggle for local resources will contribute more offspring to the next generation.

From one generation to the next, the struggle for resources (what Darwin called the "struggle for existence") will favor individuals with some variations over others and thereby change the frequency of traits within the population. This process is natural selection. The traits that confer an advantage to those individuals who leave more offspring are called adaptations.

In order for natural selection to operate on a trait, the trait must possess heritable variation and must confer an advantage in the competition for resources. If one of these requirements does not Prepared by Dr. Anil Kumar PK, Asst Prof, Department of Biotechnology, KAHE

occur, then the trait does not experience natural selection. (We now know that such traits may change by other evolutionary mechanisms that have been discovered since Darwin's time.)

Natural selection operates by comparative advantage, not an absolute standard of design. "...as natural selection acts by competition for resources, it adapts the inhabitants of each country only in relation to the degree of perfection of their associates" (Charles Darwin, <u>On the Origin of Species</u>, 1859).

During the twentieth century, genetics was integrated with Darwin's mechanism, allowing us to evaluate natural selection as the differential survival and reproduction of genotypes, corresponding to particular phenotypes. Natural selection can only work on existing variation within a population. Such variations arise by mutation, a change in some part of the genetic code for a trait. Mutations arise by chance and without foresight for the potential advantage or disadvantage of the mutation. In other words, variations do not arise because they are needed.

#### **Evidence of Natural Selection**

Let's look at an example to help make natural selection clear.

Industrial melanism is a phenomenon that affected over 70 species of moths in England. It has been best studied in the peppered moth, *Biston betularia*. Prior to 1800, the typical moth of the species had a light pattern (*see Figure 2*). Dark colored or melanic moths were rare and were therefore collectors' items.



During the Industrial Revolution, soot and other industrial wastes darkened tree trunks and killed off lichens. The light-colored morph of the moth became rare and the dark morph became abundant. In 1819, the first melanic morph was seen; by 1886, it

Figure 2. Image of Pepperedwas far more common -- illustrating rapidMothevolutionary change.


Eventually light morphs were common in only a few locales, far from industrial areas. The cause of this change was thought to be selective predation by birds, which favored camouflage coloration in the moth.

In the 1950's, the biologist Kettlewell did release-recapture experiments using both morphs. A brief summary of his results are shown below. By observing bird predation from blinds, he could confirm that conspicuousness of moth greatly influenced the chance it would be eaten.

### **Recapture Success**

	light moth	dark moth
non-industrial woods	14.6 %	4.7 %
industrial woods	13 %	27.5 %

### Local Adaptation - More Examples

So far in today's lecture we have emphasized that natural selection is the cornerstone of evolutionary theory. It provides the mechanism for adaptive change. Any change in the environment (such as a change in the background color of the tree trunk that you roost on) is likely to lead to local adaptation. Any widespread population is likely to experience different environmental conditions in different parts of its range. As a consequence it will soon consist of a number of sub-populations that differ slightly, or even considerably.

The following are examples that illustrate the adaptation of populations to local conditions.

• The rat snake, *Elaphe obsoleta*, has recognizably different populations in different locales of eastern North America (*see Figure 3*). Whether these should be called geographic "races" or subspecies is debatable. These populations all comprise one

species, because mating can occur between adjacent populations, causing the species to share a common gene pool



*Figure : Subspecies of the rat snake <u>Elaphe obsoleta</u>, which interbreed where their ranges meet* 

• Galapagos finches are the famous example from Darwin's voyage. Each island of the Galapagos that Darwin visited had its own kind of finch (14 in all), found nowhere else in the world. Some had beaks adapted for eating large seeds, others for small seeds, some had parrot-like beaks for feeding on buds and fruits, and some had slender beaks for feeding on small insects (*see Figure 4*). One used a thorn to probe for insect larvae in wood, like some woodpeckers do. (Six were ground-dwellers, and eight were tree finches.) (This diversification into different ecological roles, or **niches**, is thought to be necessary to permit the coexistence of multiple species, a topic we will examined in a later lecture.) To Darwin, it appeared that each was slightly modified from an original colonist, probably the finch on the mainland of South America, some 600 miles to the east. It is probable that adaptive radiation led to the formation of so many species because

other birds were few or absent, leaving empty niches to fill; and because the numerous islands of the Galapagos provided ample opportunity for geographic isolation.



### Stabilizing, Directional, and Diversifying Selection

Finally, we will look at a statistical way of thinking about selection. Suppose that each population can be portrayed as a frequency distribution for some trait -- beak size, for instance. Note again that variation in a trait is the critical raw material for evolution to occur.

What will the frequency distribution look like in the next generation?



First, the proportion of individuals with each value of the trait (size of beak, or body weight) might be exactly the same. Second, there may be directional change in just one direction. Third (and with such rarity that its existence is debatable), there might be simultaneous change in both directions (e.g. both larger and smaller beaks are favored, at the expense of those of intermediate size). Figures 5a-c

Figures 5a-c

capture these three major categories of natural selection.

Under **stabilizing selection**, extreme varieties from both ends of the frequency distribution are eliminated. The frequency distribution looks exactly as it did in the generation before (*see Figure 5a*). Probably this is the most



common form of natural selection, and we often mistake it for no selection. A real-life example is that of birth weight of human babies

Under **directional selection**, individuals at one end of the distribution of beak sizes do especially well, and so the frequency distribution of the trait in the subsequent generation is shifted from where it was in the parental generation. This is what we usually think of as natural selection. Industrial melanism was such an example.

The fossil lineage of the horse provides remarkable demonstration a of directional succession. The full lineage is quite complicated and is not just a simple line from the tiny dawn horse Hyracotheriumof the early Eocene, to today's familiar Equus. Overall, though, the horse has evolved from a small-bodied ancestor built for moving through woodlands and thickets to its long-legged descendent built for speed on the open grassland. This evolution has involved welldocumented changes in teeth, leg length, and toe structure (see Figure 7).



#### Under diversifying

#### (disruptive)

**selection**, both extremes are favored at the expense of intermediate varieties. This is uncommon, but of theoretical interest because it suggests a mechanism for species formation without geographic isolation

### KARPAGAM ACADEMY OF HIGHER EDUCATION

### CLASS: III BSC BTCOURSE NAME: EVOLUTIONARY BIOLOGYCOURSE CODE: 17BTU503BUNIT: VBATCH-2017-2020

- 1. Explain natural selection
- 2. Discuss genetic drift with example
- 3. What is camouflage?
- 4. Elaborate the characteristics of natural selection
- 5. Explain co-adaptation and co evolution
- 6. Explain industrial melanism
- 7. Illustrate bottle neck effect
- 8. Explain the evolution of antibiotic and pesticide resistance
- 9. Define adaptation
- 10. Describe mimicry
- 11. Differentiate co-adaptation and co evolution
- 12. What is polymorphism?
- 13. What is a protocell model?
- 14. Describe survival of fittest
- 15. Define Parallelism of evolution
- 16. Define co-evolution

The Neo-Darwinian synthesis reconciled:	natural selection and orthogenesis	neo-Larmarckism and natural selection	genetics and mutationism	natural selection and genetics	natural selection and genetics
Your friend remarks, "The giraffe stretched its neck while reaching for higher leaves; as a result, its offspring inherited longer necks" Which statement is the <u>best</u> response to correct your	Overproduction of offspring leads to a struggle for survival.	Only favorable adaptations have survival value.	Characteristics acquired during an organism's life are generally not passed on through	genes to its offspring	Characteristics acquired during an organism's life are generally not passed on through
Which of the following principles is NOT part of Darwin's original theory of evolution by natural	Evolution is a gradual process that occurs over long periods of time	Variation occurs among individuals in a population	Mutations are the ultimate source of genetic variation	More individuals are born than will survive	Mutations are the ultimate source of genetic variation
The <i>more</i> closely related two	more similar their habitats are	less similar their DNA sequences are	more recently they shared a common	less likely they are to have the same	more recently they shared a common
For a population in Hardy-Weinberg equilibrium, the frequency of the recessive allele	increases with each generation until it reaches 50%	decreases with each generation until it reaches 25%	remains the same in every generation	increases due to the occurrence of new mutations	remains the same in every generation
An organism's <i>relative fitness</i> is measured by its	Mutation rate	Health and stability in the face of environmental	Contribution to the gene pool of the next generation	Genetic variability	Mutation rate
Genomic studies of the chromosomal fusion in chimpanzees provided an explanation for differences in chromosomal number compared to humans. This	Acquired Characteristics	Common Ancestry	Adaptive Radiation	Artificial Selection	Common Ancestry
What is the only factor that can change allele frequencies in populations to produce <i>adaptive</i>	gene flow	non-random mating	genetic drift	selection	selection
Hybridization between different plant species producing more than two sets of	polyploidy	gametic isolation	hybrid viability	mutation	polyploidy
The age of earth is estimate to be about	a)10000 years old	b)4-5 billion years ago	c)600 million year old	d)10-20	b)4-5 billion years ago
Which one of the following are Archaebacteria?	a)Actinomycetes	b)Pseudomonas	c)Rickettisae	d)Methanogens	d)Methanogens
Formation of most amino acids as well as adenine andother nucleic acid bases from inorganic molecules was	a) Hugo de vries	b) Urey and Miller	c) Oparin and Haldane	d)Pasteur	b) Urey and Miller

The most primitive	a)plasmodium	b)tetrahymena	c)chlamydomonas	d)Giardia	d)Giardia
extant eukaryotes	· 1	, <u>,</u>			,
belong to the genus					
Cambrian	a) Origin of life	b)Origin of phyla	c) Origin of man	d)extinction of	b)Origin of phyla
Explosion refers to	, ,		, ,	Dinosaurs	
Which of the	a)Mitochondria	b)mitochondrial	c)mitochondrial	d)mitochondrial	c)mitochondrial
following statement	DNA has a circular	ribosomes are	genes code for	ribosomes are 70s	genes code for
cannot be support	genome	inactivated by the	enzymes of		enzymes of
the endosymbiotic	0	antibiotic	oxidative respiration		oxidative respiration
theory for the orgin		chloramphenicol	1		1
of mitochondria?		· · · · ·			
Aerobic respiration	a)1.0-1.5bp	b) 2.0-2.5bp	c)3.0-3.5bp	d)3.5-4.0bp	b) 2.0-2.5bp
is thought to have	.,	.,	· / · · · · · · · · · · · · · · · · · ·	.,	
first appeared in					
some organisms of					
approximate age					
Which of the	a)exon shuffling	b)intron excisions	c)transposons	d)DNA	a)exon shuffling
following process	a)enon sharring		insertions	amplification	u)enon onurring
offers the greatest			moertroms	umphiloution	
opportunities for					
accelerating the					
evolution of new					
The correct	a) Devonian	b) Focene	c) Devonian	d) Carboniferous	a) Devonian
chronological	Carboniferous	Devonian	Carboniferous	Devonian	Carboniferous
sequences of	Cretaceous Eocene	Carboniferous	Eocene Cretaceous	Cretaceous Focene	Cretaceous Eocene
reological times is	Cretaceous, Locene	Cretaceous	Locene , cretaceous	Cretaceous, Locene	Cretaceous, Locene
The extent bacterial	a)nurnle	b)archaebacteria	c) cvanobactaia	d)methanogens	a)nurnle
group that is most	a)purple	0)archaebacterra	c)cyallobactera	u)methanogens	a)puipie
gloup that is most	bactoria				bactoria
the angestor from	Dacterra				Dacterra
which mitochondria					
The first	a) Cat	h) Dee		d) Com	h) Dec
domas astad	a) Cal	b) Dog	c) Horse	a) Cow	b) Dog
animal by primi va					
Which of the	a) <b>Dinu</b> c	h) Piccio	a) Cinkgo	d) Cnotum	a) Ginkao
following is on	a) r mus	0) Riccia	c) Olikgo	u) Oliciulli	c) Olikgo
avample of living					
Example of fiving	a) Cruan altra atomia	h) Automorho	2)	d) Dhataantataanha	2)
First me on earth	a) Cyanobacteria	b) Autographs	C) Chamabatanatuanha	d) Photoautotrophs	C) Chamabatanatnanka
Was Most abundant	a) Drotain	b) Callulana	a) Staroida	d) Linida	b) Callulaça
Most adundant	a) Protein	b) Centulose	c) Steroids	d) Lipids	b) Cellulose
Which is not a	a) Naile	b) Third molor		d) Sagmantad	a) Naila
which is not a	a) maiis	b) Third motai	c) Coccyx	u) Segmenteu	a) Indiis
Cono. o dri7	a) Larga	h) Smaller	a) Island	d) Mondoolion	h) Smallar
Gene c dri/	a) Large	b) Smaller	c) Island		b) Smaller
The animals of cold	popula olis	b) Dollo's low	a) Baramann'a law	d) Allen's law	d) Allon's low
The animals of cold	a) Cope's law	b) Dollo's law	c) Bergmann s law	d) Allen's law	d) Allen's law
countries have					
relavely shorter and					
poorly developed					
ears, eyes, nairs and					
other phenotypic					
Interactors. This is					
known by wnich		1) N ( 101		1) T 1 1 4	1) N ( 101
Phenomenon of	a) Geographical	b) Natural Selec on	c) Reproduc ve	a) Induced muta on	b) Natural Selec on
industrial	isola on		isola on		
meianism					
Convergent	a) Rat and Dog	b) Bacterium and	c) Starfish and	d) Dogfish and	d) Dogfish and
evolu on 1s		Protozoan	Cu@le fish	whale	whale
Correct order is	a) Paleozoic->	b) Archaeozoic->	c) Coenozoic -	d) Mesozoic->	a) Paleozoic->
	Mesozoic->	Coenozoic -	>Paleozoic->	Archaeozoic->	Mesozoic->
<b>T</b> . 10	Coenozoic	>Paleozoic	Archaeozoic	Coenozoic	Coenozoic
First life on earth	a) cyanobacteria	b) autotrophs	c) photo autotrophs	a)	a)
was				cnemoheterotrophs	cnemoheterotrophs

One of the possible early sources of	a) green plants	b) carbon dioxide	c) chlorophyll	d) UV rays and lightening	d) UV rays and lightening
energy were/ was					0 0
First experiment	a) Watson and Crick	b) Oparin and	c) Urey and Miller	d) Meselson and	c) Urey and Miller
regarding evolution of life was		Haldane		Stahl	
Coacervates were	a) DNA	b) radiations	c) polymerisation	d) polymerisation	d) polymerisation
formed by				and aggregation	and aggregation
Miller and Urey	a) N and H O	b) H O and CH	c) CO and N	d) CH and N	b) H O and CH
performed an					
experiment to prove					
origin of life. They					
look for gases NH					
and H along with?					
According to	a) methane	b) hydrogen	c) water vapour	d) oxygen	d) oxygen
Oparin, which one					
of the following					
was not present in					
the primitive					N
Swan neck flask	a) Oparin and	b) Darwin	c) Aristotle	d) Louis Pasteur	d) Louis Pasteur
experiment was	Haldane				
performed by					
Coacervates were	a) Urey and Miller	b) Jacob and Monad	c) Oparin	d) Fischer and	c) Oparin
				Huxley	
Finding of Millor's	a) theory of energial	h) theory of	a) theory of	d) the arra of anomia	a) theory of
Finding of Miller's	a) theory of special	b) theory of	c) theory of	d) theory of organic	c) theory of
origin of life has	creation	biogenesis	abiogenesis	evolution	abiogenesis
provided evidence					
Theory of	a) Spallanzani	b) E Redi	c) Van Helmont	d) Pasteur	c) Van Helmont
abiogenesis was put	a) Spananzani	b) P.Redi	c) van Heimont	u) i asteui	
A species	a) sympatric	b) allonatric	c) sibling	d) biospecies	b) allonatric
inhabiting different	a) sympatic	o) unopunie	c) storing	u) biospecies	o) unoputre
geographical areas					
According to De	a) jerky	b) discontinuous	c) continuous and	d) both a and b	d) both a and b
Vries theory,	/5/5	,	smooth	,	,
Mutation may be	a) Continuous	b) Phenotypic	c) Discontinuous	d) change due to	c) Discontinuous
described as	genetic variation	change	genetic variation	hybridisation	genetic variation
The theory of use	a) Stebbins	b) Lamarck	c) Aristotle	d) Vavilox	b) Lamarck
and disuse was					
The evolution of a	a) natural selection	b) isolation	c) speciation	d) human	b) isolation
species is based				conservation	
upon sum total of					
adaptive changes	· · .·	1	<u>``</u>		1.1.
Genetic drift is on	a) variations	b) mutation	c) increase in	d) decrease in	a) decrease in
Account of	a) Eighting hatwaan	h) Variations	a) Killing weeker	d) Differential	d) Differential
Darwinism natural	a) Fighting between	b) variations	organism	u) Differential	a) Differential
selection operates	organishis		organism	reproduction	reproduction
through					
Sympatric	a) Geographic	b) barrier to mating	c) barrier to gene	d) genetic change	a) Geographic
speciation develops	barrier	- ,	flow	-, 88-	barrier
reproductive					
Quick change in	a) Founder effect	b) Genetic bottle	c) Genetic grift	d) Gene flow	a) Founder effect
phenotypes in a		neck			
small band of					
colonisers is called					
Genetic drift is	a) Small population	b) large population	c) plant population	d) animal	a) Small population
found in	with or without	with random mating		population	with or without
	mutated genes				mutated genes
		4			
Which is related to	a) genetic isolation	b)temporal isolation	c) behavioural	d) all of these.	d) all of these.
reproduce isolation			isolation		

In which condition	a) gene flow	b) mutation	c) random mating	d) sexual selection	c) random mating
gene ratio remains	-		_		_
constant in a					
Lamarck theory of	a) Natural selection	b) Inheritance of	c) Descent with	d) continuity of	b) Inheritance of
organic evolution is	,	acquired characters	change	fermplasm	acquired characters
usually known as		1	0	Ĩ	1
Which one is used	a) Degree of	b) Genetic drift	c) Proportion	d) Hardy Weinberg	d) Hardy Weinberg
for knowing	evolution	, 	between acquired	equation	equation
whether or not a			variations	1	1
Balancing selection	a) Homozygous	b) homozygous	c) heterozygous	d) all of the above	c) heterozygous
is concerned with	recessives	indivduals	individuals	,	individuals
successful					
reproduction of					
During which	a) Orosirian period	b) Ediacaran period	c) Devonian period	d) Ordovician	a) Orosirian period
geological period	, <b>1</b>	· · ·	, <u> </u>	period	, <u> </u>
did the earth				1	
The first green	a) Ediacaran period	b) Devonian period	c) Orosirian period	d) Ordovician	d) Ordovician
plants and fungi	· · · ·	/ I	· 1	period	period
appeared on land				1	1
during which					
Flowering plants	a) Jurassic period	b) Carboniferous	c) Cretaceous period	d) Silurian	c) Cretaceous period
first appeared	· · · · · ·	period	,	,	, <b>r</b>
during		r · · ·			
The present epoch	a) Holocene	b) Miocene	c) Pleistocene	d) Pliocene	a) Holocene
in the Earth's age is	,	,	<i>,</i>	,	,
known as					
A method for	cladistics	phenetics	polyphenetics	numerology	phenetics
constructing		r · · · ·	r		r · · · ·
phylogenies based on					
the numerical ranking					
of the greatest					
similarity in as many					
features as possible is					
A species that	evolutionary species	chronospecies	living fossil	stagnant species	chronospecies
changes morphology					
over time without					
diversifying into					
separate species is					
Assorting to	a) math an a	UNIT II		d)	d) ann ann
According to	a) methane	b) nydrogen	c) water vapour	d) oxygen	d) oxygen
oparin, which one					
of the following					
the primitive					
Green we als fleat		1.) D	-) A	1) Louis Destaur	1) Louis Destaur
Swan neck flask	a) Oparin and	b) Darwin	c) Aristotie	u) Louis Pasteur	a) Louis Pasteur
experiment was	панане				
	a) Linex or 4 M(11	h) Isaah ar i Mari I	a) On anin	d) Eisshan 1	a) On arin
Coacervates were	a) Urey and Miller	b) Jacob and Monad	c) Oparin	u) Fischer and	c) Oparin
experimentally				nuxley	
produced by				1) (1) (2) (3)	
ring of Miller's	a) theory of special	b) theory of	c) theory of	u) theory of organic	c) theory of
experiment on	creation	biogenesis	abiogenesis	evolution	abiogenesis
origin of life has					
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Theory of	a) Spallanzani	b) F.Redi	c) Van Helmont	d) Pasteur	c) Van Helmont
abiogenesis was put		1 \ 11 .	\ <b>'1 1'</b>	1.1	1
A species	a) sympatric	b) allopatric	c) sibling	d) biospecies	b) allopatric
inhabiting different					
geographical areas					
According to De	a) jerky	b) discontinuous	c) continuous and	d) both a and b	d) both a and b
Vries theory,			smooth		

Mutation may be	a) Continuous	b) Phenotypic	c) Discontinuous	d) change due to	c) Discontinuous
described as	genetic variation	change	genetic variation	hybridisation	genetic variation
The theory of use	a) Stebbins	b) Lamarck	c) Aristotle	d) Vavilox	b) Lamarck
and disuse was		1	· · ·	1 1	1
The evolution of a	a) natural selection	b) isolation	c) speciation	d) human	b) isolation
species is based				conservation	
upon sum total of					
adaptive changes					
Genetic drift is on	a) variations	b) mutation	c) increase in	d) decrease in	d) decrease in
account of			population	population	population
According to Neo-	a) Fighting between	b) Variations	c) Killing weaker	d) Differential	d) Differential
Darwinism, natural	organisms		organism	reproduction	reproduction
selection operates					
through					
Sympatric	a) Geographic	b) barrier to mating	c) barrier to gene	d) genetic change	a) Geographic
speciation develops	barrier		flow		barrier
reproductive					
Quick change in	a) Founder effect	b) Genetic bottle	c) Genetic grift	d) Gene flow	a) Founder effect
phenotypes in a		neck			
small band of					
colonisers is called					
Genetic drift is	a) Small population	b) large population	c) plant population	d) animal	a) Small population
found in	with or without	with random mating		population	with or without
	mutated genes				mutated genes
Which is related to	a) genetic isolation	b)temporal isolation	c) behavioural	d) all of these.	d) all of these.
reproduce isolation			isolation		
In which condition	a) gene flow	b) mutation	c) random mating	d) sexual selection	c) random mating
gene ratio remains					
constant in a					
Lamarck theory of	a) Natural selection	b) Inheritance of	c) Descent with	d) continuity of	b) Inheritance of
organic evolution is		acquired characters	change	fermplasm	acquired characters
usually known as					
Which one is used	a) Degree of	b) Genetic drift	c) Proportion	d) Hardy Weinberg	d) Hardy Weinberg
for knowing	evolution		between acquired	equation	equation
whether or not a			variations		
Balancing selection	a) Homozygous	b) homozygous	c) heterozygous	d) all of the above	c) heterozygous
is concerned with	recessives	indivduals	individuals		individuals
successful					
reproduction of					
During which	a) Orosirian period	b) Ediacaran period	c) Devonian period	d) Ordovician	a) Orosirian period
geological period				period	
did the earth					
The first green	a) Ediacaran period	b) Devonian period	c) Orosirian period	<ul> <li>d) Ordovician</li> </ul>	d) Ordovician
plants and fungi				period	period
appeared on land					
during which					
Flowering plants	a) Jurassic period	b) Carboniferous	c) Cretaceous period	d) Silurian	c) Cretaceous period
first appeared		period			
during					
The present epoch	a) Holocene	b) Miocene	c) Pleistocene	d) Pliocene	a) Holocene
in the Earth's age is					
known as					
The rise of human	a) Holocene	b) Pleistocene	c) Pliocene	d) miocene	a) Holocene
civiliza#on is the					
main characteris#cs					
of					
Which geological	a) Orosirian period	b) Devonian period	c) Ediacaran period	d) Ordovician	b) Devonian period
period in the age of				period	
earth is also known					
as the Age of Fish?					

As per the latest	a) 4 billion years	b) 4.54 billion years	c) 4.45 billion years	d) 4.64 billion years	b) 4.54 billion years
radiometric da#ng.		,	·, · · · · · · · · · ·		,
what is the age of					
During which	a) Plaistocopa	b) Iurassia pariod	a) Carboniferous	d) crotocoous	a) Carboniferous
During which	a) Fleistocelle	b) Jurassie period	c) Carbonnerous	u) cretaceous	c) Carbonnerous
period in the age of	period		period		period
earth did terrestrial					
life was well					
First birds and	a) Jurassic period	b) Carboniferous	c) Pleistocene	d) cretaceous	a) Jurassic period
lizards appeared on		period	period		
Earth during					
Angiosperm	a) upper cretaceous	b) lower Jurassic	c) mid cretaceous	d) carboniferous	c) mid cretaceous
originated during					
During evolu#on	a) 1 billion years	b) 2 billion	c) 600 million	d) 200 millions	a) 1 billion years
the first	ago				ago
mul#cellular	e				5
Maximum diversity	a) Iurassic	b) Ordovician	c) Triassic	d) Cretaceous	d) Cretaceous
of ren#les was	u) surussie	o) ordovietan	c) massic	d) cretaceous	d) Cretaecous
Which of the	a)Mitochondria	h)mitochondrial	a)mitachandrial	d)mitochondrial	a)mitachandrial
following statement	DNA has a gircular	ribosomos aro	ganas codo for	ribosomos ara 70s	ganas codo for
some of he summer	DINA has a cheulai	in a stimula d har the	genes code for	noosonnes are 70s	genes code for
cannot be support	genome	mactivated by the	enzymes of		enzymes of
the endosymbiotic		antibiotic	oxidative respiration		oxidative respiration
theory for the orgin		chloramphenicol			
of mitochondria?					
A method for	cladistics	phenetics	polyphenetics	numerology	phenetics
constructing					
phylogenies based					
on the numerical					
ranking of the					
greatest similarity					
in as many features					
A species that	evolutionary species	chronospecies	living fossil	stagnant species	chronospecies
changes	evolutionally species	emonospecies		0 1	F
changes morphology over	evolutionary species				F
changes morphology over time without	evolutionally species				r
changes morphology over time without	evolutionally species				
changes morphology over time without diversifying into	e) Continueus	h) Dhonostonia			
changes morphology over time without diversifying into Mutation may be	a) Continuous	b) Phenotypic	c) Discontinuous	d) change due to	c) Discontinuous
changes morphology over time without diversifying into Mutation may be described as	a) Continuous genetic variation	b) Phenotypic change	c) Discontinuous genetic variation	d) change due to hybridisation	c) Discontinuous genetic variation
changes morphology over time without diversifying into Mutation may be described as Genetic drift is	a) Continuous genetic variation a) Small population	b) Phenotypic change b) large population	<ul><li>c) Discontinuous genetic variation</li><li>c) plant population</li></ul>	d) change due to hybridisation d) animal	c) Discontinuous genetic variation a) Small population
changes morphology over time without diversifying into Mutation may be described as Genetic drift is found in	a) Continuous genetic variation a) Small population with or without	<ul> <li>b) Phenotypic</li> <li>change</li> <li>b) large population</li> <li>with random mating</li> </ul>	<ul><li>c) Discontinuous genetic variation</li><li>c) plant population</li></ul>	d) change due to hybridisation d) animal population	c) Discontinuous genetic variation a) Small population with or without
changes morphology over time without diversifying into Mutation may be described as Genetic drift is found in	a) Continuous genetic variation a) Small population with or without mutated genes	<ul> <li>b) Phenotypic change</li> <li>b) large population with random mating</li> </ul>	<ul><li>c) Discontinuous genetic variation</li><li>c) plant population</li></ul>	d) change due to hybridisation d) animal population	c) Discontinuous genetic variation a) Small population with or without mutated genes
changes morphology over time without diversifying into Mutation may be described as Genetic drift is found in	a) Continuous genetic variation a) Small population with or without mutated genes	<ul> <li>b) Phenotypic</li> <li>change</li> <li>b) large population</li> <li>with random mating</li> </ul>	<ul> <li>c) Discontinuous genetic variation</li> <li>c) plant population</li> </ul>	d) change due to hybridisation d) animal population	c) Discontinuous genetic variation a) Small population with or without mutated genes
changes morphology over time without diversifying into Mutation may be described as Genetic drift is found in Which of the	a) Continuous genetic variation a) Small population with or without mutated genes Egg	b) Phenotypic change b) large population with random mating Sperm	<ul> <li>c) Discontinuous genetic variation</li> <li>c) plant population</li> <li>Primary Oocyte</li> </ul>	d) change due to hybridisation d) animal population All of the above	c) Discontinuous genetic variation a) Small population with or without mutated genes Sperm
changes morphology over time without diversifying into Mutation may be described as Genetic drift is found in Which of the following is the	a) Continuous genetic variation a) Small population with or without mutated genes Egg	<ul> <li>b) Phenotypic change</li> <li>b) large population with random mating</li> <li>Sperm</li> </ul>	<ul> <li>c) Discontinuous genetic variation</li> <li>c) plant population</li> <li>Primary Oocyte</li> </ul>	d) change due to hybridisation d) animal population All of the above	c) Discontinuous genetic variation a) Small population with or without mutated genes Sperm
changes morphology over time without diversifying into Mutation may be described as Genetic drift is found in Which of the following is the Normal mammalian	a) Continuous genetic variation a) Small population with or without mutated genes Egg Haploid	b) Phenotypic change b) large population with random mating Sperm Monoploid	<ul> <li>c) Discontinuous genetic variation</li> <li>c) plant population</li> <li>Primary Oocyte</li> <li>Tetraploid</li> </ul>	d) change due to hybridisation d) animal population All of the above Both A & B	c) Discontinuous genetic variation a) Small population with or without mutated genes Sperm Both Haploid and
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changes morphology over time without diversifying into Mutation may be described as Genetic drift is found in Which of the following is the Normal mammalian gametes are: The male sex organs and female	a) Continuous genetic variation a) Small population with or without mutated genes Egg Haploid Ovaries	b) Phenotypic change b) large population with random mating Sperm Monoploid Govarestes	<ul> <li>c) Discontinuous genetic variation</li> <li>c) plant population</li> <li>Primary Oocyte</li> <li>Tetraploid</li> <li>Testes</li> </ul>	d) change due to hybridisation d) animal population All of the above Both A & B Gonads	c) Discontinuous genetic variation a) Small population with or without mutated genes Sperm Both Haploid and Monoploid Gonads
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changes morphology over time without diversifying into Mutation may be described as Genetic drift is found in Which of the following is the Normal mammalian gametes are: The male sex organs and female sex organs are Which of the following describes the process of DNA- The yolky side of an egg is called its: is the process of structural male	a) Continuous genetic variation a) Small population with or without mutated genes Egg Haploid Ovaries Transcription Animal side Spermatogenesis	b) Phenotypic change b) large population with random mating Sperm Monoploid Govarestes Translation Vegetal side Spermiogenesis	<ul> <li>c) Discontinuous genetic variation</li> <li>c) plant population</li> <li>Primary Oocyte</li> <li>Tetraploid</li> <li>Testes</li> <li>Replication</li> <li>Vegetable side</li> <li>Spermatoformicon</li> </ul>	<ul> <li>d) change due to hybridisation</li> <li>d) animal population</li> <li>All of the above</li> <li>Both A &amp; B</li> <li>Gonads</li> <li>All of the above</li> <li>Vegan side</li> <li>All of the above</li> </ul>	c) Discontinuous genetic variation a) Small population with or without mutated genes Sperm Both Haploid and Monoploid Gonads Replication Vegetal side Spermatogenesis
changes morphology over time without diversifying into Mutation may be described as Genetic drift is found in Which of the following is the Normal mammalian gametes are: The male sex organs and female sex organs are Which of the following describes the process of DNA- The yolky side of an egg is called its: is the process of structural male gamete maturation	a) Continuous genetic variation a) Small population with or without mutated genes Egg Haploid Ovaries Transcription Animal side Spermatogenesis	b) Phenotypic change b) large population with random mating Sperm Monoploid Govarestes Translation Vegetal side Spermiogenesis	<ul> <li>c) Discontinuous genetic variation</li> <li>c) plant population</li> <li>Primary Oocyte</li> <li>Tetraploid</li> <li>Testes</li> <li>Replication</li> <li>Vegetable side</li> <li>Spermatoformicon</li> </ul>	<ul> <li>d) change due to hybridisation</li> <li>d) animal population</li> <li>All of the above</li> <li>Both A &amp; B</li> <li>Gonads</li> <li>All of the above</li> <li>Vegan side</li> <li>All of the above</li> </ul>	c) Discontinuous genetic variation a) Small population with or without mutated genes Sperm Both Haploid and Monoploid Gonads Replication Vegetal side Spermatogenesis
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changes morphology over time without diversifying into Mutation may be described as Genetic drift is found in Which of the following is the Normal mammalian gametes are: The male sex organs and female sex organs are Which of the following describes the process of DNA- The yolky side of an egg is called its: is the process of structural male gamete maturation Oocytes that are discarded in the	a) Continuous genetic variation a) Small population with or without mutated genes Egg Haploid Ovaries Transcription Animal side Spermatogenesis Antigens	b) Phenotypic change b) large population with random mating Sperm Monoploid Govarestes Translation Vegetal side Spermiogenesis Epitopes	<ul> <li>c) Discontinuous genetic variation</li> <li>c) plant population</li> <li>Primary Oocyte</li> <li>Tetraploid</li> <li>Testes</li> <li>Replication</li> <li>Vegetable side</li> <li>Spermatoformicon</li> <li>Non-polar bodies</li> </ul>	<ul> <li>d) change due to hybridisation</li> <li>d) animal population</li> <li>All of the above</li> <li>Both A &amp; B</li> <li>Gonads</li> <li>All of the above</li> <li>Vegan side</li> <li>All of the above</li> <li>Polar bodies</li> </ul>	c) Discontinuous genetic variation a) Small population with or without mutated genes Sperm Both Haploid and Monoploid Gonads Replication Vegetal side Spermatogenesis Polar bodies

The correct order of	Fertilization	Gametogenesis	Fertilization	Gametogenesis	Gametogenesis
the stages of early	Gametogenesis	>Fertilization	Gametogenesis	>Fertilization	>Fertilization
development is:	>Blastulation	>Restulation	Gastrulation	Gastrulation	Blastulation
development is.	>Gastrulation	Castrulation	>Blastulation	>Blastulation	Castrulation
		>Gastrulation	>Diastulation	>Diastulation	
Cutoplasmia	Chorionomoros	Cutochennols	Can Junctions	Ding conals	Ping conels
Cytopiasinic	Chomonomenes	Cytoenanneis	Gap Junctions	King canais	King canais
colle developing					
during cogonogia in					
Dressentile and					
Drosopnila are	M	Manantati	Maaaaalaanaa	G(	Manager
The dissue layer	Mezzanine	Monopioid	wiesenchyme	Stephnyme	Mesenchyme
with loosely packed					
cens, with a					
considerable					
amount of extra	G 1		Ŧ		
The imaginal discs	Gonads	Eyes	Legs	All of the above	All of the above
of drosophila					
include separate					
groups of 40 cells					
Pigment granules in	Animal	Vegetable	Mineral	Vegetal	Animal
amphibian eggs are					
located in the					
cortex on the					
Which structure of	Dorsal lip	Blastopore	Ventral lip	Blastocoelum	Dorsal lip
the amphibian					
embryo is					
intimately related to					
The cells in an	early blastula stage	mid blastula stage	late blastula stage	post-modern	late blastula stage
amphibian blastula				blastula stage	
are equivenlant					
until the beginning					
The placenta is	Excretion	Gas exchange	Nutrition supply	Hormone production	Hormone production
NOT responsible					
for regulation of					
which of the					
The default state of	skin tissue	cartilage tissue	vascular tissue	neural tissue	Neural tissue
ectoderm is					
Which of the	Kidneys	Heart	Pancreas	Muscle	pancreas
following is an					
endodermal germ					
The first blood and	As extraembryonic	By the process of	As embryonic	As a maternal	As extraembryonic
vascular tissue of	blood island	angiogenesis	blood islands near	mesoderm coming	blood island
amniotes forms	formation near the		the yolk sac	from the placenta	formation near the
initially:	yolk sac			-	yolk sac
Which animal	Grouse	Quail	Peacocks	Snakes	Quail
served as a useful					
model organism in					
addition to chickens					
in the investigation					
The anterior-most	Stomach region	Cloacal region	Pharyngeal region	Pancreal reagion	Pharyngeal region
region of the				0	
endodermal tube					
that gives rise to the					
thymus, salivary					
glands, and oral					
Which of the	Ecdyson	Thyroxin	Iuvenile Hormone	Pax 6	Juvenile Hormone
following is the	200,001	11,10,101		- 411 0	
hormone that slowe					
the metamorphic					
The normal	Bind the small	Serve as an origin	Serve as an	Serve as a hinding	Serve as a binding
function of the	subunit of the	of replication	accentor for	site for RNA	site for RNA
nromoter is to	ribosome	or representation	transfer RNA	nolymerase	nolymerase
Promoter is to	110030110			Porymerase	Porymerase

For some traits	diversifying	directional	adaptive radiation	stabilizing selection	stabilizing selection
How does artificial	by changing the	by stimulating the	by changing the	by selecting only	by changing the
selection produce	frequency of alleles	species to increase	number of	dominant genotypes	frequency of alleles
ranid changes in the	and selecting for	the production of	chromosomes		and selecting for
nhenotype of	new combinations	new mutations	enromosomes		new combinations
organisme?	of traits	new mutations			of traits
organisins (	or traits				
How door natural	Under conditions	Natural solastion	All mutations	When there is no	Natural salastion
How does natural	Under conditions	Natural selection	All mutations	when there is no	Natural selection
selection affect the	of high selection	does not affect the	increase when	selection pressure,	does not affect the
frequency of	pressure, beneficial	frequency of	selection pressure is	mutations do not	frequency of
mutations?	mutations occur	mutations	high	occur	mutations
	more frequently				
		Linit III			
Which of the	a) Pinus	b) Riccia	c) Ginkgo	d) Gnetum	c) Ginkgo
following is an		-,	-,	-, 0	-, 0
example of living					
First life on comb	a) Cyanobaotoria	b) Autographs	c)	d) Photosutotropha	c)
must me on earth	a) Cyanobacteria	o) Autographs	Chemoheterotropho	u) Filotoautotrophs	Chemoheterotropho
was Most abundant	a) Protain	b) Cellulosa	c) Steroida	d) Lipide	b) Cellulosa
organic compound		o) Cenulose	c) steroius	a) Lipius	o) Cenulose
Which is not a	a) Nails	b) Third molar	c) Coccyx	d) Segmented	a) Nails
ves gial organ of	u) 1 (uii)	o, mina motar	c, coccyr	muscles of abdomen	<i>aj</i> 1 10110
Gene c dri7	a) Large	b) Smaller	c) Island	d) Mendealian	b) Smaller
operates only in	popula ons	popula ons	popula ons	popula ons	popula ons
The animals of cold	a) Cone's law	b) Dollo's law	c) Bergmann's law	d) Allen's law	d) Allen's law
countries have	u) Cope 5 law	o, Dono 5 law	c, Dergmann s iaw	a, minon 5 law	a, mini s law
relayely shorter and					
noorly developed					
poor avag hairs and					
cars, eyes, nairs and					
other phenotypic					
cnaracters. This is					
known by which					
Phenomenon of	a) Geographical	b) Natural Selec on	c) Reproduc ve	d) Induced muta on	b) Natural Selec on
Industrial	isola on		isola on		
melanism'					
Convergent	a) Rat and Dog	b) Bacterium and	c) Starfish and	d) Dogfish and	d) Dogfish and
evolu on is		Protozoan	Cu@le fish	Whale	Whale
Correct order is	a) Paleozoic->	b) Archaeozoic->	c) Coenozoic -	d) Mesozoic->	a) Paleozoic->
	Mesozoic->	Coenozoic -	>Paleozoic->	Archaeozoic->	Mesozoic->
	Coenozoic	>Paleozoic	Archaeozoic	Coenozoic	Coenozoic
First life on earth	a) cyanobacteria	b) autotrophs	c) photo autotrophs	d)	d)
was				chemoheterotrophs	chemoheterotrophs
One of the possible	a) green plants	b) carbon dioxide	c) chlorophyll	d) UV rays and	d) UV rays and
early sources of				lightening	lightening
energy were/ was					
First experiment	a) Watson and Crick	b) Oparin and	c) Urey and Miller	d) Meselson and	c) Urey and Miller
regarding evolution		Haldane		Stahl	
of life was					
Coacervates were	a) DNA	b) radiations	c) polymerisation	d) polymerisation	d) polymerisation
formed by		- ,	· / F - /	and aggregation	and aggregation
Miller and Urey	a) N and H O	b) H O and CH	c) CO and N	d) CH and N	b) H O and CH
performed an	,	,	,	,	,
experiment to prove					
re					
origin of life They				-	1
origin of life. They look for gases NH					
origin of life. They look for gases NH and H along with?					

According to	a) methane	b) hydrogen	c) water vapour	d) oxygen	d) oxygen
Oparin, which one					
of the following					
was not present in					
the primitive					
Which one of the	a)Actinomycetes	b)Pseudomonas	c)Rickettisae	d)Methanogens	d)Methanogens
following are					
Archaebacteria?					
Formation of most	a) Hugo de vries	b) Urev and Miller	c) Oparin and	d)Pasteur	b) Urev and Miller
amino acids as well	.,	- /	Haldane	.,	-,,
as adenine andother					
nucleic acid bases					
from inorganic					
molecules was					
The most primitive	a)plasmodium	h)tetrahymena	c)chlamydomonas	d)Giardia	d)Giardia
extant eukarvotes	a)plasillouralli	o)tetranymena	e)emaniyaomonas	u)Olardia	u)Olarula
belong to the genus					
Combrian	a) Origin of life	h)Origin of phylo	c) Origin of man	d)artination of	h)Origin of phylo
Explosion refers to	a) Origin of file	0)Oligin ol phyla	c) Origin of main	Diposaure	b)Origin or phyla
Which of the	a)Mitochondria	h)mitochondrial	a) mitochondrial	d)mitochondrial	a)mitachandrial
fallowing statement	a)Millociloliulla			u)IIIItochonullai	
following statement	DNA has a circular	ribosomes are	genes code for	ribosomes are 70s	genes code for
cannot be support	genome	inactivated by the	enzymes of		enzymes of
the endosymbiotic		antibiotic	oxidative respiration		oxidative respiration
theory for the orgin		chloramphenicol			
of mitochondria?				2.2.5.4.01	
Aerobic respiration	a)1.0-1.5bp	b) 2.0-2.5bp	c)3.0-3.5bp	d)3.5-4.0bp	b) 2.0-2.5bp
is thought to have					
first appeared in					
some organisms of					
approximate age					
Which of the	a)exon shuffling	b)intron excisions	c)transposons	d)DNA	a)exon shuffling
following process			insertions	amplification	
offers the greatest					
opportunities for					
accelerating the					
evolution of new					
The correct	a) Devonian,	b) Eocene,	c) Devonian,	d) Carboniferous,	a) Devonian,
chronological	Carboniferous,	Devonian,	Carboniferous,	Devonian,	Carboniferous,
sequences of	Cretaceous, Eocene	Carboniferous,	Eocene ,Cretaceous	Cretaceous, Eocene	Cretaceous, Eocene
geological times is		Cretaceous			
The extant bacterial	a)purple	b)archaebacteria	c)cyanobacteia	d)methanogens	a)purple
group that is most	photosynthetic	,	/ 5	, E	photosynthetic
closely related to	bacteria				bacteria
the ancestor from					
which mitochondria					
The first	a) Cat	h) Dog	c) Horse	d) Cow	h) Dog
domes cated	u) Cui	0) 005		u) com	0) 005
animal by primi ve					
The normal	Bind the small	Serve as an origin	Serve as an	Serve as a binding	Serve as a binding
function of the	subunit of the	of replication	accentor for	site for RNA	site for RNA
promoter is to	ribosome	or reprication	transfer $RN\Delta$	nolymerase	nolymerase
Protein moleculos	DNA mosloulo	Amino acid	Fatty acid molecules	Sucrose modeulos	Amino acid
are polymers of	DIA INCELUIC	molecules	any actu molecules	Sucrose moticules	molecules
The pertide hand in	A covalant joina	A covalant hand	A hydrogon hand	A covalant hand	A covalant hand
The peptide bond is	A covarent joing	A covalent bond	A fiyurogen bonu	A covalent bolld	A covarent bond
	together to form a	joining nucleotides	together to form	together to form a	together to form a
	nogemer to form a	rogemer to form a	nogemer to form	nogemer to form a	nogemer to form a
	porypeptide	nucleic acid	porypoende	porypeptide	porypeptide
To solution of the	II	China D 1	Duthana C	T A T A 1	Chine D 1
in prokaryotes, the	Hogness sequence	Snine-Dalgarno	Pribnow Sequence	IAIA box	Snine-Dalgarno
ribosomal binding		sequence			sequence
site on mRNA is					

During translation,	transfer of	amino acid	peptide bond	binding of	peptide bond
the role of enzyme	phosphate group	activation	formation between	ribosome subunits	formation between
peptidyl transferase			adjacent amino	to mRNA	adjacent amino
Polysomes are	Aggregation of	aggregation of	mRNA molecules	a strech of tRNA	mRNA molecules
-	ribosomes	lysosomes	to which many	assemblies	to which many
		2	ribosomes are		ribosomes are
			attached		attached
			simultaneously		simultaneously
Translation is the	Synthesis of DNA	Synthesis of protein	Synthesis of RNA	Synthesis of RNA	Synthesis of
Translation is the	from a mRNA	from a mRNA	from a mRNA	from a DNA	protein from a
	tomplata	tomplata	tomplata	tomplato	mPNA templete
Dunin a tuan alatian	hu nih ocomoo wain o	her here a series	template	her nik ocenne voin e	hu ribasamaa usina
During translation,	by fibosoffies using	by tysosome using	by fibosoffies using	by hoosomes using	by fibosoffies using
proteins are	the information on	the information on	the information on	the information on	the information on
synthesized	DNA	DNA	MRNA	rRNA	MRNA
			1 DNA	: 1 DN14	1. D.M.A
The enzyme	ATP synthetase	aminoacyl tRNA	aminoacyl mRNA	aminoacyl rRNA	aminoacyl tRNA
involved in amino		synthetase	synthetase	synthetase	synthetase
Which of the	rRNA	mRNA	tRNA	tRNA and mRNA	tRNA
following RNA					
molecules serves as					
an adaptor					
In eukaryotes,	Pribnow box	Hogness box	5' CAP	poly A tail	5' CAP
translation is					
inititated by					
binding of					
Which is the energy	ATP synthetase	GTP	СТР	AMP	GTP
rich molecule	"J				
required for					
Which of the	DNA makes RNA	RNA makes	DNA makes	Protein makes	DNA makes RNA
following best	makas Protoins	DNA makas Protains	protoing makes	DNA makas PNA	makas Protains
avalaing the	makes r totenis	DIVAIIIAKES FIOTEIIIS	DNA	DINA IIIakes KINA	makes riotems
explains the			KINA		
sequence of central	. 1.1	1 1 1 1 1	1	1 1	1
Many primary	translated	polyadenylated	processed	replicated	processed
transcripts of					
noncoding RNAs					
must be1n					
RNA polymerase	rRNA	DNA	RNA	mRNA	DNA
used for the					
transcription of					
genes require a					
Which of the	Transcription but	Bacterial non	The regulation of	Linking of exons	Transcription but
following	not translation is	coding RNAs mus t	the transcription	must precede	not translation is
statements is not	regulated in bacteria	be processed by	initiation complex	translation in	regulated in bacteria
true?	C	cleavage to form	is a key feature of	eukaryotes	C
		functional	gene expression		
Regarding RNA	The holoenzyme is	The holoenzyme	The core enzyme	The holoenzyme	The holoenzyme
nolymerase in	used to synthesize	consists of five	and not the	binds to DNA	consists of five
E Coli which of the	mRNA while the	subunits including	holoenzyme is	unstream of the	subunits including
following describes	core enzyme	$\sigma$ while the core	required for the	promoter while the	$\sigma$ while the core
the difference	synthesizes	enzume laeks a	initation of DNA	core enzyme binde	enzume laeks a
hotwoon the hele	synucsizes	chizyme lacks o	aunthoric	to downwater are of	enzyme lacks o
oetween the noio	noncoding KNAS		synthesis	to dounwstream of	
enyzyme and the				the promoter	
core enzyme?					
RNA polymerase II	rRNAs	proteins	snRNAs	miRNAs	rRNAs
transcribes all of					
the following					
except genes					

	1	1. Your of the same of the s		1	
The recognition	downstream of the	b)upstream of the	within the first intron	downstream of the	upstream of the
sequence to which	promoter target	gene to be		transcription bubble	gene to be
RNA polymerase	sequence	transcribed			transcribed
binds at the					
initiation of					
transcription is					
Which of the	An element that	A regualatory	A specific target	An extracellular	A specific target
following best	promotes	protein that	sequence to which	environmental	sequence to which
describes a	termination of	accelerates mRNA	RNA polymeraase	inducer that	RNA polymeraase
promoter?	transcription	turnover	binds	controls gene	binds
Some eukarvotic	the TATA box	the pribnow box	an initiator (Inr)	an inverted repeat	an initiator Inr
promoters contain			sequence	······································	sequence
an element			sequence		sequence
nositioned around					
positioned around nucleotide $\pm 1$					
	tuona aninti an har	nononcion of	Instaniala la atom	inchility to he	nonnainn of
Null genes are	Transcription by	possession of	invariable start	madinity to be	possession of
characterized by	RNA polymerase I	neither IAIA box	position of	transcribed	neither IAIA box
their	and II	nor an Inr sequence	transcription		nor an Inr sequence
Ecosil anosimono		trum a la acional amanciona	u hu la consti a		
rossii specimens	biological species	typological species	phylogenetic	morphospecies	morphospecies
are often classified	concept	concept	species concept	concept	concept
into species					
Examples of	habitat selection	different mating	species specific	competition	species specific
behavioral isolation		seasons	courtship displays		courtship displays
Darwin was	stasis	uniformitarianism	gradualism	habitat selection	growth
influenced by					
reading books on					
geology by Lyell					
and Hutton. The					
concept that					
geological					
processes that are					
currently operating					
are the same ones					
Which of the	Guppies would	Guppies would	Guppies would not	Guppies would	Guppies would
following would	become more	become less colorful	change in coloration	evolve to have	become more
you predict would	colorful	become less coloriur	change in coloration	females prefer less	colorful
you predict would	coloriul.			colorful malos	coloriul.
takan from straams				coloriul males	
taken non streams					
with predators that					
key in on prey color					
and put into					
What determines	Mendelian genetics	random mutations	the species in	the fit of the trait to	the fit of the trait
which traits will be	of the trait	in the trait	which the trait	the environment	to the environment
passed on to the			occurs		
next generation in					
Natural selection is	able to generate	increasing the	working on existing	causing the death of	working on
BEST described as	new traits that	perfection of a	variation of traits to	a significant	existing variation of
	better suit the	species	favor those better	proportion of the	traits to favor those
	species		suited to the	population	better suited to the
			organism's		organism's
			environment.		environment.
Which of these	individuals	populations	communities	mutations	populations
actually evolves?					1 I "

In a population of	0.15	0.25	0.3	0.55	0.55
50 squirrels on the					
UWL campus, fur					
color is controlled					
by a single gene					
with two alleles, A					
and a. Fifteen of					
the squirrels are					
homozygous					
dominant, 25 are					
heterozygous, and					
10 are homozygous					
recessive. What is					
the frequency of the					
If the weather in	The cold weather	If a mutation	Evolution would	Natural selection	If a mutation
Richmond	would cause a	occurred which	definitely occur	would cause a new	occurred which
Virginia, changed	mutation in	caused white fur to	resulting in white	genotype to appear	caused white fur to
to very cold (snow	squirrels which	develop such white	squirrels	in the population	develop such white
on the ground 8	causes their fur to	squirrels would	squireis	resulting in	squirrels would
months of each	be white	have a better		squirrels with white	have a better
vear) over the next		chance to survive		fur	chance to survive
few years, what		and produce more		1.01	and produce more
change might occur?		offspring with the			offspring with the
Which of the	Plants with thorns	Bastorial	Scientists broad	Emit fly longo with	Scientists brood
following is NOT	ara less likely to be	populations in	cowe that give	an enzyme to brock	cowe that give
an axample of	aton by harbivoras	populations in bospitals develop	cows that give	down alashol are	greater amounts of
an example of	then other members	registeres to drugs	greater amounts of	hottor able to feed	mills then their
natural selection?	of the same species	resistance to drugs		or	
	that look thorna	infaction by them	ancestors	OII	ancestors
	that fack thorns	infection by them			
For some traits	diversifying	directional	adaptive radiation	stabilizing selection	stabilizing selection
For some traits (such as birth	diversifying selection	directional selection	adaptive radiation	stabilizing selection	stabilizing selection
For some traits (such as birth weight in	diversifying selection	directional selection	adaptive radiation	stabilizing selection	stabilizing selection
For some traits (such as birth weight in mammals) patural	diversifying selection	directional selection	adaptive radiation	stabilizing selection	stabilizing selection
For some traits (such as birth weight in mammals), natural selection favors	diversifying selection	directional selection	adaptive radiation	stabilizing selection	stabilizing selection
For some traits (such as birth weight in mammals), natural selection favors individuals that are	diversifying selection	directional selection	adaptive radiation	stabilizing selection	stabilizing selection
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the	diversifying selection	directional selection	adaptive radiation	stabilizing selection	stabilizing selection
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are	diversifying selection	directional selection	adaptive radiation	stabilizing selection	stabilizing selection
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial	diversifying selection	directional selection	adaptive radiation	stabilizing selection	stabilizing selection
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial ealaction produce	diversifying selection by changing the frequency of alleles	directional selection by stimulating the	adaptive radiation	stabilizing selection by selecting only	stabilizing selection
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the	diversifying selection by changing the frequency of alleles	directional selection by stimulating the species to increase	adaptive radiation	stabilizing selection by selecting only dominant genotypes	stabilizing selection by changing the frequency of alleles
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the	diversifying selection by changing the frequency of alleles and selecting for new combinations	directional selection by stimulating the species to increase the production of	adaptive radiation by changing the number of chromosomes	stabilizing selection by selecting only dominant genotypes	stabilizing selection by changing the frequency of alleles and selecting for new combinations
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms?	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits	directional selection by stimulating the species to increase the production of new mutations	adaptive radiation by changing the number of chromosomes	stabilizing selection by selecting only dominant genotypes	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms?	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits	directional selection by stimulating the species to increase the production of new mutations	adaptive radiation by changing the number of chromosomes	stabilizing selection by selecting only dominant genotypes	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms?	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits	directional selection by stimulating the species to increase the production of new mutations	adaptive radiation by changing the number of chromosomes	stabilizing selection by selecting only dominant genotypes	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms?	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits	directional selection by stimulating the species to increase the production of new mutations	adaptive radiation by changing the number of chromosomes	stabilizing selection by selecting only dominant genotypes	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms?	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits Under conditions of high selection	directional selection by stimulating the species to increase the production of new mutations Natural selection does not affect the	adaptive radiation adaptive radiation by changing the number of chromosomes All mutations increase when	stabilizing selection by selecting only dominant genotypes When there is no	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits Natural selection does not affect the
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms? How does natural selection affect the fragmency of	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits Under conditions of high selection pressure heneficial	directional selection by stimulating the species to increase the production of new mutations Natural selection does not affect the frequency of	adaptive radiation adaptive radiation by changing the number of chromosomes All mutations increase when selection pressure is	stabilizing selection by selecting only dominant genotypes When there is no selection pressure, mutations do not	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits Natural selection does not affect the frequency of
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms? How does natural selection affect the frequency of mutations?	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits Under conditions of high selection pressure, beneficial mutations occur	directional selection by stimulating the species to increase the production of new mutations Natural selection does not affect the frequency of mutations	adaptive radiation adaptive radiation by changing the number of chromosomes All mutations increase when selection pressure is biob	stabilizing selection by selecting only dominant genotypes When there is no selection pressure, mutations do not occur	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits Natural selection does not affect the frequency of mutations
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms? How does natural selection affect the frequency of mutations?	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits Under conditions of high selection pressure, beneficial mutations occur more frequently	directional selection by stimulating the species to increase the production of new mutations Natural selection does not affect the frequency of mutations	adaptive radiation adaptive radiation by changing the number of chromosomes All mutations increase when selection pressure is high	stabilizing selection by selecting only dominant genotypes When there is no selection pressure, mutations do not occur	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits Natural selection does not affect the frequency of mutations
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms? How does natural selection affect the frequency of mutations?	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits Under conditions of high selection pressure, beneficial mutations occur more frequently	directional selection by stimulating the species to increase the production of new mutations Natural selection does not affect the frequency of mutations	adaptive radiation adaptive radiation by changing the number of chromosomes All mutations increase when selection pressure is high	stabilizing selection by selecting only dominant genotypes When there is no selection pressure, mutations do not occur	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits Natural selection does not affect the frequency of mutations
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms? How does natural selection affect the frequency of mutations?	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits Under conditions of high selection pressure, beneficial mutations occur more frequently	directional selection by stimulating the species to increase the production of new mutations Natural selection does not affect the frequency of mutations	adaptive radiation by changing the number of chromosomes All mutations increase when selection pressure is high	stabilizing selection by selecting only dominant genotypes When there is no selection pressure, mutations do not occur	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits Natural selection does not affect the frequency of mutations
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms? How does natural selection affect the frequency of mutations?	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits Under conditions of high selection pressure, beneficial mutations occur more frequently	directional selection by stimulating the species to increase the production of new mutations Natural selection does not affect the frequency of mutations	adaptive radiation by changing the number of chromosomes All mutations increase when selection pressure is high	stabilizing selection by selecting only dominant genotypes When there is no selection pressure, mutations do not occur	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits Natural selection does not affect the frequency of mutations
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms? How does natural selection affect the frequency of mutations?	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits Under conditions of high selection pressure, beneficial mutations occur more frequently	directional selection by stimulating the species to increase the production of new mutations Natural selection does not affect the frequency of mutations UNIT IV	adaptive radiation by changing the number of chromosomes All mutations increase when selection pressure is high	stabilizing selection by selecting only dominant genotypes When there is no selection pressure, mutations do not occur	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits Natural selection does not affect the frequency of mutations
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms? How does natural selection affect the frequency of mutations? Which of the	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits Under conditions of high selection pressure, beneficial mutations occur more frequently Ecdyson	directional selection by stimulating the species to increase the production of new mutations Natural selection does not affect the frequency of mutations UNIT IV Thyroxin	adaptive radiation by changing the number of chromosomes All mutations increase when selection pressure is high Juvenile Hormone	stabilizing selection by selecting only dominant genotypes When there is no selection pressure, mutations do not occur Pax 6	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits Natural selection does not affect the frequency of mutations Juvenile Hormone
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms? How does natural selection affect the frequency of mutations? Which of the following is the	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits Under conditions of high selection pressure, beneficial mutations occur more frequently Ecdyson	directional selection by stimulating the species to increase the production of new mutations Natural selection does not affect the frequency of mutations UNIT IV Thyroxin	adaptive radiation by changing the number of chromosomes All mutations increase when selection pressure is high Juvenile Hormone	stabilizing selection by selecting only dominant genotypes When there is no selection pressure, mutations do not occur Pax 6	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits Natural selection does not affect the frequency of mutations Juvenile Hormone
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms? How does natural selection affect the frequency of mutations? Which of the following is the hormone that slows	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits Under conditions of high selection pressure, beneficial mutations occur more frequently Ecdyson	directional selection by stimulating the species to increase the production of new mutations Natural selection does not affect the frequency of mutations UNIT IV Thyroxin	adaptive radiation by changing the number of chromosomes All mutations increase when selection pressure is high Juvenile Hormone	stabilizing selection by selecting only dominant genotypes When there is no selection pressure, mutations do not occur Pax 6	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits Natural selection does not affect the frequency of mutations Juvenile Hormone
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms? How does natural selection affect the frequency of mutations? Which of the following is the hormone that slows the metamorphic	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits Under conditions of high selection pressure, beneficial mutations occur more frequently Ecdyson	directional selection by stimulating the species to increase the production of new mutations Natural selection does not affect the frequency of mutations UNIT IV Thyroxin	adaptive radiation by changing the number of chromosomes All mutations increase when selection pressure is high Juvenile Hormone	stabilizing selection by selecting only dominant genotypes When there is no selection pressure, mutations do not occur Pax 6	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits Natural selection does not affect the frequency of mutations Juvenile Hormone
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms? How does natural selection affect the frequency of mutations? Which of the following is the hormone that slows the metamorphic The normal	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits Under conditions of high selection pressure, beneficial mutations occur more frequently Ecdyson Bind the small	directional selection by stimulating the species to increase the production of new mutations Natural selection does not affect the frequency of mutations UNIT IV Thyroxin Serve as an origin	adaptive radiation by changing the number of chromosomes All mutations increase when selection pressure is high Juvenile Hormone Serve as an	stabilizing selection by selecting only dominant genotypes When there is no selection pressure, mutations do not occur Pax 6 Serve as a binding	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits Natural selection does not affect the frequency of mutations Juvenile Hormone Serve as a binding
For some traits (such as birth weight in mammals), natural selection favors individuals that are average and the extremes are How does artificial selection produce rapid changes in the phenotype of organisms? How does natural selection affect the frequency of mutations? Which of the following is the hormone that slows the metamorphic The normal function of the	diversifying selection by changing the frequency of alleles and selecting for new combinations of traits Under conditions of high selection pressure, beneficial mutations occur more frequently Ecdyson Bind the small subunit of the	directional selection by stimulating the species to increase the production of new mutations Natural selection does not affect the frequency of mutations UNIT IV Thyroxin Serve as an origin of replication	adaptive radiation adaptive radiation by changing the number of chromosomes All mutations increase when selection pressure is high Juvenile Hormone Serve as an acceptor for	stabilizing selection by selecting only dominant genotypes When there is no selection pressure, mutations do not occur Pax 6 Serve as a binding site for RNA	stabilizing selection by changing the frequency of alleles and selecting for new combinations of traits Natural selection does not affect the frequency of mutations Juvenile Hormone Serve as a binding site for RNA

				a 1.1	
Protein molecules are polymers of	DNA moelcule	Amino acid molecules	Fatty acid molecules	Sucrose moelcules	Amino acid molecules
The pentide bond is	A covalent joing	A covalent bond	A hydrogen bond	A covalent bond	A covalent bond
The peptide bolid is	A covarcia joing				
	simple sugars	joining nucleotides	joing nucleotides	joining aminoacid	joining aminoacid
	together to form a	together to form a	together to form	together to form a	together to form a
	polypeptide	nucleic acid	polypoetide	polypeptide	polypeptide
In prokaryotes, the	Hogness sequence	Shine-Dalgarno	Pribnow Sequence	TATA box	Shine-Dalgarno
ribosomal binding		sequence			sequence
site on mRNA is					-
During translation.	transfer of	amino acid	peptide bond	binding of	peptide bond
the role of enzyme	nhosnhate group	activation	formation between	ribosome subunits	formation between
nentidyl transferase	phosphate group	activation	adjacent amino	to $mRN\Delta$	adjacent amino
Delusernes ere	A compaction of	a a a manage tion of	mDNA malaaulaa	o strach of (DNA	mDNA malagulag
Polysomes are	Aggregation of	aggregation of	mRNA molecules		InkinA molecules
	ribosomes	lysosomes	to which many	assemblies	to which many
			ribosomes are		ribosomes are
			attached		attached
			simultaneously		simultaneously
Translation is the	Synthesis of DNA	Synthesis of protein	Synthesis of RNA	Synthesis of RNA	Synthesis of
	from a mRNA	from a mRNA	from a mRNA	from a DNA	protein from a
	template	template	template	template	mRNA template
During translation	by ribosomes using	by lysosome using	by ribosomes using	hy ribosomes using	by ribosomes using
proteins are	the information on	the information on	the information on	the information on	the information on
sumthasized			mDNA		mDNA
synthesized	DINA	DNA	IIIKINA	IKNA	IIIKINA
The enzyme	ATP synthetase	aminoacyl tRNA	aminoacyl mRNA	aminoacyl rRNA	aminoacyl tRNA
involved in amino		synthetase	synthetase	synthetase	synthetase
Which of the	rRNA	mRNA	tRNA	tRNA and mRNA	tRNA
following RNA					
molecules serves as					
an adaptor					
In eukaryotes,	Pribnow box	Hogness box	5' CAP	poly A tail	5' CAP
translation is		0			
inititated by					
hinding of					
Which is the energy	ATP synthetase	GTP	СТР	AMP	GTP
rich molecule	ATT synthetase	011	CII	711011	011
nen molecule					
required for		DATA 1	DNL 1	D i l	
Which of the	DNA makes RNA	RNA makes	DNA makes	Protein makes	DNA makes RNA
following best	makes Proteins	DNAmakes Proteins	proteins makes	DNA makes RNA	makes Proteins
explains the			RNA		
sequence of central					
Many primary	translated	polyadenylated	processed	replicated	processed
transcripts of					
noncoding RNAs					
must bein					
RNA polymerase	rRNA	DNA	RNA	mRNA	DNA
used for the					
transprintion of					
genes require a		<b>D</b>			
Which of the	Transcription but	Bacterial non	The regulation of	Linking of exons	Transcription but
tollowing	not translation is	coding RNAs mus t	the transcription	must precede	not translation is
statements is not	regulated in bacteria	be processed by	initiation complex	translation in	regulated in bacteria
true?		cleavage to form	is a key feature of	eukaryotes	
		functional	gene expression		

Regarding RNA polymerase in E.Coli which of the following describes the difference between the holo enyzyme and the core enzyme?	The holoenzyme is used to synthesize mRNA, while the core enzyme synthesizes noncoding RNAs	The holoenzyme consists of five subunits including $\sigma$ , while the core enzyme lacks $\sigma$	The core enzyme and not the holoenzyme is required for the initation of RNA synthesis	The holoenzyme binds to DNA upstream of the promoter while the core enzyme binds to dounwstream of the promoter	The holoenzyme consists of five subunits including $\sigma$ , while the core enzyme lacks $\sigma$
RNA polymerase II transcribes all of the following except genes	rRNAs	proteins	snRNAs	miRNAs	rRNAs
The recognition sequence to whiich RNA polymerase binds at the initiation of transcription is	downstream of the promoter target sequence	b)upstream of the gene to be transcribed	withinthe first intron	downstream of the transcription bubble	upstream of the gene to be transcribed
Which of the following best describes a promoter?	An element that promotes termination of transcription	A regualatory protein that accelerates mRNA turnover	A specific target sequence to which RNA polymeraase binds	An extracellular environmental inducer that controls gene	A specific target sequence to which RNA polymeraase binds
Some eukaryotic promoters contain an element positioned around nucleotide +1	the TATA box	the pribnow box	an initiator (Inr) sequence	an inverted repeat	an initiator Inr sequence
"Null" genes are characterized by their	transcription by RNA polymerase I and II	possession of neither TATA box nor an Inr sequence	Invariable start position of transcription	inability to be transcribed	possession of neither TATA box nor an Inr sequence
The conversion of a clsoed rpomoter complex to an open promoter complex in bacteria requires-	the activity of alternative promoters	hydrogen bond breakage of base pairs around the initiation site	a G-C rich sequence around to +1 site	strong interaction between the core enzyme and the -10 box	hydrogen bond breakage of base pairs around the initiation site
An improtant difference between the initiation of prokarytoic and eukaryotic transcription of	only prokaryotic genes use upstream sequence	only eukaryotic RNA polymerase possess a σ subunit	eukaryotic promoters indirectly recognize core promoter sequences	d)only prokaryotes cells alter the rate of transcription	eukaryotic promoters indirectly recognize core promoter sequences
Each time a ribonucleotide is added to the elongating RNA molecule during transcription a	deoxy ribonucleotide	sugar-base component	c)pyrophosphate	phosphate	pyrophosphate
The 5'end of mRNAs made by RNA polymerase II possess a distinct cap structure depicted in short-	7-MeGppNpN	7-MeGpppNpN	pppN- 7MeGppppNpN	рррNрN	7-MeGpppNpN
The formation of hairpin loops at the 3' end of prokaryotic RNAs during transcription results in	stabilization of DNA:RNA pairing promoting further elongation of the transcript	activation of poly ( polymerase	a reduction in base pairing between the template strand and the RNA transcript	Rho-dependent activation of transcription	a reduction in base pairing between the template strand and the RNA transcript

Which of the following statements regarding the poly ( tail of eukaryotic Translation occurs What is the main	The poly ( tail is located at the 3, end nucleus	The poly ( tract is transcribed from the DNA template cytoplasm	poly ( tails are found on transcripts made by RNA polyemrase II nucleolus identifies amino	Tissue specific gene expression patterns soemtimes correlate with laternative lysosome promoter binding	The poly ( tract is transcribed from the DNA template cytopalsm identifies amino
function of tRNA in relation to protein synthesis?	synthesis	proor reading	acids and transport them to ribosomes	promoter binding	acids and transport them to ribosomes
Which site of tRNA molecule hydrogen bonds to a mRNA molecule?	codon	anticodon	5, ends of the tRNA molecule	3' ends of the tRNA molecule	anticodon
In the context of prokaryotic gene expression, which of the following is the msot appropriate	A cluster of genes that are rqgulated by a single promoter	A DNA-binding protein that regulates gene expression	A non-coding regulatory DNA sequence that is bound by RNA polymerase	A non-coding regualtory DNA sequence that is bound by a repressor protein	A non-coding regulatory DNA sequence that is bound by a repressor protein
In terms of lac operon regulation, what happens when E. Coli is grown in meidum containing both glucose and	Both CAP and the lac repressor are bound to the DNA	CAP is bound to the DNA but the lac repressor is not	Lac repressor is bound to the DNA but CAP is not	d)Neither CAP nor the <i>lac repressor</i> are bound to the DNA	Neither CAP nor the lac repressor are bound to the DNA
In the Ames test:	mutagens cause lethal mutations, reducing the numebr of colonies	Mutagens cause mutations that disrupt the ability of the cell to produce histidine	Mutagens will cause an increas in the number of revertants	only mutagens that cause transitions can be identified	Mutagens will cause an increas in the number of revertants
Which of the following forms of DNA repair doest NOT require DNA	Direct DNA repair	Base excision repair	Nucleotide excision repair	Mismatch repair	Direct DNA repair
Why is alkyltransferase only able to be used once?	The protein is hydrolyzed in the process of repairing the DNA	The protein is chemically changed by the addition of a methyl group	The protein becomes attached to the DNA strand	Inability to bind to another region	The protein is chemically changed by the addition of a methyl group
how does recombinational repair differ from nucelotide excision repair (NER)?	Unlike NER, recombinational repair is unable to repair damage caused by thymine dimers	NER replaces the thymine dimer while recombinational repair leaves it in place	NER requires DNA polymerase and ligase function, while recombinationalrepa ir does not	NER involves nick translation, which recombinational repair does not	NER replaces the thymine dimer while recombinational repair leaves it in place
A point mutation that replaces a purine with another purine, or a pyrimisine with	Transition	Transversion	c)Nonsense	Missense mutation	Transition
A point mutation that involves a purine being replaced by a	Transition	Transversion	Nonsense	Silent mutation	Transversion
A change in a DNA sequence that has no effect on the expression or functioning of any	Transition	Transversion	Nonsense	silent mutation	silent mutation

An alteration in a	Transition	Transversion	missense	Silent mutation	missense
nucleotide sequence					
that converts a					
codon for one					
amino acid int a					
codn for a second					
An alteration to the	Transition	Transversion	a)Lesion	Missonso mutation	Logion
All alteration to the	Transition	Transversion	C)Lesion	wissense mutation	Lesion
of the DNA					
of the DNA		a :		TT '1	
5-bromouracil is an	Inymine	Guanine	cytosine	Uracil	Inymine
analog ofthat					
can react with					
deoxyribonucleic					
acid to produce a					
polymer with					
increased					
All transposons	DNA glycosylase	Excisionase	Transposase	d)integrase	Transposase
encode awhich					
catalyzes the					
Small DNA	Exons	introns	LTRs	Transposons	Transposons
sequences that can					
move to virtually					
any position in a					
In base excision	DNA glycosylase	Transposase	Excisionsase	DNA polymerase	DNA glycosylase
repair, the lesion is					
removed by					
The exchange of	IS elements	Illegitimate	Retrotransposons	RecA	RecA
non homologus	is ciements	recombination	Retrotransposons	Recht	Recht
regions of DNA at		recombination			
specific sites is					
Specific sites is	Evonuelesse	DNA photolyagae	Transpagaga	DNA nolumoroso	DNA photolyaca
Cyclobultane	Exonuclease	DINA photolyases	Transposases	DINA polymerase	DNA photolyases
pyrimaine aimers					
can be					
monomerized again					
by in the					
The dispersed	Transposition	homologus	site specific	General	Transposition
repetitive sequences		recombination	recombination	recombination	
found in higher					
eukaryotic DNA					
(eg LINES and					
SINES) probably					
spread through the					
The enzyme of	RNA polymerase	b)DNA polymerase	RecBCD	DNA ligase	RecBCD
E.Coli is a nuclease					
that initiates the					
repair of double					
stranded DNA					
breaks by					
Which of the	Transition	Transversion	Nonsense	Missense mutation	Nonsense
following DNA					
mutation that result					
in the appearance					
of a stop codon in					
the resulting mRN $\Delta$					
Which type of	deletion	translocation	inversion	transition	inversion
mutation is most	acientiti	ansiocation		ualisiuoli	
Which type of	Deletion	translocation	inversion	transition	deletion
mutation is least	Deletion	alisiocation		u alisiuoli	ucietion
mutation is least	1	L	L	I	1

The hydrolysis of an -NH2 group from a base is called, while intercalating agents such as proflavin function as	deamination; transversions	deamination; deletions or insertions	excision repair; deletion or insertions	excision repair; transversions	deamination; deletions or insertions
ultraviolet radiation is most likely to produce what form	deaminations	b)depurination	double stranded breaks	thymine dimers	thymine dimers
Duplication of multiple three- nucelotide repeats	Sickel cell anemia	b)trisomy 21	alkaptonuria	xeroderma pigmentosum	alkaptonuria
Errors in DNA replication are most often corrected by	SOS systems	Base excision repair	Nucleotide excision repair	methyl-directed mismatch repair	Base excision repair
A mutation in the UvrC protein of E.Coli would result in which of the	an increase in overall mutation rate	a decrease in over allmutation rate	an increase in transposition events	a decrease in transposition events	a decrease in transposition events
The are heritable changes in base sequences that can affect phenotype	mutation	duplication	replication	d)transcription	mutation
A mutation that changes a wild type allele of a gene to a different allele is	forward	reverse	inversion	deletion	forward
Amutation causes a novel allele to be converted back to a	forward	reverse	inversion	deletion	reverse
If the weather in Richmond, Virginia, changed to very cold (snow on the ground 8	The cold weather would cause a mutation in squirrels which causes their fur to	If a mutation occurred which caused white fur to develop, such white squirrels would	Evolution would definitely occur resulting in white squirrels	Natural selection would cause a new genotype to appear in the population, resulting in	If a mutation occurred which caused white fur to develop, such white squirrels would
Which of the following is NOT an example of natural selection?	Plants with thorns are less likely to be eaten by herbivores than other members of the same species	Bacterial populations in hospitals develop resistance to drugs used to combat	Scientists breed cows that give greater amounts of milk than their ancestors	Fruit fly larvae with an enzyme to break down alcohol are better able to feed on	Scientists breed cows that give greater amounts of milk than their ancestors
For some traits (such as birth weight in mammals), natural selection favors	diversifying selection	directional selection	adaptive radiation	stabilizing selection	stabilizing selection
How does artificial selection produce rapid changes in the phenotype of organisms?	by changing the frequency of alleles and selecting for new combinations of traits	by stimulating the species to increase the production of new mutations	by changing the number of chromosomes	by selecting only dominant genotypes	by changing the frequency of alleles and selecting for new combinations of traits
How does natural selection affect the frequency of mutations?	Under conditions of high selection pressure, beneficial mutations occur more frequently	Natural selection does not affect the frequency of mutations	All mutations increase when selection pressure is high	When there is no selection pressure, mutations do not occur	Natural selection does not affect the frequency of mutations

Genomic studies of	Acquired	Common Ancestry	Adaptive Radiation	Artificial Selection	Common Ancestry
the chromosomal	Characteristics		1		2
fusion in					
chimpanzees					
provided an					
explanation for					
differences in					
chromosomal					
number compared					
What is the only	gene flow	non-random mating	genetic drift	selection	selection
factor that can	8		8		
change allele					
frequencies in					
populations to					
produce <i>adaptive</i>					
Hybridization	polyploidy	gametic isolation	hybrid viability	mutation	polyploidy
between different	polypiolay	Sumerie Isolution	nyond viaonity	induction	polypiolay
plant species					
producing more					
than two sets of					
The age of earth is	a)10000 years old	b)4.5 billion years	c)600 million year	d)10 20	b)4.5 billion years
astimate to be about	a)10000 years old	0)4-5 billion years	old	u)10-20	0)4-5 Union years
Which one of the	a) Actinomycotos	ago h)Beaudomonae	a)Pickettisse	d)Mathanagang	ago d)Mothonogong
following are	a)Actinoinycetes	b)r seudomonas	c)Rickettisae	u)Methanogens	u)Methanogens
Archeobectorio?					
Formation of most	a) Uugo da urrias	b) Uray and Millor	a) Onarin and	d)Dectour	b) Uroy and Millor
Formation of most	a) Hugo de vries	b) Urey and Willer	c) Oparin and	d)Pasteur	b) Orey and Miller
amino acids as well			Haidane		
as adenine andother					
from in one on in					
from morganic					
molecules was					
		• • • •			
The most primitive	a)plasmodium	b)tetrahymena	c)chlamydomonas	d)Giardia	d)Giardia
The most primitive extant eukaryotes	a)plasmodium	b)tetrahymena	c)chlamydomonas	d)Giardia	d)Giardia
The most primitive extant eukaryotes belong to the genus	a)plasmodium	b)tetrahymena	c)chlamydomonas	d)Giardia	d)Giardia
The most primitive extant eukaryotes belong to the genus Cambrian	a)plasmodium a) Origin of life	b)tetrahymena b)Origin of phyla	<ul><li>c)chlamydomonas</li><li>c) Origin of man</li></ul>	d)Giardia d)extinction of	d)Giardia b)Origin of phyla
The most primitive extant eukaryotes belong to the genus Cambrian Explosion refers to	a)plasmodium a) Origin of life	b)tetrahymena b)Origin of phyla	<ul><li>c)chlamydomonas</li><li>c) Origin of man</li></ul>	d)Giardia d)extinction of Dinosaurs	d)Giardia b)Origin of phyla
The most primitive extant eukaryotes belong to the genus Cambrian Explosion refers to Which of the	a)plasmodium a) Origin of life a)Mitochondria	b)tetrahymena b)Origin of phyla b)mitochondrial	<ul> <li>c)chlamydomonas</li> <li>c) Origin of man</li> <li>c)mitochondrial</li> </ul>	d)Giardia d)extinction of Dinosaurs d)mitochondrial	d)Giardia b)Origin of phyla c)mitochondrial
The most primitive extant eukaryotes belong to the genus Cambrian Explosion refers to Which of the following statement	a)plasmodium a) Origin of life a)Mitochondria DNA has a circular	b)tetrahymena b)Origin of phyla b)mitochondrial ribosomes are	<ul> <li>c) chlamydomonas</li> <li>c) Origin of man</li> <li>c) mitochondrial genes code for</li> </ul>	d)Giardia d)extinction of Dinosaurs d)mitochondrial ribosomes are 70s	<ul> <li>d)Giardia</li> <li>b)Origin of phyla</li> <li>c)mitochondrial genes code for</li> </ul>
The most primitive extant eukaryotes belong to the genus Cambrian Explosion refers to Which of the following statement cannot be support	a)plasmodium a) Origin of life a)Mitochondria DNA has a circular genome	<ul> <li>b)tetrahymena</li> <li>b)Origin of phyla</li> <li>b)mitochondrial</li> <li>ribosomes are</li> <li>inactivated by the</li> </ul>	<ul> <li>c) chlamydomonas</li> <li>c) Origin of man</li> <li>c) mitochondrial genes code for enzymes of</li> </ul>	d)Giardia d)extinction of Dinosaurs d)mitochondrial ribosomes are 70s	<ul> <li>d)Giardia</li> <li>b)Origin of phyla</li> <li>c)mitochondrial genes code for enzymes of</li> </ul>
The most primitive extant eukaryotes belong to the genus Cambrian Explosion refers to Which of the following statement cannot be support the endosymbiotic	a)plasmodium a) Origin of life a)Mitochondria DNA has a circular genome	<ul> <li>b)tetrahymena</li> <li>b)Origin of phyla</li> <li>b)mitochondrial</li> <li>ribosomes are</li> <li>inactivated by the</li> <li>antibiotic</li> </ul>	<ul> <li>c)chlamydomonas</li> <li>c) Origin of man</li> <li>c)mitochondrial genes code for enzymes of oxidative respiration</li> </ul>	d)Giardia d)extinction of Dinosaurs d)mitochondrial ribosomes are 70s	<ul> <li>d)Giardia</li> <li>b)Origin of phyla</li> <li>c)mitochondrial genes code for enzymes of oxidative respiration</li> </ul>
The most primitive extant eukaryotes belong to the genus Cambrian Explosion refers to Which of the following statement cannot be support the endosymbiotic theory for the orgin	a)plasmodium a) Origin of life a)Mitochondria DNA has a circular genome	<ul> <li>b)tetrahymena</li> <li>b)Origin of phyla</li> <li>b)mitochondrial</li> <li>ribosomes are</li> <li>inactivated by the</li> <li>antibiotic</li> <li>chloramphenicol</li> </ul>	<ul> <li>c)chlamydomonas</li> <li>c) Origin of man</li> <li>c)mitochondrial genes code for enzymes of oxidative respiration</li> </ul>	d)Giardia d)extinction of Dinosaurs d)mitochondrial ribosomes are 70s	<ul> <li>d)Giardia</li> <li>b)Origin of phyla</li> <li>c)mitochondrial genes code for enzymes of oxidative respiration</li> </ul>
The most primitive extant eukaryotes belong to the genus Cambrian Explosion refers to Which of the following statement cannot be support the endosymbiotic theory for the orgin of mitochondria?	a)plasmodium a) Origin of life a)Mitochondria DNA has a circular genome	b)tetrahymena b)Origin of phyla b)mitochondrial ribosomes are inactivated by the antibiotic chloramphenicol	c)chlamydomonas c) Origin of man c)mitochondrial genes code for enzymes of oxidative respiration	d)Giardia d)extinction of Dinosaurs d)mitochondrial ribosomes are 70s	d)Giardia b)Origin of phyla c)mitochondrial genes code for enzymes of oxidative respiration
The most primitive extant eukaryotes belong to the genus Cambrian Explosion refers to Which of the following statement cannot be support the endosymbiotic theory for the orgin of mitochondria? Aerobic respiration	a)plasmodium a) Origin of life a)Mitochondria DNA has a circular genome a)1.0-1.5bp	b)tetrahymena b)Origin of phyla b)mitochondrial ribosomes are inactivated by the antibiotic chloramphenicol b) 2.0-2.5bp	<ul> <li>c) chlamydomonas</li> <li>c) Origin of man</li> <li>c)mitochondrial genes code for enzymes of oxidative respiration</li> <li>c)3.0-3.5bp</li> </ul>	d)Giardia d)extinction of Dinosaurs d)mitochondrial ribosomes are 70s d)3.5-4.0bp	<ul> <li>d)Giardia</li> <li>b)Origin of phyla</li> <li>c)mitochondrial genes code for enzymes of oxidative respiration</li> <li>b) 2.0-2.5bp</li> </ul>
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The most primitive extant eukaryotes belong to the genus Cambrian Explosion refers to Which of the following statement cannot be support the endosymbiotic theory for the orgin of mitochondria? Aerobic respiration is thought to have first appeared in	a)plasmodium a) Origin of life a)Mitochondria DNA has a circular genome a)1.0-1.5bp	b)tetrahymena b)Origin of phyla b)mitochondrial ribosomes are inactivated by the antibiotic chloramphenicol b) 2.0-2.5bp	<ul> <li>c) c) chlamydomonas</li> <li>c) Origin of man</li> <li>c) mitochondrial genes code for enzymes of oxidative respiration</li> <li>c) 3.0-3.5 bp</li> </ul>	d)Giardia d)extinction of Dinosaurs d)mitochondrial ribosomes are 70s d)3.5-4.0bp	<ul> <li>d)Giardia</li> <li>b)Origin of phyla</li> <li>c)mitochondrial genes code for enzymes of oxidative respiration</li> <li>b) 2.0-2.5bp</li> </ul>
The most primitive extant eukaryotes belong to the genus Cambrian Explosion refers to Which of the following statement cannot be support the endosymbiotic theory for the orgin of mitochondria? Aerobic respiration is thought to have first appeared in some organisms of	a)plasmodium a) Origin of life a)Mitochondria DNA has a circular genome a)1.0-1.5bp	b)tetrahymena b)Origin of phyla b)mitochondrial ribosomes are inactivated by the antibiotic chloramphenicol b) 2.0-2.5bp	c)chlamydomonas c) Origin of man c)mitochondrial genes code for enzymes of oxidative respiration c)3.0-3.5bp	d)Giardia d)extinction of Dinosaurs d)mitochondrial ribosomes are 70s d)3.5-4.0bp	<ul> <li>d)Giardia</li> <li>b)Origin of phyla</li> <li>c)mitochondrial genes code for enzymes of oxidative respiration</li> <li>b) 2.0-2.5bp</li> </ul>
The most primitive extant eukaryotes belong to the genus Cambrian Explosion refers to Which of the following statement cannot be support the endosymbiotic theory for the orgin of mitochondria? Aerobic respiration is thought to have first appeared in some organisms of approximate age	a)plasmodium a) Origin of life a)Mitochondria DNA has a circular genome a)1.0-1.5bp	b)tetrahymena b)Origin of phyla b)mitochondrial ribosomes are inactivated by the antibiotic chloramphenicol b) 2.0-2.5bp	c)chlamydomonas c) Origin of man c)mitochondrial genes code for enzymes of oxidative respiration c)3.0-3.5bp	d)Giardia d)extinction of Dinosaurs d)mitochondrial ribosomes are 70s d)3.5-4.0bp	<ul> <li>d)Giardia</li> <li>b)Origin of phyla</li> <li>c)mitochondrial genes code for enzymes of oxidative respiration</li> <li>b) 2.0-2.5bp</li> </ul>
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The most primitive extant eukaryotes belong to the genus Cambrian Explosion refers to Which of the following statement cannot be support the endosymbiotic theory for the orgin of mitochondria? Aerobic respiration is thought to have first appeared in some organisms of approximate age Which of the following process	a)plasmodium a) Origin of life a)Mitochondria DNA has a circular genome a)1.0-1.5bp a)exon shuffling	<ul> <li>b)tetrahymena</li> <li>b)Origin of phyla</li> <li>b)mitochondrial ribosomes are inactivated by the antibiotic chloramphenicol</li> <li>b) 2.0-2.5bp</li> <li>b)intron excisions</li> </ul>	c)chlamydomonas c) Origin of man c)mitochondrial genes code for enzymes of oxidative respiration c)3.0-3.5bp c)transposons insertions	d)Giardia d)extinction of Dinosaurs d)mitochondrial ribosomes are 70s d)3.5-4.0bp d)DNA amplification	<ul> <li>d)Giardia</li> <li>b)Origin of phyla</li> <li>c)mitochondrial genes code for enzymes of oxidative respiration</li> <li>b) 2.0-2.5bp</li> <li>a)exon shuffling</li> </ul>
The most primitive extant eukaryotes belong to the genus Cambrian Explosion refers to Which of the following statement cannot be support the endosymbiotic theory for the orgin of mitochondria? Aerobic respiration is thought to have first appeared in some organisms of approximate age Which of the following process offers the greatest	a)plasmodium a) Origin of life a)Mitochondria DNA has a circular genome a)1.0-1.5bp a)exon shuffling	b)tetrahymena b)Origin of phyla b)mitochondrial ribosomes are inactivated by the antibiotic chloramphenicol b) 2.0-2.5bp b)intron excisions	<ul> <li>c) chlamydomonas</li> <li>c) Origin of man</li> <li>c)mitochondrial genes code for enzymes of oxidative respiration</li> <li>c)3.0-3.5bp</li> <li>c)transposons insertions</li> </ul>	d)Giardia d)extinction of Dinosaurs d)mitochondrial ribosomes are 70s d)3.5-4.0bp d)DNA amplification	<ul> <li>d)Giardia</li> <li>b)Origin of phyla</li> <li>c)mitochondrial genes code for enzymes of oxidative respiration</li> <li>b) 2.0-2.5bp</li> <li>a)exon shuffling</li> </ul>
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The first	a) Cat	b) Dog	c) Horse	d) Cow	b) Dog
domes cated					
animal by primi ve					
Which of the	a) Pinus	b) Riccia	c) Ginkgo	d) Gnetum	c) Ginkgo
following is an		,	, ,	,	, 0
example of living					
First life on earth	a) Cvanobacteria	b) Autographs	c)	d) Photoautotrophs	c)
was	<i>,</i> , ,	, , , ,	Chemoheterotrophs	· · · ·	Chemoheterotrophs
Most abundant	a) Protein	b) Cellulose	c) Steroids	d) Lipids	b) Cellulose
organic compound	u) 1 1010111	c) contaiose	ey storoids	a) Elpias	c) contaiose
Which is not a	a) Nails	b) Third molar	c) Coccyx	d) Segmented	a) Nails
ves gial organ of		- )	-,j	muscles of abdomen	
Gene, c dri7	a) Large	b) Smaller	c) Island	d) Mendealian	b) Smaller
operates only in	nopula ons	popula ons	popula ons	nopula ons	popula ons
The animals of cold	a) Cone's law	b) Dollo's law	c) Bergmann's law	d) Allen's law	d) Allen's law
countries have	u) cope s ium	o) Dono s law	e) Derginann 5 iaw	a) Thick 5 law	a) Thick 5 law
relayely shorter and					
noorly developed					
ears eves hairs and					
other phenotypic					
characters. This is					
known by which					
Phenomenon of	a) Geographical	h) Natural Selection	c) Reproduce ve	d) Induced muta on	h) Natural Selection
'Industrial	isola on	b) Natural Select Off	isola on	d) induced india off	b) Natural Select Off
melanism'					
Convergent	a) Bat and Dag	h) Postarium and	a) Starfish and	d) Deafich and	d) Doofish and
Convergent	a) Kat and Dog	D) Bacterium and	C) Startish and	d) Dogrish and	d) Dogrish and
Compact order is	a) Delegacia >	Protozoan		d) Magazaia	whate
Correct order is	a) Paleozoic->	b) Archaeozoic->	c) Coenozoic -	d) Mesozoic->	a) Paleozoic->
	Mesozoic->	Coenozoic -	>Paleozoic->	Archaeozoic->	Mesozoic->
Elect life an exatle		>Paleozoic	Archaeozoic		
First life on earth	a) cyanobacteria	b) autotrophs	c) photo autotrophs	a)	d)
was	<b>)</b>	1 1 1 1 1	× 1.1 1 11	chemoneterotrophs	chemoneterotrophs
One of the possible	a) green plants	b) carbon dioxide	c) chiorophyli	d) $\cup$ v rays and	d) $\cup$ v rays and
early sources of				lightening	lightening
energy were/ was					
First experiment	a) Watson and Crick	b) Oparin and	c) Urey and Miller	d) Meselson and	c) Urey and Miller
regarding evolution		Haldane		Stanl	
of life was					
Coacervates were	a) DNA	b) radiations	c) polymerisation	d) polymerisation	d) polymerisation
formed by				and aggregation	and aggregation
Miller and Urey	a) N and H O	b) H O and CH	c) CO and N	d) CH and N	b) H O and CH
performed an					
experiment to prove					
origin of life. They					
look for gases NH					
and H along with?					
According to	a) methane	b) hydrogen	c) water vapour	d) oxygen	d) oxygen
Oparin, which one					
of the following					
was not present in					
the primitive					
Swan neck flask	a) Oparin and	b) Darwin	c) Aristotle	d) Louis Pasteur	d) Louis Pasteur
experiment was	Haldane				
performed by					
Coacervates were	a) Urey and Miller	b) Jacob and Monad	c) Oparin	d) Fischer and	c) Oparin
experimentally				Huxley	
produced by					
Finding of Miller's	a) theory of special	b) theory of	c) theory of	d) theory of organic	c) theory of
experiment on	creation	biogenesis	abiogenesis	evolution	abiogenesis
origin of life has					
provided evidence					
Theory of	a) Spallanzani	b) F.Redi	c) Van Helmont	d) Pasteur	c) Van Helmont
abiogenesis was put					

A species	a) sympatric	b) allopatric	c) sibling	d) biospecies	b) allopatric
inhabiting different		· •		· •	
geographical areas					
According to De	a) jerky	b) discontinuous	c) continuous and	d) both a and b	d) both a and b
Vries theory.		.,	smooth	.,	.,
Mutation may be	a) Continuous	b) Phenotypic	c) Discontinuous	d) change due to	c) Discontinuous
described as	genetic variation	change	genetic variation	hybridisation	genetic variation
The theory of use	a) Stebbins	b) Lamarck	c) Aristotle	d) Vavilox	b) Lamarck
and disuse was	a) Steeenis	o) Eulitarek	c) / mistorie	d) vuvnok	o) Eumaren
The evolution of a	a) natural selection	b) isolation	c) speciation	d) human	b) isolation
species is based	a) hatarar sereetion	0) 150141011	e) spectation	conservation	0) 100141011
upon sum total of				conservation	
adaptive changes					
Genetic drift is on	a) variations	b) mutation	c) increase in	d) decrease in	d) decrease in
account of	a) variations	b) indiation	population	nonulation	nonulation
According to Neo	a) Fighting between	b) Variations	c) Killing weaker	d) Differential	d) Differential
Darwinism natural	organisms	0) variations	organism	reproduction	reproduction
selection operates	organisins		organishi	reproduction	reproduction
through					
Gummatria	a) Casaranhia	h) hamian ta mating	a) hamian ta aana	d) constin shares	a) Casarahia
Sympatric	a) Geographic	b) barrier to mating	c) barrier to gene	d) genetic change	a) Geographic
speciation develops	barrier		now		barrier
reproductive				1) C C	
Quick change in	a) Founder effect	b) Genetic bottle	c) Genetic grift	d) Gene flow	a) Founder effect
phenotypes in a		neck			
small band of					
colonisers is called					
Genetic drift is	a) Small population	b) large population	c) plant population	d) animal	a) Small population
found in	with or without	with random mating		population	with or without
	mutated genes				mutated genes
Which is related to	a) genetic isolation	b)temporal isolation	c) behavioural	d) all of these.	d) all of these.
reproduce isolation			isolation		
In which condition	a) gene flow	b) mutation	c) random mating	d) sexual selection	c) random mating
gene ratio remains					
constant in a					
Lamarck theory of	a) Natural selection	b) Inheritance of	c) Descent with	d) continuity of	b) Inheritance of
organic evolution is		acquired characters	change	fermplasm	acquired characters
usually known as					
Which one is used	a) Degree of	b) Genetic drift	c) Proportion	d) Hardy Weinberg	d) Hardy Weinberg
for knowing	evolution		between acquired	equation	equation
whether or not a			variations		
Balancing selection	a) Homozygous	b) homozygous	c) heterozygous	d) all of the above	c) heterozygous
is concerned with	recessives	indivduals	individuals		individuals
successful					
reproduction of					
During which	a) Orosirian period	b) Ediacaran period	c) Devonian period	d) Ordovician	a) Orosirian period
geological period				period	
did the earth					
The first green	a) Ediacaran period	b) Devonian period	c) Orosirian period	d) Ordovician	d) Ordovician
plants and fungi	-	-	-	period	period
appeared on land				-	-
during which					
Flowering plants	a) Jurassic period	b) Carboniferous	c) Cretaceous period	d) Silurian	c) Cretaceous period
first appeared		period	, î		
during		-			
The present epoch	a) Holocene	b) Miocene	c) Pleistocene	d) Pliocene	a) Holocene
in the Earth's age is					
known as					
The rise of human	a) Holocene	b) Pleistocene	c) Pliocene	d) miocene	a) Holocene
civiliza#on is the	.,	,	.,	.,	.,
main characteris#cs					
of					
	L	I		I	

Which geological period in the age of earth is also known	a) Orosirian period	b) Devonian period	c) Ediacaran period	d) Ordovician period	b) Devonian period
as the Age of Fish?					
As per the latest	a) 4 billion years	b) 4.54 billion years	c) 4.45 billion years	d) 4.64 billion years	b) 4.54 billion years
radiometric da#ng,					
what is the age of					
During which	a) Pleistocene	b) Jurassic period	c) Carboniferous	d) cretaceous	c) Carboniferous
period in the age of	period		period		period
earth did terrestrial					
life was well	\T · · 1			1. (	\T · · 1
First birds and	a) Jurassic period	b) Carboniferous	c) Pleistocene	d) cretaceous	a) Jurassic period
lizards appeared on		period	period		
Earth during		1.) 1 T	->	1)	-)
Angiosperm	a) upper cretaceous	b) lower Jurassic	c) mid cretaceous	d) carboniferous	c) mid cretaceous
During avolution	a) 1 billion years	b) 2 billion	a) 600 million	d) 200 millions	a) 1 billion years
the first	a) I UIIIUII years	0) 2 0111011	c) 000 minion	d) 200 minions	a) I billion years
mul#cellular	ago				ago
Maximum diversity	a) Iurassic	h) Ordovician	c) Triassic	d) Cretaceous	d) Cretaceous
of rep#les was	a) Julassie	b) Ordoviciali	c) massic	d) Cretaceous	d) Cletaceous
Which of the	a)Mitochondria	b)mitochondrial	c)mitochondrial	d)mitochondrial	c)mitochondrial
following statement	DNA has a circular	ribosomes are	genes code for	ribosomes are 70s	genes code for
cannot be support	genome	inactivated by the	enzymes of		enzymes of
the endosymbiotic	-	antibiotic	oxidative respiration		oxidative respiration
theory for the orgin		chloramphenicol			
of mitochondria?					
A method for	cladistics	phenetics	polyphenetics	numerology	phenetics
constructing					
phylogenies based					
on the numerical					
ranking of the					
greatest similarity					
in as many features					
A species that	evolutionary species	chronospecies	living fossil	stagnant species	chronospecies
changes					
morphology over					
time without					
diversitying into				1. 1	
Mutation may be	a) Continuous	b) Phenotypic	c) Discontinuous	d) change due to	c) Discontinuous
described as	genetic variation	change	genetic variation	nybridisation	genetic variation
Genetic drift 1s	a) Small population	b) large population	c) plant population	a) animai	a) Small population
	with or without	with random mating		population	mutated genes
	matated genes				matated genes