

*"The man...the enigma....who singularly changed the course of intellectual discourse"*

## **Physical → New Physical → Biological Anthropology**

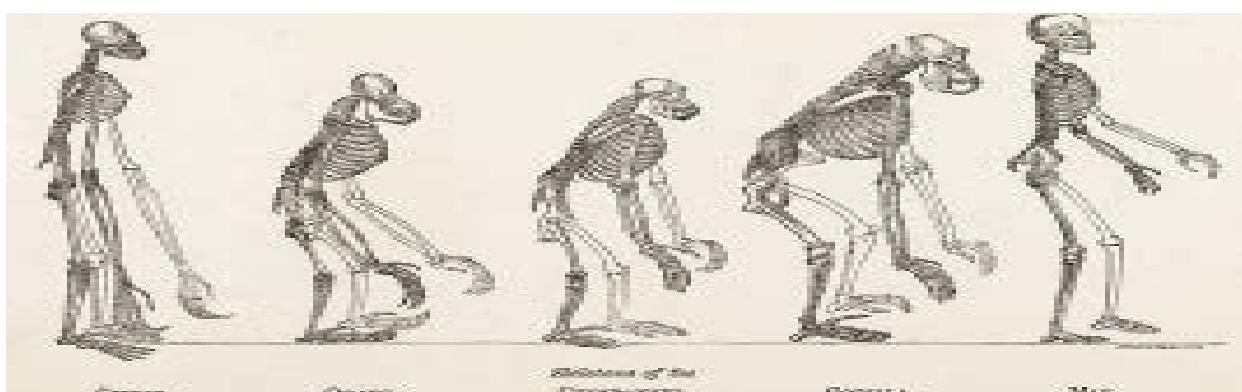
**Handwritten Notes: 1.4 + 9 + 10 + 11 + 12**

by

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**(AIR 70 CSE 2021)**

**166+140=306(Highest)**



# My thoughts on Biological Anthropology

Getting 306 in Anthropology is the 'single reason' for me getting this rank. I think there aren't too many topper notes of Physical available easily. So I hope my notes will help many aspirants who are finding Physical tough. My notes are very good. Even today Physical is more scoring than Social. But you have to be careful in choice of questions. Always remember that 'Biological Anthropology is also a Social Science' so never become totally like a biology student even though biological focus is heavy here. You must always bring in 'holistic' picture. Now about topic in hand:

- 1) Diagrams are of paramount importance in Physical without which heavy reduction of marks will take place. Thus try to put in maximum number. Especially in 9.7, 9.8 & 10 labelling the x-y axis becomes very very important.
- 2) Be crystal clear with topic 1.7(no need for notes; just concepts). You can selectively refer this playlist by Prof. Eric Lander@MIT.  
<https://www.youtube.com/watch?v=TnpCMgtDPgk&list=PL7647D2E28A51087B>. Also the terminology of Genetics is crucial to understand Physical.
- 3) Bring in views of scientists like JBS Haldane, RA Fischer, Sewall Wright, etc. Give examples that are more related to humans. Also try to give examples of communities impacted by gene flow, etc. Even case studies can be written.
- 4) Be clear with Pre & Post Darwinian theories also. Also clearly understand concepts like Genetic Drift, Genetic Load, Hardy Weinberg Law, Mendelian Population, Polygenic Inheritance, Epistasis, etc. Keep interlinking concepts.
- 5) Also remember approaches to Ecological & Epidemiological Anthropology.
- 6) In 9.8, the examples are a bit tough to find so keep googling. I have tried to put the maximum number I could but keep improving slowly.
- 7) Revision is important here to remember factual data. Ex: 9.4.
- 8) Those who are short on time can skip(at your own risk) following topics:
  - a) 1.4: Dolls Law, Cope's Law and Gauss Law(Outdated syllabus topic)
  - b) 1.7: (Irrelevant for note making)
  - c) 9.1: Only prepare Pedigree Analysis and Twin Studies(High chance that if this topic asked only these will be asked)
  - d) 9.6: Only prepare for Genetic Markers, ABO, Rh, Hb, MNS and Fat Level(In last 12 years only 1 question on Rh asked from this topic)
  - e) 12: Only prepare for Kinanthropometry, Design of Defense/Other Equipment, Nutritional AP, Racism & Eugenics, Forensic AP & PI(High chance that if this topic asked only these will be asked)

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1.3

### a) Biological AP

Defn : ✓ : (Start with what is Anthro)

Scope : 1. Paleontology & Neontology  
2. Evolution & Genetics  
3. Population Biology

Link : with Biology

### Development:

a) Initially called 'Physical AP'; it began in 19<sup>th</sup> century to study Race, Fossils and Primates. Emphasis was mainly morphological [physical/outer appearance]. It dealt with very simple questions.

{ Charles Darwin = "Descent of Man, 1871". Colonial Powers everywhere. Dryopithecus & Neanderthal Fossil, etc. It is 'Traditional Physical AP'.

b) But changes started in 20<sup>th</sup> century:

i) 1900: ABO by Landsteiner

ii) 1905: Mendel's Law

iii) 1908: Hardy Weinberg Law

4) 1920's : Cytology, Cytogenetics & Bio-chemistry

5) 1927 : 1<sup>st</sup> survey of ABO by Mourant.

6) 1930's : Synthetic Theory of Evolution

Thus 'Scope of Phy AP' changed a lot.

Such as Heredity-Env Interaction, Social Biology & Application Oriented it became.

Thus it was called as "New Physical Anthropology" acc. to <sup>SL</sup> Washburn (1951). It became popular due to IIA post WW2. Thereafter Race was rejected.

c) What was New in 1951; has become integral part of subject now. Also there is 'nothing physical' about it.

⇒ 'Biological AP' : Molecular Biology  
Facial reconstruction

d) Medical Sciences: Also see 'Q. 8' Unit

- Linked by Medical AP & - - - → Ep. AP.
- Role of Practitioners like Shaman.
- P.O vis 2<sup>o</sup> Info from Hospitals.
- Subject Matter is different; yet the techniques have been adopted.

Speciation

Ernst Mayr: The divergence of populations within a species due to geo, env & drift factors resulting in the incability of populations to mate thus forming new species is called SI "Systematics & Origin of Species" (1942).

Even the behaviour might change leading to behavioural isolation. The pre-requisite for speciation is 'reproductive isolation'. It is accomplished by isolating mechanisms:

↓ Dobzhansky (1937) ↓

Pre-Mating

- No wastage of gametes
- Imp by NS.
- Ex: Behaviours
- Biological Facts

Post-Mating

- Wastage of gametes
- No directly by NS.
- Ex: Even if sperm fertilizes still viable zygote may not develop.

→ Isolation: (1) Intra - efficiency of mating prevents Hybrid bet <sup>wn</sup> closely rel species.

↓                  ↓                  ↓

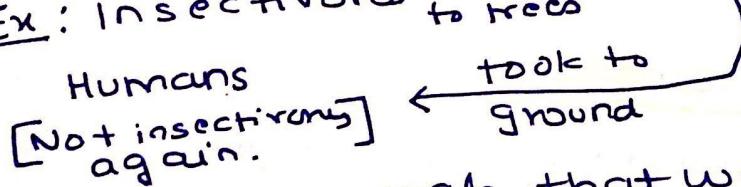
Ecological      Temporal      Behavioural      Mechanical      Chemical

Dollo's Law

By Louis Dollo (1895) : "Doctrine of Irreversibility of Evolution"

Major evolutionary 'Δ's are result of many smaller ones each preserved by NS. That such a sequence occurring by chance once should by chance again be exactly reversed would be most extraordinary.

There are no examples of present forms that look exactly like some ancient prototype even when they have returned to their ancestral habitats & modes of life. Ex: Insectivores  $\xrightarrow[\text{to trees}]{\text{took}}$  Primates



Ex: Reptiles & Mammals that went back to aquatic life assumed their streamlined body & webbed feet. Yet their skeleton is very different to their ancestral forms.

Ex: Angiosperms that returned to water get algal like appearance but are still vascular flowering plants.

Gross superficial similarity due to env might be there but it in no way implies evolutionary reversal has taken place.

Criticism : - Law cannot be applied to indv characters as these are reversible by mutation.

# **U.P.S.C.**

Cope's Law : Cope - Depéret Principle

By Edward Drinker Cope, an American  
paleontologist in 1891.

He said during course of evolution, the organisms have tendency to ( $\uparrow$ ) in size.

Ex : Giraffe Necks.  
Link with Lamarck's Use & Disuse principle.

Newell: Many of largest are now extinct.  
→ Herbs?

Hooyer: ( $\downarrow$ ) in size characteristic of many vertebrates during Quaternary period.

Vertebrates

Ex: *Giganthropithecus* extinct; Birds smaller & lighter

## Gauss's Law :

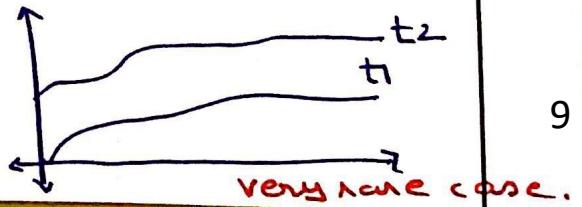
By Gregory Gause; an Russian Biologist who gave "Competitive Exclusion Principle", in 1934.

If 2 organisms occupy the same 'trophic' level in the ecosystem; then they will struggle with each other. Adaptive radiation may occur in either of them over a period of time leading to them occupying different niche's of the trophic level, thus lowering the competition.

trophic level, thus lower.] However more frequently; if they continue to keep occupying similar niches a situation will arise when neither succeeds in the presence of the other. Thus one of the species will gain an adv over the other such that the less <sup>adapted</sup> species is driven to extinction.

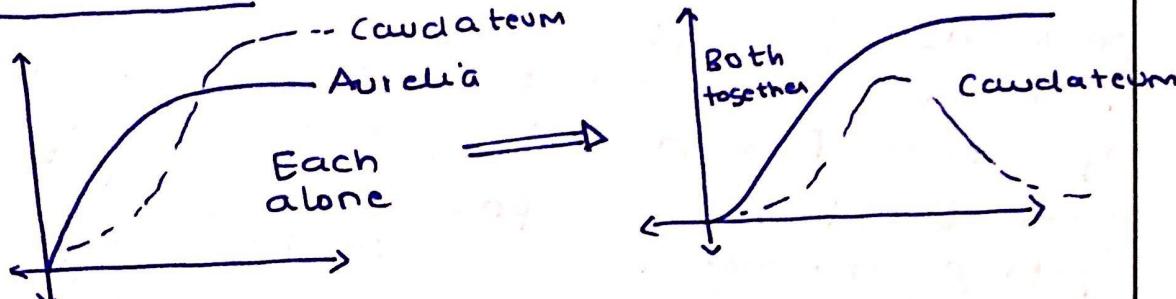


⑤ Very rarely do both stay in state of equilibrium.



Note: Resource Partition is an exception to Gause's Law.

Case Study: Paramecium Studied



Ex: Even Duckweed (demng) shows it.  
(various species)

Mosaic Evolution: Evn of Parts & Wholes

Evolution of species tends to be inconsistent & assymetrical. <sup>rate differs among & between species also</sup>

It may be rapid at one time & slow at another. It can affect different body parts & different groups at diff times.

Ex: Man  $\Rightarrow$  Early evolution for locomotion occurred during which brain & skull was constant

$\Rightarrow$  Then skull & brain evolved.

$\Rightarrow$  There can also be feedback to earlier trend. Bigger brains reinforced bipedalism. But all is one part of evolutionary whole.

# U.P.S.C.

→ Mosaic evolution throws light on the study of missing links.

This makes it unwise to draw conclusions about the relationship of 2 fossil forms on basis of single systems. Instead it is necessary to follow the evolution of whole functional systems along with the total morphological pattern of the animal in so far it is preserved.

→ The locomotion, respiratory & nervous systems respond differently to the environment. Hence they can be studied differently.

It is also called as Modular Evolution. It mostly relates to Macro-evolution.  
Ex : Mammalian evolution especially horse evolution is an example of it.

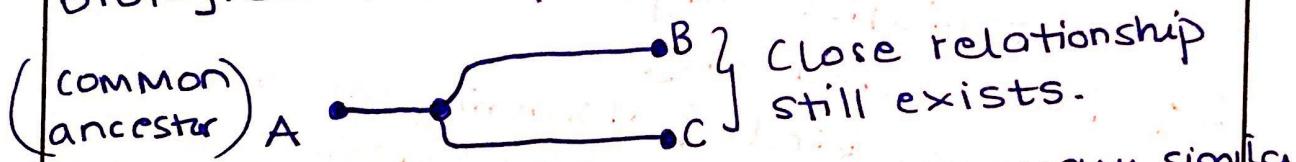
Parallelism :

Dev of similar adaptive features or the structures in species that are related to each other. The similarities are the realisation of genetic potential that is present in the entire group.

Ex: OWM & NWM.

It occurs when ancestor of organisms was not too ancient & the subsequent descendants followed a similar evolutionary course. Some changes could have been acquired by the different lineages.

∴ Parallelism also implies similarity in biological makeup of ancestor forms.



Ex: Lemur of & Hoot of Gibbon → features as in same order.  
Madagascar

⇒ Huge role in establishing & confirming the evolutionary & phylogenetic linkages.

# U.P.S.C.

## Convergence:

When 2 species that are not closely related to each other develop similarities in adaptive relationships or structures; the two are said to converge.

It is mainly due to similar adaptation of various species in the similar env. Thus selective pressure of env causes convergence & it is considered to be one of the strongest evidence of NS. The same adaptation might be beneficial to a wide range of organisms hence convergence occurs based on the env.

It is usually limited to a few characteristics only.

Ex: Bat & Bird wings

Ex: Humming Bird & Humming Moth are not related but have similar flying patterns.

Ex: Fish, Dolphins & Whales  $\Rightarrow$  Streamlined bodies.

Ex: Flying Lemur & several Prosimii have incisor tooth comb.

Ex: Tasmanian Wolf (Marsupial) & N. American Mammal [Placental] diverged 100Mya yet they are morphologically very similar due to similar adaptations as large terrestrial carnivores. Infact Tasmanian Wolf is evolutionarily more closer to the Kangaroo.

Simon Comwallis  $\rightarrow$  'Convergence' reflects the power of 'NS'.

# U.P.S.C.

इस भाग में कुछ  
न लिखें।  
(Don't write anything  
in this part)

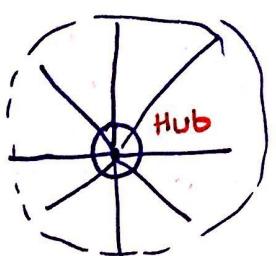
Dichotomy: Rod cells in eyes of nocturnal animals like bats & owls may be an adaptation to minimal light which points to convergence.

But it might also be due to evol from the same parts of the basic eye in most animals thus implying parallelism.

∴ Hence not all cases of similarity are easy to classify as convergent/parallel.

## Adaptive Radiation

Darwin: Emergence of many new species from one or few ancient species.



Spoke & Wheel Analogy

Simpson (1953): Rapid proliferation of species from a single ancestral group.

Unlike C & P which explains why species become/stay similar. AR explains divergence & differentiation.

Factors of A.R

→ Adaptive Potential of species

①

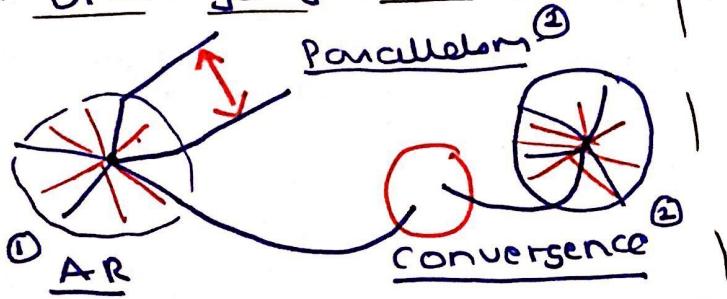
② Adaptive Opportunities available in local env.  $\Rightarrow$  niches

# U.P.S.C.

Ex: Mammals AR to diff parts of earth  
(as env got colder).

Ex: Primates Tree ✓; OWM especially in the  
Bat → Air ✓ tropical forests.  
Wales & seals → water ✓

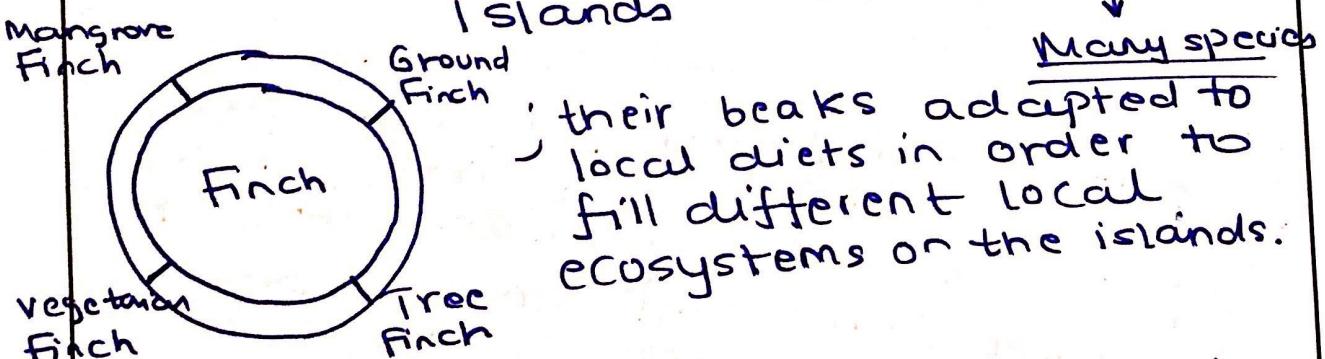
Here various orders are generated which  
can undergo further differentiation.



Beutner Janusch → Spoke of ecobniche formation  
during AR.  
→ Study via morphology  
& comparative anatomy.

Ex: Darwin's Finches on Galapagos Islands.

Many Mya → 1 Finch came  
to Galapagos  
Islands → Sfs → AR



their beaks adapted to  
local diets in order to  
fill different local  
ecosystems on the islands.

Adaptive radiation need not be a planet  
wide event.

→ Parallel Evolution

Homologous : Similarity of origin ; common ancestor.

Analogous : Similarity in function but not origin.

→ Convergence Evolution

Ex : wings of birds & bat are analogous  
but not homologous.

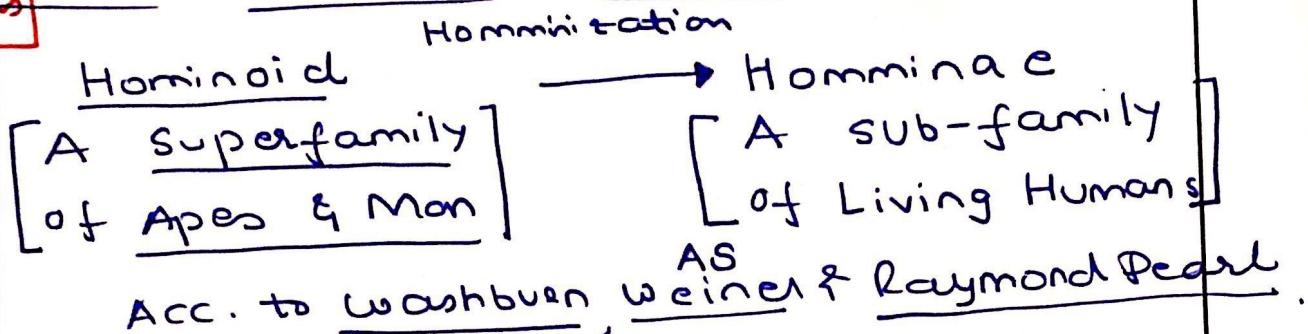
Ex : wings of bat & limbs of monkey  
one homologous but not analogous.

Ex : Serial Homology refers to similarity of  
structures of different parts of the  
same animal. ⇒ Hands & Legs.  
→ But not Analogous.

# U.P.S.C.

Q. Biological & Causal Factors that led to Human Evolution.

**6 factors**



< Biological Features >

a) Bi-pedalism & erect Posture : (6 mya)

→ constancy in 'size of spines' that are protruding from each vertebrae to avoid stress points on spine.

→ Lower vertebrae are enlarged to absorb forces of compression.

→ Sacrum - Pelvis Joint is closer to pelvic - femur joint for better transmission of weight.

→ Femur curves inward to put knee in line of body.

→ Hand no longer opposable

→ Arch in foot  $\Rightarrow$  Better-balance.

Ex: Laetoli Footprints, etc.

John Napier  $\rightarrow$  Bipedalism  $\rightarrow$  Brain dev., like solving  $3^{\circ}$  problem diff eqn.

# U.P.S.C.

perceptrual  
incl → speech  
इस पाग में कृत  
न लिखें  
(Don't write anything  
in this part)

b) Expansion & Dev of Brain : Hyoid Bone Complex (2 mya)

c) Re-modelling of Face & Teeth (5.5 mya)

→ skull is rounded

→ brain covers larger part of the face.

→ loss of sagittal crest & simian shelf.

→ Development of chin

→ Non-honing chewing complex (5.5 mya)

↳ Nut cracker Model of Australopithecus  
due to change in weather.

→ Hyoid bone & speech complex (2 mya)  
→ larynx gone into throat  
→ tongue short & thick

Language  
(both)

→ Broca Area

Frontal lobe left cortex area activates lips, larynx, etc.

→ Wernicke Area

verbal comprehension

→ Angular Gyrus : source info is received.

## Cultural Features

① Fire ; (2-1.5 mya)

② Tools ; (2.5 mya)

③ Living in 'Social Groups'

# U.P.S.C.

- ① (Dkya) Domestication of Plants & Animals
- ② Hunting; but being doubted as Glen Isaac  
(Imya) has moved from 'Man the Hunter' to  
'Man the Scavenger'. Even Sussman agreed. to satisfy  
brain needs
- ↳ Actually energy efficient!!

Peter Rodman → Helped humans go

&  
Henry McHenry  
Patchy Forest Hypothesis

far & wide acc. to his 'radiation hypothesis'  
↳ Heating & Cooling.

Both  $B^{cal}$  &  $C^{cal}$  factors one interacted. we needed minimum  $B^{cal} Evo^n$  before  $C^{cal} Evo^n$  could operate.

**Sherwood Washburn**  
↓  
Bio-cultural Feedback Mechanism  
Yet;  $C^{cal} Evo^n$  is exponentially faster.  
⇒ Bio - Cultural Evolution

- Ex: Post - Partum feeding problem → Marriage;
- Ex: Fire → Teeth(↓) & digestive tract 'A'
- Ex: Hunting → New exp. Brain → developed frontal lobe

## Organic Evolution

Organic → Living Beings

Evolution → Descent with modification,  
acc. to Darwin

### Pre-evolutionary Theory

\*) It succeeded the "Theory of Fixity of Species".

### Evidences of Evolution

- Taxonomy; Fossils; Paleontology, etc.
- Vestigial organ presence. | Ex: Euglena → Animal Plant +
- Distribution of living org's | Ex: Platypus → Reptile Mammal
- Ex: Marsupials in Australia.
- Recapitulation: Baer's Law says that organism shows its ancestral stages in embryonic dev. Ex: Müller studied the similarity of human & fish zygotes in the initial weeks.
- Immunological [Antigen - Antibody] - Cyto genetic: Similarity of Nucleosome G bands.  
Albumins

**Post - Darwinian**

- ① → Mutational Theory of Hugo-De-Vries
- ② → Hardy Weinberg Law
- ③ → A. Wiesmann Given below.
- ④ → Synthetic Theory
- ⑤ → Neo-Darwinism

**Pre-Darwinian Theories:**

① Theory of Pre-formation: Dev of organism is no more than unfolding of what is already present in its miniature.

(1882)

→ Theory of Continuity of Germplasm: It was given by August Wiesmann. Only it can pass on characters unlike the Somatoplasm.

③ Lamarcism

④ Creationist Theory

⑤ Social Evolution of Auguste Comte:

Theosophical  $\rightarrow$  Metaphysical  $\rightarrow$  Positivistic

⑥ Catastrophism: several creation events; but man were created in last one & he is greatest.  
(Nicholas Steno & George Cuvier) 21

⑦ Uniformitarianism: Geology Charles Lyell, Hutton

# U.P.S.C.

## Lamarckism

Jean Baptiste Lamarck in "philosophie zoologique (1809)" gave the Theory of Inheritance of Acquired Characters.

It was a Pre-Darwinian theory. He was a French Naturalist.

### Propositions

- ① Growth of Living Beings: [Naturally because of internal forces of life: 'Elan vital'. It is responsible for growth as also the limits to growth. Since he had no knowledge of heredity; these internal forces must be 'environmental in nature'. So appreciate for env & criticise for lack of heredity. Called "Theory of Growth".  $\Rightarrow$  Explains Adaptation to the environment. A hallmark of Lamarckism.]
- ② Evolution is need based: Need for new organ  $\rightarrow$  Hawk's brain which directs muscles of that particular part to dev movement. Completely wrong; not by needs but due to mutations. organ dev there due to new muscular mvt. I want wings  $\Rightarrow$  why haven't they come?

- ③ Theory of Use & Disuse: Growth of organ 'X' to use of organ only till optimal use. Overuse creates complications. Under use leads to extinction.  
Ex: Muscle's of workers, etc.

**U.P.S.C.**

Ex: Long Neck of Giraffe;

Ex: Webbed feet of Duck;

Ex: Snakes lost Legs;

But doesn't explain why vestigial organs still persist with us. Also the increase in size due to use is not justified. Also only valid wrt lifetime of indv.

Ex: Trees became Herbs.

Ex: Eyes & Heart size not ( $\uparrow$ ).

called Lamarck's Doctrine)

④ Principle of IBAC: All changes that take place in living beings during lifetime are inheritable by subsequent gen.

But contradictions:

Ex: <sup>August</sup> Weismann  $\Rightarrow$  40 gen rat tail cut.

Ex: Nose boring & feet binding

Ex: Blind person child not blind.

Reality is genetic changes in germline are inherited but somatic aren't.

Criticism

- Not based on facts nor supported by facts  $\Rightarrow$  Not a scientific theory.
- Extinction of dinosaurs which were large sized species.
- ★ Overemphasised Env over heredity. His Theory was Evolution through Adaptation to the environment.

Evaluation

It was 1st Theory on organic evolution. It moved dialogue from fixity of species to evolution of species. It was a simple, elegant & testable theory unlike Creationist.

- ① Darwin utilised Principle of Use & Disuse when he could not explain Evolution by NS, but never gave Lamarck credit.
- ② Neo-Lamarckists have demonstrated that some behavioural changes are inherited. Ex: Mouse or Pole.
- ③ Many changes during biological evolution of man can only be explained by 'TOUGHU'. Ex: Taurodontism.
- ④ RN Saraswati (2020)  $\Rightarrow$  some epigenetic traits are inheritable

Theory was remarkable (haha) for its times. Paved way for advancement in biology. Thus with all these 4 new obs, time has come to re-evaluate the contribution of Lamarck.

## Darwinism : English Biologist

Born 1809, "On Origin of species by means of Natural Selection (1859)"

Charles Lyell's Geology influenced him.

HMS Beagle → Galapagos of Peru Coast.  
(1831 - 36) Archipalego ARW & CD

It was 1st Scientific Theory; Linnean Soc'y Papers of London

Observation 1: Malthus (1798) : "An Essay on Popn"; spoke of AP & GP Logic.

Humans have enormous fertility but resources are limited. so the popn sustainable = f(resources); [Limited popn]

Inference 1 : "Struggle for Survival"

① Interspecific  $\xrightarrow{\text{Direct}}$   
→ food & shelter

② Intraspecific  
→ food, shelter & mate.

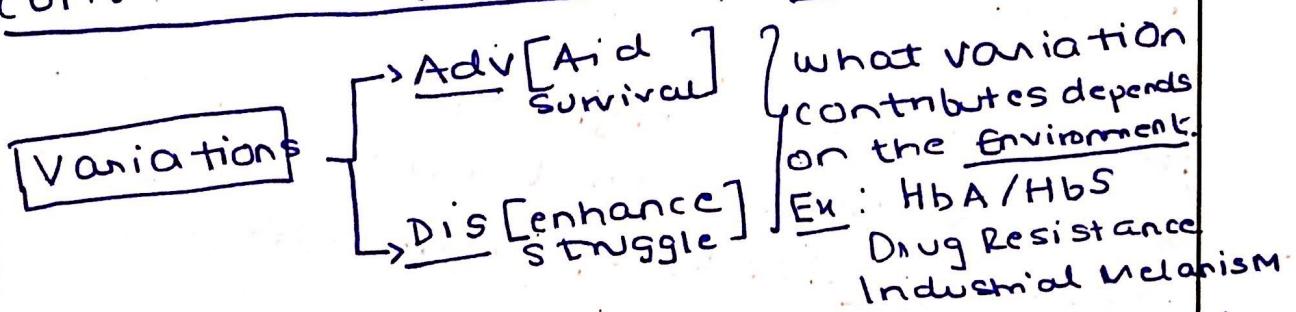
Indirect  
→ Against Env & both Lamondic & Darwin noticed it.

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But who will survive cannot be deduced based on current discussion.

## Observation 2:

Members of a gen<sup>n</sup> differ from each other & from prev gen<sup>n</sup> very minutely. Darwin called these small, fluctuating, continuous differences as Variations.



Both adv & dis variations are transferred to the next gen. Larger is the number of advantageous variations greater is the chance of "survival" & vice-versa.  
(adaptation & repnd)

Inference 2: "Natural Selection"; it is also called as Survival of Fittest coined by Herbert Spencer. Based on resources available & as directed by NS; a small group would survive having a large no. of advantageous variations. Componeed to prev gen<sup>n</sup>. This small group will give rise to a large group [obs 1] with many new variations [obs 2]. It again leads to SFE & NS resulting in a small group the members of which have more adv variations compared to prev gen<sup>n</sup>.

# U.P.S.C.

## Observation 3

After 'n' such cycles, with transfer & accumulation of variations, followed by Sfe & NS in each generation, we find that the organism is markedly different (morphologically) from the 1<sup>st</sup> parental generation.

Inference 3: "Origin of New Species"  
We thus observe that new species has already arrived. Speciation has occurred.

Alfred Russell Wallace	Observed Fact	Inference
	Malthusian Overproduction	→ Sfe
	Variation	→ NS/Sof
	Transfer & accumulation of variations	→ Origin of species

## Criticism:

- ↗ Human pop<sup>n</sup> need not increase in geometric progression due to checks. Many dev countries have  $\leq$  growth rates.
- ↖ NS operates at a diff level on man as man to an extent has been able to control negative effects of selection.  
Ex: We help PWD people around us.
- ↖ Gol advances in man demand a change in definition of the fittest.

# U.P.S.C.

- Only focussed on NS & ignored Mutation, Genetic Drift, Inbreeding, Hybridisation & role played by them in evolution.
- He didn't distinguish somatic & genetic variations. Infact if 'Darwin's' variation occur in somatic cells they are not inheritable.
- Fails to explain origin, spread & restriction (<sup>elimination</sup>) of variation. → "Amval of Fit test"
- Doesn't explain how small variations could initially be advantageous.  
Ex: Fish fin. How can such minute variation be of any selective advantage. We need to bring in mutation to explain these.
- Large no. of characters which are as such useless / non-adaptive could not have arisen through NS. It seems that such characters may be essential in terms of correlated variability.
- Over specialization & vestigial organs not explained.
- Darwin implicitly accepted Lamarck theory that acquired variations are inheritable which are wrong.

Acknowledging the Pitfalls in "Theory of NS", followers of CD [Neo-Darwinists] have modified the Theory to give imp to other micro-evolutionary processes. This theory is a Synthesis of available knowledge & hence called "Synthetic Theory" of which NS forms the core.

# U.P.S.C.

Pangenesis hypothesis: Proposed by Darwin to explain transfer of variations (heredity). He said every part of the body emits tiny particles called Germules which migrate to Gonads and are transferred to the offspring.

It was disproved by Galton who performed transplantations of reproductive organs & found offsprings still had features of original owner.

Lamarckism v/s Darwinism① Differences

- Author & Book + Dates; Postulates.
- Elaborate how each explained Giraffe.
- Not based on facts v/s based on & supported by facts.
- Individual is unit v/s Popn's unit
- Both explain evolution with a single factor: Adaptation v/s Natural Selection.
- Explains Linear Evo<sup>n</sup> v/s Both Linear & Divergent Evo<sup>n</sup>.
- Synthetic Theory gives full credit to Darwinism & Lamarckism ignored.
- Origin of diversity: Elan vital v/s Natural selection
- Considered variation : vertical fashion only v/s same & diff gen<sup>n</sup> also.
- Can draw the flowchart & elaborate.

② Similarities

- Explain evolution; role in future research.
- Both theories agree that 'acquired characters' are inherited. Lamarck used strong words but Darwin used 'variation' & thus escaped criticism.
- Both highlight role of env in evolution.
- Lamarckism doesn't explain how acquired characters are inherited. Darwinism does this through Pangenesis but fails.
- Gradual Process ; didn't distinguish somatic & genuine variation.

# U.P.S.C.

## Synthetic Theory of Evolution

Neo-Darwinists made this 'post-darwinian' theory of organic evolution by the synthesis of:

- Darwinism
- Mendelism
- Pop. Genetics
- Mol. Biology

⇒ Synthetic Theory

Proponents:

- Julian Huxley: "Evolution: The Modern Synthesis (1942)"
- R.A. Fisher: "The Genetical Theory of NS (1930)"
- G. Simpson
- Ernst Mayr; J.B.S. Haldane

They try to explain organic evn by 8 factors:

Explain each cause

### Essential

1. Gene Mutation (new variation)
2. Change in Chromosome # (new variation)
3. Genetic Recombination (express variation)
4. Isolation (restrict)
5. Natural Selection (Directs all of above factors)

### Secondary

1. Migration (spread variation)
2. Hybridisation (spread variation)
3. Genetic Drift (restrict variation)

### Evaluation

[which is best Theory?] → start with Lamarck itself [am ↓ priprly] Then Darwinism (Wallace Table)

Recent; Most scientific; recognises all evolutionary processes; best theory!

Explains sources of variation & factors for its distribution.

→ NS forms core of synthetic Theory. [As Neo-Darwinists made it]

→ Doesn't explain future evolution

→ It gives undue importance to Gen Recomb &  $\Delta$  in chromosome number which are

SYNTHETIC THEORY OF ORGANIC EVOLUTION

# U.P.S.C.

are not significant processes in evolution of man & downplays role of Hybridisation & Genetic Drift.  $\Rightarrow$  Historically both are imp factors.

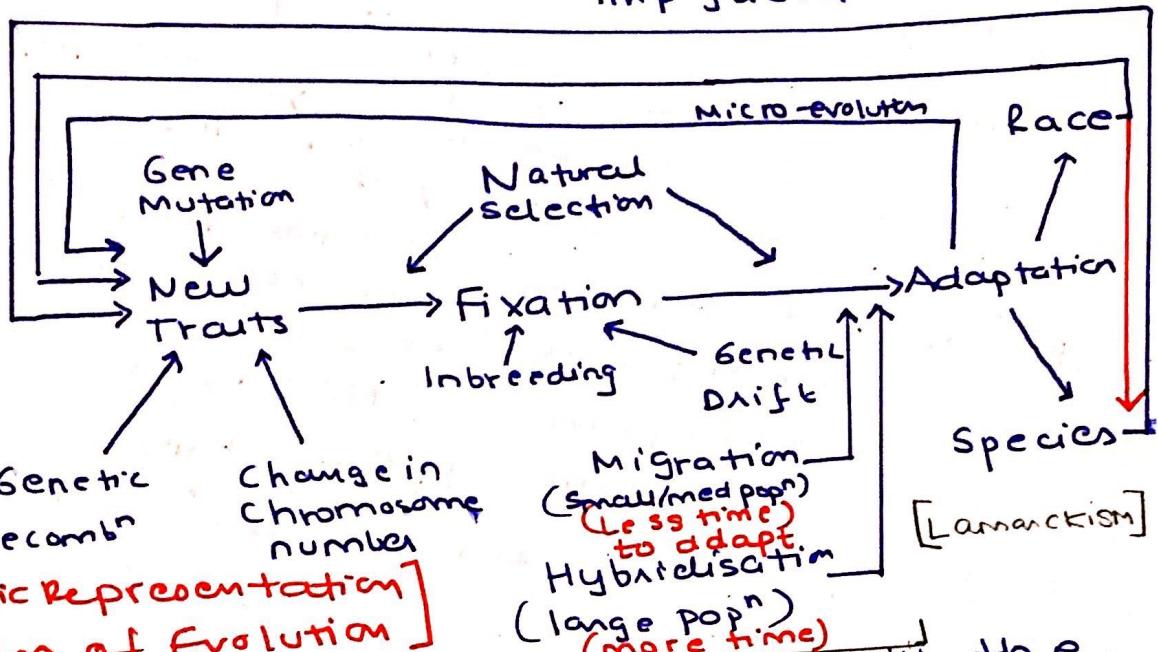


Fig  
Schematic Representation  
of Process of Evolution

→ Synthetic Theory only explains till the fixation stage. It was Lamarckism that explained adaptation. But the Synthetic Theory has completely & fully ignored Lamarckism.

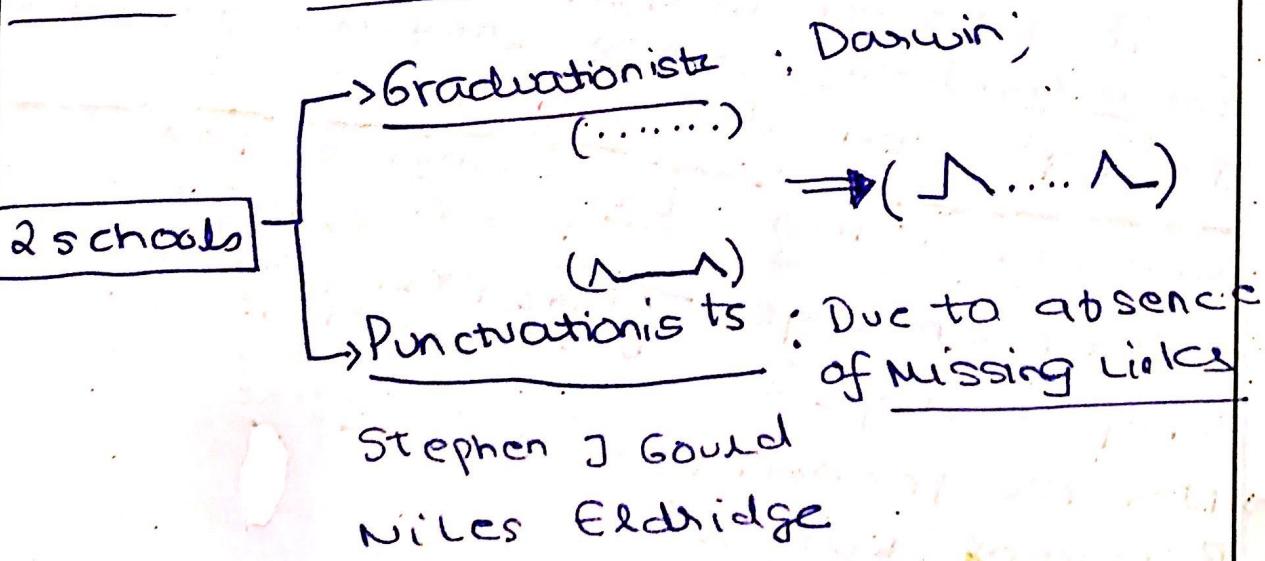
→ S.T doesn't clearly explain race formation.

→ Theory recognises that isolation forms the strongest basis for the formation of new species.

Initial Geographical Isolation  $\xrightarrow[\text{time}]{\text{over}} \text{Reproductive Isolation}$

This reproductive isolation can even continue after removal of Geographical Isolation.

- \* → Migration as a process in physical terms is meaningless unless it is followed by Gene Migration. But Gene migration itself can be explained in terms of Hyb.<sup>m</sup>. Thus inclusion of this factor in the Theory is superfluous.
- \* → for Man; if we keep 5 microevolutionary processes central then it will be a very good theory. (Better to use them)
- completely destroyed notion of the fixity of species; infact H. sapien itself from Jebel Irhoud of Morocco to today are a lot of differences.
- Many P's believed in orthogenesis; that evolution proceeded from an internal momentum. S.T showed that no such process exists & that trends are due to selection.
- Showed that tracing evo' through non-adaptive characters as done by Wood Jones in Primates by minor variations of the patterns of sutures.
- Thus S.T. has greatly affected A<sup>cal</sup> thought.



→ Don't criticise the factors &  
Explain their role in the  
Speciation.

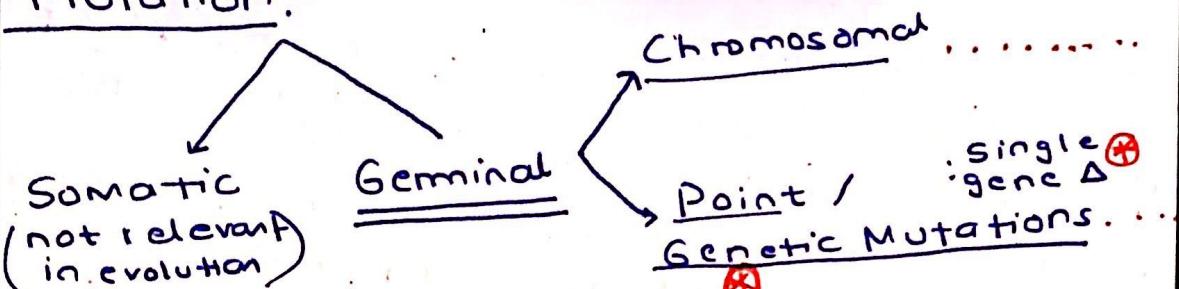
# U.P.S.C.

All loc/Genetic  
frequencies

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in this part)

## Various Factors affecting Evolution

### ① Mutation:



② Point/Gene Mutations are the only source of new traits in Man. Thus in Synthetic Theory Gene mutation means Point Mutation only.

③ Defn: Any sudden random change in nature of single gene. / Lethal, f, sub-lethal

Most Mutations are actually harmful.

Many are neutral & few are advantageous.

High variability in Gene Pool of pop<sup>n</sup> is crucial for long term survival of species; ⇒ Greater genetic variability in Gene Pool which can help the organism better adapt to changed env conditions if & when the need arises. mostly.

Thus though mutations are deletions for "individual survival" they are necessary for "pop" survival.

Ex: Change of TAA in B chain of HbA → HbS

Characteristics → Time taking; for indv sudden but for pop it is a gradual △.

humans/million humans per

Sudden change

Time taking; for indv sudden but for pop it is a gradual △.

Step change

humans/million humans per

Not too frequent (rare) → 10-50 gene

humans/million humans per

Recurrent [Rate] ✓

for  
individual  
level

CASE STUDY

- Spontaneous / Induced.
  - ↓
  - Relevant in Evolution. Better to talk about rate of Mutation.
- A  $\xrightarrow[\text{R}_r]{\text{R}_f}$  B → Next mutation sudden the rate of change of genes by mutation is very slow.  
 $\text{Net Mutation rate} = \text{R}_f - \text{R}_r$  [found by solving differential equations that are coupled along with initial conditions]
- Dominant mutations more visible in the phenotype. And respectively for different types of mutation.
- NS acts on mutation based on env & alters their frequencies.
  - ↗ Mutagenic Agents (A)
  - Causes: Chemicals, Temp  $\Delta$  & Radiation.
  - Ex: X-rays,  $\gamma$ -rays, Cosmic rays, etc.
  - Carcinogens, Benzene, etc.
- Many mutations that affect physiological & metabolic systems don't have a phenotypic expression.
- Recurrent: Permanent  $\Delta$  more likely & keep coming in every gen
- Non-Recurrent: Non-permanent.

# U.P.S.C.

Mutationism: By Hugo De Vries by study of 'Ernothera Lemaniana' in 1901.

- Saltations cause evolution.  
(Large mutations)
- Sudden occurrence, step change  
immediate effect, & discontinuous
- Source of all variation  
↳ Mutants are diff from parents  
& no intermediate,  
↳ stages occur.
- Random & directionless
- ∴ It explains progressive & regressive evolution also.
- Recurrent Mutation  $\Rightarrow$  Speciation  
(rate)
- Criticism: Cannot explain 'Dev of Mimicry'  
Most mutations are harmful & frequency not high too  
∴ Vries view that Mutation is only & most imp component of Evo is rejected.

Link with Punctuated Equilibrium of Eldredge & Gould (1972).

Ex: End of Mesozoic Era  $\rightarrow$  Many new species emerged.

↳ They were Punctuationists.

## ② Change in Chromosome Number

↓  
Euploidy  
[n, 2n, 4n]

Aneuploidy  
[+1 +2, -1, -2]

In plants & lower species of animals both type of changes can result in macro as well as micro evolution.

Huskins  
(1920)

In man & higher species of animals Euploidy leads to "spontaneous abortion" But Aneuploidy effects depend on its type & which chromosome affected, (+/-)

15% of spontaneous  
abortion  
due to  
Euploidy.

∴ To sum up, changes in chromosome number in man do not entail any important viable situation for further human evolution. But for others it can result in "instant speciation" which occurs in just 1 generation. [Others apart Genetic Recombination take much more time]

\* Sequence of the genes on the chromosome remains the same. It is imp. point.

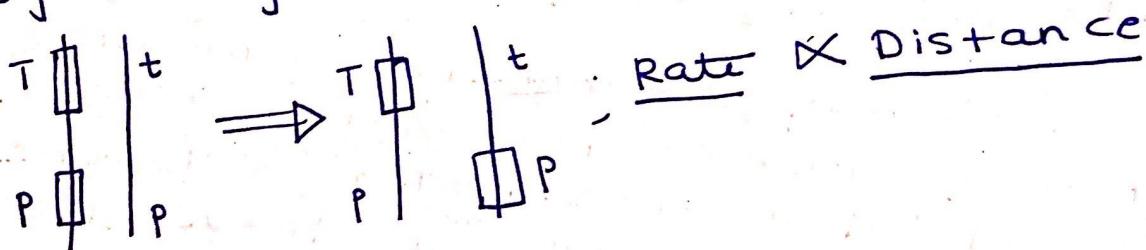
# U.P.S.C.

### ③ Genetic Recombination

It contradicts "Mendel's law of independent assortment." Here the total # of the chromosomes remains the same. But the sequence of the genes in one or more chromosome changes in all recombinations.

All the Structural Chromosomal aberrations are said to come here. The effects are same as that of change in chromosome number.

→ "Crossing over" of Genes is perfectly acceptable & leads to expression of the genetic material.



- Even radiation can cause it.
- Variations as done in flowchart.
- Translocation: 2 non-homologous chromosomes exchanging their material.
- Ex: Deletion in 'X' chromosome results in Turner Like condition. It is a type of Genetic Recombination as order of genes changes.

# U.P.S.C.

## ④ Inbreeding

Also called Isolation; Positive Assortative Mating; Non-random mating; Endogamy.

Def'n: [Mating within a mendelian pop']

The extreme expression of Inbreeding is consanguinity whereby the spouses are very closely related (genetically) to each other.

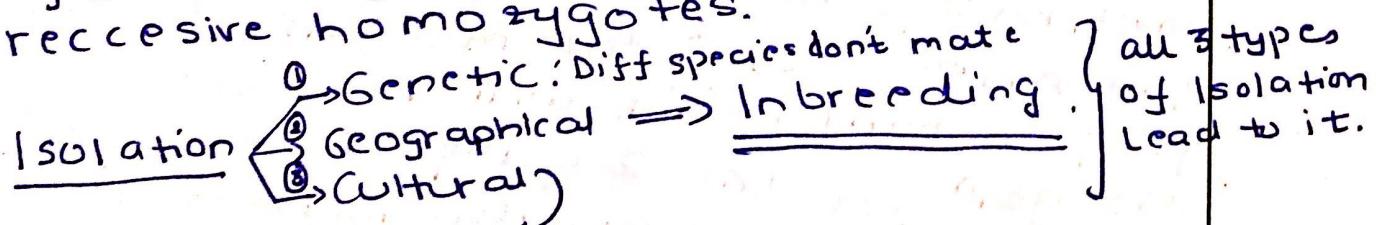
Effect: ↑ Homozygosity → ↓ Heterozygosity → ↓ G.V. → Hybrid Pop<sup>n</sup>

F<sub>1</sub> Mendel Gen initially  
Pop<sup>n</sup> constant: N

Gen	Homozygous (dominant)	Heterozygous	Homozygosity (recessive)	Homozygosity (%)	[Both TT/ tt]
F <sub>1</sub>	0	N	0	0%	
F <sub>2</sub>	N/4	N/2	N/4	50%	
F <sub>3</sub>	3N/8	N/4	3N/8	75%	
F <sub>4</sub>	7N/16	N/8	7N/16	87.5%	
F <sub>5</sub>	15N/32	N/16	15N/32	93.75%	
F <sub>6</sub>	31N/64	N/32	31N/64	96.87%	
∞	N/2	0	N/2	100%	

→ This is the effect of Inbreeding.

→ causes sudden change in gene frequencies by eliminating the lethal, sub-lethal recessive homozygotes.



Ex: Caste System

→ Ideally refers to mating of individuals with the same genotype.

# **U.P.S.C.**

⑤ Hybridisation: Exact opposite of Inbreeding.

- Not just related to diff species but also when diff genotypes mate.
  - Break's down the isolates to (1) heterozygosity.
  - Gene-flow! (2 homozygous indiv of diff alleles)  
also explained! of a gene.  
↳ Their mating is called as Hybridisation.
  - Inter-group variability(↓) & Intra-group(↑).
  - \* Hybridisation delays elimination of recessive harmful genes. Also the autosomal recessive genes through H get a chance to spread.

Until it becomes homotyous  
till then NS will not operate.

- Both are micro-evolutionary processes.
  - NS operates more fast on inbreeding than on Hybridisation as in it the same recessive lethal/sub-lethal gene remains in heterozygous condition for many gen's & NS have to wait till it becomes homozygous to eliminate it.
  - for Hy to be perfect; the 2 interacting popn must have equal size of breeding popn & if mating betw' the members of 2 groups is random; it will take exactly one gen' for the 2 groups to become one. With heterozygosity also increases the variability with the resultant popn compared to that in each of the constituent groups before Hyb.

Ex: England of IR.

Jujuy Province of Argentina  
studied by Gorro & Percey (2011)

प्रश्न संख्या  
(Question No.)

Mistand-less Gen migration  
Lowland - more

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# U.P.S.C.

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in this part)

## ⑥ Migration (Gene Flow)

By itself is no factor; it is of 2 types:  
Permanent & Temporary; the 2nd has no  
effect or even & the 1st can be  
understood in terms of Hyb. → Related with  
M.P & Pop Genetics

## ⑦ Natural Selection

wood. Gaining adaptation of PNG  
ELAH (ges) ♀ & ♂ at diff rates.

→ Mutations owe survival to NS. Simply  
a higher mutation rate doesn't imply  
that frequency will ↑ unless NS has  
mercy on it.

\* faster in inbreeding than Hybridisation.

\* NS operates on phenotypes & not genotypes.

→ If Indv with certain genotype has a  
good "Darwin fitness" w.r.t a particular  
env; then that genotype will be more  
represented in the next gen.

\* Gene is unit of evolution; but individual  
is the unit of selection.

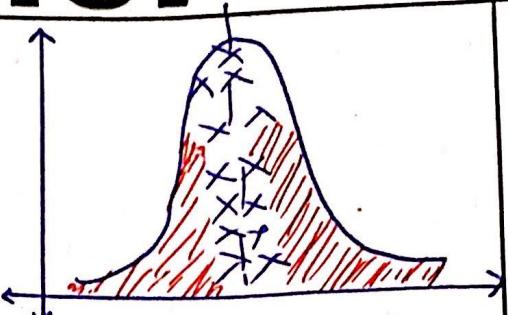
→ Individuals with more adv variation have  
higher fertility & fecundity ⇒ Better survival  
& reproduction. So more chances of the  
adv genotypes being transferred to the  
next generation. This explains how NS  
acts by fertility & fecundity. This geometric  
factor helps magnify the variations which  
in terms of mutation would have been very  
low to start off with.

Lethal Gene ⇒ No fecundity & fertility.

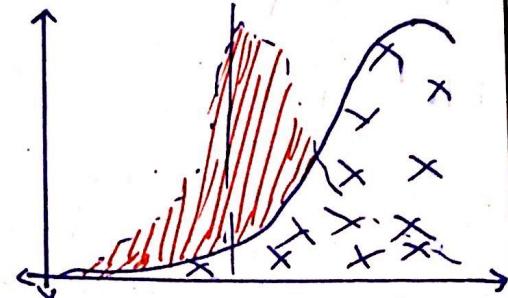
# U.P.S.C.

## Types of NS

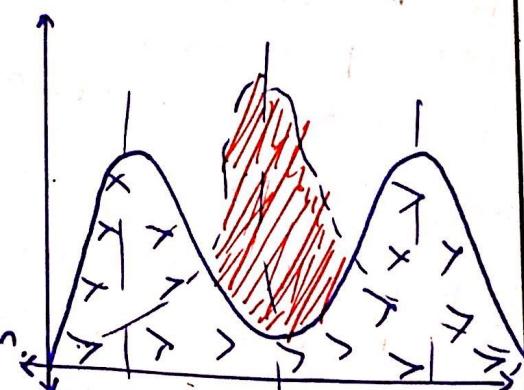
① Normalising: Removes the unwanted genotypes around a mean.  
 $GV(\downarrow)$ ; aka stabilising.



② Directional: If 'Δ' in env favouring a particular genotype.  
 $GV(\downarrow)$



③ Diversifying: If extreme genotypes provide adv then mean is selected against. Leads to bimodal-distribution.  
Ex: sexual Diannorphism in Baboons.  
aka Disruptive Selection.



Balancing NS: Multiple alleles are actively maintained in gene pool of pop at frequencies higher than that due to <sup>recurrent</sup> mutation.  
(Balanced) Polymorphism

Ex: HbA / HbS.

## ⑧ Genetic Drift

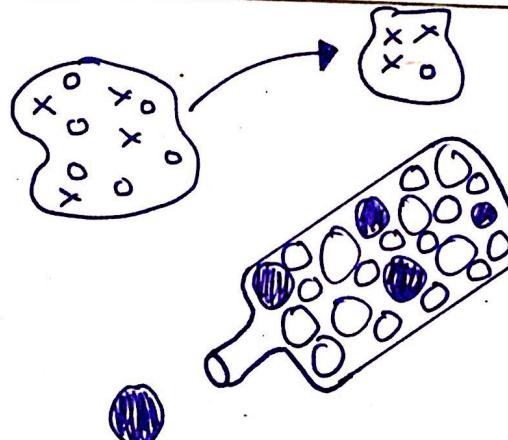
It is also called as: Founder's Effect, Chance Factor, Random Factor or Sewall Wright Effect, Sampling Error.

Gene frequencies change quickly due to a random event. There is no role for mutation or NS.

The probability of G.D. acting as a factor of "evo" was mathematically dev by Sewall Wright.

$$\text{Probability of G.D.} = \left( \frac{L_T}{L_0} \right) = \frac{-T}{[2Nc]} \quad \begin{array}{l} \text{; } T \rightarrow \text{Number of gen} \\ \text{; } Nc \rightarrow \text{pop^n size} \end{array}$$

⊕ G.D.  $\Rightarrow$  Random aspect of Evo^n



Types:

- ① Founder's Effect
- ② Bottleneck Effect

→ frequency of atleast one allele for sudden change to occur must be very low.

→ Parental pop^n  $\Rightarrow$  small; & pop^n that sep from it must be proportionately smaller.

→ HGP 1st Report (2003): All human pop^n except Africa have less G.V.  $\Rightarrow$  founder's effect.

# U.P.S.C.

- Recurrent out-migration; GD( $\uparrow$ )
- Considerable fertility diff; GD( $\uparrow$ )

## CASE STUDY

Ex: Dutch <sup>(Amish)</sup> in Penn, USA came to US in 1750's.  $A \rightarrow 0.38$ ; home  $\rightarrow 0.29$  ( $\downarrow$ ) Germany US  $\rightarrow 0.26$

Some show autosomal recessive diseases also.

Includes all those factors which cannot be explained by the earlier 7 factors:

Ex: Father only daughters  $\Rightarrow$  Y chromosome lost w/o any role of NS, etc. It is a matter of chance.

→ G.D. can affect fate of a mutant gene; deleterious or disadvantageous genes can attain a high frequency by chance.

Q. Nature v/s Nurture Debate

Human Genetics

Margaret Mead & 'C/P school'  
 Epigenetics & Epi-genome  
 Behavioural Genetics  
 Twin Studies / Growth  
 studies  
 Bio-cultural envr

- Not in fight with each other;
- Mostly Nature: Srinivasa Ramanujan;
- Mostly Nurture: Thomas Alva Edison;
- With hardwork natural limitations can be overtaken. In addition, basic genes coupled with hardwork are sufficient for extraordinary success.
- Eric Turkheimer both are important.
- Caspi Et Al (2003) :

Maltreated children if they have:

MAOA allele      If this allele not present, then violent behaviour not found.  
 Predisposition towards violence & anti-social behaviour

But non maltreated children even with MAOA allele don't show violence

→ NJ Bradshaw (2013): Twin-studies; degree of '+' attachment between mother and infant & Parental Inv (nutrient supply)



{ program dev of individual }  
{ diff in stress response in brain. }

∴ same genes express diff in the diff env. This provides capacity to physiologically alter gene expression.

→ Hunger winter of Dutch - During WW2 Famine

To study effect of pre-natal env on growth & dev. Found that women gave birth to smaller babies.

→ Elizabeth Stearns & Guang Gao (2019)

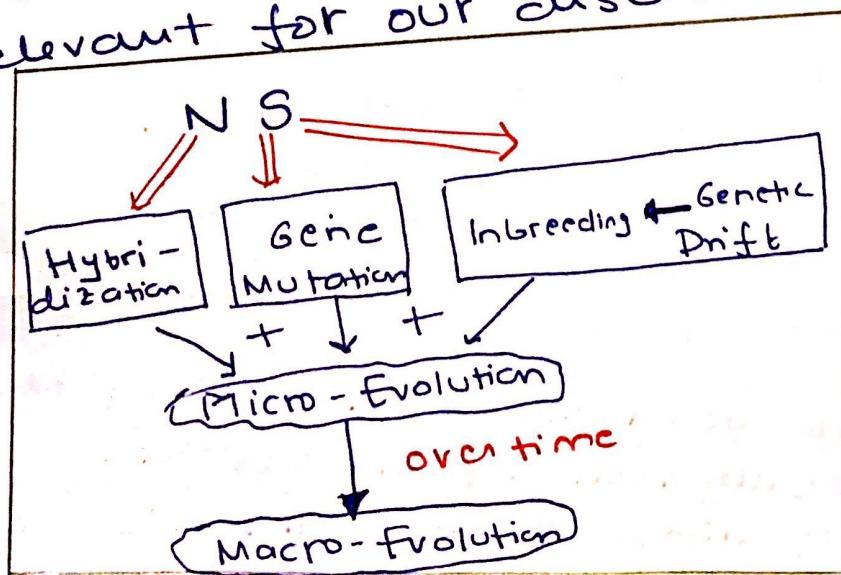
African-American Children & Unemployed Parents Children ⇒ unlikely to achieve their cognitive potential

## Macro vs Micro Evolution

As per Synthetic Theory: "Change in the gene frequencies from one gen" to the next is called as Evolution". This distinction was given by Goldschmidt (1940).

<u>Micro</u>	<u>Macro</u>
→ Small changes within species; day-day changes.	→ Large scale changes between species.
→ Not much morphological changes found.	→ Discernable ✓ → Morphological 'Δ's. → Minimum Limit is species formation.
→ Macro Limit is the formation of <u>race</u> .	
→ It can be studied in living popn.	→ fossil or other evidence needed apart from living popn
→ cannot be studied by naked eye.	→ Can be ✓
→ Ex: Pop <sup>n</sup> Genetics	→ Ex: Paleoanthropology H. erectus → H. sapiens
→ comparatively less time is needed.	Ex: Horse + Donkey → Mule [Macro Evolution] (Sterile)
Ex: wisdom tooth.	

Some biologists have created a 3rd type called MegaEvolution which is not relevant for our discussion.



# U.P.S.C.

Microevolution is not one process but an aggregate of many. 5

→ Mutation, NS, Inbreeding, Hyb & <sup>genetic</sup> drift.  
(microevolutionary processes)

The dichotomy of micro & macro evo<sup>n</sup> has only been devised for our convenience. Nature doesn't distinguish between the 2. Infact micro-evolution adds up over time leading to Macro-evolution. So Evolution continues through various micro-evolutionary processes. But there is no actual difference in both of these processes.

size of sponges ;  
Ex : AMR ;  
 Age of Monarchs ;

\* When we talk about evo<sup>n</sup> of Man we generally talk of microevolutionary factors.  
 → Migration X; Chromosome # Δ X; Gen Recomb X.  
 (Structural Δ)

Is Evolution Ongoing? Any change in pace?

- Def<sup>n</sup> of Evolution
- Types of Evolution; Diagram of Microevolution & it's characteristics in brief.
- When we say ongoing we mean micro-evo<sup>n</sup> only. Then explain the 5 micro-evolutionary processes.
- The question can be answered at 2 levels:

**Level of Selection**

a) Hardy Weinberg Law states that if there is no meaningful mutation, NS, I, H & GD then there will be no change in gene frequencies & consequently no evolution. It also lays the ideal conditions in which such Genetic Equilibrium occurs. But the truth is these ideal conditions can never be manifested. Since I & H are the opposite of each other; either of the two will always be optional. Thus at any moment of time atleast 2 factors: In/Hyb & NS will always be functional. So Evo<sup>n</sup> can never stop. So the more relevant question is whether evo<sup>n</sup> is ongoing at slower or faster rate. It is explained at 2nd level.

If possible  
give it in  
brief.

15M → 2<sup>nd</sup> point ↑

20M → Both points

**Level of Factors**

b) Last few decades have seen rise in radiations & hence more mutations. Since NS acts on mutations; its rate has also increased. The transport & communication system has ↑ so more of hybridisation is occurring than Inbreeding. This has led to spread of alleviations. The role of G.D. too has been reduced.

# U.P.S.C.

Since I & G.D. (↓); their restrictive effect on variations has reduced.

Thus Evo<sup>n</sup> is ongoing at a much faster rate today.

Ex: Dissapearance of 3<sup>rd</sup> Molar;

1960's → Erupted in Mid-Late Teens

2020 → Erupts in 40-50.

Next Gen → Lost? ; thus the feature of 32 teeth which has been with us for 30mya might be lost in next few gen<sup>n</sup>.

Ex: Rate of Evo<sup>n</sup> during covid-19.

Case Study: Laurence Hurst (2019); UNV of Bath  
"The Conversation, 2019"

Rich society → Less } Although as a whole  
Poor society → More } the rate is much higher.

Ex: US → Selection for Reduced BP & cholesterol due to changes in diet.

Andes & Tibet → Selection for high altitudes.

Case Study: John Hawks (2007); UNV of Wisconsin.  
PNAS

→ Global Pop<sup>n</sup> (↑) ⇒ Faster Evo<sup>n</sup> as more mutations occur.

→ % of human genes → Recent evo<sup>n</sup> occurred in them based on

Ex: Skin & Blue eyes → Europe. Haplotype Maps.  
Melanin → Africa. Was early as Sky9.

Ex: Lactose Tolerance (↑) across world.

They believe that in future, tendency to start late families will also drive the Evolution.