Unit 4. Evolution.

21. How Evolution Works.

Darwinian revolution challenged traditional views of young earth inhabited by unchanging species

Endless forms most beautiful.

3 key observations - organisms are well suited for life in their environments.

- many shared characteristics of life (unity)
- rich diversity of life

Evolution : descent with modifications. - < Pattern of change (facts) / Process of evolution - consist of mechanisms that cause the observable pattern of change

Scala Naturae and classification of species (자연의 사다리)

Aristotle - life forms could be arranged on ladder or scale of increasing complexity (Life is perfect, Permanent)

Linnaeus - Developed 2 part (binomial) format for naming species ex) Homo sapiens

not linear hierarchy of scala naturae, but nested classification system.

Ideas about change over time.

Paleontology : study of fossil

-Georges Cuvier : older stratum(지층), more dissimilar fossils to current life-forms

layer 넘어갈 때 new species appeared while others disappeared. but evolution은 거부.

재앙으로 해당 지역에서 사라짐, 이주해온 것으로 설명. (Sudden event)

-Charles Lyell : same geologic processes operating today as in the past, and at the same rate.

-Charles Darwin : Earth must be much older than widely accepted age.

Similarly slow and subtle process could produce substantial biological change.

Lamarck's Hypothesis of Evolution. : use and disuse : 많이 쓸수록 강화되고, 안 쓸수록 퇴화된다.

→ inheritance of acquired characteristics : organism could pass these modifications to offsprings.

Descent with modification by natural selection explains adaptations of organisms and unity and diversity.

Darwin's focus on Adaptation. - Inherited characteristics of organisms that enhance survival and reproduction in Env.

He perceive adaptation and origin of new species are closely related processes.

Natural selection : 특정 inherited traits 가진 개체들이 tend to survive and reproduce in higher rate than others

Ideas from Origin of species → descent with modification by natural selection explains 3 broad observations about nature.

-unity of life, diversity of life, way of organisms suited for life in their Environment.

Descent with modification : Phrase that summarizes his view of life.

history of life - tree 구조  same extinction → 각 그룹의 큰 차이를 보이는 이유.

Artificial selection : Humans modified species over many generations by selecting, breeding that possess desired traits

Natural selection : observation 1 - members of population often vary in inherited traits

observation 2 - All species can produce more offspring than their env can support (over reproduction)

Inference 1 - 더 생존, 번식 유리한 개체가 더 많은 자손을 남김

Inference 2 - Unequal ability of 개체 leads to accumulate of favorable traits over generation

Key features of Nature selection.

- Individuals do not evolve. Population이 evolve by favorable traits.
- Natural selection can increase frequency of adaptation that are favorable in Environment.
  → trait이 heritable 하지 all individuals are genetically identical, evolution by natural selection not occur.
- Natural selection always operating. but which traits are favorable depends on context in which a species live (Env) and mates.

Evolution is supported by an overwhelming amount of scientific evidence. strain 균주

Direct observations of evolutionary change.

Natural selection in response to introduced species. ex) soapberry bug. : 과일의 씨앗을 먹는 벌레. 주둥이 길이가 씨앗까지 갈 수 있어야 영양분을 잘 먹음 → 각 지역의 식물들의 과일 표면-씨앗 거리에 따라 주둥이 길이 변화.
새로운 식물이 도입된 지 수십년 밖에 되지 않았음에도 자연선택이 빠르게 일어났음.

The Evolution of Drug-Resistant Bacteria. → Resistant strains can proliferate very quickly by. short period of producing 박테리아는 서로 gene exchange 가능 : 항생제 출시 수년안에 내성을 가짐.

⇒ by 2 example, natural selection is process of editing, not creative mechanism [Select resistant individuals that already exist in population]

, natural selection can occur rapidly (번식 주기 ↓ 일때)

, natural selection depends on time and place. 곤충 날개, 새 날개.

Homology (Similarity from common ancestry among different organisms) ↔ Analogy (조상은 다르지 모습만 비슷)

Anatomical and Molecular Homologies - view of evolution as a remodeling process leads to the prediction that closely related species should share similar features - really they do

ex. forelimb of all mammals. show same arrangement of bones.

성체에는 안 보이는 Anatomical Similarity 가 Early stage of development 에서는 보이는 경우가 있음 (사람-닭)

Vestigial structure (흔적기관) - remnants of features of ancestors ex) Snake's leg.

Molecular level : All life use same genetic code and pseudogene으로 남은 흔적 gene

Homologies and "Tree Thinking" - pattern of descent from common ancestors with an evolutionary tree.
- More closely related if share more recent common ancestor (branch point)
Different cause of Resemblance : Analogous (상동기관) - convergent evolution
- distantly related organisms can resemble
Fossil Record : documents pattern of evolution. - descent with modification produce increasingly large diversity of life
Biogeography : Scientific study of geographic distributions of species. ex. continental drift.

22. Phylogenetic Reconstruction.

Phylogeny (계통학) - evolutionary history of species or group of species.

Binomial nomenclature (Latin scientific names) by Linaeus.

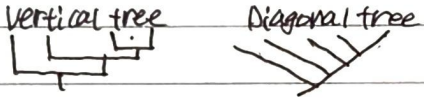
Genus	Specific epithet
which species belong	unique for each species within genus
Capitalize. Italicize.	Italicize.

Hierarchical classification. - Species that appear to be closely related are grouped into same genus

Linnaean system : species 종 - Genus 속 - Family 과 - Order 목 - Class 강 - Phylum 문 - kingdom 계 - Domain 역

⇒ does not necessarily reflect evolutionary history. (taxon : named group at any level of hierarchy)

Linking classification and phylogeny → not Phenotypic similarity.



Phylogenetic tree (계통수) : evolutionary history of group of organism

branch point : represent common ancestor.

evolutionary lineage : sequence of ancestral organisms leads to particular descendant taxon.

Sister taxa : groups of organisms that share immediate common ancestor that is not shared by other group

ex. Human, Chimpanzees

Order of taxa doesn't represent sequence of evolution.

basal taxon : lineage that diverge from all other members of its group early in the history of the group

Phylogenies are inferred from morphological and molecular data.

Morphological and molecular Homologies (상동성) → Phenotypic, genetic similarities due to shared ancestry.

Sorting Homology from Analogy

confusion by convergent evolution (analogy) by similar environmental pressures and natural selection

최대한 Homology 하면 서로 상관없는 대상이 가능할 정도로 비슷함

Evaluating molecular Homologies.

deletion 한번 많은 돌연변이 다른 유전자 배열처럼 보일 수 있음 → realign by computer program.

Morphologically huge different ≠ common ancestor가 없다 - Molecular difference ↑

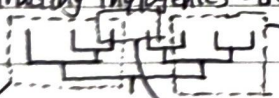
⇒ distinguish homology from analogy by evaluating molecular similarities.

but coincidental match 가 있을 수 있다.

Shared characters are used to construct phylogenetic trees. → only homology reflects evolutionary history.

key step in reconstructing phylogenies = distinguish homologous features from analogous one

Cladistics



→ Paraphyletic group : consist of ancestral species and some of descendants

Monophyletic group (clade)
: consist of ancestral species and all of its descendants

Polyphyletic group
: most recent common ancestor of its members isn't part of group

Shared Ancestral and Shared Derived characters.

Shared Ancestral character: character originated from ancestor ex) 척추-mammal은 vertebrate에서 구분지어주는 특징.

Shared Derived character: evolutionary novelty unique to a clade ex) 털: character shared by all mammals but not in their ancestors.
어떤 특징이 사라지는 것도 shared Derived character가 될 수 있다.
Shared Ancestral character ≤ shared Derived character가 될 수 있다 (경우에 따라서)

Inferring Phylogenies using Derived characters.

determine clade in which each shared derived character first appeared and use that information to infer evolutionary relationships. (outgroup: 우리가 관심있는 그룹 외의 것들)

Phylogenetic trees with Proportional branch Lengths.

기존 Phylogenetic tree의 branch length do not indicate degree of evolutionary change in each lineage

① Make tree diagrams branch length = Proportional to the amount of evolutionary change or time.
→ 길이 짧은 fewer genetic changes have occurred in that lineage.

② Phylogenetic tree that branch lengths are proportional to time.
→ branch points in the context of geologic time.

①+② - combine two types by labeling branch points with information about rates of genetic change

Maximum Parsimony and Maximum Likelihood.

Maximum Parsimony (절약성) - occam's razor과 비슷. (unnecessary complications을 shaving away)

Most parsimonious tree = fewest evolutionary events (based on morphology)
fewest base changes (based on DNA)

Maximum Likelihood. - based on probability rules about how DNA sequences change over time.

Phylogenetic trees as Hypothesis: any Phylogenetic tree represents hypothesis about how organisms in the tree are related to one another.

olfactory	후각의, 냄새의
versatile	다재다능한, 다용도의
elapse	경과하다.
proportional	비례하는
deviate	벗어나다, 편향되다

An organism's evolutionary history is documented in its genome
→ find out fungi is more closely related to animals than plants.

Gene Duplications and Gene families

Orthologous gene: Ancestral gene이 speciation (종분화) 되면서 diverge : 종은 달라져도 보통 같은 기능.

Paralogous gene: gene duplication, diverge within a species.

Genome evolution - 환경과 수는 perceive된 phenotypic complexity와 같은 rates로 증가하지 않는다.
- lineage that diverged long ago often share many orthologous genes.

dichotomize 분기하다
2분하다.

Molecular clocks help track evolutionary time.

Molecular clocks : approach for measuring absolute time of evolutionary change based on some genes appear to evolve at constant rates (not complete precise)

Orthologous genes: number of nucleotide substitutions is proportional to the time that has elapsed since genes branched from common ancestor

Paralogous genes: number of nucleotide substitution is proportional to the time since the ancestral gene was duplicated.

Differences in clocks speed for different genes : related to how important a gene is.

- exact sequence is less critical : 조금변해도 살아갈 가능성↑ : 측정 속도↑
- exact sequence is critical : 조금만 변해도 quickly remove by selection : 측정속도↓

문제점 : 일정하지 않다. ∴ 최대 보고 average 이용. + 여러 gene clocks 한꺼번에 average

Applying a molecular clock - ex) Dating the origin of HIV infection in humans

- HIV descended from virus that infect chimpanzees and other primates.

Understanding of the tree of life continues to change based on new data.

옛날은 2 kingdom : Plants, animals → 5 kingdom : Monera (Prokaryotes), Protista (대부분의 unicellular organism) Plantae, Fungi, Animalia → 3 domain : Bacteria, Archaea, Eukarya.

(classification level higher than kingdom level)

Role of Horizontal Gene transfer.

Eukarya 와 Archaea 서로 가까움, bacteria는 제일 멀리 분리. (analyze based on rRNA genes comparison)

최근엔 yeast 의 metabolism gene은 bacteria 에 훨씬 가까움.

Comparison of complete genomes from three domains show that there have been substantial movement of genes between organisms in the different domains

⇒ Horizontal gene transfer: gene transferred through exchange of transposable elements and plasmids, viral infection, fusion of organisms

우리가 Phylogenetic tree 만들때 vertical gene transfer (한세대에서 다음세대로) 로 가정해서 만들었기 때문.

→ History of life should be represented not as dichotomously branching tree, but rather as tangled network

23. Microevolution. myriad 무수한

Individuals did not evolve. / Proportion of particular trait in population fluctuate gen to gen.

Microevolution : change in allele frequency in population over generation.

by natural selection / genetic drift / gene flow.

Genetic variation makes evolution possible.

Genetic variation : either-or, gradation (continuum)

Genetic variation이 항상 phenotypic variation을 나타내는 것은 아님. - Intron / exon이나 amino acid sequence에 영향 없는 차이들 / environmental influence

But without genetic variation, Evolution cannot occur.

Source of Genetic variation.

Formation of new Allele. - arise from mutation. : cause by error in DNA replication, expose chemicals ...

Mutation in noncoding region, redundancy in genetic code } neutral variation.

: mostly harmful, quickly removed / But in DNA organism, harmful allele that are recessive can hidden from selection - heterozygote protection.

only mutations that produce gametes can be passed to offspring.

Altering gene number or position. - Duplication of gene due to error in meiosis, slippage during DNA replication activity of transposable elements

ex) human's proliferation of olfactory genes (환경에 적응하기에 지금 보다, 다양한 냄새 인식)

Rapid reproduction : Prokaryotes ↑ ex) HIV: 2 days.

sexual reproduction : unique combination of alleles that each from parents.

shuffle random - crossing over, independent assortment of chromosome, fertilization.

Hardy-weinberg equation can used to test whether population is evolving.

Gene pools and Allele Frequencies

Gene pool : consist of all copies of every type of allele at every locus.

만약 only 1 allele만 있으면 fixed.

frequency = proportion. ex) 500개 중 320 Red ⇒ f = 0.64 at 표현형

1000개 중 640 + 160 ⇒ P = 0.8 at 유전자형 (P + q = 1)

P: frequency of one allele q: frequency of other allele.

deviation 벗어남 일탈
plummet 폭락하다
specimen 표본, 견본, 시료

Hardy-Weinberg equation.

Hardy-Weinberg equilibrium.: such population that not evolving / allele and genotype frequency remain constant / provided that Mendelian segregation + recombination of alleles.

ex) Gene pool of initial generation : C^R 80% ($p=0.8$), C^w 20% ($q=0.2$)

$p^2+2pq+q^2=1$ 이면 진화 X.

⇓ sperm

egg	p	q
p	$p^2=0.64$	$pq=0.16$
q	$qp=0.16$	$q^2=0.04$

$C^R = 0.64+0.16 = 0.8$

$\Rightarrow C^w = 0.16+0.04 = 0.2$

(=) ∴ X evaluated.

Conditions for Hardy-Weinberg Equilibrium : NO mutation, Random mating, NO natural selection, Extremely large population size, NO gene flow

Applying Hardy-Weinberg Equation.

1. Initial test of whether evolution is occuring in population.
2. Medical application ex) Phenylketonuria (PKU)의 frequency of individual in population born with PKU.
   $=q^2$ in hardy-weinberg equation.
   → $q^2=0.0001$ 임을 통해서 알 수 있으므로 $q=0.01$, $p=0.99$.
   heterozygous people : $2pq = 2\times0.99\times0.01 = 0.0198$ (약 2%)

Natural selection, Genetic drift, Gene flow can alter allele frequency in population.

Mew mutation : can alter allele frequency, but very rare to change from one generation to next.

Not random mating : allele frequency를 바꾸지 못함. 유전자형 (PP, Pq, qq) 비율만 바뀔 뿐

Natural selection : based on differential success in survival and reproduction.

In genetic term, selection results in alleles being passed to next gen differ from present gen.

∴ Natural selection can cause adaptive evolution - enhance survival, reproduction tend to increase frequency over time.

Genetic Drift : Natural selection과 무관하게 우연히 확률적으로 기대값과 다른 정도의 수로 자손 남김 (모집단에서 ↑)

ex) 동전던지기 10번 - 7/3 나올 수도 있다. (unpredictable change)

극단적으로, White와 Red 각 자손 생성 실패, Red만 남아서 White allele 유실 / fertilization에서도 발생가능 (C^R, C^w중 C^R만)

→ Founder effect : few individuals isolated from large population ⇒ new population : Genetic Drift 발생가능

→ Bottleneck effect : severe drop in population size can cause bottleneck effect.

named because populations has passed through a bottleneck that greatly reduce its size

유전적 다양성 ↓, may increase frequency of harmful alleles

frank 측면 솔직히
choosy 까다로운 가리는

Gene flow : transfer of alleles into or out of population., leads to reduce genetic differences between populations / can transfer alleles that improve the ability of populations to adapt to local conditions.

Natural selection is only mechanism that consistently causes "adaptive evolution" → that mean, 자연선택은 다른것과 다르게 random이 아님. reproductive advantage ⇒ adaptive evolution.

Relative Fitness : 생존 개체간 direct competitive contest가 아닌, given environment에서 certain trait lead to greater relative fitness. = contribution an individual makes to gene pool of the next generation reative to the contributions of other individuals.

remember, the entity of subjected to natural selection is 완전한 한 개체. not genotype. only phenotype.

selection type.


Directional selection : when conditions favor individuals exhibiting one extreme phenotype range.


Disruptive selection : favor variants at both extreme ends of phenotype range


stabilizing selection : act against both extreme phenotypes and favor intermediate variants.

선택 selection favors individuals whose heritable phenotypic traits provide higher reproductive success than other

The key role of natural selection in Adaptive evolution.

Physical, biological components of an organism's environment may change

-adaptive evolution is continuous, dynamic process.

Natural selection is the only evolutionary mechanism that consistently leads to adaptive evolution.

-Sexual selection : whom with certain inherited characteristics are more likely than other individuals of the same sex to obtain mates

→ can result "sexual dimorphism" (동종 이형), difference in secondary sexual characteristics between males and females of the same species

Intrasexual selection : selection within same sex (대부분 males), 같은 sex 내에서 경쟁.

Intersexual selection (mate choice) : one sex are choosy in selecting mates from other sex.

여러 동물 생식 포식동물 위험이 크더라도 mate rate↑ 면 그쪽으로!

How female preferences for certain male characteristics evolve? ⇒ good, healthy gene을 reflect하는 trait에 끌림

-Balancing selection : what prevent natural selection from reducing the variation at those loci by culling (선별제거, 골라냄) all unfavorable alleles?

- unfavorable recessive alleles persist by hidden from selection when in heterozygous individuals.
- selection itself may preserve variation - balancing selection - frequency dependent selection / heterozygous advantage

Toonitini

constraint 강제, 강요, 억제
compromise 타협하다, 절충하다, 타협하다
agility 민첩, 예민함

→ Frequency dependent selection : fitness of Phenotype depends on how common it is in population.

ex) left mouthed scale eating fish ↔ right : 당하는 쪽은 가장 많이 당하는 쪽을 막으려 함
결국 둘 다 각각 50%로 균형을 이루게 됨.

→ Heterozygote advantage : individuals who are heterozygous have greater fitness than both homozygotes.
defined in terms of genotype, not Phenotype.

If Phenotype of heterozygote is intermediate to Phenotypes of both homozygotes,
then heterozygote advantage is a form of stabilizing selection ex) β Polypeptide subunit of hemoglobin.

Why natural selection cannot fashion perfect organisms

1. selection can act only on existing variations
2. Evolution is limited by historical constraints.
-설계와 동떨어진 새로운 걸 만들어 내는게 아니라 이미 있는것을 다른 용도로 쓰는 수준임.
3. Adaptations are often compromises : organisms face many trade-offs in which ability to perform one function may reduce the ability to perform another.
4. Chance, Natural selection, and the environment interact.
Chance event : 바람에 의해서 멀리 날아가는 등의 이벤트 ⇒ 어떤 곳의 환경에 적합한 애만 골라 남는게 아님
환경 자체가 계속 바뀌기도 함

즉, Natural selection operates on "better than" basis

Sterile 불임의. 메마른
feeble 허약한, 기운이 없는
teeming ~로 가득 차 있는, 바글바글한.
hindering 방해하다

24 Species and Speciation

Speciation : Process by which one species split into another species.

This explain many features that organisms share (unity of life) - because of common ancestors

Also, conceptual bridge between microevolution and macroevolution

biological species concept emphasizes reproductive isolation.

biological species concept : Species is group of population whose members have potential to interbreed in nature and produce viable (개체의 독립생존성), fertile offspring (reproductively compatible)

reduction or lack of gene flow inter population - key role in formation of new species.

- Reproductive Isolation : existance of biological factors (barriers) that impede members of two species from interbreeding and producing viable, fertile offspring (limit formation of hybrids)
  (block gene flow)

⇒ Prezygotic barriers : X mating Attempt. - Habitat isolation / Temporal isolation (시간적.) / Behavior isolation : attracting mates behaviors are unique

O mating Attempt. - Mechanical isolation / Gametic isolation

: morphological (형태차이) 생식기의 구조차 실패 : Sperm of one species may not be able to fertilize the eggs of another species.

After Fertilization

⇒ Postzygotic barriers : Developmental errors on hybrid embryos / Reduced hybrid viability / Reduced hybrid fertility / Hybrid breakdown - first gen hybrids are viable and fertile but second gen are feeble or sterile.

Limitations of the biological species concept

- No way to evaluate the reproductive isolation of fossils.
- Can't apply to organisms that reproduce asexually (ex. Prokaryotes)
- Species are designated by absence of gene flow.

but 예외가 있다. morphologically and ecologically distinct, and yet gene flow occur.

ex) grizzly bear + polar bear → Grolar bear.

niche 틈새. 적소. 딱 맞는 자리
formidable 광장한, 만만찮은 감당할 수 없

Other definitions of species

- morphological species concept : distinguish species by body shape and other structural feature.

주관적이라는 단점, but asexual 에도 적용가능, gene flow 없어도 상관X.

- ecological species concept : by ecological niche. - If they occupy different ecological niche, considered separate species eventhough gene flow 있어도.

Toonitini

2n = 4
반수체(세트의 개수 절반으로 가지는 생식체 개수)

Propagate 번식하다.
Allopatric 다른지역인
Sympatric 동일지역인

Speciation can take place with or without geographic separation.

Allopatric speciation : geologically isolated subpopulations (환경이 갈라놓아서 스스로 이동하여서)

Process of Allopatric speciation - 두 갈라진 곳에서 gene pools may diverge.

ex) mosquitofish - female이 자신과 비슷한 형태의 male을 선호 (behavioral reproductive barrier)

region that isolated or highly subdivided typically have more species ex) Hawaiian Islands.

Sympatric speciation : by polyploidy, sexual selection, habitat differentiation.

Polyploidy : during cell division, result in extra set of chromosomes.

1. autopolyploid - has more than 2 chromosome sets that are all derived from single species

ex) 2n → 4n (tetraploid) $X \times 2n=4 \rightarrow XX_{x\,x}$ 4n=8

↳ reproductive isolation with 2n (2n은 reduced fertility) : 4n의 gametes = 2n

2. allopolyploid : when two different species interbreed, and produce hybrid offspring. most of them are sterile. but may be able to propagate itself asexually.

(chromosomes from one species cannot pair during meiosis with the set of chromosomes of other species)

In subsequent generations, various mechanisms can change sterile to fertile → only with them (X parent)

=allopolyploid

$X\,x\,x \rightarrow$ 2n=6 (n=3) / $x\,x \rightarrow$ 2n=4 (n=2) → (n=5) → error → $XXx\,xx$ 2n=10

error 없고 그냥 완전히 합쳐져 2배 염색체 2n=10 되면 완벽!

: gametes 2배 만들어서 2n이 되는 목표.

Sexual selection : ex. mate choice based on male breeding coloration can act as reproductive barriers

Habitat Differentiation : when habitat or resources exploited not used by parent population (Habitat Isolation)

Hybrid zones reveal factors that cause reproductive isolation.

If incomplete reproductive barriers come into contact with one another ⇒ formation of hybrid zone.

patterns within Hybrid zones. - frequency of alleles (without geographic barriers)

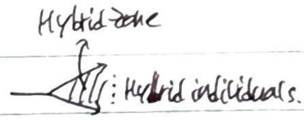
can infer there's an obstacle to gene flow

- hybrids have increased rates of embryonic mortality + morphological abnormality, poor survival and reproduction (환경차이 외에 원인일 수도 있다)

Hybrid zones that Environmental conditions change : existing hybrid zone can move, novel hybrid zone may form

Hybrid zone can be source of novel genetic variation that improves ability of one or both parent species to cope with environmental change (새로운 A로 변형, 혹은 새로운 B로 변형)

Hybrid zones over time : speciation이 일어나기도 하지만 아닌 경우도 있다.



- reinforcement : Strengthening Reproductive barriers → 더 크게.
  - Natural selection strengthen prezygotic barriers to reproduction, reducing formation of unfit hybrids
  - Barriers to reproduction between species : sympatric populations >> allopatric populations
    - ↳ 여기서는 절대 안할 교배를 여기서는 종종 벌어짐.
- fusion : Weakening Reproductive barriers
  - So much gene flow may occur - reproductive barriers weaken - gene pools become increasingly alike
  - ⇒ fusion into one species
- Stability : continued formation of Hybrid Individuals
  1. hybrid가 parent보다 안정적인 경우
  2. 안정적이진 않지만 다른 species의 parents 들이 자주 만날수 있는 환경인 경우 (이동을 많이 하거나, Hybrid 교배에 좋거나

Speciation can occur rapidly or slowly and can result from changes in few or many genes.

Time course of speciation

- Patterns in Fossil Record. 1. Punctuated equilibria (갑자기 나타났다가 오랫동안 그대로) / 2. Gradual Model (점진적 변화.)
- Speciation rates (Punctuated pattern : rapidly)
  - total length of time speciation : 4000 ~ 40 million years.
  - once gene flow is interrupted, populations diverge genetically to such an extent that they become reproductively isolated. - all before other events cause gene flow to resume.
- Studying Genetics of Speciation : How many genes influence the formation of new species? : 1 ~ many

25. Macroevolution.

Conditions on early earth made origin of life possible.

Hypothesis of Producing simple, first cells.

1. abiotic(nonliving) synthesis of small organic molecules, such as amino acids and nitrogenous bases.
2. Joining of these small molecules into macromolecules, such as proteins, nucleic acids.
3. Packaging of these molecules into protocells, droplet (작은 물방울, 비눗방울) with membranes that maintained an internal chemistry different from that of their surroundings.
4. Origin of self replicating molecules that eventually made inheritance possible

Synthesis of organic compounds on Early Earth

Atmosphere with thick water vapor + compounds from volcanic eruptions

↳ reducing environment : organic compounds could have formed from simpler molecules.

필요한 Energy는 come from lightning + UV radiation

early ocean : solution of organic molecules "primitive soup"

Neutral environment 환경도 가능성 있다. 이것도 produce organic molecules 가능

forming numerous amino acids hypothesis.

1. volcanic eruption
2. deep sea hydrothermal vents - black smokers
3. deep sea alkaline vents

] abiotic synthesis of organic molecules possible under various conditions

4. meteorites

Abiotic Synthesis of macromolecules ex) enzymes, proteins, nucleic acids ···

Adenine, Guanine, Cytosine, Uracil 모두 spontaneously formed from simple precursor molecule 을 통한

Amino acids 랑 RNA nucleotides 도 hot sand, clay, rock on solution 형태로부터 자연적인 polymer 을

형성하는 것도 확인.

protocells. : vesicle - fluid filled compartments enclosed by membrane like structure.

Maintenance of internal chemical environment, different from their surroundings.

Abiotically produced vesicles can reproduce own, grow self, selectively permeable bilayer.

Self Replicating RNA - first genetic material is not DNA / RNA can also be enzyme like catalyst - ribozymes

특정한 3차원 구조를 가짐으로써 자기 복제와 가능하게 됨.

Vesicle with self-replicating RNA 형성 성공.

fossil record documents the history of life.

fossil record : sedimentary rock (퇴적암) 에 보존. layers : strata (지층)

incomplete chronicle of evolution. / fossilization에 유리한 것들에 더 특징적인 분포.

How Rocks and Fossils are dated.

Radiometric dating (방사성연대) by decay of radioactive isotopes.

rate of decay (half-life, 반감기) carbon 14 → Nitrogen-14, : 75000 years 까지만 가능.

더 오래된것 : 긴 반감기 동위원소 생물의 포함X + 주변 rocks 가 다른 나이의 sediment를 가질수도 있음

⇒ Indirect method. - sandwiched between two layers of volcanic rock (new rocks)

(it contains long half life elements)

The origin of New groups of organisms.

bone 처럼 구별점이 많은 Tetrapods [non mammals / mammals] 특징 bone 개수, teeth 모습 등.

fossil record. - Some reflect how the feature of a group that dominates life today gradually arose from previously existing group / others would reveal side branches of tree of life (extinct)

key events in life's history include origins of unicellular and multicellular organisms and colonization of land.

First single celled organisms : Earth's first organisms = single celled prokaryotes ex. Stromatolites.

Photosynthesis and oxygen Revolution.

most atmosphere oxygen gas (O_2) is biological origin. - Prokaryotes 에서 나온 O_2 dissolved in surrounding water until it reaches high enough concentration to react with elements dissolved in water.

ex) iron : sediments compressed into banded iron formation (red layer)

더 방출하는 양이 물에 계속 용해 되다가 일정량 넘으면 gas out of the water. and enter the atmosphere.

⇒ oxygen revolution 대기중 O_2 ↑ → rising O_2 at atmosphere doomed many prokaryotic groups by O_2 attacking chemical bonds, ...

→ adaptation : cellular respiration.

First Eukaryotes - have nuclear envelope, mitochondria, endoplasmic reticulum, well developed cytoskeleton

Eukaryotes originated by "Endosymbiosis" (Prokaryotes cell engulf small cells that become organelle)

→ by undigested prey or internal parasite → symbiosis become beneficial → inseparable

Serial endosymbiosis : Ancestral Prokaryotes - cell with nucleus and endomembrane system - Ancestral Eukaryote with Mitochondria - Ancestral Photosynthetic eukaryote with Plastid.

Evidence of endosymbiotic ① inner membrane of organelles have enzymes and transport system that homologous to plasma membranes of living bacteria.

② contain own circular DNA like bacteria and splitting, replicating like bacteria.

③ have cellular machinery (ex. Ribosome)

④ size, DNA sequence, sensitivity to antibiotics are similar to bacteria.

Toonitini

The origin of Multicellularity

Early multicellular eukaryotes : oldest known multicellular eukaryotes : red algae (홍조)

Multicellular 가 되면 다양한 기능성 발생가능 (diversification) - cambrian explosion.

Cambrian explosion. - prior to cambrian explosion, all large animals were soft bodied, and almost are not hunter (X predation). After, they get clacus to predation, so their prey get sharp spines, heavy body armor (화석보존 확률↑) + 실제로 생물 다양성도 ↑

Colonization of Land : Prevent dehydration, possible to reproduce on land, plants with fungi, Arthropods (insects), tetrapods.

Rise and fall of groups of organisms reflects differences in speciation and extinction rates

Rise of group of organisms occurs when more new species are produced than are lost to extinction.

Such changes influences by large scale processes ex) plate tectonics, mass extinctions, adaptive radiation.

Plate Tectonics : three occasions, most landmases of earth came together, form supercontinent.

Continental drift : movement in mantle cause plates to move.

Infer past location : using magnetic signal recorded in rocks at time of their formation.

- consequences of continental Drift.

Pangaea : shallow coastal seas 면적↓, most marine species inhabited shallow waters + 내륙cold and dry

⇒ 대멸종.

When supercontinents break apart, allopatric speciation occur

아 멀리 떨어진 대륙 사이에 똑같은 화석 존재.

Mass Extinction

The big Five mass extinction events (documented in the fossil record) 중에서 2번과 5번.

Permian mass extinction (boundary of paleozoic, mesozoic) - by extreme volcanism, produce enormous carbon dioxide → global warming + CO_2 ocean acidification + 많은 nutrients 추가로 growth of microorganisms ↑ + 그에 따라 bacterial decomposers ↑에 의한 많은 oxygen↓

Cretaceous mass extinction - have thin layer of iridium = meteorites impact - huge cloud block sunlight → global winter 이후 global warming over 100,000 years.

Is sixth mass Extinction underway? (by human)

Consequences of mass extinctions : once an evolutionary lineage disappears, cannot reappear.

다양성 많이 회복하는데 매우 긴 시간이 걸린다 + after types of organisms can reside there.

Mass extinctions can pave the way for adaptive radiations, in which new groups of organisms proliferate.

Adaptive Radiations (적응 방산) : form many new species / 대멸종 이후 여러 계통으로 adaptive radiation 발생.
also occures in groups that possessed major evolutionary innovation (face little competition)
- worldwide adaptive radiations ex) Mammals after extinction of terrestrial dinosaurs.
↓ associates with major evolutionary innov. colonization of land by plants, insects, tetrapods ···
- Regional Adaptive Radiations ex) Hawaiian archipelago

Major changes in body form can result from changes in the sequences and regulations of developmental genes
Effects of Developmental Genes.
- changes in Rate and Timing
heterochrony : evolutionary change in the rate or timing of developmental events
- organism's shape depends on relative growth rates of different body parts during development.
ex) human, chimpanzees - fetus skull similar but adult X.
ex) growth rate of finger bones - wings of bats, hind limbs in whales.
- alter timing of reproductive development relative to the development of non reproductive organs.
ex) Paedomorphosis : sexually mature stage of a species may retain body features that were juvenile structures in an ancestral species.
∴ Overall genetic change 적은 큰 형태적 변화 가능.
- Changes in spatial pattern : result from alterations in genes that control spatial organization of body parts
ex) homeotic genes (Master regulatory genes) - HOX gene (Provide positional information in animal embryo)
Evolution of development. - new morphological forms can arise from changes in nucleotide sequences or regulation of developmental genes.
- Changes in Gene sequence. ex) Crustacean - 다리 more than 6개. : Ubx expresses in the body segments - X suppress legs.
insects - 6 legs : Ubx expresses in the body segments - O suppress legs.
⇒ 같은 gene 인데 영향 다름 : Particular changes in the nucleotide sequence of a developmental gene contribute to major evolutionary change.
- Change in Gene Regulation.
Change in nucleotide sequence of gene : affect wherever the gene is expresses.
Change in regulation of gene expression : can be limited to one cell type.
ex) Stickle back fish { marine : has spine
lake : X spine - regulation of expression of Pitx1
⇒ Change in nucleotide sequence 가 아닌 이유 : Pitx1 이 정상발현 또는 다른 특정 (뼈)에서는 정상적으로 발현.

Evolution is not goal oriented - evolution is like tinkering : new forms arise by modification of existing structures or existing developmental genes.

Evolutionary novelties - arise as gradual modifications of ancestral structures.

ex) eyes : patch of pigmented cells - Eyecup - pinhole camera type eye - Eye with primitive lens - complex camera lens type eye.

Mollusc (연체동물) 은 vertebrate의 eye와 같은 복잡한 눈은 서로 독립적으로 발전

Natural selection cannot predict future. only improve structure in the context of current utility.

Evolutionary trends - evolution is result of interactions between organisms and their current environment.

Patterns of macroevolution and evolutionary trends observed in the fossil record.

ex) horse tend to be large body. (진화적 ↑)

-Extracting single evolutionary progression from the fossil record may misleading (Just single twig) branching evolution can result in a real evolutionary trend even if some species counter the trend.

-Species selection model → views species as analogous to individuals

speciation is their birth / extinction is their death / new species diverge from them are their offsprings

Individual formation 이 natural selection 을 결정한다면, species 는 species selection 을 결정한다

differential speciation success play role in macroevolution, similar to role of differential reproductive success in microevolution.

(rate) (rate)