What is adaptive radiation?

Adaptive radiation is the evolutionary diversification of many related species from a common ancestral species in a relatively short period. Osborne (1902) coined the term **"Adaptive Radiation".** He stated that each large and isolated region, with sufficiently varied topography, soil, vegetation, climate, will lead to organisms with diverse characteristics. Darwin had called it "Divergence", i.e. the tendency in an organism descended from the same ancestor to diverge in character as they undergo changes. Adaptive radiation plays a significant role in macroevolution. Adaptive radiation gives rise to species diversity in a geographical area.

Adaptive Radiation Causes:

Adaptive radiation is more common during major environmental changes and physical disturbances. It also helps an organism to successfully spread into other environments. Furthermore, it leads to speciation. Moreover, it also leads to phenotypically dissimilar, but related species. Major causes of adaptive radiation are:

- **Ecological opportunities:** When an organism enters a new area with lots of ecological opportunities, species diversify to exploit these resources.
  - When a group of organism enter a new adaptive zone then organisms tend to adapt themselves differently. It results in adaptive divergence
  - An adaptive zone is an unexploited area with numerous ecological opportunities, e.g. nocturnal flying to catch small insects, grazing on the grass while migrating across Savana, and swimming at the ocean's surface to filter out Plankton
  - Vacant adaptive zones are more common on islands, as fewer species inhabit islands compared to mainland
  - When adaptive zones are empty, they get filled by species, which diversify quickly, e.g. Cichlids of African Great Lakes, Darwin's Finches of Galapagos island, Hawaiian honeycreepers, etc.
- **Mass extinction:** When there is mass extinction due to major environmental changes or physical disturbances it may lead to adaptive radiation due to various reasons.
  - Extinction produces empty adaptive zones which provide new opportunities to species that remain, e.g. after the extinction of dinosaurs, mammals quickly diversified and exploited various adaptive zones
  - As a result of the extinction of competition, species that remain, flourish, e.g. mammals had coexisted with reptiles but they were very small so that they could hide and save themselves from giant dinosaurs
- **Acquisition of novel adaptive traits:** Evolutionary innovation may trigger adaptive radiation.
  - Evolutionary novelties are a variation of pre-existing structures, called "preadaptations". A change in the basic pattern produces something unique, which adapts to a different role. E.g.
    - Feathered wings on birds, which evolved from reptilian scales, represent preadaptation of flight
    - Flowers on plants speeded up the ability to engage in sexual reproduction and took great advantage of terrestrial animals for pollination and increased the reproduction rate
    - Amniotic egg
    - Wings on insects
  - A slight alteration in regulatory genes or gene mutation can result in major structural changes in the organism, e.g. adult of some salamander species retain external gills and tail fin throughout life (pedomorphosis), which is found only in larval stages. These features alter salamander's behavioural and ecological characteristics. It is caused due to gene mutation which blocks the production of hormones responsible for metamorphosis. The pedomorphic forms can escape their typical terrestrial predators.

Adaptive Radiation Examples:

1. Adaptive Radiation in Mammals:

- **Adaptive radiation in placental (eutherian) mammals:** Placental mammals illustrate a great example of adaptive radiation, where multiple diverse forms have developed from the common lineage of a primitive, short-legged,, insectivorous, rat-like creature, that coexisted with dinosaurs. Extinction of dinosaurs triggered a global adaptive radiation event that resulted in the rich mammal diversity that exists today. Adaptive radiation in mammals followed 5 different lines with respect to limb structure:
  i. **Arboreal:** Limbs adapted to live on trees (scansorial legs), e.g. squirrel, monkeys, etc.
  ii. **Aerial:** Limbs adapted for flying, eg. bats. Gliding mammals like flying squirrels
  iii. **Cursorial:** Limbs suitable for rapid movement

1. **Plantigrade**– walking with the whole sole on the ground, e.g, bears, primates, human beings
2. **Digitigrade**– Digits touch the ground, e.g. lion, tiger, cat, leopard, dog
3. **Unguligrade**– animals having hoofs. They walk on the tips of their fingers or toes, e.g.
    a. **Artiodactyls**– They have double hoofs, e.g. cattle, buffaloes, sheep, etc.
    b. **Perissodactyls**– They have one hoof, e.g. horses, zebras

iv. **Fossorial:** Burrowing mammals, e.g. moles, badgers

v. **Aquatic:** Limbs adapted for living in water, e.g whales, porpoises. Seals, walrus, sea lions can move on land as well. Polar bears can walk and swim equally well

Adaptive radiation is also applied to teeth structure or mode of feeding in mammals.

- **Adaptive radiation in marsupial (metatherian) mammals:** Australian Marsupials show a great diversity. They are a classic example of adaptive radiation. There is a wide variety of marsupials that evolved on the Australian continent
    1. Grazing – Kangaroo
    2. Burrowing- Marsupial moles
    3. Arboreal- Koala, tree kangaroo
    4. Teeth like rodents- Wombats, marsupial rats
    5. Rabbit-like – Hare wallabies
    6. Wolf-like – Tasmanian wolves
    7. Ant eating – Banded anteater
    8. Badger-like – Tasmanian Devil

  Marsupials exhibit adaptive radiation into varieties of animals. Each of which appears to be similar to the corresponding placental mammal. This is called “convergent evolution”. It happens when the two unrelated species develop the same features because they live in similar habitats.

2. Adaptive radiation in Darwin’s Finches:

Darwin’s Finches

Galapagos Islands are a chain of islands resulting from volcanic action. These islands were never connected to mainland South America. Darwin’s finches descended from small sparrow-like birds that once inhabited the mainland and migrated to Galapagos islands.

- There are around 14 distinct species present, each well adapted to a specific niche
- Not all the species are found on each island
- Size and shape of their beaks differ markedly which correlates to their feeding habits
- Some are specialised for crushing seeds (ground finches) whereas others to eat insects (tree finches)
- Small beaked finch feed on small grass seed, those feeding on hard fruit have large beaks, cactus eating finches have thicker, decurved, flower-probing beaks
- Woodpecker finch possesses a stout straight beak

3. Cichlids of African Great Lakes: There are more than 2000 species of cichlids fishes found in these lakes, which are a remarkable example of adaptive radiation. They have varied morphological characteristics and play various roles like predators, herbivore, scavengers. Their head shape and dentition varies according to their dietary habits.

4. Adaptive radiation in reptiles: Adaptive radiation in reptiles occurred between the Permian and Cretaceous era. They ruled over the land in the Mesozoic era, which is also referred to as the “Age of Reptiles”. The initial success of the reptiles is due to the evolutionary shift from aquatic to completely terrestrial development, i.e. **amniotic eggs** of reptiles. Variety of reptiles blossomed from Cotylosauria (stem reptile).

5. Adaptive radiation in Hawaiian honeycreepers: These are a group of related birds found in the Hawaiian Islands. Honeycreepers diversified quickly and occupied the available adaptive zones. There were more than 50 species found, of which only 17 species remain today. Many species went extinct after the discovery and subsequent colonisation of the island. Their beaks are specialized to satisfy their dietary requirements. Some are curved to extract nectar out of tubular flowers, whereas others are short and thick to rip away bark of trees in search of insects.

6. Adaptive radiation in Hawaiian silverswords: There are 28 species of closely related plants found in the Hawaiian Islands. There were diverse environmental conditions present, such as cool, arid mountains, shady moist forests, wet bogs, dry woodlands, exposed lava flows, which were unoccupied when the ancestor of silverswords reached the Islands. Silverswords rapidly diversified in structure and physiology to occupy the main adaptive zones. The diversity of their leaves is a good illustration of adaptive radiation.

- Leaves of the plants in shady and moist areas are large, whereas silverswords in arid areas have small leaves
- The leaves of silverswords present on volcanic slopes are covered with dense silvery hairs that may reflect intense UV radiation off the plant

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