BIO 120

LECTURE ONE

Chapter 1

William Cronon, Uncommon Ground

1. Nature tends toward a self-restoring equilibrium when left alone; “the balance of nature”
2. In the absence of human action, nature exists in a pristine state

Organism approach: individual’s adaptation and limitations
Population approach: population dynamics (age, sex, number etc.)
Community approach: “common” currencies (energy, elements etc.)
Biosphere approach: movement of air and water (ocean current, wind etc.)

Temporal variation: environment change over time, intrinsic (fire cycle) or extrinsic (disease)
Spatial variation: “patchiness”, the faster it moves, the smaller the scale of spatial, & temporal variation

Nile perch into Lake Victoria
The introduce perch annihilated the natural cichlid populations, driving many unique species to extinction, destroying the native fishery, and severely reducing its own food supply

The California sea otter
Sea otters’ recovery caused the availability of sea urchins and such to decrease, while letting the kelp forest harvest; Orcas are seeking sea otters as an alternative food source as regular prey population declines

Chapter 4

Equilibrium water vapour pressure: <100kpa evaporation, >100kpa precipitation

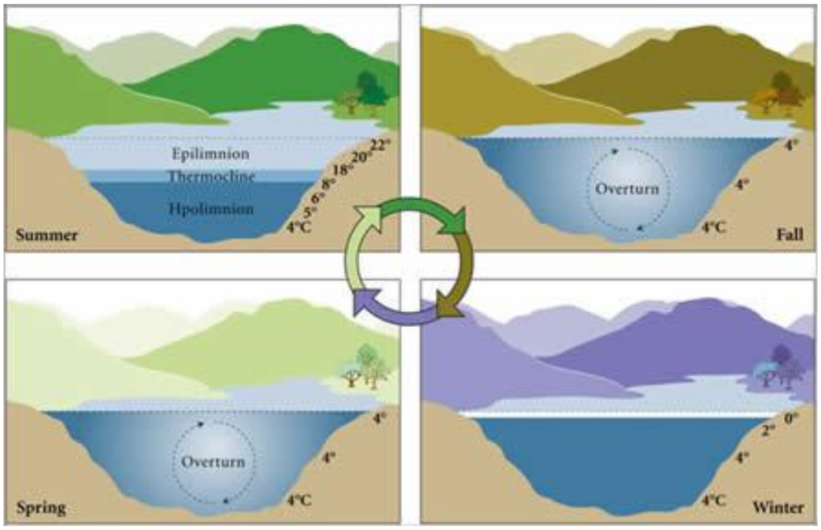
Hadley circulation: Hadley cell (intertropical convergence) -> Ferrel cell (subtropical high-pressure belts) -> Polar cell

Coriolis Effect: veer to right in the N. Hemisphere; veer to left in S. Hemisphere, affect ocean current

Thermohaline circulation: current drive by change in density caused by variation in salinity and temperature (N. Atlantic Deep Water)
Younger Dryas: after a recent glacial period, fresh melt water shutdown thermohaline circulation and a cold spell casted over N. America ad N. Europe

The movement of the intertropical convergence follows the solar equator, producing a moving belt (20◦ N/S) of rainfall

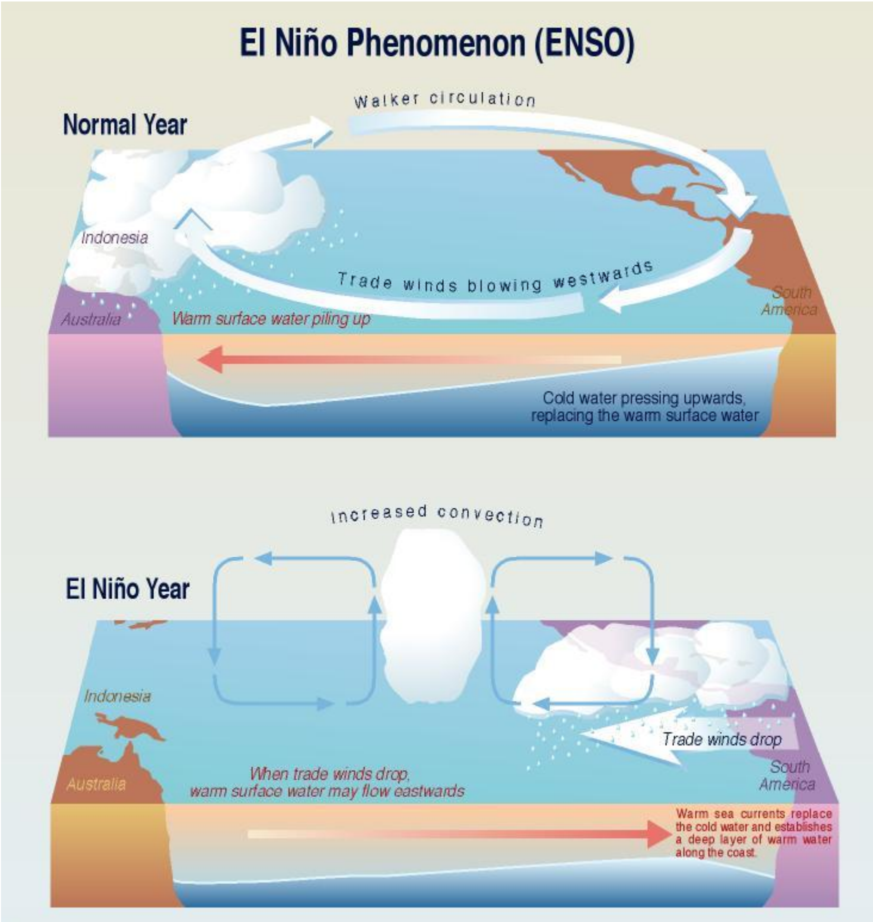
- Merida, Mexico – single rainy season, and a marked dry season
- Bogota, Colombia – two rainy seasons, two moderately dry season
- Rio de Janeiro, Brazil – single dry season, single rainy season



Summer –Stratification of thermoclines (zone of abrupt temp. change), depressed productivity

Normal year

1) Cold Peru current flows along the coast of S. America
2) Peru current moves W. and warms
3) Warm air rises in the W. Pacific and travels E. then descends over S. America



El Nino

1) Sea surface is warm in the C. ad E. Pacific
2) Warm air rises in the C. Pacific, travels E. and W. then descends
3) Warm water piles up the coast of N. America

A Half-million year climatic record
Isotopes dating of sediment core taken from the bottom of the N. Atlantic Ocean shows 100,000 year cycles of temperature, corresponding to glacial and interglacial climatic cycles proving that temperature changes at the bottom of the ocean parallel those at the surface, confirming that no place on earth escapes variations in climate.

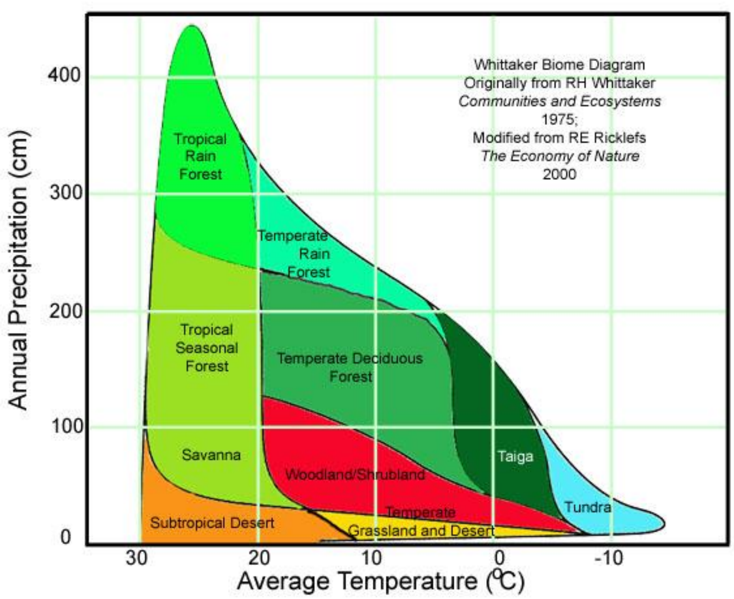
Topographic influences: riparian forests between hillsides; S. facing slopes in N. hemisphere are limit to xeric forms

Adiabatic cooling: 6- 10˚C/ 1000m

Life zones in SW United States mountains
1. Lower Sonoran
2. Upper Sonoran
3. Transition
4. Canadian (Hudsonian)
5. Alpine

Which came first, the soil or the forest?
From a sediment core from Lake Kis-Mohos, Hungary, it is clear that the soil retained its nature until well after the establishment of deciduous vegetation, so apparently this vegetation changes caused the soil change in this case.

Chapter 5



Walter: Climate zones, Climate diagrams (area where precipitation is higher than temperature allows plant growth)

Whittaker's Biome Schemes

Biome	Climate	Vegetation
Tropical rain forest, Equatorial (I)	Always moist and lacking temperature seasonality	Evergreen tropical rain forest
Tropical seasonal forest/ Savannah, Tropical (II)	Summer rainy season and "winter" dry season	Seasonal forest, scrub, or savannah
Subtropical desert, Subtropical/ Hot desert (III)	Highly seasonal, arid climate	Desert vegetation with considerable exposed surface
Woodland/ Shrubland,	Winter rainy season and summer	Sclerophyllous (drought-

Mediterranean (IV)	drought	adapted), frost-sensitive shrublands and woodlands
Temperate rain forest, Warm temperate (V)	Occasional frost, often with summer rainfall maximum	Temperate evergreen forest, somewhat frost-sensitive
Temperate seasonal forest, Nemoral (VI)	Moderate climate with winter freezing	Frost-resistant, deciduous, temperate forest
Temperate grassland/ Desert, Continental/ Cold desert (VII)	Arid, with warm or hot summers and cold winters [prairies, steppes]	Grassland and temperate deserts, rhizomes
Boreal forest, Boreal (VIII)	Cold temperate with cool summers and long winters	Evergreen, frost-hardly needle-leaved forest (taiga)
Tundra, Polar (IX)	Very short, cool summers and long, very cold winters	Low, evergreen vegetation, without trees, growing over permafrost

Lecture Notes

Nothing about the earth or biodiversity is random, there are patterns. "Patchiness" prevails in every scale (lichen, desert slope flowers)

Abiotic factors:
- Resources are exhaustible: nutrients, space etc.
- Conditions are not exhaustible: temperature, salinity etc.
- Conditions vary across space and time; we envision gradients of conditions
- Organisms perform best at certain levels or certain portions of a gradient

Species have range of tolerance along environmental gradients; bell shape on performance vs. gradient

Temperature and soil moisture are generally the two most important factors for terrestrial plants. Terrestrial animals also place food and water as their top priorities which make sense that animals tend to follow plants.

Temperature is mostly a function of latitude. At higher latitude with colder temperature, seasonality is a function of temperature. At lower latitude with no winter, seasonality is a function of rainfall. Rainfall mostly depends on atmospheric circulation, offshore ocean currents, and rain shadows.

Temperature and rainfall are factors that determine biomes.

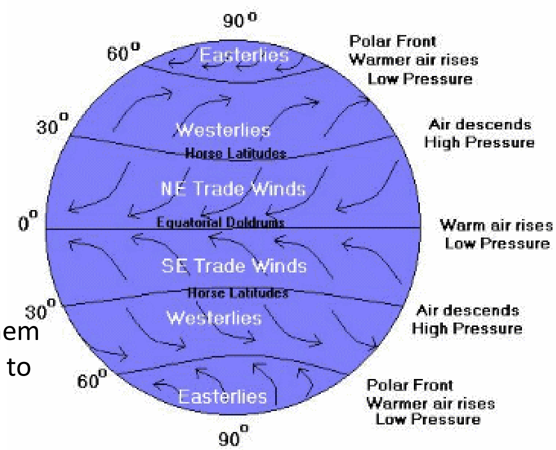
Global patterns of temperature and rainfall
Differential heating drives the Earth's atmospheric heat engine.
Greenhouse gases are trapping heat E in the atmosphere.
The sun is the elementary source of heat and because of the earth's tilt; higher latitudes are colder because a unit of sun E is spread over a large area than at the equatorial latitude.

Atmospheric circulation: Hadley cells
Heated air rises at the equator. Rising air cools and water vapour condenses and falls as rain near equator. Air warms as it falls, delivering a high pressure zone with clear weather and drives another cell.

This pattern is continued with the 6 cells model that covered that earth.
Hedley cell is the biggest and strongest and the essential driving force of the circulation.

Latitudinal patterns complicated by distribution of landmasses.
Temperatures vary more in the N. Hemisphere where the moderating influence of water is less.

The intertropical convergence zone is always over N. S. America and W. Africa causing perpetual rain all year round in those areas.
Monsoonal pattern has a dry and extreme wet season.



Coupled cells + Coriolis effect = prevailing wind patterns
Doldrums (equator) and horse latitudes are areas where there are no wind due vertical raising and falling of air.

The "roaring forties" in the S. hemisphere is much stronger than its counterpart as there is virtually no land to disturb.

Wandering albatross has a very large wingspan and they use them to glide through the "roaring forties". It would travel the world to along the trade wind rather than against it.

General trends of terrestrial vegetation with climatic variables

- Vegetation growth increases with moisture and temperature
- Vegetation statues also increases so regions with certain combinations of moisture and temperature develop predictable, characteristic types of vegetation; biomes
- Seasonality is secondarily important

Tropical rainforests have the highest productivity and deserts have the lowest productivity.

Maritime climates are moderate as oceans provide thermal inertia. In cold climate, grape and cherries grows in maritime pockets where the conditions are more moderate.

The driest deserts occur inland of cold water upwelling as it brings cold dry air inland that suck moisture more of the area.

<u>LECTURE TWO</u>

Chapter 3

Kangaroo rats hide from the heat in their burrow during the day, and then forage during the cooler night.
Ground squirrels forage during the day, but they retreat to their burrow periodically to cool down.
Camels' big body allow better thermal inertia and can wait until the night to dump the excess heat.

Dense hair and spine are adaptation to avoid water loss and overheating.
Hairs produce a still boundary layer of air that trap moisture and reduce transpiration.
Insulating boundary air layer on flat surface is often disturbed by air turbulence.
Finely subdivided leaves, leaflets and protective thorns for reducing heat loads.

Thick, waxy cuticles reduce water lost.
Hiding stomata in deep pits and filled them with hair to reduce transpiration.

10°C increase give a 2-4 times faster rate for most biological processes.
Higher temperature accelerates life processes but the molecules become less stable, proteins denatured and fat are melted.
Thermophilic bacteria with their strongly bonded proteins can tolerate high temperature; photosynthetic bacteria can tolerate up to 75°C, archaebacteria can live in up to 110°C.

Most vertebrates freeze at high temperature than freezing.
Antarctic fish raise the glycerol concentration in their blood and tissue with glycoprotein, a 10% solution drop freezing point about 2.3˚C.
Terrestrial invertebrates can have up to 30% glycerol.
Glycoproteins in blood impede ice formation by coating developing crystal seeds to allow supercooling.

An organism's optimum is determined at the cellular level (enzymes, lipids, etc.) and thought its physiological/ physical properties.
Rainbow trout produce different enzyme depending on the season to maintain at its optimum.

Lizards bask on hot rock to gain heat from the sun's radiation and conduction.
Convection lets more air rotate make way for more air to take heat away from the body.
In dry air, the rate of evaporation doubles for every 10˚C increase.

Large individual has better thermal inertia because of their smaller surface to volume ratio.

Keeping cool on tropical islands
Sooty terns (bird) stay near watery food source and rotate incubating partner for higher survival and reproduction rate. Whereas the Shearwaters hunt far away and all the food E is used on the journey and when they return to their nest, only fat remain as the E source. However, fat is not hydrating so the single incubator often overheats and has to abandon its nest and sacrifice its egg.

Homeothermy allows bodily processes to adjust to work efficiently in a consistent temperature.
For most mammals and bird, 36- 41˚C is the optimum temperature and stays at that range even the outside temperature is as high as 51˚C through homeostasis.
Poikilothermic organisms conform to the external environmental and thus could only survive in a narrow temperature range. (Frogs, grasshoppers)

Ectotherms are cold blooded, small, with low metabolic rate that adjust heat balance behaviourally. (Insects, reptiles, amphibians)

Endotherms generate heat metabolically. Their ability to maintain a high body temperature is limited by their physiological capacity in the short term and by their ability to get food in the long term.
Torpor is a voluntary, reversible condition of low body temperature and inactivity, changing the thermostate to conserve E. (West Indian Hummingbirds, drop to 18- 20˚C)

Countercurrent circulation has blood flowing outward encounters blood returning and transfers heat conductively. (Seagulls' legs)

C_3 photosynthesis is favored in cold climates.

1. CO_2 + RuBP(5C sugar) -> 2 G3P
2. 2 G3P enters Calvin-Benson cycle
3. 1 RuBP is regenerated, 1 reduced C atom is made available to synthesize glucose
4. RuBP carboxylase-oxidase/ Rubisco with low CO_2 is due for C assimilation but the mesophyll has low [CO_2]
5. To higher insufficiency, Rubisco is packed in some plant to 30% of the leaf dry weight
6. High [O_2] and low [CO_2]: Rubisco bind O_2 instead, reverse the cycle for photorespiration

C_4 photosynthesis are found in grass plants in hot, arid environments to battle photorespiration by letting the stomates to close longer although it uses more E and it leaves the plant with less tissues devoted to photosynthesis.

1. CO_2 + PEP -> OAA (oxaloacetic acid); catalyzed by high CO_2 affinity PEP carboxylase
2. the mesophyll cells converts into malic acid and diffuse into the bundle sheath cells surrounding the leaf vein
3. enzyme break down malic acid to CO_2 and pyruvate
4. CO_2 goes under the light reaction of C_3 photosynthesis
5. the resulting 2 G3P enters the Calvin- Benson cycle just as in C_3 plants
6. the pyruvate is converted back into PEP and retreat back to the mesophyll

Crassulacean acid metabolism/ CAM plants are often in water-stressed environment (pineapples, cacti). CAM allows extremely high water use efficiency.

- Night: stomoates open for gas exchange in minimum transpiration cool conditions; assimilated CO_2 converted to OAA and OAA to malic acid and stored at high concentration in vacuoles in mesophyll
- Day: the stomates close and the stored malic acid is gradually broke down to release CO_2 and process to the Calvin- Benson cycle

Lecture Notes

1. Relationship between physiological range and geographical range: contrasting examples
2. Example of one environmental challenge: Heat balance/ thermal ecology of animals
    a. Modes of heat gain and loss; homeostasis
    b. Size, shape, insulation, evaporative cooling
    c. Trade off principle and adaptive compromises (weasel body shape)

Physiological ecology

- Ranges of tolerance ultimately limit distribution
- Organisms rely complex chemical reactions
- Reactions (enzyme) occur best at optimum temperature and osmotic conditions, where fitness is maximized
- Many mechanisms for homeostasis have evolved to challenge hostile environments
- Maintenance of homeostasis required E and is often limited by constraints and trade offs

Geographical ranges can sometime be limited

- by special habitats (behavioural habitat selection)
    - Pronghorn broad temperature tolerance, narrow habitat range; it chooses not to stay in its narrow range (short-grass prairie, North America High Plains)
    - Yellow- rumped warbler vs. Kirtland's warbler; very close relatives but the yellow-rumpeds are in abundance and are an extreme habitat generalist, whereas the Kirtland's

    warblers with the similar niches are rare and are an extreme habitat specialist. The difference is completely behavioural probably due to some cognitive limitations of the Kirtland's

- by the dependence on other organisms
  - Gila woodpeckers drill holes into the Saguaro cactus and nest inside the hollows but each nest is only used once and abandoned. The abandoned nests are homes to cactus wren and elf owls. The woodpeckers are only found where the cacti are, the owls and the wren are found only where the woodpeckers and the cacti are.
- by transcending biomes.
  - Tigers have a really wide range and are carnivores so there any limited imposed by plants. (Tropical rainforest, Sumatra to boreal forest, Siberia)
  - Coyotes are also super generalists; however the recent expansion could be due to human activities. As wolves are nearing extinction due to exploitations, coyotes are taking their over their range.

Thermal ecology mechanisms: radiation, conduction, convection, evaporation, and redistribution

Size matters
Surface area determines equilibrium rate, while volume provides the thermal inertia.
Homeostasis relies on the surface area: volume ratio.
Bergman's Rule: Homeotherms tend to be larger at high latitudes to combat the cooler climates.

- At high latitude the species of bear have longer fur and have a massive volume compared to the bear of the tropics
- Some animals might seem to contradict the rule such as the elephant but we just don't see the comparison as the relative better adapted to the cooler climate could already be extinct

Shape matters
Allen's Rule: Appendages reduced in cold climates
Sometime particular shapes are needed for function in trade-offs and adaptive compromises.

- *Chrysopelea* gliding snake has a very large SA: V and it conforms to the Allen's rule as it is restricted to warm tropics
- A sphere has the least SA: V and the shape is imitated by animals of cold climate to retain heat as exemplified by the alpine tundra rabbit specie, pika, with its spherical shape and reduced ears
- Arctic hares is more spherical shaped with small hidden ears; desert hares have large ears and large skinny legs

Insulation retains heat.
Terrestrial animals have furs (even some dinosaurs), while some aquatic animals have blubber to avoid drag.
Clark's Nutcrackers fluff up their feathers to gain a spherical shape to retain heat.

Convection cooling enhanced by vascularization

- Desert hares with thin large ears where blood can dump heat to the air in the ears
- Some animals can selectively pump blood to body parts to increase surface area for cooling

Countercurrent circulation to limbs conserves heat by recollecting heat that would be lost otherwise.
Countercurrent flow maintains gradient, so heat is always flowing from outgoing blood to incoming blood.

Convection enhanced by evaporation through wet surface for cooling
- Human sweat
- Furred animals can't sweat but can expel heat through their nose and tongue
- Elephants spray themselves with water
- Kangaroos lick themselves

LECTURE THREE

Chapter 2

Lecture Notes

Apparent paradox which does not follow the pattern: Weasels are small predators, active year round, short furred, very long and thin thus lose heat quite easily but they do not live in hot climates. Woodrats curls into a ball to retain heat when cold; the best a weasel could do it curls into a flat disk, losing more heat. The weasels shape is an adaptive compromise. Typical weasel prey such as the pocket gopher lives in underground burrows, being long and lean allowing the weasel to be a better predator allowing it to chase down the burrows.

Why can't nature selection produce perfect adaptation?
Organisms have trade-offs. For the weasel, the fitness gains of being a good hunter offset the fitness costs of an expansive metabolism with a lean body. The phenotypes of all organisms are riddled with compromises dictated by trade-offs. Natural selections cannot create, it changes from what it already has thus it has to promise.

Kangaroo rat deals with extreme water stress
- Erect posture, bipedal makes for less heat gain from ground
- Super- efficient kidneys reduce water loss with very concentrated urine
- Metabolic water from fat is sufficient, it does not need to drink water to stay hydrated
- It is nocturnal and spend hot days underground
- Cache seeds underground which recapture water vapour from exhalation allowing the hydration to re-enter to body later

Options when stress becomes overwhelming: Evasions
- Enter dormant stage (seeds, aquatic cysts, eggs, pupae)
- Nest (protected microhabitat), store food
- Hibernate as adult, store fat and wait until better conditions
- Migrate to milder climate
- [Hibernation and migration usually are driven more by food supply than abiotic stress]
    - Garter snakes hibernate in a bundle to conserve heat
    - Muskrats also hibernate in pack
    - Chipmunks are true hibernators and rely completely on fat gained from warmer times
    - Birds migrant generally because of food supply
    - Cross brills do not migrant as it is adapted to feed on pinecones
    - Grey jays are smart generalists and will eat whatever so they don't migrate either
    - Clark's Nutcracker caches seeds for winter and don't migrate
    - Pikas do not hibernate, they make hay during the summer to eat during the winter

<u>LECTURE FOUR</u>

Chapter 3

Lecture Notes

Plant eco-physiology of carbon balance
Plants are autotrophs and make their own food, their behaviour adaptations come in the form of growth and development.
To acquire proper growth; a plant needs suitable temperature, osmotic balance, enzymes, dissolved nutrients and etc.
Any of these components can limit fitness

Size and shape matter, just as they are for animals
Large leaf surface area is good for harvesting light and CO_2 but the area is bad for overheating, and water loss by evapotranspiration.

Large leaved plants combat overheating by growing in shady habitats and by evaporative cooling by opening stomata.

Plants with large leaves combat water loss by closing their stomata. This shuts off gas exchange and photosynthesis and plant stops growing while risking overheating and tissue damage. This is a fundamental trade-off between water conservation and rapid growth. Consequences are most obvious in desert plants.

Palo Verde/ “green stick” have tiny leaflets or microphylly and photosynthetic bark on trunks and branches can grow without incurring heat load and water loss though leaves

Mesquite also has microphylly but it does not have photosynthetic trig, equal with the surrounding temperature more quickly and less heat is lost.

Santa Rita prickly pear has no leaves, it stores water in sponge like tissue and has modified thorns to protect its water store.

Cacti have extensive but shallow roots to absorb the large amount of water that are available only in big burst and short periods. Saguaro cactus has accordion pleated trunks for swelling up due to water stores.

Deciduous habit: dropping leaves during dry or cold seasons can reduce water stress and tissue damage but the rebuilding is costly.

Not all conifers are evergreens.

Mesophyll plants are thin leaved, flimsy, fragile and frequently deciduous.
Sclerophyll plants are tough, and are often evergreen with needles or scales.

Leaf shapes can influences gas exchange through laminar vs. turbulent flow of fluid over surfaces.
Laminar flow on a smooth surface which allows a still boundary layer to form and exchange between fluid and object is minimal.

Turbulent flow from a bumpy surface and disrupt the boundary layer and beneficially there's more exchanges.
Shade leaves experience more laminar flow and sun experience more turbulence for better cooling.
Monstera deliciosa has dissected outlines on their sun leaves for more turbulence.

Nurse tree effect: saguaro seedling sheltered by Palo Verde is common for better survival

Epiphytes grow on trees, so they aren't able to put their roost in to the soil leading to water stress and nutrient shortages.
Convergent evolution with the cacti.
Water is stored with sponge, tank, and by being succulence.

Plants with sclerophyll leaves common in four situations: the leaves are suited for snow, and hot climate. Also it is tough enough to stand the acid soils

1. Boreal spruce-fir forests
2. Pine barrens
3. Maine bogs
4. Mediterranean heaths

LECTURE FIVE

Chapter 11

Chapter 12

Lecture Notes

Population size (*N*) is the number of individuals
Population density (*N*/area)

Aspen: one seed produce many identical, connected stems thus it is essentially just one individual
Larkspur: many unique seeds produce many unique plants
Dandelion: no sex, many identical seeds produce many identical, unconnected plants create a single genetic individual
Strangler fig: multiple different seedling fuse together to make one tree with several genotypes

Continuous generation (differential equation)
Discrete generation (difference equation)

The goal of most population models predict the trajectory of population growth through time:
N_t = population size at t
$t + 1$ = time advance one step
N_{t+1} = population size one step later
$N_{t+1} = f(N_t)$ = general model

$N_{t+1} = \lambda(N_t)$, $N_t = N_0 \lambda^t$,geometric growth of the discrete models: λ change over one time unit
$dN/dt = rN$, $N_t = N_0 e^{rt}$,exponential growth of the continuous time model: r instantaneous, per capita rate of population change

No species has ever sustained λ>1.0 or λ<1.0 for long thus the simple exponential growth is a bad model of reality over the long time. Two other factors may be acting, density – dependent or density-independent limit. λ is no longer a constant.

$dN/dt = rN [1-(N/K)]$
$N_t =(KN_0e^{rt})/ [K +N_0(e^{rt}-1)]$
K = the carrying capacity of the population
Exponential equation braked by a density dependence factor
Trajectories are sigmoid only when starting from low numbers , the lower the population, the bigger the growth

Alternate forms of density-dependence 2: time-delayed logistic: population reached carry capacity but it keeps growing until it concludes in a catastrophic consequence
$dN_t/dt = rN_t [1- (N_{t-\tau}/N)]$
This situation of population continue to use up its resource rather than communally recognizing a problem and waiting voluntarily for a solution, is more common

Allee effect states that having a certain number of individual could be optimum for growth
Populations may fluctuate between carry capacity K and some lower limit and dropping below the lower threshold could cause the population to extinction
Very important in conservation

LECTURE SIX

Chapter 7

Lecture Notes

Age- structured population growth with fecundity and survivorship varying with age

Age-sex pyramids shows the size of age groups of different sexes

Age-class intervals are arbitrary units of time chosen to give a reasonable number of age classes for the organism in question

Survivorship schedules
x = age class
L_x = probability of being alive at age x
L_o = 1.0 by definition of birth
"survivorship curve" = graph of L_x vs. x
L_x necessarily declines with x

Simplified types of survivorship
Part I: initial mortality rate is low but rapidly increase near old age (human)
Part II: mortality is constant with age
Part III: mortality rate is high in youth but decline as people age (insects)

Fecundity schedules
b_x (m_x) = # daughters born to female of age x during the interval x to $x-1$

shape of b_x curve characteristic of species
Reproductive period usually preceded by resource- accumulation phase
Fecundity-survivorship trade-offs = cost of reproduction

Population growth rates
R_0 = net reproductive rate
$R_0 = \Sigma L_x b_x$
Σb_x would be the total #of daughters produced by a mother who doesn't die earl, multiplying by L_x discounts expected production by the probability that some mothers do die early

Generation time T
T = average age at which a female gives birth
$T = \Sigma x L_x b_x / \Sigma L_x b_x = \Sigma x L_x b_x / R_0$

Approximate relationship between R_0 & λ
$R_0 = \lambda^T$
$\lambda = R_0^{1/T}$

Generally, organisms with higher λ's have higher fitness because there would be more copies made and with different genetic variance that have a hereditable component to their birth rate there should be a selective advantage to reproducing early. What are the limitations?
Constraints and trade-offs: reproduction is costly, longer pre-reproductive periods allow time to accumulate more resources

Glacier lily, plants that make a lot of fruits suffered in their relative corm growth rate and shrunk. No fruit lilies are the only ones that grew.

Iteroparous organism is one like to reproduce in a number of age classes through its life. Iteroparous plants are called perennials.
Semelparous organisms may delay reproduction so they are accumulate more resources and then engage in this one time pregnancy or big bang then possibly died.(Salmon) These kind of plants are either annual, biennial, or monocarpic perennial. (Monument plant which incredible synchrony for sex)

The pollinator could be the selective force as it chooses to pollenate the bigger, juicer flower.
Bamboo, extremely synchronized semelparity, jungle rats bloom with the unlimited bamboo seeds then after it goes after the human food and cause crop failure.
Blue Oak, "masting", iteroparity plus local synchrony, predator satiation: dump a lot of seeds for a great bloom follows with bust years of lesser resource resulting in a declining population for the next bloom that would let some seeds escape.

Reproductive value
V_x = expected number of further daughter left to an individual of age x
highest point is not at birth, maximum at late teens just entering reproductive year.
v_x affected by the success of captive breeding/ release programs for conservation, prospective success following dispersal to new habitat, age of high V_x should maximize attractiveness to potential mates.

Pleiotropy refers to one gene that could have multiple different functions.
Antagonistic pleiotropy refers to genes with opposite effects on survival at different ages.
P53 protein or Guardian angel gene prevent cancer from young age but later in life, the protein destroys

stem cells and challenge you.
A gene with positive value in young animals but negative value in old animals will be favoured by natural selection because reproducing early increases fitness.
Accumulation of such genes causes senescence.

LECTURE SEVEN

Chapter 14

Chapter 15

Chapter 16

Lecture Notes

Consumer-resource interaction between two species (+/-)

- Predator- prey
- Plant- herbivore
- Host- parasite

Competition (-/-)
Mutualism (+/+)

Foci of study of species interactions

- Population dynamics (effects on *N*'s)
- Evolutionary dynamics (adaptation, co-evolution)

Interspecific competition has the Lotka-Volterra equations as the basic model for two species competing for resources. It adds an extra braking term of specie to the logistic equation.
Intraspecific competition has only one braking term for its own population growth.
Interspecific competition adds a second braking term to stimulate the effect of interaction.

Braking from sp. 1

$$\frac{dN_1}{dt} = r_1 N_1 \left(\frac{K_1 - N_1}{K_1} \right)$$

GO!

1. Rewrite logistic with subscripts to indicate Species 1

Braking from sp. 1 Braking from sp. 2

$$\frac{dN_1}{dt} = r_1 N_1 \left(\frac{K_1 - N_1 - \alpha_{12} N_2}{K_1} \right)$$

2. Add a term to show effect on Sp.1 by Sp. 2

$$\frac{dN_2}{dt} = r_2 N_2 \left(\frac{K_2 - N_2 - \alpha_{21} N_1}{K_2} \right)$$

3. Write matching equation for Species 2

4. α_{ij} = per-capita effect on *i* by *j* = "competition coefficient"

5. These paired differential equations are the *Lotka-Volterra model* for combined intraspecific and interspecific competition

The magnitude of α is proportional to the effort of the interactions.

Possible outcomes of L-V competition

- Species 1 always win ($N_1 = K_1, N_2 = 0$)
- Species 2 always win ($N_2 = K_2, N_1 = 0$)
- Both species stably coexist ($N_2 < K_2, N_1 < K_1$)
    - Requires both species to inhibit their own growth more that they inhibit each other's
    - Could coexist indefinitely, without complication
- Unstable situation where the identity of the winner depends on the starting *N*'s

Outcomes depend on values of *K*'s and *α*'s
Can expand to consider *n* species, at a community level

L-V outcomes were widely interpreted as basically unstable and often phrased as "complete competitors cannot coexist, earning the name "Law of Competitive Exclusion".
However, this might be true for the simple math models; natural systems are more permissive than models.

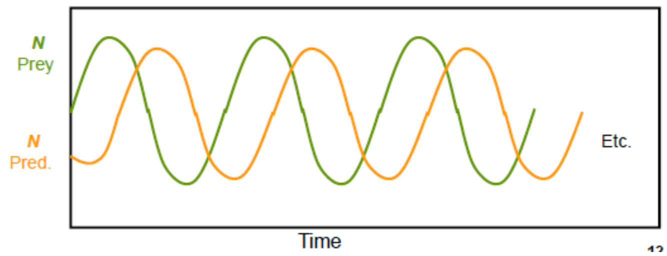
Gause (1930's)
Good description of competition by protozoa in artificial culture vessels
saw both stable/ unstable coexistence and competitive exclusive by using different combination of interactions.
Competition is shows as one species continue to growth and the other is driven to extinction.
Stable coexistence is evidenced by both species living under its *K* value but still growing
Predator-prey strongly tended to be unstable as predators tend to eat up all the prey and starve unless habitat complexity is added.
Competitive exclusion in nature is less likely to go to completion with absolute extinction.
Abundance can be drastically affected and cause extreme rarity but seldom absolute.
Species can continue to survive with hidden members living off in the many microhabitats that are unaffected by the interaction.

Distribution of the species in space could be altered as the winning species take over better habitats and the weaker species is limited to marginal space.
Biological effects interact with physical effects.

- Tensley shows this affect as the pH soil determines the result of the competition between plants
- Connel's removal experiment shows that the barnacles in the intertidal zone has upper limited set by desiccation, while the lower limit is set by competition for space.

Natural selection tends to favour higher competitive ability.

L-V models for predator-prey interaction tend to cycle with predict coupled, lagged population cycles. The prey population grows which lets the predator to grow as well. Overeating occurs and the prey number decrease. Starving predator leads to population decline and allows the prey population to regain its number. The cycle continues.



The cycles do occur in nature but they are difficult to sustain.

Huffaker; prey and predator mites on oranges, like most common lab result, the competitions do not coexist, interaction is unstable. Many manipulations are made to achieve three cycles.

The most famous natural cycles belong to the lynx and hares. But cycles in nature are unusual, and this example is not simply an L-V model. Additional research found that the heavy browsing degrades quality of plant food available to hares. The lynx are following the hares as the hares are cycling with food plants. Another factor is the social stresses (endocrine collapse) in overcrowded hare populations. Most natural cycles have complex causes and are more common in less diverse smaller communities.

Niche theory of community composition
We would use the quantifiable ecological niche that describes each species role and resource use to represent the value of α. The competition coefficient can be estimated with niche overlap measures.

MacArthur observed insectivorous warblers. It would seem that with the warbler's needs for the similar resources, they would drive each other to extinction. However it is found that their niches were slight difference which allows their co-existence.

Attractive features of the niche differentiation theory
Limiting similarity: niches had to be sufficiently different to allow co-existence
Resource partitioning: expect to see similar organisms dividing up resources
Assembly rules: some species pairs are incompatible; if A is already established in an area, B cannot
Character displacement: coexisting similar species should evolve differences

The dismay
The model is too simple and too much reality is ignored. Communities are seldom at a competitive equilibrium for the model to work. Not many species are kept very high nearing their *K*, populations are kept below by weather, disease, predators and etc. which have competition as a much lesser issue. Conditions also fluctuate, favouring different species at different time. Most species do not occur in isolated populations but rather in metapopulations connected by dispersal.

Pisaster starfish predation prevents mussels from competitively excluding species in rocky intertidal communities shown in a removal experiment.

From population dynamics to metapopulations dynamics
From a simple unstable predator-prey interaction, whole populations with extinct at the end.
But if you put different stages of the interaction on various areas that allows some occusional migrations in between, a group of locally unstable systems can be globally stabe.
Metapopulation structure can allow predator-prey coexistence.

Metapopulation also allows unstable competition.
A always outcompetes B locally.
For global coexistence, A must sometime go extinct in a patch or occusional new patches must be created, B must be a better disperser (fast reproduction than leave,weed) than A.
Coexistence possible because of different life histories, not different resource-use niches.

Dichotomy: a scheme for broad life-history strategies

1. *K* strategy: good competitors, more investment in somatic growth
2. *r* strategy: poor competitors, good dispersal, smaller, quicker, more investment in gonad

LECTURE EIGHT

Chapter 18

Lecture Notes

Application of spatial and metapopulation models to predict butterfly and pika dynamics

Population persistence of a rare butterfly in habitat patches:
Fender's Blue butterfly depends on a rare Kincaid's Lupine that only grows in the prairie. It is rediscovered in recent years and found there is an annual pulse of reproduction followed by heavy larval mortality. Butterflies must disperse and discover prairie or will die without reproducing. By building a metapopulation, the small areas that were experiencing high mortality rate could now enjoy global stability.

Smith's pika research, tailings piles from hard-rock mining crate many small replicated patches of pika habitat. From years of % patch occupancy recordings, a stochastic metapopulation model is built for Bodie pikas. It is found that the N. zone has stable, high occupancy, is a source or net exporter to M. The middle zone is a sink, accepting colonists from N, it is also a stepping stone providing a flow from N to S. The S. zone is a sink and needs stream of new colonists (rescue effect). If zones are separated, the M and S zone will have no occupants as all of the pikas will stay in the N. zone and expands its growth there.

Deterministic models have fixed parameters, and single outcomes (logistic, niche theory etc.)
Stochastic models include chance, varied parameters and multiple outcomes (standard deviant)

Stability and coexistence
Model populations can be driven to extinction: Strong density-dependence interactions, unstable competition, unstable predator-prey (disease-prey), Allee effects at low density.

These tendencies are countered by non-equilibrial conditions shaped by extrinsic factors, habit patchiness allowing mosaic of coexistence, rescue by migration, variation in life=history strategy.

Plant community ecology (1900s)
Some clusters of plants are usually found together, species associations (beech-maple forest, oak-hickory forest etc.)

Conflicting views of causes of associations:
Organismal/ Holistic hypothesis: certain species are found together because they are biologically integrated and depend on each other's presence (Clements)

Individualistic hypothesis: species are distributed independently of each other and bought together through the similar range of tolerance; important limitations are dispersal and filtering by the physical environment(Gleason)

Actual data supported Gleason
Whittaker's direct gradient analysis, plot species abundance curves along gradients and found no ecotones of distinct transitional zones and species are situated with no dependence to other species.
Curtis's indirect more objective gradient analysis did not find strong clustering of species either.
Davis's use pollen data and found difference species of trees migrated along different paths.

Modern consensus for terrestrial vegetation
Primarily individualistic: contemporary and paleo data agree that variation is fundamentally continuous, not discrete, and that the strongest environmental filtering is driven by physical factors but species interactions do affect some functions.

LECTURE NINE

Chapter 10

Chapter 19

Lecture Notes

Predictable successional change in plant communities:
Pioneer species get in first from dispersal or seed bank in soil and later replaced by better inhabitant.
Plant soil-building processes and shade thought to be critical.
Happens at many levels, but most heavily studied in human-impacted landscapes in E. N. America ("old field" succession from abandoned land to forest).
Vegetation changes spontaneously as the vegetation itself modifies the environment.

Classic successional sequence: pioneer species -> temporary, non-equilibrium seres/ seral stages -> climax stage, stable equilibrium, no more change

Primary succession: new substrate created, no pre-existing vegetation
Secondary succession: pre-existing vegetation undergoes a disturbance
Disturbance: discrete event that causes abrupt change and sets back succession (fire, windstorm, etc.)

Kilauea Volcano, Hawaii
Primary succession on lave flows -> soil develop as solid lava breaks down into finer particles, dead plants contribute organic matter -> plants attract birds -> birds bring in seeds -> herbaceous plants cover ground, tree grows -> tree canopy close in, soil is well developed, shade becomes important

Koffler Reserve
Secondary succession in temperate deciduous forest (Old-field succession) -> year 1, annual weeds -> perennial weeds -> woody shrubs move in -> tree saplings -> tree canopy close in -> shrub layer thin out ->only shade tolerant plants remain

Drivers of terrestrial succession:
Soil development: especially accumulation of organic matter, N content, pH buffering, and water retaining capacity (important in primary s.)
Shading: shade-tolerant species replace shade-intolerant ones (important in secondary s.)
Succession may reach a stable climax configuration but often does not.

No climax-type equilibrium attained:
Boreal forest: seral stages lead to spruce-fir forest, not replacement after the spruce-fir
Acid, sandy soils: pin-oak leaf litter make soil more acid, stopping the sequence
Fire-prone ecosystems: pinelands, grasslands, chaparral
Systems driven by seasonality: plankton in temperate lakes, starts again every summer
Cycling of dominants: rotating dominants replacing each other
Transient substrates: decay of a log
Spatial scale matters: gap-phase succession (open patch of canopy from fallen tree).

Fire-dominated communities: fine forest at a flammable stage, no shade tolerant species, and no stable climax (ground fire on the understories, crown fire where the fire jump up to the canopy). Serotinous trees (Jack Pine) release their seeds only after been blazed.

Intermediate disturbance hypothesis for maximum species diversity:
There is a tendency for shad- intolerant species to be replaced by shade-tolerant species.
Diversity peak at the middle of the succession, at the final climax stage, a monoculture result.
To prevent this monoculture, fire spreads and empties cells, starting secondary succession in patches.
There is an optimum level of disturbance for maximum diversity.

Habitat is a mosaic of patches in different stages of regrowth after disturbance. Regions and ecosystems have characteristic disturbance regimes; most “equilbria” are quasi-equilbria at most.

LECTURE TEN

Chapter 17

Chapter 20

Lecture Notes

Trophic levels
Primary producers: plant
Primary consumers: herbivores

Secondary consumers: carnivores who eat herbivores
Tertiary consumers: carnivores who eat secondary consumers
Detritivores: eat dead organic matter

Functional web: shows which consumption has actual effect on the population growth rate of a species

Hairston, Smith & Slobodkin; Trophic cascades
There must be some supply other than green tissues that limit the size of herbivore populations, or there would be a growing population of herbivores until all the greens are eaten. The herbivore population is kept down by carnivores so the world plant growth is not limited. Carnivores are beneficial to plants as an indirect effect.

Indirect effect: one trophic level exerts influence on a second by affecting a third.
Cascades involve effects that alternate across trophic levels and it can drastically affect simple communities.

Caribbean small island trophic levels: plants-> beetles -> spiders -> lizards
Lizards eat the spider, both the lizards and spiders eat the herbivores
Lizards do benefits plants because of unequal interaction strengths. The effect of the lizards on the spider is weak, while their effects on the herbivores are stronger. So lizards are reinforcing, rather than counteract, the effects of spider.
However, the strength of the interaction could have gone the other way, experiment is the only concrete resolution.

Knight et al.
Ponds with fish prey on the larval dragonfly, which can affect the population of the adult dragonfly population. Dragonflies eat pollinators. The fish has an indirect effect on adult dragonfly, pollinators, and the plants. Fish's consumption of larval dragonfly is beneficial to the population of pollinators and plants.

Direct and indirect effect can be opposed.
Indirect effects can be as strong as direct.
Keystone consumers can shift communities between alternative states(starfish, lizards, fish)
Outcomes not fundamentally predictable depend on interaction strengths which can only be determined accurately with long term experiments.

Special difficulties of herbivory:
Physiologically speaking, it is easy to be a carnivore as it is relatively easy to turn animal tissues to more animal tissues.
Plant tissues hard to convert into animal tissues as it requires more processing

- cellulose and lignin are tough and indigestible without microbial symbionts
- plant tissues are heavily defended against herbivores, mechanically (spine) and chemically (poison)
- co-evolutionary race between plants and insect herbivores is responsible for much of biodiversity: specialization is common as an insect try to overcome a particular plant's defense

Milkweeds haves repellent latex under pressure in the leaf veins. A bite from an insect will let the poisonous squirt out of the leaf. The monarch butterfly larva is a milkweed-feeding specialist and cut the leaf midrib to reduce pressure before eating the plant. Cardiac glycosides is the toxic and the larvae has a way around it by routing the poison to the outside of the body and using it to their advantage as a defense for themselves. Monarch butterfly has brightly coloured insects (aposematic) to signal its toxicity.

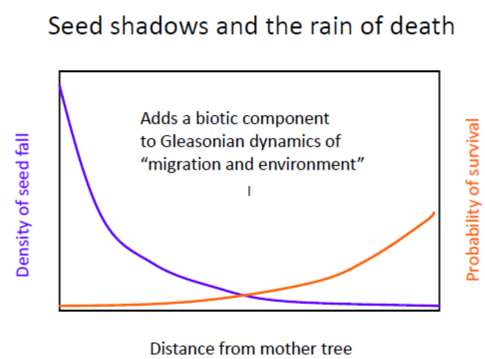
Chemical defense:
Very common, we don't taste them in our food because our crops have been selected for low toxicity.
Many types of "secondary chemicals" (potent and prominent alkaloids)
The toxic chemicals are called secondary because they do not participate in the process of photosynthesis.
No plat species is toxic enough to escape from specialist herbivores as they have evolved to use the toxic as their feeding stimulants or defense compounds.
These combats between plant s and specialists lead to escalation of co-evolution.

Vertebrate grazers & browsers:
Graminoids (grasses and similar) are defended mechanically rather than chemically(meristems is underground and protected, abrasive silica).
Chemically defended forbs(broad-leafed herbs) are dealt with by dilution or food avoidance.
Grazes detoxify with the microbes in the fermenting chamber and have elaborate grinding molars.
The poisons don't really affect the animals due to their size.

Veratrum has cyclopamine that cause one eyed mutation in fetal sheep. It has great effect on developmental pathway and it seems to work against skin cancer.

Toxins are even more challenging to small mammals like pikas. However the pikas manipulate the toxin plants. *Trifolium* is chemically undefended and they eat a lot of it during the summer. However, during the winter, the pikas eat a large amount of toxic *Acomastylis* instead. This is because while the *Trifolium* decomposes quickly in storage, the *Acomastylis* are better preserve as the toxin as a preservative and let the pikas store a lot of them for winter. The toxins also break down over months in storage so the toxin is less effective when the pikas finally eat them .

Janzen-Connell hypothesis:
The phenomenal diversity in rainforests is partly due to unremitting attack from specialist insects and fungi in mild climate. The seedlings have a low chance of success in the vicinity of the mother plant as the area would be infested with specialist herbivores. This strong density-dependence prevents any species from monopolizing habitat as the herbivores would just clear out the one species.



<u>LECTURE ELEVEN</u>

Lecture Notes

Species: distribution & abundance (Glacial lily)
Summary:
Long-lived, iteroparous; grow as a "vegetative" plant for years before flowering.
Resource storage organ is underground; corm. Seeds subject to desiccation unless in moist conditions.
Seed dispersal distance is minimal.

Suggestions:
The desiccation suggests the lily should be found more away from thin soil around rock outcrops which is contradicted. The minimal dispersal suggests most seedlings are near flowering plants.
Quantitative data:
Flowering plants and non-flowering plants has the similar distribution, which is expected. Flowering plants and seedling are displaced which is not expected, as flowers like it on rocks but the seedlings like deep moist soils. Gophers avoided rock and are disturbed everywhere else which makes sense.
Reconciling:
Most seeds are produced in rocky areas and fall there, but most desiccate and die. The few seeds that reach moist, deep-soil areas are more likely to survive and produce seedlings. But seedlings that get established in deep-soil areas are likely to be killed by gophers before they each flowering age.
Conclusion:
Rock-refuge conclusion

Cantor & Whitham
Trapping gopher at aspen-meadow interface allows aspen to invade the meadow.
Concluded that aspen grow better in deep soil areas but only if protected from gophers. Also aspen clones are centred on rock outcrops; outward expansion is limited by gophers cutting root. Rock-refuge conclusion. Pocket gophers are keystone species in the aspen-meadow mosaic.

Michael Soule
Gophers are notoriously generalized in their plant diet but they won't eat aspen root because of the poisonous alkaloid in them. However this can be reconciled with Cantor's experiment as the effect on the aspen root could be something other than gophers eating the roots.

LECTURE TWELVE

Chapter C1

Lecture Notes

Organisms on earth have changed through time.
The changes are gradual not instantaneous.
Lineages split or branch by speciation resulting in the generation of biodiversity.
All species have common ancestors.
Most evolutionary changes results from natural selection- the only process responsible for the evolution of biodiversity and adaptation.

Proximate questions involve determining the physiological or genetic mechanisms responsible for aspects of a trait.
Ultimate questions involve determining the ecological function and adaptive significance of a trait.

Biodiversity is the variety of life on earth; the number and kinds of living organisms in a given area.

Adaptation is any trait that contributes to fitness by making an organism better able to survive or reproduce in a given environment; it is also the evolutionary process that leads to the origin and maintenance of such traits.

The theory of evolution is the central unifying concept of biology and it affects many other areas of knowledge as one of the most influential concepts of Western thought.

Dobzhansky: Fruit fly geneticist and founder of the modern evolutionary synthesis

Watson: molecular biologist and partly responsible of the structure of DNA; no conflict between religion and fact

Major sub-fields:

1. Evolutionary history (macro-evolution)
    - Determining evolutionary relationships of organisms in terms of common ancestry- phylogenetics
    - Affinities of organisms provide a basis for classification- taxonomy and systematics
    - Comparative data from many source
2. Evolutionary mechanism (micro-evolution)
    - determining the ecological and genetic mechanisms responsible for evolutionary change
    - involve population level studies of natural selection, adaptation, and speciation using diverse organisms
    - testing of theoretical models by experiments in the laboratory and field

Barrett Lab project

1. discovery of Darwin's missing form of water hyacinth and patterns of genetic diversity
    - wold's most serious invasive aquatic plant now distributed worldwide in tropical and subtropical areas
    - reproduces by both clonal and sexual reproduction
    - three mating types (morphs) restricted to native range
    - most reproduction in the introduced range by cloning
    - massive founder event associated with human introduction to alien range, the short-styled morph by chance just never made it out of S. America
    - Haldane organized the largest outreach study in an failed attempt to find the missing short-styled morph; morph later found by Barrett in the Amazon
2. novel adaptation promoting outcrossing in plants (Rat's Tail)
    - birds are major plant pollinator and wither hover (New W.) or perch (Old W.) during nectar feeding
    - Rat's tail has an unbranched inflorescence axis that serves as a bird perch facilitating nectar feeding
    - Experimental removal of perch lowers fertility and increases self-fertilization
    - The perch is therefore an adaptation promoting plant reproductive success
    - Further studies are required to determine the mechanism responsible for the origin of the perch

Founder event is an introduction of a small number of individuals that possess a small sample of the genetic diversity of the source population.

<u>LECTURE THIRTEEN</u>

Lecture Notes

Charles Darwin and The Theory of Evolution

Two controversial ideas

1. Concept of a changing universe; replaced view of a static world
2. A phenomenon with no purpose; replaced view that the causes of all phenomena had to have a purpose

Jean-Baptiste de Lamarck (1744- 1829)

- First to use the term evolution
- Incorrect view of linear rather than branching view of evolution
    - simplest forms evolve directly to complex forms with no evolutionary tree
- First to provide a causal mechanism- the inheritance of acquired characters
    - Giraffe's neck is due to the progressive increase in neck during the life time of an individual which is passed on to offspring

August Weismann (1834- 1914)

- Inheritance only by gametes; somatic cells do not function as agents of heredity
- thus genetic information cannot pass from soma to gametes and onto next generation
- modern interpretation stated in molecular terms, genetic information flows in one direction only from DNA to protein

Charles Darwin & Alfred Russell Wallace co-discover the chief mechanism of evolution: Natural selection

The Origin of Species is arguably the most important scientific book ever written
The History:

- It is the accumulation of 20years worth of evidence after the Beagle for the theory of evolution
- Darwin wrote but did not publish an essay on natural selection in 1844
- He began work on the natural selection book in 1856
- June 1858, Darwin received the manuscript of "On the tendency of varieties to depart indefinitely from the original type" by A.R. Wallace
- July 1858, the Darwin-Wallace paper on natural selection is presented to the Linnean Society presentation in London, no much questions from scientists
- 1859 marks the publication of "The origin of species by means of natural selection or the preservation of favoured races in struggle for life", big sell and controversy for the public

Book's two key components:

1. All organisms have descended with modification from common ancestors
2. The major agent of modification is natural selection operating on variation among individuals

Development of Darwin's ideas:
Exploration encouraged by the botanist Henslow at Cambridge.
Gradualism: Lyell's "Principle of Geology" argued that present day geological process can explain the history of the earth as sparked the notion of a dynamic world emerged in Darwin's thinking.
Variation patterns of Galapagos mockingbirds made Darwin doubt fixity of species and challenged the idea of specially creation.
Malthus' essay on the Principle of Population mentioned how species have carrying capacity which sparked Darwin thoughts on how resources are competed for and the idea of natural selection for the fittest emerged.

The essence of a Darwinian world view:

- Recognition that variation among individuals is not imperfection, but the material from which natural selection fashions better adapted forms of life
- This involves a move away from typology and the notion of an ideal species to population thinking

Requirements for Darwin's theory to work: variation, heredity, and selection

Creationist believes the reading of *Genesis* and all living organisms are created and designed by divine order in 6 days by a purposeful creator. It is not scientific.

LECTURE FOURTEEN

Chapter C4

Lecture Notes

Tropical forests in Brazil:
Very high species diversity of plant and animal
Many more biotic interactions, especially co-evolved mutualism between plants and animals
Year-round warmth results in rapid growth of insect and microbial population which made pest and disease pressures on plants more intense. 50% of insects are pest feeding on plants.

Tropical trees are largely animal-pollinated whereas temperate tree are mostly wind-pollinated: Individuals of the same species are widely separated, and mostly evergreen, unlike the temperate forests. Also dense canopies and long distance between same species make animals better pollinators than wind (Bees, butterflies, moths, birds, bats).

Tropical ecologist, Janzen, has made several major contributions to our understanding of topical forest plant-insect interactions

1. demonstrated that bees can travel up to 23km/day; recognized that bees, moths, and hummingbirds travel long distances during "trapline" foraging
2. pest pressure hypothesis predicts that tropical tree seedlings are less likely to establish close to the maternal parent because of the pest in that area
3. Ant- plant mutualism in Acacia: extrafloral nectaries and Beltian bodies for the ant, in exchange for a defense mechanism

Frederickson conducted experiments Peru demonstrating that ants defend their hosts against plant competitors using formic acid as an herbicide to clear shade thus benefitting from more nest sites.

Giant Amazon Water Lily/ Victoria in the wild compared to in grass houses show intense herbivory damage and consumption of plant biomass.

Epiphytes are common in the tropics with increasing species diversity and the life form has evolved independently in many unrelated families (convergent evolution).

Patagonia with tougher abiotic factors and lower diversity:
Adaptation: Spiny cushion plants are avoided by grazing animals, fruits with adhesive hooks dispersed o animal fur

Galapagos Islands:
Flora and fauna colonized by species capable of long distance dispersal fro S. America mainland.
Distinct races and species on different islands provide evidence of early stages of speciation.
Prickly pear cacti are the first colonizers of the volcanic slopes of the islands with long distance dispersal by bird eating their fleshy fruits.

The Grants are conducting the longest study of natural selection in Galapagos finches.

Adaptive radiation is the evolution of ecological and phenotypic diversity within a rapidly multiplying lineage as a result of speciation from a single common ancestor resulting in an array of species that differ in traits allowing exploitation of a range of habitats and resources.
Commonly identified features:

- Recent common ancestry from a single species
- Phenotype environment correlation
- Trait utility
- Rapid speciation

Iguana adaptive radiation: marine iguanas feed on seaweeds; terrestrial iguana feed mostly on prickly pear cactus.

Loss of flight on oceanic islands could be a result of natural selection as there isn't any advantage to flying with no predators and it could actually be a disadvantage to fly out to sea.

Darwin's founding of sexual selection; frigate bird

Australia:
Distinct flora and fauna with high levels of endemism or endemic species, and many unique adaptations.
Biological uniqueness due to long history of isolation from other land masses.
Although Australia is a continent and an island, it shows many islands characteristics.

Koala is an endemic arboreal herbivorous marsupial with a specialized diet of Eucalyptus leaves- can detoxify phenolics and terpenes in leaves that are toxic to other animals.

Rodent pollinated Banksia where the flowers are produced on the ground.

<u>LECTURE FIFTEEN</u>

Chapter 6

Chapter 13

Lecture Notes

A gene is a complex concept and has various definitions; it is the functional unit of inheritance, a unit of hereditary info located on the chromosomes consisting of DNA, and a DNA sequence composed of codons essential for a specific biological function.

Genetic variation comes from four sources: Mutation, Recombination, Gene flow, and Hybridization.

Recombination is the major source of variation from one generation, however mutation is the ultimate source in the long term population. Meiosis generates enormous diversity.

Sickle cell anemia: a single nucleotide mutation in the gene encoding the human beta-hemoglobin molecule cause red blood cells to be sickle shaped.

McClintock's discovery of "jumping genes" or mobile/ transposable genetic. A mutation that allows chucks of DNA to move around and inset itself to various parts of the genome.

Mutation is the ultimate source of genetic variation:
Mutation is a stable change in DNA sequence resulting in a change of genotype and it occurs at a very low but variable rate in all organisms.
Mutations could be neutral, deleterious, lethal , or beneficial; in many cases their fitness effects depend on environment.
To be important for evolution, the mutation must occur in germ cells- somatic mutations not inherited.

Characteristics of mutation:
It is unstoppable despite cellular mechanisms to correct errors during DNA replication.
Mutation is random with respect to effects on fitness.
Rates depend on the type of mutation
Environmental insults can affect mutation rate: mutagens, high temperature etc.

Types of mutations:
1. Point mutations: most important to evolution
2. Insertions/ deletions
3. Changes in repeat number
4. Chromosomal rearrangements: dramatic effect, usually lethal or deleterious

Very few mutations are beneficial with the large majority being either deleterious or neutral

Motoo Kimura (1924- 1994)
Theoretical population geneticist was first to recognize the importance of neutral mutation

Each human carries 3-5 recessive lethal alleles that would cause death if it was homozygous; inbreeding causes a higher incidence of offspring mortality and recessive genes prevails through increasing probability.

Gregor Mendel , a priest and the "father of modern genetics" and established the law of inheritance. Inheritance determined by discrete particles (gene); most organisms carry 2 copies of each gene (alleles) and are diploid, one allele in gametes, offspring inherit one allele from each parent at random

Discrete traits are simply inherited by 1 or 2 genes and usually unaffected by environment– Mendelian genetics (flower colour). Discontinuous variation has major genes, dominance, recessiveness, and genetic polymorphism.

Continuous traits, complex hesitance by polygenes of small genes of small effect which can be largely affected by the environment- quantitative inheritance. (height) Continuous variation has polygenes, selection response, and artificial selection experiments.

Genetic polymorphism is the coexistence of two or more discrete forms of a species in the same locality by mendelian genes and at such proportions that the rarest form cannot be maintain at a frequency >5%. <5% would generally be a mutation.

Discontinuous variation: major recessiveness, genetic polymorphism, Mendelian genetics
Continuous variation: polygenes, selection response, artificial selection experiments, And quantitative genetics.

Fisher's fundamental theorem of Natural Selection: rate of fitness increase = genetic variances in fitness

LECTURE SIXTEEN

Chapter 6

Chapter 13

Lecture Notes

Fisher showed theoretically there is a relationship between the amounts of genetic variability in a population and its ability to evolve. Low variability will handicap future adaptations.

Haldan was Fisher's UK rival counterpart, both trying to fuse genetic with Darwin's ecology.

Theoretical population genetics was initiated by Fisher, Haldane, and Wright and provided the foundation for Neo-Darwinism/ New Synthesis. They showed that continuous variation and Darwinian natural selection were entirely consistent with Mendel's Laws. They demonstrated the evolutionary significance of genetic variation.

Ecological genetics was about studying observable variation in phenotypes which was then studied genetically.

Key Questions:
What processes influence patterns of genetic diversity in natural populations?
How much and what types of genetic variation occur in populations? Major/minor
How can we obtain empirical estimates of the amounts of variation in populations?

Polymorphism(*P*) refers to the proportion of gene loci that are polymorphic.
Heterozygosity (*H*) refers to the average frequency of heterozygous individuals per gene locus

Processes that influence patterns of genetic diversity:

1. Mutation: ultimate source of genetic variation and it's caused by random errors during replication
2. Recombination: introduces new combinations of mutations into a population
3. Random genetic drift: random events shrink a population and by chance some of the genetic variation is lost
4. Natural selection:
    a. Purifying (negative) selection removes mutations that reduce fitness
    b. Positive selection leads to adaptation and the enhancing mutation is spread
    c. Balancing selection: natural selection maintains diversity

Diverse mechanisms maintain genetic variation within population:

1. Mutation-selection balance
    - Less fit genotypes maintained by repeated mutation
    - Mutation rate that is bringing in diversity and strength of selection that is eliminating bad alleles
2. Different selective forces
    - Variation that is maintained because of differences in fitness between the alleles that are consider in a polymorphic gene
    - Heterozygote advantage; the heterozygote has better fitness and thus that variability will be maintain but the heterozygote can't be fixed because heterozygote also gives the possibility of homozygotes
    - frequency-dependent selection; sex is a polymorphism of two phenotypes, the selection that varies depending on the frequency of each phenotypes with no constant fitness. The fitness of each type is dependent on their frequency in their population. The minority has the better fitness until equilibrium is reached and there is a 0.5 frequency for both sex maximizing both fitness.
    - spatial and temporal heterogeneity affect selection as fitness in different space and time.
3. Variation selectively neutral
    - Alleles at polymorphic loci do not differ in fitness hence none eliminated by selection

Early evidence for the existence of genetic variation:
Selection experiments on quantitative traits in different groups of organisms. This involves controlled breeding and selection of individuals for many generations. This is how breed would attempt to create a better crop or organism with better yield. This is artificial selection.

Artificial selection & fruit fly:
Breeding the top 5% of fruits flies with the most bristle. After many generations for artificial selection, the resulting fruit flies have significantly more bristles. The trait is enforced over, however if selection is set back to controlled/random, the progression of the bristles is reversed. The amount seems to return to the distribution before the experiment as if that is the optimum that the species is best fitted for.

Artificial selection with maize with periods of relaxed selection and intense selection, it is shown that there is genetic variability as the selection could be dynamic.

Artificial selection for large and small flowers in a wild population of monkey flowers with a normal distribution of flower size.

Variation at the population level is enough to produce speciation if the selected trait is favoured by evolution.

Selection responses demonstrate that abundant genetic variation exists for polygenic traits. But no information on key population genetic parameters (*P, H*), also comparative studies are difficult as traits studied are often group specific.

Looking at enzyme and protein variability allow us to test and compare the genetic variability across species.

How two schools differed in their predictions on how much genetic variation occurs in natural populations.

Classical school: Morgan & Muller, lab mutants (fruit flies), high homozygosity, low polymorphism, wild types is the best fittest genotype; purifying selection reduces diversity by taking out anything that is not the wild type

Balance school: Ford & Dobzhansky, natural populations, low homozygosity, high polymorphism, no best or ideal genotype as situation varies; balancing selection favours diversity

Lewontin and the electrophoresis revolution:
What proportion of genes are variable (polymorphic)?
Large scale surveys of electrophoretic variation in enzymes and proteins in diverse organisms proved that first empirical evidence supporting the balance school.

Tests showing monomorphic gene result can determine the gene loci to be invariant.
Protein electrophoresis showing polymorphic gene shows that the loci is variable.
Generalists have high variability, while specialists have low genetic variability.

Advantages of studies of enzyme polymorphism:
- Many loci can be examined
- Can be used I nearly any organism
- Loci co-dominant, heterozygotes can be identified from dominant homozygote
- Variation examined close to DNA level
- Provides genetic marker loci for other studies

The studies suggest that this enzyme variation is largely neutral or nearly neutral (not under selection) which does not help to study adaptability; studies of quantitative inheritance are necessary to find out how much variation occurs for ecologically-relevant traits that affects fitness.

What is the genetic basis for rarity/ extinction? It is found that there is contrasting levels of polymorphism in rare vs. widespread plants species. This indicates that rare species have low genetic diversity.

DNA sequencing allows difference between individuals in single nucleotides to be identified.
SNP's = single nucleotide polymorphisms, which can be measured for thousands of genes.

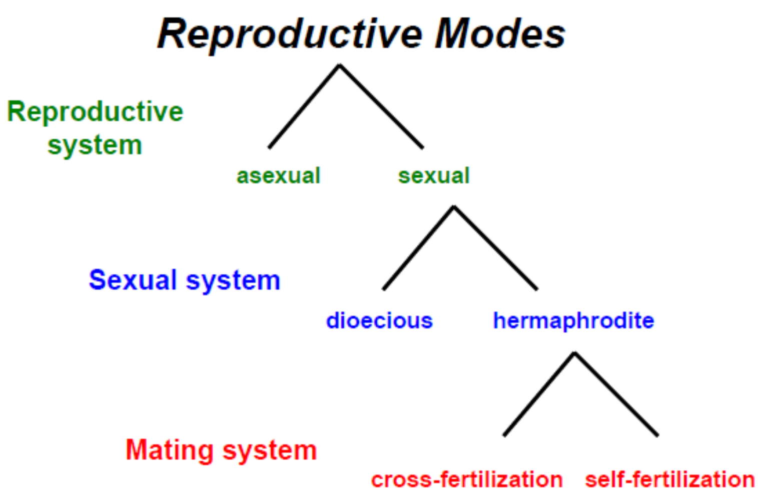
The human genome project:
There is no single "human genome", individuals differ by thousands of SNP's in their genome sequence.

<u>LECTURE SEVENTEEN</u>

Chapter 8

Chapter C6

Lecture Notes



Why did sex evolve?

Water fleas have different reproductive systems occurring in different environment. Sexuals in warmer, turbulent water. Asexuals in cooler, calm water. There is an ecological relationship between the way they reproduce and their environment.

Many perennial plants reproduce through both sexual and clonal reproduction (water hyacinth). It also has a relationship with its surroundings as it only flowers with soil.

"The paradox of sex", benefits of sex? Why did sexual reproduction evolved from asexual reproduction? There must have been a period where sexuals were invading the asexuals.

Sex is costly:

- Time and E to find and attract mates
- Increased energetic costs
- rick of predation and infection during sexual period
- cost of producing males
- 50% less genetic transmission; why break up adaptive gene combination of supreme fitness with someone's less impressive fitness?

Canadian researchers: Otto, Agrawal, Bell

Advantage of a gene for asexuality:
All things being equal a population of asexual will increases at twice the rate because of the 'cost of producing males'. (Fisher) A sexual female contributes only half of her genes to the next generation compared with an asexual female. There is a transmission bias favouring asexuals.

Hypotheses for the advantages of sex:
Sex has a long term benefit of bringing together favourable mutations. Sex has a faster selection and can eliminates bad gens and gathers good gene better.
It also offers short term benefit of genetic variation in variable environment (lottery model).

- 'Tangled Bank hypothesis' – spatially heterogeneous environments
    - Becks & Agrawal; sex declined rapidly in homogenous environments but persisted at a much higher level wit spatial heterogeneity
- 'Red Queen hypothesis' – temporally heterogeneous environments
    - Snail

Evolutionary history of asexuality:
Asexuality (parthenogenesis) is sporadically distributed across the animal kingdom; more common in invertebrates but rare in vertebrates.
Clonal propagation is much more common in plants although few species (if any)are exclusively asexual.

Asexual species are usually at the tips of phylogenies; their long term evolutionary potential is probably low due to lack of genetic variation.

Bdelloid rotifers is a rare case of ancient asexuality in which males are unknown but diversification has led to more than 300 species. It should be extinct but it manages to branch out by itself.

Two fundamentally different sexual systems:

1. Separate sexes (dioecy) with females and males enforcing obligate outbreeding- most animals, espically vertebrates.
2. Combined sexes (hermaphroditism) providing opportunities for diverse patterns of mating- most plants (some plants F, M, H co-oocur). Twice the genetic transmission as the paternal and maternal parent.

Outbreeding has mates less closely related than random. Advantage variation of genes for greater diversity.

Inbreeding has mates more closely related than random. Inbreeding cause genotypic frequencies to change while the allele frequencies stay the same. Heterozygosity is reduced by 50% per generation with self-fertilization. Homozygosity for deleterious recessive alleles results. The closer the relation of the partner, heterozygosity decreases at different rate. Self- fertilization has the biggest rate of decline.

Inbreeding depression:
The reduction in fitness of inbred offspring in comparison with outcrossed offspring is manifested by reductions in viability and fertility. Strong inbreeding depression favours survival of outbred offspring this favouring outcrossed mating systems.

Lily flowers are hermaphroditic. It stops inbreeding my recognizing self-tissue and reject its own pollen. 50% of plants have this mechanism. Dioecy only occurs in 7% of flowering plants.

Sexual selection results in gender dimosphism in plant also. Extravagant features on male attract pollinators. Female save E for maintaining fruit.

Water hyacinth populations from Brazil are mostly outcrossing and visited by long-tongued bees although selfing forms do occur. Jamaican and Cuban populations are selfers. Their selfing is an adaptation because they don't have pollinator. Long distance dispersal favours selfing forms because a single individual can start a colony without mates or pollinators, this is known as Baker's Law and it applies to the water hyacinth. For the Jamacian populations, selfing is beneficial as although it's less fit.

	Outcrosser	Selfer
Seed	1	2
Pollen	1	1
Total Gene Copies	2	3 Selfing forn transmissic

Fisher:
An outcrosser delivers one copy of its gene in pollens and another in seeds, with total gene copies of two. A selfer will have two copies of its gene from being both parental sources, along with the gene copy in pollen left over for others, there is a total gene copy of three. This is the empirical evidence of the transmission bias selfers have against outcrosser.

LECTURE EIGHTEEN

Lecture Notes

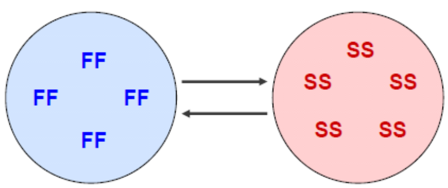
The Fisher- Wright debate:
Wright saw an important role for population structure and genetic drift in evolution.
Fisher disagreed and argued that most evolution occurred in large population by natural selection.

Gene flow is the movement of genes from one population to another.

Human population differentiation:
93-95% of genetic variation occurs within populations; population are not strongly differentiated. This is a general pattern for most of the genome.

The two forces that can increase differentiation of populations: genetic drift, & natural selection
Extensive gene flow between populations prevents strong differentiation from occurring.

Gene flow is head to observe and measure. We need to distinguish between potential and actual flow. Whether it would travel in the form of gamete or individuals. Experimental approach with genetic markers is the best way to measure gene flow. A genetic maker is a polymorphic neutral genetic variation used to study population processes affecting genetic diversity.



- Score heterozygotes FS in offspring

The frequency of the maker heterozygotes would correspond to an estimate of gene flow. The possibility that a mutation produce a heterozygote is negligible.

Gene flow could be asymmetrical between populations. For example, wind flowing N. cause more gene flow to the N. population.

Escape of transgenes into wild relative by gene flow. Gene from recombinant DNA could be transfer into the wild. Many crops have close relatives with which they are inter-fertile. Hybridization between crops and related weeds is well documented. [Gene flow between crop and weed sunflowers. Most gene flow occurs over a short distance, but a small amount still occurs as far as 1km.]

Risk assessment:

- Proximity of wild relatives
- Pollination system- wind vs. animal
- Mating system- selfer vs. outcrosser

High risk: wind pollinated outcrosser with relatives nearby

Low risk: selfer with no relatives nearby

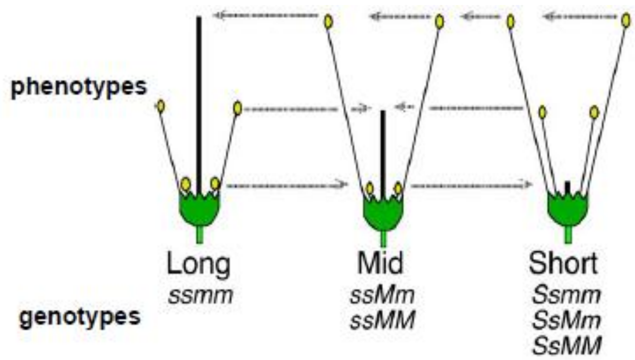
Stochastic evolutionary forces: Mutation, Recombination, Gene flow, Genetic drift
Determinisitc evolutionary force: Natural selection

Genetic drift: stochastic change in allele frequency due to random variation in fecundity and mortality; most imporatnt when populations are small (bottleneck, founder event)

Population bottleneck: a single sharp reduction in numbers causing a loss of diversity

Founder evetns: colonization by a few individiuals that start a new population with only limited diversity compared with the source population

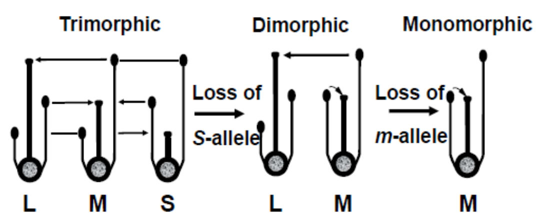
Can genetic drift be important for adaptation?



Epistasis: interaction between alleles at different loci affecting phenotype

- Fisher
- Mating only between morphs (disassortative mating)
- Rare morph enjoys fitness nenefit
- 1:1:1 morph frequencies at equilibrium
- Polymorphism maintedn by frequency-dependent selection

Evolutionary breakdown of tristyle:
Genetic drift would affect the the allele of the least frequency. The S allele would be most affected and the short styly would correspond and also decline in frequency. Now a trimorphic population has evolved to a dimorphic one.



Evolution of selfing from outcrossing:
As a smaller dimorphic popualtion, the middle styly adapt to selfing. Selfing lead to increaes homozygosity and eventually leads to the loss of the m allele. Without the m allele, the long styly diappear and the population is now a selfing monomorphic population.

Joint action of genetic drift and natural selection results in evolution of selfing from outcrossing

<u>LECTURE NINETEEN</u>

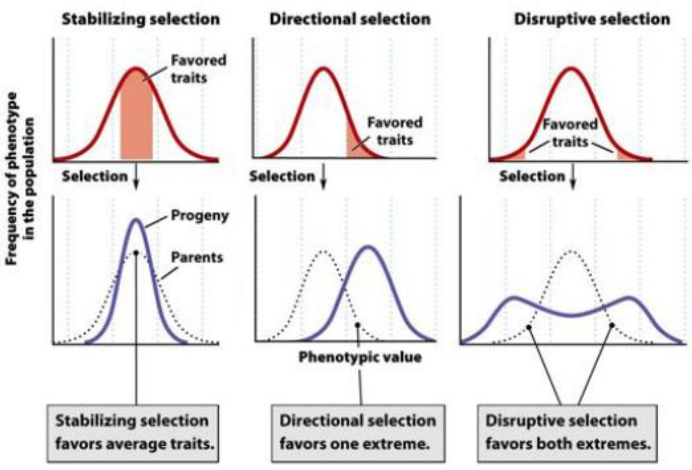
Chapter C5

Lecture Notes

Darwin predicted, looking at the Madagascar orchid with long floral tube, that there should be a nigth-flying moth with exceptionally long proboscis. The moth was found a century later and it is a exmple of co-evolution as the orchid has no other pollinator.

Artificial selection has a purpose directed by humans dealing with domesticated plant and animals. Natural selection has no purpose. It is a blind mechanistic process all organism experiece and it is directed by the environment.

Many phenotypic traits (quantitative inheritance) show continuous distrubutions (bell curve).



Three types of natural selection on quantitave trait: Stabilizing, directional, and disruptive

Stabilizing selection: the mean does not change, however it is more favored. (Human birth weight)

Directional selection: the favoured trait in on one end of the bell curve and the curve shift. (beak size in Galapagos finches; decrese population and seed abundance, average beak size increase for harder seeds)

Disruptive selection: it is not common and it favors both extremes and give us two peaks in the graph. (beak size in Africa finches, soft seeds adapted beaks and hard seeds adapted beaks)
Disruption selection can leads to character divergence and in some case may lead to speciation. This would require spatial heterogeneity and discrete resources.

Climate change is likely to impose directional selection on the traits of many seasonal species. Great tit populations lay eggs earlier in the season due to warmer springs. However, there is not varied genetic involved in this change, thus the change are due to adaptive plasticity instead.

Evolution of cyanide resistance:
Population starts out with few cyanide-resistant individual then through natural selection imposed by cyanide fumigation, generations later, their genes increase in proportion over time.

Evolution of industrial melanism in the peppered moth:
Industrial pollution blackened tree trunks near cities resulting in increase in black form. Black variant replaces white forms in polluted area; white form predominates in rural unpolluted area as always.
Mechanism of selection thought to be predation by birds and difference in crypsis(camouflage) depending on the background of tree trunks.
Ford recruits Kettlewell to investigate the bird predation hypothesis. Their findings were thought to provide the first demonstration of the mechanism of natural selection in the wild.
However, doubts raised as the moths were raised and put in unnatural situations (day, high densities, uncommon site, and bat predation).
Decline in black forms concise with the introduction of the ‘Clean Air Act’.
Majerus studies support Kettlewell with much more sophisticated data however the conclusion is still not absolute.

Hoekstra and the mouse coat colour polymorphism in contrasting habitats maintained by avian predators. Similar situation as the peppered moths.

Evolution of heavy-metal tolerance in grass species:
Mine waste heavily polluted with heavy metals. Bradshaw observed tolerant genotypes invade mine tailings from nearby pastures. Gene flow between pasture and mine is restricted because of flowering

time difference between mine and pasture. The tolerance gene is not diluted and maintained on mines. Heavy metal tolerance in plants has evolved independently in many geographical areas.
Heavy metal tolerant genotypes occur at very low frequency in uncontaminated areas but the origin is unconcluded. The tolerant gene does not spread in pasture because the detoxifying process cost the plant to become poor competitor.

'Experimental evolution':
Lenski is the founder of experimental evolution. A single strain of E.coli is propagated to 42,000 generations of serial culture. All populations rapidly increased in fitness with similar adaptions across strains. There are parallel mutations at the same time, and some unique adaptation and distinct genetic changes. A rare novel key innovation mutation in single strain is found after 33000 generation with only beneficial effect.

LECTURE TWENTY

Chapter C7

Lecture Notes

Speciation authorities: Schluter & Coyne
"Speciation" by Coyne & Orr

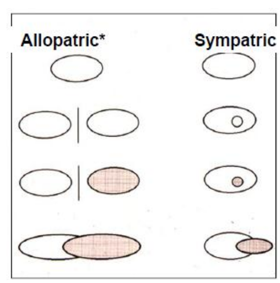
There is no universal species concept
Two main species concepts:

1. Taxonomic/ morphological is based primarily on distinct morphological differences which lost its popularity as it is quite arbitrary.
2. Biological is based on inter-fertility among individuals

Although Mayr first formally defined the biological species concept, Dobzhansky first suggested the idea.

Two main modes of speciation:

1. Allopatric or the theory of geographic speciation as geographical isolation is involved; common (secondary contact)
2. Sympatric controversial and rare for animal speciation as there should be gene flow that prevent this; coyne's criticism argue that it could be secondary contact instead



Allopatric speciation: Californian salamander has seven subspecies.

Reproductive isolation can occur at all stages of reproduction from find mates to fertility of offspring.
Premating isolation:

- Preventing zygote formation (geographical, ecological, temporal, behavioural, mechanical)
  - Apple maggot flies' sympatric speciation: host shift to apple tree brought about restricted hybridization and gene flow is reduced to 6%
  - Schemske's monkey flowers: preference for bumblebees at lower altitude, preference for hummingbirds at higher altitude; hybrids show a wide range of character combinations but are rare

Postmating isolation:

- Preventing the proper functioning of zygotes once they formed (inviability, sterility, abnormal development of hybrids, hybrid F_2 breakdown (sterility, lethality))
    - Intrinsic postmating isolation: mule is sterile hybrid from a male donkey and a female horse
    - Extrinsic postzygotic isolation: low fitness of hybrids generates narrow 'hybrid zone' where species meet and do not spread (European crow species)

Is the evolution of adaptation required for speciation?
In many cases, the evolution of local adaptation is a result of divergent selection leading to reproductive isolation and speciation. This is commonly referred to as 'ecological speciation' and much current research focuses on determining the mechanism of selection and identifying 'speciation gene'.

Schluter's study on adaptation to freshwater in 3-spined stickleback involves loss of bony defensive armour. Eda is the key gene for the body armour, however freezing is a more series threat than predatation. The freshwater stickleback loss of plates increases growth rate and helps fish to survive wainter and breed later.

Adaptive radiation is the evolution from a single common ancestor to an array of species that exploit different range of habitats and resources.
The cause of radiation:

1. Ecological opportunity: the opportunity of empty niches with few competitors (African rift lakes)
2. High rates of speciation characterize the clade: some species are more prone to speciation (Darwin's finches, Hawaiian honeycreepers [not so much on mainland], vs. Galapagos mockingbirds that have more radiated much on mainland or islands)
3. Origin of a key innovation: being able to fly with open more opportunities for speciation

Hybridization is the exchaneg of genes between species as a result of occasional inter-specific mating. It can result in complex pattern of variation and is more common in plants and fish, while it is rare in mammals. Variation can be of evolutionary significance resulting in speciation, espically by polyploidy.

Polyploidy:
an organism, tissue, or cell wih more than two complete sets of homologous chromoes. Conditions range from autopolyploidy (AAAA) to allopolyploidy (AABB). Allopolyploidy arises from hybridization and is the commonest type. Even-ploids are fertile.

Evolutionary significance of polyploidy:
Polyploids reproductively isolated from their diploid parents hence a form of sympatric speciation. It exhibit novel phenotypes allowing exploitation of new habitats. Hybrid strength evident due to heterozygosity. Approximately half of all flowering plants are of polyploidy origin including many crops plants and invasive species (bread wheat).

Abbott's observed three new species radiate from polyploidy from two species.

<u>LECTURE TWENTYONE</u>

Lecture Notes

Linnaeus is the 'father' of taxonomy:
Binomial nomenclature & hierarchical system of classification

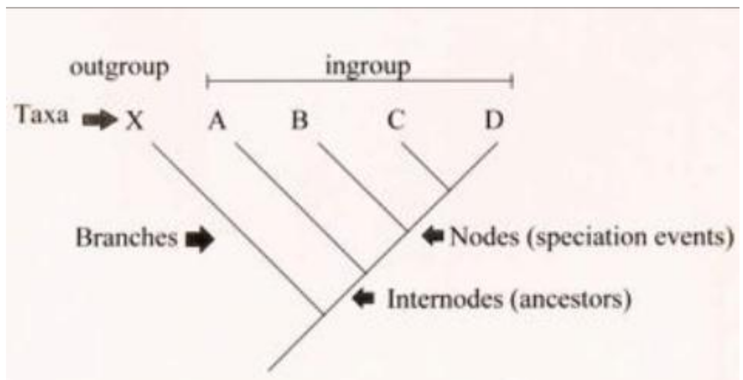
kingdoms
phyla
classes
orders
families
genera
species

Taxon: a named taxonomic unit at any level
Taxonomy: the theory and practice of classification
Systematics: the study of biodiversity and the evolutionary relationship among organisms

Schools of taxonomy:
Phenetics classifies species based solely on overall resemblance, and it is now large dead as it was arbitrary.
Cladistics classifies species on the basis of their phylogenetic relationships.

Willi Hennig:
The birth of cladistics and the building of phylogenetic tress, which provide a depiction of the evolutionary relationships among groups of organisms- important to appreciate they are a hypothesis.

Phylogenetic tree:
Monophyletic group is a single ancestor gave rise to all species in that taxon and no species in any other taxon.
Monophyletic classifications are much preferred.



Non-monophyletic group is a taxon whose members are derived from two or more ancestral forms not common to all members.

Homology refers to the similarity of traits due to shared ancestry.
Ancestral trait is a trait shared with a common ancestor. (Human & fish skeletons)

Homoplasy refers to similiarty of traits as a result of convergent evolution.
Derived trait is a trait that differs from the ancestral trait in a lineage.

Convergent Evolution is the evolution of structures that resemble one another and perform similar functional roles due to the shared ecology of unrelated organisms.
Succulence & spiny growth form in desert environment: the Cactus family is restricted to the New World and are not succulence vs. the Spurge family and Milkweed family in the Old World.

Cichlid fish in Great African lakes:
The lakes have experienced independent radiation producing striking arrays of eco-morphological diversity. (scrapers, egg predators, etc.).
The lakes have also experienced convergent evolutions as there are similarities in feeding strategies from the independent radiation.

Species can be asseseed for change in the sequence of nucleotides.
DNA sequencing in enabling rapid construction of the tree of life.

W. Maddison and D. Maddison: Tree of life project

Key innovations speeds up diversity:
Origin of a novel trait resulting in adaptive radiation.
Carriers of the trait can exploit new resources or sets of habitats.
Usually associated with rapid evolutionary diversification.

Nature paper on columbines:

- 16 fold variation in nectar spur length among species
- 7 independent pollinator shifts
- Clear directionality in spur length evolution with no evidence of reversal to shorter spurs
- Pollinator shifts associated with speciation event due to premating isolation

Sexual conflict and the arms race in water striders:
in striders the optimal mating rate is lower for females than males, thus females tend to resist most mating attempts by males. Males have evolved grasping structures to overcome resistance. Females also evolve behaviour to aid in resisting. This antagonistic co-evolution has the potential to escalate like an arms race. An arm race predicts escalation gain of armaments over loss across evolutionary time.

LECTURE TWENTYTWO

Chapter 26

Lecture Notes

Lantana camara invasions in India threaten Tiger habitat affecting mating process.

Cane toad invasion of Tropical Australia was not successful in reducing cane beetles. The toads multiplied prolifically and reducing biodiversity, especially reptiles.

Introduction of the Nile Perch to African Lakes has resulted in the extinction of endemic cichlid fish species.

'Asian Carp' invaded the Mississippian and estimated $30 million was spent in 2010 to prevent the species invading the Great Lakes.

Brown tree snake invasion on Guam have devastated forests and cause much human trauma.

The global expansion of a single ant super colony in the case of the Argentina ant.

Biological invasions are successful establishment of a species in a region not previously occupied followed by rapid range expansion. Mostly harmful.
Alien = adventive = exotic = introduced

Negative consequence:
Dirsrupt ecological processes in natural plant and animal communities.
Displace native species leading to their extinction.
Adverse effects on human health.
Serious economic and social impacts through reduction of yields.

Enemy release hypothesis: native range has competitions that keep the alien species in check, their fitness is increased significantly in introduced range without the normal enemy

Invasive species thrive in disturbed sites. The more disturbances the more vulnerable to invasion as there are less competition to battle. (pampas grass invasion along fire trail)

Common attributes of successful invasion species:

- Rapid development to reproduction

- High reproductive output
- Well-developed dispersal mechanisms
- Broad ecological tolerance
- High phenotypic plasticity

Evolution in invasive species of agriculture:
Selection of barnyard grass plants that mimic cultivated rice; weeds that look more like the crop escape detection inadvertently selecting for mimicry.
Selection of herbicide resistant weed species; increasing amount of resistant weeds worldwide

Zebra mussel invasion in the Great Lakes:
Extensive damage to water intake pipes and commercial and sport fisheries. They improve water quality being filter feeders but it is also a source of avian botulism leading to death of many birds.

Purple loosestrife in Ontario:
Plants competitive with high phenotypic plasticity, produce millions of small, easily dispersed seeds with high viability. Populations genetically diverse due to multiply introductions, outbreeding and polyploidy; provides opportunities for rapid evolution of local adaptation. Flowering time should correlates with latitudinal gradient of seasonality as evidence of adaptation.

Water hyacinth native to lowland South America but now worldwide in tropical and warm temperate regions. Highly colonial species with a strong genetic bottleneck.

Kariba weed is a floating fern that is genetically sterile.

Biological control of invaders: the planned introduction of natural enemies to control unwanted populations of invaders in alien range. Asexual species are easier to control as there are less genetic diversity and thus less chance to evolve resistance.

LECTURE TWENTYTHREE

Lecture Notes

How organisms are responding to climate change:
Migrate to more favourable environmental condition.
Adapt to changing environmental conditions.
Go extinct.

Drought has shortened the growing season in S. California. There has been a directional selection on flowering time. Earlier flowering plants set more seed than later flowering plants. From the resurrection paradigm, the earlier flowering is a genetic change.

Wilson, biodiversity leading figure: the loss of biodiversity is the only process that is wholly irreversible.

Keeling; Keeling curve measures the progressive buildup of CO_2 in the atmosphere

Tillman, The Cedar Creek Experiment: biodiversity results in resistance to environmental perturbation and greater productivity; higher species richness retained more of their biomass after drought, plant biomass was highest in plots with more plant guilds.

Extinction is natural but its current rate is not. During the past century massive habitat destruction, particularly in tropical regions, has increased rates of extinction. Studies of the causes of extinction require demographic and genetic investigations on the cause of rarity.

Three types of extinction:

1. Background extinction: turnover of species at a low rate, a natural feature of ecosystem; ~1 species per year
2. Mass extinction: very large number of extinction due to natural catastrophes
3. Anthropogenic extinction: caused by human, ~4-6000 species per year

Major cause of extinction now: Habitat destruction, overexploitation of species, introduction of competitions (not climate change is a big issue yet)

Conservation biology is the study of those species, ecological communities and ecosystems that are being negatively affected by human activities. It provides the biological concepts and tools for preserving biodiversity and ecosystem function. It has a core ecological and genetic framework.

Issues in conservation biology:
Community-level studies:

- Habitat preservation and the maintenance of species diversity
- Application of island biogeographic theory of design of nature reserves
- SLOSS: single large vs. several small
- Single large is better but several small are more manageable but we do not have isolated small islands, we can corridors between those reserves to preserve diversity

Studies of individual species:

- Effects of habitat fragmentation on population ecology and demography; species like to be in large fragment to breed (golden lion tamarin in Brazil)
- Keystone species that play an enormous role in an ecosystem; they should be more cared for (beaver, fig tree)
- Minimum viable population (MVP)size; the number of individuals necessary for a species to maintain or increase its number in a region, no single number for all species

The maintenance of genetic diversity in rare and endangered species:

- Relationship between heterozygosity and fitness;
- Preventing inbreeding and inbreeding depression
- Reducing the stochastic loss of genetic diversity from small populations; loss of heterozygosity, inbreeding depression and fixation of deleterious genes
- Cheetah; restricted to two wild populations in S. & E. Africa, a survey of 52 enzyme loci indicated complete monomorpism compared to the other cats that have 8-24% of loci that are polymorphic. The species has high juvenile mortality and low spermatozoal counts suggesting inbreeding depression. It has been proposed that low genetic variation results from an historical bottleneck in population size.

Nikolai Vavilov, Russian crop geneticist and founder of crop genetic resource conservation