

자연지리학개론

final

지리학과 2020-17530 곽지호

# 1. Essentials of Geography

## 1.1. The Science of Geography

### # What is Geography?

-The science that studies the relationships among

- natural systems
- geographic areas
- society
- cultural activities

-and the interdependence of all of these over space: 공간이라는 렌즈를 끼고 바라보는 것

### # Five Spatial Themes

- ① Location: absolute and relative
- ② Region: areas having uniform characteristics
- ③ Human-Earth Relationships: human impact and management
- ④ Movement: interdependence across Earth's surface
- ⑤ Place: unique due to (in)tangible (non)living components

### # The Content of Geography

-종합과학으로서의 지리학: synthetic, holistic view

### # What is then Physical Geography?

-The spatial exploration of all the physical elements and processes that make up the environment

-energy, air, water, weather, climate, ...

## 1.2. Earth System Concepts

### # Systems Approach in Physical Geography

-Physical geography considers the Earth as a set of interrelated systems using an approach called systems analysis

|               |                                                                                                                                                                                  |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| system        | -any ordered, interrelated set of things<br>-linked by flows of energy and matter<br>-distinct from the surrounding environment outside the system                               |
| open system   | -a system that exchanges energy and matter with the surrounding environment outside it<br>-energy and matter are not self-contained<br>예 plant photosynthesis, plant respiration |
| closed system | -A system isolated from the surrounding environment<br>-Energy and matter are self contained<br>☞ rarely found in nature<br>예 Earth in terms of physical matter and resources    |

### # Feedback

-As a system operates, it produces feedback that influences its own operations

|                               |                                                                                                                                                                                                                                       |
|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Negative Feedback<br>(음의 되먹임) | -opposing response to changes in the input of the system<br>-attenuation of such changes<br>-continuation of system stability (steady-state equilibrium)<br>-self-regulation, homeostasis (항상성)<br>예 운동 ☞ 열이 발생 ☞ 땀을 흘림 ☞ equilibrium |
|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

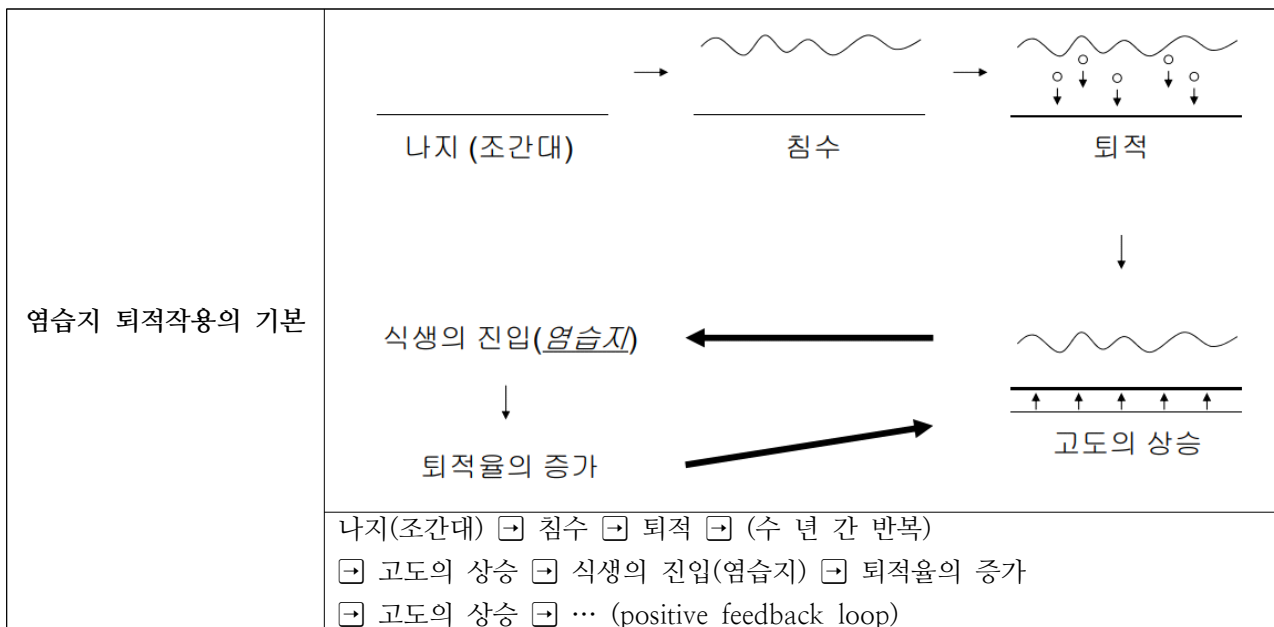
|                               |                                                                                                                                                                      |
|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Positive Feedback<br>(양의 되먹임) | -response to changes in the input in the same direction<br>-amplification of such changes<br>-system instability<br>예) 소규모의 산불 → production of more fuel → 더 큰 불로 증폭 |
|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|

-positive feedback: burn fossil fuels → release carbon dioxide → warm the atmosphere → oceans release more carbon dioxide → warm the atmosphere

-negative feedback: increased carbon dioxide → increased plant growth → removes carbon dioxide → cool the atmosphere

-positive feedback: 지구온난화 → 영구동토층 녹음 → 메테인 가스 유출 → 대기 온도 상승 → 해빙 용해 가속화

## ## Feedback Mechanisms in Salt Marshes



-pioneer species(염습지 선구 종): spartina (경쟁력은 낮지만 침수 stress에 강함)

-식생의 진입으로 유속이 감소, 부유물 포집 및 뿌리 주변으로 고착화되어 퇴적을 증가

-고도 상승률에 크게 기여

-고도가 해수면과 같아질 경우: 침수가 발생하지 않음 → 퇴적을 감소 → negative feedback?

|                    |                                                                                                                                                                                    |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| succession<br>(천이) | spartina의 진입 → 죽으면서 유기물 형성, 고도 상승, 침수 stress 감소(spartina의 facilitation)<br>→ 후기 천이종의 진입 → spartina가 바다쪽으로 밀려나게 됨(or 아예 배제되기도, out-competed, competitive exclusion → 국지적 공간적 변이 발생) |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## 1.3. Location and Time on Earth

### # Latitude

-angular distance N/S of the equator(기준점)

-vary from 0~90° N/S of the equator

-parallel(위선): a connection of all points along the same latitude

-latitudinal geographic zones(북반구 기준)

| arctic     | subarctic   | midlatitude | subtropical | equatorial. tropical |
|------------|-------------|-------------|-------------|----------------------|
| 66.5° ~ 북극 | 55° ~ 66.5° | 35 ~ 55°    | 23.5° ~ 35° | 23.5° ~ 적도           |

- 위도에 따라 에너지 분포 달라짐 → 공간적 변이 → 종 다양성... etc

### # Longitude

- angular distance W/E of the reference location(기준점 필요 → 그리니치 천문대)
- runs north and south
- meridian(경선): a connection of all points along the same longitude
- distance between  $1^\circ$  : 69.2 mi(111km) at the equator, 0 mi at the poles
- reference meridian(Prime meridian)  $0^\circ$  runs through the Royal Observatory in Greenwich, England
- sun travel 15 degrees every hour

## 2. Solar Energy to Earth and the Seasons

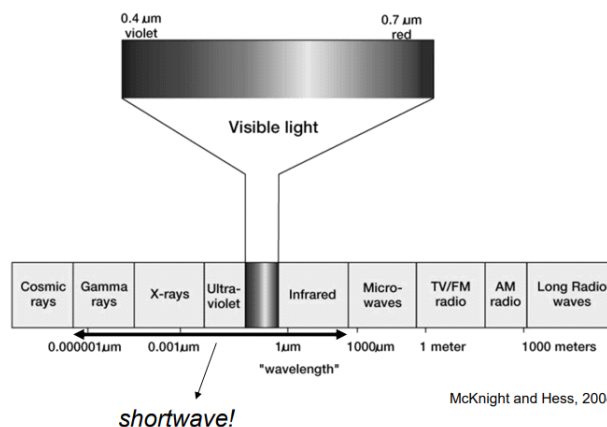
### 2.1. Solar Energy: From Sun to Earth

#### # Earth-Sun Relationship

- Why is this important?
- Sun is the ultimate energy source for most life processes on Earth
- Sun is one of the most important controls on climate
- Solar energy input + Earth's tilt and rotation = patterns of changing day length and sun angle

#### # Solar Energy

- electromagnetic wave(전자기파)
- wavelength(파장): the distance between corresponding points on any two successive waves
- frequency(빈도): the number of waves passing a fixed point in 1 second
- electromagnetic spectrum
- 47% visible / 45% infrared / 8% gamma, X-ray, ultraviolet



- 태양 복사 에너지는 단파 에너지
- Wien's Displacement Law(빈 변위 법칙): "the hotter an object, the shorter its wavelengths emitted"
- Sun → shortwave radiation
- Earth → longwave radiation
- 모든 물체는 에너지를 발산함 → 표면 온도의 차이는 곧 에너지의 차이를 의미

#### # Earth's Energy Budget(Energy Balance)

- insolation(일사): solar radiation that reaches a horizontal plane at Earth
- uneven distribution of insolation(· 지구가 평평하지 않음): 적도가 극지방에 비해 연평균 2.5배 더 많은 에너지를 받음
- angle of incidence(입사각): the angle at which light is striking a surface
- 낮은 입사각 → 일사량이 도달하는 표면적이 넓어짐

## 2.2. The Seasons

### # Seasonality

-angle of insolation → daylength의 변이: midnight sunshine or 24 hrs darkness

-reason for 시간적 변이

|            |                                                                                              |
|------------|----------------------------------------------------------------------------------------------|
| revolution | -원일점(7월 4일)과 근일점(1월 3일)                                                                      |
| axial tilt | -23.5° 기울어진 채로 공전하기 때문(결정적)<br>-23.5° N/S → 북회귀선(Tropic of Cncer), 남회귀선(Tropic of Capricorn) |

-계절에 따른 일사량의 변화

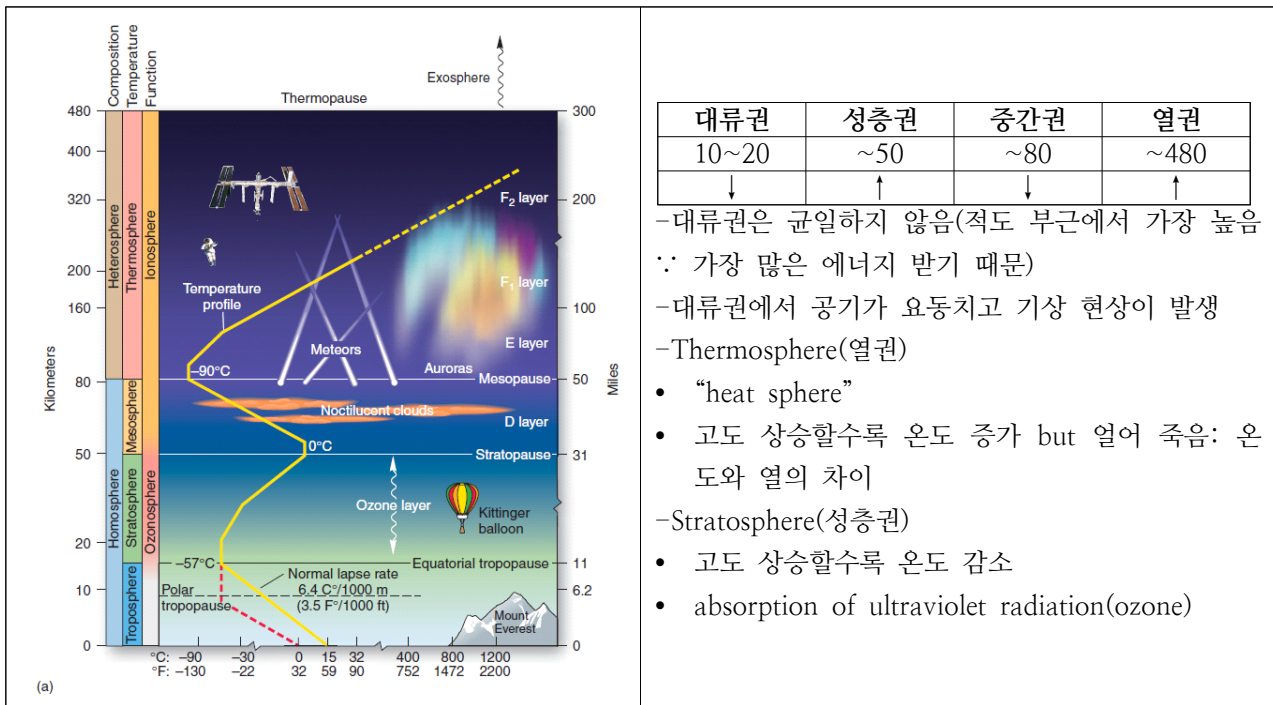
|                      | June Solstice                  | December Solstice              | March Equinox      | September Equinox  |
|----------------------|--------------------------------|--------------------------------|--------------------|--------------------|
| Arctic Circle        | -24 hrs of daylight / darkness | -24 hrs of daylight / darkness | 12 hrs of daylight | 12 hrs of daylight |
| 12 hours of daylight | Equator                        | Equator                        | all loccations     | all locations      |
| vertical ray         | Tropic of Cancer               | Tropic of Capricorn            | Equator            | Equator            |

## 3. Earth's Modern Atmosphere

### 3.1. Atmospheric Composition, Temperature, and Function

#### # Atmospheric Temperature Criterion

-기온을 기준으로 대기권을 구분



#### # Atmospheric Function Criterion

-오존권(19~50km)

- removal of harmful wavelengths and particles
- absorbs UV energy and converts it to heat energy

|                     |                                                                                                                 |
|---------------------|-----------------------------------------------------------------------------------------------------------------|
| Stratospheric Ozone | -the ozone layer<br>-contains 90% of atmospheric ozone<br>-beneficial role: acts as primary UV radiation shield |
|---------------------|-----------------------------------------------------------------------------------------------------------------|

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                    | -threat to ozone layer <ul style="list-style-type: none"> <li>• very thin layer(3 mm) when compressed to surface pressure</li> <li>• thinning due to CFCs</li> <li>• CFC molecule migrate into the stratosphere → intense UV radiation splits them, freeing chlorine(Cl) atoms</li> </ul> $\text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2$ $\text{ClO} + \text{O}_3 \rightarrow \text{Cl} + 2 \text{O}_2$ <ul style="list-style-type: none"> <li>• concern over ozone hole sparked the Montreal Protocol(1987)</li> </ul> |
| Tropospheric Ozone | -contains 10% of atmospheric ozone<br>-harmful impact: toxic effects on humans and vegetation<br>-“smog” ozone                                                                                                                                                                                                                                                                                                                                                                                                                        |

### 3.2. Variable Atmospheric Components

#### # Anthropogenic Air Pollution

-carbon monoxide, nitrogen oxide, sulfur dioxide, etc → automobiles account for 50 to 60% of all air pollution

-photochemical smog(광화학 스모그)

- NO<sub>2</sub> + 휘발성 VOC 유기화합물 → 오존 생성 → “smog ozone”

#### # Acid Rain

-sulfur and nitrogen (di)oxides + water vapor → acids

-pH

- < 7.0: acidic
- normal precipitation = 5.3~6.0
- rain pH = 2.0 in eastern USA and Europe

-kill fishes, trees, damage soils and buildings

#### # Natural Air Pollution

-sources of natural variable gases and materials

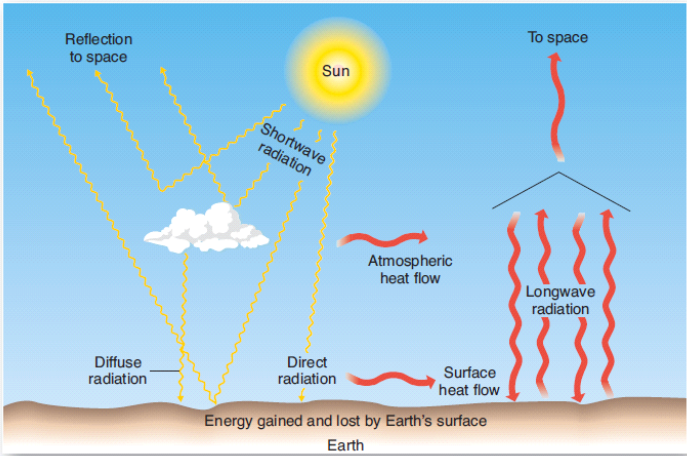
- volcanoes: sulfur oxides, particulates
- forest fires: carbon monoxide and dioxide, nitrogen oxides, particulates
- plantes: hydrocarbons, pollens

## 4. Atmosphere and Surface Energy Balance

### 4.1. Energy Essentials

#### # Energy Pathways

|                                   |                                                                                                                                                                                                                                                                                          |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| transmission<br>(radiation)       | -energy traveling through the atmosphere or water<br>-shortwave radiation → direct radiation → longwave radiation                                                                                                                                                                        |
| scattering<br>(diffuse radiation) | -changing direction of light's movement, without altering its wavelengths<br>-에너지의 고유한 특성은 바뀌지 않음<br>-대기 중의 여러 가지 물질(CO <sub>2</sub> , O <sub>3</sub> , 수증기)FH 인해 방향을 바꾸거나 반사<br>-7% of Earth's albedo(반사시켜 우주로 내보내는 에너지)<br>-Rayleigh Scattering: based on wavelength and particle size |

|                                                                                     |                                                                                                                                                                                                                                                                                                                |
|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                     | <ul style="list-style-type: none"> <li>the shorter the wavelength, the greater the scattering</li> <li>the longer the wavelength, the lesser the scattering</li> <li>석양 때의 붉은 빛(장파) → 산란의 결과(파란 빛은 산란되어 사라짐)</li> <li>저녁에는 대기 중 긴 구간을 통과하기 때문에 산란될 가능성이 더 높음</li> </ul>                                        |
| refraction(굴절)                                                                      | <ul style="list-style-type: none"> <li>-'bending' of insolation</li> <li>-change in speed and direction of light</li> <li>-changing mediums 예) from empty space into atmospheric gases, from air to water → bending different wavelengths to different angles</li> <li>-해가 뜨지 않았는데도 해가 보이는 현상</li> </ul>       |
| reflection(albedo)                                                                  | <ul style="list-style-type: none"> <li>-portion of energy that is not absorbed = reflected amount / total insolation</li> <li>-light surfaces → high albedo</li> <li>-dark surfaces → low albedo</li> <li>fresh snow: 80~95%</li> <li>average: 31%(나머지는 구름, 바다, 지표면에서 흡수)</li> <li>black top: 5~10%</li> </ul> |
|  |                                                                                                                                                                                                                                                                                                                |

#### # Transfer of Heat Energy

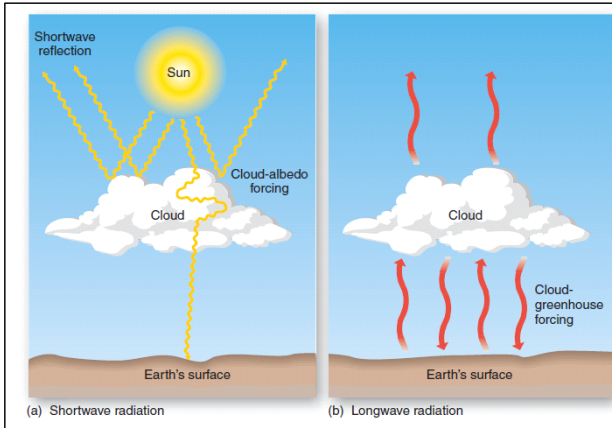
|                |                                                                                                                                                                                                                                                                                                                          |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| conduction(전도) | <ul style="list-style-type: none"> <li>-molecule-to-molecule transfer of heat as it diffuses through a substance</li> <li>-as molecules warm, their vibration increases causing an increased number of collisions that produce motion in neighboring molecules</li> <li>-열을 받음 → 운동 에너지 발생 → 옆의 분자와 충돌 → 열 발생</li> </ul> |
| convection(대류) | <ul style="list-style-type: none"> <li>-transfer of energy by movement of a gas or liquid</li> <li>-in atmospheric sciences, convection often refers to mixing with a strong vertical motion</li> <li>예) atmospheric and oceanic circulations</li> </ul>                                                                 |
| advection(이류)  | <ul style="list-style-type: none"> <li>-lateral(horizontal) movement of energy</li> <li>-대류의 특별한 경우</li> <li>예) advection fog, 불을 쥘 때</li> </ul>                                                                                                                                                                         |

## 4.2. Energy Balance in the Troposphere

### # Greenhouse Effect and Atmospheric Warming

- greenhouse: its glass performs as a one-way filter
- atmosphere does not act exactly as a greenhouse... but
- no trapping but delay in the passage of longwave energy into space

- absorption of longwave by CO<sub>2</sub>, water vapor(가장 핵심적: 에너지 가장 많이 흡수/방출 as 장파), methane, NO<sub>2</sub>, CFC, etc
- reradiation of longwave energy both up/downward → important mechanism for maintaining the warmth of the Earth, 기온이 밤낮으로 급상승/급강하하는 것 방지



-구름에서 에너지 흡수 → 에너지 방출(하늘/땅으로) → reradiation → 밤에도 최소한의 따뜻함 유지 가능

-밤에 구름이 없는 날에 안개가 낄 확률 높은 이유

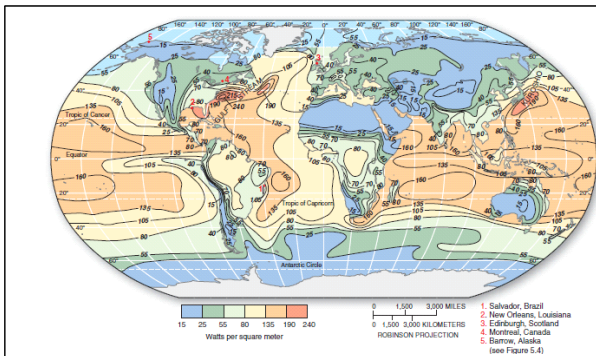
- 지표면의 에너지 전부 방출되어 온도가 이슬점 이하로 내려가면 수증기 응결

### # 잠열과 현열(Latent vs Sensible Heat)

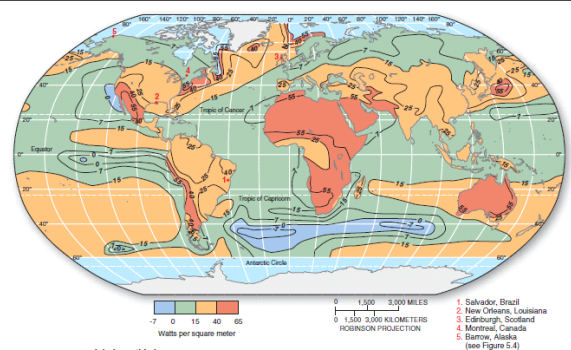
|               |                                                                                                                          |
|---------------|--------------------------------------------------------------------------------------------------------------------------|
| latent heat   | -energy transfer due to evaporation or condensation of water<br>-증발: 열이 기체가 되면서 날아감 → evaporation cooling<br>-응결: 열을 빼앗김 |
| sensible heat | -heat you can sense<br>-a transfer of kinetic energy(molecular motion)<br>-transferred through convection and conduction |

-assume same amount of insolation

- 식생이 많은 지역: 많은 수분을 머금을 수 있음 → latent heat 30, sensible heat 70
- 사막 지역: 수분 거의 없음, 증발 발생하지 않음 → latent heat 1, sensible heat 99
- net radiation = H(sensible heat) + G(ground heating/cooling) + LE(latent heat)



global latent heat of evaporation



global sensible heat

### # Urban Heat Island(도시 열섬 현상)

-a metropolitan area that has higher temperatures than nearby rural areas

-도시 열섬 현상의 원인

- 녹지 부족 → 수분 적음, 잠열 낮고 현열 높음
- albedo 낮음(아스팔트 많음) → 흡수량 증가
- 온실효과 큼(자동차, 건물...)

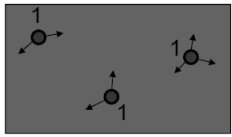
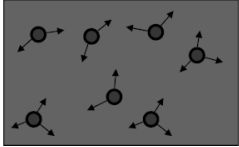
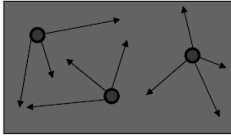
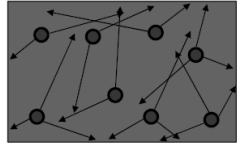
\*albedo로 인한 양의 되먹임: 빙하 녹음 → 알베도 감소 → 열(net radiation) 증가 → 해빙 가속화

## 5. Global Temperatures

## 5.1. Temperature Concepts and Measurement

### # Heat versus Temperature

-kinetic energy: the energy of motion, vibration/movement of molecules

|                |                                                                                                                                                            |                                                                                   |                                                                                    |                                                                                     |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| heat           | -flow of kinetic energy from one object (or system) to another<br>-the total amount of energy possessed by molecules in a piece of matter(분자들의 운동 에너지의 총량) |                                                                                   |                                                                                    |                                                                                     |
| temperature    | -a measure of the average kinetic energy of individual molecules in a matter                                                                               |                                                                                   |                                                                                    |                                                                                     |
|                |                                                                           |  |  |  |
| kinetic energy | low                                                                                                                                                        | low                                                                               | high                                                                               | high                                                                                |
| heat           | low                                                                                                                                                        | higher                                                                            | still low                                                                          | high                                                                                |
| temperature    | low                                                                                                                                                        | low                                                                               | high                                                                               | high                                                                                |

-열권의 온도가 높지만 얼어 죽는 이유

- 공기 분자의 밀도가 아주 낮음(∴ 중력)
- 하지만 태양과 가까우므로 태양복사에너지로 인해 엄청난 운동 에너지 가짐

-대기권에서는 공기 분자의 밀도가 높기 때문에 열 = 온도

### # Basic Heat Definitions

|                       |                                                                                                                                      |
|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| latent heat           | -energy stored or released from phase changes(상변화)<br>-energy transfer due to evaporation or condensation of water                   |
| sensible heat         | -heat you can sense<br>-a transfer of kinetic energy(molecular motion)<br>-transferred through radiation, convection and conduction  |
| specific heat<br>(비열) | -the measure of heat energy required to increase the temperature of a unit quantity of a substance by a certain temperature interval |

## 5.2. Principal Temperature Controls

### # Principal Temperature Controls

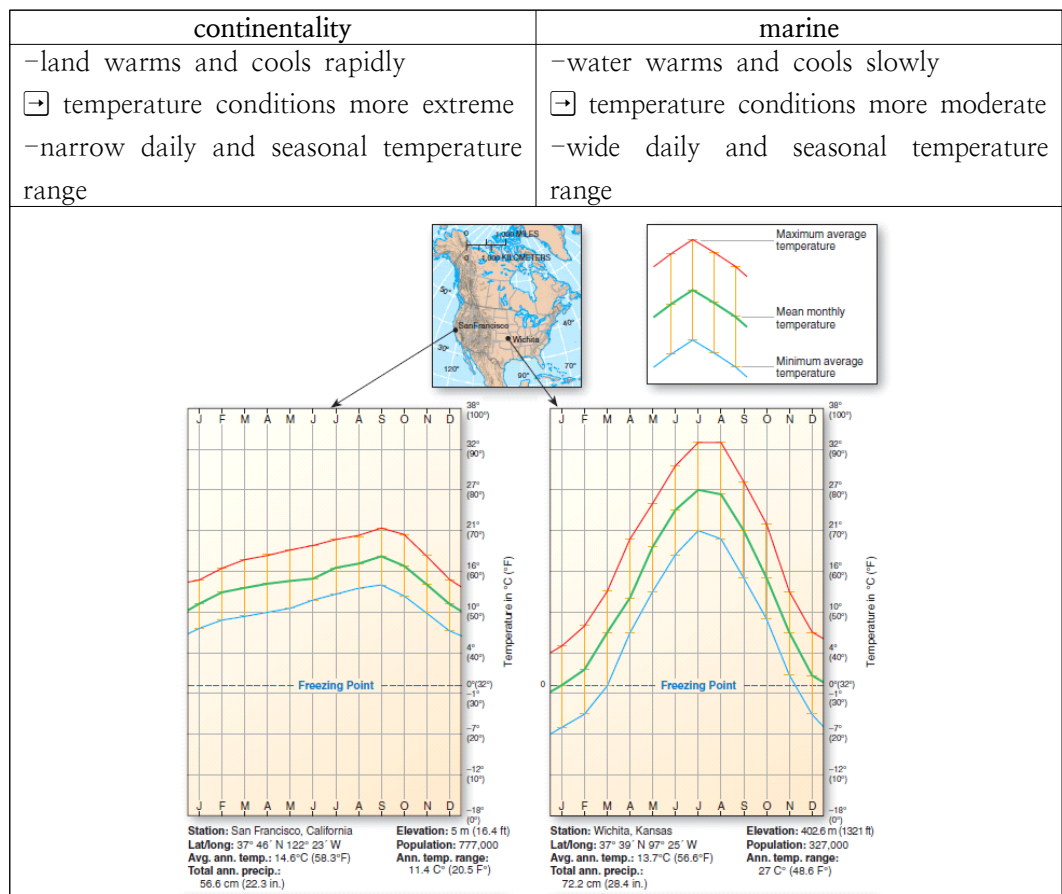
-기온의 시간, 공간적 변이를 설명하기 위한 통제 인자

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| latitude           | -fundamental control of global temperature pattern<br>-influences daylength, angle of insolation ☞ 연평균 기온의 차이 발생                                                                                                                                                                                                                                                                                                                                   |
| altitude           | -decrease of the density of the atmosphere with increasing elevation<br>☞ decrease of the ability to absorb and radiate energy(열을 흡수할 수 있는 온실 기체 감소)<br>☞ decrease of temperature with increasing elevation                                                                                                                                                                                                                                        |
| cloud cover        | -cloud = high albedo<br>-moderates temperature<br>-moisture in clouds reflects, absorbs, and liberates large amounts of energy<br>-clouds lower daily maximum temperatures and raise nighttime minimum temperatures <ul style="list-style-type: none"> <li>• night: act as an insulation ☞ delay release of longwave radiation from the Earth surface(reradiation)</li> <li>• daytime: reflects shortwave insolation due to high albedo</li> </ul> |
| land-water heating | -"land heats and cools more rapidly than water"<br>-그 이유                                                                                                                                                                                                                                                                                                                                                                                           |

difference

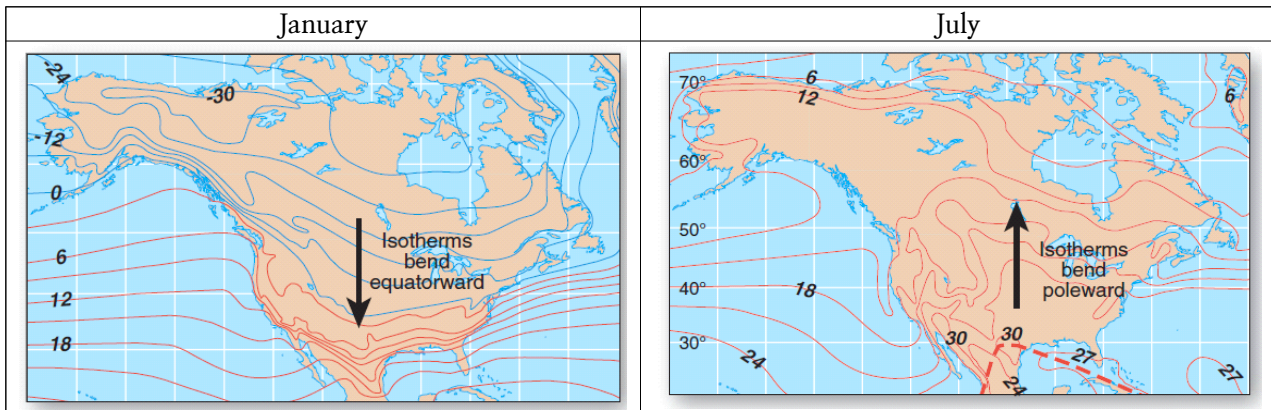
|               |                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                     |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| evaporation   | -84% of all evaporation of Earth is from the oceans<br>-during evaporation, heat energy is absorbed in the process and is stored in the water vapor as latent heat<br>☞ delay in the increase of sea surface temperature<br>-due to this evaporation cooling(증발열 손실), more energy is required to heat the ocean surface |                                                                                                                                                                                                     |
| transparency  | land                                                                                                                                                                                                                                                                                                                    | -opaque: no penetration of light into a soil surface but absorption only, heating the ground surface<br>-energy is accumulated during exposure and rapidly lost at night or in shadows              |
|               | ocean                                                                                                                                                                                                                                                                                                                   | -transparent: insolation penetrates into deep water(60m on average) ☞ photoic layer(발광층)<br>-distribution of available heat energy over greater depth and volume, forming a larger energy reservoir |
| specific heat | -Q for land vs 4~5Q for water<br>-물의 비열 = 1 (가장 높음)<br>☞ more energy is needed to heat water body<br>☞ heating or cooling of water body is a slower process)                                                                                                                                                            |                                                                                                                                                                                                     |
| movement      | -mixing of deep and shallow water ☞ spread of heat energy over large body of ocean water                                                                                                                                                                                                                                |                                                                                                                                                                                                     |
| ocean current | -redistribution of heat energy from equatorial to polar reagions                                                                                                                                                                                                                                                        |                                                                                                                                                                                                     |

-대륙효과와 해양효과



## # Annual Temperature Ranges

-위도 + 대륙효과



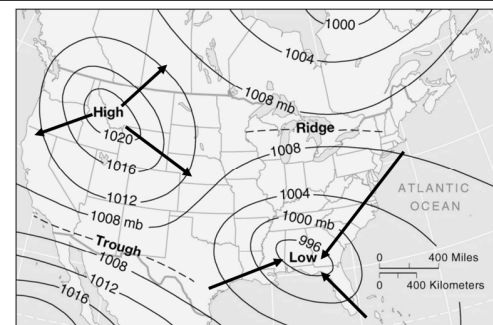
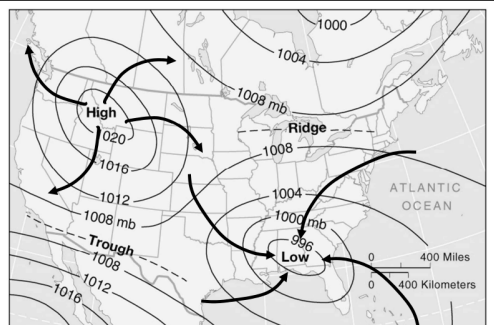
## 6. Atmospheric and Oceanic Circulations

### 6.1. Wind Essentials

#### # Wind

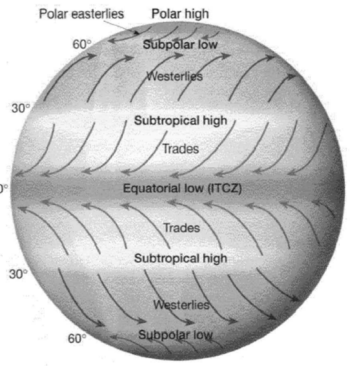
- wind: horizontal motion of air
- anemometer: measures wind speed
- wind vane: measures wind direction
- naming wind: direction from which they originate
- 예) 'westerly': a wind from the west (blows eastward)
- 바람이 부는 원인: 기압의 공간적 불균형

#### # Controls on Wind speed and Direction

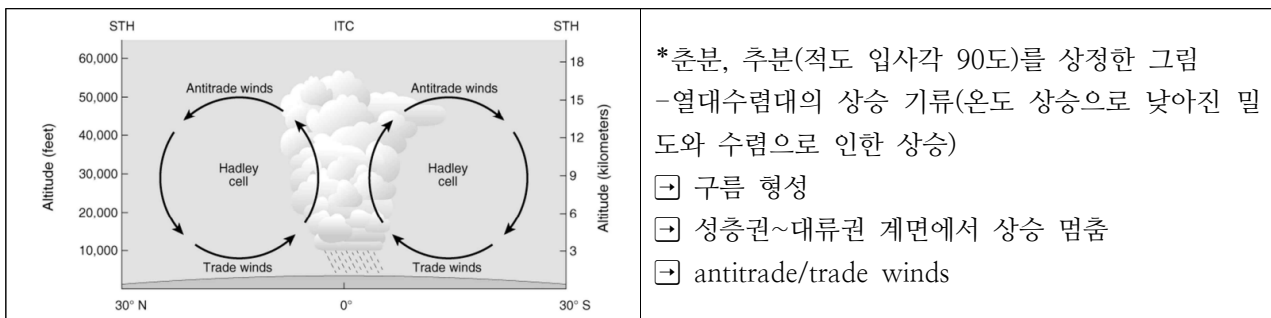
|                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>pressure<br/>gradient force<br/>(기압경도력)</p> | <ul style="list-style-type: none"> <li>-causes wind to blow from high → low pressure</li> <li>-고기압 = 공기의 밀도 높음</li> <li>-steep vs moderate gradient <ul style="list-style-type: none"> <li>• wider spacing = gentle slope = light winds</li> <li>• closer spacing = steep slope = strong winds</li> </ul> </li> </ul>                                                                                                                                                                                                                 |
| <p>Coriolis<br/>force/effect<br/>(전향력)</p>     | <ul style="list-style-type: none"> <li>-an apparent deflection of moving objects (하늘에 떠있는 물체에 관한 힘)</li> <li>-due to the Earth's eastward rotation (W → E spin)</li> <li>-affects only the direction of movement</li> <li>-deflection is to the right in NH, to the left in SH</li> </ul> <div style="display: flex; justify-content: space-around;">   </div> |

### 6.2. Atmospheric Patterns of Motion

#### # Primary Pressure Areas

|                      |                                   |                                                                                     |
|----------------------|-----------------------------------|-------------------------------------------------------------------------------------|
| Equatorial Low(ITCZ) | -rising warm air<br>-clouds       |  |
| Subtropical High     | -sinking cool air<br>-clear skies |                                                                                     |
| Subpolar Low         | -polar front<br>-clouds           |                                                                                     |
| Polar High           | -cold dense air<br>-clear skies   |                                                                                     |

#### -Hadley Cells



#### # Equatorial Low Pressure

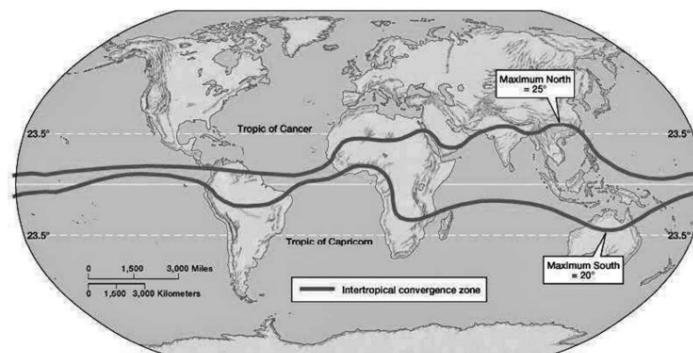
-0~10° N/S

-a lot of energy

- constant high angle of incidence
- consistent day length(ca. 12h)
- surface air heats up and rises(∴ 공기 밀도 감소 ☐ 부력 > 중력)

-air rises, converges, and cools(잠열) ☐ a lot of clouds and rain, full of latent heat energy

-Intertropical Convergence Zone: 열대수렴대 남북으로 이동



- 하지에 maximum north, 동지에 maximum south
- 대륙효과: 땅이 더 잘 데워짐 ☐ 상승기류 형성 용이

#### # Subtropical High Pressure

-20~35° N/S

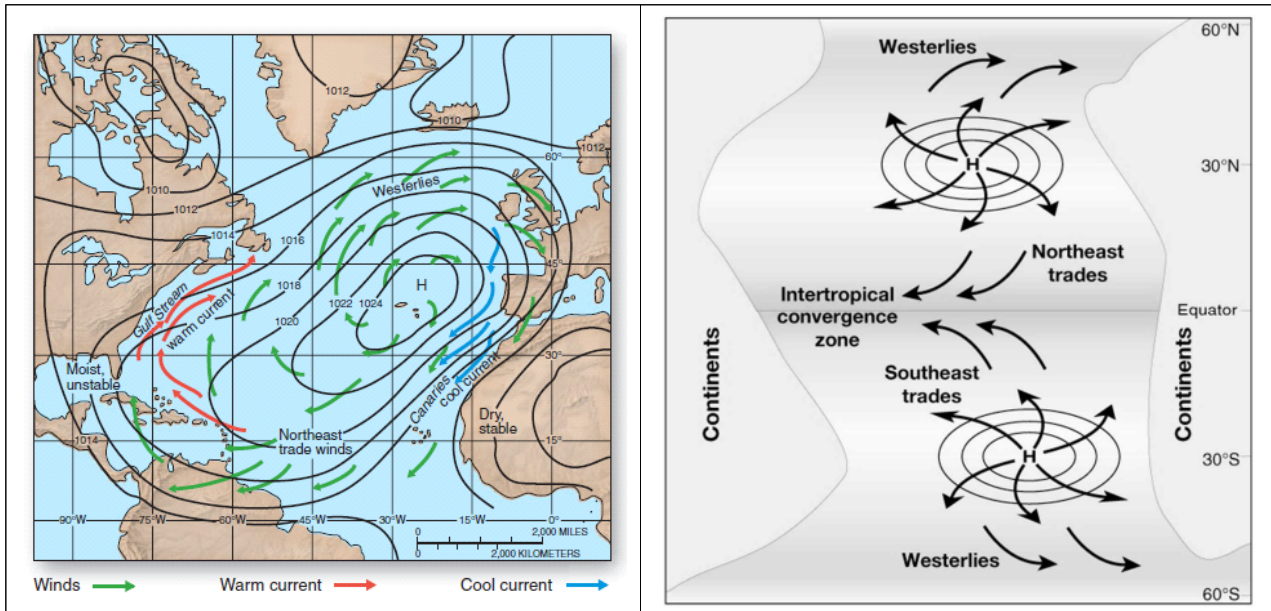
-air cools, descends, diverges in the subtropics

-clear skies, low rainfall, hot & dry air

-major deserts

-migrates 5~10° latitude with season

-subtropical high pressure cells: Azores High, Hawaiian High



- 동서가 정반대의 기후 조건을 갖게 됨

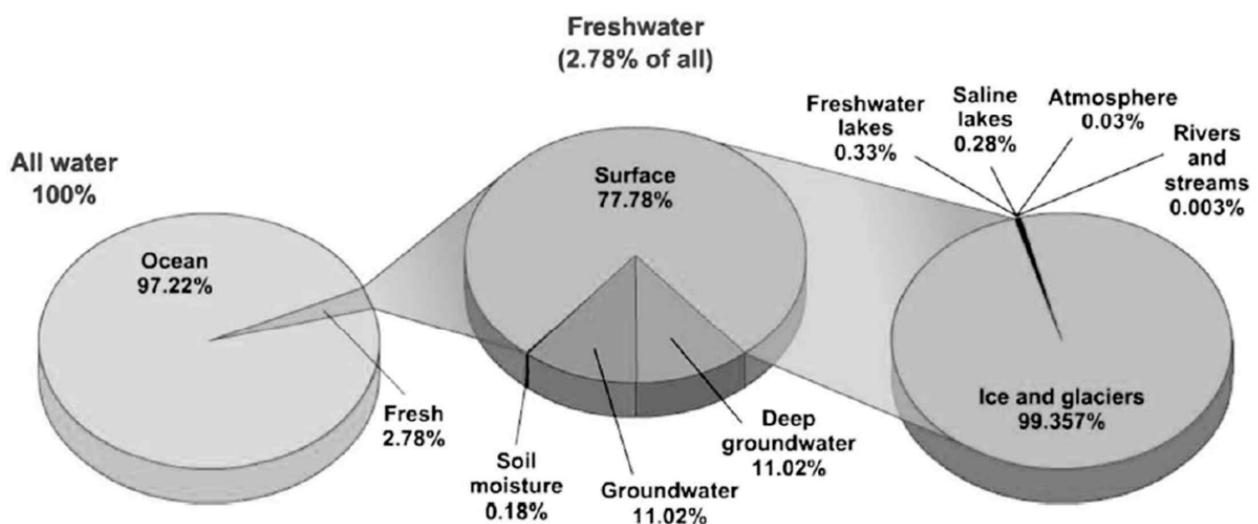
| Western side        | Eastern side                |
|---------------------|-----------------------------|
| -moist              | -dry                        |
| -warm ocean current | -cool ocean current(from N) |
| -temperate forests  | -major deserts              |

- 대륙 서안에 사막이 발달하는 이유

## 7. Water and Atmospheric Moisture

### 7.1. Water on Earth

#### # Distribution of Earth's Water Today

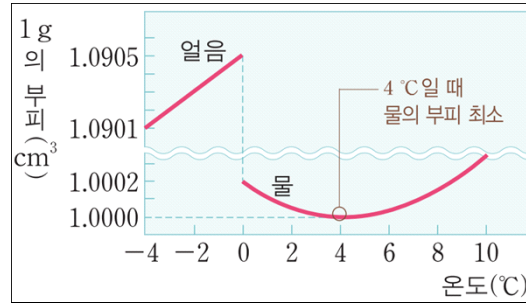


#### # Phases of Water

- heat energy is needed to change a phase to another to break the hydrogen bonds between water molecules → phase change of water = absorption or release of energy → latent heat
- evaporation(증발): liquid → vapor(증발로 인한 잠열의 흡수 - 증발 냉각)
- condensation(응결): vapor → liquid(잠열 방출)
- sublimation(승화): solid → vapor

-deposition(침적): vapor → solid(frost)

## # Unique Properties of Water



-when water freezes, it expands in volume(8~9%)

- decrease in density
  - important for physical weathering: 암석 내부 절리로 물이 스며들면 부피 증가에 따라 압력 증가
- its greatest density is at 4°C → ice floats(물의 밀도 커지면 부력 증가)

## 7.2. Humidity

### # Humidity

-humidity: the amount of water vapor in the air

-measures of humidity: absolute, specific(비습), relative

-dew point(이슬점)

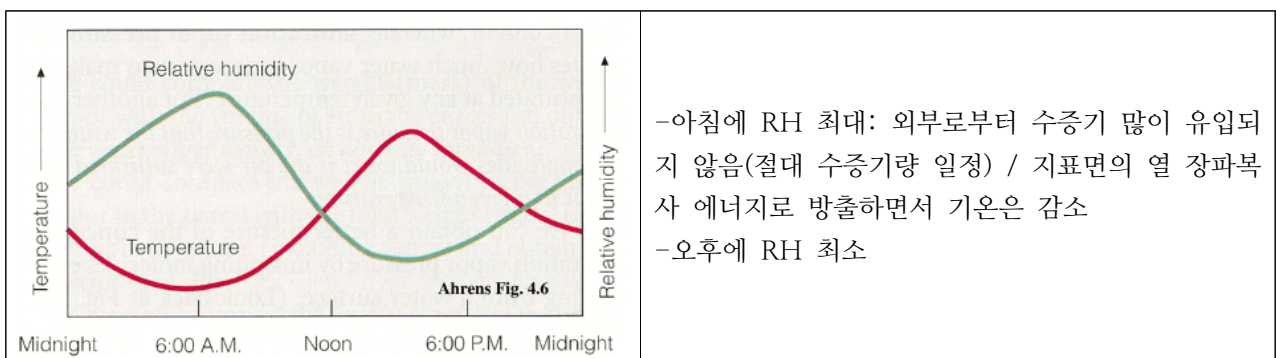
### # Absolute Humidity

-(mass of water vapor) / (volume of air)

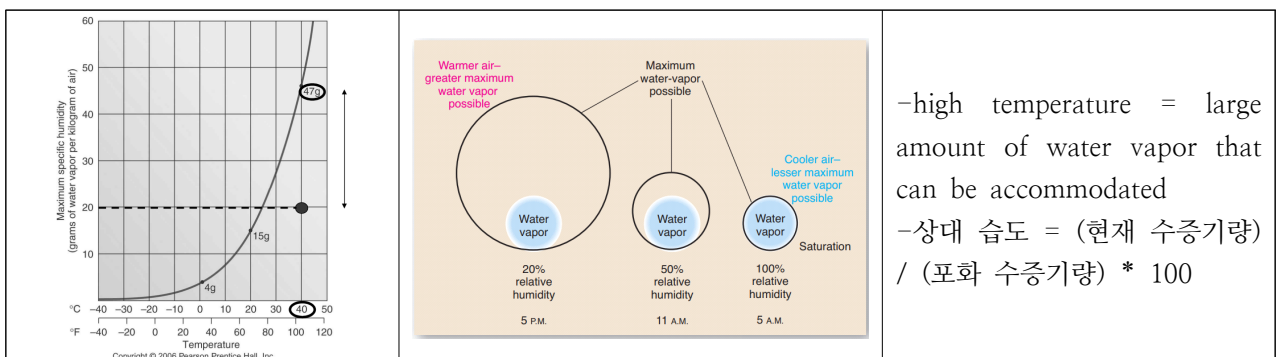
-same mass of water vapor → double the volume → half the absolute humidity

### # Relative Humidity and Temperature

-when temperature changes, relative humidity also does, even if the absolute amount of water vapor is constant



-maximum water holding capacity



-high temperature = large amount of water vapor that can be accommodated

-상대 습도 = (현재 수증기량) / (포화 수증기량) \* 100

### # Dew Point Temperature

-RH = 100%

-temperature to which the air must be cooled for water vapor to condense and form fog or clouds

예) cold glass chill the surrounding air to the dew-point temperature → condensation

## 7.3. Atmospheric Stability

### # Atmospheric Stability

-air parcel(공기 덩어리): body of air with particular temperature and humidity

- two opposing forces: gravity(pulling it earthward) + buoyancy(pushes it skyward)

- 부력과 중력의 상대적 함수, 결국 밀도의 문제

-temperature determines density(density = mass / volume)

- warm T → lower density

- cool T → higher density

-stability: tendency of an air parcel to remain in place or NOT to change vertical position

## 7.4. Clouds and Fog

### # Clouds

-cloud: aggregation of tiny moisture droplets and ice crystals that are suspended in the air

-fog: simply a cloud in contact with the ground(땅에 붙어 있는 구름)

-구름의 형성 과정

- 구름 응결핵(cloud-condensation nuclei) → 수분 입자(moisture droplets) → 빗방울(raindrop)

- 빗방울은 ~ 1 million moisture droplets로 구성

- 병합설: 수분 입자들이 모여서 중력을 견디지 못하고 떨어짐 → 비

-lifting → cooling(단열 냉각) → condensation(응결)

- air parcel cools internally as it expands under lower air pressure(외부의 압력 감소 → 부피 팽창 → 열에너지가 퍼짐, 평균 온도 감소) cf. 증발 냉각: 상변화, 잠열과 관련

- 이슬점만큼 떨어지면 condensation

예) 적도 수렴대: a lot of energy → 대기의 부피 팽창 → 상승(안정성 낮음) → 단열 냉각 → 비

-name of clouds: based on height and shape

- 적란운(cumulonimbus), 적운(cumulus), 층운(stratus)

### # Fog

|                                     |                                                                                                                                                                                                                                               |
|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| advection fog<br>(이류안개)             | -warm, moist air moves over a cooler surface(by 바람)<br>-cooled to dew point<br>-common along Pacific Coast(편서풍대)<br>-온도 차이가 큰 새벽: 물 표면의 warm, moist한 공기 → 비교적 차가운 육지로 이동<br>• 특히 '맑은 밤' + 습한 날에 더 자주 발생(지구 표면 더 식기 때문)                        |
| evaporation/<br>steam fog<br>(증발안개) | -cool air over warm water or wet surfaces(☹ vegetation)<br>-a type of advection fog: 공기 덩어리의 수평 이동 but 반대 상황<br>-아주 맑은 밤: 지표면의 차가운 공기 → 따뜻한 물 표면 위로 이동(이슬점)                                                                                   |
| radiation fog<br>(복사안개)             | -land surface loses heat energy(그 자리에서) rapidly during night time<br>-air near the ground is cooled to the dew point temperature → condensation<br>-clear skies: 구름이 있었다면 재복사, 급격하게 에너지 잃지 않도록 완충 작용<br>-분지 지형(호수, 바다 없음)의 안개는 복사 안개일 확률이 99% |

## 8. Weather

### 8.1. Weather Essentials

#### # Weather vs Climate

-weather

- short-term, day-to-day condition of the atmosphere
- snapshot of atmosphere: 기온, 강수량, 기압, 상대습도, 풍향, 풍속

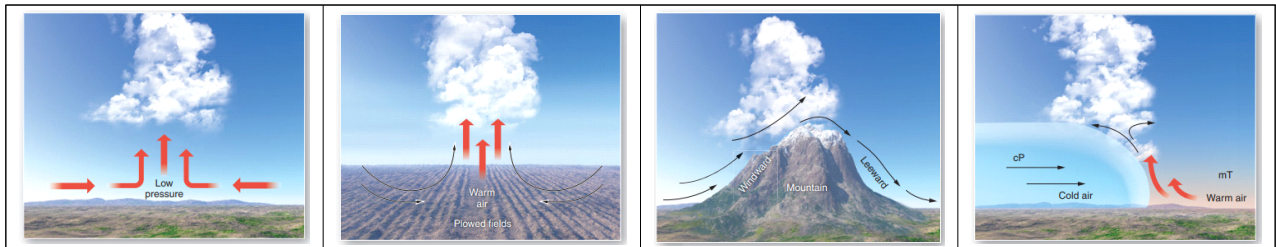
-climate

- long-term(over decades), average weather conditions
- 시공간적 스케일의 차이

### 8.2. Atmospheric Lifting Mechanisms

#### # Atmospheric Lifting Mechanisms

-공기 덩어리의 상승: 모든 기상 현상의 시작



|                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| convergent lifting<br>(수렴상승)   | -공기가 수렴하여 위쪽으로 상승 → 기압 감소, 단열 팽창...<br>-ITCZ, Hadley Cell의 수렴                                                                                                                                                                                                                                                                                                                                                                                         |
| convectional lifting<br>(대류상승) | -local heating<br>-maritime → continental: Florida에 천둥/번개 많이 발생하는 이유<br>• land-water difference 극명하게 달라지는 조건 → 땅이 데워진 상태에서 습한 공기 지나가면서 많은 비<br>-urban heat island<br>-unstable atmosphere                                                                                                                                                                                                                                                             |
| orographic lifting<br>(지형적 상승) | -장애물 만나서 상승 → ascending air cools adiabatically to dew point(단열 팽창에 의한 단열냉각), water vapor condenses<br>-rain shadow area: descending air warms adiabatically(건조한 공기)<br>-분수계(산 꼭대기를 연결한 선)을 통해 드러남                                                                                                                                                                                                                                                    |
| frontal lifting<br>(전선성 상승)    | -front: leading edge of advancing air mass(기단)<br>• line of discontinuity and conflict: 기온, 습도, 풍향, 풍속, 구름의 양<br>-cold front(한랭전선), warm front(온난전선) → 다른 종류의 기단이 만나 상승<br><div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>(a) 한랭 기단의 이동</p> <p>-밀도 낮아 낮게 깔려서 이동함<br/>-온난 기단의 급격한 상승 → 적란운</p> </div> <div style="text-align: center;"> <p>온난 기단의 이동</p> <p>-점진적 상승 → 층운, 고층운, ...</p> </div> </div> |

### 8.3. Violent Weather

## # Thunderstorms(뇌우)

-three conditions that can develop within

- in a warm, moist air mass
- along a cold front or convergent boundary
- orographic lifting(upslope winds)

-formation: when layers of warm, moist air rise in a large, swift updraft to cooler regions of the atmosphere(급격한 상승 → 북반구 기준 반시계 방향 소용돌이)

-result: lightning and thunder, high winds, etc

-hail(우박): forms within a cumulonimbus(적란운) cloud

- circulate repeatedly above and below the freezing level in the cloud
- 적란운 안에서 소용돌이 → 상하운동 → 얼고 녹는 과정 반복

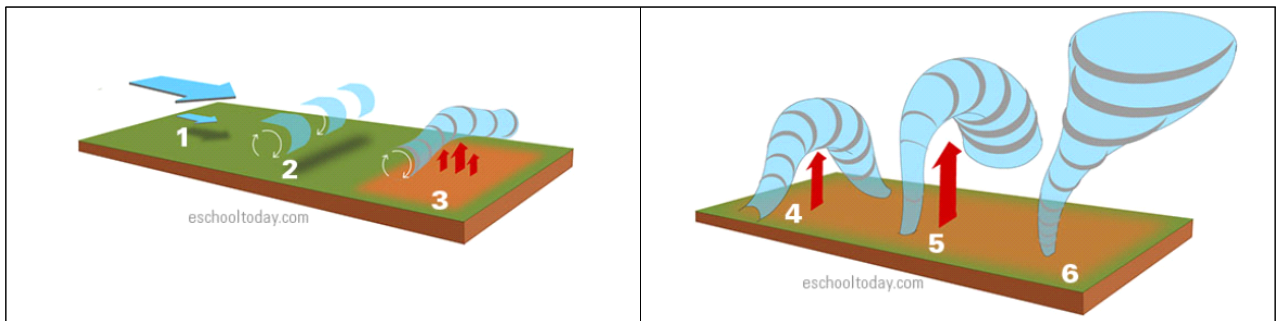
## # Tornadoes

-tornadoes: severe or super-cell thunderstorm

-general characteristics

- 100~600m diameter
- travel SW-NE
- average ground speed: 48km/h, Fujita scale 4등급 이상 = 풍속 333km/h 이상

-formation of a tornado



-높이별로 층 형성(상부에서의 풍속 더 큼)

-spinning along horizontal axis

-updraft → 반시계 방향 tornado

-2023 US Tornadoes: 중부대평원 지역에서 다수 발생(∴ 상부, 하부의 바람 잘 볼수 있는 조건)

## # Hurricanes

-Why don't hurricanes form along the equator nor in the mid-latitudes?

- too close to equator = no Coriolis force
- too far from equator = water is too cold

→ form between 5~20 degrees N/S of equator

-Tropical Cyclones: powerful weather system that originates in tropical air masses

- surface temperature should exceed ca. 26°C: hurricane(USA), typhoon(west Pacific), cyclone
- pathways: 10~30도에서는 서쪽으로(무역풍 우세), 30~50도에서는 동쪽으로(편서풍대)
- CCW in N.Hem., CW in S.Hem.

-death of hurricane: 육지에 상륙하면 곧바로 소멸(absence of warm, moist air)

-impact of hurricanes

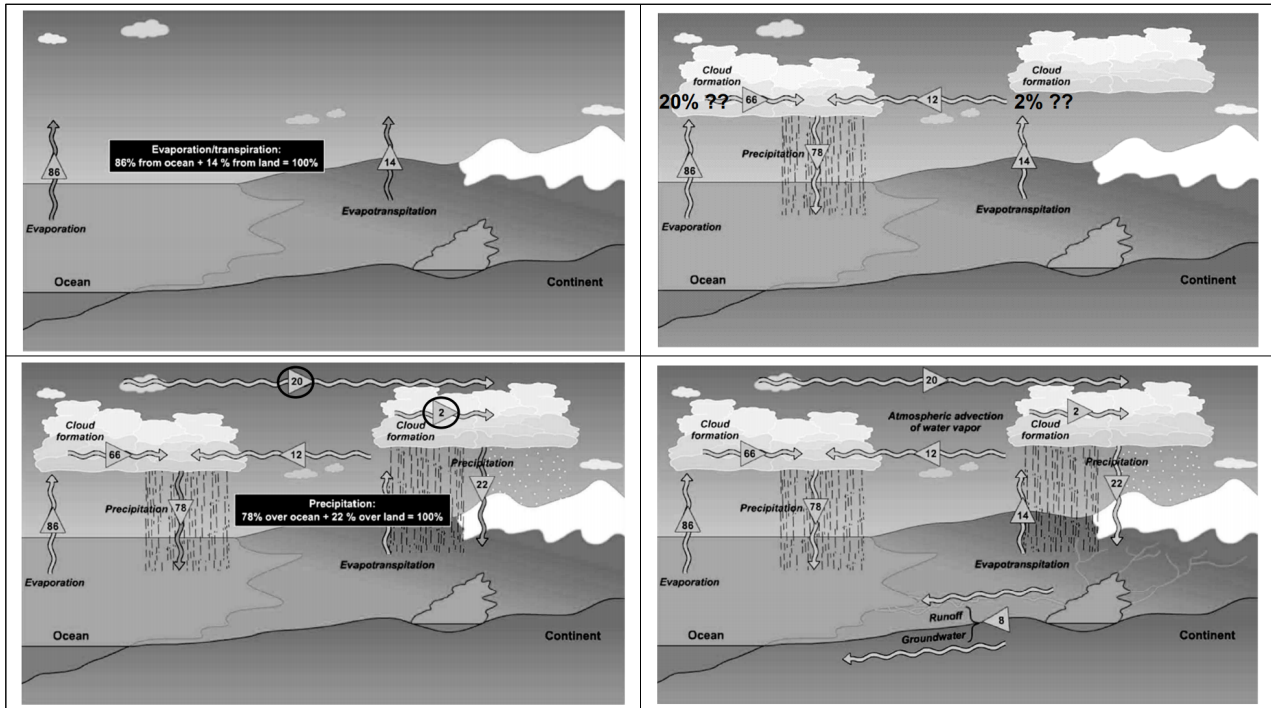
- widespread flooding
- high winds
- storm surge

- tornadoes: weak tornadoes can form in right flank(이동 방향의 오른쪽 피해 더 큼)

## 9. Water Resources

### 9.1. The Hydrologic Cycle

#### # 수문순환



-모든 유형의 물(고체, 액체, 기체)이 지표면 위에서 그리고 그 하부에서 끊임없이 순환함

-육상: 강수량 > 증발량 → 잉여: runoff

-해상: 강수량 < 증발량

-이류(advection): 육상은 매해 37,000km³ 만큼의 물을 해상으로부터 공급받음 → 이후 runoff 통해 보충

-강수 이후에 생기는 현상

- 물이 땅 속에 저장:  $\Delta$  storage
- 물이 하천에 공급: runoff(surplus)
- 물이 대기로 유입: actual ET(ACTET)

### 9.2. Soil-Water-Budget Concept

#### # 가뭄

-해당 기후조건(POTET, 잠재증발산량: 역사적으로 보이는 기후조건으로부터 기대되는 증발산량)에 비해, 혹은 실제로 필요한 양에 비해 낮은 양의 강수현상

- POTET > ACTET

-자연적으로 발생하는 전지구적 기상현상

## 10. Global Climate Systems

### 10.1. Climate and Climatology

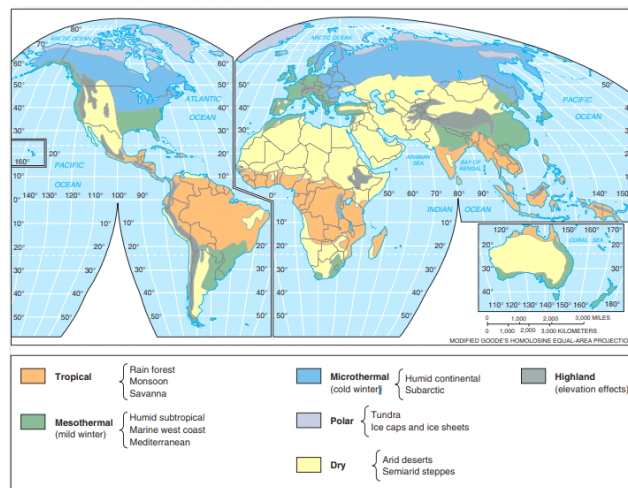
#### # What is Climate?

-average weather conditions over a long period of time

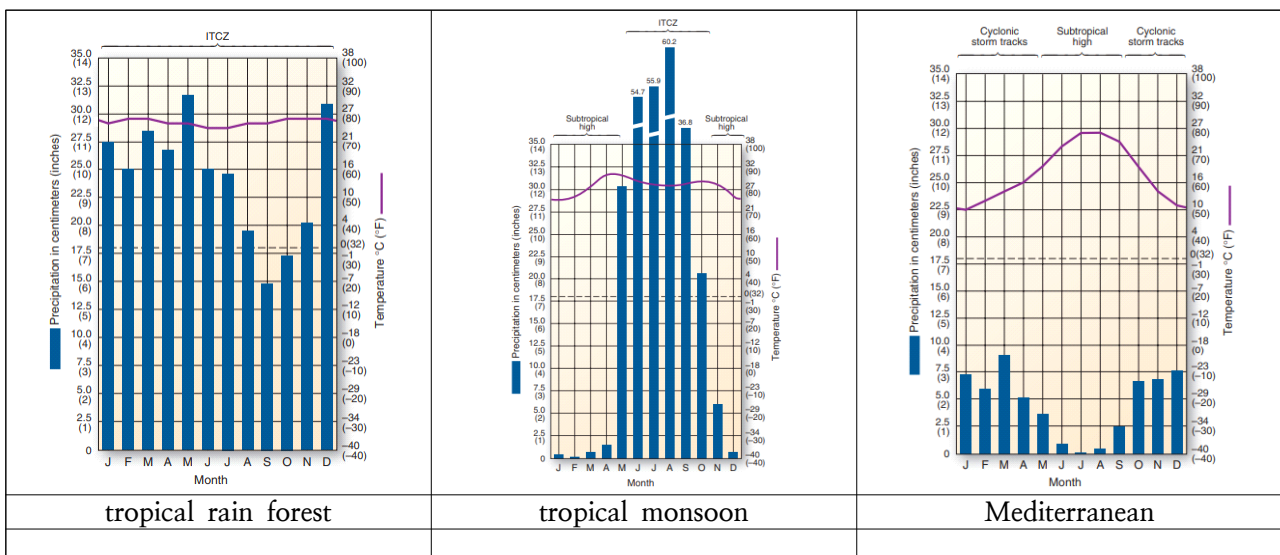
- based on temperature, precipitation, etc
- helps to determine global distribution of ecosystems(biomes)

## # Climatology

- the study of climate
- analysis of long-term weather patterns over time and space to find areas of similar weather statistics (climate regions, 기후 지역)
- climograph: a graphic representation of the climate of a region
  - mean monthly temp / precip
  - annual temp range / total precip
  - seasonality
- Koppen climate classification: based on mean monthly(annual) temperature and precipitation
- classification in the textbook: tropical, mesothermal(중열), microthermal(소열), polar, highland, desert



## 10.2. Major Climate Regions of Earth

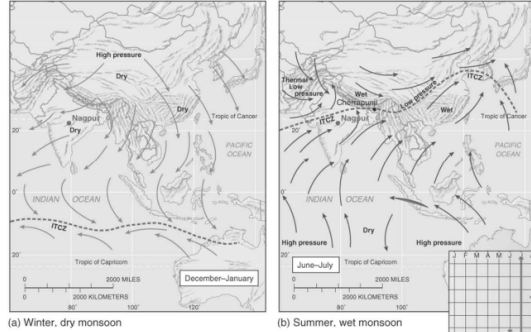


## # Tropical Climates

- tropical rain forest, tropical monsoon, tropical savanna

|                      |                                                        |
|----------------------|--------------------------------------------------------|
| tropical rain forest | -rainy all year, 1년 내내 높은 기온<br>-적도 열대 수렴대 → 충분한 열과 수분 |
|----------------------|--------------------------------------------------------|

|                  |                                                                                                                                                                                                  |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| tropical monsoon | <p>-6~12 months rainy</p> <p>-때에 따라 영향권 바뀜(ITCZ ~ subtropical high): 지구의 기울어진 자전축으로 인한 열대수렴대의 이동 때문</p> <p>-전반적이고 온난 습윤, but 명백한 건기(겨울) 존재</p> <p>-monsoonal winds: ITCZ 남회귀선(동지) / 북회귀선(하지)</p> |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|



### # Mesothermal Climates

- mid-latitudes, mild winters (cf. microthermal: mid-high latitudes, cold winters)
- humid subtropical, marine west coast, Mediterranean

|               |                                                                                                                      |
|---------------|----------------------------------------------------------------------------------------------------------------------|
| Mediterranean | <p>-dry summers</p> <p>-여름: subtropical high의 영향 / 겨울: 대다수가 눈의 영향</p> <p>-Hawaiian High(북태평양)와 Azores High(북대서양)</p> |
|---------------|----------------------------------------------------------------------------------------------------------------------|

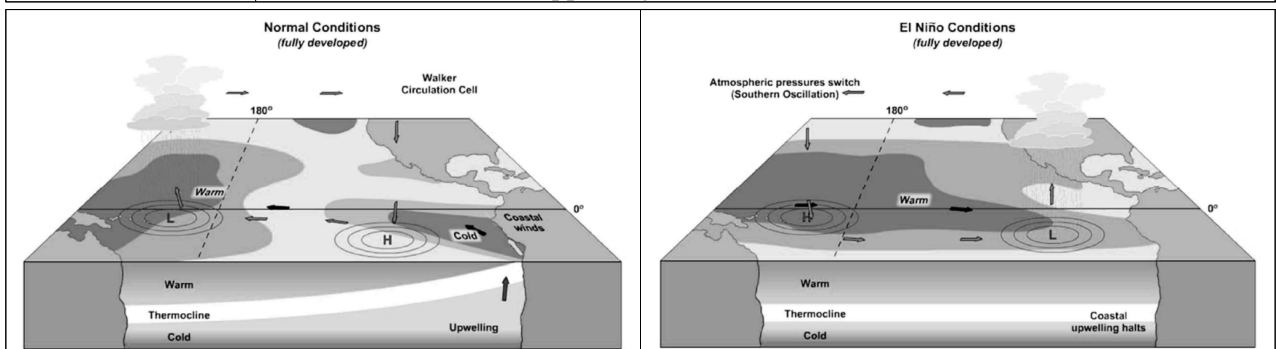
### # Desert Climates

- desert: permanent moisture deficits
- two major reasons for desert formation
  - orographic lifting: 장애물을 만나 상승하면서 공기 건조해짐(rainshadow area)
  - subtropic high pressure cells: CW 회전하는 고기압대, 한류가 이동하여 서늘한 공기가 해안에 도착

## 10.3. Global Climate Change

### # El Nino

|                                    |                                                                                                                             |
|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| El Nino Southern Oscillation(ENSO) | <p>-shifting patterns of pressure, ocean temperatures, trade winds</p> <p>-weak warm current appearing around Christmas</p> |
|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|



-normal conditions(남태평양)

- Walker Circulation Cell: 서태평양 저기압, 동태평양 고기압 형성 → 무역풍(동풍) → 표층수가 바람에 의해 동쪽으로 이동 → 차가운 바닷물 융승(upwelling)
- 바닷물은 비교적 따듯(적도 어간)
- thermocline(수온약층): 바닷물이 급격히 차가워지는 시점

-El Nino conditions: 무역풍 약해짐

- 차가운 바닷물 다시 아래로 내려감 → 기압 역전 현상 발생하기도
- 남아메리카에 많은 비, 어업의 어려움 등

-엘니뇨의 영향

- warmest winter in North America(high temperature in Alaska, Northern Canada)
- drought in 서태평양
- floods in 동태평양
- 20cm rise in sea-level off California(동-서 바람이 약해지면서 해수면 상승)

-La Nina: 반대로 무역풍이 평상시보다 강해지는 것

- 차가운 바닷물 융승 현상 심화 → 전체적으로 수온 감소, 건조 기후 형성

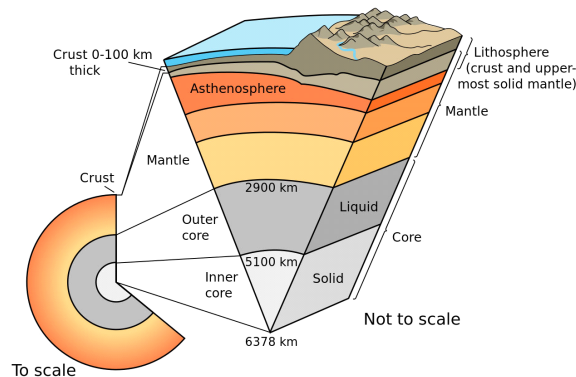
## 11. The Dynamic Planet

### 11.1. Earth's Structure and Internal Energy

#### # Layers of the Earth

-upper and lower mantle

- 80% of earth's volume
- increase of temperature and density toward core
- asthenosphere(연약권): plastic layer, convective currents 존재 → slow movement in this zone creates tectonic activity



-lithosphere(암석권): Earth's crust(지각) and the uppermost mantle(최상부 맨틀), ~ 70km

#### # Earth's Crust

-composition, texture, density differences

|             | continental(대륙 지각)               | oceanic(해양 지각)                   |
|-------------|----------------------------------|----------------------------------|
| composition | -granite(화강암): high in Si, Al, K | -basalt(현무암): high in Si, Mg, Fe |
| texture     | -crystalline                     | -granular                        |
| density     | -2.7g/cm³                        | -3.0g/cm³                        |

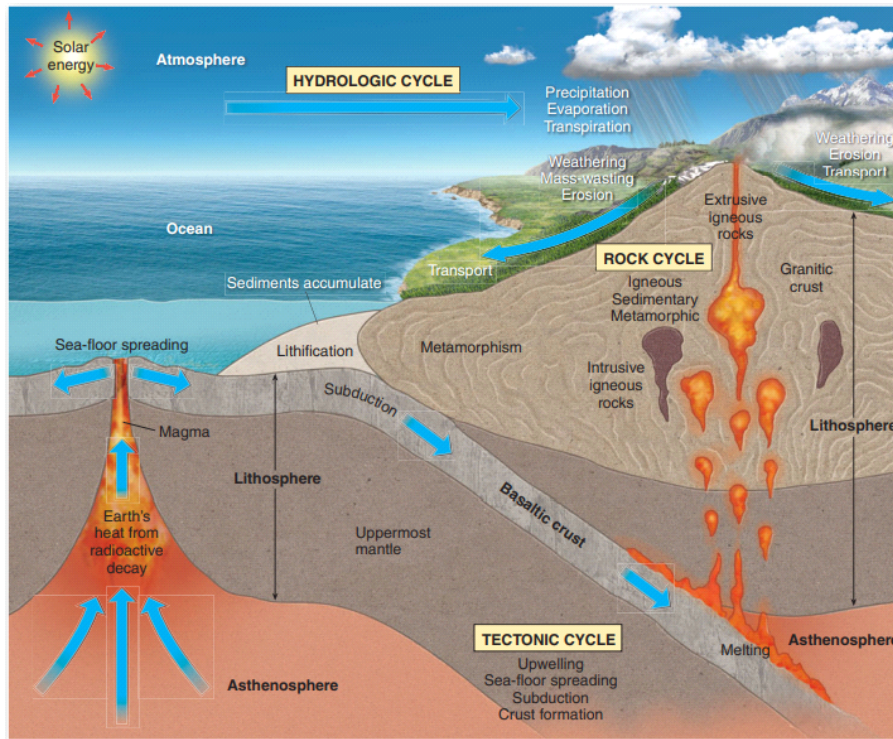
- 공통점: 화성암으로 구성
- 미세한 밀도 차이가 연약권의 움직임으로 판과 판이 만날 때 조산 운동과 섭입 현상 발생하는 원인

### 11.2. The Geologic Cycle

#### # The Geologic Cycle

-지구 내부 에너지로 이루어지는 순환 (cf. 에너지 순환은 지구 외의 에너지가 원인)

-Earth's heat from radioactive decay → 판과 판 만남 → 해양 지각의 subduction(섭입) → 깊은 곳까지 섭입되면서 온도와 압력 증가 → 녹음 → 마그마로 recycle됨 → 대륙 지각에서의 순환(수문 순환...)

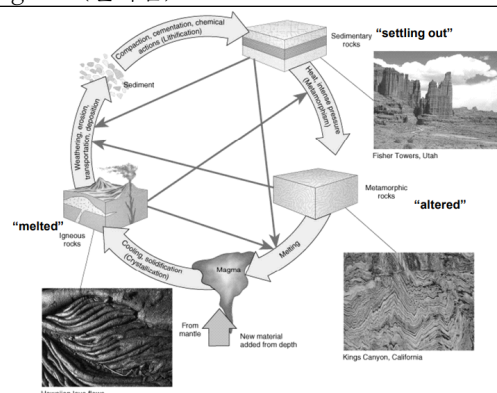


-exogenic(external) processes와 endogenic(internal) processes 간의 상호작용 = geologic cycle

### # Rock Cycle

-three main rock groups → 모든 암석은 화성암, 퇴적암, 변성암이 될 수 있음

|                                     |                                                                                                                                                                                                                                                                                                                                   |
|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>화성암</b><br/>(igneous)</p>     | <p>-products of the crystallization of magma and lava</p> <ul style="list-style-type: none"> <li>• magma: molten rock beneath the surface(intrusive, 관입)</li> <li>• lava: molten rock at the surface(extrusive, 분출)</li> </ul> <p>-지점에 따라 속도 차이</p> <p>-compose approximately 90% of the Earth's crust</p>                        |
| <p><b>퇴적암</b><br/>(sedimentary)</p> | <p>-sediments worn from other rocks</p> <ul style="list-style-type: none"> <li>• sediments: loose particles of former rocks ranging from mineral grains to boulders</li> </ul> <p>-acted upon by cementation, compaction and hardening of sediments</p> <p>→ "lithification(암석화)"</p> <p>예) sandstone, shale, limestone, coal</p> |
| <p><b>변성암</b><br/>(metamorphic)</p> | <p>-igneous or sedimentary rocks are transformed due to extreme pressure and heat</p> <p>-changing the chemistry, mineralogy, or texture of other rocks</p> <p>-hardened and more resistant to erosion</p> <p>예) granite → gneiss(편마암)</p>                                                                                        |



## 11.3. Plate Tectonics

### # A Brief History

-plate tectonics: changes in the configuration of the earth's crust due to internal forces

- internal forces, upwelling of magma, sea-floor spreading, plate movement, subduction, ...

-early ideas: continental drift(대륙이동설)

- Pangea: super-continent that existed during the Triassic
- evidence for continental drift: jigsaw puzzle, fossil evidence, paleoclimatic evidence, similar rock types

-further development of plate tectonics: concept of sea-floor spreading(해저확장설)

- 대서양 한가운데 산맥 존재 발견(mid-oceanic ridge)
- upwelling of basaltic magma가 해저의 차가운 바닷물 만나 새로운 암석 생성 → 점점 양쪽으로 퍼지게 됨("spread") → subduction → remelts and is recycled as magma

### # Plate Boundaries

-Earth's crust is composed of 14 plates'

-plate boundaries are the primary location of earthquakes and volcanic activity



## 12. Tectonics

### 12.1. Crustal Deformation Processes

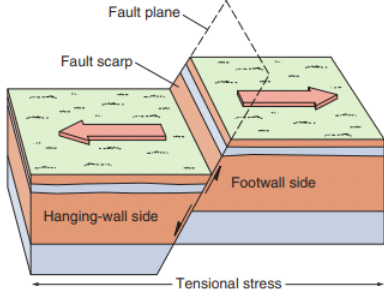
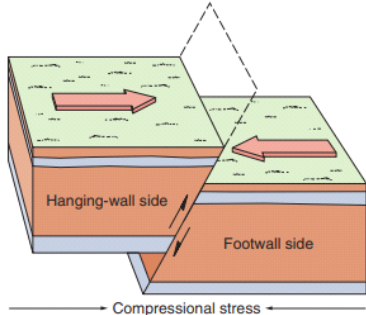
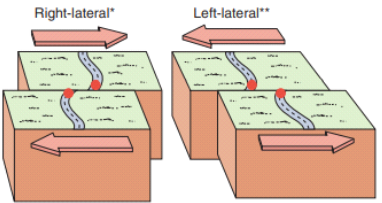
#### # 지각변형과정

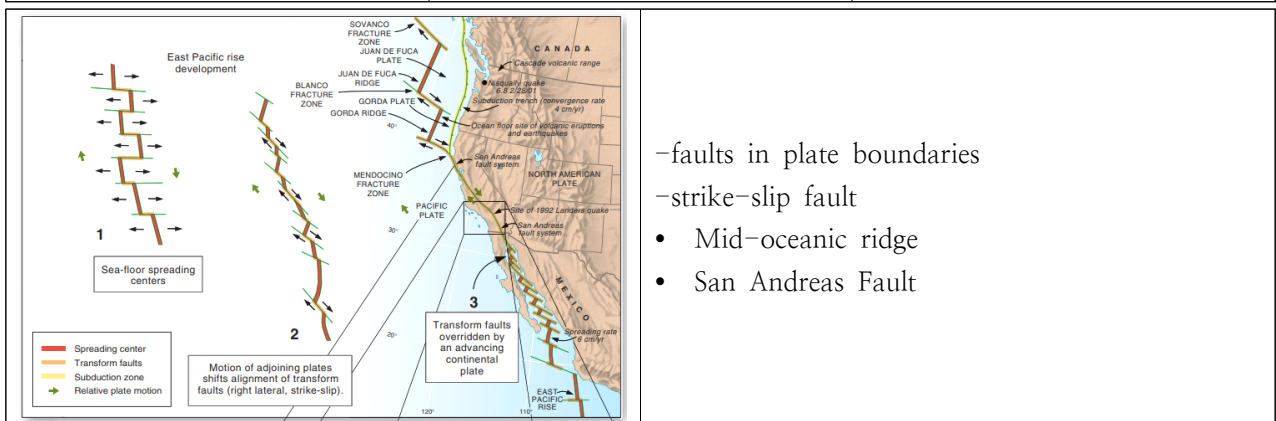
-stress and strain, folding, faulting, earthquakes, volcanoes

|                          |                                                                                                                                                                                                                                                                |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>stress and strain</p> | <p>-all rocks are subject to forces(=stress) that act to deform them</p> <p>-strain: how rocks respond to stress</p> <ul style="list-style-type: none"> <li>• if the rock is brittle, it will fault</li> <li>• if the rock is ductile, it will fold</li> </ul> |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                   | stress                                                                                                                                                                                                                                       | resulting strain                                 | surface expressions                                |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|----------------------------------------------------|
|                   | tension(장력)                                                                                                                                                                                                                                  | stretching(당겨짐)                                  | thinning crust<br>normal fault(정단층)                |
|                   | compression(횡압력)                                                                                                                                                                                                                             | shortening(압축)                                   | folding<br>reverse fault(역단층)                      |
|                   | shear(전단력)                                                                                                                                                                                                                                   | shearing, twisting laterally<br>(전단응력-측면으로 비틀어짐) | bending horizontally<br>strike-slip fault(주향이동 단층) |
| folded landscapes | -result of compressional stresses(유연한 물질)<br>-landscape: 낮고 높은 곳 반복됨 ☹ Zargos Mountains, Appalachian Mountains                                                                                                                               |                                                  |                                                    |
| faults            | -faulting: when rocks under stress are unable to remain a solid unit, they fracture and slide past each other<br>-earthquake: the sharp release of energy at the moment of fracture<br>-types of fault: normal, reverse(thrust), strike-slip |                                                  |                                                    |

-stress → strain → surface expression → resulting fault

| normal fault                                                                                                         | reverse(thrust) fault                                                                                                               | strike-slip fault                                                                                                                    |
|----------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| -tension<br>-stretching<br>-thinning                                                                                 | -compression<br>-shortening<br>-folding                                                                                             | -shear<br>-shearing<br>-bending                                                                                                      |
|  <p>(a) Normal fault (tension)</p> |  <p>(b) Thrust or reverse fault (compression)</p> |  <p>(c) Strike-slip fault (lateral shearing)</p> |



## 13. Weathering and Karst Landscapes

### 13.1. Geomorphology

#### # 지형학

- science of landforms: their origin, evolution, and spatial distribution
- want to know what aspects of landform change can be expected to affect us
- key processes and agents

- endogeneous: tectonic uplift and volcanism
- exogeneous: denudation(any process that wears away or rearranges landforms)
- principal denudation processes: weathering, mass movement, erosion, transportation, deposition
- agents: water, air, waves, ice, and gravity

## 13.2. Weathering Processes

### # Weathering: in situ Breakdown

-weathering: processes that alter the physical or chemical state of rocks at or near Earth's surface

- physical disintegration of rock
- chemical dissolution of rock
- biological weathering

-암석이 ~하여 자기가 가지고 있던 성질을 잃어버리는 것(약해지는 것) → 붕괴(화학적, 물리적)

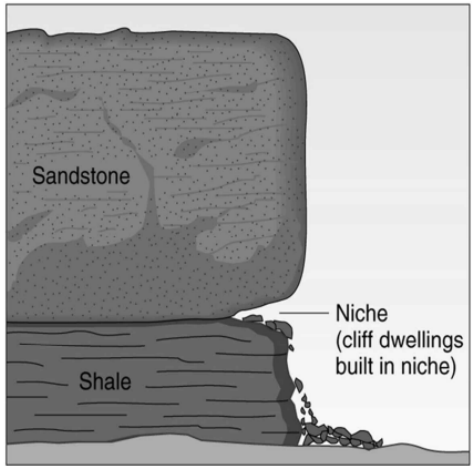
-weathering does not transport the materials (cf. erosion is denudation by agents such as wind, water, or ice)

-bedrock(기반암): unweathered parent material

-regolith(표토): weathered rock that is loose and incoherent(broken-up)

### # Types of Weathering

-physical weathering: with little chemical alteration

|                                                 |                                                                                                                                                                                                                                                                                                                      |                                                                                      |
|-------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| freeze-thaw action<br>(결빙작용)                    | -freezing expands water by 9%<br>-freeze-thaw action → joint-block separation                                                                                                                                                                                                                                        |                                                                                      |
| salt-crystal growth<br>(염풍화)                    | -moisture that is confined within the interstices of rocks evaporates<br>-salt crystallizing within the pores produces stresses, widening them<br>-salt = 화합물을 의미<br>-arid climates(증발 많음 but 어느 정도 비 오는 지역)<br><br>빗물이 투수되지 않는 shale과 sandstone의 경계에 염이 성장 →                                                        |  |
| pressure-release jointing<br>(수축과 팽창에 따른 절리 과정) | -disappearance of pressure(by 풍화, 침식) → 부피 팽창<br>-many rocks are formed under high temperature and pressure<br>-as erosion of the overlying rocks proceeds, these rocks are exposed at the surface removing the confining pressure<br>-rocks develop joints which allow them to break off into large slabs(sheeting) |                                                                                      |

-weathering increases surface area → more weathering

-chemical weathering = breakdown

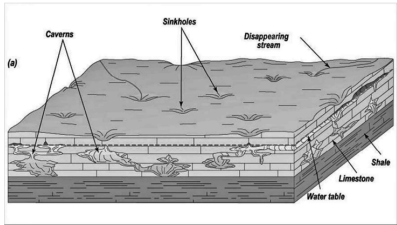
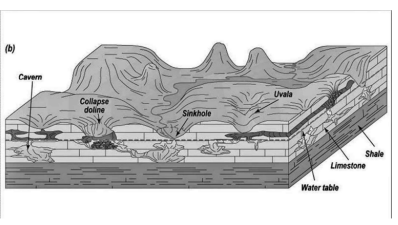
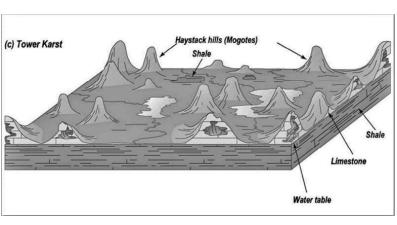
- decomposition or chemical change of minerals in rock
- dominant form of weathering in warm, moist climates
- minerals combine with oxygen or carbon dioxide, or dissolved in water
- 예) spheroidal weathering(구상풍화) → 입상붕괴

|                                         |                                                                                                                                                                                                                                                                               |
|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| hydrolysis<br>(가수분해)                    | -minerals chemically react with water to produce different compounds<br>⇨ result in breaking down silicate minerals in rocks<br>-formation of new materials<br>• feldspar + water ⇨ silica + clay + dissolved minerals<br>-weakens rock, causes granular disintegration(입상붕괴) |
| oxidation<br>(산화)                       | -when certain metallic elements combine with oxygen to form oxides<br>-산소와 결합함으로써 기존의 성질 잃어버림<br>$-Fe + O_2 \rightarrow Fe_2O_3$ : rusting                                                                                                                                    |
| solution and carbonation<br>(용해와 탄산화작용) | -water = universal solvent<br>-carbonation: water vapor + carbon dioxide ⇨ carbonic acid<br>-carbonic acid reacts strongly with limestone and any rocks containing Ca, K, Mg, Na<br>-limestone eroded to form karst topography                                                |

### 13.3. Karst Topography and Landscapes

#### # Karst

- landforms resulting from the weathering and erosion of limestone
- characteristics of limestone
- 퇴적암 ⇨ 선천적으로 절리 존재 ⇨ 투수율 높고 동굴 형성 쉬움
- development of karst landscape

|                                                                                     |                                                                                     |                                                                                       |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|  |  |  |
| early                                                                               | middle                                                                              | last                                                                                  |
| -sinkholes, disappearing stream<br>(소멸하천)                                           | -용식 진행, 기복 심해짐                                                                      | -tower karst 형성<br>-충분히 온난 습윤해야 가능                                                    |

## 14. River Systems and Landforms

### 14.1. Fluvial Geomorphology

#### # Why are rivers important?

- essential water supplies
- freshwater for industry
- transportation networks
- settlements, military purpose etc

#### # Fluvial Geomorphology(하천지형학)

- fluvial processes: erosion, transportation, and deposition by stream water

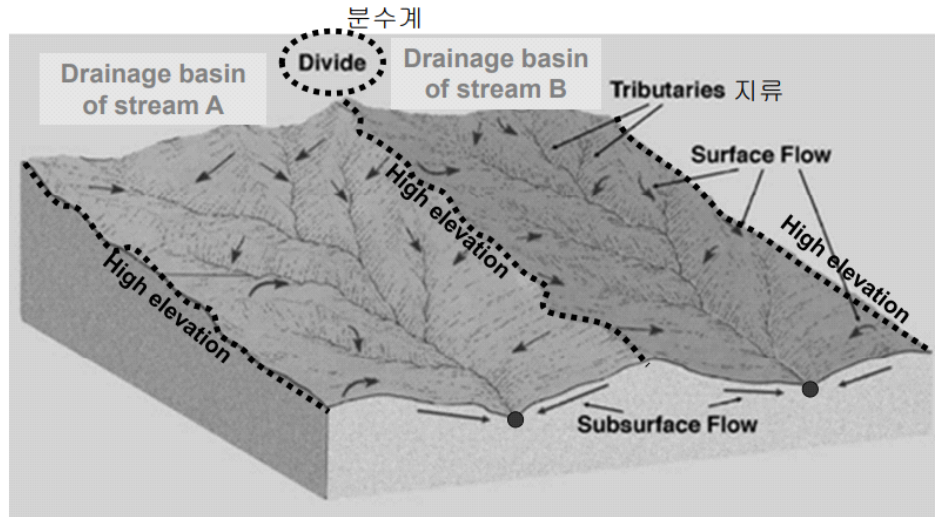
|                |                                                                                                            |
|----------------|------------------------------------------------------------------------------------------------------------|
| erosion        | -dislocation, dissolution, removal of surface material                                                     |
| transportation | -movement of eroded material from one location to another<br>-solution, suspension or mechanical transport |
| deposition     | -laying down of sediments<br>-transported by wind, water, or ice                                           |

-fluvial geomorphology: study of landforms created by streams through fluvial processes

## 14.2. Fluvial Processes and Landforms

### # Drainage Basin(catchment, 유역분지)

-an area that contributes runoff(overland, groundwater flow) to a specific stream/point

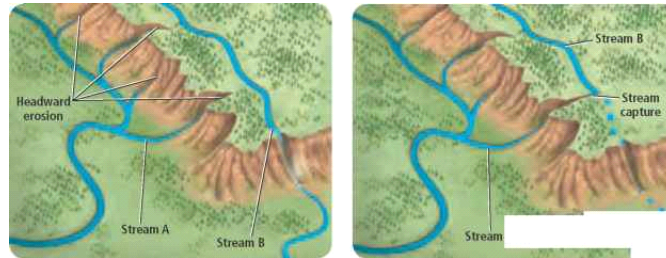


-drainage basin characteristics

|                               |                                                                                                                                                                                                                                                                                                                                                      |                                                    |                  |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|------------------|
| drainage density<br>(하계망 밀도)  | -total length of all streams / basin area<br>-high: humid climates, less resistant rock(soft, easy to erode by 하방침식)<br>-low: arid climates, resistant rock                                                                                                                                                                                          |                                                    |                  |
| drainage networks<br>(하계망 패턴) | -pattern of the interconnected network of streams in an area<br>-common drainage patterns<br><div style="display: flex; justify-content: space-around; align-items: flex-end;"> <div style="text-align: center;"> <br/>(a)         </div> <div style="text-align: center;"> <br/>(b) </div> <div style="text-align: center;"> <br/>(c) </div> </div> |                                                    |                  |
|                               | dendritic(수지상)                                                                                                                                                                                                                                                                                                                                       | trellis(격자상)                                       | radial(방사상)      |
|                               | <br>(a) Dendritic                                                                                                                                                                                                                                                                                                                                    | <br>(b) Trellis                                    | <br>(c) Radial   |
|                               | -가장 전형적<br>-angles < 90°<br>-경사 더 심하면 parallel                                                                                                                                                                                                                                                                                                       | -작은 지류들이 수직으로 합류<br>-습곡 형태의 지질 (folded topography) | -대부분 화산 지형에서 나타남 |

## # Changing Drainage Patterns: Stream Capture/Piracy(하천 쟁탈)

- common in folded rock terrains(trellis)
- occurs due to the migration of divides
- one stream captures the drainage network of another stream



- headward erosion(두부침식): 더 높은 곳으로 깎여 올라감, 상류로 길이 길어짐
- wind gap(풍극): a gap in ridge through which a stream, abandoned as a result of stream piracy, once flowed

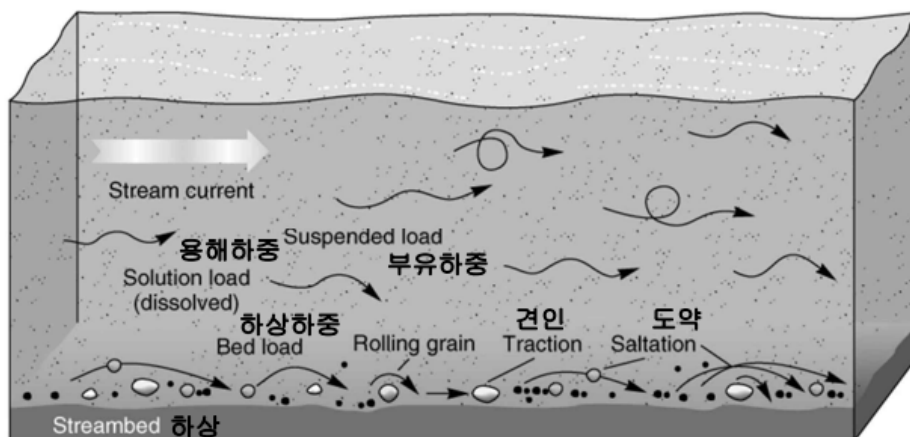
## # Stream Erosion

- stream erosion occurs by ...

|                              |                                                                                                                                                                                                      |
|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| hydraulic action<br>(유수의 작용) | -물이 흐르는 압력 그 자체<br>-ability of flowing water to pick up and move rock and sediment                                                                                                                   |
| solution<br>(용해)             | -물은 강력한 용해제<br>-dissolving of rocks 예) limestone                                                                                                                                                     |
| abrasion<br>(마식)             | -작은 암석 소용돌이치게 하여 깎는 것<br>-grinding away of stream channel by the friction and impact of the sediment load<br>-potholes(포트홀): eroded into streambed by abrasive action of sediment load in the stream |

## # Sediment Transport

- quantity of solid material depends on the streams' carrying capacity(=stream velocity)
- 4 processes that transport sediments



|                      |                                                               |
|----------------------|---------------------------------------------------------------|
| solution load(용해하중)  | -dissolved minerals and salts                                 |
| suspended load(부유하중) | -fine-grained particles(silt and clay)                        |
| saltation(도약)        | -material that is bounced along the bottom                    |
| traction(견인)         | -material that is dragged, pushed, or rolled along the bottom |

## # Stream Deposition

- deposition of sediment by a stream
- due to decrease in velocity: sediment begins to drop out

- stream sediments(alluvium, 충적층): generally well sorted(분극이 잘 되어 있음: 비슷한 크기의 알갱이 들끼리 모여 있음) → 본류에 가까울수록 coarse ~ fine

|              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| bars<br>(사주) | <ul style="list-style-type: none"> <li>-하중도, 모래톱</li> <li>-ridges of sediment(usually sand or gravel)</li> <li>-deposited in the middle or along sides of a stream</li> <li>-braided streams(망상하도): 사주 여러 개가 복잡하게 분포 <ul style="list-style-type: none"> <li>• an overabundance of sediment: discharge(유량) &lt; 퇴적물</li> <li>• deposited as numerous bars around which water flows in a system of highly interconnected rivulets</li> <li>• 빙하 지형에서 잘 발달: 겨울에는 빙하가 꼭대기에서 아래로 확장 → 바닥을 긁으면서 많은 양의 물질 발생 → 용빙수에 의해 아래로</li> </ul> </li> </ul> |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

-landforms created by deposition

|                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| floodplain<br>(범람원)            | <ul style="list-style-type: none"> <li>-flat, low-lying area flanking a stream channel that is subject to recurrent flooding (about once every 1~3 yrs)</li> <li>-formed when river overflows its channel → leaves behind alluvial deposits</li> <li>-하천습지, 우각호(oxbow lake), 자연제방(levee)</li> <li>-land use of floodplain <ul style="list-style-type: none"> <li>• freshwater available</li> <li>• the most fertile for farming</li> <li>• transportation</li> <li>• easier to develop than hilly land</li> </ul> </li> </ul> |
| stream rejuvenation<br>(하천 회춘) | <ul style="list-style-type: none"> <li>-침식 기준면의 하강으로 하방 침식이 부활</li> <li>-entrenched meanders</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                       |
| stream terraces<br>(하안 단구)     | <ul style="list-style-type: none"> <li>-resulting entrenchment of the river in its on floodplain produces alluvial terraces on either side of the valley that look like topographic steps</li> <li>-하천 하방침식의 결과 → 지반을 깎아내려 감</li> <li>-직선 하도가 곡류로 변모 → 양의 feedback으로 곡류 점점 심해짐 → 하방침식 &lt; 측방 침식 가속화 → 측방침식 계속, 하도의 변경(구하도, 우각호) → 지반 융기 → 다시 하방 침식 우세(침식 기준면까지 밑으로 깎으려는 물의 경향 때문)</li> </ul>                                                                                                                                 |
| river delta<br>(삼각주)           | <ul style="list-style-type: none"> <li>-when a river reaches a base level(㉠ around river mouth), velocity rapidly decelerates</li> <li>-sediment load spreads out <ul style="list-style-type: none"> <li>• coarse sediments deposited close to the river's mouth</li> <li>• finer sediments are carried farther</li> </ul> </li> <li>-each flood stage deposits a new layer of alluvium → grows outward</li> </ul>                                                                                                            |

### 14.3. Floods and River Management

#### # Flood

-flood: a high water level that overflows the natural riverbank along any portion of a stream

-factors that influence flooding: output < input (too much water entering a stream system)

- excessive rainfall
- snowmelt off mountains
- severe storms
- blockage of stream channel: trees, rock avalanches

## 15. Eolian Processes and Arid Landscapes

### 15.1. The Work of Wind

#### # Eolian Process

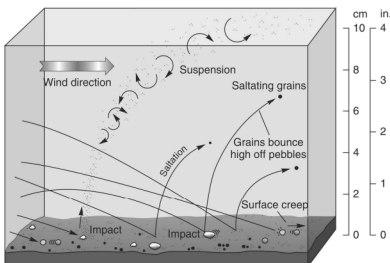
- wind-related processes
- moving air causes erosion, transportation, and deposition
- air is similar to water, except that it is a thinner fluid
- Why study eolian sand transport?
  - dry climates occupy 26% of land surface
  - wind has a large impact on erosion and shapes the landscape in arid locations
  - in the desert, winds can carry more sediment than any other geomorphological agent

#### # Eolian Erosion

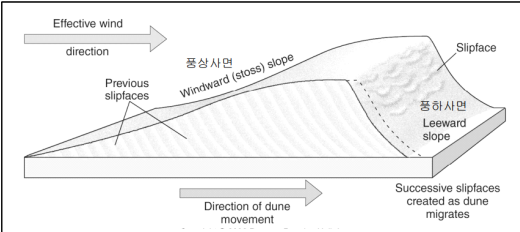
-eolian erosion occurs by

|                   |                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                          |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| deflation<br>(취식) | -removal and lifting of loose, non-cohesive particles<br>☞ produces desert pavement(사막포도) and blowout depressions(취식와지)                                                                                                                                            |                                                                                                                                                                                                                          |
|                   | desert pavement                                                                                                                                                                                                                                                    | -fine materials are eroded away by wind deflation (and moving water)<br>-leaving behind a concentration and cementation of coarse materials<br>☞ protects underlying sediment from further deflation (and water erosion) |
|                   | blowout depressions                                                                                                                                                                                                                                                | -단발적 사건으로 거대한 와지가 형성되는 것                                                                                                                                                                                                 |
| abrasion<br>(마식)  | -grinding, wearing down rock surfaces through sandblasting by particles suspended in the air<br>-rate of abrasion is determined by <ul style="list-style-type: none"> <li>• hardness of rock surface</li> <li>• wind velocity</li> <li>• wind constancy</li> </ul> |                                                                                                                                                                                                                          |
|                   | ventifact<br>(풍식력)                                                                                                                                                                                                                                                 | -rocks exposed to abrasion appear pitted, grooved, or polished and aerodynamically shaped in prevailing wind direction                                                                                                   |
|                   | yardang<br>(야르당)                                                                                                                                                                                                                                                   | -a wind-abraded ridge formed in cohesive material, often streamlined aligned to prevailing wind                                                                                                                          |

#### # Eolian Transportation

|                                                                                     |                                                                                                                                                                                                                      |
|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | -saltation(도약)                                                                                                                                                                                                       |
|                                                                                     | <ul style="list-style-type: none"> <li>• bouncing sand grains along the ground</li> <li>• accounts for ~79% of aeolian transport</li> <li>• powers other methods transport(creep): 위치E ☞ 운동E</li> </ul>              |
|                                                                                     | -creep(지표면 포행)                                                                                                                                                                                                       |
|                                                                                     | <ul style="list-style-type: none"> <li>• particles rolling or sliding along the surface</li> <li>• driven by the impact of saltating particles</li> <li>• accounts for ~20% of aeolian sediment transport</li> </ul> |
|                                                                                     | -suspension(부유운동)                                                                                                                                                                                                    |
|                                                                                     | <ul style="list-style-type: none"> <li>• only the finest particles are transported by turbulent air</li> <li>• may last for days at high altitudes</li> <li>• Yellow Sand</li> </ul>                                 |

## # Eolian Depositional Landforms

|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| sand ripples<br>(연흔) | -a series of crests and troughs created by saltation and deposition of individual sand grains<br>-form at right angles(transverse) to the wind: 바람의 방향과 직각으로 언덕열 형성                                                                                                                                                                                                                                                                                                                                                                                                                           |
| sand dunes<br>(사구)   | -accumulation of sand-sized particles deposited by wind<br>-연흔이 확장된 것(모래의 양, 바람의 세기 크면)<br>-dune initiation: 식생이 진입하여 퇴적에 영향을 줌 <ul style="list-style-type: none"> <li>a nucleus to disrupt wind and reduce wind velocity for deposition to occur</li> <li>양의 되먹임: 유체의 이동속도 감소 → 퇴적물 형성 → 더 많은 식생 진입...</li> </ul> -dune cross section<br><div style="display: flex; align-items: center;">  <div style="margin-left: 20px;"> <p>-풍상사면: 완경사</p> <p>-풍하사면: 급경사</p> <p>-dune의 확장: 바람 진행 방향으로</p> </div> </div> |
| barchan<br>(바르한)     | -초승달 모양의 사구<br>-barchanoid ridge: 모래 많은 경우 연결, right angle to wind                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| parabolic<br>dune    | -바다의 해륙풍은 바람의 방향이 비교적 일관적<br>-formed from blowouts(취식 와지)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| star dune            | -wind blows from several directions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

## 15.2. Desertification

### # 사막화

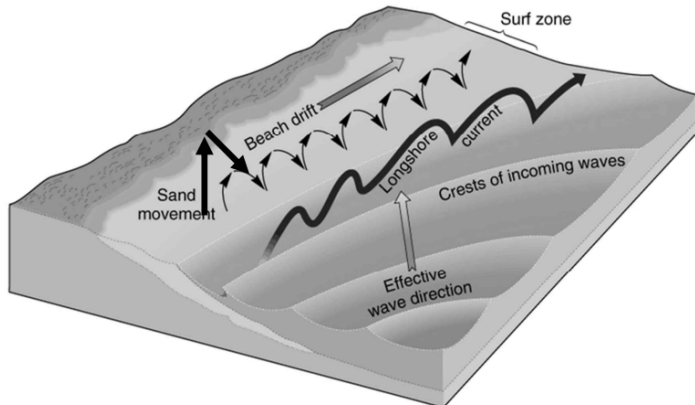
- unwanted expansion of Earth's desert land
- world-wide phenomenon along the margins of semiarid and arid lands
- due principally to
  - poor agricultural practices(overgrazing and agricultural activities that abuse soil structure)
  - improper soil-moisture management
  - erosion and salinization, deforestation
  - ongoing global climate change

## 16. The Oceans, Coastal Processes, and Landforms

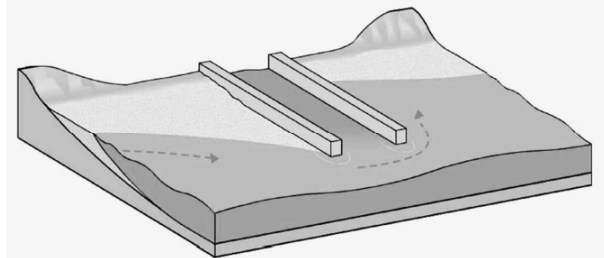
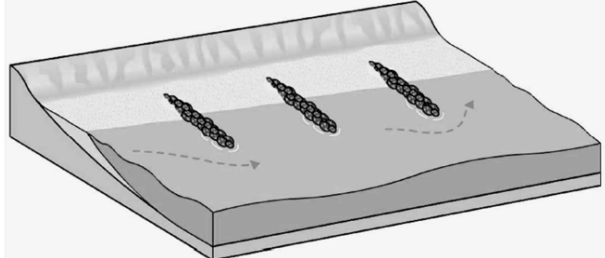
### 16.1. Coastal System Components

#### # Some Basics

|               |                                                                                                                                                                                                                      |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| tides<br>(조석) | -solar tide(미미), lunar tide<br>-forces: gravity, centrifugal force(inertia)<br>-24h 50m cycle: 2 highs and 2 lows generally <ul style="list-style-type: none"> <li>highs = flood tides / lows = ebb tides</li> </ul> |
| waves<br>(파랑) | -produced by friction between wind and water surface<br>-물방울의 '상하'운동<br>-higher, with longer period → more energy<br>-wave refraction(파랑의 굴절): submarine topography refracts, or bends approaching waves             |

|                                                                  | <p>-해저 등고선과 직각 방향으로 에너지 들어옴</p> <p>-해안의 공간적 변이(충격에 견디는 정도)에 따라 지형 다르게 나타남</p> <table><tr><th>bay</th><th>headlands</th></tr><tr><td><p>-diverge</p><p>☐ diffused(low wave energy)</p><p>-퇴적 위주</p></td><td><p>-converge</p><p>☐ concentrated(high wave energy)</p><p>-침식 위주</p></td></tr></table>                                                                               |  | bay | headlands | <p>-diverge</p> <p>☐ diffused(low wave energy)</p> <p>-퇴적 위주</p> | <p>-converge</p> <p>☐ concentrated(high wave energy)</p> <p>-침식 위주</p> |
|------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-----|-----------|------------------------------------------------------------------|------------------------------------------------------------------------|
| bay                                                              | headlands                                                                                                                                                                                                                                                                                                                                                                       |  |     |           |                                                                  |                                                                        |
| <p>-diverge</p> <p>☐ diffused(low wave energy)</p> <p>-퇴적 위주</p> | <p>-converge</p> <p>☐ concentrated(high wave energy)</p> <p>-침식 위주</p>                                                                                                                                                                                                                                                                                                          |  |     |           |                                                                  |                                                                        |
| longshore current<br>(연안류),<br>swash                             | <p>-longshore current: waves usually approach coasts at some angle other than parallel</p> <p>-after breakers crash on the beach, water moves forth(swash) and back(backswash)</p> <p>☐ beach drift(해빈표류): transport large amounts of sand, gravel, sediment and debris along the shore</p>  |  |     |           |                                                                  |                                                                        |

#### # Hard Protection(경성 호안 전략)

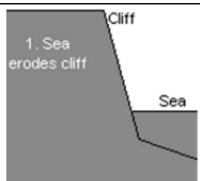
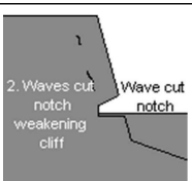
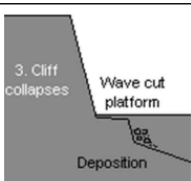
| jetty(돌제)                                                                           | groin                                                                                |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|  |  |

-딱딱한 구조물에 막힌 에너지 보존 ☐ 더 큰 침식을 유발함

## 16.2. Coastal System Outputs

### # Erosional Coastal Processes and Landforms

- erosional coasts: rugged, high relief
- 거대한 고원 ☐ 약한 부분이 파랑에너지에 의해 깎이고 각여 침식에 내성에 강한 부분만 남게 됨
- sea arch, sea stacks, sea cave, sea cliffs(해식애), wave-cut notch, marine terrace

|                                  |                                                                                                                                                                                                             |                                                                                     |                                                                                       |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| wave-cut notch and terrace (파식대) | -wave action cut a horizontal bench in the tidal zone, extending from a sea cliff out into the sea: 아랫부분이 깎여 무너진 잔해가 퇴적, 평평한 바닥 형성<br>-multiple platforms or terraces may rise like stair steps ☐ 융기하면 해안단구 |                                                                                     |                                                                                       |
|                                  |                                                                                                                          |  |  |

## # Depositional Coastal Processes and Landforms

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |               |                                                        |            |                                                                                             |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|--------------------------------------------------------|------------|---------------------------------------------------------------------------------------------|
| barrier spit<br>(사취)    | -depositional landform which consists of material deposited in a long ridge extending out from a coast<br>-파랑의 에너지가 사선으로 접근하면서 연안류 흐름 → 물질이 이동, 퇴적<br>• longshore current + beach drift = sediment transport                                                                                                                                                                                                                                                                   |               |                                                        |            |                                                                                             |
| barrier island<br>(사주섬) | -a long, narrow strip of sand forming islands<br>-protect inland areas from ocean waves and storms<br>-dynamic equilibrium with natural forces of sea level, tides and waves=<br><table border="1"> <tr> <td>inlet(조수 유입구)</td><td>-the channel of water between adjacent barrier islands</td></tr> <tr> <td>lagoon(석호)</td><td>           -a body of water cut off from a larger body by a reef of sand or coral<br/>           -사취가 연결되어 형성되기도 함         </td></tr> </table> | inlet(조수 유입구) | -the channel of water between adjacent barrier islands | lagoon(석호) | -a body of water cut off from a larger body by a reef of sand or coral<br>-사취가 연결되어 형성되기도 함 |
| inlet(조수 유입구)           | -the channel of water between adjacent barrier islands                                                                                                                                                                                                                                                                                                                                                                                                                         |               |                                                        |            |                                                                                             |
| lagoon(석호)              | -a body of water cut off from a larger body by a reef of sand or coral<br>-사취가 연결되어 형성되기도 함                                                                                                                                                                                                                                                                                                                                                                                    |               |                                                        |            |                                                                                             |
| tombolo<br>(육계사주)       | -occurs when sediment deposits connect the shoreline with an offshore island or sea stack                                                                                                                                                                                                                                                                                                                                                                                      |               |                                                        |            |                                                                                             |
| beach<br>(해빈)           | -a place along a coast where sediment is deposited by waves and currents<br>-shingle beaches: composed of pebbles and cobbles                                                                                                                                                                                                                                                                                                                                                  |               |                                                        |            |                                                                                             |

## 16.3. Coastal Wetlands

### # Salt Marshes(염습지)

- tendency to form north of the 30<sup>th</sup> parallel in NH: 열대, 아열대 벗어난 지방
- usually form in estuaries(기수역) and behind barrier beaches
- accumulation of fine grains(모래보다 더 미립질) produces a site for the growth of halophytic(염생식물, salt-tolerant) plants

### # Mangrove

- tendency to form around the equator where plants can avoid the effect of freezing conditions

## 17. Glacial and Periglacial Processes and Landforms

### 17.1. Glacial Processes

#### # Some Basics

- 77% of Earth's freshwater is in ice
- most glaciers are in Greenland and Antarctica
- today ca. 11% of Earth's land area is covered by ice → decreasing in size
- glaciers: a large mass of ice resting on land or floating as an ice shelf in the sea adjacent to land
  - = 'rivers of ice'
  - formed by the continual accumulation of snow that recrystallizes under its own weight into an ice mass (frozen lakes or groundwater ice are not glaciers)
  - formed in areas of permanent snow, at high latitudes or at high elevation
    - alpine / continental glaciers

#### # Glacial Erosion

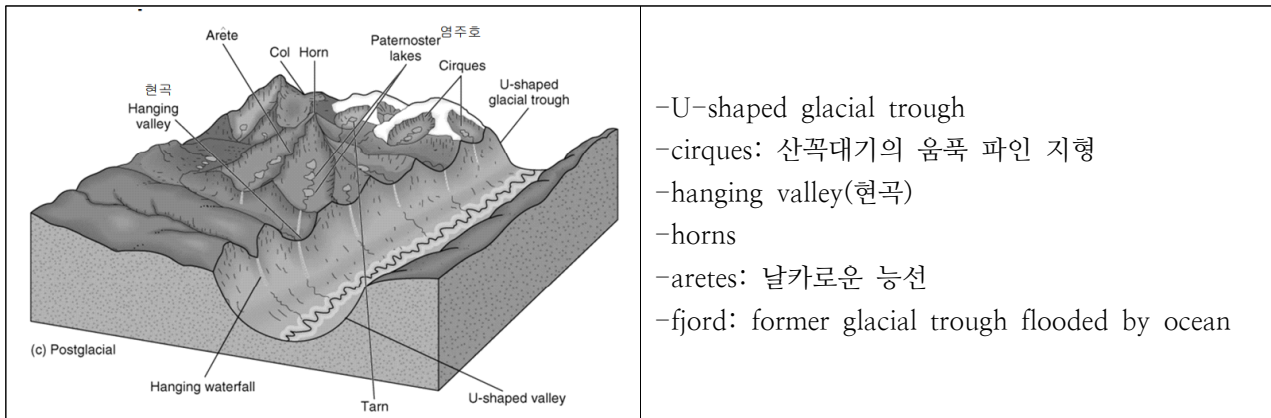
|                             |                                                                                                    |
|-----------------------------|----------------------------------------------------------------------------------------------------|
| glacial plucking<br>(빙하 굴식) | -passing glaciers mechanically pluck or pick up rock materials and carry it away                   |
| glacial abrasion<br>(빙하 마식) | -the plucked rocks that are embedded in glacial base scour and sandpaper the landscape as it moves |

|  |                              |                                                                      |
|--|------------------------------|----------------------------------------------------------------------|
|  | glacial polish<br>(빙하 연마)    | -a smooth surface on exposed rock by glacial abrasion                |
|  | glacial striation<br>(빙하 찰흔) | -scratches or gouges cut into bedrock by process of glacial abrasion |

## 17.2. Glacial Landforms

### # Alpine Glacial Landforms

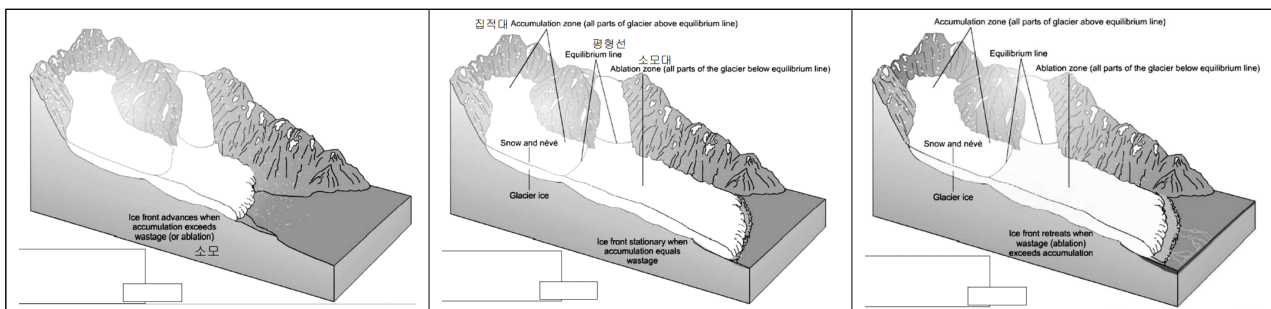
-erosional



-depositional

|                          |                                                                  |                                                                            |
|--------------------------|------------------------------------------------------------------|----------------------------------------------------------------------------|
| glacial drift<br>(빙하 표석) | -general term for all glacial deposits, both unsorted and sorted |                                                                            |
|                          | stratified drift<br>(성층 표석)                                      | -sediments deposited by glacial meltwater → sorted by size                 |
|                          | till<br>(빙력토)                                                    | -direct ice deposits → unstratified and unsorted debris (= colluvium, 붕적토) |

### \* Overview of Glacial Processes

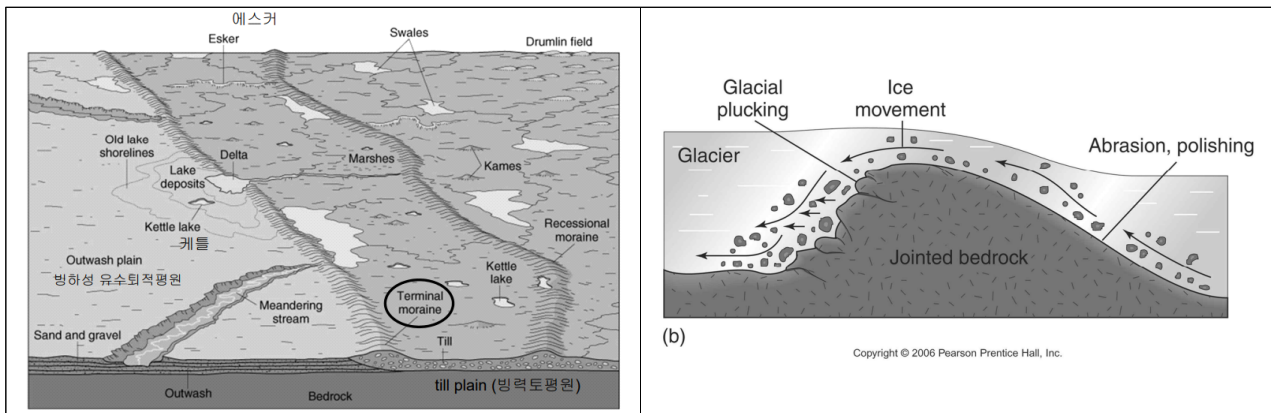


- 권곡에 눈이 쌓이기 시작, 점차 성장하면서 계곡 아래로 이동 → glacial plucking
- ice front advances when accumulation exceeds wastage(소모 < 공급)
- ice front stationary when accumulation equals wastage
  - accumulation zone(집적대): above equilibrium line
  - equilibrium line(평형선)
  - ablation zone(소모대): below equilibrium line
- ice front retreats when wastage exceeds accumulation → 용빙수에 의한 망상하도 형성, 성층표석
- 시간차를 두고 후퇴 → 빙하 말단 부분에 쌓인 빙력토를 빙퇴석(terminal moraine)이라고 함

### # Continental Glacial Landforms

- outwash plain(빙하성 유수퇴적평원): 용빙수에 의해 쌓인 alluvium
- till plain(빙력토평원): glacier의 최대 성장선

-drumlin field: plucking, abrasion and polishing of glacier



## 18. The Geography of Soils

### 18.1. Soil Characteristics

#### # Some Basics

- soil: a dynamic natural material composed of fine particles in which plants grow, and it contains both mineral fragments and organic matter → 여러 동식물이 자라는 지하 공간을 의미
- soil science: interdisciplinary(pedology, edaphology)
- soil profiles(토양 단면): from the surface to the deepest extent of plant roots, or to where regolith or bedrock(표토, 풍화토/기반암) is encountered
- solum(성토체): A, E, B층의 결합 → true, definable soil of the pedon / zone of active soil processes
- pedon: basic sampling unit used in soil surveys
- polypedon(토양체): an essential soil individual, or an identifiable series → basic mapping unit in preparing local soil maps
- soil horizons(토양 층위): each distinct layer exposed in pedon → each layer has distinct physical and chemical characteristics

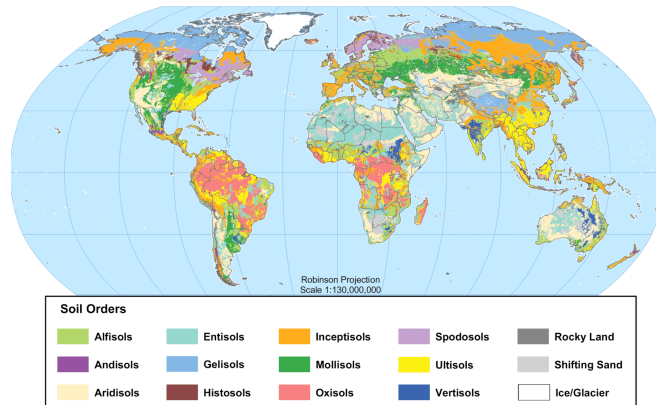
|           |                                                                                                                                                                                                                                                                                                                                                               |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| O horizon | <ul style="list-style-type: none"> <li>-organic layer, dark color</li> <li>-derived from plant and animal litter that are transformed into humus(부식토) <ul style="list-style-type: none"> <li>• humus: mixture of decomposed and synthesized organic materials</li> </ul> </li> <li>-important because of the ability to retain water and nutrients</li> </ul> |
| A horizon | <ul style="list-style-type: none"> <li>-richer in organic content</li> <li>-darker than lower zones</li> </ul>                                                                                                                                                                                                                                                |
| E horizon | <ul style="list-style-type: none"> <li>-made up of coarse sand and silt</li> <li>-zone of leaching(용탈) or eluviation(세탈) <ul style="list-style-type: none"> <li>• eluviation: removal(downward movement) by water of silicate clays and oxides of Al and Fe</li> </ul> </li> </ul>                                                                            |
| B horizon | <ul style="list-style-type: none"> <li>-accumulate clays, Al, Fe</li> <li>-zone of illuviation(집적)</li> </ul>                                                                                                                                                                                                                                                 |
| C horizon | <ul style="list-style-type: none"> <li>-zone of regolith(표토, 풍화토) or weathered bedrock</li> <li>-outside of the biological influences</li> </ul>                                                                                                                                                                                                              |
| R horizon | <ul style="list-style-type: none"> <li>-(un)consolidated bedrock</li> </ul>                                                                                                                                                                                                                                                                                   |

### 18.2. Soil Classification

#### # Soil Taxonomy

| soil category       | orders<br>(토양목) | suborders<br>(토양아목) | great groups<br>(토양대군) | subgroups<br>(토양아군) | families<br>(토양과) | series<br>(토양통) |
|---------------------|-----------------|---------------------|------------------------|---------------------|-------------------|-----------------|
| # of soils included | 12              | 47                  | 230                    | 1200                | 6000              | 15000           |

### Global Soil Regions



USDA NRCS US Department of Agriculture Natural Resources Conservation Service Soil Survey Division World Soil Resources soils.usda.gov/use/worldsoils

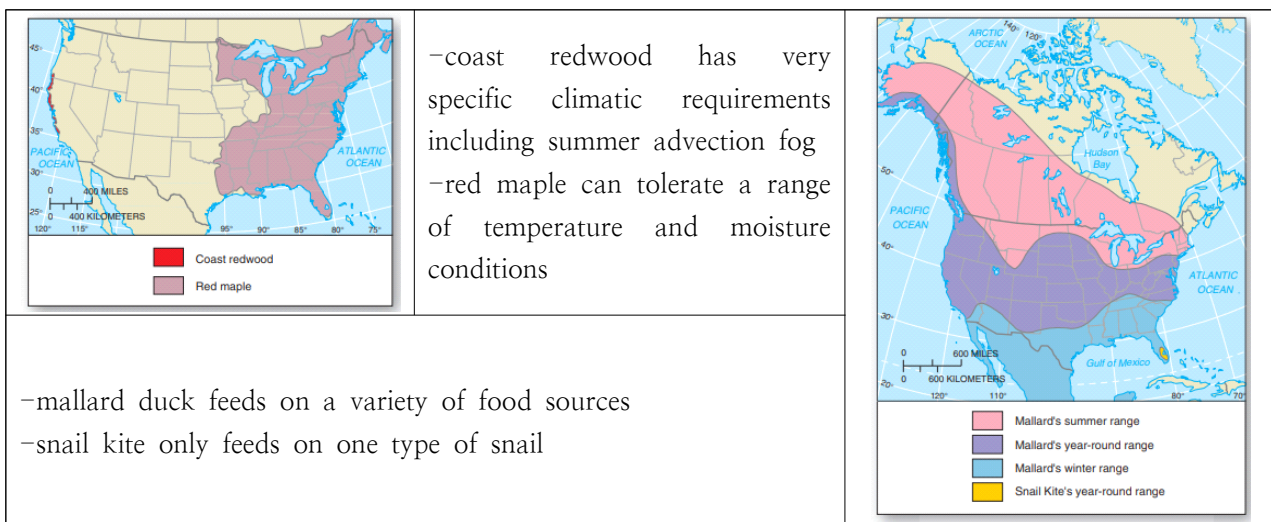
November 2005

## 19. Ecosystem Essentials

### 19.1. Ecosystem Components and Cycles

#### # Some Basics

- ecology: study of the relationships between organisms and their environment
- biogeography: study of the distribution of plants and animals → geographic relationships between organisms and their environments



-Why are organisms found where they are?

- pattern and processes that influence the distribution
  - what happens when these patterns and processes change? → what can we do to preserve
- controlling factors

|                            |                                                                                                                                                                                  |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| biotic(living)<br>controls | <ul style="list-style-type: none"> <li>-disease, preadators, parasites</li> <li>-food availability</li> <li>-ability to adapt, compete, migrate, reproduce and defend</li> </ul> |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                              |                                                                                                                                                                                                            |
|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| abiotic(non-living) controls | -climatic controls: temp, precip, wind, sunlight, photoperiod etc<br>-geomorphic/edaphic controls: slope, aspect, soil type, relief, etc<br>-element, nutrient, chemical cycling: availability of C, N etc |
|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## 19.2. Photosynthesis and Respiration

### # Abiotic Ecosystem Components

|               |                                                                                                                |
|---------------|----------------------------------------------------------------------------------------------------------------|
| climate       | -ecosystems are determined by both temp and precip<br>-dry tundra ~ tropical forest                            |
| geomorphology | -slope and aspect: important control of temperature and moisture<br>-북쪽 바라보고 있는 사면에서 나무들이 잘 자람(∵ 토양 수분 증발량 적음) |
| soil types    | -fertility, texture, depth, water holding capacity, ...                                                        |

## 19.3. Biotic Ecosystem Operations

### # Ecological Hierarchy

-생태적 위계: biomes - ecosystem - community - population - individual

- increasing geographic and taxonomic scale

|                 |                                                                                                                                                                                                                                                                                            |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| population(개체군) | -all individuals of given species in a prescribed area<br>-close enough in proximity to be able to interact and interbreed frequently                                                                                                                                                      |
| community(군집)   | -all populations of organisms that live and interact within a given area<br>-formed by interactions among populations of different species that occur together in space and time<br>cf. habitat(서식지): the place where an organism resides or is biologically adapted to reside(물리적, 실제 장소) |
| ecosystem(생태계)  | -self-sustaining association of living plants and animals and their nonliving physical environment                                                                                                                                                                                         |

## 19.4. Ecosystems, Evolution, and Succession

### # Disturbance, Succession, and Biodiversity

-disturbance(교란): 예측 어려움, 갑작스럽게 생태계에 큰 피해(예 병충해, 산사태, 홍수, 가뭄)

-succession(천이): gradual replacement of species by other species over time

- landscapes usually transform from simple communities to more complex ones
- disturbance opens up space for new species to colonize → 천이 발생
- primary succession(일차 천이): 척박한 조건 견딜 수 있는 제한적인 종의 진입
- succession of vegetative communities(forbs and grasses → shrubs → trees → forest): 경쟁을 통해 나무들이 몰아내는 과정

## 20. Terrestrial Biomes

### 20.1. Earth's Major Terrestrial Biomes

#### # Biomes

-biome: a large, stable terrestrial ecosystem characterized by specific plant and animal communities

-each biome is usually named for its dominant vegetation

-terrestrial biomes

- forest

- savanna
- shrubland
- desert
- grassland
- tundra

#### # Major Terrestrial Biomes

|                                              |                                                                                                                                                                     |
|----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| equatorial and tropical rainforest<br>(열대우림) | -tropical climate<br>-warm all year<br>-high precipitation<br>-water and nutrient surplus                                                                           |
| tropical savanna<br>(열대 사바나)                 | -tropical savanna climate<br>-precipitation less than 6 months<br>-water deficits<br>-xerophytic(건생 식물) vegetation: 어느 정도 나무 지탱 가능                                  |
| needleleaf and montane forest                | -also called 'boreal' and 'taiga'<br>-dominate in high latitudes and altitudes<br>-short growing season<br>-long winters, moderate rainfall<br>-needleleaf conifers |
| midlatitude grasslands                       | -humid subtropical: hot summer climate<br>-continental temperature<br>-tallgrass prairies<br>-shortgrass steppes                                                    |
| arctic and alpine tundra                     | -tundra, subarctic climate<br>-cold and dry<br>-dwarf shrubs, sedges, mosses, lichens, short grasses<br>-가장 큰 stress, 극한의 환경                                        |